

PORTSMOUTH NAVAL SHIPYARD  
PORTSMOUTH, N. H.

IN REPLY REFER TO

**UNCLASSIFIED**

7 June 1963

~~CONFIDENTIAL~~

From: President, Court of Inquiry (USS THRESHER)  
To: Office of the Judge Advocate General  
Attn: Investigations Division (CAPT)

Subj: Record of investigation of flooding of engine room of USS  
BARBEL (SS 580) on 30 November 1960

Ref: (a) JAG spdltr JAG:332:mjw Ser. 048 dtd 6 May 1963

Encl: (1) Complete record of subject investigation, Bnd. #10035-61

1. Subject record is returned as requested in reference (a).

For: VADM B <sup>1</sup> , USN

*Ret'd 6/11*

*B-1#  
10035-61*

*6-10-63*

*pm  
All B6*

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ras  
Ser 09BLL  
20 Dec 1962

~~CONFIDENTIAL~~ - Unclassified upon removal of  
basic record

**EIGHTH ENDORSEMENT** on Board of Investigation to inquire into  
the circumstances surrounding the flooding  
of the engine room on USS BARBEL (SS-580)  
on 30 November 1960

**From:** Chief of Naval Operations  
**To:** Judge Advocate General

**Subj:** Investigation to inquire into the circumstances surround-  
ing the flooding of the engine room on board USS BARBEL  
(SS-580) on 30 November 1960(U)

1. Returned, contents noted.

*m*  
By direction

*By*  
*B-H*  
*10035-61*  
*1-22-62*  
*pm*  
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Pers-F21-ber  
Ser F2/074  
28 DEC. 1961

SEVENTH ENDORSEMENT on Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on USS BARBEL (SS-580) on 30 November 1960

From: Chief of Naval Personnel  
To: Chief of Naval Operations

SS580

Subj: Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS-580) on 30 November 1960 (U)

1. Forwarded.
2. On 30 November 1960, the USS BARBEL (SS-580) was submerged at sea at 600' proceeding at 5 knots when a joint consisting of a 5" pipe in the salt water service system separated from the elbow flooding the engine room. The flooding was effectively controlled in about 3 minutes. The flooding caused extensive damage to the engine room, including such units as the #2 and #3 generators, trim pump pumping motor, salt water service pump and tank level indication-transmission cables.
3. The investigation brought out that the casualty was caused directly by a combination of poor workmanship and the unknowing use of corrosion-resistant steel piping in lieu of the specified 70 - 30 copper nickel piping which made a satisfactory silver solder joint improbable. The improper substitution of piping was made by persons whose identity could not be established. The most likely supervisors of the workmen in question were Mr. 1 or Mr. both leadingmen coppersmiths.
4. The investigation also brought out other deficiencies that existed and restricted the operations of the BARBEL. These deficiencies reflected on design and materials used. These problems are often encountered in new construction, particularly in a lead ship.
5. The board made the following recommendations:
  - (a) Replace all CRES tubing and fittings larger than  $\frac{1}{2}$ " in the hydraulic system with copper nickel tubing.
  - (b) Initiate an examination of silver-brazed joints in vital areas of the salt water system of all submarines to prevent reoccurrence of this casualty.
  - (c) Radiographic examination of silver-brazed joints and other methods of investigation should be further developed.
  - (d) BUSHIPS disapprove further use of certain tubing and fittings until sufficient testing has been accomplished to insure lasting tightness.

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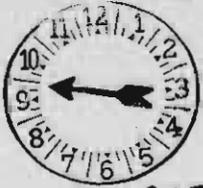
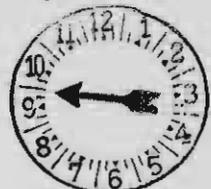
- (e) A copy of these proceedings be furnished to the Portsmouth Naval Shipyard to help them restore the shipyard's performance to high levels.
  - (f) Due to lack of evidence to establish persons responsible for the joint that failed, no disciplinary action is recommended against naval personnel or employees of the Department of Defense.
6. Commandant, FIRST Naval District approved the proceedings and Commander Submarine Force, Atlantic reported that the Commander Portsmouth Naval Shipyard is taking steps to restore the shipyard's performance and reputation.
7. Commander in Chief, Atlantic Fleet approved the investigation and BUSHIPS reports the following action taken:
- (a) All CRES tubing and fittings larger than 1/2" have been replaced in BARBEL and fittings of this type greater than 1" have been prohibited in all submarines.
  - (b) An extensive program has been initiated to develop revised techniques for examination of silver-brazed joints in vital systems of submarines.
  - (c) Instructions have been issued to improve the control of material and its usage and to assure highest quality workmanship.
8. The Chief, Bureau of Ships, further commented that he "recognizes the situation highlighted by the BARBEL casualty as one which directs that the utmost vigor be applied to correct deficiencies.....every effort will be expended toward this end."
9. The Chief of Naval Personnel agrees with the assessment given in this case and does not contemplate further administrative action.

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by direction

RECEIVED  
NAVY DEPARTMENT  
OPNAV CENTRAL MAIL ROOM  
7 JAN 1962

RECEIVED  
NAVY DEPARTMENT  
OPNAV CENTRAL MAIL ROOM  
4 JAN 1962



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Reg. No. 3702737  
Page No. 1-1

Reg. No. \_\_\_\_\_  
Page No. \_\_\_\_\_

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of Index 3  
of Index 2

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Ser 0597  
NOV 13 1961

SIXTH ENDORSEMENT on Board of Investigation to inquire into the circumstances surrounding the flooding of the engine on board USS BARBEL (SS580) on 30 Nov 1960

From: Chief, Bureau of Yards and Docks  
To: Chief of Naval Operations  
Via: Chief of Naval Personnel

SS580  
F2-AC1

Subj: Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS580) on 30 Nov 1960 (U)

1. Forwarded.
2. A review of the investigation indicates there are no matters under the cognizance of the Bureau of Yards and Docks.

*[Handwritten signature]*

By direction

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DECLASSIFIED AFTER 12 YEARS.  
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C-SS580  
Ser 525-0288  
24 OCT 1961

FIFTH ENDORSEMENT on Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS580) on 30 Nov 1960

C-2962

From: Chief, Bureau of Ships  
To: Chief of Naval Operations  
Via: (1) Chief, Bureau of Yards and Docks  
(2) Chief of Naval Personnel

Subj: Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS580) on 30 Nov 1960 (U)

1. Forwarded.
2. As a result of BARBEL's flooding, the following specific actions which relate to the recommendations, page 20, were taken by the Bureau of Ships:
  - a. All CRES tubing and bite-type fittings larger than 1/2" I.P.S. in BARBEL's hydraulic system have been replaced. Bite-type fittings have been prohibited in all submarines in pipe sizes greater than 1".
  - b. An extensive program has been initiated to develop techniques which will provide a means for non-destructive examination of silver brazed joints in vital systems in submarines. This program is divided into the immediate need to apply existing techniques and devices, and the longer range development of specific test equipment for this purpose. The immediate need has been satisfied through the application of a more rigorous hydrostatic-visual examination while physically disturbing the joint, the use of impulse techniques, and invoking radiographic requirements for the larger joints in critical systems. Instructions for conducting these examinations have been promulgated in the form of NAVSHIPS publication 250-648-8. The longer range program to develop specific test equipment has shown considerable progress through the efforts of Naval Laboratories, Shipyards and private contractors. Electrical conductivity and hydrostatic cycling have been proven unreliable, but ultrasonic techniques have been demonstrated to be feasible and are now being perfected. Standards are being developed and it is anticipated that equipment and techniques will be available in early 1962 for non-destructive examination of silver-brazed joints.
  - c. Instructions have been promulgated to improve the control of material throughout procurement and usage sequences. These controls are proving effective in all activities responsible to the Chief, Bureau of Ships. Similarly, instructions for performing work in critical systems have been strengthened and are being aggressively supervised to assure highest quality workmanship.

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DOD DIR 5200.10

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C-SS580  
Ser 525-0288

3. In addition to the above progressive steps, the following major improvements have been accomplished on BARBEL during her shipyard availability:

a. The complete hydraulic system has been inspected and reworked to provide a tighter and more efficient system with proper materials throughout. During sea trials during the first two weeks in October this system was observed to be tight.

b. The bow planes, proven to be a material and operational liability in all BARBEL class submarines, have been redesigned and relocated to the sail area. In addition to improved reliability, these planes effectively increase the available ships hydraulic system capacity by approximately 20%, through decreased hydraulic demand.

c. The entire salt water piping system of 4" and larger diameter has all welded fittings (no sil-braze).

4. The Chief, Bureau of Ships, recognizes the situation highlighted by the BARBEL casualty as one which directs that the utmost vigor be applied to correct deficiencies in both the Bureau of Ships and its activities to prevent similar incidents in the future. Every effort will be expended toward this end.

Copy to:  
JAG  
CINCLANTFLT  
COMSUBLANT  
COMONE  
COMNAVSHIPYD PTSMH

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DECLASSIFIED AFTER 12 YEARS.  
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DEPARTMENT OF THE NAVY  
OFFICE OF THE JUDGE ADVOCATE GENERAL  
WASHINGTON 25, D. C.

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IN REPLY REFER TO  
JAG:332.2:pm  
Bnd. #10035-61

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FOURTH ENDORSEMENT on subject record

25 AUG 1961

From: Judge Advocate General  
To: Chief of Naval Operations  
Via: (1) Chief, Bureau of Ships  
(2) Chief, Bureau of Yards and Docks  
(3) Chief of Naval Personnel

Subj: Inves. - Flooding of the engine room on board USS BARBEL  
(SS580) on 30 Nov 1960 (U)

1. Forwarded for information and return.
2. The proceedings in the attached case have been conducted in substantial compliance with the requirements of the Naval Supplement to the Manual for Courts-Martial and are therefore legal.

*[Signature]*  
By direction

ENCLOSURES RECEIVED IN 233

This endorsement is automatically declassified when removed from the basic record.

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FF1-2

Serial: 01456 /141  
22 August 1961

~~CONFIDENTIAL~~ (Unclassified when removed from basic material)

**THIRD ENDORSEMENT** on Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS580) on 30 Nov 1960

From: Commander in Chief U. S. Atlantic Fleet  
To: Judge Advocate General

Subj: Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS580) on 30 Nov 1960 (U)

1. The proceedings, findings of fact, opinions and recommendations of the board of investigation and action of the Commander Submarine Force, U. S. Atlantic Fleet are approved and the endorsement of the Commandant, First Naval District is concurred in.

*[Signature]*  
Deputy and Chief of Staff

Copy to:  
COMSUBLANT  
COMONE  
COMNAVSHIPYD, PTSMH, N. H.

*B-8 #*  
*10035-61*

*Wpac*  
*30 Nov 1960*

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5830/1  
Ser ~~1000~~/ 977

~~CONFIDENTIAL~~ (Unclassified when removed from basic)

12 JUL 1961 11

SECOND ENDORSEMENT on Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS580) on 30 Nov 1960

From: Commander Submarine Force, U.S. Atlantic Fleet  
To: Judge Advocate General  
Via: Commander in Chief U.S. Atlantic Fleet

Subj: Board of investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS580) on 30 November 1960

Ref: (a) CDR , UEN, . . . . . ltr ser 01 of 3 Jan 1961 with, inter alia, COMSUBLANT 3rd end ser 082 of 23 Feb 1961

1. Forwarded.

2. The instant investigation was precipitated by reference (a), the investigation report concerning the engine room flooding of BARBEL on 30 November 1960. COMSUBLANT is pleased to note from this inquiry into the matters recommended by his endorsement on reference (a) that Commander Portsmouth Naval Shipyard is taking steps to restore the shipyard's performance and reputation to previous high levels. He hopes that these steps will be successful and that BARBEL, when she finally leaves the yard in October 1961, will be an effective fleet unit.

3. Subject to the foregoing comment, the proceedings, findings of fact, opinions, and recommendations of the board of investigation are approved and the action of the convening authority is concurred in.

Copy to:  
COMONE  
NAVSHIPYD, PFSMH, NH

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5830/CSF/erk  
Ser: 0253ND22

19 MAY 1961

FIRST ENDORSEMENT on Board of Investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS-580) on 30 Nov 60

From: Commandant, First Naval District  
To: Judge Advocate General  
Via (1) Commander Submarine Force, U.S. Atlantic Fleet  
(2) Commander in Chief, U.S. Atlantic Fleet

Subj: Board of investigation to inquire into the circumstances surrounding the flooding of the engine room on board USS BARBEL (SS-580) on 30 November 1960

1. Readdressed and forwarded.

2. It is noted that the findings of fact fail to disclose whether the salt water service system containing the joint that failed was submitted to tests by the Shipyard upon completion of construction. Exhibit 30, however, indicates that the system was tested hydrostatically with satisfactory results in accordance with pertinent directives.

3. Subject to the foregoing comments, the proceedings, findings of fact, opinions and recommendations are approved.

Copy to:  
NavShipyd, Ptsmh, NH

953-313-03

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The Board, having thoroughly inquired into all the facts and circumstances connected with the incident which occasioned the investigation, and having considered the evidence adduced, finds as follows:

FINDINGS OF FACT

1. On 30 November 1960, BARBEL was at sea, submerged, proceeding to the exercise area designated for Operation SLAMEX. At 1003R she was at Latitude 31° 48' N, Longitude 67° 41' W, in 2750 fathoms submerged to 600 feet proceeding at 1/3 speed (5 knots) on course 293° True.
2. At 1003R a joint consisting of a five-inch pipe (C-3 on Exhibit #22) separated from an elbow (F-22 on Exhibit #22) in the salt-water service system, flooding the engine room.
3. As a result of immediate, correct and effective response by the crew, the flooding was controlled within approximately 3 minutes.
4. The flooding caused the following damage:
  - (a) No. 2 generator, zero ground.
  - (b) No. 3 generator, zero ground.
  - (c) Trim pump priming pump motor, zero ground.
  - (d) Salt water Service Pump, zero ground.
  - (e) Tank level indication transmission cables flooded.
  - (f) Atwood-Morrill blow and trim control valves grounded.
  - (g) Trim Pump Service parallel valve flooded and grounded.
  - (h) Lighting fixture at Frame 61 portside grounded.
5. Examination and tests of the joint and sighting and examination by the Board established that:
  - (a) The pipe was stainless steel (CRES).
  - (b) The elbow was bronze.
  - (c) The silver-alloy insert had not fully melted.
  - (d) There was no indication of deposit of silver alloy ground the pipe except for sharp linear delineation in the area of the fillet.
  - (e) The brazing of the joint had been primed or supplemented by face-feeding or both.
  - (f) The measurements taken on the pipe and fitting indicated that clearances between the pipe and fitting were greater than those specified for a pipe of this size.
6. Copper nickel pipe was specified by Exhibit #22 for the salt-water system in general, and pipe C-3 in particular.
7. The substitution of corrosion-resistant steel for copper nickel was not authorized in that system.
8. The joint which failed had not been broken since originally installed during construction.
9. The affected joint had given no indication of being defective prior to the casualty.

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10. The specified silver alloy solder was used in the insert ring and the face-fed fillet.
11. The estimated cost of repairing the main generators, the major items damaged in the casualty, is \$58,000.
12. The estimated cost of repairing the joint which failed is \$3,000.
13. At the time of the casualty the materiel condition of BARBEL was essentially the same as that described in the Final Acceptance Trials and Materiel Inspection conducted 27-29 June 1960, (Exhibit 3), amplified by Findings of Fact 14 through 46.
14. There was excessive external leakage in the hydraulic system and internal leakage.
15. The hydraulic system had questionable capacity for operating necessary equipment under the most demanding operating conditions.
16. There were difficulties in rigging out and rigging in the bow planes.
17. Bow planes interfered with passive sonar.
18. One five-inch silver solder joint failed in the salt-water circulating system.
19. An additional silver soldered joint in the salt water circulating system had improper material, no insert ring and inadequate adhesion.
20. There were numerous silver soldered joints in the salt water circulating system which had leaked and had been repaired.
21. There were silver soldered joints which were leaking.
22. Other silver brazed joints in the salt water and air system were suspect because of appearance.
23. The use of Cellulube in the air compressors resulted in damage to Buna "O" rings and gaskets.
24. The installed submersible salt water pump was not continuously operable due to seal failures.
25. The check features of the high pressure air stop check regulator valves on the main ballast tanks failed to operate.
26. The periscope bounced at the upper end of its travel.
27. ECM and UHF-IFF masts would not retract with regularity due to intermittent binding.

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28. A thumping noise, attributed by ship's personnel to the seating of masts, was heard in the Control Room when the ship changed fore-and aft vertical attitude while submerged.
29. There were no provisions for isolating the salt-water side of the battery water cooling system from the salt-water circulating system.
30. There were no provisions for splitting the salt-water circulating system into forward and after plants.
31. No. 1 and No. 2 salt-water circulating pumps were leaky and noisy.
32. The Muffler Exhaust valves for the main engines failed to seat properly on occasion.
33. The negative tank vent indication on the ballast control panel showed both open and shut when the vent was open.
34. Marotta air blocking valves leaked.
35. The anchor weight is 1000 pounds below original specifications.
36. There were no provisions for isolating the Sanders servo valve in the steering system.
37. "Quick-as-a-wink" valve in the snorkel head did not operate fast enough to prevent excessive water from entering the snorkel system.
38. The dimmer switch on the bridge gyro repeater was so located as to result in flooding of the gyro repeater.
39. The position indicator lights on the port whip antenna showed "raised" when the whip was housed.
40. Main ballast tank flood closures on tanks 2A, 2B, 5A and 5B did not operate properly.
41. There were a large number of "O" ring failures and excessive leakage in "O" ring joints.
42. The MK-19 gyro standby supply had burned out several times.
43. The main generator housings were not watertight below the main bearing centerline.
44. There were no inspection ports in the lower half of the main generator housings.
45. The battery was approaching the end of its life.

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46. The power assist for No. 1 periscope was not operable.
47. Bow plane rigging difficulties were due to a complicated installation which required careful and exact sequential operations and adjustments.
48. The significant dates in the construction of BARBEL are:

Keel laid	5-18-56
Launched	7-18-58
First sea trials began	5-13-59
Preliminary Acceptance trials	5-15-59
Completion	5-29-59

49. The dates, places and purposes of BARBEL's availabilities are:

<u>DATES</u>	<u>TYPE</u>		<u>PURPOSE</u>
8-31-59 - 9-13-59	RAV	Portsmouth Naval Shipyard	Install instrumentation for BUSHIPS Laboratory characteristics trials.
9-28-59 - 10-1-59	RAV	Portsmouth Naval Shipyard	Change instrumentation.
11-2-59 - 12-14-59	PSA	Portsmouth Naval Shipyard	Correct Part I PAT items and Voyage deficiencies.
12-14-59 - 12-31-59 (extended)	PSA	Portsmouth Naval Shipyard	Hydraulic system deficiencies.
12-31-59 - 1-12-60 (extended)	PSA	Portsmouth Naval Shipyard	Complete work on hydraulic system.
1-12-60 - 2-26-60 (extended)	PSA	Portsmouth Naval Shipyard	Correct additional hydraulic deficiencies.
2-26-60 - 4-15-60 (extended)	PSA	Portsmouth Naval Shipyard	Correct continued deficiencies in hydraulic system.
4-15-60 - 4-29-60 (extended)	PSA	Portsmouth Naval Shipyard	Replace material in air systems adversely affected by Cellulube.
4-29-60 - 5-6-60 (extended)	PSA	Portsmouth Naval Shipyard	Repair section of snorkel exhaust piping between frames 46 and 48.

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1-9-61 - 2-17-61	RAV	Portsmouth Naval Shipyard	Corrected deficiencies listed by COMSUBLANT, principally hydraulic system deficiencies. RAV date modified to include repair of damage caused by flooding casualty on 11-30-60.  On 28 Feb 61, RAV modified to regular overhaul.
1-9-61 - 5-26-61	Overhaul	Portsmouth Naval Shipyard	Regular overhaul approved by CNO (28 Feb).

50. The Organizational Structure and the vesting of responsibilities in its personnel are and were in conformity with that prescribed in Portsmouth Naval Shipyard Instruction P5450.1A of 21 February 1961.
51. Changes in Organization and responsibilities, particularly in Design Division and the Shops Division of the Shipyard were made during the period 1956-1961.
52. The prescribed mission and tasks for the BARBEL are listed in OPNAV Confidential Instruction 0901.92 OP 433 serial 062343B of 24 June 1955.
53. There were increasing ship workload manpower requirements placed on Shop 56 starting in 1956.
54. From about 1956 there was a sharp increase in the proportion of Shop 56 effort relative to the total shops effort in the construction of new submarines.
55. There was a sharp increase in the level of technological skills required for Shop 56 personnel starting about 1956.
56. That the labor market is extremely limited and did not and does not provide persons with the skills required by Shop 56.
57. Intense training of in-hires is essential.
58. Personnel ceilings were imposed on the Portsmouth Naval Shipyard during the building period of BARBEL.
59. New construction ships of higher priority and ships undergoing repair drained off the best mechanics from Shop 56 leaving mechanics of lesser skills for BARBEL.

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60. BARBEL was behind schedule most of her construction period.
61. The Master of Shop 56, Mr. \_\_\_\_\_ was absent for extended periods in 1959 and '60 due to illness. /
62. Mr. \_\_\_\_\_ retired on 13 January 1961. /
63. Mr. \_\_\_\_\_ was the Acting Head of Shop 56 during the time of Mr. \_\_\_\_\_ absences, and since 13 January 1961.
64. The basic system of material control used in this Shipyard is defined in Portsmouth Naval Shipyard Instruction 4410.1 of 23 March 1956. (Exhibit 24)
65. There were and are amplifying and implementing documents in use in various departments which were issued to assure conformance to Portsmouth Naval Shipyard Instruction 4410.1.
66. The implementation of Portsmouth Naval Shipyard Instruction 4410.1 resulted in following flow and control; Design specifies on a plan the details necessary to identify the requisite materials. The Planning and Estimating Division transfers the material specifications to the Material and Progress Sheet and the Material Notification Sheets identifying specific material by individual stub numbers. The Supply Department uses the information in the Material Notification Sheets to obtain bids and let contracts for the required material, maintaining the stub number identification. The material may be inspected at source or arrival at the Shipyard. In either event, on receipt, the Supply Department identifies it and marks it with information provided either by the Inspector of Naval Material or from Supply Department Material Identification inspection. After identification and marking of material, it is stored in a Supply Control Direct Material Inventory warehouse retaining stub number identification. The material is held by DMI warehouse until ordered by the shop by means of a written form (PNS 955). This material is then delivered to the shop where it is placed into the DMI material cage and identified by the stub number to the Material and Progress Sheet previously forwarded from the P&E Division. It is drawn when needed from the DMI material cage by a Production Dispatcher responsible for the material cage upon the request of the mechanic. Both mechanic and dispatcher witness the withdrawal of the material and the markings thereon, comparing them against the information on the M&P sheet. The identity of the mechanic drawing the material is recorded on the M&P sheet. The safeguarding of the identity of the material becomes the responsibility of the mechanic at this point. There was no formal requirement for the shop or its personnel to re-identify the material by testing before 1961.
67. During the period 1956 to the present, management, including that at the command level, devoted much time and effort to the improvement and implementation of the material control plan.

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68. The Portsmouth Naval Shipyard has a system of quality control which provides for design control, material control, in-process control and final product control.
69. Quality of in-process work in Shop 56 at the time of building of BARBEL was and is currently the responsibility of the mechanic(s) performing the work.
70. During the period 1956-1960, there were issued design instructions, process instructions, technical notes and memoranda relative to silver brazing of joints and to the making of bite-type fittings.
71. In-process inspection to assure quality in Shop 56 work during construction of BARBEL was the responsibility of first-line supervision, i.e., the leadingman in most cases.
72. Final inspection of Shop 56 work was and is in accordance with the test memo prescribed for the particular system by the Design Division.
73. Final inspection is the responsibility of the Inspection Division of the Production Department.
74. Design specifications for the hydraulic system of BARBEL required copper nickel (70:30) tubing.
75. Because of unavailability of copper-nickel tubing over a long period, and, upon recommendation of the Portsmouth Naval Shipyard, BuShips approved substitution of uniformly and fully annealed corrosion-resistant steel tubing.
76. The original ferrules for the bite-type fittings provided by the vendor, and used by the Shipyard in making up some of the fittings were not of the right composition to insure tight joints when used with corrosion-resistant steel tubing. The ferrules came with the fittings, but were not marked, leading to problems of mixing and identification during the early stages of assembling the hydraulic system. The ferrules were later marked by the vendor so that positive identification was possible.
77. The condition of the anneal of the corrosion-resistant steel tubing for the hydraulic system, supplied to the Shipyard, varied from pipe to pipe and was at the upper end of the allowable hardness range.
78. Tests for hardness were made on 136 samples from stocks bearing the same stub numbers as the corrosion-resistant steel tubing installed in the BARBEL.
79. The samples tested were representative of the corrosion-resistant steel tubing installed in the BARBEL during construction.

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80. Instruction was given to Shop 56 personnel in the make-up of bite-type fittings by vendors' representatives during the building period and subsequent thereto.
  81. Instructions for installing bite-type fittings recommended, inter-alia:
    - a. A pre-set condition;
    - b. The additional number of turns to make a tight joint;
    - c. The maximum additional turns to re-make joints;
    - d. That leaky joints should be repaired by cleaning and restoration to the condition for initial tightness;
    - e. That the maximum number of turns should not be exceeded.
  82. It is more difficult to make tight a bite-type fitting with corrosion-resistant steel tubing than with copper nickel.
  83. Bite-type fittings were made up by Shop 56 personnel in accordance with instructions furnished them by Design, and oral and written instructions by vendors' representatives.
  84. Some bite-type fittings in the hydraulic system leaked immediately after being made up.
  85. Some bite-type fittings were tight as initially made up but later developed leaks.
  86. There was no evidence of correlation between the leakage and the instructions given for making up the fittings.
  87. The hydraulic system passed the prescribed hydrostatic tests at the completion of the original construction of the ship and at the end of the post-shakedown availability.
  88. Even though the system initially passed the hydrostatic tests, leakage did develop later after operations.
  89. The Shipyard, the ship's force, the tender's force and the vendors made extensive efforts to make the bite-type fittings tight. The efforts were not successful in reducing the hydraulic leakage to an acceptable level.
  90. Difficulty in making bite-type fittings increases with size.
  91. Shop 56 personnel expressed their lack of confidence in their ability to make tight the bite-type fittings.
  92. Ship personnel have expressed their lack of confidence in the tightness of the bite-type fittings.
  93. During the construction of BARBEL, Shop 56 personnel (mechanics) were not required to re-identify by tests the material furnished to them from the DMI shop storage.

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94. Sil-brazing of corrosion-resistant steel to bronze requires a higher degree of brazing skill than joining copper nickel to bronze.
95. Training was given in the silver-brazing of joints in the pipe shop, starting at least as early as 1951. It was modified in 1956.
96. During construction of BARBEL, there was no formal requirement that only brazers who had met prescribed standards and were designated as qualified brazers were permitted to make sil-brazed joints.
97. Leadingmen in the pipe shop supervise up to 20 men.
98. After the casualty, an attempt was made by Shipyard officials to determine the cause and fix responsibility.
99. After the casualty, the design of the salt water circulating system was reviewed by the Shipyard.
100. All silver brazed joints 4" and above in the salt water circulating system were specified to be changed to welded construction.
101. Forty-three (43) leaking or suspect sil-brazed joints were removed from the salt water circulating system for destructive test and analysis.
102. Every suspected joint in the circulating salt water system not removed from the ship was x-rayed.
103. The main salt water circulating system piping and fittings were removed from the ship for rework and alterations.
104. An x-ray technique for examination of silver soldered joints was developed.
105. A brochure for technical inspection of sil-brazed joints was developed. (Exhibit 6)
106. New instructions for silver brazing were issued by the Bureau of Ships and the Shipyard.
107. All material must be reidentified in the shop and in the field by Shop 58.
108. All material must be inspected by the Shop for correct marking.
109. Brazers must be requalified to the requirements of the American Society of Mechanical Engineers boiler code.

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110. The new course training plan for silver brazing, issued 2 March 1961, increased the training by 100% (i.e. to 80 hours).
111. The use of insert ring type fittings was directed for all sizes above 1/2".
112. Face feeding of insert ring type fittings by the mechanic was prohibited, except with instructor or supervisor present as authorized.
113. 100% inspection of prepared joints by the supervisor prior to brazing and 25% inspection of prepared joints prior to brazing by the Inspection Division is required.
114. Brazing of joints must be done with an instructor or supervisor present.
115. Brazed joints must be 100% inspected by the supervisor and in addition 25% by the Inspection Division (Code 303).
116. Each joint is to be identified by number, marked with the identifying numbers of the man making the joint, and records are to be kept of the joints, and the persons making and inspecting the joints.
117. X-ray inspection is required of all joints marked by Code 303 as suspect.
118. All joints shall be inspected by visual and feel inspection method by Shop 56 and the Inspection Division (303) while the system is undergoing hydrostatic tests.
119. All piping systems now must be certified as containing the proper materials by the Shipyard.
120. A formal requirement was instituted to insure that all brazing would be done by a qualified, card-carrying brazer.

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121. The materiel deficiencies in BARBEL listed in Findings of Fact 13 through 46 have been or are being corrected subject to the following comments:
- (a) In the hydraulic system (Findings 14, 15, and 41) Portsmouth Naval Shipyard will replace all removed CRES tubing with copper nickel. Walseal fittings will be used in all new fittings and to replace leaking bite-type fittings. Portsmouth Naval Shipyard is recommending the replacement of all CRES tubing and all bite-type fittings except that installed in smaller sizes, such as gauge lines and on gauge boards. "O"-rings are being replaced and joints containing "O"-rings are being remade. Valves are being overhauled and reinstalled.
  - (b) In connection with Findings 15, 16, and 17, pursuant to Bureau of Ships direction, a study of oil capacity of BARBEL and SKIPJACK classes is being made. No work is planned specifically to increase the capacity pending completion of the study. Relocation of bow planes to the sail and concomitant elimination of rigging mechanism will have the effect of increasing capacity about 10 gallons per minute or the equivalent of about 1/2 an extra pump and elimination of sonar interference.
  - (c) As to Finding 35, Bureau of Ships has directed that the anchor be replaced only when necessary for other reasons.
122. Material identification of incoming shipments has been extended by the Supply Department.
123. Marking of incoming material has been improved by adding permanent type etching to the continuous strip ink-rolled markings previously used.
124. A listing of trade skills required for Shop 56 and an inventory of skills available were made in 1960.
125. Twenty-six (26) trade skill areas needed for Shop 56 were identified, and a training program was established and implemented to provide training in the requisite skill areas.
126. Shop 56 facilities for work have been improved as follows:
- (a) Brazing stations have been set up in the shop and in the field;
  - (b) Mock-ups of subassemblies have been set up;
  - (c) Additional work area space has been provided in the Shop 56 mezzanine; and
  - (d) Brazing school facilities have been improved.

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127. Full scale mock-ups of certain spaces in submarines have or will be provided.
  128. Chemical and magnetic material re-identification facilities have been provided to shop and field stations.
  129. Shop 56 has gradually increased in number of personnel on board since 1956 with a sharp increase in mid-1959.
  130. The quality of workmanship in Shop 56 has improved and is now satisfactory.
  131. The silver-brazed joint which failed was fabricated and brazed either inside Shop 56 or on the BARBEL.
  132. There is no documentary evidence in the Shipyard that indicates which mechanic or mechanics made up the faulty joint, or the leadingman responsible for his supervision.
  133. There is no testimonial evidence as to the identity of the mechanic(s) responsible for fabricating and brazing the joint, or the supervisors responsible therefor.
  134. Shop 56 procedures in use at the time of making the joint required that it be made by a coppersmith and supervised by a leadingman coppersmith.
  135. Mr. \_\_\_\_\_ was the leadingman coppersmith in the inside shop at the time of fabrication and installation of the failed joint. He was offered and accepted the rights of an interested party.
  136. Mr. \_\_\_\_\_ was a leadingman coppersmith working on the BARBEL at that time. He was offered and accepted the rights of an interested party.
  137. In addition to the foregoing, the following leadingmen coppersmith worked on BARBEL during the construction phase:  
Mr. \_\_\_\_\_, Mr. \_\_\_\_\_, and Mr. \_\_\_\_\_.
  138. Other leadingmen coppersmith could have supervised the fabrication and brazing of the joint which failed.
  139. Mr. \_\_\_\_\_ was the quarterman coppersmith at the time of fabrication and installation of the joint. He was offered and accepted the rights of an interested party.
  140. Mr. \_\_\_\_\_ as the Chief Quarterman coppersmith during the period of BARBEL construction. He was offered and accepted the rights of an interested party.

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141. The following military personnel are involved in the chain of responsibility from the pipe shop: Shop Superintendent, Commander from 3-15-58 to the present date; Production Officer, Captain , from 7-28-56 to 7-29-60; Captain ., from 7-29-60 to the present; Shipyard Commander, Rear Admiral from 2-29-56 until 4-22-59; Captain USN, from 4-22-59 to 2-28-61; and Rear Admiral USN, 2-28-61.

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OPINIONS

1. The casualty was caused directly by a combination of poor workmanship and the unknowing use of corrosion-resistant steel piping for Part C-3 of BuShips Plan SS580-209-1699459 dated 29 April 1957 (Exhibit #22) in lieu of the 70-30 copper nickel alloy piping specified, which made a satisfactory silver soldered joint to piece F-22 of the same plan extremely improbable.
2. Poor workmanship in this joint consisted of:
  - (a) Improper sizing and fitting.
  - (b) Failure to apply the proper amount of heat.
  - (c) Improper application of face-feeding technique.
3. The improper substitution of corrosion-resistant steel piping was made by persons whose identity can not be ascertained. This substitution was contrary to the prescribed Shipyard material control procedure.
4. The most likely point for this improper substitution was in the Pipe Shop, hereinafter referred to as Shop 56, at the time the mechanic(s) and the stock controlman obtained the material from the shop Direct Material Inventory storage.
5. The pipe joint which failed was made during the period July to December 1958 by coppersmith mechanic(s) whose identity cannot be ascertained.
6. The most likely supervisor(s) was Mr. \_\_\_\_\_, Leadingman Coppersmith, or Mr. \_\_\_\_\_, Leadingman Coppersmith, or both.
7. There is reasonable possibility that other leadingmen coppersmiths employed by Shop 56 at that time supervised this effort in whole or part.
8. The material condition of the BARBEL at the time of the casualty was not satisfactory for unrestricted operations of the ship in accordance with her prescribed mission. This condition existed because of the total effect of the following deficiencies:
  - (a) Excessive leakage of the ship's hydraulic system;
  - (b) Insufficient capacity of the ship's hydraulic system;
  - (c) Bow plane rigging difficulties;
  - (d) Bow plane noise interference with passive sonar; and
  - (e) An accumulation of less important deficiencies whose cumulative effect detracted from the ship's ability to perform her mission.

Of the deficiencies, the hydraulic system leakage most seriously impaired the ship's capability to perform her missions and tasks. This leakage and the additional problems it generated, were the major cause of the ship's long availability periods. These hydraulic problems were so overwhelming in their demands as to require the preponderant portion of the ship's manpower available for maintenance. The ship's efforts in this regard were continuous and intense. Its overwhelming effect also

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had adverse repercussions on the Shipyard's efforts to eliminate other deficiencies.

9. The excessive leakage of the hydraulic system was caused by the use of flareless (bite type) fittings, hereinafter called bite type fittings, in conjunction with corrosion-resistant steel piping. ←

The decision to use bite type fittings with copper nickel piping was sound.

10. The decision to substitute corrosion-resistant steel piping for then unobtainable copper nickel was sound.

However, the new combination of materials in the joint added greatly to the difficulties of making tight joints. The difficulties were further increased by the following: ←

- (a) Lack of uniform hardness from pipe to pipe in the corrosion-resistant steel piping used.
  - (b) Although not foreseeable at the time of installation, it became apparent later that much more development and/or testing by the Shipyard and/or vendors was required before joints which would remain tight under operating conditions could be made with corrosion-resistant steel piping and bite type fittings.
  - (c) The vendors failed initially to provide the proper ferrules in the fittings or to mark them to prevent loss of identity.
  - (d) The Shipyard in general and the Pipe Shop in particular underestimated the difficulties in making tight joints and keeping them tight with the bite type fitting to corrosion-resistant steel piping combination.
11. The bow plane rigging difficulties were the result of a very complicated sequentially operating group of mechanisms which failed at times to perform the intended function because of adjustments, leakages, and lesser contributing factors.
12. The operation of the bow planes produced noises which were picked up by the installed passive sonar.
13. The accumulation of less important deficiencies are of the type often encountered in a new construction submarine, and particularly in a lead ship. Taken individually no one of them would have prevented the BAREEL from carrying out her mission.
14. The casualty and materiel deficiencies discussed above conduce to the view that the only areas of the Shipyard's management and operation which enter into the chain of causation are:
- (a) The prescribed material and quality control procedures, and;
  - (b) The performance of Shop 56.

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15. The system of material control during the building of BARBEL was sound, effective, and well implemented.
  16. Management demonstrated by its action an intense and continuing interest in these procedures.
  17. The material control system has been continuously under review, and minor changes have been made when necessary. It conforms in all important aspects with directives issued by higher authorities, insofar as could be determined.
  18. The use of the improper material in the tube end of the joint that failed was the result of a violation of the material control procedure at the mechanic or stock controlman level in Shop 56. ←
  19. During building of BARBEL the quality control system in use was generally effective, involving design control, material control, in process inspection and final inspection of the product for its intended use.
  20. The implementation of the quality control procedures, insofar as they related to design control, were inadequate. No evidence of departures therefrom was discovered. ~~AS~~
  21. In the case of the pipe shop, the in-process inspection was required during the building of BARBEL by the first-line supervisor, with some additional inspection by more senior supervisors on a spot check and trouble-shooting basis.
  22. This system of in-process quality assurance is cheap and effective provided shop management is interested, active and alert to the multitudinous factors which tend to degrade performance relative to the quality required in the product, with particular respect to new technologies, functions, work load and other requirements.
  23. The effectiveness, and, therefore, the performance of Shop 56 Master Mr. was declining during the period of BARBEL's post shakedown availability. ←
  24. Management recognized the declining level of performance relative to the demands on Shop 56 in 1959.
  25. The end product inspection of piping systems or sub-systems performed by the Inspection Division of the Production Department was adequate to insure that the specified function was performed at the time of test performance, but it did not include material reidentification.

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26. This system in the Pipe Shop was apparently adequate for ships being built with priorities higher than BARBEL, but did result, with the less skilled mechanics assigned to BARBEL, in marginal performance, unsightly appearance, and in at least one case, the failure of a silver soldered joint. Further, the excessive leakage of the hydraulic system was partially due to workmanship.
27. As regards BARBEL, the principal weaknesses in the quality control system were:
- (a) In its failure to assure high quality silver brazing, and
  - (b) In failing to assure a tight hydraulic system.

In the matter of silver brazing, the failure consisted of:

- (a) One 5-inch joint in the salt water circulating system which parted;
  - (b) One high pressure air pipe joint in the stop check regulator valves for Main Ballast Tank #1 which parted; a similar casualty occurred on MBT #5;
  - (c) One 5-inch joint adjacent to the joint which failed was improperly bonded and improperly contained corrosion-resistant steel in the nipple.
28. Other allegations of poor silver brazing were based on poor outward appearance, leakage, or both.
29. Destructive tests of the worst appearing joints and X-ray examination of other joints established that they were satisfactory for strength. However, examination of the bonding areas indicated a below-normal brazing performance in some cases.
30. In the matter of the hydraulic system, the failure consisted of continued excessive leakage as discussed above.
31. With regard to Shop 56, the factors affecting quality control contribution to the silver brazing and hydraulic system inadequacies were:
- (a) A sharp increase in the proportion of skilled pipe shop personnel required in submarine new construction;
  - (b) An inability to hire additional trained mechanics as fast as the need arose;
  - (c) The lack of suitable labor market for hiring the requisite skills, thus necessitating skill augmentation of hirees by training;
  - (d) The pressing need for full on-the-job utilization of trained mechanics thus preventing all of the training made necessary by rapidly advancing technology or full maintenance of qualifications in all pipe skill areas. There was training in silver brazing in the period 1956-1960.
  - (e) The tremendous upward revision of the technical skills required for pipe shop personnel resulting from the nuclear building program which required assigning many of the best mechanics to training for and retention for work within this program.

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- (f) The declining effectiveness of the Shop Master due to absences and illnesses.
32. In addition to the foregoing, pertinent factors affecting the quality control aspects of the hydraulic system bite type fittings were:
- (a) The common practice of tightening joints other than bite types by taking extra turns cannot be applied to bite types since it serves only to aggravate leaking in most cases.
  - (b) Once the ferrule seating area on corrosion-resistant steel tubing is damaged, repairs to tubing, replacement of the ferrule, or re-making the bite type fitting are not likely to produce a satisfactory joint.
  - (c) The efforts of Shop 56 in connection with bite type fittings must be evaluated in light of the fact that the tremendous efforts by Shipyard, ships' force, tender force, and vendors did not succeed in making acceptable joints in the BARBEL.
33. Further efforts with bite type fittings on corrosion-resistant steel tubing installed in BARBEL will not produce an acceptable system.
34. Management, having discerned the lowered performance of the pipe shop, did institute alleviating and corrective action. Such action is continuing. The main corrective items are:
- (a) An extensive training program in the pipe shop to eliminate the deficiencies of trade skills required compared to those on board.
  - (b) Additional facilities for the pipe shop.
  - (c) Sharp increase in the number of personnel employed in the shop.
  - (d) Provision of improved leadership with the appointment of Mr. \_\_\_\_\_ as Acting Head of the shop since January 1961.
35. Action to improve the quality of silver brazing was taken by the Bureau of Ships and the Portsmouth Naval Shipyard. This includes improved techniques, improved inspection methods, increased and separate in-process inspection, joint identification, additional training and re-qualification of brazers. It is considered adequate to preclude a repetition of the type of casualty suffered by BARBEL.
36. These actions have already improved the quality of silver brazing to the point where it is now considered adequate.
37. The bite type fitting problem has been alleviated by action of the Shipyard. Complete solution essentially requires replacement of the bite type fittings and the corrosion-resistant steel tubing combination in the hydraulic system.

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38. The complete solution depends on funding of the last element of replacement and assignment of BARBEL for an availability of sufficient length.
  39. The ship's hydraulic capacity will be more nearly adequate as a result of the relocation of the bow planes, and the action to reduce the internal leakage by hydraulic system overhaul. Further, tests of capacity at the end of this current overhaul are being required with possible additional corrective action to be directed.
  40. Bow plane rigging difficulties are being corrected by relocation of the bow planes to the sail, thus eliminating the need for rigging in and out. This will also eliminate the noise interference with the passive sonar.
  41. Adequate corrective action is completed or planned for the less important deficiencies.
  42. On completion of the foregoing corrective actions, which should include the replacement of all corrosion-resistant steel piping and bite type fittings combinations, BARBEL will be enabled to carry out her primary missions and tasks.
  43. Shop 56 has shown improvement in workmanship and management since 1959.
  44. This improvement is due to the combined efforts of Shipyard and Shop 56 management.
  45. The proximate cause of the pipe joint casualty was the faulty original installation.
  46. The faulty installation occurred sometime during the period July - December 1958 with highest probability during the latter part of that time.
  47. Shipyard officials did attempt to determine responsible parties.
  48. Due to the two year time lapse between installation and casualty and records disposal procedures, no documentary evidence as to the mechanics and supervision responsible for the installation exist.
  49. Due to the time lapse, the identity of pipe shop personnel who fabricated and assembled the joint or sub-assembly which failed cannot be ascertained.
  50. Disciplinary action is warranted against the personnel who fabricated and assembled the joint and the supervisor(s) responsible for in-process inspection thereof.
  51. No culpability exists in regard to the excessive leakage in the hydraulic system.
  52. The material deficiencies in BARBEL are not due to the fault, inefficiency, neglect or culpability of any person in the naval service, or, except as indicated above, any person employed by the Department of Defense.

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RECOMMENDATIONS

1. All CRES tubing and bite-type fittings larger than 1/2" I.P.S. in BARBEL hydraulic system be replaced by copper nickel tubing and proven fittings.
2. The Bureau of Ships initiate a program of nondestructive examination of silver-brazed joints in vital areas of salt water systems of submarines now in service to prevent the possibility of a casualty such as that which occurred in BARBEL.
3. Radiographic examination of silver-brazed joints be further developed to increase the ability to nondestructively ascertain the quality of the joints.
4. The Bureau of Ships investigate and develop other methods of nondestructive examination of silver-brazed joints.
5. The Bureau of Ships disapprove the use of bite-type fittings with CRES tubing in sizes greater than 1/2" until sufficient development and testing is accomplished to insure joints of lasting tightness.
6. It is recommended that a copy of the proceedings of the investigation be furnished the Commander of the Portsmouth Naval Shipyard to assist him in restoring the shipyard's performance and reputation to the high levels attained in the past.
7. In view of the lack of documentary or testimonial evidence as to the persons responsible for the joint which failed, it is recommended that no disciplinary action be taken against any person in the naval service or employed by the Department of Defense.

Rear Admiral, U. S. Navy; (Ret.)

Captain, U. S. Navy

Captain, U. S. Navy

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