

MIL-STD-1607A(SH)  
11 August 1987  
SUPERSEDING  
MIL-STD-1607(SHIPS)  
30 March 1973  
(See 4.15)

MILITARY STANDARD  
CHEMICAL CLEANING OF MAIN AND AUXILIARY BOILERS  
(SULFAMIC-CITRIC ACID METHOD)



AMSC N/A

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FSC 4410

MIL-STD-1607A(SH)

11 August 1987

DEPARTMENT OF THE NAVY  
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-5101

Chemical Cleaning of Main and Auxiliary Boilers (Sulfamic-Citric Acid Method).

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 5523, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

MIL-STD-1607A(SH)

11 August 1987

## CONTENTS

		<u>Page</u>
Paragraph	1. SCOPE -----	1
	1.1 Scope -----	1
	1.2 Application -----	1
	2. REFERENCED DOCUMENTS -----	1
	2.1 Government documents -----	1
	2.1.1 Specifications and standards -----	1
	2.1.2 Government publications -----	2
	2.2 Order of precedence -----	2
	3. DEFINITIONS -----	2
	4. GENERAL REQUIREMENTS -----	2
	4.1 Mill scale and waterside deposit removal -----	2
	4.2 Utilities available -----	2
	4.3 Solution disposal -----	2
	4.4 Equipment for acid descaling -----	3
	4.5 Chemicals required -----	3
	4.6 Preparation of boiler and equipment -----	4
	4.7 Specific cleaning procedure -----	6
	4.7.1 Acid neutralizing solution -----	8
	4.7.2 Spent acid discharge -----	8
	4.7.3 Acid disposal -----	8
	4.8 Rinsing procedure -----	8
	4.9 Mild acid treatment -----	9
	4.10 Passivating steps -----	9
	4.11 Inspection following the cleaning operation -----	10
	4.12 Safety precautions -----	10
	4.12.1 Boiler isolation -----	11
	4.12.2 Personnel protective gear -----	11
	4.12.3 Explosion hazards -----	11
	4.12.4 Use of ship's pumps -----	11
	4.13 Procedure following cleaning and inspection -----	12
	4.14 Subject term (key word) listing -----	12
	4.15 Changes from previous issue -----	13

## FIGURES

Figure	1. Acid mixing tank -----	13
	2. Piping diagram -----	14

MIL-STD-1607A(SH)

11 August 1987

## 1. SCOPE

1.1 Scope. This standard covers the requirements governing the procedure for chemical cleaning of main propulsion boilers of ferrous construction. Auxiliary (hotel load) boilers or waste heat boilers of ferrous or silicon - bronze (Herculay) construction can also be chemically cleaned using this standard. Differences in the configuration and volume of auxiliary and waste heat boilers must be considered when this standard is used to clean nonpropulsion boilers. The procedure may be used by ship's force, Naval shipyards, and private contractors.

1.2 Application. The procedure described herein can be used for cleaning superheaters or other sections of stainless steel construction. This method shall not be used for cleaning desuperheaters or other sections of 16 percent chromium - 1 percent nickel construction. The cleaning method described in this standard is intended for use in the removal of mill scale from new boilers and the removal of waterside deposits found in boilers after extensive operation. It is not effective in the removal of waterside deposits containing more than 5 percent silicates and 10 percent sulfates.

## 2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards, of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this standard to the extent specified herein.

## SPECIFICATIONS

## FEDERAL

- |          |   |
|----------|---|
| O-S-571  | - Sodium Carbonate, Anhydrous, Technical.   |
| O-S-598  | - Sodium Hydroxide, Technical.  |
| BB-N-411 | - Nitrogen, Technical.  |
| TT-E-490 | - Enamel, Silicone Alkyd Copolymer, Semigloss<br>(For Exterior and Interior Use). |

## MILITARY

- |                |  |
|----------------|--|
| MIL-F-16377    | - Fixtures, Lighting; and Associated Parts;<br>Shipboard Use, General Specification for.                                     |
| MIL-F-16377/51 | - Fixtures, Lighting; Incandescent, Light Extension 25 Watts, 120 Volts, Explosionproof and Watertight, Symbols 290 and 291. |
| MIL-R-19180    | - Regulators, Pressure, Compressed Gas.  |
| MIL-P-24138    | - Passivator Compound, Navy Boiler.  |
| MIL-B-24155    | - Boiler Scale Removing Compound.  |
| MIL-H-29210    | - Hose Assembly, Rubber, Metal Lined, Wire Reinforced, 250 PSIG, Saturated and Superheated Stream Service.                   |

MIL-STD-1607A(SH)

11 August 1987

## STANDARDS

### FEDERAL

FED-STD-595 - Colors.

### MILITARY

MIL-STD-796 - Chemical Cleaning of Main and Auxiliary Boilers  
(Hydrochloric Acid Method).

2.1.2 Government publications. The following Government publications form a part of this standard to the extent specified herein.

## PUBLICATIONS

### NAVAL SEA SYSTEMS COMMAND (NAVSEA)

S9086-GY-STM-000/CH 221 - NSTM, Boilers.

S9086-GX-STM-020/CH 220 V2 - NSTM, Boiler Water/Feedwater Test  
and Treatment.

S9086-T8-STM-000/CH 593 - NSTM, Pollution Control.

(Copies of specifications, standards, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

## 3. DEFINITIONS

Not applicable.

## 4. GENERAL REQUIREMENTS

4.1 Mill scale and waterside deposit removal. This procedure shall be used in the removal of mill scale from new boilers prior to final contract acceptance trials as well as for removal of waterside deposits that may be found in boilers after extensive operation. This cleaning method is not effective in the removal of waterside deposits containing more than 5 percent silicates or 10 percent sulfates.

4.2 Utilities available. The following utilities are normally available at dockside:

- (a) Fresh water.
- (b) Steam at 100 pounds per square inch (lb/in<sup>2</sup>).
- (c) Compressed air at 90 to 100 lb/in<sup>2</sup>.
- (d) Electrical power.

4.3 Solution disposal. This specification provides procedures for neutralizing the solutions used for cleaning, rinsing and passivating. Shipboard neutralizing of these solutions may not be required. All solutions shall be disposed in accordance with local, state and federal regulations (see NAVSEA S9086-T8-STM-000/CH 593).

## MIL-STD-1607A(SH)

11 August 1987

4.4 Equipment for acid descaling. Personnel shall read and be thoroughly familiar with the safety requirements specified in 4.12 before proceeding with the cleaning operation. The following equipment shall be required:

- (a) An acid mixing tank as shown on figure 1 or equal and a spent acid neutralizing tank with an approximate capacity of 1500 gallons.
- (b) An acid pump capable of recirculating 50 gallons per minute (gal/min) but not more than 100 gal/min against a 50-foot head.
- (c) Steam generator or equivalent for heating solutions to required temperatures (not required if 100 lb/in<sup>2</sup> steam is available).
- (d) Water treatment equipment to provide water of feedwater quality or water having hardness values less than 50 parts per million (p/m) as calcium carbonate (not required if water meeting these requirements is available).
- (e) pH test paper indicator strips having a pH range from 2 to 10. Indicator test strips are available from Fischer Scientific, - Springfield, New Jersey.
- (f) 500 feet of 1-1/2 inch acid hose for admitting solutions to boilers (rated at 150 lb/in<sup>2</sup>). Hypalyn acid and chemical hose series 7267 available from Dayco Industries, Dayton, Ohio or equal is an acceptable hose for the applicaion.
- (g) Assorted hoses for air, nitrogen, and water supply as well as for hydrogen vent lines. Flexible metallic steam hose meeting the requirements of MIL-H-29210.
- (h) Explosimeter (Mine Safety Appliances, Model 3 or equal).
- (i) Portable pyrometer (Alnor Pyrocon or equal). Assorted thermometers.
- (j) Assorted nonsparking tools, including hammers, wrenches, and screwdrivers. Also tools for repairing acid cleaning equipment.
- (k) Portable, watertight, vaporproof lights (see 4.12.3.3).
- (l) Equipment that is normally required for hydrochloric acid cleaning may also be used.

4.5 Chemicals required. Chemicals employed in this cleaning procedure are either in crystal line or flaked form and shall be dissolved in hot water that is being recirculated through the mixing tank and the boiler. Chemicals used to neutralize the partially spent descalant shall be dissolved in water in the neutralizing tank. Chemicals and quantities required for descaling, passivating, and neutralizing shall be as follows:

- (a) Boiler scale removing compound shall be in accordance with MIL-B-24155 and prepared in the following quantities required to fill the boiler to air cock:
  - (1) For descalant (strong solution), 1000 pounds of boiler scale removing compound per 1000 gallons of water.
  - (2) For acid rinse (mild solution), 20 pounds of boiler scale removing compound per 1000 gallons of water.
- (b) Passivator compound shall be in accordance with MIL-P-24138 and the solution shall be prepared with 84 pounds of passivator compound per 1000 gallons of water required to fill the boiler to air cock. Only feedwater or water with a hardness value of 50 p/m or less as calcium carbonate shall be used for the passivating solution.

MIL-STD-1607A(SH)

11 August 1987

- (c) Sodium hydroxide (caustic soda) shall be in accordance with type I of O-S-598. The solution shall be prepared with 200 pounds of sodium hydroxide (to be dissolved in 200 gallons of cold water) to neutralize 1000 gallons of spent acid solution.
- (d) Nitrogen (oil free) shall be in accordance with type I, grade C, class 1 of BB-N-411. Nitrogen cylinders shall be fitted with regulators in accordance with type II, class B2-W of MIL-R-19180.
- (e) Exterior enamel, silicone alkyd copolymer, semigloss (color no. 27886 of FED-STD-595) shall be in accordance with TT-E-490.
- (f) Sodium carbonate, anhydrous shall be in accordance with type I of O-S-571.

4.6 Preparation of boiler and equipment. Due to differences in boiler configurations, auxiliary boilers and waste heat boilers shall have those requirements for main propulsion boilers eliminated which are not applicable to auxiliary or waste heat boilers. Preparation of the boiler and equipment shall be as specified as follows (see figure 2):

- (a) Valves controlling admission of water or steam to the unit to be cleaned (boiler, economizer, superheater, auxiliary boiler or waste heat boiler) shall be closed, tagged and locked (or security wired). Gauges, valves and fittings that are not to be employed during cleaning of the unit shall be blanked off. Any nonferrous valves, fittings or trim components shall be removed and their connections blanked. System valves shall not be used for blanking purposes and shall be isolated from the acid. Safety valves shall be removed and the openings shall be blanked. One blank shall be provided with a 1-1/2 inch ripple.
- (b) The boiler shall be drained and opened. Watersides shall be inspected for oil contamination or preservative coatings and, if present, shall be analyzed to determine quantity. If the amount of organic contaminants found are greater than 3 percent of the waterside deposits, a boil-out shall be applied. The procedure in accordance with NAVSEA S9086-GY-STM-000/CH 221 shall be utilized for removing the organics. The boil-out solution shall be disposed in accordance with 4.3.
- (c) A screen tube, not recently installed, shall be removed from the first row furnace side of each boiler to be cleaned. Removal shall be from an area about 1/2 to 2/3 of the furnace depth. The tubes shall be replaced or the tube seat holes plugged. Two 30-inch sections shall be cut from the mud drum part of the removed tube. These sections shall be hung securely, in a vertical position, in the steam drum. These tubes will provide a means for assessment of the effectiveness of the cleaning operation. The remainder of the tube shall be reserved for future reference. It shall not be necessary to remove a tube from new, unsteamed boilers or from new boilers that have loose deposits such as those to be cleaned immediately after the completion of acceptance trials. The method for determining the effectiveness of the cleaning shall be as specified in 4.11.3.
- (d) Desuperheaters shall be removed and cleaned mechanically. At no time shall the desuperheaters be pickled. The desuperheater inlet and outlet connections shall be blanked in the boiler to prevent acid leakage into these nipples. (Rubber gaskets shall

MIL-STD-1607A(SH)

11 August 1987

- be used.) The inlet and outlet desuperheater nipples (in the boilers) shall be coated with exterior semigloss enamel, silicone alkyd copolymer (color no. 27886 of FED-STD-595) in accordance with TT-E-490. The nozzles shall be wire brushed to remove adhering deposits. A single coat of enamel shall be applied and allowed to dry for 2 hours. After the cleaning operation, the enamel shall be removed from the nipples and other parts of the boiler watersides by wire brushing or chipping.
- (e) At least two steam separators and all girth plates shall be removed and left in the drum so as not to cover the tubes.
  - (f) If inspection reveals that cleaning of the economizer and superheater is not required, the economizer and superheater shall be back filled with feedwater and these units shall be blanked off. The economizer and superheater shall be blanked off as shown on figure 2. A blank shall be installed at the economizer inlet to isolate the economizer from the feed system. A closed feed valve is not considered satisfactory for proper isolation. Blanks shall be placed on both sides of the check valve at the economizer outlet. Blanking both sides of the check valve prevents acid damage to the check valve. The superheater inlet shall be blanked at the steam drum using the acid wash plug. The superheater outlet shall be blanked at the closest possible location to the superheater outlet header. A closed main stop valve is not considered satisfactory for proper isolation.
  - (g) If the economizer and superheater require cleaning, they shall be cleaned while blanked from the boiler as specified in 4.6(f).
  - (h) If the boiler economizer and superheater all require acid cleaning, only the economizer and boiler shall be cleaned simultaneously. The superheater shall be cleaned separately using fresh descalant. Descalant used to clean the boiler and economizer shall not be used to clean the superheater.
  - (i) During superheater cleanings, two or three water rinses shall be applied following the strong acid treatment. The presence of acid shall be determined using the pH test paper indicator strips. The water rinses shall be used instead of the mild acid rinse and passivating step to eliminate the possibility of acid or passivator remaining in the superheater.
  - (j) A tee shall be attached to the air cock, with valves on each side. The hydrogen vent hose shall be attached to one of the valves and shall lead to the weather deck or pier. The hose shall not be crimped or obstructed in any way to prevent escape to the evolving hydrogen gas. A length of copper tubing or hose (capable of withstanding a pressure of 100 lb/in<sup>2</sup>) shall be connected from the nitrogen supply to the valve on the other side of the tee.
  - (k) A 1-1/2 inch valve shall be attached to the safety valve blank flange on top of the boiler. The 1-1/2 inch acid resistant discharge hose shall be connected to the nipple on this valve and the line shall be led back to the mixing tank to permit recirculation of the descaling solution.
  - (l) Bottom blow valves shall be disconnected from the boiler and a temporary valve manifold shall be installed as shown on figure 2. At one end of the manifold, a tee shall be installed with

MIL-STD-1607A(SH)

11 August 1987

- 1-1/2 inch valves attached to each side to permit alternate introduction of steam or acid into the boiler. A schematic diagram of the piping setup is shown on figure 2.
- (m) The unit to be cleaned shall be piped up to insure that the descalant is injected into the lowest point of the system and is returned from the highest available opening on the unit.
  - (n) The acid mixing tank shall be located (see figure 1) on the pier or a weather deck compatible with minimal hose requirements. The 1500-gallon neutralizing tank shall be located in an area easily accessible for receiving the spent acid from the boiler to permit neutralization of the descalant prior to disposal. The acid fill line shown on figure 2 shall later serve as the acid disposal line. The lines shall be kept to minimal lengths.
  - (o) Economizer and superheaters that are not to be acid cleaned shall be kept filled with water during the entire cleaning operation.
  - (p) The boiler shall be closed and a hydrostatic test shall be applied. The hydrostatic test shall be in accordance with NAVSEA S9086-GY-STM-000/CH 221 with the following exceptions: The test pressure shall be 150 lb/in<sup>2</sup> for main propulsion boilers and shall not exceed 100 percent of maximum allowable working pressure for all other boilers. And, the feed quality water shall not be treated with sodium nitrite. After a successful hydrostatic test, the pressure shall be relieved on the boiler and the valve shall be opened on the acid return line. Steam shall be injected into the boiler through the valve on the temporary manifold. The steam shall be secured when the temperature is between 175 ± 5 degrees Fahrenheit (°F) as determined by readings obtained from a pyrocon or equal thermometer attached to the manhole cover on the steam drum. To obtain valid temperatures, the metal surfaces shall be clean in the area that these readings are taken.

4.7 Specific cleaning procedure. Personnel shall wear protective clothing (see 4.12.2). Boiler scale removing compound and its solutions are corrosive and cause burns to skin, eyes, and body tissues. Affected personnel shall flush skin with cold water (see 4.12.2(a)). Eye wash equipment and a safety shower shall be available. If the compound or its solutions enter the eyes, the eyes shall be flushed with cold water and medical attention shall be obtained immediately. Due to differences in boiler volumes, the amount of chemicals applicable to the volume of the unit being cleaned shall be used. The specific cleaning procedure shall be as specified:

- (a) The hot preheat water (175 ± 5°F) in the boiler shall be recirculated through the mixing tank and back to the boiler through the temporary bottom blow manifold. The approximate flow rate shall be determined and the boiler scale removing compound shall be added to the mixing tank at a rate of 1 pound for each 1 gallon per minute of water flow. The inhibitor, diethylthiourea (DETU) shall be packaged separately in the boiler scale removing container. The DETU shall be added to the water with the descaling chemicals. Steam shall be used to agitate and dissolve the chemicals as they are added.

MIL-STD-1607A(SH)

11 August 1987

- (b) During addition of the chemicals, the volume of solution in the mixing tank will increase. The draw off (overflow) line shall be used to periodically reduce this volume to prevent overflow from the tank.
- (c) The recirculation operation shall be continued until the required amounts of chemicals have been dissolved and injected into the boiler. Recirculation shall be continued for an additional 15 minutes.
- (d) Shipyards or contractors may formulate concentrated solutions of the descalant (2 pounds of dry descalant for each 1 gallon of water). This concentrated solution shall be blended 1:1 with water while being injected into the boiler. Temperatures of  $175 \pm 5^{\circ}\text{F}$  shall be maintained. After filling the boiler with the required amount of descaling solution, the descalant shall be circulated for 15 minutes throughout the boiler to obtain good distribution.
- (e) The descaling solution shall remain in the boiler for a soaking period of 7 hours. Hourly, the solution shall be recirculated through the boiler for periods not to exceed 15 minutes. Every other hour, during the recirculating period, the valve shall be secured to the water drum to allow the descalant to preferentially circulate through the side and rear wall sections of the boiler.
- (f) When descaling economizers and superheaters, the hourly recirculation shall occur for 5 minutes instead of the 15-minute period as specified for boilers in 4.7(e).
- (g) The temperature of the descaling solution shall be maintained at  $175 \pm 5^{\circ}\text{F}$  throughout the soaking period. Steam shall be added through the temporary manifold to the boiler when not recirculating. The steam shall not be admitted at the boiler in excess of 10 minutes during any 1-hour period. While steam is being admitted to the boiler, the valve on the acid injection line shall be secured. When recirculating the acid, the steam valve at the boiler shall be closed. However, steam may be added at the mixing tank during recirculation to maintain the temperature at the tank.
- (h) Steam shall not be injected directly into the superheater and economizer to maintain the temperature at  $175 \pm 5^{\circ}\text{F}$  as pressure build-up would occur. Steam shall be applied to the mixing tank to heat the acid solution during the 5-minute recirculation period.
- (i) During recirculating periods, the hydrogen vent line shall be secured. When circulation is stopped, the valve on the vent line shall be opened. Opening of the valve shall be delayed 5 to 10 minutes to permit equalization of the pressure built up during circulation.
- (j) Acid leakage into the water-filled superheater shall be checked. Following acid cleaning of the boiler, the superheater shall be checked for the presence of acid using the pH test paper indicator strips. If acid is present, the superheater shall be thoroughly rinsed with distilled water to remove all traces of the acid.

MIL-STD-1607A(SH)

11 August 1987

4.7.1 Acid neutralizing solution. Personnel shall wear protective clothing (see 4.12.2). Caustic soda solutions are corrosive and cause burns to skin, eyes, and body tissues. Affected personnel shall flush skin with cold water. If caustic soda or its solutions enter the eyes, the eyes shall be flushed with cold water and medical attention shall be obtained immediately. Approximately 1 hour before completion of the 7-hour soaking period, the acid neutralizing solution shall be prepared as follows:

- (a) Add 200 gallons of water at ambient temperature to the 1500-gallon spent acid tank.
- (b) Carefully add 200 pounds of technical grade sodium hydroxide.
- (c) Stir carefully to ensure that the sodium hydroxide is dissolved. This solution is capable of neutralizing approximately 1000 gallons of partially spent acid.

4.7.2 Spent acid discharge. At the end of the 7-hour soaking period, the partially spent acid shall be discharged from the boiler to the spent acid tank as follows:

- (a) Secure the hydrogen vent and acid recirculating lines.
- (b) Disconnect the acid fill line from the discharge end of the pump and lead this hose to the spent acid neutralization tank. Fasten the hose to the inside of the tank to prevent whipping while the acid is discharged from the boiler.
- (c) Open the nitrogen valve on top of the steam drum and inject nitrogen gas into the boiler at a pressure of 40 to 50 lb/in<sup>2</sup>.
- (d) When approximately 1000 gallons of the partially spent descalant have been discharged to the neutralizing tank, secure the nitrogen valve.
- (e) Test the solution in the neutralizing tank with the pH test paper indicator strips to see that the pH is in the range of 5.0 to 9.0. If not, adjust the spent solution to this range by adding small amounts of sodium hydroxide.
- (f) A new batch of neutralizing solution shall be prepared and the spent acid shall be displaced with nitrogen gas until the boiler is completely drained. Each bottom blow circuit shall be blown twice. The nitrogen valve shall be secured.

4.7.3 Acid disposal. The neutralized acid shall be disposed in accordance with 4.3.

4.8 Rinsing procedure. The rinsing procedure shall be as follows:

- (a) Open the acid recirculating line from the steam drum to the acid mixing tank. Open the hydrogen vent line. Unfasten the acid hose attached to the spent acid tank and reconnect it to the discharge end of the pump.
- (b) Fill the boiler with hot water ( $170 \pm 5^{\circ}\text{F}$ ). While filling, secure the hydrogen vent line. After the boiler is full (as evidenced from the effluent from the return line), recirculate through the boiler for 15 minutes.
- (c) If the economizer was cleaned, it shall also be rinsed. If the superheater was cleaned, it shall be rinsed as specified in 4.6(i).

## MIL-STD-1607A(SH)

11 August 1987

- (d) The boiler rinse water shall be neutralized to a pH range of 5.0 to 9.0. The following procedure shall be used to dump the boiler:
- (1) Secure the steam, hydrogen vent, and return lines.
  - (2) Disconnect the acid fill line at the pump and lead this line to the spent acid neutralizing tank. The hot effluent shall not come in contact with painted surfaces.
  - (3) Apply nitrogen gas through the steam drum at 40 to 50 lb/in<sup>2</sup> until the tank is nearly filled. Add small amounts of sodium hydroxide to neutralize to the pH range of 5.0 to 9.0. Dispose of the neutralized solution in accordance with 4.3. Repeat this procedure until the boiler is completely emptied.
  - (4) Secure the nitrogen supply and open the hydrogen vent and return lines.
  - (5) Reconnect the acid fill line to the acid pump.

4.9 Mild acid treatment. Personnel shall wear protective clothing (see 4.12.2). Boiler scale removing compound and its solutions are corrosive and cause burns to skin, eyes, and body tissues. Affected personnel shall flush skin with cold water. If the compound or its solutions enter the eyes, the eyes shall be flushed with cold water and medical attention shall be obtained immediately. The procedure for the mild acid treatment shall be as follows:

- (a) Close the hydrogen vent line and fill the boiler with hot water ( $170 \pm 5^{\circ}\text{F}$ ). Slowly add the required amounts of chemicals (see 4.5(a)) while filling. After the boiler is full, recirculate the solution through the boiler watersides for 15 minutes and allow to soak for an additional 15 minutes (total 30 minutes). Inject steam into the boiler through the bottom blow system to keep the temperatures in the prescribed range. After the 15-minute soak, empty the boiler as specified in 4.8(d).
- (b) The mild acid rinse may be made up in the dockside tank and shall be in the quantities specified in 4.5(a).
- (c) The economizer shall also be treated if it was cleaned.

4.10 Passivating steps. Passivating steps shall be as follows:

- (a) While dumping the mild acid solution, rinse the acid mixing tank with feedwater. After the boiler has been dumped, reconnect the acid fill line to the pump. Fill the boiler with hot feedwater ( $170 \pm 5^{\circ}\text{F}$ ) or water having hardness values of less than 50 p/m as calcium carbonate. While recirculating the hot feedwater through the mixing tank and the boiler, slowly add the passivator compound based on capacity and filling time. Quantities shall be as specified in 4.5(b).
- (b) Circulate for 15 minutes and allow the passivator to soak the boiler watersides for an additional 30 minutes at  $170 \pm 5^{\circ}\text{F}$ . Use steam to maintain this temperature. Empty the boiler while hot. Clean, compressed air may be used for solution displacement at this point. Dispose of the passivating solution in accordance with 4.3.
- (c) The economizer shall also be passivated if it was cleaned.

MIL-STD-1607A(SH)

11 August 1987

- (d) The contractor or Naval activity performing the cleaning operation shall prepare a complete record of the entire operation, including a log of temperature checks, and submit same to the authorizing activity following completion of the cleaning procedure.

4.11 Inspection following the cleaning operation. For safety precautions see 4.12. An explosimeter shall be used around the boiler and in the steam drum to ascertain the absence of explosive gas before proceeding with the inspection. If nitrogen gas was used for displacement of the final rinse solution, the oxygen sufficiency shall be checked before entering the boiler. Inspection following the cleaning procedure shall be as follows:

- (a) When the boiler is completely empty, the water and steam drums as well as some handhole plates shall be opened. The boiler shall be opened as soon after dumping as is practical. A portable blower shall be used to ventilate the boiler.
- (b) For at least 12 hours following drainage of the passivating solution, red devil blowers shall be directed into the water drum. A flexible ventilation hose shall be directed from the steam drum to the atmosphere overboard. At the end of 12 hours and after certified to be gas free by the gas free engineer, the boiler may be entered for inspection. When entering the water drum, operation of the blower into the water drum shall be continued behind the inspector. After completion of the inspection of the water drum, the steam drum shall be inspected. The red devil blower shall be moved to the steam drum and air shall continue to blow through the steam drum behind the inspector. After inspection, the use of the blower shall be discontinued.
- (c) The tube surfaces shall be brushed and examined to ensure the boiler is cleaned to bare metal.
- (d) Tube sections that were hung in the steam drum during the cleaning operation shall be split and brushed. The tube shall be crimped in a vice and the waterside surface examined for signs of hard deposits. If hard deposits are present (excluding fine powdery deposits and fireside deposits), the boiler shall be recleaned. NAVSEA approval shall be obtained before recleaning.
- (e) Before making a firm decision for recleaning with the sulfamic acid formulation, analyses shall be made by a shipyard laboratory to determine whether the deposits have high amounts of silicates (5 percent or above) or sulfates (10 percent or above). It is not possible to adequately remove deposits of this type by the sulfamic-citric-DETU formulation. To remove deposits of this type, the inhibited hydrochloric acid procedure in accordance with MIL-STD-796 shall be employed. NAVSEA approval shall be obtained prior to acid cleaning.
- (f) This procedure shall only be used to clean boilers one at a time, when utilizing the mixing tank shown on figure 1.

4.12 Safety precautions. Safety precautions shall be as specified in 4.12.1 through 4.12.4.

MIL-STD-1607A(SH)

11 August 1987

4.12.1 Boiler isolation. The boiler to be cleaned (including the economizer and superheater, if these units require cleaning) shall be isolated from the remainder of the feed and steam systems. Valves shall be blanked off. Controls and instrumentation shall be isolated from the descaling solution.

4.12.2 Personnel protective gear. Personnel shall wear the following protective gear and shall observe the following safety precautions:

- (a) All chemicals involved are harmful to the eyes and skin. Personal contact with chemicals shall be avoided. Medical attention shall be obtained immediately if acid or caustic materials get in the eyes. A supply of fresh water and sodium carbonate in accordance with O-S-571 shall be available in the fireroom and at the acid mixing tank to wash any acid from the skin.
- (b) Face shields shall be worn by personnel dumping chemicals into mixing tank.
- (c) Chemical resistant rubber or plastic gloves, goggles, boots, and aprons shall be worn when handling acids or alkalies.

4.12.3 Explosion hazards. Hydrogen gas is evolved during acid cleaning operations. This gas, when mixed with air, can form a violently explosive mixture. To reduce the potential for an explosion hazard, the precautions shall be as follows:

- (a) A vent line shall be installed from the highest point on the unit being descaled. The line shall be piped to the atmosphere at a safe location. The discharge from this vent shall never be released in any part of the ship's hull at any time.
- (b) "No Smoking", "No Burning", and "No Welding" signs shall be posted in the fireroom and the immediate vicinity of the vent discharge line.
- (c) Nonsparking tools and hand electric flashlights shall be used if work on the boiler is necessary prior to the passivating step. Naked lights shall be prohibited. Portable, watertight, and vaporproof lights in accordance with MIL-F-16377 and MIL-F-16377/51 shall be used.
- (d) The boiler shall not be lit-off for preheating purposes or at any time during the cleaning operation. A boiler shall not be fired in the same fireroom where a boiler is being acid cleaned.
- (e) The acid mixing tank shall not be located in the fireroom or other enclosed areas.
- (f) Continuous safety watches shall be provided in the fireroom at the acid mixing tank, and at the vent outlet during the entire chemical cleaning procedure to prevent smoking, burning, or welding in the area and to ensure other safe practices.
- (g) Fireroom ventilation supply blowers shall be run on low speed and exhaust blowers shall be run on high speed to prevent dispersal of fumes into the rest of the ship.

4.12.4 Use of ship's pumps. Ship's pumps or other equipment shall not be used for filling the boiler with acid or for recirculating the descalant solution.

## MIL-STD-1607A(SH)

11 August 1987

4.13 Procedure following cleaning and inspection. Following a successful descaling operation the following procedures shall be performed as follows:

- (a) All boiler waterside surfaces shall be water-jet cleaned or wire brushed. Coatings applied in accordance with 4.6(d) shall be scraped from the affected areas. Loose deposits shall be removed mechanically. If water washing is required to remove debris from inaccessible areas, it shall only be accomplished with a solution containing 0.1 to 0.2 percent of sodium nitrite (8 to 16 pounds per 1000 gallons of feed quality water).
- (b) Temporary connections shall be removed, fittings reinstalled, and all manhole gaskets and any valve gaskets or packing that were in contact with the descalant shall be renewed. Blanks shall be removed and all boiler parts that were removed prior to acid cleaning shall be reinstalled.
- (c) Before closing the boiler, 25 pounds of sodium nitrite shall be dissolved in a small volume of feed quality water and poured into the water drum. The boiler shall be closed and filled with feed quality water. A hydrostatic test shall be applied to the boiler and bottom blow system at 125 percent of design pressure. The sodium nitrite treated water shall be disposed in accordance with 4.3.
- (d) Prior to light-off, the boiler shall be filled with deaerated feedwater and chemically treated in accordance with NAVSEA S9086-GX-STM-020/CH 220 V2. When the boiler is first lit-off after cleaning, it shall be brought up slowly to operating temperature.
- (e) Normally, following acid cleaning, the boiler water contains suspended matter that imparts a dark color to the water for the first few days. After light-off, the boiler shall be bottom blown frequently during the first few days of operation until the boiler water is clear. Proper water treatment levels shall be maintained during this frequent blowdown period as well as during normal operation conditions.

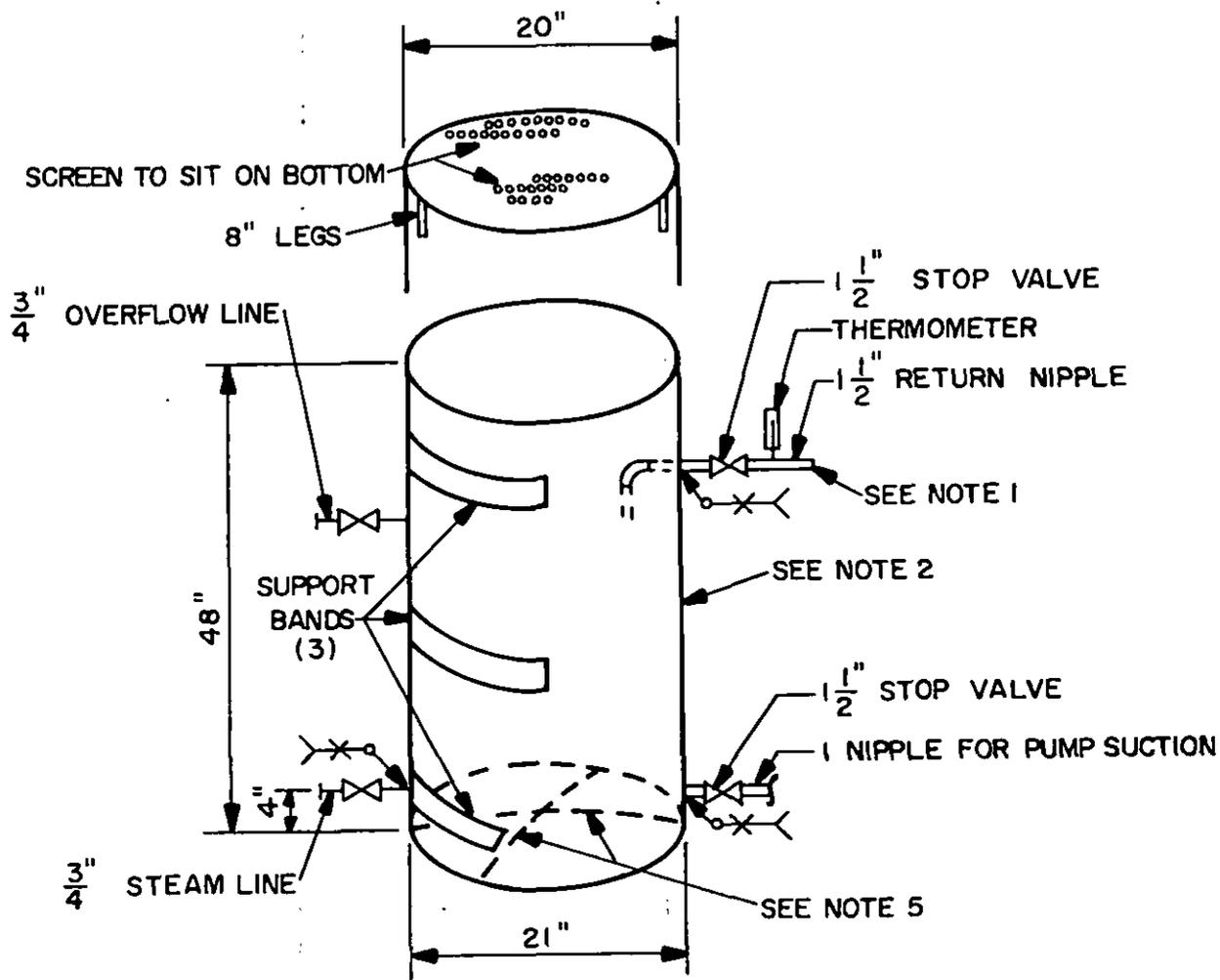
4.14 Subject term (key word) listing.

Acid, sulfamic-citric  
 Calcium carbonate  
 Diethylthiourea  
 Hydrogen  
 Passivator  
 Sodium hydroxide  
 Nitrogen

4.15 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:  
 Navy - SH  
 (Project 4410-N058)

MIL-STD-1607A(SH)  
11 August 1987



SH 13202671

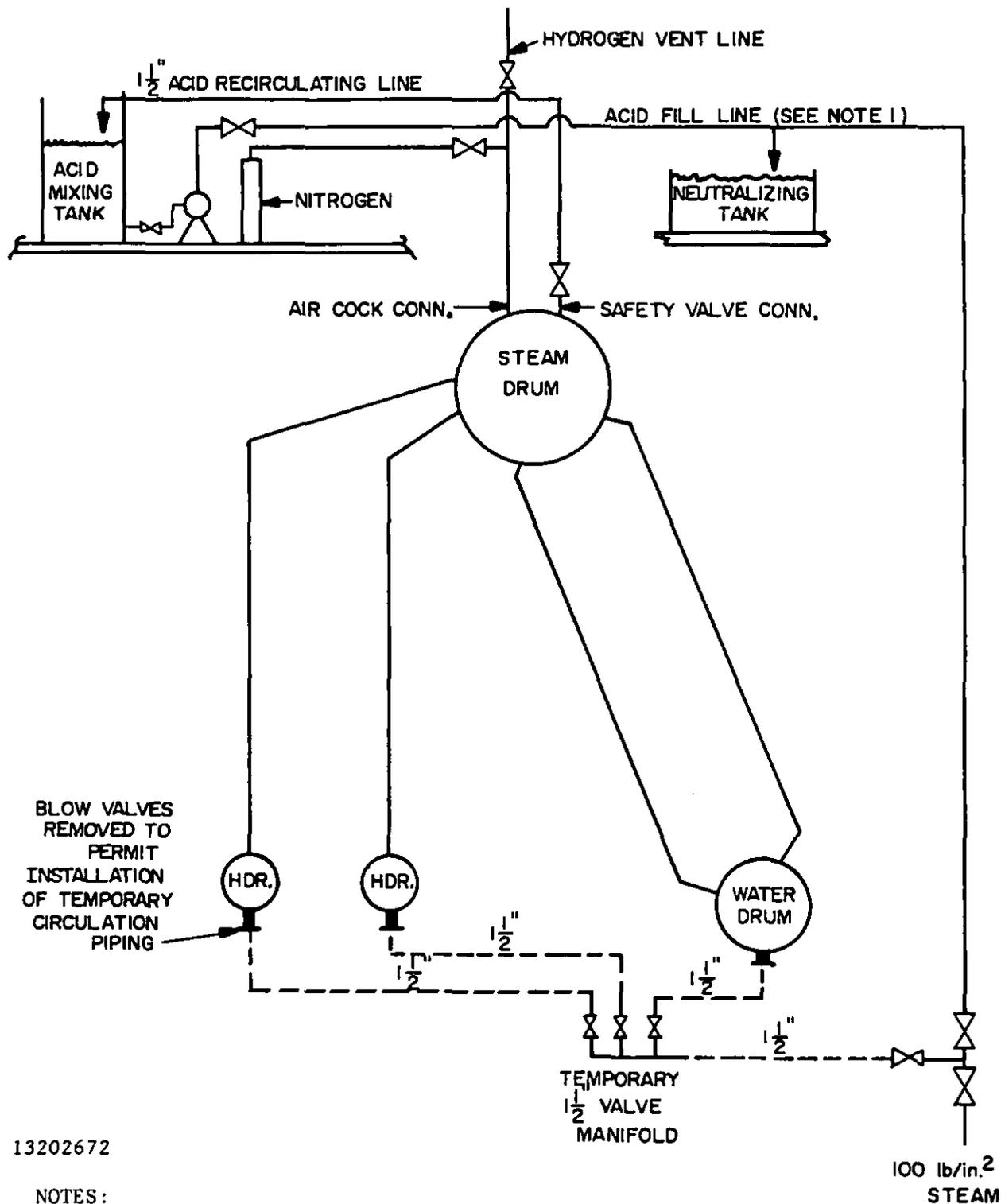
NOTES:

1. Install three assemblies in tank to connect return lines.
2. Use twelve gauge stainless steel for tank.
3. Use all high pressure fittings.
4. Install 4 by 1/4 inch support bands around top, center, and bottom of mixing tank.
5. Concave bottom 4 inches for strength.

FIGURE 1. Acid mixing tank.

MIL-STD-1607A(SH)

11 August 1987



SH 13202672

## NOTES:

1. Acid fill line, spent acid discharge line, and overboard discharge line are the same line. Nomenclature depends on service.
2. Arrangement for simultaneous economizer-boiler cleaning, if required.

FIGURE 2. Piping diagram.