

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 221

BOILERS

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SAFETY SUMMARY

SUMMARY OF SAFETY PRECAUTIONS

WARNING

Whenever personnel are to enter either the firesides or the watersides, precautions shall be taken to protect them from steam, water, and gases. Refer to detailed precautions in [paragraph 221-2.2.4](#). (Page 2-11)

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WARNING

When ever personnel are to enter either the Firesides or the watersides precautions shall be taken to protect them from steam, water, and gases. Refer to detailed precautions in [paragraph 221-2.2.4](#). (Page 2-23)

WARNING

A respirator is required during wirebrush cleaning operations to protect personnel from dust inhalation. (Page 2-28)

WARNING

Whenever personnel are to enter either the firesides or the watersides precautions shall be taken to protect them from steam, water, and gases. Refer to detailed precautions in [paragraph 221-2.2.4](#). (Page 2-31)

WARNING

A respirator is required during cleaning operations to protect personnel from dust inhalation. (Page 2-32)

WARNING

Always wear personal protective gear (i. e. safety goggles, safety harness and respirator when cleaning uptakes space and smokepipes. (Page 2-34)

WARNING

Ceramic fibers are suspected animal carcinogens. The strict handling and personnel exposure guidance given in the Main Boiler Repair and Overhaul Manual, NAVSEA S9221-C1-GTP-020, Appendix 10A, and NSTM Chapter 635 shall be followed. (Page 2-68)

WARNING

Ceramic fibers are suspect animal carcinogens. The strict handling and personnel exposure guidance given in the Main Boiler Repair and Overhaul Manual, NAVSEA S9221-C1-GTP-020, Appendix 10A, and NSTM Chapter 635 shall be followed. (Page 2-69)

WARNING

Observe electrical safety precautions when using electric equipment. Electrical equipment shall be properly grounded. (Page 2-79)

WARNING

Boilers using burners without safety shut-off devices shall display the following WARNING label on the boiler fronts to reduce the chance of accidental admission of fuel into the operating spaces: Ensure that both the fuel oil supply header valve and the manifold valve are closed before attempting to remove the atomizer assembly. (Page 3-11)

WARNING

When the nozzle ring is adjusted with pressure on the boiler, the valve should be gagged as a safety precaution. (Page 3-28)

WARNING

When a huddling chamber safety valve adjusting ring is adjusted with pressure on the boiler, the valve should be gagged as a safety precaution. (Page 3-30)

WARNING

Do not inspect for seat leaks by removing the plugs in the soot blower heads and pressurizing the system. (Page 3-39)

WARNING

Do not attempt to tighten further. If leakage persists, the problem is with gasket fit-up. (Page 3-50)

WARNING

No attempt shall be made to modify or adjust thermometers other than by shifting the scale or dial to improve their accuracy. These thermometers shall NOT be removed from their fittings while the boiler is under pressure. (Page 3-59)

WARNING

In entering the uptake for inspection or cleaning, care shall be taken not to damage pyrometer units, which project into the uptake. (Page 3-60)

WARNING

Verify the gauge or electronic transmitter is out of service before blowing back lines to prevent rupture of gauge diaphragms or possible damage to electronic transmitter. (Page 3-61)

WARNING

Personnel performing boiler maintenance and boiler light-off, standing watch, and working in boiler/fireroom spaces during boiler operations shall wear fire retardant engineering coveralls to provide flash and fire protection in addition to any specialized protective devices or clothing outlined in the boiler procedures. (Page 4-1)

WARNING

Initial burner light-off is a two man procedure, requiring one man to operate the burner fuel oil supply manifold valve, and one man to insert the lighting off torch, open the safety shut-off device/atomizer valve, and operate the air register. (Page 4-7)

WARNING

The torch man shall wear fire-retardant engineering coveralls, eye shield, and gloves. When lighting fires, stand well clear of the burner air register and the lighting off port to avoid injury in case of flareback. (Page 4-9)

WARNING

Stand well clear of the light-off port while removing the torch. (Page 4-14)

WARNING

Stand well clear of the lighting-off port while removing the torch. (Page 4-17)

WARNING

When lighting fires, stand well clear of the burner register and lighting-off port to avoid injury in case of boiler explosion. (Page 4-18)

WARNING

A potentially explosive situation is deemed to exist after generating white smoke for more than one minute. A potentially explosive situation is deemed to exist after generating heavy black smoke for more than two minutes. (Page 4-19)

WARNING

Do not adjust fuel oil header pressure as a means of clearing white smoke. (Page 4-44)

WARNING

Ship's force should conduct emergency egress and Emergency Escape Breathing Device (EEBD) training in accordance with NSTM 077 (3.4.5.3) and NSTM 079 (46.11.5). Personnel must be trained in advance to find a safe escape route from their watch station, even in total darkness.

If evacuation becomes necessary and personnel are in the Enclosed Operating Space (EOS), don EEBD, secure plant, Ensure EOS doors are shut prior to opening the scuttle then immediately evacuate through scuttle in overhead of EOS. Muster in repair 5 and report to locker leader status of the main space and source of steam leak if known.

Avoid areas where steam leaks are thought to exist.

To avoid a chimney effect, when evacuating a main machinery space that has been filled with live steam, ensure all personnel are inside the escape trunk or enclosed operating station with the door/scuttle secured before opening the upper door/scuttle. At no time should both the lower and upper doors be opened simultaneously. (Page 4-50)

WARNING

Chemical cleaning of stainless steel alloy coils with hydrochloric acid is not permitted. Hydrochloric acid will induce stress corrosion cracking of the tube metal, and may cause eventual tube failure. (Page 5-23)

WARNING

Sulfamic-citric acids may cause chemical burns if they come into contact with skin or eyes. DETU, a suspect carcinogen, is also considered as a moderate irritants to the skin and eyes. Personnel handling this material shall wear rubber gloves, chemical workers goggles or plastic face shields, rubber aprons and boots.

In case of skin contact, the affect area shall be thoroughly flushed with fresh water. If any acid gets into the eyes, allow fresh water to flow into the opened eyes for 15 minutes and get immediate medical attention.

No smoking, burning or welding is permitted in the vicinity of the acid tank, engine room and vent discharge while the cleaning is in progress. Non-sparking tools shall be used.

Sodium bicarbonate shall be used in cases of acid spills. (Page D-3)

WARNING

Mild steel shall be used for all valves, fittings, piping, pumps and tanks. No copper material shall be used. Ship's pumps SHALL NOT be used to pump acid. (Page D-4, page D-11)

WARNING

Scale removing compound shall be added only upon completion of filling mixing tank with feedwater. DO NOT add water to acid. Fill mixing tank with feedwater first, the add acid. (Page D-6)

WARNING

Hydrochloric acid can cause chemical burns if it comes into contact with skin or eyes. Also, Rodine 213 and DETU (a suspect carcinogen) are considered as moderate irritants to skin and eyes. Personnel handling these materials shall wear rubber gloves, goggles, face shields, rubber aprons and boots.

In case of skin contact, the affected area shall be thoroughly flushed with fresh water. If any acid gets into eyes, allow fresh water to flow into the opened eyes for 15 minutes and get immediate medical attention.

No smoking, burning or welding is permitted in the vicinity of the acid tank, engine room or vent discharge while the cleaning is in progress. Non-sparking tools shall be used.

Sodium carbonate shall be used to neutralize spills. (Page D-10)

WARNING

Concentrated acid must be slowly added to water, otherwise a violent reaction will occur. (Page D-10)

WARNING

Hydrochloric acid shall be added only upon completion of filling mixing tank with feedwater.

DO NOT add water to acid. Filling mixing tank with feedwater first, then add acid.

Mixing tank may become HOT after the addition of acid. (Page D-12)

WARNING

Acid shall be added only upon completion of filling mixing tank with feedwater.

DO NOT add water to acid. Fill the mixing tank with feedwater first, then add acid.

Mixing tank may become HOT after addition of acid. (Page D-13)

WARNING

Trisodium phosphate and sodium metasilicate are highly alkaline chemicals that can cause burns to the skin and eyes. Affected personnel shall flush the skin with large amounts of water; for eyes, flush with potable water for at least 15 minutes, lifting upper and lower lids, and obtain immediate medical attention. Use of dust mask, face shield, chemical worker's goggles, rubber gloves and rubber apron is mandatory when handling these chemicals and the wetting agent. (Page E-1)

WARNING

Adequately tie down and secure all steam and rubber hoses to prevent movement during operation. (Page E-3)

WARNING

Trisodium phosphate and sodium metasilicate are highly alkaline materials that can burn the skin and eyes. Affected personnel shall flush the skin with large amounts of water; for eyes, flush with potable water for at least 15 minutes and obtain immediate medical attention. Use of dust mask, face shield, chemical worker's goggles, rubber gloves and rubber apron is mandatory when handling these chemicals and the wetting agent. (Page E-5)

WARNING

Adequately tie down and secure all hoses to prevent movement during operations. (Page E-6)

WARNING

All personnel conducting the hydrostatic test shall wear eye shields to avoid injury in case of a spray of high-pressure water. (Page G-5)

CAUTION

Personnel performing boiler maintenance or light off, standing watch, or working in boiler or fireroom spaces during boiler operations shall wear fire retardant engineering utility coveralls to provide flash and fire protection in addition to any specialized protective devices or clothing outlined in the boiler procedures. (Page 2-1)

CAUTION

When sodium nitrite is injected into the boiler the water level shall be closely observed to prevent the boiler water from spilling over into the superheater, thereby chemically contaminating the superheater steamsides with chloride and boiler water treatment chemicals. (Page 2-10)

CAUTION

Sodium nitrite is an oxidizing agent that may support combustion. Exercise caution in stowing and using this chemical. For storage and handling precautions refer to NSTM Chapter 670. Sodium nitrite is chemically incompatible with hydrazine. Store these chemicals separately. Do not mix sodium nitrite and hydrazine solutions. (Page 2-10)

CAUTION

Do not contaminate the boiler with wet or oily compressed air. (Page 2-12)

CAUTION

Sodium nitrite adversely affects water chemistry in a steaming boiler. (Page 2-13, page 2-15)

CAUTION

If deposits are hard and adhering, take special care to prevent damage to tubes during cleaning. (Page 2-33)

CAUTION

Do not use MIL-PRF-16173 corrosive preventative oil for fireside cleaning. It has a flash point that is too low for safe use. (Page 2-35)

CAUTION

Only approved welding methods shall be used for large diameter tube renewal. Plans shall be checked to determine the material being welded. (Page 2-41)

CAUTION

Piping shall not be used instead of tubing without obtaining explicit written approval and detailed installation guidance from NSWCCD-SSSES. Such substitution is not normally recommended because tubes and pipes are measured differently. Tube holes and tube expanding equipment are sized for tube dimensions. (Page 2-44)

CAUTION

For elevated pressure hydrostatic tests above 100%, aimed at verifying integrity, the handhole plates should be checked at 100% pressure to verify that there are no leaks sufficient to prevent the reaching of the ultimate hydro pressure because of exceeding the pump capacity. Personnel must not enter a boiler and assist handhole plates in sealing at elevated pressures, if the boiler integrity has not been first verified. (Page 2-53)

CAUTION

Comply with safety precautions of OPNAVINST 5100.19 Volumes 1 and 2. (Page 2-63)

CAUTION

The encapsulating material may irritate skin, and should be washed off at the first opportunity. Contact with eyes must be avoided and should be treated by rapid and thorough washing. If swallowed, induce vomiting and seek medical advice. (Page 2-63)

CAUTION

The main feed pump shall not be used for hydrostatic testing except in emergencies when an operable test pump is not available. In that event, the use of the main feed pump shall be limited to the 100 percent maximum steady state operating pressure hydrostatic test. Use of the main feed pump or emergency feed pump should be restricted to filling the boiler with water. (Page 2-78)

CAUTION

During the hydrostatic test of the boiler, the desuperheater shall, be filled with water and pressurized along with the boiler to prevent exceeding the design pressure of the assembly. This requires that any shutoff valve between the superheater outlet and the desuperheater inlet be open during the test. (Page 2-82)

CAUTION

Do not enter the boiler during the 150 percent hydrostatic test. (Page 2-82)

CAUTION

When an existing gasket cannot be confirmed as non-asbestos, and cannot be removed intact, refer to NSTM Chapter 078 paragraph 9.3.2 for appropriate precautions, asbestos hazard control and disposal requirements. Any suspected asbestos containing gaskets and remnants must be wet prior to scraping. A sharp brass scraper is the best tool to separate the gasket from the gauge body without causing abrasion and further deterioration. Wire brushing, power tools and compressed air should never be used. (Page 3-44)

CAUTION

Spring cones must be stacked as illustrated. Make sure spring cones are the correct diameter and thickness for the gauge as shown. (Page 3-45)

CAUTION

Spring cone washers must be stacked as illustrated. Make sure spring cones are the correct diameter and thickness for the gauge as shown. (Page 3-48)

CAUTION

Do not lift safety valves. (Page 4-6)

CAUTION

Ensure that the water level in the steam drum is in sight at all times. (Page 4-7)

CAUTION

The furnace should not be purged until all traces of unburned fuel have been removed. Raw fuel on the furnace floor cannot be removed by purging; access to the furnace floor is required to remove all remaining oil.

A clear stack condition shall be maintained during purge. (Page 4-8)

CAUTION

If ignition fails to occur within 2 to 3 seconds, shut the burner fuel oil supply manifold valve and safety shutoff device/atomizer valve. Ensure that the

fuel oil manifold recirculating valve remains open. Before making any further attempt to relight fires, proceed according to [paragraph 221-4.5.8](#). (Page 4-9)

CAUTION

A clear stack condition shall be maintained after ignition. (Page 4-14)

CAUTION

Be sure that sufficient steam pressure and drainage is maintained as long as fires are lighted. (Page 4-14)

CAUTION

If ignition fails to occur within seconds, shut the number 2 burner fuel oil manifold valve, atomizing steam manifold valve, and safety shut-off device. Shut the number 2 burner air register, and remove the atomizer. (Page 4-16)

CAUTION

Excessive firing rates before the boiler is up to pressure, can damage the superheater and furnace refractory. Do not exceed established limits for the firing rate after light-off while raising steam pressure. (Page 4-16)

CAUTION

Do not attempt a second light-off until the cause of the first, unsuccessful light-off attempt has been corrected. (Page 4-17)

CAUTION

Do not insert atomizer into the burner until it has been inspected by the space supervisor. (Page 4-18)

CAUTION

If ignition is not verified immediately upon opening the air register, shut burner fuel oil supply manifold valve and safety shut-off device, air supply valves and burner atomizing steam/air at safety shut-off device. Ensure fuel oil manifold recirculating valve remains cracked open. Before making any

further attempt to light fires, proceed as follows: Remove burner atomizer assembly from the boiler and determine the cause of ignition failure. Stop the port use fan, inspect the furnace for unburned fuel and remove all traces of unburned fuel. (Page 4-18)

CAUTION

A timed purge of the furnace shall not be accomplished nor shall a second light-off be attempted until the furnace has been inspected for unburned fuel and all traces of unburned fuel have been removed. (Page 4-20)

CAUTION

Ships using Todd Combustion (TCI) safety shut-off devices of the original bronze alloy that regularly experience operating temperatures above 475 degrees F, shall verify temperatures at the burner front using a recently calibrated thermometer. If temperatures exceed 475 degrees F, the safety shut-off devices shall be upgraded to the newer Todd steam bronze alloy, which has a service limit of 550 degrees F, or steel. (Page 4-21)

CAUTION

When securing electric light-off fans and shifting to the on-coming forced-draft blower, always lock the damper or shutters of the secured light-off fan (port use blower) in the closed position. (Page 4-26)

CAUTION

Steam flow shall be provided through the superheater at all times when fires are lighted. (Page 4-28)

CAUTION

When securing electric light-off fans and shifting to an oncoming forced-draft blower, always lock the damper or shutters of the secured light-off fan in the closed position. (Page 4-28)

CAUTION

Whenever the boiler water level drops or rises completely out of sight in the gauge glasses, immediate steps shall be taken to secure the boiler. Refer to [paragraphs 221-4.18.16](#) through [221-4.18.16.2](#) for specific actions to be taken for high and low water. (Page 4-37)

CAUTION

It is realized that local port regulations will prohibit operation of soot blowers in most instances. This does not mean that the need to blow tubes during extended periods of low steaming rate operation does not exist. Ships whose operating profile includes extended in-port steaming must make sure all combustion and atomizing steam quality issues are resolved prior to deployment. Increases in stack gas temperature (where equipped) and wind-box pressure levels over anticipated values for a given steaming rate can be an indicator of soot accumulation on firesides. A decline in economizer outlet water temperature (where equipped) from anticipated values for a given steaming rate may also be an indicator. It is not advisable to steam a boiler at low rates, even one with no known combustion problems, more than 500 hours without getting underway for the purpose of standard operation of soot blowers. (Page 4-41)

CAUTION

In boiler furnaces having refractory decks, pay particular attention to accumulated fuel that may have seeped through expansion joints and collected in the brick pan. (Page 4-46)

CAUTION

No. 3 waste heat boilers on DD-963/DDG-993/CG-47 class ships are susceptible to freezing and tube damage during extremely cold weather. Dry lay-up is required for No. 3 waste heat boiler in periods when outside temperatures are expected to be extremely cold to prevent boiler freeze up. (Page 5-26)

CAUTION

Do not allow the water level to go out of sight in the gauge glass. (Page 5-33)

CAUTION

EDTA forms an alkaline solution. Personnel mixing solution shall wear rubber gloves, rubber apron, safety goggles, and dust mask. If solution is splashed in eyes or on skin, wash with copious amounts of water. Flush with potable water for 15 minutes while lifting upper and lower lids. Seek medical attention immediately. (Page C-3)

CAUTION

Do not allow hot fluid to reach differential pressure units. (Page C-5)

CAUTION

Sodium nitrite should not be added to the water since it can form toxic fumes hazardous to personnel when in contact with fireside deposits. (Page F-1)

CAUTION

Maintain a close watch on the hydrostatic pump discharge gauge (g-1). NEVER EXCEED FUEL OIL SERVICE PRESSURE (NORMALLY 400 +5 -0 psig). (Page G-6)

CAUTION

Maintain a close watch on the hydrostatic pump discharge gauge (g-1). NEVER EXCEED STEAM ATOMIZATION PRESSURE NORMALLY 135 TO 150 psig). (Page G-9)

LIST OF ACRONYMS

ABBREVIATION	DEFINITION
ACC	Automatic Combustion Control
ANSI	American National Standards Institute
APL	Allowance Parts List
ASME	American Society of Mechanical Engineers
BID	Boiler Inspection Device
BIS	Boiler Igniter System
BIRMIS	Boiler Inspection and Repair Management Information System
BMS	Burner Management System
BS&W	Bottom Sediment and Water
BTIU	Boiler Tube Inspection Unit
CAI	Completion of Availability Inspection
CASREP	Casualty Report
CDNSWC	Carderock Division, Naval Surface Warfare Center
CE	Combustion Engineering, Inc. (Alstom)
CFM	Cubic Feet Per Minute
CNO	Chief of Naval Operations
COI	Completion of Overhaul Inspection
CPU	Central Processing Unit
CRES	Corrosion Resistant Steel
CSMP	Current Ships Maintenance Program
DETU	Diethylthiourea
DFM	Diesel Fuel Marine
DFT	Deaerating Feed Tank
DPU	Differential Pressure Unit
DSP	Disodium Phosphate
EABC	Electronic Automatic Boiler Control
EDTA	Ethylene-Diamine-Tetraacetate
EEBD	Emergency Escape Breathing Device
EEPROM	Electrically Erasable Programmable Read-Only Memory
EOCC	Engineering Operational Casualty Control
EOP	Engineering Operational Procedures
EOSS	Engineering Operational Sequencing System
FDB	Forced Draft Blower
FED	Federal
FPC	Feed Pump Control
FWC	Feed Water Control
GTG	Gas Turbine Generator
HCL	Hydrochloric Acid
HP	High Pressure
IMA	Intermediate Level Maintenance Activity
INSURV	Board of Inspection and Survey
ISV	Industrial Support Visit
KW	Kilowatt
LCEM	Life Cycle Engineering Manager
LED	Light Emitting Diode

ABBREVIATION	DEFINITION
LP	Low Pressure
MRC	Maintenance Requirement Card
MT	Magnetic Particle Test
NAVSEA	Naval Sea Systems Command
NDE	Non-Destructive Examination
NEMA	National Electrical Manufacturers Association
NPS	Nominal Pipe Size (Refer to ANSI Standard B36.10)
NSFO	Navy Special Fuel Oil
NSN	National Stock Number
NSTM	Naval Ships' Technical Manual
OLV	On-Line Verification
OOD	Officer of the Deck
PMS	Planned Maintenance Systems
POT&I	Pre-Overhaul Tests and Inspection
PSAI	Pre-Start of Availability Inspections
SOI	Pre-Start of Overhaul Inspection
PT	Dye Penetrant test
RCC	Recirculation Control
RFEC	Remote Field Eddy Current
RTD	Resistance Temperature Detector
RVI	Remote Visual Inspection
RWLI	Remote Water Level Indicators
SAI	Start of Availability Inspection
SARP	Ship Alteration and Repair Package
SEAADSA	NAVSEA Automated Data Systems Activity
SGPI	Steam Generating Plant Inspector
SHPS	Superheater Protection Steam
SOI	Start of Overhaul Inspection
TSP	Trisodium Phosphate
TYCOM	Type Commander
UPS	Uninterrupted Power Supply
UT	Ultrasonic Test
VP	Vented Plunger
VT	Visual Test
WHB	Waste Heat Boiler aste Heat Boiler

CHAPTER 221

BOILERS

SECTION 1

INTRODUCTION

221-1.1 TERMINOLOGY.

221-1.1.1 DEFINITIONS. The following terms, which appear frequently throughout this chapter, are defined here to ensure uniform use of boiler terminology.

- a. **Fireroom.** A compartment containing boilers and the station for firing or operating the boilers.
- b. **Boiler Room.** A compartment containing boilers but not containing the station for firing or operating the boilers. This term applies specifically to bulkhead enclosed boiler installations.
- c. **Main Machinery Room.** A compartment containing boilers and the station for firing or operating boilers and other machinery, such as the main propulsion engines.
- d. **Boiler Operating Station.** A station from which a boiler or boilers are operated, applying particularly to the compartment from which the boilers are operated.
- e. **Boiler Full Power Capacity.** The total quantity of steam required (in pounds per hour), at the pressure and temperature specified in the contract specifications of a ship, to develop the contract shaft horsepower of the ship, divided by the number of boilers installed.
- f. **Boiler Overload Capacity.** As specified in the design of a boiler, usually 120 percent of boiler full power capacity, either in steaming or firing rate as specified for the individual installation.

NOTE

Some boilers may have capacities specified differently from the above definitions of full power and overload. This circumstance may be found on older ships or on ships acquired to commercial specifications. Commercial designations of capacities will generally be expressed as normal steaming rate and maximum steaming rate with maximum being 150% of normal. When this correlation exists (i.e. maximum equals 150% of normal), the commercial maximum steaming rate is equivalent to the Navy overload condition. Other variations may exist. If the Navy full power and overload capacities cannot be determined, contact the Life Cycle Manager (LCM) for boilers, Carderock Division of the Naval Surface Warfare Center (NSWCCD-SSES), Code 922 (formerly NAVSSES) for guidance.

- g. **Superheater Outlet Pressure.** The pressure at the superheater outlet.
- h. **Steam Drum Pressure.** The pressure in the steam drum.
- i. **Design Pressure.** The pressure specified by the boiler manufacturer as a criterion for boiler design. According to MIL-B-18381, propulsion boiler design pressure must be at least 50 psig, or 3% whichever is greater above the maximum operating pressure. For example, an LHD-1 Class boiler has a maximum operating pressure of 700 psig and the design pressure is 750 psig.

- j. **Operating Pressure (Nominal).** The constant pressure (at the boiler superheater outlet or in the steam drum) at which the boiler is operated in service.
- k. **Maximum Operating Pressure.** The highest pressure under normal operating conditions. This corresponds to the steam drum pressure at the overload (120 percent full power steaming rate) condition.
- l. **Superheater.** That part of the boiler specifically designed to raise the temperature of the steam, to a predetermined amount above the saturation point for the design pressure of the boiler. Superheaters are classified by the predominant type of heat transfer for which they are designed. Radiant superheaters are those not screened from the furnace by intervening tubes of the generating surface; convection superheaters are located behind a portion of the generating surface. All Navy propulsion boilers have convection superheaters; ships with radiant superheaters have all been stricken.
- m. **Steaming Hours.** The time during which a boiler has fires lighted for raising steam and during which it is generating steam. Time during which fires are not lighted in an oil burning boiler should not be included in steaming hours.
- n. **Engineer Officer.** Wherever the term Engineer Officer is used in this chapter it refers to the head of the ship's engineering department.

221-1.2 TYPES OF NAVAL BOILERS.

221-1.2.1 **GENERAL.** Boilers installed aboard Navy ships can be classified as follows:

- a. Main propulsion boilers supply steam to the main propulsion turbines and to auxiliary services, as required.
- b. Auxiliary boilers supply steam for all services except main propulsion.

221-1.2.2. **MAIN PROPULSION BOILERS.** D-type boilers are the only boiler design currently installed in Navy ships for main propulsion service. The D-type boiler is also generally described by such terms as two-drum, bent-tube, single-furnace, and integral-super-heater. It consists of steam and water drums connected by screen and main bank steam generating tubes and by external (unheated) downcomers to provide natural circulation. The superheater is located between the screen and main bank generating tubes and may have either horizontal or vertical tubes. The furnace walls are covered either by refractory and insulation or by waterwall tubes that run between upper and lower headers connected to the steam and water drums. Burners are located in a front wall. Heat recovery is provided by an economizer after the main bank. A desuperheater is provided in either the steam or the water drum to reduce the steam temperature as required for auxiliary services. Steam separators and dryers are installed in the steam drum to reduce the moisture content of the steam below a maximum specified level before sending it to the superheater. See [Figure 221-1-1](#) for a typical arrangement.

NOTE

The procedures specified in this chapter apply in general to all naval boilers.

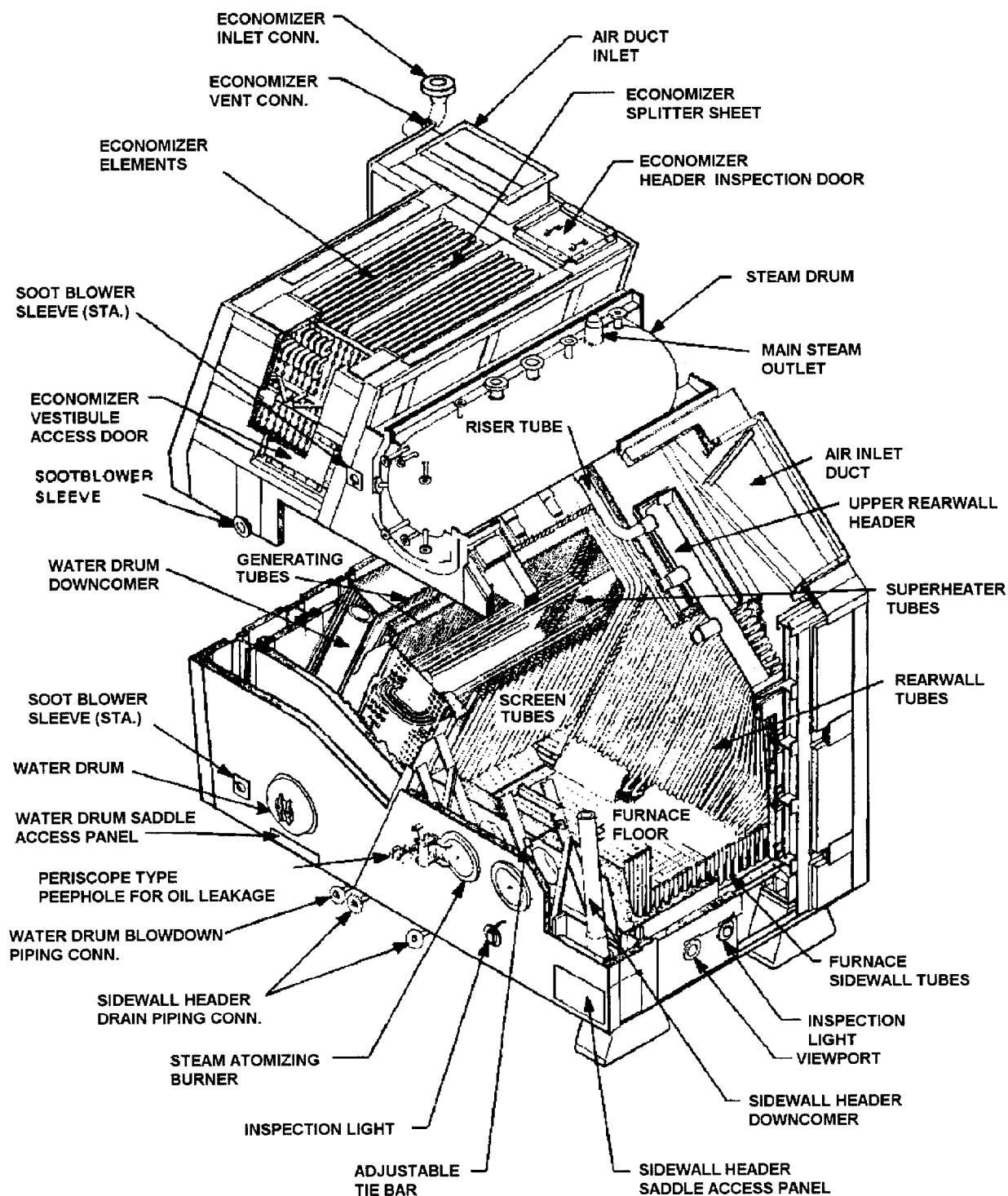


Figure 221-1-1. D-Type Boiler - Front Fired With Horizontal Superheater

221-1.2.3 AUXILIARY BOILERS. The term auxiliary boilers is used to define small boilers that supply steam for distilling plants, space heating, oil heating, water heating, and galley and laundry services. These boilers are equipped with the required auxiliaries, accessories, and controls to form a unit assembly. Except for waste heat boilers, they are arranged to operate as complete and self-contained steam generating plants. These boilers are described in detail in [Section 5](#). Depending on design, auxiliary boilers are divided into the following types:

- a. Watertube natural-circulation boilers
- b. Waste heat boilers

SECTION 2

MAIN PROPULSION BOILER MAINTENANCE

221-2.1 GENERAL REQUIREMENTS.

CAUTION

Personnel performing boiler maintenance or light off, standing watch, or working in boiler or fireroom spaces during boiler operations shall wear fire retardant engineering utility coveralls to provide flash and fire protection in addition to any specialized protective devices or clothing outlined in the boiler procedures.

NOTE

Preventive maintenance shall be according to Maintenance Requirement Cards (MRC's) of the Planned Maintenance System (PMS).

NOTE

Refer to [Appendix K](#) for Summary of Ship's Force Responsibilities for boiler inspection preparation, requirements for documentation, material inspection and pre-operational checks.

221-2.1.1 BOILER CARE. The Engineer Officer shall be fully cognizant of the general condition of each boiler and the manner in which each is being operated and maintained. The Engineer Officer shall ensure by periodic inspection that the exterior and interior surfaces of the boiler are clean; that furnace linings adequately protect casing, drums, and headers; that integrity of pressure parts is being maintained; and that operating conditions of burners, safety valves, operating instruments, and other boiler appurtenances are satisfactory. The Engineer Officer shall ensure that fuel used while steaming is free of seawater and that feedwater used is free (within prescribed limits) of contamination and dissolved oxygen. The boiler water shall be maintained within the prescribed limits and conditions listed in NSTM Chapter 220, Volume 2, Boiler Water/Feedwater Test and Treatment. The Engineer Officer shall also ensure that idle boilers are properly laid up.

221-2.1.2 BOILER INSPECTION. All parts of the boiler shall be carefully examined whenever they are exposed for cleaning, maintenance, or overhauling; and their conditions as found upon these examinations shall be described in the boiler water chemistry worksheet/log and the engineering log. In addition, boilers are subject to the following periodic inspections (whichever occurs first following the last inspection):

221-2.1.2.1 Planned Maintenance System Periodic Inspections.

- a. Waterside. Periodic inspections are not required for ships on chelant treatment.

NOTE

Prior to adoption of chelant boiler/feedwater treatment, an inspection was required every 1,800 to 2,000 steaming hours unless the ship was equipped with make-up feedwater demineralizers and morpholine condensate treatment; with this equipment the inspection was extended to 3,600 to 4,000 steaming hours.

- b. Firesides. Firesides shall be inspected annually.
- c. Planned Maintenance. Planned maintenance inspections are conducted by the ship's force in accordance with the PMS (except as noted below in [paragraph 221-2.1.2.2](#), when TYCOM routine inspections coincide). The 3M Coordinator is responsible to highlight the requirement on the weekly schedule until accomplished.

221-2.1.2.2 TYCOM (Routine) Inspection. Both firesides and watersides shall be inspected every 18 months. To provide scheduling flexibility, this inspection may be performed as early as 12 months or as late as 24 months after the previous inspection. According to OPNAVINST 9220.3, the Type Commander (TYCOM) may approve extensions beyond 18 months for ships on extended deployment to permit inspection upon their return. Such extensions shall not result in the inspection interval exceeding 24 months. A certified Steam Generating Plant Inspector (SGPI) shall perform this inspection.. This inspection shall be documented in the Boiler Inspection and Repair Management Information System (BIRMIS).

221-2.1.2.3 Ship's Pre-inspection Checklist For Up-coming Routine Boiler Inspection by U.S. Navy Steam Generating Plant Inspector (SGPI).

- a. PURPOSE. The primary purpose of this Pre-Inspection checklist is to provide ships force and the SGPI's with Pre-Inspection requirements for up-coming boiler routine inspections.
- b. CHECKLIST. Ship's Force shall prepare the boiler for the routine inspection in accordance with the Boiler Inspection Manual, S9221-D2-MMA-010, and as follows:
 - 1. Conduct outer casing leakage inspection using hand and soap film techniques before the start of routine boiler inspection per [paragraph 221-2.13.7](#). Mark all leaks clearly on the casing. Provide a casing map to the designated SGPI for determining the extent of casing removal required. The "map" consists of external casing drawings from volume II of the applicable Main Boiler Technical manual.
 - 2. Take movement indicator readings on all sliding feet during the last boiler light-off. Record the results in the engineering log and provide a report of the results to the SGPI inspector. If movement indicators are not installed, verify the sliding foot movement according to [paragraph 221-2.15.2](#).
 - 3. Prior to opening the boiler watersides, conduct a pre-inspection hydrostatic test at 100 percent maximum steady state operating pressure according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#). Contact the local SGPI to witness the hydrostatic test.
 - 4. The following items shall be conducted by ships force and witnessed by the designated SGPI inspector:
 - a. Conduct sliding feet PMS check.
 - b. Provide ship's service air for operating soot blower air motors.
 - c. Conduct safety valve hand easing gear check (PMS).
 - d. Make keys available to open the GIS safety valve panels to inspect canister assembly and grease three-way valve.
 - e. Open chelant control cabinet, hydrazine storage and safety lockers and batch injection funnel.
 - f. Make keys available for all oil lab inspection items.

- g. Perform all final control element, Uninterrupted Power Supply (UPS) and air lock checks in accordance with PMS/EOSS.
- h. Demonstrate the Boiler Inspection Device (BID).
- 5. After completion of hydrostatic testing, secure, wire shut, and tag DO NOT OPEN appropriate valves according to current OPNAV tag-out instructions.
- 6. Drain and dry out boiler, superheater, economizer, blow piping, header drains and any other piping systems that may permit entry of water into the boiler. Open the boiler watersides as follows:

AS-39 Class Combustion Engineering Boilers.

- a. Remove two handhole plates from each of the lower sidewall, rearwall and screen headers. The handhole plates shall be removed from the header ends adjacent to each bottom blow nozzle.
- b. Remove one handhole plate from each superheater header end, and one each on either side of the diaphragm plates. (See volume II of the Main Boiler technical manual for location of diaphragm plates).
- c. Remove one each economizer inlet and outlet header oval handhole plate.
- d. Open steam drum and water drum manway plates.

LCC Class FW Boilers.

- a. Remove two handhole plates from each of the lower sidewall and screen headers. The handhole plates shall be removed from the header ends adjacent to each bottom blow nozzle.
- b. Remove one handhole plate from each superheater header end, and one each on either side of the diaphragm plates. (See Volume II of the main Boiler technical manual for location of diaphragm plates.)
- c. Remove one each economizer inlet and outlet header inspection flange cover plate.
- d. Open steam drum and water drum manway plates.

LPD Class FW Boilers.

- a. Remove two handhole plates from the lower side wall header ends adjacent to the bottom blow nozzles.
- b. Remove one handhole plate from each superheater header end and one each on either side on the diaphragm plates. (Refer to Volume II of the main boiler technical manual for location of diaphragm plates).
- c. Remove one each economizer inlet and outlet header inspection flange cover plate.
- d. Open steam drum and water drum manway plates.

LHA-1/LHD-1 Class Combustion Engineering Boilers.

- a. Remove two handhole plates from each of the lower side wall, lower front wall, lower rear wall and screen wall header ends adjacent to the bottom blow nozzles.
- b. Remove one handhole plate from each superheater header end at the drain nozzle and one each on either side on the diaphragm plates. ((Refer to Volume II of the boiler technical manual for location of diaphragm plates).
- c. Remove two handhole plates from each of the upper front wall and rear wall header ends.
- d. Remove two handhole plates from each of the economizer inlet and outlet header ends at the drain nozzle.
- e. Open steam drum and water drum manway plates.

NOTE

Do not remove the water drum closure plate. Do not remove welded in economizer handhole plates.

7. Move the desuperheater on LPDs. Remove steam drum internals as required to expose about 50% of the tube sheet. Carefully match mark all removed drum internals with their position in the steam drum to ensure proper reinstallation. Stow nuts, bolts, washers and other small parts in a container outside the drum to prevent them from being lost in the boiler. Additional internals may be removed at the discretion of the SGPI.

NOTE

LHA-1/LHD-1 Class ships shall not remove desuperheaters or the steam drum dry box for Routine inspections. Removal of desuperheaters is only applicable to the five year Strength and Integrity Inspection. The dry box should not be removed unless directed by the SGPI Inspector.

8. Dry out the boiler watersides, including the economizer, using the hot air lay-up method per [paragraph 221-2.3.3.1](#). Install temporary closures over handholes and manways to maintain hot air lay-up until preparations for entering the boiler begin.
9. Conduct hydrostatic test of the desuperheater assembly in accordance with [paragraph 221-2.16.5.7](#).
10. Install temporary closures over nozzle openings, handholes, and the other bored openings whenever practicable to prevent entry of industrial debris and foreign objects.

NOTE

It is not necessary to mechanically clean (wire brush) or water-jet the waterside surfaces to be inspected for an 18 month inspection. The need for cleaning will be determined by the inspection results.

11. Remove whatever doors or panels are necessary to provide access to the firesides, this is to include the economizer U and return bends and the generating bank tubes. Remove only bolted panels; not permanent panels.
12. Provide access to the furnace either through one burner register (normally the hinged burner) or the door opening. Also, remove the boiler uptake access plates leading to the air and gas sides. Remove stack gas analyzers and store them in a protected area.
13. Open, dry out and maintain the Deaerating Feed Tank (DFT) on dry lay up in accordance with PMS and DFT technical manual. Certify as safe for entry by personnel according to NAVSEA S6470-AA-SAF-010, Navy Maritime Confined Space Program manual.
14. Open FDB plenum chamber.
15. Remove generating bank upper rear wall brick shelf. (LHA-1/LHD-1 Class ships only).
16. Ensure that the boiler is gas free and gas free certificate is signed, dated and posted in accordance with NAVSEA S6470-AA-SAF-010, Navy Maritime Confined Space Program manual prior to the scheduled arrival time of the inspector. The certificate is to include both firesides and the watersides.
17. Ensure fuel oil atomizer assemblies are disassembled for inspection and an inventory of the atomizers and burner barrels is conducted. Compare the quantity to the requirements of [paragraphs 221-3.1.4](#) and [221-3.1.5](#), and procure more atomizers if necessary.
18. Have the following special tools available for the inspector to use: Go-No Go gages, gage or scale for measuring burner tip nut protrusion, diffuser withdrawal, concentricity of diffuser and bladed cone, refractory cone angle template, and any other tools that ships force normally uses in conducting its own boiler inspections.
19. Also, provide copies of:
 - a. Boiler tube renewal sheets.

- b. Most recent boiler inspection report (BIRMIS).
- c. Boiler CASREP summaries and all current boiler DFS's.
- d. Results of the most recent nondestructive testing (NDE) tube evaluation.
- e. Record of the boiler work performed since the last availability.
- f. Boiler operating records for the last 6 months
- g. Machinery Plant Water Treatment Log package for the last 6 months of operation.
- h. Hydrostatic test data for all burner barrels.
- i. Provide certificates for personnel who have completed the Chelant Basic (A-651-0019) and Chelant Supervisor course (A-651-0016).
- j. Results of soot blower head blowing pressure tests.
- k. All outstanding maintenance actions not covered by OPNAV 4790/2K forms recorded in the ship's Current Ship's Maintenance Project (CSMP).
- l. Results of the last two on-line verifications (OLV's) and last two boiler flex tests.

NOTE

Ship's force shall provide the inspector with a list of known deficiencies and problems not covered in the CSMP.

- 20. Most recent NDE UT results for the soot blower heads, soot blower piping system and the bottom blow piping:
 - a. Soot Blower Heads (goosenecks - Diamond Power) 5 years, (60M)
 - b. Soot Blower Heads (Copes Vulcan) 10 years, (120M)
 - c. Soot Blower Piping not to exceed 60 months
 - d. Boiler (Carbon Steel) Surface and Bottom Blow Piping 5 to 6 years should be scheduled to coincide with the 5 Year Strength and Integrity Inspection.
 - e. Monel Surface and Bottom Blow Piping system 10 years (120M)

NOTE

The piping wall thickness replacement criteria for boiler bottom blow piping is in NSTM Chapter 505 - Piping (NAVSEA S9086-RK-STM-010/CH-505). The minimum boiler bottom blow piping wall thickness criteria for pressurization, and the soot blower and high pressure steam drain piping replacement criteria are also in NSTM Chapter 505 Piping.

NOTE

Any incomplete UT inspection reports or reports with rejectable readings are RBO items.

- 21. Ensure control air is available for the following cold checks:
 - a. Testing of the airlocks for the EABC system.
 - b. Testing of the airlocks for the auxiliary steam reducers.
 - c. Stroking of the auxiliary diaphragm control valves.

When the designated SGPI (SGPI assigned to perform the routine inspection) is not on-site, contact the local Steam Generating Plant Inspector's (SGPI) office for assistance.

221-2.1.2.4 **Unscheduled Inspection.** Boiler watersides and steamsides shall be inspected:

- a. Prior to further steaming if, as a result of a serious contamination incident, boiler water conductivity is greater than 8,000 micromhos/cm.
- b. According to other Naval Sea Systems Command (NAVSEA) program requirements.
- c. If steaming without continuous treatment system due to treatment malfunction or lack of EDTA for more than 168 steaming hours has occurred, then the boiler watersides shall be inspected during the next upkeep or repair period.
- d. If steaming with boiler water conditions that meet the criteria for significant damage, then the boiler watersides shall be inspected during the next upkeep or repair period.
- e. If boiler water conductivity exceeds 2000 micromhos/cm superheater steamsides shall be flushed and inspected prior to further operation.
- f. Whenever the Engineer Officer considers an inspection necessary..

221-2.1.2.5 **Strength and Integrity Inspection.** Strength and Integrity Inspection. The boiler shall be visually inspected periodically from the outside and inside (as accessible) for integrity of welds and nozzle connections. The inspection should be scheduled to coincide with Chief of Naval Operations (CNO) scheduled depot level overhaul/availabilities. To provide scheduling flexibility, the boiler strength and integrity inspection may be performed as early as 48 months or as late as 72 months after the last strength and integrity inspection. Every effort shall be made to conduct this inspection within 60 months of completion of the previous strength and integrity inspection; in no case shall this interval exceed 72 months. This inspection is conducted by a Carderock Division, Naval Surface Warfare Center (NSWCCD-SSES) inspector accompanied by the cognizant Naval Shipyard and the Regional Maintenance Center (RMC) (SGPI). The initial light-off date of boiler, following the Strength and Integrity Inspection, shall be entered as the Last Strength and Integrity Inspection Visual Inspection in the BIRMIS steaming hour review data.

221-2.1.2.6 **Boiler Overhaul Related Inspections.** These include Pre-overhaul Test and Inspection (POT&I), Pre-start of Overhaul/Availability (PSOI/PSAI), Start of Overhaul/Availability Inspection (SOI/SAI), Industrial Support Visit (ISV), and Completion of Overhaul/Availability Inspection (COI/CAI). These fireside and waterside inspections are conducted by the Carderock Division of the Naval Surface Warfare Center (NSWCCD-SSES) personnel (Code 922) with other cognizant activities whenever boiler overhauls are planned or performed, whether boiler overhaul coincide with ship overhauls or not. These inspections shall be documented in BIRMIS.

221-2.1.2.7 **Board of Inspection and Survey.** Fireside and waterside inspections are conducted by the Board of Inspection and Survey (INSURV). Schedules for these inspections are set by INSURV.

221-2.1.2.8 **Boiler Maintenance Inspection.**

- a. A Boiler Inspection by a Steam Generating Plant Inspector (SGPI) or NSWCCD Inspector is required whenever major boiler work is accomplished. Major boiler work is defined as any welding or grinding on the pressure vessel including piping, repairs to safety systems, boiler tube renewal, sliding foot repair, or refractory renewal. If no other boiler inspection is scheduled, this will be conducted as a special inspection. This ensures that all required boiler work is completely identified, documented, the work is accomplished correctly and the boiler is safe to light off and steam.

- b. If major boiler work needs to be accomplished when deployed and a SGPI is not readily available, contact your RMC SGPI via distance support. The SGPI will determine if work can be authorized via distance support.
- c. During the special inspection, the SGPI will complete a special BIRMIS report including the tube renewal diagram if tube plugging or replacement has been accomplished and provide to NSWCCD for upload to the BIRMIS system. Ship's force is required to update their properly marked tube renewal diagram as described in [paragraph 221-2.9.5](#).
- d. Whenever a furnace or watersides is opened for corrective maintenance, a Special Inspection by a SGPI is recommended. The SGPI will provide guidance for the maintenance.

221-2.1.2.9 Pre-inspection Operational Tests. The main propulsion boiler pre-inspection operational test should be accomplished whenever the ships operating schedule permits. The test consists of a checklist of items known as the Operational Test Check Sheet for Main Propulsion Boilers. The check sheet is provided in the Boiler Inspection Manual, NAVSEA S9221-D2-MMA-010.

221-2.1.3 REPORTING INSPECTION RESULTS. All unusual cases of damage or deterioration discovered at any time shall be reported to the Type Commander (TYCOM), stating in detail the extent of damage sustained, remedies applied, and, as far as can be determined, the causes. If considered of sufficient importance, or if technical assistance of the Naval Sea Systems Command (NAVSEA) is desired, a copy of the correspondence shall be forwarded to NAVSEA and NSWCCD-SSES. Inspectors are to refer to the Boiler Inspection Manual for general guidance. These cases shall also be documented in BIRMIS. Information on tube failure reporting is contained in [paragraph 221-2.8.10](#).

221-2.1.4 PRECAUTIONS AND CONTROL OF BOILER WATER. The methods and precautions used to obtain pure feedwater and the procedures used to control the water in the boilers are contained in NSTM Chapter 220, Volume 2, and shall be carefully followed. If inspection indicates that excessive deposits are present, they shall be removed at the first available opportunity. Boilers with adherent deposits on waterside surfaces are subject to tube overheating and serious damage. Significant quantities of grease, oil, or other foreign matter in suspension in the water tend to produce foaming and may reduce evaporative efficiency. In such circumstances it is particularly important that boilers not be steamed at high firing rates, except in an emergency. In the case of reactivated ships, sludge originating from preservatives in the system (sometimes not entirely removed before placing the ship in service) may collect in the boilers. Particular care shall be taken to detect and remove such deposits.

221-2.1.5 BOILER ROTATION. Boiler operation shall be rotated so that the total number of steaming hours on each boiler since commissioning is the same within 2,000 hours. Use may be staggered, however, to avoid cleaning all boilers at the same time.

221-2.2 CARE OF IDLE BOILERS.

221-2.2.1 IDLE BOILERS NOT TO BE USED FOR TRIMMING SHIP. Idle boilers shall not be used for trimming the ship, or as reservoirs for storing any water other than that intended for steaming purposes. They may be run down or emptied when necessary for examination, cleaning, dry lay-up, overhauling, or removing contaminated water.

221-2.2.2 IDLE BOILER FIRESIDE CLOSURE. To inhibit corrosion as much as possible, care shall be taken to prevent the entry of water or moisture into the uptakes and firesides of idle boilers. After rain, fog, snow, or a period of excessive atmospheric humidity during which the firesides of idle boilers may have become damp, boilers shall be promptly inspected and, if necessary, dried out. Fireside deposits will become chemically active if moistened. This phenomenon can cause rapid deterioration of tube metal and may lead to failure if not arrested. Precautions include completely draining the boiler before opening handholes, using stack covers for secured boilers in port, and using proper boiler lay-up procedures. The furnace and burner air registers of all idle boilers shall be kept closed except for occasional opening and closing of the register air doors to ensure that they are in proper operating condition and ready for use.

221-2.2.3 IDLE BOILER FREEZING PREVENTION. Care shall be taken during cold weather to prevent freezing damage to any parts of boilers or fittings containing water. For dry lay-ups ensure that the economizer, drain piping, blowdown piping, and the like are free of water. For added protection the temperature of compartments containing such parts shall be kept above 5° C (40° F).

221-2.2.4 BOILER ENTRY PRECAUTIONS. To reduce the possibility of boiler damage and danger to personnel, the following precautions shall be observed whenever a boiler is being drained and opened:

- a. **Outside Guard.** While personnel are working in the boiler interior, a person shall be stationed outside to render assistance in case of an accident.
- b. **Warning Signs.** Warning signs calling attention to the fact that personnel are working in the boiler shall be placed at the top watch station in the fireroom, and the sign shall not be removed until it is determined that work has been completed and personnel are clear of the secured boiler.
- c. **Ventilation.** Before sending personnel into the boiler, allow it to air out thoroughly. Because of the possible presence of flammable or noxious vapors, the gas free engineer shall approve entry into the boiler. Special precautions shall be taken to ensure an adequate supply of fresh air in a dead fireroom if the boilers in that fireroom are connected to the same smoke pipe as steaming boilers in another fireroom.
- d. **Stack Limitations.** Unless a ship is equipped with division plates that provide an individual gas passage to the top of the smoke pipe for each boiler, work involving opening the uptake or furnace doors shall not be done on boilers connected to the same smoke pipe as steaming boilers.
- e. **Electric Lights.** The use of naked lights in an open boiler is prohibited. Portable electric lights may be used, but the use of hand flashlights is preferable. If portable lights are used in a boiler, the electric leads shall be thoroughly insulated, and the portable lighting fixture shall be of the explosion-proof and watertight type (refer to [Appendix A](#)). This type has a substantial glass globe around the light bulb and a guard around the globe. As a safety precaution, electrical equipment and portable receptacles used to supply power for work within a boiler shall be tested according to NSTM Chapter 300, Electric Plant General.

NOTE

When a boiler is to be entered and valves secured and tagged, notice shall be entered in the ship's tag out log according to the ship's tag out procedures.

- f. **Valve Security.** To prevent the accidental admission of steam or water to the boiler, close, tag, and lock (or securely wire) all valves that might permit steam or water flow to the boiler. Remote valve-actuating gear shall be included in this precaution. On steam lines containing two-valve protection, open the 1/2-inch test valve located in a branch between the isolation valves. The isolation and shutoff valves connecting the dead boiler

with live systems shall be secured, blanked if possible, and tagged, indicating that personnel are working in the secured boiler. The tags shall not be removed nor valves opened until it is determined that work has been completed and workers are clear of the secured boiler.

- g. **Leaky Valves.** Steam or hot water may leak to an idle or open boiler through a leaky bottom blow valve connected in line with the blow valves of other boilers. This is also true of stop valves, feed valves, and superheater high-pressure drain valves. Open the superheater bilge drain valves to permit drainage of any water leaking into headers. If pressure is to be applied to any valve on an open boiler, no personnel shall be allowed in the boiler until pressure has been applied to the valve and its tightness has been positively assured. Special precautions are required in checking the tightness of boiler blow and guarding valves of an open boiler that has a common boiler blow connection with a steaming boiler. To ensure the tightness of the valves on the idle (open) boiler, the steaming boiler shall be blown down before personnel are permitted to work on the idle boiler, to check that the valves of the idle boiler are proved closed and tight.
- h. **Drains.** Drain connections to the atmosphere on all dead interconnecting piping shall be opened for visual observation of drainage.
- i. **Steam-Smothering.** Wire and tag in the closed position the valves to the steam-smothering systems while personnel are working in the vicinity and remove wires and tags when the work is finished.

221-2.3 LAY-UP OF IDLE BOILERS.

NOTE

Some ships use a Carbohydrazide treatment system in place of Chelant. Use of Sodium Nitrite has the same effect as Chelant treatment. Therefore use of sodium nitrite prior to placing boiler on hot air or desiccant lay-up is prohibited unless the ship is in an industrial repair period.

221-2.3.1 LAY-UP INFORMATION IN NSTM CHAPTER 220. Refer to Chapter 220 (NAVSEA S9086-GX-STM-020) for all lay-up information except for dry lay-up procedures. The following subjects on lay-up are located in Chapter 220: Lay-up Requirements, Documentation of Lay-up, Selection of Lay-up Method, Comparison of Lay-up Methods, Lay-up Change, Lost Lay-up and the following wet lay-up methods:

- a. Hydrazine with Steam Blanket
- b. Steam Blanket
- c. Nitrogen Blanket
- d. Sodium Nitrite

221-2.3.2 DRY LAY UP METHODS. Dry methods include hot air and desiccant lay-up. Procedures common to both methods are listed in [paragraph 221-2.3.3](#). Specific materials and procedures for hot air and desiccant methods are listed in [paragraphs 221-2.3.3.1](#) and [221-2.3.3.2](#), respectively.

221-2.3.3 PREPARING BOILER FOR DRY LAY-UP. Prepare the boiler for hot air or desiccant lay-up using the following guidance:

NOTE

In ships using chelant treatment, use of sodium nitrite prior to placing boiler on hot air or desiccant lay-up is prohibited unless the ship is in an industrial repair period.

NOTE

Some ships use a Carbohydrazide treatment system in place of Chelant. Use of Sodium Nitrite has the same effect as Chelant treatment. Therefore use of sodium nitrite prior to placing boiler on hot air or desiccant lay-up is prohibited unless the ship is in an industrial repair period.

CAUTION

When sodium nitrite is injected into the boiler the water level shall be closely observed to prevent the boiler water from spilling over into the superheater, thereby chemically contaminating the superheater steamsides with chloride and boiler water treatment chemicals.

1. Draining:

- a. When the boiler pressure drops to 100 psig, add 10 pounds of sodium nitrite (refer to [Appendix A](#)) per 1,000 gallons of boiler water volume (refer to [Table 221-2-1](#)) to the water in the boiler using the DFT when feasible. Fill the boiler with water to the top of the gauge glass. The addition of sodium nitrite is not required following EDTA cleaning (refer to [Appendix C](#)).

CAUTION

Sodium nitrite is an oxidizing agent that may support combustion. Exercise caution in stowing and using this chemical. For storage and handling precautions refer to NSTM Chapter 670. Sodium nitrite is chemically incompatible with hydrazine. Store these chemicals separately. Do not mix sodium nitrite and hydrazine solutions.

- b. As soon as the boiler pressure has dropped to zero psig, empty the boiler. By emptying the boiler when the metal is warm, better dry out is ensured.
- c. Never attempt to empty a boiler overboard through the bottom blow sea valve. The boiler shall be emptied by one of the following methods, preference being given in the order stated:
 1. Pump down with a fire and bilge pump or portable pump connected by a steam hose to the hose connection in the bottom blow line. The bottom blow, superheater drain, drum vent, and economizer drain valves shall be open during the pumping.
 2. Flood the bilges with about 12 inches of water. Drain the boiler to the bilges and immediately pump the bilges dry. These precautions are necessary to avoid damage to the protective covering on steel work in the bilges by water containing high percentages of boiler water treatment chemicals.
- d. Dispose of bilge water according to NSTM Chapter 593, and local environmental laws.

WARNING

Whenever personnel are to enter either the firesides or the watersides, precautions shall be taken to protect them from steam, water, and gases. Refer to detailed precautions in [paragraph 221-2.2.4](#).

Table 221-2-1. Cold Total Boiler Water Volume

Volume (gals)	Ships
1,600	EX-FF-1052 Class (Foreign military)
2,200	EX-FF-1038 (Foreign military)
2,500	LPD-7 thru LPD-10, LPD-13, EX-LPD-14 (Foreign military), LPD-15, EX-LSD-38 (Foreign military)
2,900	AS-39, AS-40
3,100	T-AFS-5, T-AFS-7, LCC-19, LCC-20
3,200	T-AE-26, T-AE-32 thru T-AE-35
4,000	CV-63
4,700	CV-67
5,100	LHA-4, LHA-5, LHD-1 thru LHD-7
6,200	LKA-113 thru LKA-117

2. Opening:

- a. Ensure that drains and vents of all drums and headers are open before loosening manhole or handhole plates. Stand clear of all openings when initially opening them after service.

CAUTION**Do not contaminate the boiler with wet or oily compressed air.**

3. Drying:

- a. Blow out headers and accessible horizontal tubes with dry filtered air.
- b. Mop out pockets of water.
- c. Thoroughly inspect to make sure that waterside and steamside surfaces are dry.

221-2.3.3.1 Hot Air Lay-up. The installation shall be inspected each watch for proper operation. Refer to [paragraph 221-2.3.3](#) for boiler preparation procedure.

1. Materials Required.

- a. Electric blower
- b. Electric heater
- c. Boiler adapters
- d. Sodium nitrite

NOTE

In ships using chelant treatment, use of sodium nitrite prior to placing boiler on hot air lay-up is prohibited unless the ship is in an industrial repair period.

NOTE

Some ships use a Carbohydrazide treatment system in place of Chelant. Use of Sodium Nitrite has the same effect as Chelant treatment. Therefore use of sodium nitrite prior to placing boiler on hot air or desiccant lay-up is prohibited unless the ship is in an industrial repair period.

2. Procedure.

- a. Secure all waterside and fireside points of access except for boiler hot air entry and exit points shown on [Table 221-2-2](#). Close the burner air registers.
- b. Circulate heated air through watersides and firesides as long as the boiler is idle. Connections to drums, headers, and furnaces listed in [Table 221-2-2](#) may be completed by using inlet adapters shaped to match the header or furnace opening, with hose connection at center. See [Figure 221-2-3](#) for typical adapters to use with drum manholes, header handholes, furnace access doors, and the portable blower and heater. Flexible duct hose shall be used to connect the heater outlet to the boiler air entry points. A filtering element shall be attached to each blower air inlet to preventive circulation of potentially harmful debris through the boiler watersides and firesides.
- c. Secure as many air casing accesses as possible to reduce drafts resulting in loss of heat.
- d. The equipment and material used for this lay-up shall conform to the following specifications:
 - (1) Electric Blower: centrifugal, direct drive, 440 volts, 3-phase with TEFC motor. For capacity ratings refer to [Table 221-2-3](#).
 - (a) To achieve the desired blower flow characteristics for pressure and cfm, the blower motor shall be rated at or above one horsepower. Avoid blowers with fractional horsepower motors. Verify the proper direction of rotation with each installation.
 - (b) Ensure that the blower air inlet filter does not drastically reduce the airflow through the blower, which would result in damage to the heater through excessive temperatures. If the filter becomes dirty, remove, clean with hot water, and replace it.
 - (2) Electric Heater: 440 volts, 3-phase. For capacity ratings refer to [Table 221-2-3](#). Blowers and heaters are designed for a 17 to 23° C (30 to 40° F) temperature rise from the inlet to the outlet of the heater. Blower and heater controllers shall be spray proof.
 - (3) Flexible Duct Hose: 2-ply, wire reinforced, polyester/neoprene air exhaust hose.
 - (4) Adapters: 1/16-inch thick stainless steel or 1/8-inch thick aluminum.
 - (5) Gaskets for Adapters: fiberglass cloth or Rubatex black rubber.
 - (6) Hose Clamps for Duct Hose: adjustable.
 - (7) Air Inlet Filter: panel type, metallic mesh, dry, cleanable, FED Spec FF-300, type IV or equivalent.
 - (8) Duct Tape.
3. Lost Lay-up. Lay-up is considered lost when the blower or heater fails and cannot be restarted within 24 hours.
4. Time Limit. None.

CAUTION

Sodium nitrite adversely affects water chemistry in a steaming boiler.

5. Preparation for Light-off. Flush by refilling the boiler, economizer, and superheater with feed quality water and dumping. Do not light-off with sodium nitrite in the boiler. Refill the boiler and conduct a hydrostatic test according to [paragraphs 221-2.16 through 221-2.16.6.6](#).
6. Disposal. Dispose of the sodium nitrite solution according to NSTM Chapter 593.

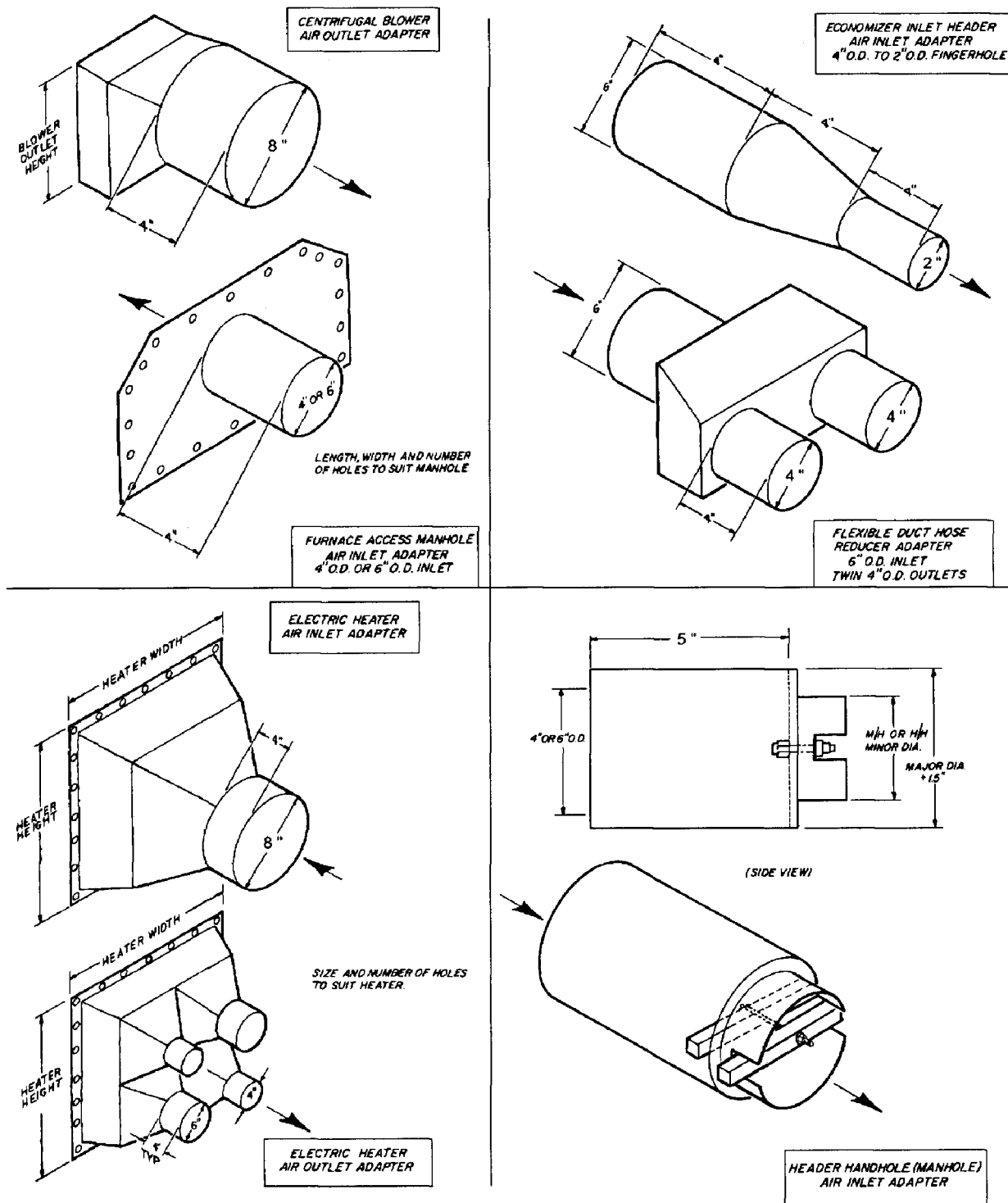


Figure 221-2-1. Hot Air Lay-up Boiler Adapters.

221-2.3.3.2 Desiccant Lay-up. Refer to [paragraph 221-2.3.3](#) for boiler preparation procedure.

1. Materials Required.

- a. Desiccant (refer to [Appendix A](#))
- b. Humidity indicator cards (refer to [Appendix A](#))
- c. Plexiglas manhole covers
- d. Sodium nitrite

NOTE

On ships using chelant boiler water treatment, use of sodium nitrite prior to placing a boiler on desiccant lay-up is prohibited unless the ship is in an industrial repair period.

NOTE

Some ships use a Carbohydrazide treatment system in place of Chelant. Use of Sodium Nitrite has the same effect as Chelant treatment. Therefore use of sodium nitrite prior to placing boiler on hot air or desiccant lay-up is prohibited unless the ship is in an industrial repair period.

e. DC PLUGS

2. Procedure.

- a. Evenly distribute bags of desiccant into all drums and headers, including superheater and economizer headers. Sixteen pounds of desiccant for every 1,000 gallons of cold water capacity (refer to [Table 221-2-1](#)) are required. Record in the boiler water chemistry worksheet/log the number and location of desiccant bags. Place indicator cards in the drums to indicate the boiler air humidity.
- b. Close the handholes. Manholes shall use wood, metal, or Plexiglas covers. Plexiglas covers are recommended so that humidity cards can be observed without opening the boiler.
- c. The Oil King shall inspect the humidity cards daily and log the results in the boiler water chemistry worksheet/log.
- d. When cards indicate that humidity is over 50 percent, replace the desiccant with fresh material.
- e. Before freshly filling, remove all desiccant. Desiccant left in the boiler will adversely affect the boiler water chemistry following light-off or during wet lay-up.

NOTE

During this lay-up, the firesides should also be protected by heated air or heat lamps, if available.

- 3. Lost Lay-up. Lay-up is considered lost when fresh desiccant is not available after humidity cards indicate a humidity of over 50 percent.
- 4. Time Limit. None.

CAUTION

Sodium nitrite adversely affects water chemistry in a steaming boiler.

- 5. Preparation for Light-off. Remove the desiccant and close the boiler. Flush by refilling the boiler, economizer, and superheater with feed quality water and dumping. Do not light-off with sodium nitrite solution in the boiler. Refill the boiler and conduct a hydrostatic test according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#).
- 6. Disposal. Dispose of the sodium nitrite solution according to NSTM Chapter 593.

221-2.4 BOILER OVERHAUL.

221-2.4.1 REQUIREMENTS FOR OVERHAUL. The requirements of paragraphs [paragraphs 221-2.4.2](#) through [221-2.4.9](#) supersede the requirements of other paragraphs of this chapter and shall be adhered to when boiler repair work is being accomplished by depot level activities. These requirements apply to the boiler designated for overhaul for ships in the Phased Maintenance Program. When boiler repairs are accomplished by organizational (ship's force) or Intermediate Maintenance Activities (IMA), these requirements shall be used as a guide and adhered to as much as possible, considering the availability of necessary hardware and feedwater and the capabilities of the activity performing the work.

221-2.4.2 BOILER OVERHAUL PLANNING. Planning for boiler overhaul includes preparations such as initiating procurement of long lead-time materials, defining the work package, and scheduling inspections. When renewal of long lead items such as economizer elements is a consideration, these should be sampled and inspected during an upkeep period approximately 1 year.

Table 221-2-2. Hot Air Lay-Up, Boiler Ar Entry And Exit Points

D-Type Boilers		
	Firesides	Watersides
Inlet points & Size	Furnace Access 6" ID	<ul style="list-style-type: none"> • Sidewall header handhole - 4" ID • Water drum manhole - 6" ID • Economizer inlet header handhole - 4" ID
Outlet points	Covered Stack	<ul style="list-style-type: none"> • Superheater outlet header handhole (last pass) • Water screen header handhole • Superheater outlet header drains • Superheater backfill connection • Economizer outlet header handhole • Lower rearwall header handhole • Lower frontwall header handhole

Table 221-2-3. Hot Air Lay-Up Equipment Ratings

Boiler Waterside Capacity: Gallons	Unit Type	Centrifugal Blower Minimum Capacity	Electric Heater Minimum Rating
1,600-2,000	I	750 CFM at 4" S.P.	10 KW
2,100-2,900	II	1,100 CFM at 4" S.P.	15KW
3,000-4,700	III	1,600 CFM at 4" S.P.	22 KW
4,800-6,200	IV	2,200 CFM at 4" S.P.	30 KW

NOTES:

1. Boiler Waterside Capacity to be determined from [Table 221-2-1](#).
2. In order to achieve desired blower flow characteristics for pressure and CFM, blower motor shall be rated at or above one horsepower. Avoid blowers with fractional horsepower motors. Verify proper direction of rotation with each installation.
3. When choosing blower and heater for lay-up service, the ratio of BLOWER CFM/HEATER KW shall be no greater than 75 in order to achieve the desired temperature increase across the heater.

4. Ensure that the blower air inlet filter does not drastically reduce the air flow through the blower which would result in damage to the heater through excessive temperatures. If the filter becomes dirty, remove, clean with hot water and replace.
5. Inspect installation each watch for proper operation.
6. Blower-heaters designed for 30 to 40° F (17 to 23° C) temperature rise from inlet to outlet of heater.
7. Secure as many air-casing accesses as possible to reduce drafts resulting in loss of heat.

WARNING

Whenever personnel are to enter either the firesides or watersides, precautions shall be taken to protect them from steam, water, and gases. Refer to detailed precautions in [paragraph 221-2.2.4](#).

221-2.4.3 PREPARATION FOR START OF OVERHAUL/AVAILABILITY INSPECTION (SOI/SAI). The following procedures shall be used to prepare the boiler for the SOI/SAI. The preparation procedures discussed in [step 10](#) apply when a Strength and Integrity Inspection has been scheduled in accordance with [paragraph 221-2.1.2.5](#).

1. Conduct outer casing leakage inspection using hand and soap film techniques before overhaul or availability per [paragraph 221-2.13.7](#). Mark all leaks clearly on the casing. Forward the results to NSWCCD-SSES Code 922 for determining the extent of casing removal required.
2. Remove the outer casing flashing and insulation under the flashing per NSWCCD-SSES direction before starting the SOI/SAI (not applicable to Combustion Engineering boilers).
3. When boilers are secured in preparation for SOI/SAI, lay-up according to [paragraph 221-2.3.1](#) (sodium nitrite lay-up).
4. Take movement indicator readings on all sliding feet during the last boiler light-off before the SOI/SAI. Record the results in the engineering log and provide a report of the results to the SOI/SAI inspector. If movement indicators are not installed, verify the sliding foot movement according to [paragraph 221-2.15.2](#).
5. Secure, wire shut, and tag Do Not Open appropriate valves according to current OPNAV tag-out instructions.
6. Mechanically clean stack, rain gutters, and expansion joints. Do not waterwash without NSWCCD-SSES (LCEM Code 922) approval.
7. Remove at least one burner register. Open access doors for firesides, gas sides, airsides, and stack. The inspecting activity shall provide an itemized list.
8. Certify as safe for entry by personnel according to NAVSEA Technical Manual NAVSEA S6470-AA-SAF-010, Gas-Free Engineering Program.
9. Remove the drum and header refractory coping pours.

NOTE

On LHA/LHD Class ships that have header brick coping modifications installed, mark position of cap bricks and then remove the cap bricks and all Fiberfrax material.

10. Unless otherwise directed by the NSWCCD-SSES inspector, all insulation shall be removed from the drums, headers, all external areas of downcomers, soot blowers piping, steam piping from the steam drum outlet to the superheater inlet header, superheater main steam piping from the superheater outlet header to the first valve and to desuperheater inlet, desuperheater outlet steam piping to first valve, economizer outlet piping to steam drum inlet and economizer inlet feedwater piping back to first valve, chemical injection system tank and piping, boiler sample cooler and piping, desuperheater sample cooler and piping, and gage piping to expose weld joints, nozzle connections and external surface conditions in preparation for the Strength and Integrity Inspection. Removal of welded type drybox internals shall be at the discretion of the inspector. Insulation removal shall be done in accordance with the requirements of NSTM Chapter 635, Thermal, Fire, and Acoustic Insulation. Identification, removal and disposition of asbestos shall be done before starting the SOI/SAI.
11. Perform a pre-inspection hydrostatic test at 100 percent maximum steady state operating pressure according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#). The report is to be available for the inspector at the SOI/SAI.
12. Drain the boiler watersides just before opening the boiler for water-jet cleaning.
13. Open steam and water drums; remove and tag all internals. Install temporary covers on the upper ends of downcomers and risers.
14. Remove one screen tube, 2/3 furnace depth for analysis to determine if the boiler requires acid cleaning because of hard waterside deposits. This requirement may be invoked at the discretion of the NSWCCD-SSES inspector. Anomalies in water treatment records, NDE reports or the physical appearance may warrant selective sampling.
15. Refer to [paragraphs 221-2.5.7](#) and [221-2.6.2](#) for a discussion of acid cleaning. In unusual cases where acid cleaning is performed after the SOI/SAI, re-inspect boiler watersides for defects.
16. Water-jet the boiler, including fan jetting drum and header surfaces, with sodium nitrite treated water. On ships using chelant treatment, sodium nitrite treated water is permitted for water jetting. Water jetting following acid cleaning will satisfy this requirement if acid cleaning is performed before SOI/SAI.
17. Upon completion of water-jet cleaning, accomplish the following:
 - a. Dry out the boiler, including the economizer, using the hot air lay-up method per [paragraph 221-2.3.3.1](#).
 - b. Remove all handhole and fingerhole openings except those that have been welded closed.
 - c. Mechanically clean (wire cup brush) all unwelded handhole and manhole seats. Visually inspect the seats for defects.
 - d. Dry out the bilge and boiler air casings beneath the boiler.
 - e. Ensure that suitable temporary covers are installed on all openings for downcomers, risers, feedlines, and blowdown lines that enter drums and headers to prevent tools, parts, and debris from being dropped into them.
18. Wire brush superheater header internal seal welds and the tube sheet in welded tube joint superheaters. For externally welded superheater tubes, wire brush header tube bore openings and the tube sheet.
19. Ensure that the following documents are available at the SOI/SAI.
 - a. Boiler tube renewal sheets
 - b. Most recent boiler inspection report
 - c. Boiler CASREP summaries
 - d. Results of the most recent nondestructive testing (NDE) tube evaluation, such as Boiler Tube Inspection Unit (BTIU) results

- e. Record of the boiler work performed since the last regular overhaul
- f. Record of the boiler work performed during the last regular overhaul (BIRMIS)
- g. Fireroom operating records for the last 6 months
- h. Machinery Plant Water Treatment Log Package for the last 6 months
- i. All outstanding maintenance actions not covered by Ship's Alteration and Repair Package (SARP), such as OPNAV 4790/2K forms recorded in the ship's Current Ship's Maintenance Project (CSMP).

NOTE

The ship's force shall provide the inspector with a list of known deficiencies and problems not covered in the SARP or recorded in the CSMP.

- 20. Removal of permanent casing panels to facilitate the inspection of all downcomer to nozzle welds, desuperheater inlet and outlet nozzle to steam/water drum welds, economizer and superheater inlet and outlet nozzle to header welds will be at the inspector's discretion to support the SOI or SAI inspections.

221-2.4.4 START OF OVERHAUL/AVAILABILITY INSPECTION (SOI/SAI). Conduct the SOI/SAI according to the following guidance:

1. The SOI/SAI and strength and Integrity Inspection is a joint inspection by NSWCCD-SSES, a certified SGPI, the overhauling activity, TYCOM, and ship personnel.
2. Generally, a non-destructive tube evaluation is performed concurrently with the SOI/SAI. This will require additional Naval activity or TYCOM personnel trained in the use of currently authorized boiler tube NDE equipment. Currently authorized equipment includes BTIU, remote visual scopes, RFEC and immersion UT. This equipment is further described in [paragraph 221-2.9.3](#). Equipment lists, operating procedures, and the procedure to determine the need for tube renewal in main propulsion boilers can be found in the Boiler Inspection Manual. Other equipment may only be used when authorized by NAVSEA and NSWCCD-SSES.
3. The need for non-destructive evaluation of tubes shall be determined by the NSWCCD-SSES inspector based on review of the [paragraph 221-2.4.3, step 19](#) documents and visual inspection of the tube conditions. This effort will be coordinated with the respective TYCOM boiler inspector.
4. On the basis of observed conditions and results of the NDE evaluation, sample tubes for destructive evaluation may be required and will be identified by the NSWCCD-SSES inspector.
5. If considered necessary by the inspector an NDE (MT or PT) shall be done of welds identified during a Strength and Integrity Inspection.
6. An NDE (UT) shall be conducted on pressure vessel piping to include all vents, drains and sensing piping to first valve. Special NDE requirements for the bottom blow, soot blower and chemical injection system are shown in NAVSEA S9221-D2-MMA-010 Appendix D. This NDE work is performed as a result of a PMS scheduling aid on the main boiler MIP. Should visual and/or NDE indicate questionable areas, repairs shall be accomplished in accordance with NAVSEA S9221-C1-GTP-010 for drums, headers, and nozzles and in accordance with NAVSEA S9086-RK-STM-010/ Chapter 505 for piping systems. All indications and repairs must be NDE cleared in accordance with [paragraphs 221-2.11.1](#) and [221-2.12.5](#). For welds inaccessible from the inside, use remote visual inspection methods described in [paragraph 221-2.9.3](#). A final hydrostatic test of the repair must be applied according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#).

221-2.4.5 SHIP'S FORCE RESPONSIBILITIES DURING OVERHAUL. The ship's force shall document the status of boiler lay-up in the boiler water chemistry worksheet/log daily. The cold iron watch shall monitor and log the results of the lay-up inspections in the cold iron log according to the requirements in [paragraph 221-2.3.1](#). Additionally, the following requirements apply:

1. Boilers not under lay-up because of continuing repair work shall be inspected daily to ensure compliance with [paragraphs 221-2.4.6](#) through [221-2.4.6.3](#).
2. The cold iron watch shall notify the duty engineer immediately if there are any problems with the lay-up. The ship is responsible for bringing unsatisfactory conditions to the attention of the Naval Shipyard or RMC representatives. Advise the TYCOM and NSWCCD-SSES when unsatisfactory conditions cannot be resolved between the ship and the industrial activity.
3. The Engineer Officer shall certify that water/steam sides are free of obstructions before final close-up and light-off.

221-2.4.6 BOILER CORROSION AND CONTAMINATION CONTROL DURING OVERHAUL. Boiler work should be scheduled so periods of ineffective waterside lay-up are concentrated rather than spread out over the duration of the overhaul. By minimizing the time a boiler is under repair and consolidating the periods of ineffective lay-up, the corrosion of boiler watersides and firesides will be reduced.

221-2.4.6.1 Preparation for Initiating Boiler Work. Prepare and paint firesides of drums, headers, and tube ends, which are normally covered with refractory, with heat-resistant, aluminized paint (refer to [Appendix A](#)) as soon as practicable after inspection.

221-2.4.6.2 Maintaining a Protective Environment. During most of the overhaul period, conventional boiler lay-up according to [paragraphs 221-2.3.1](#) through [221-2.3.3.2](#) will be impractical because boiler watersides and airsides are not intact. To ensure that boilers are adequately protected from corrosion under these adverse conditions, the industrial activity tasked with a boiler overhaul shall be responsible for maintaining a protective environment for the boilers as follows:

1. Remove any freestanding water from boiler watersides and firesides within one work shift of completing the process that caused the water to accumulate.
2. Prevent water from dripping onto any part of the boiler from any source unrelated to boiler work.
3. Remove industrial debris from watersides and firesides within 24 hours after completing the work that caused it.
4. Install temporary closures over tube holes, nozzle openings, handholes, and the like whenever practical, to prevent entry of industrial debris.
5. Maintain dry bilges around and beneath the boilers and minimize water accumulations anywhere else in the space.
6. During non-work periods apply heat, using hot air blowers (preferred) or heat lamps, where condensation occurs. Heat should also be applied where condensation occurs during work periods to the extent practical considering personnel comfort.
7. Keep the stacks covered with conventional stack covers or elevated rain guards.
8. If boiler work is stopped for more than 72 hours, restore waterside and airside integrity to the greatest extent

practical by using temporary closures, and apply hot air lay-up per [paragraph 221-2.3.3.1](#). For work stoppages of less than 72 hours, applying heated air is also desirable.

221-2.4.6.3 Temporary Closures. The following considerations apply to using temporary closures for preventing the entry of industrial debris and for restoring boiler integrity for the purpose of circulating heated air:

1. Durable covers of wood, metal, or plastic shall be used on all manhole openings and in open ends of downcomers, risers, support tubes, and blowdown connections that are susceptible to the accumulation of dirt and debris.
2. Open tube holes and handholes on such apparatus as headers and water drums, which are subject to abrasion from walking or the movement of tools and material, shall be covered by durable material such as wood, metal, or plastic. Tube and handhole openings that are more protected, such as on steam drums and upper headers, may be sealed by less durable means, such as tape.
3. Wood, canvas or plastic may be used to cover openings in boiler airtides to minimize air circulation. Any other material suitable to prevent the free movement of air through the openings can be used.
4. All temporary closures shall be firmly fixed in place and sufficiently sealed to prevent free movement of air through the openings. Heavy reinforced tape is normally suitable for this purpose.
5. Temporary covers or plugs shall be installed on all steam plant system piping disconnected from the boiler and opened for work, except during the time that the opening shall actually be uncovered to perform the work. Plugs shall be designed to prevent dirt and debris from entering the steam plant. Plugs and covers shall be of rubber, metal, wood, or rigid plastic and shall be securely fastened to the pipe, component, or tank. Use of other materials for covering or plugging openings, such as rags or tape, is prohibited. Tape may be used to secure a plug or cover in place or to seal around the edges of a plug or cover.

221-2.4.7 INDUSTRIAL SUPPORT VISITS (ISV). An ISV may be required when extensive pressure part repairs are required. The requirement for this inspection and an approximate time will be determined at the SOI/SAI.

221-2.4.8 COMPLETION OF OVERHAUL/AVAILABILITY INSPECTION (COI/CAI). The intent of the boiler COI/CAI is to ensure that all work authorized at the SOI/SAI has been satisfactorily completed. This is a joint inspection by NSWCCD-SSES, a certified SGPI, the repair activity, and TYCOM personnel. The COI/CAI should be performed when approximately 90 percent of all boiler work has been completed.

221-2.4.8.1 COI/CAI Requirements. Specific inspection requirements are:

1. Before scheduling the COI/CAI, work should be complete on watersides, steamsides, casings, refractory, permanent drum and header insulation, supports and foundations, uptakes, pressure vessel piping, safety valves, direct water level gauges, drum internals (not installed), soot blowers (in shop or installed), burners (in shop or installed), and all hydrostatic tests above 100 percent as required by repairs.
2. The above items should be ready for inspection. Areas that have been inspected and accepted during ISVs, however, need not be reopened.
3. Work should also be complete on oil burners (including final settings) in addition to the areas above.
4. Work may still be in progress on painting, castable refractory copings over headers, smoke indicators, gauges, igniters, and flame scanners.

5. Boilers to be inspected should be cleaned to remove industrial debris and water-jetted before the inspection. If required by the presence of new tube preservative, boiling out of the boilers should also be completed. Water-jetting may not be required for boilers with small repair packages. This should be determined at the conclusion of the SOI/SAI.
6. COI/CAI shall be limited to a single visit. The determination that a multiple visit COI/CAI is required shall be made at the SOI/SAI.
7. Steam and water drum internals shall not be installed before inspection.
8. The repair activity shall formally schedule the COI/CAI, noting any areas or items not ready for inspection.

221-2.4.8.2 COI/CAI Prerequisites. In preparation for the inspection, the following prerequisites should be met:

1. Prepare the boiler according to [paragraph 221-2.2.4](#).
2. Open sufficient access panels or doors for inspection of repairs accomplished on firesides, gassides, airsides, and stack. Areas previously inspected need not be reopened.
3. Secure boiler lay-up. Open steam and water drums.
4. Sufficient handhole plates shall be removed to allow for inspection of header repairs and handhole seat repairs, and to inspect for industrial debris. Remove additional handhole plates as requested by the inspector.
5. Ensure that following documents are available at the COI/CAI:
 - a. Tube renewal sheets reflecting tube work performed during repair
 - b. Complete record of additional boiler repair work accomplished in addition to that identified at SOI/SAI.

221-2.4.9 HYDROSTATIC TESTING DURING OVERHAUL. Boiler hydrostatic tests shall be conducted according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#).

221-2.4.10 PREPARATION FOR INITIAL BOILER LIGHT-OFF. Accomplish the following in preparation for boiler light-off:

1. After the successful final hydrostatic test, Hydrazine lay-up should be applied to ensure a smooth transition from lay-up to light-off. When conducting final hydrostatic test on ships using chelant or Carbohydrazide treatment, do not add sodium nitrite to the hydrostatic test water. Sodium nitrite is chemically incompatible with hydrazine or Carbohydrazide. Following a satisfactory hydrostatic test, the hydrostatic test water should be dumped. The boiler should be flushed if residual sodium nitrite is present.
2. Flush the feed and condensate systems per NSTM Chapter 505, Piping Systems. This requirement applies to overhauls only. For ships in the Phased Maintenance Program, flush the feed and condensate systems only when maintenance or repair has been performed on these systems.
3. Sample the boiler water and all feed tanks for silica IAW NSTM Chapter 220 Vol 2 Para 22.89.
4. Ensure that each DFT is operational by using shore or ship steam to test for dissolved oxygen only, while recirculating the DFT through the DFT warm-up line. Ship steam shall be used for the test if it is available from another plant where the DFT is operational. This test shall be considered satisfactory when the dissolved oxygen level meets the requirements of NSTM Chapter 220 Vol 2.
5. Shore steam meeting the requirements of NSTM Chapter 220, Volume 2, need not be used for this test, providing the DFT is dumped, filled, and flushed with feed quality water following completion of DFT testing.

6. Preparations for initial boiler light-off at the conclusion of the overhaul shall include proper injection of water treatment chemicals per NSTM Chapter 220, Volume 2.

NOTE

The requirements of NSTM Chapter 220, Volume 2, apply to boilers being steamed during overhaul.

221-2.4.11 **BOILER LAY-UP FOLLOWING LIGHT-OFF.** Boiler lay-up after light-off and before completion of the overhaul or availability shall be according to [paragraph 221-2.3.1](#).

221-2.4.12 **DOCK AND SEA TRIALS.** Particular attention shall be paid to boiler water treatment levels during dock and sea trials. Additional tests of water chemistry and increased bottom blowdown frequency shall be planned. The requirements of NSTM Chapter 220, Volume 2, shall be strictly adhered to during any steaming period. Close coordination between light-off crews and oil lab personnel is essential. A schedule of equipment tests should be available so that all personnel are prepared for the evolutions.

221-2.5 WATERSIDE/STEAMSIDE MAINTENANCE.

WARNING

When ever personnel are to enter either the Firesides or the watersides precautions shall be taken to protect them from steam, water, and gases. Refer to detailed precautions in [paragraph 221-2.2.4](#).

221-2.5.1 **IMPORTANCE OF WATERSIDE CLEANLINESS.** It is of the utmost importance that the Engineer Officer ensures that the watersides of boilers are maintained free from scale, oil, or accumulations of sediment. Failure to do so may result in tube failures.

221-2.5.2 **BOILER WATER TREATMENT.** Boilers that are operated at normal water level and with boiler water conditions according to NSTM Chapter 220, Volume 2, will provide continued operation without excessive corrosion, deposit buildup, or failure.

221-2.5.3 **INSPECTION FREQUENCY.** Boiler watersides and steamsides shall be inspected according to [paragraph 221-2.1.2](#).

221-2.5.4 **PREPARATION FOR INSPECTION.** For the 18 month inspection, mechanically clean (wire brush) or water-jet the waterside surfaces to be inspected. Mechanical cleaning or water-jet is not necessary if inspection reveals that watersides are clean. An arbitrary EDTA cleaning, without first determining condition via an inspection, is not advisable. Follow the requirements of the Boiler Inspection Manual. For SOI/SAI, refer to [paragraph 221-2.4.3](#). For all other inspections follow these procedures:

1. Review boiler water treatment logs for indications of corrosive or deposit forming conditions.

2. Open drums and headers. Remove a sufficient number of steam drum internals to allow inspection of tubes in each generating circuit. At least one handhole plate shall be opened on each pass of the superheater.

NOTE

Internal fittings that are removed, especially cyclone steam separators and plates, are to be carefully marked and identified for their position in the steam drum to ensure proper reinstallation. Extreme care shall be used to ensure that cyclone steam separators and plates are tight and securely fastened after reinstallation.

3. If significant damage has occurred (as defined in NSTM Chapter 220, Volume 2), all boiler, waterwall, economizer, and superheater tubes and headers shall be inspected.
4. Completely dry out the boiler before inspection.
5. Remove debris using an industrial type vacuum cleaner.

221-2.5.5 WATERSIDE INSPECTION PROCEDURES. For inspection procedures for the 18-month Routine inspection, refer to [paragraph 221-2.1.2.3](#). For all other inspections follow the procedures given below. For SOI/SAI, refer also to [paragraph 221-2.4.4](#). Refer to the Boiler Inspection Manual for a detailed discussion of boiler inspection criteria.

1. Visually inspect all accessible parts of the boiler for the presence of cracks, corrosion, and deposits. Probe accessible pits and tube ends with a sharp tool to remove corrosion and deposits completely. For inaccessible parts of the boiler or suspect areas, make maximum use of available non-destructive evaluation methods described in [paragraph 221-2.9.3](#).
2. If hard deposits are found or suspected, remove one tube for splitting, crimping, and deposit analysis.
3. If boiler water carry-over has been found, determine the cause of the carryover and correct. Flush the superheater according to [paragraph 221-2.6.7](#).
4. If oil contamination is suspected, refer to [paragraphs 221-2.6.8 through 221-2.6.8.2](#).
5. Record the results of the inspection in detail in the engineering log and the boiler water chemistry worksheet/log.
6. Waterwash drums and headers with 1-1/2 inch hose and nozzle normally used with fresh or feedwater immediately prior to hydrostatic testing or placing the boiler on an appropriate lay-up. The boiler should be dried out prior to placing on a dry lay-up.

221-2.5.6 REMOVING TUBES FOR INSPECTION. In cases where a tube is removed for any reason, take the opportunity to split it and examine the waterside carefully. Once it has been definitely determined that scale and corrosion are within allowable limits, the removal of tubes from the boiler thereafter should be limited. Tube removal and retention shall be as required in this chapter.

NOTE

All cases of tube removal shall be documented on the boiler tube renewal diagram and in BIRMIS, as described in [paragraph 221-2.9.5](#).

- a. Tube samples should be removed following the procedure given in the Main Boiler Repair and Overhaul Manual. The removed tube should be cut into convenient lengths and split carefully so the waterside can be examined. In this way an exact determination of pitting and general corrosion can be made. Consideration for tube sampling should be given to the oldest tube, one possessing the most distortion or unsatisfactory external condition, or one that is most accessible without unnecessarily wasting good tubes. When tubes are removed and split for examination, a portion of the split tube shall be wire brushed to remove soft deposits and placed in a vise and squeezed to crack loose any hard deposits that may be present.
- b. When generating bank tubes are sampled they shall be cut through about 8 or 10 inches above the water drum, with the corroded section adjacent to the drum kept intact; the lower section of each tube shall then be removed in a manner that will not damage the corroded portion. If the section is straight or nearly straight it may be removed by backing it into the water drum; if curved, the end should be crimped in on the inside of the drum and the section removed from the outside of the drum.

221-2.5.7 INTERPRETATION OF RESULTS. If soft deposits are found, the boiler shall be cleaned using the method deemed appropriate by the Engineer Officer. If hard deposits are found, use [Figure 221-2-2](#) to determine if acid cleaning should be recommended or steaming restrictions should be imposed. Forward deposit analysis data, including thickness and composition, to NSWCCD-SSES (Code 922/Phila. site) for interpretation, and approval before acid cleaning.

221-2.6 BOILER WATERSIDE CLEANING METHODS.

221-2.6.1 Boiler cleaning shall be accomplished only by one of the methods described in the following paragraphs.

221-2.6.2 HARD DEPOSIT REMOVAL. If acid cleaning is authorized perform it according to the Main Boiler Repair and Overhaul Manual and applicable military standards. Refer to discussions and photographs in the Boiler Inspection Manual for assistance in interpreting results. When hydrochloric acid (HCL) cleaning is authorized, the cleaning procedure shall be according to MIL-STD-796, except the HCL acid concentration to be used shall be 5 percent.

NOTE

Acid cleaning results in corrosion of all internal boiler parts and can cause severe post cleaning chemistry control problems. For these reasons acid cleaning should be accomplished only when it is necessary to avoid tube failure from deposit buildup or active oxygen attack.

221-2.6.3 SOFT DEPOSIT REMOVAL. The following cleaning methods are authorized for removing soft waterside deposits:

- a. High-pressure water-jet
- b. Ethylene-diamine-tetraacetate (EDTA)
- c. Power-driven wire-brush.

NOTE

Before starting waterjet or wire brush cleaning, plug all drain and blowdown nozzles in drums and headers with tapered wooden plugs to prevent debris from entering lines and causing subsequent damage to drain and blowdown valves. Refer to [paragraph 221-2.16.3.1](#) for flushing guidance following cleaning.

221-2.6.4 HIGH PRESSURE WATERJET CLEANING. Boiler waterside cleaning may be accomplished by water-jet cleaning to remove all soft deposits. The high pressure water-jet boiler cleaning system consists of a diesel powered, hydraulic, high pressure pump to develop a high velocity, high pressure water-jet for removing soft deposits from tube watersides and drum internals. This method is not normally used to clean boiler superheaters. Approval shall be requested from NSWCCD-SSES LCM, however, if unusual conditions indicate the need for such action. Only personnel qualified as outlined in NTP-S-30-7602 or personnel successfully completing the applicable courses conducted by NSWCCD-SSES C922 are to utilize and apply the water-jet cleaning method. All safety precautions relative to the water pump, flexible hoses, and other components operating at high pressures shall be observed. Clean potable water shall be used for water-jet cleaning. Sodium nitrite is added during water-jetting to prevent rusting of clean waterside surfaces. If civilian contractors are used, they first shall satisfactorily demonstrate their ability to properly use their equipment, demonstrate their use of equipment of the correct size for a particular boiler, and provide proper safety measures in all areas of the ship where their equipment and personnel are employed. Refer to S6300-AE-MMA-010, WATER JET, MODEL WBD-150N; OPERATION MAINTENANCE, REPAIR AND OVERHAUL PROCEDURES.

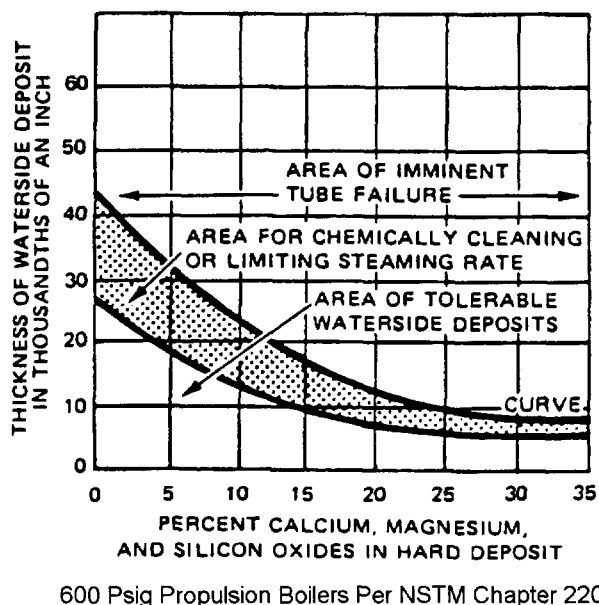
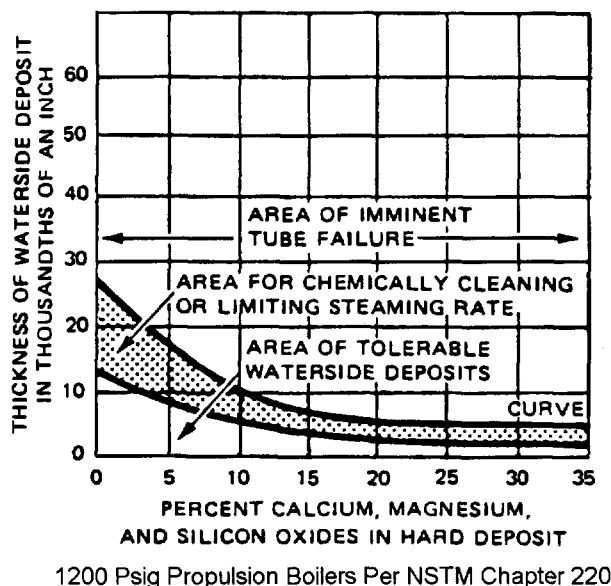


Figure 221-2-2. Guideline for Acid Cleaning Boilers or Reducing Steaming Rate.

221-2.6.5 EDTA CLEANING. EDTA cleaning is a method for removing soft waterside deposits. Excessively dirty boilers will not be completely cleaned by this method because the chemical will become exhausted before all the deposits are removed. Whether the boiler watersides have been adequately cleaned is determined by the inspection after cleaning. Re-cleaning may be required. Water-jet cleaning is preferred for ships that have problems with chemical hideout, since EDTA cleaning tends to aggravate the hideout conditions. Refer to [Appendix C](#) for detailed procedures for EDTA cleaning.

221-2.6.6 POWER DRIVEN WIREBRUSH CLEANING. The only power driven wirebrush cleaning outfit authorized for cleaning boilers is the pneumatic turbine driven cleaner consisting of an air motor, an air hose, flexible brush holder, and an expanding type wire bristle brush. This outfit is furnished for use in boilers having tubes up to 4 inches in outside diameter. Refer to the ship's COSAL under "Tube and Flue Cleaners" as well as the boiler technical manual for specifics on this equipment.

WARNING

A respirator is required during wirebrush cleaning operations to protect personnel from dust inhalation.

221-2.6.6.1 Operation of Power-Driven Tube Cleaners. Gauge the length of each size tube by inserting the cleaner, with the power off, into the tube and attach a rag or other marker to the hose at a point where the end of the brush is even with the opposite end of the tube and does not project outside. Do not use a larger size brush than prescribed for cleaning individual tubes. Start cleaning by inserting the brush into the end of the tube. Rotate and pass it slowly along until the marker indicates the entire length of the tube has been traversed. Immediately reverse the motion through the tube, withdrawing the cleaner to the inlet end. Make as many passes as necessary to clean the tube thoroughly. If the tube cleaner binds inside the tube do not try to force it through; instead, remove it and determine the cause. Ensure that the motion of the cleaner along the tube length is not stopped at any point, since the revolving brush or cleaner will probably damage the tube if allowed to operate at one point even for a short time. Steady the brush assembly with the hands to prevent whipping and consequent breaking of parts. Ensure that the brush does not protrude through the tube at the end of the pass, since doing so will probably result in damage. Inspect the ends of the tubes remote from the operator after completion of cleaning. If the expanded portion of the tubes were not satisfactorily cleaned (soft deposits removed), further tube cleaning shall be accomplished from the remote ends. This is commonly referred to as short punching.

221-2.6.6.2 Lubrication of Power-Driven Tube Cleaners. Automatic lubrication devices shall not be used with the air motors. For this type of motor, a lubricant shall be prepared by mixing one part light hydraulic oil (MIL-PRF-17672/MS 2110TH) with three parts kerosene. This mixture should be injected through a squirt can into the air motor through the exhaust ports. The cleaner should then be held outside the boiler drum manhole and operated until all signs of the atomized lubricant have disappeared from the exhaust stream. Use the cleaner until the need for re-lubricating is indicated by its reduced speed. Lubrication is required after about every 10 minutes of operation. Exercise care to ensure that the lubricant is not deposited within the boiler tubes or drums.

221-2.6.6.3 Types of Brushes for Tube Cleaning. Expanding type wire bristle brushes are used with pneumatic power driven outfits. When worn beyond efficient use, the body should be retained and a new refill of steel wire brush cartridges installed. Hand push sectional wire brushes are used in fire tube auxiliary boilers.

221-2.6.6.4 Accountability for Gear. After the tube cleaning operation, all tube cleaning gear should be surveyed. If any tube cleaning components are missing, the Engineer Officer shall ensure that a tube search is conducted.

221-2.6.6.5 Storage of Gear. Because of the close tolerances used with the tube cleaning equipment, the gear should be thoroughly cleaned and properly stored after use.

221-2.6.7 SUPERHEATER FLUSH. Excessive moisture carryover of boiler water with the saturated steam can result in harmful deposits on superheater steamside. These deposits shall be removed in order to prevent damage to superheater materials. When boiler water conductivity exceeds 2,000 micromhos/cm, it is assumed deposits harmful to steamside have carried over to the superheater. Refer to NSTM Chapter 220, Volume 2, for other indications of carryover. The amount of solids deposited on superheater steamside will increase with increasing conductivity. While there is a tendency for the deposits to prevail in the first pass of the superheater, this does not always happen. Deposits are not always discernable by visual inspection. Therefore, whenever carryover is known to have occurred, the flush procedure shall be accomplished before further boiler operation. The number and location of rundown/ backfill connections on a boiler may vary. Most ships have a backfill connection on the superheater outlet; some may have a rundown connection on the outlet of the desuperheater; others may have a hose connection on the saturated steam line between the steam drum and the superheater; and still others may have a hose connection on the superheater inlet. Whatever the particular configuration, the hose connection that will provide a displacement of water through the superheater should be used. On ships without hose connections, a suitable flange connection should be located and used. Where a hose connection exists on the desuperheater outlet and the stop-check valve in the line from the superheater to the desuperheater can be bypassed, use of the

desuperheater outlet hose connection is preferred for flushing the superheater. The procedure below introduces hot feedwater from the Deaerating Feed Tank (DFT) through the superheater into the steam drum, allowing for a 1 hour soak to dissolve any remaining deposits. For high conductivity not due to chlorides, one complete soak should be adequate.

1. Drain boiler including superheater.
2. Flush by backfilling boiler through the appropriate hose connection with hot 65° C to 93° C (150° F to 200° F) feedwater from the DFT. Use water that has been chemically tested for chloride per NSTM Chapter 220, Volume 2, and containing 0.02 EPM chloride maximum.
3. After boiler has been filled, as shown by an overflow from each vent, carefully chemically test a cooled superheater inlet drain sample for chloride.
4. Allow boiler to remain filled for 1 hour and retest superheater for chloride. If this chloride result agrees with initial superheater results within 0.01 EPM, flushing operations are complete.
5. If the second result, is 0.02 EPM higher than initial result, then flushing shall be continued by repeating [steps 1 through 4](#) above.
6. After flushing is completed, drain boiler and superheater.

221-2.6.8 OIL CONTAMINATION INSPECTION. When the boiler is being inspected for oil contamination, examinations of the steam drum while it is still partially filled and of the other parts of the boiler while they are still wet will give the best indication of the extent and degree of oil contamination. Water samples from the economizer headers (obtained by removing handhole plates) and from the partially filled steam drum (taken through the manhole) will be useful in determining the type of contaminant and the degree of contamination. No oil film observed on the water samples is an indication that either the contaminated feed has not reached these parts or the contamination has stopped and the contaminant has been either deposited or removed by distillation.

221-2.6.8.1 Inspection Procedures. When the boiler is being inspected for oil contamination, examinations of the steam drum while it is still partially filled and of the other parts of the boiler while they are still wet will give the best indication of the extent and degree of oil contamination. Water samples from the economizer headers (obtained by removing handhole plates) and from the partially filled steam drum (taken through the manhole) will be useful in determining the type of contaminant and the degree of contamination. No oil film observed on the water samples is an indication that either the contaminated feed has not reached these parts or the contamination has stopped and the contaminant has been either deposited or removed by distillation.

1. Draw swabs through boiler and economizer tube ends to check for free oil.
2. Determine the thickness and nature of deposits in tubes from inspection of tube ends.
3. Determine the thickness and nature of deposits in tubes selected at random.
4. Determine the thickness of deposits in drums and headers and determine whether the deposits contain free oil. If the boiler has been contaminated with lubricating oil or fuel oil, a ring will usually be found in the steam drum at the steaming level near the front and rear heads. Turbine lubricating oil (lube oil) contamination will usually be no more than 1 inch wide, thin, and loaded with fine solids, but not tarry. Diesel fuel oil (distillate) contamination is similar to that of lubricating oil.

221-2.6.8.2 Interpretation of Results. Action on the findings depends in part on whether the suspected contaminant is fuel oil or turbine lubricating oil. In the event that the contaminated drain tanks, freshwater drain tanks, deaerating feed tanks, and so forth have not been inspected to determine the source and extent of contamination, they should be inspected concurrently with the boiler inspection. The following subparagraphs provide guidelines for action on the findings. They shall not be interpreted as meaning that anything less than the cleanest water-sides obtainable in the time available are satisfactory.

1. When free oil from distillate fuel or turbine lube oil contamination is found in the economizer or boiler, immediate action need not be taken to boil out parts affected on the basis of this indication alone. If the con-

tamination source is eliminated and the boiler is free of scale or sludge, the thin oil film that may exist in the boiler and economizer after they are drained will distill off cleanly when the boiler is steamed again.

2. When no free oil or deposits containing free oil are found in the boiler, but it is known that the feedwater has been contaminated (before the current inspection) by turbine lube oil or distillate fuel, clean the boiler in the normal manner if the thickness of solid deposits makes cleaning necessary. If tube deposits are thin, the boiler may be steamed without concern after the boiler is closed.
3. Generally, free oil will never be found in the superheater, and coked oil will be found only if the contamination by lube oil or fuel oil has been exceptionally heavy over a prolonged period. Nevertheless, the superheater should be inspected. If lube oil is present, boil out the superheater. If further cleaning of superheater tubes is necessary use a wire brush, bearing in mind that brushes will not completely pass through the tight bends of some superheater types. If the superheater is determined to have been contaminated with distillate fuel, swab out the tubes; no further action is required. If only thin dry deposits exist, whether carbonaceous or not, no immediate action is required. If dry deposits are thick, brush tubes or boil-out to obtain clean tube surfaces.
4. The decision about whether to boil out or de-grease shall be made on the basis of the above inspections.

221-2.6.9 BOILING OUT. Boilers should be boiled out when newly erected, after a major tube renewal, after reactivation, or when a careful examination discloses oil deposits. Boil-out is not required after reactivation if the boiler was under dry air lay-up and shows no evidence of oil deposits. New boilers shall be boiled out thoroughly so that all traces of grease or preservative compounds on the interior surface are removed. New boilers shall be inspected frequently and boiled out if required during the first 6 months of steaming to remove from the boiler all foreign material introduced through the feed system. Refer to [Appendix E](#) for boil-out procedures. Further boil-out-related cleaning and inspection guidance is given in the following paragraphs.

221-2.6.9.1 Inspection of Boiler for Pitting After Boil-Out and Cleaning. After completion of boiling out and subsequent cleaning processes, inspect the boiler carefully for signs of pitting, especially around nipples and tubes. Also inspect tubes for sagging.

221-2.6.9.2 Treatment of Pits. All pits in boiler drums, tubes, or nipples should be thoroughly cleaned down to bare metal. Pits should not be filled with cement or "Smooth-on" paste; such filling does not prevent further corrosion in the pits but does prevent reliable judgment about continuing metal reduction in the pits on subsequent boiler inspections.

221-2.6.9.3 Drum Internal Fittings. Internal fittings shall be taken out and cleaned. Pits should be cleaned thoroughly down to bare metal. Special attention should be given to inspection and cleaning of drum nozzles, especially feedwater, desuperheater inlet, and desuperheater outlet nozzles. If desuperheaters are installed in drums, tubes, tube supports, and crevices between tube and tube sheet, and between tube and tube supports shall be cleaned to bare metal and made free of debris. All internal bolting threads shall be cleaned and carefully coated with a thin application of anti-seize compound (Molykote) before reassembly to facilitate removal in the next disassembly period. All nuts and bolts shall be accounted for in these periods to prevent any nuts and bolts from falling into tubes, downcomers, and the like.

221-2.6.9.4 Drum Openings, Flanges. See that drum openings to water columns, blowdowns, and drain connections are clear; use cocks, if installed. All mechanical joints, flange bolts, and nuts should be set up properly to ensure that drum internals are properly secured and that pipe joints do not leak. After the desuperheater is bolted up, it shall be given a hydrostatic test on the steam side to check for tightness of the flange joint according to [paragraph 221-2.16.5.7](#).

221-2.6.9.5 Disposal. Pollution laws require that boil-out or degreasing solution shall not be discharged overboard in port or within a 12 mile limit. If necessary, the solution should be discharged to a storage tank or pumped ashore for disposal according to NSTM Chapter 593.

221-2.6.10 STEAM DRUM INTERNALS. The main function of the steam drum is to collect the steam/water mixture from the generating tubes, separate as much water as possible from the steam, and pass the steam through

a series of dryers for moisture removal. Centrifugal separators remove the bulk of the water. Normally dryers or scrubbers of the chevron type remove the remaining moisture. These dryers can be located directly on the separators or at the steam drum outlet. Some designs also use dry pipes or dry boxes for final moisture separation. The steam drum also serves as the entry point for boiler feedwater and chemical injection. Surface blow for the removal of boiler water scum is also accomplished in the steam drum.

221-2.6.10.1 Steam Separators and Dryers (Scrubbers). If steam separators are removed for cleaning or inspecting the boiler, they should be cleaned before reinstallation. On cyclone steam separators, where the steam dryer is fitted on the separator, care should be taken not to distort the dryer labyrinth sheets. When steam separators are removed they shall be reinstalled in their original locations and fitted tightly at the flanged metal-to-metal joints. Leaky separator joints will result in inadequate steam-water separation and might result in carryover that is not perceptible during operations. When dryers (scrubbers) are reinstalled their position shall be checked athwartships and fore and aft, to make sure they are level and firmly mated to the offtake connections before finally tightening the mounting bolts. This ensures a tight seal.

221-2.6.10.2 Apron Plates. Apron plates and end plates form an annular passageway for the steam-water mixture from the generating tubes to the separators. Apron plates and end plates should be carefully installed and secured to ensure this passageway is as tight as possible.

221-2.6.10.3 Internal Piping. Examine the feed, surface blow, and chemical feed pipes, if applicable, to ensure they are properly installed and all holes are clear.

221-2.6.11 SUMMARY OF WATERSIDE CONDITION INDICATIONS. Certain observations can be made when boiler watersides are open. These observations, which are indications of satisfactory operation or point the way to improved boiler operation and care, are summarized in the Boiler Inspection Manual, NAVSEA S9221-D2-MMA-010.

221-2.7 FIRESIDE MAINTENANCE.

WARNING

Whenever personnel are to enter either the firesides or the watersides precautions shall be taken to protect them from steam, water, and gases. Refer to detailed precautions in paragraph 221-2.2.4.

221-2.7.1 IMPORTANCE OF FIRESIDE CLEANLINESS. Boiler firesides shall be kept clean and unrestricted. Deposits of soot, scale, or slag on the tubes seriously reduce boiler efficiency and contribute to failure of equipment such as superheater support plates, heat-resisting seals, baffles, protection plates, and soot blowers. Such deposits act as insulation, preventing heat from the furnace and combustion gases from being conducted through the tubes to the water. Blocking the gas passages through the tube banks requires excess blower pressure to maintain gas flow through the boiler. This represents an additional loss of economy. Such blocking of normal passages, causes large amounts of un-cooled gases to flow over protection plates, baffles, and seal plates, resulting in early failure of these parts. Soot creates a hazard because sulfuric acid (which attacks tubes and drums) may be formed; soot also creates a fire hazard. In addition, a clean tube will not accumulate deposits as rapidly as a dirty tube. The amount of deposit will depend on the type of fuel burned, combustion efficiency, the type of burner installed, and efficiency and proper use of soot blowers. Keeping firesides clean saves fuel, material, and overall upkeep effort.

221-2.7.2 FREQUENCY OF CLEANING AND INSPECTING FIRESIDES. Boiler firesides shall be inspected according to [paragraph 221-2.1.2](#). Firesides shall be cleaned whenever, in the opinion of the Engineer Officer, accumulations of soot, dirt, debris, and deposits over the water drum and on tubes may block gas passages or, having hardened, may become a source of corrosive sulfuric acid if moistened.

221-2.7.3 PREPARATION FOR INSPECTION. For 18 month inspections follow the requirements of the Boiler Inspection Manual. For SOI/SAI, refer to [paragraph 221-2.4.3](#). For all other inspections provide access as follows:

1. Open the furnace and fireside access doors, hinged burner registers, and all access doors to the superheater and economizer cavities and vestibules.
2. Open all access doors or removable panels in the uptakes and forced draft blower ductwork.

WARNING

A respirator is required during cleaning operations to protect personnel from dust inhalation.

221-2.7.4 INSPECTION AND CLEANING PROCEDURES. Refer to Boiler Inspection Manual, NAVSEA S9221-D2-MMA-010, for a detailed discussion of boiler inspection criteria. When the fireside inspection indicates that cleaning is required, complete mechanical (manual) cleaning shall be accomplished. Mechanical cleaning is the preferred method of cleaning firesides. If unusual conditions are observed that will not permit deposits to be removed mechanically, waterwashing procedures should be used (according to [Appendix F](#)). Unusual deposits over the water drum can be removed using special water-jet methods. When furnace areas are opened for any purpose, accumulations of soot and refractory rubble found within the furnace shall be removed.

NOTE

Waterwashing or water-jetting of boiler firesides is prohibited without prior NSWCCD-SSES approval.

221-2.7.5 GENERATING BANK, SCREEN, AND WATERWALL TUBE FIRESIDES. Tubes shall be inspected carefully for evidence of sagging, bulging, acid corrosion (especially adjacent to the water drums and headers), pitting, scaling, and fireside thinning. All tube seats shall be inspected for evidence of leaks. Bulging is caused when the tube overheats because of dirty or scaled watersides. If bulging is found, immediate steps shall be taken to clean the watersides. Sagging is caused by low water or by general overheating due to dirty or scaled watersides. As in the case of bulging, immediate steps shall be taken to clean the watersides, unless a condition of low water is known to have been the cause (refer to [paragraph 221-4.18.16.2](#)). Pitting and scaling are due to localized conditions involving diverse and complex factors, but firesides attentively cleaned and kept free of moisture are less likely to show defects of this nature. Refer to the Boiler Inspection Manual for guidance concerning when the above conditions warrant repair of affected tubes.

CAUTION

If deposits are hard and adhering, take special care to prevent damage to tubes during cleaning.

221-2.7.6 METHODS OF CLEANING. Effort shall be made to remove accumulated soot, slag, and fireside scale on the tubes and in the area over the water drum at every opportunity. Cleaning shall be done from within the furnace and through access doors, where fitted. Access to the Main Generating Bank (MGB) may be obtained at the side of the boiler through the outer and inner casing access doors where fitted. Special tools for reaching between the lanes of tubes may be made from flat bars, sheet metal strips cut with a saw-toothed edge, rods, standard bottle brush and similar equipment. An air hose fitted with copper tubing can be used to blow soot and debris through the MGB. Aggravated cases may require the removal of bolted sections of boiler casings to improve accessibility for cleaning, but every effort shall be made to accomplish the work without resorting to this procedure. The use of an authorized industrial vacuum cleaner (refer to [Appendix A](#)) is particularly effective for removing soot and debris. Loose soot and debris can be removed within the tube bank by inserting a small diameter copper tube fitted to a vacuum cleaner.

221-2.7.7 TACKY FIRESIDE DEPOSITS. At some furnace inspections a tacky fireside deposit on tubes has been noted when distillate fuel is burned. This deposit may appear to be unburned oil but is usually determined to be mostly soot. Soot absorbs moisture from the air, causing the tackiness. Proper operating, soot blowing, and lay-up procedures can prevent tacky fireside deposits. Soot and wet/tacky firesides will yield sulfuric acid that attacks the tube metal. If tacky fireside deposits are allowed to go unchecked, the deposits will migrate down the tube and settle in the area between refractory and tubes and on the crown of the water drum. For this reason, it's important for ship's force to ensure that the boiler firesides are under a proper lay-up (refer to [paragraph 221-2.3](#) for boiler lay-up requirements).

221-2.7.8 EXTERNAL CORROSION OF TUBES. Careful attention to factors like correct burner settings, air settings and adjustments, and soot blowing will result in reasonably clean fireside conditions with distillate fuel. Using distillate fuel does not in itself assure the operator that fireside cleaning will not be required; only inspections will determine this point. If soot is allowed to remain on boiler surfaces or parts for any length of time, soot sulfur products (formed by oil combustion) will corrode the metal. The degree of such corrosion is proportional to the amount of moisture present, which in turn is dependent on humidity, rain, fog, condensing steam, and spray. This phenomenon can cause the tube metal to deteriorate rapidly and may lead to failure if not arrested. All precautions should be taken, therefore, to ensure that moisture does not enter the boiler firesides. Precautions include completely draining the boiler before opening handholes, using stack covers for secured boilers in port, and using proper boiler lay-up procedures.

221-2.7.9 SUPERHEATER TUBE FIRESIDES. Superheater tubes shall be inspected carefully for evidence of sagging, bulging, scaling, cracking, and fireside thinning. Overheating causes bulging. When bulging tubes are found, immediate steps shall be taken to determine the cause. Cracked alloy tubes possibly result from a combination of high temperatures, a relative difference in temperature between the furnace side and the rear side (the tubes developing stress from the unequal expansion between these sides), characteristics of the material, and material fabrication difficulties. Superheater tubes, because of inaccessibility, are more difficult to clean than water tubes. When distillate fuel is used a scale buildup on the superheater has been found to occur up to a thickness of 1/8 to 3/16 inch. This will then peel or burn off as crumbled ash under further operation. The special tools and procedures required for cleaning all the designs of superheaters installed in various boilers cannot be listed; the Engineer Officer and fireroom personnel shall therefore devise special cleaning tools suited to the shape and

accesses of superheaters installed. In some cases a split portion of tube welded to a rod for running along the tube surface will be required; in some cases a wire brush or flat foxtail brush will suffice.

221-2.7.10 ECONOMIZER FIRESIDES. Economizer tube deposits are usually soft and may be removed by mechanical methods like probing and air lancing. Economizer vestibules on main propulsion boilers are often soot traps because they are dead spaces. Efforts are made when designing these areas to make them soot free by pressurizing them with air and using baffles and casing, but these methods are not completely effective and soot does accumulate. When this soot is moistened with water from condensation or leaking joints, acid forms and the economizer loop ends and tube ends may corrode externally. When entering the area above the economizer tube bank, place wooden planks on the top row of the economizer to distribute the weight and prevent damage to the tube rows. Fin deterioration on the top rows should be left alone. Top row replacement tubes on Foster Wheeler star-finned economizers should be bare tubes.

221-2.7.11 GAS BAFFLES. Refractory baffles shall be inspected to determine their height with respect to the superheater and to determine if they are gastight or nearly so. Metal baffles should be inspected to determine if metal has wasted to an extent that impairs their effectiveness. A plus-or-minus tolerance of 1 inch from the specified baffle height is generally accepted. Greater tolerance may be permitted if superheater outlet steam temperature and other operating parameters are known to be within specified limits. Since baffle height with respect to the superheater vanes in different boiler classes, reference shall be made to the appropriate boiler drawing. Corrosion-resisting steel (CRES) baffles, seals, superheater supports, and protection plates should be inspected during all fireside inspections. Their service life is greatly decreased when the combustion gases forced over them are hotter because of fouled tube banks.

WARNING

Always wear personal protective gear (i. e. safety goggles, safety harness and respirator when cleaning uptakes space and smokepipes.

221-2.7.12 UPTAKES, PLENUM CHAMBER AND FORCED DRAFT DUCTS. The uptake/smokepipe is the ductwork that takes exhaust gases and discharges them to the atmosphere. Uptakes, plenum chamber and forced draft ducting to boiler casings shall be inspected during fireside inspection periods. At this time, uptake expansion joint and rain gutter areas shall be swept clean and an inspection made to determine that expansion joint and rain gutter drainage piping is intact and clear of accumulations of soot. The uptake/smokepipe is constructed of either low Cr, Copper-Si-Phosphorus alloy, hi-tensile steel (USS Cor-Ten or equal) or type 304 stainless steel on some LHA/LHD class ships. Each smokepipe is equipped with rain gutters and drain piping systems that discharge rain water and soot deposits overboard, to waste deposit system and drain collection tank on some LHA/LHD class ships. The drain piping system is copper nickel material, fitted with take down joints that provide easy removal for cleaning. Flushing water down the drain piping system is a good check to ensure that the piping system is clear of debris.

221-2.7.13 BURNERS. Burner diffusers, impeller plates, bladed cones, burner drip pans, and refractory cones should be cleaned after every steaming period at sea or in port. Access to the furnace may be gained by removing the furnace door or, preferably, a burner. Refer to [paragraphs 221-3.1](#) through [221-3.1.7.5](#) for further guidance on burners.

221-2.7.14 CASINGS. To prevent heat loss and maintain boiler efficiency, it is important that boiler casings be as tight as possible. Particular care should be taken to ensure proper fit at doors and panels. Casings should also be inspected for signs of overheating. Detailed procedures for casing inspection are given in [paragraph 221-2.13.3](#).

221-2.7.15 REFRACTORIES. Removing any remaining fireside scale or residue on the refractory after cleaning the boilers is important since these concentrated impurities lower the melting point of refractories. Other cleaning is normally limited to sweeping debris from floors and, if present, removing excessive carbon deposits from refractory and projections from burner throats. If excessive carbon deposits are found, attention shall be given to the cleanliness and alignment of burner components to determine if corrective measures are necessary. Refer to [paragraph 221-2.14.5](#) for further guidance on refractory inspection.

221-2.7.16 FIRESIDE DEPOSIT REMOVER COMPOUND. Elect use of sprayed fireside deposit removal oils has been discontinued. Industrial activities which seek to use this method, should contact NSWCCD-SSS for material information, procedures and safety precautions.

CAUTION

**Do not use MIL-PRF-16173 corrosive preventative oil for fireside cleaning.
It has a flash point that is too low for safe use.**

221-2.8 PRESSURE PARTS.

221-2.8.1 The pressure parts of a boiler consist of the drums, tubes, headers, and associated manhole and hand-hole plates and gaskets. Inspection and maintenance requirements are covered in the sections on waterside and fireside maintenance. A special external Strength and Integrity Inspection of drums, headers and piping is required periodically as discussed in [paragraph 221-2.1.2](#). This section will cover the watertight integrity of pressure parts.

221-2.8.2 WATERTIGHT INTEGRITY. Watertight integrity shall be maintained if a boiler is to continue steaming. Tubes that leak shall be repaired by re-rolling or welding or shall be plugged until they can be replaced. The Boiler Inspection Manual discusses in detail types of tube failures and pressure part defects. Leaks at drum manholes and header handholes, in excess of the leakage permitted in [paragraph 221-2.16.6.5](#), require that plates, gaskets, and seats be inspected and repaired as necessary. Repairs can be either temporary or permanent and can be accomplished at sea by the crew or in port by depot or intermediate-level activities.

221-2.8.3 TUBE FAILURES. Tube failures occur in the form of a rupture or leak in the tube itself or a leak in its connection to a drum or header. If a ruptured tube cannot be replaced immediately, it shall be plugged. If a leaking expanded joint cannot be corrected by re-rolling, the rolled section of the tube should be removed and replaced with a new tube or blind nipple. In most cases a leaking welded joint can be corrected by re-welding.

221-2.8.4 TUBE PLUGGING. All instances of tube removal or plugging shall be recorded on the tube renewal diagram and in BIRMIS, as described in [paragraph 221-2.9.5](#). Refer to the Main Boiler Repair and Overhaul Manual for detailed instructions for plugging tubes.

NOTE

NAVSEA approval is required for plugging any tube that is 2-inches or greater in diameter.

221-2.8.5 TUBE PLUGGING LIMITATIONS. Boiler tubes may be plugged to permit the boiler to steam to meet operational commitments. However, precautions, as discussed in [paragraphs 221-2.8.5.1 through 221-2.8.5.5](#), must be taken to ensure exposed areas of the furnace are not overheated and that gas lanes are not created which can overheat adjacent tubes or drum areas. An excessive number of plugged tubes can affect the overall satisfactory operational performance of the steam plant due to reduced steam pressure or temperature. Ship's force and NAVSEA must have an accurate mapping of which tubes in the boiler are plugged, and which have been renewed, as this is a critical part of risk assessment.

- a. Prior approval from NAVSEA is required to plug any boiler tube that is 2 inches or greater in diameter. This is necessary because engineering analysis is required to ensure these large diameter tubes can be safely plugged. Guidance will be on a case-by-case basis and will vary depending on the design of the boiler, the number of tubes that have failed, the location of the failure and the location of previously plugged or replaced tubes. Permission to plug boiler tubes that are 2 inches or greater in diameter shall be done via a major Departure From Specification (DFS) which requires technical concurrence from the NAVSEA Boiler Technical Warrant Holder (TWH).
- b. Prior approval from the TYCOM is required to plug any boiler tube less than 2 inches in diameter. This includes main propulsion generating tubes and superheater tubes, and all auxiliary boiler tubes. An evaluation is required to ensure that the plugging of these tubes is subject to the limitations of [paragraphs 221-2.8.5 and 221-5.5.4, step b](#). Permission to plug boiler tubes that are less than 2 inches in diameter shall be done via a minor DFS, approved by the TYCOM. The RMC engineering department is available as necessary to assist in the evaluation.
- c. Prior approval from the TYCOM is required to jumper economizer tubes and waste heat boiler tubes. An evaluation is required to ensure that this is subject to the limitations of [paragraphs 221-2.8.5 and 221-5.5.4, step a](#). Permission to jumper economizer tubes and waste heat boiler tubes shall be done via a minor DFS, approved by the TYCOM. If it is desired to plug these tubes, the DFS becomes a major DFS requiring technical concurrence from the NAVSEA Boiler TWH.
- d. If it is required to exceed limitations of [paragraphs 221-2.8.5 and 221-5.5.4](#), the DFS becomes a major DFS requiring technical concurrence from the NAVSEA Boiler TWH.
- e. The DFS process fulfills the mandatory requirement to report plugged tubes via a Boiler Tube Failure Report. The information required for the Boiler Tube Failure Report as listed in [Figure 221-2-3](#) shall be included in the DFS request. NSWCCD (922) will be copied on all DFS requests. It is no longer necessary to forward a marked tube renewal diagram to NSWCCD. The tube renewal diagram on BIRMIS (Boiler Inspection and Repair Management Information System) will be updated utilizing the information contained in the DFS request. SF is still required to maintain a properly marked tube renewal diagram as described in [paragraph 221-2.9.5](#) for each boiler. The DFS may be cleared at the next boiler inspection by a certified inspector. The inspector will confirm the right tube was identified and entered into BIRMIS, the right material and processes were used and that there is no evidence of leakage.

221-2.8.5.1 Superheater Tubes. When a superheater tube is plugged, it will eventually burn away after a period of steaming. When tubes are removed or burned away leaving a gas lane through the entire superheater tube bank more than 3 tube rows wide, the gas lane should be plugged with plastic or castable refractory. If this lane cannot be plugged the tubes adjacent to the gas lane may overheat. Accordingly, the boiler shall be used only in an

emergency. There is no criteria established for maximum number of superheater tubes that may be plugged. The number will vary for each boiler design. Approximately 15 percent of the total number of superheater tubes, or 20 percent of tubes in any individual pass, may be plugged without significant degradation of plant operating performance. This is provided that the gas lane elimination measures discussed above are implemented. It is possible that additional tubes, in excess of the percentages stated above, could be plugged depending on boiler design and the ship's operational requirements. If either the resulting increase in steam pressure drop through the superheater or the decrease in superheater outlet temperature effects overall satisfactory operational performance of the steam plant, renewal of plugged tubes must be considered.

221-2.8.5.2 Furnace Frontwall, Sidewall and Rearwall Tubes. When a frontwall, sidewall or rearwall tube needs to be plugged, cut the tube out 3 to 4 inches above the header and 3 to 4 inches below the steam drum or header. Pack the space left exposed after the tube has been removed with refractory material to protect the pressure parts or casing previously cooled by the plugged tube. No more than two adjacent tubes should be plugged, because an exposed area wider than two 2-inch tubes cannot be effectively protected for an extended operating period. Replace plugged frontwall, sidewall or rearwall tubes at the earliest availability. Refer to the boiler technical manual for correct bending configuration for replacement tubes. As discussed below for LHA/LHD front-wall tube FW-22, certain tube designs may have been improved to extend service life.

LHA/LHD Front Wall Tube FW-22

Boiler OEM Combustion Engineering (Alstom) added bends to the FW-22 tube to reduce inherent stress. This design has been used for LHA replacements and as original equipment on the LHD class. The modified tube is shown in LHA/LHD-1 Class main boiler technical manuals.

LHA experience indicates the life of the modified tube is in excess of 15 years. Permanently plugging FW-22 was authorized to meet operational commitments, and because not having the tube does not adversely affect boiler performance. However, LHA experience does indicate reinstalling the tube is desirable because it prevents refractory from falling out and exposing the inner casing to overheating at the tube location.

If tube FW-22 is found to be cracked or leaking during an operational cycle, submit a major DFS to obtain, and document, NAVSEA Technical Warrant Holder (TWH) approval to plug tube FW-22. Initiate planning to replace FW-22 at the next scheduled maintenance availability. If tube FW-22 is found to be cracked and/or leaking during an inspection immediately prior to or within scheduled maintenance availability, replace FW-22. Document the replacement in the BIRMIS system. Precautionary plugging or replacement is authorized at the discretion of type commanders. A major DFS to document and obtain TWH approval is required.

221-2.8.5.3 Superheater Screen Tubes. Superheater screen tubes (of 1-1/2 and 2-inch diameters) that screen out some of the intense radiant heat of gases leaving the furnace before they pass to the superheater and are subjected to the highest heat input should, in general, be replaced when they fail. However, if multiple screen rows are provided no more than one tube (only) may be plugged. In this case NSWCCD-SSES approval is required and the boiler shall be steamed only for an emergency of short duration.

221-2.8.5.4 Generating Tubes. In plugging 1 and 1-1/4 inch diameter generating tubes behind the superheater bank in D-type boilers consideration need be given only to laning and drum protection. Any complete lane through tube bank more than three tube rows wide should be re-tubed, especially if such a lane is bounded by the boiler casing. Any drum area over 4 inches by 4 inches should have refractory protection over the drums; if this is impractical blind nipples should be used to replace failed tubes (instead of plugging the failed tube) to limit the area of un-cooled drum surface exposed to combustion gases.

221-2.8.5.5 Economizer Tubes. Failed economizer tubes should be jumpered rather than plugged. Refer to the Boiler Repair and Overhaul Manual for procedures. When economizer tubes are jumpered or plugged, careful attention should be given to fireside cleanliness to avoid the hazard of an economizer fire.

221-2.8.5.6 Affect on Full Power Capability. Provided the precautions noted in the preceding paragraphs are followed, boiler full power capability will be unaffected unless more than 5 percent of the generating tube surface, 5 percent of the superheater tube surface, and 20 percent of the economizer tube elements are plugged. The combined effect will result in an increase in fuel consumption of 3 percent at full power steam rate and less at correspondingly lower loads. Replacing these tubes is unnecessary unless the boiler is to be re-conditioned to its original condition and efficiency. Normally, tubes should be replaced at the next major overhaul. The boiler inspector will make a final determination on a case basis.

221-2.8.6 DAMAGED TUBE EVALUATION. Refer to the Boiler Inspection Manual for detailed discussions of typical tube damage. The decision to renew damaged tubes shall be based on the merits of each case. In the case of bowed, sagged, or married tubes that are tight and otherwise appear satisfactory, however, the following rules and inspection guidelines will assist in decision making:

- a. Provided that tube joints are tight under hydrostatic test, tube replacement is unnecessary if affected tubes are the 1- or 1-1/4-inch tubes used in the main generating bank. If 1-1/2-inch or greater diameter screen tubes are affected or if furnace sidewalls or rear walls are bowed, tube replacement is usually required.
- b. Carefully examine external tube surfaces for blistering and other signs of overheating; if present, tubes should be replaced.
- c. Inspect watersides; check for hard scale or oil within the affected tubes. If present, the tubes should be replaced. If there is any question about a tube's condition or if a large number are married, a sample tube(s) should be removed and split for examination.
- d. Inspect the inner casing adjacent to the affected tubes to determine if it is overheating. Should signs of local casing overheating be found, correct tube alignment by replacing warped tubes.
- e. On D-type boilers, if the opening in the screen wall lane is more than 1-1/2 tubes wide, serious consideration should be given to its location and the possible overheating effects on superheater and superheater support. Should such a large lane exist near the superheater outlet header end of the boiler, the alignment of tubes should be corrected by replacing them.
- f. Tubes usually should not be straightened in place because joints may be strained, causing leaks and possibly permanent damage to other parts of the boiler. Occasionally a screen tube or furnace wall tube may bow out of position, however, for no apparent reason, and replacements may be unavailable. In this case the tube may be carefully forced back into position and re-rolled if necessary. Tubes that have bowed out of position because of low water shall not be straightened.
- g. All instances of tube replacement shall be recorded on the tube renewal diagram and in BIRMIS, as described in [paragraph 221-2.9.5](#).

221-2.8.7 SAMPLE TUBES. In addition to the tube sampling discussed in [paragraphs 221-2.4.3](#) and [221-2.5.6](#), tube sampling may also be necessary during the ship's operating cycle as determined by a boiler inspection. Replacing removed sampled tubes shall be as follows:

1. Tubes removed from superheaters should be replaced if tubes are available and replacement is convenient. If not, they can be replaced at the next major availability.

NOTE

In certain classes of ships, individual superheater tubes cannot be removed and replaced without cutting bulkheads and permanent casing panels. This factor should be considered when selecting samples.

2. Tubes removed from screens and waterwalls shall be replaced.
3. Tubes removed from generating banks need not be replaced provided there are no more than 10 plugged, as verified by inspection, or they are in the last two rows of the bank.

221-2.8.8 DOCUMENTATION OF SAMPLE TUBE EXAMINATIONS. The removed tubes shall be split; permanently identified by piece number, boiler, and location in boiler; and examined. The activity removing the tube shall also report on its findings and recommend corrective action to the ship with copies to the TYCOM, NAVSEA, and NSWCCD-SSES (Code 922). The ship shall keep reports on file and be prepared to provide copies to INSURV and other inspectors. After examining tube samples, reviewing the tube removal activity report on the samples, and the corrective action taken by the ship, INSURV may desire further examination of the boiler. Such examination shall be conducted according to applicable instructions. Tube sampling shall also be recorded in the tube renewal diagram and in BIRMIS, as described in [paragraph 221-2.9.5](#).

NOTE

The results of all sample tube examinations are to be entered in the boiler water chemistry worksheet/log. A copy of written examination reports may be attached to the boiler water chemistry worksheet/log in place of a written log entry. This information is vital for boiler inspections.

221-2.8.9 ADDITIONAL TUBE EXAMINATIONS. When the examination of the tubes reveals poor conditions and when more tube samples are necessary to determine their condition and the need for tube renewal, such sampling shall be as recommended by the boiler inspector. The boiler inspector (using guidelines in the Boiler Inspection Manual) should review the facts and make necessary inspections as the basis for recommendations to the TYCOM. The TYCOM, with this information and with knowledge of the ship's operating ability and other factors, should render a decision on the extent of repairs required.

221-2.8.10 FAILED TUBE EXAMINATIONS. When a tube has failed the reporting requirements and procedures shall be as follows:

1. When the cause of tube failure is known, the failed tube (when accessible) should be sent to the nearest shipyard or repair facility for analysis and report. A failed tube shall be considered to be any tube removed from service because of rupture, blister, perforation, or excessive warpage. In cases where there have been extensive tube failures (for example, when a condition of low water has existed in a boiler) only a few representative failed tubes need be forwarded for examination. The following rules for forwarding sample tubes shall be followed:
 - a. A tube adjacent to the failed tube should also be forwarded.
 - b. The full length of the tube (if available) should be forwarded or at least a section that includes 1 foot on either side of the failure. If a full length is sent it may be cut into sections, but a cut shall never be made through the failed or affected area.
 - c. All tubes shall be clearly identified to indicate:

- (1) Tube designation
 - (2) Top and bottom ends
 - (3) Sides upstream and downstream of gas flow
 - (4) If tube is in sections, indicate numbers and match marks so that the full length of the tube can be reconstructed.
- d. Tubes shall not be split longitudinally, and no fireside or waterside deposits shall be removed. If it should be necessary for any reason to split tubes before shipment, they shall be split dry split without using cutting oil.)
- e. Where failure has occurred close to drums or headers, care shall be taken to remove tubes so that as much of the failure as possible may be analyzed.

NOTE

Information to be forwarded with the tube shall include a Boiler Tube Failure Report (Figure 221-2-3) and a properly marked tube renewal diagram (as described in paragraph 221-2.9.5). The shipyard or repair yard shall furnish NAVSEA a report of its findings with the above forms, with a copy to NSWCCD-SSES (Code 922)

2. If the tube failure is unusual, problems arise, or there is doubt about the reason for the tube failure, the tubes and reports are to be forwarded to NSWCCD-SSES with a copy of the forwarding letter to NAVSEA. This action applies both to the individual ship and to the repair activity. Also, shore activities where laboratory facilities do not exist shall send tube samples to NSWCCD-SSES (Code 922) for inspection to determine the necessity for boiling out, chemical cleaning, tube removal, or any combination thereof. Procedures for preparing samples for shipment and making reports shall duplicate those indicated in the foregoing paragraph.

221-2.9 TUBE RENEWAL.

221-2.9.1 BOILER TUBE EXAMINATIONS FOR RENEWAL DETERMINATION. Examination of boiler tubes to determine the need for replacement relies on a combination of techniques and inspection tools. Inspection methods include visual examination of tube ends, optical examination of tube internal surfaces, ultrasonic techniques, laser-optic techniques, eddy current techniques, tube removal destructive examination, hydrostatic test, and failed tube metallurgical examination. These methods are used to determine tube wall thinning, pitting depth, pitting frequency, waterside deposit thickness, failure mode, tube seat integrity, and bell anomalies such as end pitting and splitting. Personnel planning for possible tube renewal should use inspection methods that make maximum use of nondestructive means for data gathering as described in paragraph 221-2.9.3. Decisions for general tube renewal, however, may require some tube removal to gain conclusive data to support the decision.

221-2.9.2 TUBE RENEWAL CRITERIA. Tube failures in generating banks generally occur in the outer half of the tube nest because of external corrosion just above the water drums. When such failures have occurred, either in operation or under hydrostatic test, or when examination by nondestructive testing or by destructive sampling shows that the tube thickness is less than half the original design drawing thickness, the affected tubes and those requiring removal for access shall be renewed. The existence of slight scattered pitting, even when the tube thickness in the pits is less than half the original design drawing thickness, does not necessarily require complete re-tubing of the boiler. Tubes should be evaluated according to procedures in the Boiler Inspection Manual to determine whether the pitting appears to be general throughout the boiler and is moderately heavy before re-tubing of the boiler is undertaken. Internal pitting due to improper boiler water conditions is most likely to occur in tubes subject to the highest heat flux, such as screen and furnace tubes near burners, and in areas sub-

jected to oxygen pitting. Oxygen pitting occurs mostly at the steam drum ends of generating and downcomer tubes and in the superheater. If active pits are apparent from inspection, or internal pitting is suspected based on the boilers previous operating history, tubes in which active pitting is likely to be found should be nondestructively evaluated.

221-2.9.3 NONDESTRUCTIVE EVALUATION (NDE) METHODS. NDE methods include visual inspection of tube ends, remote visual inspection and ultrasonic inspection. NDE methods are described in detail in Appendix C of the Steam Generating Plant Inspection Manual and are summarized below.

221-2.9.3.1 Visual inspection. Visual inspection is conducted whenever watersides are opened for inspection or repair. The inspection can be aided by a small hand-held magnifying glass. The general categories of deficiencies this inspection reveals are waterside deposits, tube bell defects and visible surface defects. Specific criteria for conditions found are listed and discussed in the Steam Generating Plant Inspection Manual. If the purpose of the inspection is the assessment of pressure vessel surface condition, the water and steamsides shall be clean. Firesides shall also be clean for direct visual inspection of lower tube surfaces and suspect areas to identify areas of external corrosion.

221-2.9.3.2 Remote Visual Inspection (RVI). RVI devices allow the boiler inspector to visually examine the interior surfaces of boiler tubes, downcomers, pipes and headers, as well as otherwise inaccessible areas of the firesides. Remote visual inspection devices include rigid borescopes, flexible fiberoptic scopes and flexible videoscopes. The scopes come in various lengths and diameters. Adaptable accessories allow still camera and video recordings. Users of these devices should exercise size determinations. Scopes are available at several activities, including NSWCCD-SSES.

221-2.9.3.3 Boiler Tube Inspection Unit (BTIU). BTIU is a system of older technology devices used to determine the need for tube renewal primarily of generating and furnace wall tubes. A dual-element contact ultrasonic transducer is used to measure the minimum tube wall thickness in the 8 to 12 inches of tube above the water drum or lower water wall headers. A rigid optical Endoprobe (borescope) and a manual pit depth gage are used to measure pit depth and frequency in the zero to 24 inches of straight tube at the steam drum.

221-2.9.3.4 Ultrasonic Test (UT) Inspection. UT inspection systems are available for remaining tube wall thickness assessment. External UT provides localized remaining tube and/or pipe wall thickness measurement by direct contact with suspect areas. Removal of castable refractory protection, however, is required to access the external surface. External UT is performed with standard UT equipment.

221-2.9.4 LARGE DIAMETER TUBE RENEWAL. Large diameter tubes (3-inch OD and greater) such as downcomers and risers shall be replaced whenever any defect, external or internal, such as a pit, gouge, or erosion, is found to exceed 1/3 of the originally specified minimum wall thickness.

CAUTION

Only approved welding methods shall be used for large diameter tube renewal. Plans shall be checked to determine the material being welded.

Replacement of defective sections of the downcomer or riser will be considered satisfactory provided the replacement section is the same size and material and can be adequately welded and NDE tested. Renewal of large diameter tubes may consist of replacing a complete tube involving a new joint at the steam drum and header

(or water drum) or may consist of cutting the tube about 1 to 2 feet away from the defective joint and replacing the short length. Refer to the Main Boiler Repair and Overhaul Manual for renewal procedures. When renewing large diameter rolled tubes between casings, seal weld according to [paragraph 221-2.12.4](#). Seal welding is also required for tubes that have been in service, but where re-rolling cannot stop leakage.

INSTRUCTIONS - Check or fill in as applicable. A separate report should be filled out for each circuit, for each type of failure noted. Derangements of a particular circuit (warping, sagging, marriages, blisters, and so forth) which accompany but do not constitute failure (rupture, perforation, crack, and so forth) may be described under REMARKS on last page. Forward report to Carderock Division, Naval Surface Warfare Center(NSWCCD-SSES), Philadelphia, PA 19112-5083. When failed tube is forwarded for analysis, forward adjacent tube.

A. SHIP: USS _____ BOILER NO. _____ DATE _____

DATE OF FAILURE _____ CIRCUIT _____

TYPE OF FAILURE _____

RUPTURE _____: THIN-LIPPED _____ THICK-LIPPED _____

CRACK _____: LONGITUDINAL _____ TRANSVERSE _____

PERFORATION _____.

PITTING _____: FIRESIDE CORROSION _____ WATERSIDE CORROSION _____

OTHER _____ (Describe under COMMENTS)

FAILED TUBE NO.(S) _____

TUBE IDENTIFICATION ACCORDING TO: BIRMIS TUBE SHEET

TUBE PLAN IN MFRS. INSTRUCTION BOOK: __ TUBE SHEET

B. WATERSIDE DEPOSITS _____ FIRESIDE DEPOSITS _____

THICKNESS OF DEPOSITS: W/S _____ F/S _____

INDICATIONS ON WATERSIDES: OIL _____ FOREIGN OBJECTS _____

C. APPROXIMATE LOCATION OF FAILURE FROM:

FURNACE FLOOR (Water Wall Tube) _____ FT

WATER DRUM (Generating Bank Tubes) _____ FT

SUPERHEATER HEADER: _____ FT FROM INLET OF _____ OR OUTLET OF

PASS NO. _____.

ECONOMIZER HEADER: _____ FT FROM INLET _____ OR OUTLET _____ HEADER

DESUPERHEATER HEADER: _____ FT FROM INLET _____ OR OUTLET _____ HEADER

ORIENTATION OF FAILURE: _____ TOWARD FURNACE _____ AWAY FROM FURNACE

D. OPERATING CONDITIONS AT TIME OF DISCOVERY OF FAILURE:

I STEAM RATE _____ (% FULL POWER)

BOILER LOAD: INCREASING _____ DECREASING _____ STEADY _____

SPRAYER PLATE(S) IN USE _____

NUMBER AND LOCATION OF BURNER(S) IN USE _____

II LIGHTING OFF _____ SECURING _____ LAY-UP _____

III UNDER HYDROSTATIC TEST...AT _____ PSIG

Figure 221-2-3. Boiler Tube Failure Report (Sheet 1 of 2)

- E. IF RUPTURE OCCURRED: ACTION TAKEN IMMEDIATELY AFTER DISCOVERY
(DESCRIBE)
TOTAL STEAM HOURS ON FAILED TUBE(S): SINCE INSTALLATION _____ ON _____ WATER
SIDES: SINCE LAST CHEMICAL CLEANING _____ SINCE _____ LAST
MECHANICAL CLEANING
ON FIRESIDES SINCE LAST CLEANING
FAILED TUBE(S): PLUGGED _____ RENEWED _____ DATE _____ IF RENEWED: INSTALLING
ACTIVITY: SHIP'S FORCE
SHIPYARD (NAME)
TENDER/REPAIR ACTIVITY (NAME)
SAMPLES FORWARDED FOR ANALYSIS: DATE _____ TUBE NO.(S)
- F. REMARKS: (ADDITIONAL INFORMATION, SUSPECTED CAUSE OF FAILURE.)

Figure 221-2-3. Boiler Tube Failure Report (Sheet 2 of 2)

221-2.9.5 TUBE RENEWAL RECORD. To assist in keeping a record of the tube renewals, a BIRMIS tube sheet (similar to the one shown in [Figure 221-2-4](#)) shall be kept for each boiler. It shall be kept in a separate log or folder permanently stored in the log room and shall show all tube renewals, with date of renewal, the tubes that have actually failed during operation, and the cause of such failures. Other tubes that have been removed from service shall also be shown. During routine boiler inspection, the SGPI shall ensure that this information has been documented in BIRMIS. The activity renewing tubes shall submit to the Engineer Officer a BIRMIS tube sheet showing tubes renewed and the dates of renewal. The Engineer Officer shall forward a copy of all annotated BIRMIS tube sheets, whether prepared by the ship or a repair activity, to the TYCOM and NSWCCD-SSES (Code 922). No forwarding letter or transmittal sheet is required. Accurately maintained tube renewal records are required for adequate future tube evaluations. Only in this way can progressive tube renewal be accomplished economically while maintaining reasonable boiler reliability. BIRMIS tube sheets may be obtained by accessing BIRMIS or contacting NSWCCD-SSES. Refer to [paragraph 221-2.8.10](#) for documentation of failed tube reports.

221-2.9.6 TUBE REMOVAL. Refer to the Main Boiler Repair and Overhaul Manual for tube removal procedures.

CAUTION

Piping shall not be used instead of tubing without obtaining explicit written approval and detailed installation guidance from NSWCCD-SSES. Such substitution is not normally recommended because tubes and pipes are measured differently. Tube holes and tube expanding equipment are sized for tube dimensions.

221-2.9.7 TUBE REPLACEMENT. Tubes shall be replaced with tubing material identical to the tubes removed unless NAVSEA and NSWCCD-SSES authorize a substitute material. All procuring and repair activities shall order replacement tubes through the Navy supply system. If tubes are not available through the supply system, a private vendor may be contracted only if quality assurance certification to the applicable military specification is invoked with the contract. For 1200 and 600 psi boilers, only MIL-T-16286 seamless tubes shall be used as replacement tubes. Safe end welds in CRES superheater elements shall not employ backing rings. When generating bank tubes are renewed, always plan for reinstallation or renewal of soot blower element bearings. Refer to the Main Boiler Repair and Overhaul Manual and [paragraph 221-3.3.3](#) for information on installing soot blower bearings.

221-2.9.7.1 Tube Bending. Flattening (or out-of-roundness) of tubes bends shall be minimized to prevent flow distortions and allow passage of cleaning and inspection probes. The maximum out-of-roundness for tubes up to and including 2 inches is 10 percent. This flattening should occur only in the most severe bends. Out-of-roundness of less than 8 percent is desirable. For tubes more than 2 inches in diameter, the maximum out-of-

roundness is 5 percent. Out-of-roundness is calculated by measuring the maximum and minimum outside diameter (OD) in the bend and relating the measurements by the equation:

$$\frac{OD_{\max} - OD_{\min}}{OD_{\text{nominal}}} \times 100 = \text{Percent Out-of-Roundness}$$

OD max	Maximum outside diameter in the bend
OD min	Minimum outside diameter in the bend
OD nominal	Nominal outside diameter of the tube

221-2.9.7.2 Precautions Before Inserting New Tubes. Before new tubes are inserted, the holes shall be thoroughly cleaned and trimmed to eliminate gouges, and the outside tube surfaces shall be polished at the ends (where the joint is formed with headers or drums) until smooth and free of mill scale. Place wood plugs or plastic caps in newly repaired or prepared tube holes in drums and headers to protect them from damage (by grinding and cutting debris of adjacent holes and areas), from oil, and from moisture. Plastic caps (refer to [Appendix A](#)) can protect tube holes, especially in water drums. All oil and grease compounds, which may have been used for care and preservation purposes during storage, shall be removed before installing new boiler tubes. Kerosene or diesel oil is effective for this purpose. In addition, oil used with expanding and rolling tools may be deposited upon tubes and nipples and into pockets of headers. Oil from this source is liable to cause bulging and rupture of tubes. If re-tubing and cleaning has been extensive, the boiler should be boiled out as described in [Appendix E](#).

221-2.9.8 TUBE EXPANDING PROCEDURES. Refer to the Main Boiler Repair and Overhaul Manual for detailed procedures.

221-2.10 PRESERVATION OF SPARE TUBES.

221-2.10.1 PRESERVATIVE COATINGS. Each boiler tube intended for use in erecting or re-tubing of boilers shall be inspected for evidence of corrosion, sludge and preservative residue. Tubes shall be cleaned before installation. If tubes are not to be immediately installed, any corrosion must be removed and they must be protected against further corrosion by interim measures or re-application of preservative compounds. Preservative coatings are not normally re-applied in shipyards unless installation is delayed for a month or more or tubes are being returned to storage. Interim preservation could involve sodium nitrite passivation, the capping of ends and/or full length vapor barrier (plastic) wrapping or application of code-03 (see MIL Std-2073-1E, Appendix J) preservative coating depending on anticipated humidity, exposure to salt air and other corrodents. If any doubt exists about the severity of ambient conditions, a preservative coating must be re-applied. Tubes without a preservative coating, and all tubes scheduled for immediate installation, shall be stored indoors in a controlled environment. Tubes stored for use as spares shall be inspected for corrosion periodically. When corrosion is found, tubes shall be cleaned and preservative reapplied. Type code-19 and code-02 are rated for one year shed storage and limited outdoor storage. Code-03, which is non-drying and easier to remove, is rated for 6 months shed storage; it should not be used for outdoor storage. Additional information on the properties of preservative types can be found in MIL-PRF-16173.

221-2.10.2 PRESERVATIVE APPLICATION. Preservative coatings should be applied to tube exteriors by brushing, spraying, or dipping, and to tube interiors by dipping or spraying. Preservative compounds are applicable to various tube materials as follows:

- a. The interior and exterior of all tubes (except 18- Cr-8Ni (CRES) and 16Cr-1Ni (ferritic stainless steel) shall be kept protected with a coating of type code-02 preservative on the outside and type code-03 preservative on the inside (refer to [Appendix A](#)) while stored in the shipyard. code-19 or other preservative combinations may be used to prepare tubes for overseas shipment or long term storage.
- b. Tubes or tube assemblies of 18Cr-8Ni or 16Cr-1Ni require no preservative on the inside or the outside, but shall be properly sealed in vapor barrier material. 18Cr-8Ni tubes are sensitive to chlorides and caustic, and shall be stored in an area protected from weather and spillage, preferably in waterproof containers. All pre-fabricated tube assemblies should be stored in low traffic areas, protected from mechanical damage.

221-2.10.3 PRESERVATIVE REMOVAL AND WASTE WATER DISPOSAL. Preservative should be completely removed from tubes before installation in a boiler by boiling out in an alkaline cleaning solution containing sodium metasilicate. Solvents such as MIL-PRF-680 type II and MIL-PRF-1190H are also effective. MIL-PRF-16173, the specification for corrosion preventive compounds, requires testing for removability by MIL-PRF-680 dry cleaning solvent; type code-02, code-03 and code-19 preservatives are identified as grades 2, 3 and 4 respectively in this specification. However, in accordance with Navy HazMat policy, solvent use should be minimized when alternative cleaning methods are effective. Hot tank cleaning using proprietary powdered cleaner-degreasers containing sodium metasilicate, sodium carbonate, phosphates and other compounds have been employed in shipyards with good results. The 50/50 solution of sodium metasilicate and trisodium phosphate, discussed in [Appendix E](#) for boiling out, can also be used. If tubes cannot be completely immersed, a steam jet siphon can be used to draw the cleaner from a drum or bucket (refer to [Appendix E](#) for guidance and safety precautions). This hot mixture is applied to the interior and exterior of tubes. After cleaning, tubes should be rinsed with hot fresh water. Removal of preservative from a small number of tubes onboard ship (where hot tank cleaning facilities are not available) should be done by repeated wiping and dipping using MIL-PRF-680 type III solvent. All spent solvents and alkaline waste water must be disposed of in accordance with NSTM Chapter 593 requirements. Tube preparation must be carefully planned and scheduled to eliminate unnecessary and costly evolutions of preservation removal and re-application.

221-2.11 DRUMS AND HEADERS.

221-2.11.1 CRACKS AND DEFECTS. Refer to the Boiler Inspection Manual and the Main Boiler and Repair and Overhaul Manual for additional information on defects and deferral of repairs.

- a. Whenever a boiler is opened for inspection, boiler drums and headers should be carefully examined for evidence of cracking, with particular attention given to manhole knuckles, drum head knuckles, and nozzles. Any defects noted shall be described in the boiler water chemistry worksheet/log and the engineering log.
- b. When defects in nozzle connections to headers and drums cannot be repaired, they shall be replaced using joint configurations indicated in MIL-STD-22 and according to NAVSEA S9074-AR-GIB-010/278. For nozzle connections of 2-inch NPS and below, weld joints P-70 and P-71 of MIL-STD-22 shall be used.
- c. If blowdown piping is only being replaced, use original weld joint geometry for piping to nozzle connection.
- d. When inspections reveal defects in welds connecting superheater diaphragms or division plates to headers they shall be repaired according to the Main Boiler Repair and Overhaul Manual.
- e. Boiler drum exteriors shall be watched for indications of corrosion under the coverings. Any sign of rusty

streaks from the covering or corrosion around the covering edges or around the drum tubes or pads shall be investigated immediately. Where equipment or piping joints are located above the boilers, there is always danger that water will drop onto the boiler drums and find its way under the boiler covering, accelerating corrosion of the drum exteriors. All boiler drum exteriors are periodically inspected for external corrosion as part of the 5-year Strength and Integrity Inspection discussed in [paragraph 221-2.1.2.5](#). Whenever the drum exterior is exposed through removal of insulation or lifting of boiler casings, the condition shall be recorded in the engineering log.

[illegible]

OUTLET ↑			BOILER INSPECTION AND REPAIR MANAGEMENT INFORMATION SYSTEM TUBE SHEET			BOILER INSPECTION AND REPAIR MANAGEMENT INFORMATION SYSTEM TUBE SHEET															
46	-	-	-	-	46	MODEL: 40	MFR: CE	BANK: SUPERHEATER	REF: CE DWG E-173-440												
45	-	-	-	-	45	REF: CE DWG E-173-440															
44	-	-	-	-	44	REF: CE DWG E-173-440															
43	-	-	-	-	43	REF: CE DWG E-173-440															
42	-	-	-	-	42	REF: CE DWG E-173-440															
41	-	-	-	-	41	REF: CE DWG E-173-440															
40	-	-	-	-	40	REF: CE DWG E-173-440															
39	-	-	-	-	39	REF: CE DWG E-173-440															
38	-	-	-	-	38	REF: CE DWG E-173-440															
37	-	-	-	-	37	REF: CE DWG E-173-440															
36	-	-	-	-	36	REF: CE DWG E-173-440															
35	-	-	-	-	35	REF: CE DWG E-173-440															
34	-	-	-	-	34	REF: CE DWG E-173-440															
33	-	-	-	-	33	REF: CE DWG E-173-440															
32	-	-	-	-	32	REF: CE DWG E-173-440															
DIAPHRAGM					AD-41	REF: CE DWG E-173-440															
31	-	-	-	-	31	AD-42	REF: CE DWG E-173-440														
30	-	-	-	-	30	AD-43	REF: CE DWG E-173-440														
29	-	-	-	-	29	AD-44	REF: CE DWG E-173-440														
28	-	-	-	-	28	REF: CE DWG E-173-440															
27	-	-	-	-	27	REF: CE DWG E-173-440															
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18	-	-	-	-	18	REF: CE DWG E-173-440															
17	-	-	-	-	17	REF: CE DWG E-173-440															
16	-	-	-	-	16	REF: CE DWG E-173-440															
DIAPHRAGM					15	REF: CE DWG E-173-440															
15	-	-	-	-	15	REF: CE DWG E-173-440															
14	-	-	-	-	14	REF: CE DWG E-173-440															
13	-	-	-	-	13	REF: CE DWG E-173-440															
12	-	-	-	-	12	REF: CE DWG E-173-440															
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4	-	-	-	-	4	REF: CE DWG E-173-440															
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221-2.11.2 HANDHOLE AND MANHOLE SEAT MAINTENANCE. Handhole and manhole seat resurfacing or grinding shall be accomplished only when inspection and measurements indicate deterioration. Resurfacing and grinding are repair methods to correct deficiencies, not routine periodic maintenance tasks.

221-2.11.2.1 Handhole and Manhole Seat Repair Frequency. The following guidelines for the frequency of manhole and handhole seat repair shall be adhered to:

- a. Seats that allow hydrostatic test leakage in excess of that specified in [paragraph 221-2.16.6.5](#) shall be repaired. Boiler inspections during the ship operational cycle shall include measurements specified in [paragraph 221-2.11.2.3](#) only when handhole or manhole seats fail the hydrostatic test or seat repair is required because of defects such as linear indications.
- b. Handhole and manhole seats shall be inspected during the SOI/SAI inspection cycle by hydrostatic tightness test and visual inspection. Measurements according to [paragraph 221-2.11.2.3](#) shall be accomplished on seats that leak during hydrostatic test and on any other seats designated by the SOI/SAI inspector. Seats that fail the SOI/SAI hydrostatic test or have relevant defects shall be repaired.

221-2.11.2.2 Handhole and Manhole Seat Repair Criteria. Manhole and handhole seat grinding and resurfacing shall be accomplished according to the Main Boiler Repair and Overhaul Manual. [Figure 221-2-5](#) shows the location of minimum dimensions allowed before a handhole seat shall be built up to restore original thickness. The Repair and Overhaul Manual provides minimum handhole seat thicknesses for waterwall and superheater headers. Minimum thicknesses for economizer headers are not included in the Repair and Overhaul Manual. Use [Table 221-2-4](#) to determine minimum handhole seat dimensions for economizer headers and headers not specifically listed in the Repair and Overhaul Manual. Care shall be exercised to ensure that the minimum amount of metal is removed to obtain a satisfactory seat. This will allow several repair operations on a seat before weld build-up is required to restore seat taper/flatness. The addition of external header weldment as permanent repair to compensate for reduced handhole seat wall thickness is prohibited.

221-2.11.2.3 Handhole and Manhole Seat Repair Measurements. The handhole and manhole seat repair critical dimensions include seat flatness, wall thickness, minimum overlap and centered clearances (manway only). These measurements are usually taken during scheduled depot level availabilities in accordance with work specifications. The measurements must also be done following manhole cover renewal and following gasket failures in service. They need not be taken routinely when plates are removed, unless hydrostatic testing reveals a leakage problem.

- a. Taper is the slope of the seating surface across its width from the outer to inner edge. It is measured by holding a rigid template firmly against the seat's outer circumference and measuring from the template to the inner seat edge. This measurement and out-of-flatness measurement shall be performed according to the Main Boiler Repair and Overhaul Manual. Out-of-flatness shall be measured in the same manner as taper (template-to-seat inner edge), but represents a peak-to-valley height measurement. The maximum combined taper and out-of-flatness/waviness for handhole seat measured in this manner is 0.008 inch. Manhole seat surface out-of-flatness (combined taper and waviness) shall not exceed 0.012 inch.
- b. [Figure 221-2-5](#) shows handhole minimum wall (Dimension B) and seat thickness (Dimension C) measurements. Thickness measurements shall be taken at 90 degree locations, i.e., two (2) in the header axial direction and two (2) in the header cross-sectional plane. On round or semi-flattened round headers two (2) additional readings (B radial measurements) must be made as shown on [Figure 221-2-5](#). These minimum wall measurements must be taken with a point micrometer. Some round header handhole seats have original design external weld buildup (factory stress relieved) to increase wall thickness in areas adjacent to the seat. These weldments compensate for the machine cut of the seat and the contour of the header to provide adequate remaining wall thickness.
- c. The minimum overlap between handhole plate seating surface and header seating surface is 1/16 inch, when the plate is in its maximum misaligned position. If overlap is less than 1/16 inch, weld repair is required.
- d. The clearance between the shoulder of the manhole plate and the manhole must be determined when the plate is accurately centered. If clearance is greater than 3/32 inch then either the drum opening is oversized, or the manway plate shoulder dimension is undersized; see [Figure 221-2-6](#). Determine by measurement the source

of the excessive clearance. Oversized manway openings will require weld repair by an industrial activity. Undersized plates may be replaced or weld repaired by building up the inner edge of the shoulder. Except in an emergency, such welding shall be performed by an industrial activity in order that the plate may be stress relieved after welding and the welded surface refaced. If the manhole plate is so warped that the gasket seating surface cannot be machined to drawing specifications, it shall be discarded. Should the seating surface of the plate be ground down over 1/32 inch from its original thickness, the seating surface shall be built up by welding and restored to its original thickness or the plate replaced.

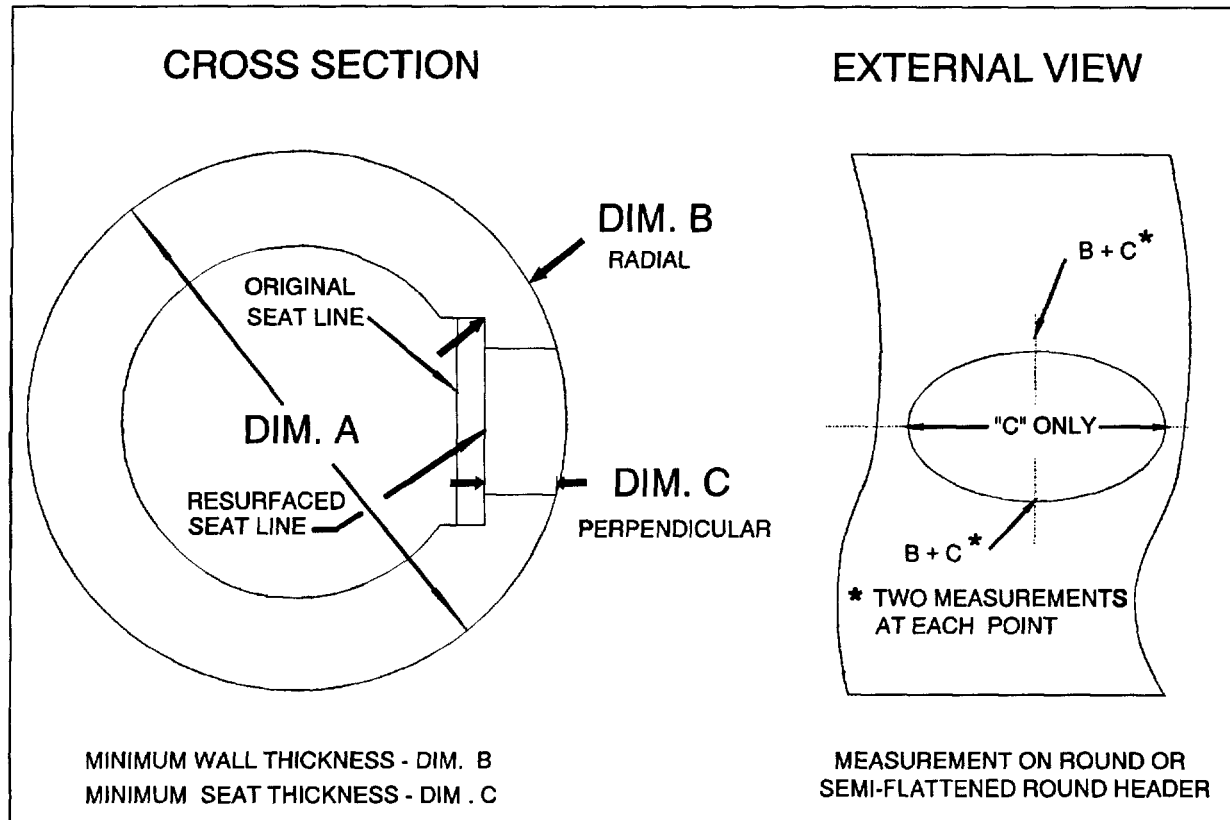


Figure 221-2-5. Handhole Seat and Wall Thickness Measurements.

221-2.11.2.4 Repair Qualifications. Personnel assigned to the repair of handhole and manhole seats shall be skilled in operating seat-grinding equipment and in the methods of taking seat measurements. Personnel refurbishing handholes must qualify for the refacing procedure on a header mock-up (with the equipment type to be used in accordance with Chapter 5 of the Main Boiler Overhaul and Repair Manual).

221-2.11.2.5 Repair Equipment Equipment used for seat resurfacing or grinding shall be checked before each issuance or repair application. The equipment spindles, air motors and extension arm pivots must be examined for wear by measuring shaft end play, wobble etc. as applicable to the machines being used. Tolerances must be such that the seat out-of-flatness requirements of 0.008 inch can be met.

221-2.11.3 HANDHOLE PLATE INSTALLATION. The procedure for installing handhole plates is as follows:

1. Clean and check seating surfaces on header and handhole plates. Use power-driven wire cup brushes on both seats to ensure that they are clean and free of any oxides. Cleaning should be done just before installing the handhole plate to minimize the time in which oxidation can occur.
2. Replace handhole plates that are nicked or badly scarred. Resurfacing seats is not permitted, nor is it cost effective.

3. Wire brush the threads on the handhole plate stud and nut, chase with die nut and apply a high temperature thread lubrication such as Molykote G. On superheater outlet headers graphite and oil or colloidal graphite should be used. High temperature thread lubricant should also be applied to the area between the convex washer and the strongback on Babcock and Wilcox handhole plates. This will aid in properly seating the handhole plate. No makeup compound or lubricant shall be used on the handhole seat or plate gasket surface.

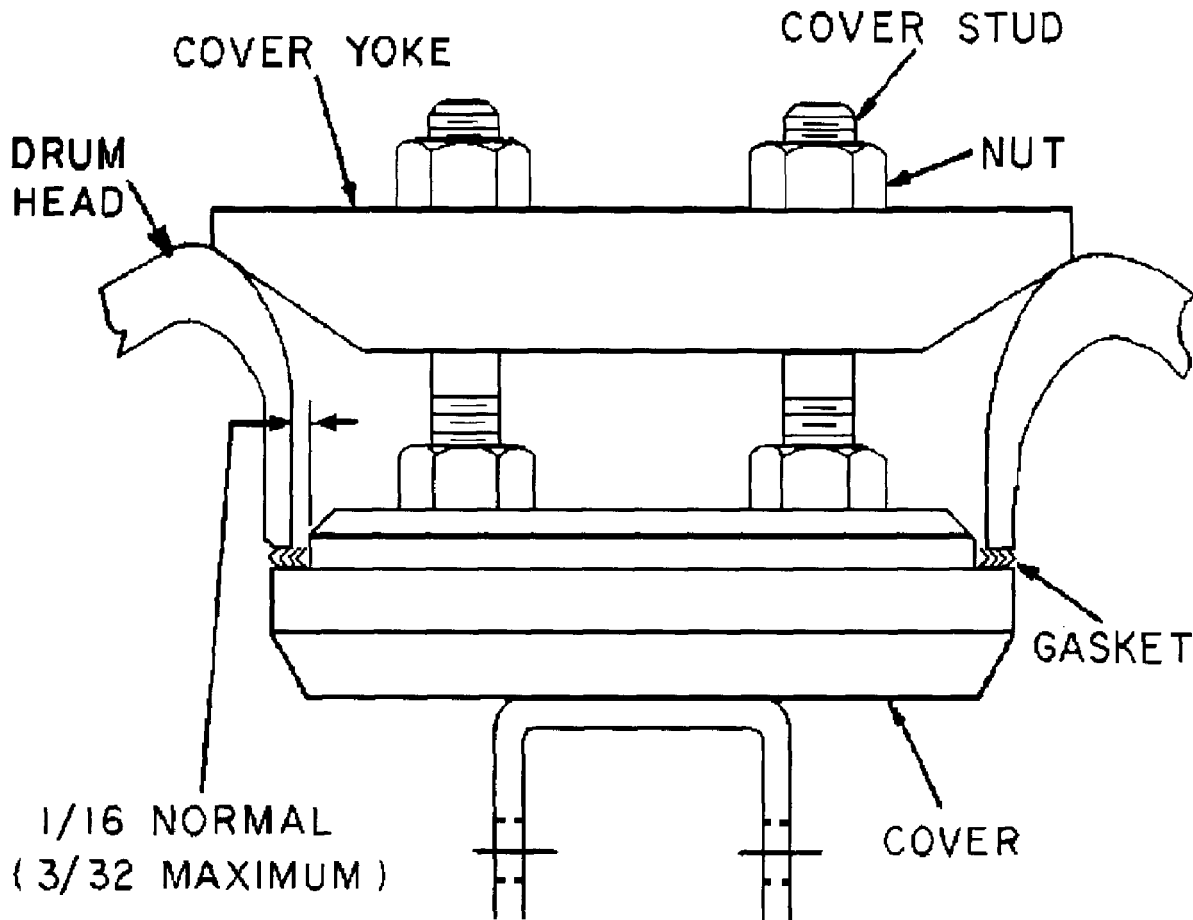


Figure 221-2-6. Manhole Plate Clearance

4. Because of gasket and plate manufacturing tolerances, some gaskets will fit over some plates easier than others; also for the same reasons some plates may pass through certain handholes easier than others. Various gaskets and plates should therefore be matched together until the best combination of fit is obtained. The plate then selected for a certain location should always be used at that location.
5. Do not force the plate through the handhole by hammering on it. The plate should be passed through the opening without the gasket. The gasket is then installed while the plate is held within the header.
6. Fit the gaskets to the plate, rejecting any that are so wide that the gasket bearing surface overhangs the edges of the plate.
7. With the plate and gasket in position, the plate should be rocked slightly to make certain it is seating evenly against the handhole seat and is not hung up. Hold it snugly in this position while placing the arch bar washer and nut on the stud.
8. Tighten the nut 1/2 flat beyond finger tight before filling the boiler for hydrostatic test.

9. Fill boiler and observe for leakage. On leaking plates, loosen nuts just enough to assure the gasket is no longer loaded and reseal the plate with hammer taps. Re-tighten nuts no more than (1) flat beyond finger tight.
10. Apply the hydrostatic tightness test according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#). Newly renewed handhole gaskets do not have to be replaced following a 150% hydrostatic test, provided that the gasket sets in a fully recessed seat that supports the periphery of gasket 360 degrees around its perimeter.

NOTE

Some square headers, per the boiler manufacturers' drawings, have a round gasket seat that does not support an oval gasket along the long axis sides. When these seats are ground with a machine that follows the handhole shape the resultant seat will adequately support the gasket.

Gaskets shall be renewed following the second 150% hydrostatic test. Any gasket that does not set in a fully supporting recessed seat (3/32 inch minimum) or that has an unknown hydrotest history shall be replaced after the first 150% test.

CAUTION

For elevated pressure hydrostatic tests above 100%, aimed at verifying integrity, the handhole plates should be checked at 100% pressure to verify that there are no leaks sufficient to prevent the reaching of the ultimate hydro pressure because of exceeding the pump capacity. Personnel must not enter a boiler and assist handhole plates in sealing at elevated pressures, if the boiler integrity has not been first verified.

11. While building up hydrostatic pressure, additional taking up on the nut by hand will be necessary. The pressure loading on the gasket is increased with the increase in hydrostatic pressure. Hydrostatic pressure should be increased slowly (that is, approximately 100 psi per minute).
12. Examine joints continuously while raising hydrostatic pressure. Leaking joints may be tapped to assist in seating the handhole plate up to a hydrostatic pressure of 100% hydro pressure. If gross leakage continues above 300 psig hydro pressure, hydro pressure should be relieved and cause of leakage investigated.
13. When the hydrostatic pressure reaches 100 percent boiler operating pressure, the pressure loading on the gasket is nearly sufficient in itself to provide a satisfactory seal. The final tightening of all fittings with a handhole wrench shall be accomplished by loosening the nuts just enough to assure the gasket is not loaded. Then, the nut is retightened on (1) flat beyond finger tight. Excessive tightening or using a hammer to drive the wrench will result in over compression and ultimate failure of the gasket. Any leakage occurring after the above procedure has been followed is due to an improperly fitted gasket or plate installation, or defect(s) in the seat. Refer to [paragraph 221-2.16.6.5](#) for leakage criteria.
14. When hydrostatic test pressures are to be applied that are higher than the 100 percent maximum operating pressure test for tightness, the highest hydrostatic pressure will be applied first. Only after the higher hydrostatic tests have been satisfied will the final tightening of the handhole plate (one flat beyond finger tight) be accomplished at the 100 percent maximum operating pressure. This will apply up to 150% hydrostatic tests, provided that the gaskets meet the criteria of [step 9](#) for not requiring gasket renewal.

221-2.11.4 MANHOLE PLATE AND GASKET INSTALLATION. Manhole plates and gaskets shall be installed according to the following procedures. Gaskets to be used must meet requirements of [paragraph 221-2.11.5](#).

1. Wire brush the threads on the manhole bolts and nuts, chase with a die nut, and apply a high temperature thread lubricant such as Molycote G.
2. Clean and inspect gasket seating surfaces of both drum and manhole cover. Do not attempt to install gasket if defects exist or dirt particles are adhering to the surfaces.
3. Install a new gasket on the manhole cover. If the gasket aperture dimensions and manhole cover shoulder are within specified tolerances, no special provisions should be required to hold the gasket in place.
4. The outer edge of the bearing face of the gasket shall not protrude at any point beyond the cover: nor should the gasket overhang the seating surface in the drum head. On flued in heads, have a second person enter the drum and temporarily close the cover to observe whether the gasket will extend beyond the drum head seat. When inspection of the joint has been completed and final closure is approved, re-verify the seating surfaces are clean and pull the cover into the fully closed position. While supporting the cover in a centered position, install the yoke and bolt assemblies.
5. Tighten nuts alternately. Graphite filled spiral wound gaskets require less torque than the previous asbestos type to achieve nut rotation. Nuts must be tightened two (2) flats beyond the point where pressure is being applied to the gasket.
6. Fill the boiler and apply hydrostatic test pressure. As pressure approaches 300 psi, tap the cover if necessary, to obtain complete gasket seating and minimize leakage. When 100% of operating pressure is reached, re-tighten the nuts finger tight if found to be loose. Then re-tighten the nuts one (1) flat beyond finger tight. If leakage exists; disassembly, gasket renewal and seat inspection will be required.

221-2.11.5 HANDHOLE AND MANHOLE GASKETS. Spiral wound gaskets in accordance with MIL-G-15342 and Navy Standard Drawing 803-5959278 are prescribed for main boiler handholes and manholes. Use of non MIL-SPEC. gaskets is prohibited except as noted below for auxiliary boiler manholes. Procurements made outside the supply system by government activities or contractors must invoke the specification.

221-2.11.5.1 APPLICATIONS. All gaskets for current fleet applications are 0.175 +/- 0.005 inch thick. Propulsion boiler manway gaskets have been standardized to the 3/4-inch seat width type, and are suitable for use up to nominal 1200 psi service. The 1/2 inch wide gaskets available should only be used up to nominal 600 psi service on applications where narrow seat width necessitates or for auxiliary boilers where ease of compression is desired. However, a commercial mica-graphite 15/16 inch wide manway gasket, specified by the OEM, is preferred for auxiliary boiler use (refer to [Appendix A, Table 221-A-1](#)). Handhole gaskets of sizes used in 1200, 600 and 150 psi service are only stocked in the highest pressure (1200 series) version to avoid mix-up. The higher rated handhole gaskets are suitable for all applications.

221-2.11.5.2 BOILER GASKET INSPECTION. All identifying packing, shipping forms and other records received with gaskets must be retained until gaskets are inspected shipboard and, if necessary, a Report of Discrepancy (ROD) (formerly product Quality Deficiency Report (QDR)) is filed in accordance with NAVSUPINST 4400.189. The screening point for ROD is NAVICP Mechanicsburg, Code 10422. Reports can be filed via SALTS (Streamlined Automated Logistic Tool Set) or at the NAVICP web site. Gaskets shall be inspected in accordance with the standard drawing requirements in the following areas prior to use:

- a. Thickness and width measurements.
- b. Verify that the number of metallic (CRES) plies and number of graphite filler plies exceeds minimum number shown on the standard drawing.

- c. Check that shape corresponds to plate shape and gasket ID fits properly on plate shoulder. Check that gasket does not overhang the plate seating surface.
- d. Verify starting and stopping locations of spiral windings are at correct positions. (180 degrees apart on hand-hole gaskets; 90 degrees apart on manway gaskets. Reject gaskets with windings that start and stop at the same location.)
- e. Verify correct number and location of spot welds on inner winding and at end of outer winding. Three spot welds are required at start and end of winding. An additional 6 welds are required on opposite sides of the manhole gasket inner winding.
- f. Check graphite filler ply surface for defects (gaps through thickness) and cuts or scratches fully across seat.

Table 221-2-4. Economizer Header Handhole Seat Minimum Wall Thickness¹

Boiler Manufacturer	Header Size Dimension A (Inches) (See Figure 221-2-5)	Minimum Wall Thickness Dimension B or C (Inches) (See Figure 221-2-5)
700 PSI Designed Boilers and Below		
Babcock and Wilcox	All headers	1/4 or 0.250
Foster Wheeler (See Note ²)	All headers	1/4 or 0.250
Combustion Engineering	12.75 round	3/8 or 0.375
	12.00 round	1/2 or 0.500
	10-3/4 round	3/8 or 0.375
	9-3/8 oval	
	8-5/8 round	
	7-1/4 square	
	6-3/4 6-7/8 sectional (3/4 thick design)	
	6-3/4 6-7/8 sectional (9/16 thick design)	1/4 or 0.250
6-5/8 round		
5-9/16 round		
1,300 PSI Designed Boilers		
Babcock and Wilcox (See Note ³)	All headers	3/8 or 0.375
Foster Wheeler (See Note ²)	All headers	1/4 or 0.250
Combustion Engineering	7-3/4 oval square	7/16 or 0.438
	8-3/8 oval square	5/8 or 0.625
	12-3/4 round	9/16 or 0.563

¹This table provides minimum wall thickness values for economizer headers and waterwall headers not specifically listed in the Repair and Overhaul Manual.

²In square headers, where Dimension B is not applicable, Dimension C should be 7/16 or 0.438 inches.

³In headers with external weld reinforcement around handholes, both Dimension B and C shall meet the minimum thickness requirement.

221-2.11.6 DESUPERHEATER. Modern controlled superheat boilers are furnished with internal desuperheaters to provide auxiliary steam for various purposes in the steam plant. The desuperheater inlet should have a stop-check valve equipped with a locking device or lock and chain that keeps the valve locked open during normal boiler operation. The check feature prevents reverse steam flow should the auxiliary steam line pressure be above the desuperheater outlet pressure (This condition can occur when a boiler is placed on the line with other boilers in the system already operating). The stop-check valve also isolates the desuperheater for hydrostatic testing. If a boiler displays evidence of chemicals in desuperheated steam samples or losses in boiler water conductivity, Ph, phosphate, or chloride per NSTM Chapter 220, Volume 2, check the gasketed flange area of the desuperheater tube nest inlet and outlet flange within the boiler drum that houses the desuperheater. When a boiler cannot raise or maintain proper auxiliary steam outlet pressure, especially after welding repairs have been made near the desuperheater inlet stop-check valve, inspect the internals of the stop-check valve for warpage or malfunction that would result in an excessive pressure drop across the valve. In an emergency the damaged valve internal components may be removed to steam the boiler.

221-2.11.6.1 Desuperheater Materials. The desuperheater assembly, including tubes and tube flanges or headers, shall be fabricated from 16-percent chromium and 1-percent nickel alloy steel according to the boiler spec (MIL-B-18381).The chemical composition and properties shall be as follows:

- a. Carbon - 0.035 maximum
- b. Manganese - 1.00 maximum
- c. Silicon - 0.75 maximum
- d. Chromium - 14.0 to 16.5
- e. Nickel - 0.80 to 1.50
- f. Sulfur - 0.030 maximum
- g. Phosphorus - 0.030 maximum
- h. Elongation in 2 inches (minimum) - 20 percent
- i. Tensile strength minimum - 60,000 lb/in²
- j. Yield point minimum - 35,000 lb/in²
- k. Hardness - 207 BHN or R 95 maximum.

221-2.11.6.2 Replacement Material. The replacement material for desuperheater thermal sleeve liners shall be according to ASME SA-213 type 321, 347, or 348 material.

221-2.11.6.3 Protection During Acid Cleaning. Desuperheaters shall be removed from boilers before cleaning the boiler with acid. Refer to the Main Boiler Repair and Overhaul Manual for procedures to protect the remaining alloy components that are not removable.

221-2.11.7 PIPING AND VALVES. Piping from the boiler steam and water drums waterwall header, screen headers to the first or most proximate blowdown valve of the boiler, and drain and vent piping from the drums and headers to the first valve, shall be considered part of the boiler pressure vessel. Pressure vessel blowdown piping shall be inspected in accordance with PMS and the boiler Inspection Manual. All blowdown and drain piping beyond the pressure vessel blow, drain, and vent valves shall be inspected to ensure compliance with NSTM Chapter 505. When performing Ultrasonic Inspections, use the requirements and techniques contained in NSTM Chapter 505 and the General Specifications for Overhaul Section 505, as applicable.

- a. When inspection indicates an unsatisfactory material condition or when thinning or pitting has reduced the remaining wall thickness, replacement action shall be considered. For 1-1/2-inch pressure vessel piping the following applies:
 - 1. 600 psi (and below) boilers - When thinning or pitting reduces the wall thickness to 0.115 inch replace the piping at the next availability, but no later than 12 months from the date of inspection. When the wall thickness has been reduced to 0.090 inch, replace the piping before pressurizing the boiler.
 - 2. 1,200 psi boilers - When thinning or pitting reduces the wall thickness to 0.130 inch, replace the piping at the next availability, but no later than 12 months from the date of inspection. When the wall thickness has been reduced to 0.110 inch, replace the piping before pressurizing the boiler.
- b. For pressure vessel piping less than 1-1/2-inches, including sample cooler, drain and vent piping use the replacement criteria in the NSTM Chapter 505 Table for Soot Blower and High Pressure Steam Drain Piping.
- c. Complete replacement piping shall be carbon steel schedule 80 except for superheater drain and fill piping, which should be in accordance with class drawings and requirements of MIL-STD-777. Replacement of piping shall be from nozzle to valve. Partial replacement of pressure vessel bottom blow piping is permitted as follows:

1. Nominal 1,200 or 600 Psi System built or modified to conform to NAVSEA standard drawing 803-841773 which requires MIL-STD 22, P-73 Butt Joints. Preferred replacement shall be schedule 80 carbon steel piping per MIL-P-24691/1 Grade B (formerly MIL-T-20157 Type E) or ASTM A-106 Grade B from valve to header nozzle. When partial replacement is necessary it shall extend beyond any corroded area to where the pipe has a minimum of 0.150 inch remaining wall. Replacement section joints shall be in accordance with MIL-STD 22, P-73; all additional joints (associated with partial renewal) shall be located within the boiler casing/skirts where applicable. The replacement section shall be the same nominal size, schedule, and material as the existing piping in order to avoid high stress areas and formation of corrosion products caused by discontinuities in wall thickness.
2. Existing 600 Psi Systems that contain socket welded fittings in accordance with class construction drawings.

NOTE

This group only includes 600 psi ships constructed with MIL-STD 22, P-14 joints and on which no SHIPALTS have been accomplished to upgrade to standard drawing 803-841733 requirements.

600 psi socket welded systems may have pipe sections renewed between fittings as long as the entire section between the fittings is renewed. Replacement piping shall be equivalent to the schedule of the adjacent piping sharing a common fitting. When boundary socket weld fittings are to be re-used they must be inspected for adequate remaining wall in both the body and socket area. These wall thicknesses and the socket depth ("J" dimension) must meet minimum ASME B16.11 forged fitting requirements; this is J = 0.50 inch socket depth for a 1-1/2 inch fitting. Only 3,000 psi rated replacement fittings shall be used (bored out for SCH 40 where required to eliminate a discontinuity on the ID). Pipe adjacent to elbows and tees that is to remain in service shall be UT scanned within three feet of the fitting to assure it has not been thinned by erosion related to abrupt change in flow direction.

- d. Blowdown and drain areas where piping penetrates through casings shall be carefully checked for thickness reduction. If welded casing penetrations are currently used, replace them with approved expansion joints, consulting NAVSEA drawings 804-6397303 for blowdown piping and 200-4603889 for drains and vents.
- e. If inspection of drain piping indicates steam or water impingement on boiler blowdown piping or valves it shall be the basis for corrective relocation. Where drain piping to bilges, tank tops, and funnels is found to be long enough to fall below the waterline of such areas, shorten the piping. Drains of excess length into bilge water can result in this contaminated or relatively cool water being drawn into the boiler as a secured boiler cools and may cause shock in superheater headers. Unless specifically authorized by the LCEM (NSWCCD-SSES Code 922), and NAVSEA, blowdown and drain valves shall be located, or relocated as necessary, as close to the boiler as possible to minimize the length of the boiler pressure vessel section; but, they shall also be located so that they can be operated safely from the floor plate or grating levels without the use of long-arm-reach tools, universal joint, or bevel gear box extensions. Careful attention shall be given to this last requirement when planning and laying out replacement blowdown piping and blow valves. Where surface blow valves are located at the end opposite the boiler gauge glass they shall not be relocated to the gauge glass end of the drum. Such action increases the length of exposed boiler pressurized piping.
- f. Surface and bottom blow piping and the respective surface blow valve and bottom blow valves that make up the boiler pressure vessel are to be made of carbon steel piping and flanged valve bodies. For replacement purposes blow piping shall be 1-1/2-inch schedule 80 carbon steel piping (alternative, schedule 160). Monel piping and valves that may be used in the blowdown system downstream of boiler blow valves are not to be used in the pressure vessel area. Replacement surface and bottom blow valves shall be according to MIL-V-17737.
- g. All header bottom blow stop valves shall be operated with T-handle wrenches. Steam drum surface blow

valves shall have handwheels. Water drum bottom blow valves with tee wrench operators are permitted where the deck grating is too far above the valve to permit adequate handwheel operation or where local obstructions prevent access.

221-2.12 WELDING REPAIRS.

221-2.12.1 The primary documents that shall be invoked in boiler repairs, including applicable weld repairs, are NAVSEA S9074-AR-GIB-010/278 and the Main Boiler Repair and Overhaul Manual.

221-2.12.2 **WELDING REQUIREMENTS AND WELDER QUALIFICATIONS.** Welding shall be performed on the boiler (including superheater and economizer) drums and headers only by welders qualified for the applicable welding process, filler metal, and position of welding as specified by NAVSEA S9074-AQ-GIB-010/248 and the Main Boiler Repair and Overhaul Manual NAVSEA S9221-C1-GTP-010.

221-2.12.3 **ECONOMIZER HANDHOLE PLATE WELDING.** Weldable design economizer handhole plates may be seal welded. Seal welding economizer handhole plates is considered a permanent repair. To facilitate inspection and drying of economizers, arbitrary seal welding of handhole plates is discouraged. A minimum of two handhole plates per header, to include one at each end, shall be left unwelded. Weldable design handhole plates can be requisitioned from the supply system. Welding procedures for handhole plate seal welding and handhole plate seal weld removal information is found in the Main Boiler Repair and Overhaul Manual.

221-2.12.4 **LARGE DIAMETER TUBE SEAL WELDING.** When seal welding large diameter tubes (3-inch OD and greater) is required per [paragraph 221-2.9.4](#), the following procedure applies:

1. Ensure that the tubes are properly expanded according to the detailed procedures in the Main Boiler Repair and Overhaul Manual.
2. Apply a 125 percent hydrostatic test according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#).
3. If leakage from the joint exceeds five drops per minute and cannot be corrected by rerolling, replacement of the tube or a portion of the tube is required. Such leakage is considered serious and indicates a basic deficiency, such as a split tube.
4. The seal weld between tubes and drums shall be a fillet weld at the inside of the drum. After milling off the flare on the tube end (if present), the fillet tube weld shall be made between the drum and the tube. The seal weld between tubes and headers shall be a fillet weld at the outside of the header. The weld shall have a 3/8-inch throat, shall comprise at least three beads and shall be made by a qualified welder. Welding shall be according to NAVSEA S9074-AR-GIB-010/278. Pay particular attention to the materials being welded. All welding beads shall be inspected by MT to ensure sound welds. Particular care should be taken in the first and last passes. Do not re-roll after welding.

NOTE

Stress relief is not required after large diameter tube seal welding.

5. When replacing large diameter tubes, apply a 150 percent design hydrostatic test according to [paragraph 221-2.16](#) through [paragraph 221-2.16.6.6](#). During the subsequent 125 percent hydrostatic test, the joint should be dry.

6. If only seal welding or repair to seal welds has been accomplished, apply a 125 percent hydrostatic test and ensure that the joint is dry.

221-2.12.5 INSPECTION AND REPAIR OF SEAL WELDS. Inspection of large diameter tubes and seal welds shall be made whenever the Engineer Officer deems it necessary and at least at every Boiler Strength and Integrity Inspection (refer to [paragraph 221-2.1.2.5](#) and [221-2.4.3](#)) for information on Strength and Integrity Inspection. To ensure that the weld is sound and that no incipient cracks are present, each seal weld on the downcomers shall be inspected visually and, if defects are found, MT or PT shall be performed. If cracks are discovered in the seal weld or adjacent material, the old weld or affected portion shall be chipped or ground out, the basic metal of the header and tube shall be tested by the MT method for any possible remaining cracks, and the tube shall be re-welded. If cracks are found in the tube, it shall be replaced unless the cracks can be ground out in the portion of the tube protruding beyond the weld. If cracks are found in the basic metal of the header or drum, they shall be ground down and removed until sound metal is reached and repaired. After any repairs to the seal weld or renewal of downcomers due to this inspection, hydrostatic testing shall be according to [paragraphs 221-2.16 through 221-2.16.6.6](#).

221-2.13 CASINGS.

221-2.13.1 Two general types of casings are used on Naval boilers:

- a. **Single Casing (with wind box).** In the design and construction of single-casing boilers, a wind box is employed. Air discharged into a single box surrounding the burners provides combustion air (forced draft) for the boiler.
- b. **Double Casing (air-encased boiler).** In double-casing or air-encased boilers, forced draft blowers provide air (through ductwork) directly into a casing surrounding the boiler. This arrangement materially reduces the noise level in firerooms. Furthermore, in air-encased boilers, some heat lost through radiation from the inner casing is recovered. The inner and outer casings of air-encased boilers are constructed of steel panels, either welded or flanged, and bolted together with gaskets. Removable bolted access doors are provided as required.

221-2.13.2 IMPORTANCE OF TIGHT CASINGS. In a single-casing boiler, any leaks allow boiler gases to escape into the fireroom, resulting in a hot and dirty fireroom with soot accumulations. In a double casing boiler no boiler gas can leak into the fireroom, but air leaks are equally undesirable, for the following reasons.

- a. Air leaks into the fireroom through the outer casing reduce the air available for combustion, requiring increased forced draft fan output.
- b. Since the air in the double casing is at higher pressure than the gases in the boiler, air tends to leak through the inner casing into the boiler, with several serious results:
 1. Air leaking through boiler casings does not become mixed with the fuel and, therefore, does not aid in combustion. On the contrary, it has a decidedly chilling effect on both the combustion gases and the heating surfaces. No air should enter the boiler at any place except through the air registers and the soot blower scavenging air system. Every effort shall be made to make boiler casings airtight. This is a serious source of efficiency loss.
 2. Since this air does not assist combustion, this leak also requires increased forced draft fan output.
 3. Since leaks cool the boiler gases, stack gas temperatures will be falsely low, leading to an incorrect assumption that efficiency is high.

4. Gas-analysis instrument readings cannot be depended on to determine optimum combustion when boiler casings are not airtight.

221-2.13.3 CASING INSPECTION. Refer to the Boiler Inspection Manual for detailed procedures. An inspection of the boiler casing and insulation envelope should be conducted at periodic intervals as directed by PMS requirements. The following general inspection should be carried out under cold iron conditions.

1. Inspect the outside insulation for oil soaking, damaged sections, missing clips, and damaged sheathing. Replace and repair as necessary.
2. Remove casing doors as needed to gain access to the space between the inner and outer casing.
3. Inspect the casing tie bars for deterioration and the securing nuts for tightness.
4. Inspect the inner casing for thinning, discoloration, or other evidence of overheating. If an overheated area is found it may indicate failure of furnace side brick or insulation. Inspect the furnace area for brickwork integrity.
5. Check superheater doors for tightness, door clamps, nuts, and studs. Check for the presence of soot, which would indicate gas leakage. At these leakage areas, remove door(s) and check frame edges for warpage. Also, check the condition of sealing gaskets. Repair and replace as necessary if it is within the capability of the ship's force to do so or record it for repair during availability or overhaul.
6. Remove the outer and inner casing doors of the economizer.
7. Examine packed-type outer doors for deterioration. Examine sealing gaskets for warped or bent edges that might cause leakage. Examine the condition of inner door gaskets. Examine the integrity of clamps, studs, and nuts for both inner and outer casings. Examine the insides of structural for deterioration. Repair them if it is within the capability of ship's force to do so or record for repair during availability or overhaul.

NOTE

Sections requiring repair in the inner casing which are in contact with combustion gases (i.e. furnace and cavity access frame) and operate at temperatures in excess of 370° C (700° Fahrenheit) shall be made from corrosion resistant steel, type 300 series in accordance with ASME SA-240.

8. Remove boiler front door(s), furnace side outer and inner doors, and air inlet section uppermost outer door(s) to gain entry to these spaces. Carry out steps three through five as applicable.
9. Inspect casing expansion joints (bolted, bellows, or packed).
10. Inspect the brick pan for over heating and corrosion. If such evidence exists, check the boiler floor refractory.
11. If the casing shows signs of warping, buckling, or twisting that cannot be attributed to overheating, check and repair the boiler expansion provisions (sliding feet, saddles, bellows joints, packed joint).
12. The casing frames should be carefully inspected for cracks, especially in corner sections. Cracks should be repaired, if practical, and reinspected at intervals for re-cracking. Evidence of re-cracking may indicate an expansion problem; details should be reported to NSWCCD-SSSES.
13. LHA-1/LHD-1 Class Windbox Baffles. Most LHA-1/LHD-1 Class boilers have flow redirection baffles installed between the inner and outer casing at the entrance to the boiler front casing windbox area and circumferentially around each burner. Flow baffles equalize air flow to each burner, improving combustion. Baffles are fabricated from perforated (5/8" holes) steel plate and are installed using bolted and tack welded

support clips so that they are portable. Loose baffles and excessive gaps should be repaired prior to operating the boiler. Baffles should be installed, inspected and repaired in accordance with following drawings: NAVSEA 221-7379524D (LHA) and NAVSEA 221-7379540A (LHD).

221-2.13.4 STEAM SMOTHERING PIPING. The General Specifications for Ships and General Specifications for Overhaul (Section 555) provide detailed requirements for permanently fitted steam smothering lines in the bottom outer casing or skirt of air-encased boilers. The steam smothering piping located inside the boiler air casing shall be visually inspected at each boiler cleaning. Particular attention shall be given to the condition of the line in the casing, beneath the boiler, because of its importance in the event of a casing fire.

Ends of the steam smothering piping should be equipped with loose fitting tapered plugs, retained by cotter pins, for maintenance ease. The general configuration of the boiler steam smothering system is shown in [Figure 221-2-7](#).

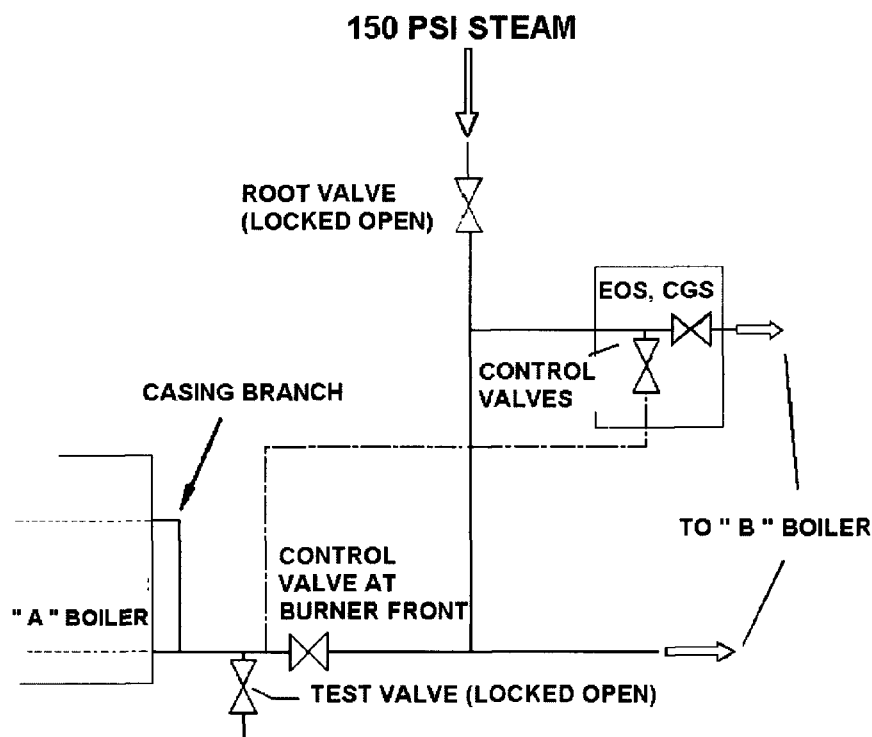


Figure 221-2-7. Typical Piping Diagram for Propulsion Boiler Steam Smothering

221-2.13.5 STOPPING CASING LEAKS. All boiler casing joint seams should be made up with gaskets and sealing compound as required by the boiler design. In the event that the casing door edges become slightly warped (from age and service), an improved seal can be obtained with the use of a tadpole type sealing gasket. This gasket has a cross section with a raised lip on one side. Leaks in seams be closed by caulking with an approved joint sealing compound. Approved compounds are nonflammable and can withstand a temperature of approximately 290° C (550° F) and still retain a limited amount of plasticity. [Appendix A](#) lists the stock numbers of both flat and tadpole type casing gasket material, and the joint sealing compound.

221-2.13.6 CASING MAINTENANCE. The casings, brickpans, and other exterior parts of boilers shall be kept free of scale and rust, well protected with paint, as described in succeeding paragraphs, unless made of CRES, and kept as clean and dry as possible. CRES casings shall not be cleaned with abrasives or acids. They shall occasionally be wiped off with oil.

- a. Air spaces in air encased boilers, uptake enclosures, and the air duct and casing of forced draft systems shall be examined frequently and any accumulation of dirt and rust shall be removed.
- b. The paint used on casings shall be heat-resistant aluminum-silicon paint (refer to [Appendix A](#)). When boiler casings, bilges, double bottoms, and bulkheads in firerooms are scaled and painted, paint shall be put on as soon as the surface is scaled to avoid oxidation. Rust under the paint causes the paint to blister or peel off. Bilges, double bottoms, and bulkheads shall be painted according to the requirements of NSTM Chapter 631, Preservation of Ships in Service (Surface Preparation and Painting). These requirements shall also be followed strictly when painting any boiler. CRES casings shall not be painted; instead, they shall be kept clean and dry.
- c. After every extended period of steaming, the wind box casing should be inspected for the presence of fuel oil, and any accumulation should be wiped up.
- d. Millboard (1/4 inch or 1/2 inch) is used between some inner and outer casings of most boilers to reduce heat loss. Replace with SPROULE WR-1200 (refer to [Appendix A](#)) thermal block insulation (expanded perlite).

221-2.13.6.1 Encapsulating Asbestos Millboard. An encapsulating procedure shall be used as an alternative to removal/replacement of asbestos millboard.

NOTE

Due to the high temperature of drums and headers, coating material shall not be applied to these surfaces.

CAUTION

Comply with safety precautions of OPNAVINST 5100.19 Volumes 1 and 2.

CAUTION

The encapsulating material may irritate skin, and should be washed off at the first opportunity. Contact with eyes must be avoided and should be treated by rapid and thorough washing. If swallowed, induce vomiting and seek medical advice.

1. Preparation. All surfaces to be treated must be clean and dry. Excessive dust, and oil or similar contaminants should be removed. A careful inspection of the surface should be made to detect signs of damage or defects. All repairs should be completed before application may proceed. If the millboard to be coated is intact, the encapsulant, Polarof Firegard (Refer to [Appendix A](#)), shall be sprayed or brushed on. Apply two coats. If the millboard is frayed or loose, a surface primer, Polaprime II (refer to [Appendix A](#)), shall be brushed on followed by two coats of encapsulant, also brushed on. Porous surfaces shall be primed with Polaprime II.
2. Application. When preparation is completed and primers are thoroughly dry, a uniform coating of Polarof Firegard is applied by brush, roller, or airless spray onto a smooth surface at a rate of one gallon per 180 square feet. When this coat is dry, a second coat may be applied at a rate of 90 square feet per gallon. If fabric is required for additional reinforcement, it should be incorporated into this coat while wet. Fiberglass mesh cloth may be used. The overall coverage equates to one gallon per 60 square feet at a wet film thickness of 25 mils. The drying time is from 1/2 to 1-1/2 hours touch dry, from 2 to 6 hours thorough dry, depending upon temperature and humidity.

3. Cleaning of Equipment. Cleaning of tools and equipment may be accomplished with water while still wet. If the material has dried, a suitable cleaning solvent may be used.

221-2.13.6.2 Replacing Asbestos Millboard. If it is deemed necessary to replace asbestos millboard, the recommended replacement material is SPROULE WR-1200 (refer to [Appendix A](#)) thermal insulation which is composed of a fine grade perlite and sodium silicate binder. Material can be installed essentially in the same manner as asbestos millboard. The standard size suitable for windbox areas is 1 inch thick by 1 inch by 36-inch sections. Sections of perlite should be installed over existing fasteners. A light gauge metal sheathing shall be installed over the perlite block to retain it in position and to protect it from erosion. Do not substitute for recommended material without NSWCCD-SSES/NAVSEA approval.

221-2.13.7 CASING LEAK DETECTION. Leakage shall be detected by closely examining the entire boiler exterior while the boiler is steaming at 50 to 75 percent full power capacity. Areas that shall be closely examined are scorch marks, bolted joints, removable panels, and corners. Using the back of a bare hand held 6 inches from the casing, identify any draft indication on the hand and mark it either on a drawing or sketch of the boiler or on the casing with chalk. These areas shall be repaired at an appropriate downtime, availability, or overhaul. After repair of these areas or if the casing gaskets have been replaced, the above test may be used to determine if the affected areas are now satisfactory. Spraying or brushing liquid soap on questionable areas may be used as a leakage detector, but this kind of search is not to be used as a quantitative device.

221-2.13.8 UPTAKES AND STACKS. Uptakes and stacks shall be inspected and maintained according to the following:

1. Repair all leaks around the base of stacks that allow water to enter the boiler casing.
2. Scrape and wire brush the interior, take care to prevent rust and soot from falling into the tube nests. Carefully examine expansion joints to see that they are free of soot, rust, and corrosion. Expansion joint seals should be removed permanently, because their use is being discontinued. Flow liners in non-metallic, composition, type expansion joints shall not be removed. Flow liners on some LHA-1 and LHD-1 Class uptakes have been removed as a test. Do not replace without NSWCCD-SSES 922 approval.
3. Stack rain gutters shall be examined at each fireside inspection and, if necessary, cleaned to remove soot accumulations and to assure that the drains are not plugged. Failure to inspect drains and allowing drains to become plugged will cause the gutters to rapidly deteriorate. If drains plug repeatedly consideration shall be given to increasing the drain piping size and to modify sharp bends that cause blockage.
4. Stack covers shall be kept on idle boilers to keep moisture out of uptakes and boiler firesides. When circumstances prevent the use of covers on idle boilers, the Engineer Officer will require fireside examinations daily (or more frequently if weather conditions warrant) to check for moisture. If moisture is present, action shall be taken to dry boiler firesides.

221-2.14 REFRACTORY AND INSULATION.

221-2.14.1 The object of lining a boiler with refractory material is to protect casings and pressure parts, such as drums and headers, from the intense heat of high temperature gases and flame. Baffles and corbels act to direct or deflect combustion gases toward a desired flow pattern or away from a specific area.

221-2.14.2 REFRACTORY LINING LIFE FACTORS. The life of the lining is influenced primarily by:

- a. Quality of installation, including refractory anchoring
- b. Service environment
 - 1. Sustained high furnace temperature
 - 2. Rapid changes in temperature
 - 3. Panting and vibration (refer to [paragraph 221-4.18.15](#))
 - 4. Slag formation from seawater in fuel
- c. Proper application of inspection criteria.

221-2.14.2.1 Quality of Installation. Refractory arrangement drawings have been distributed widely for most boiler classes. These drawings include numerous improved arrangements and standardization features. They supersede all previous refractory arrangement drawings for applicable boilers and shall be used when the refractory is completely renewed and when major repairs are made. Personnel installing refractory shall consult the drawing applicable to the boiler class for details of location and type of anchors, thickness' and types of materials, expansion joints, and clearances to tubes. Supervisory personnel shall provide for in-process inspection as, giving consideration to the skill and experience of personnel accomplishing the installation. Replacing refractory merely to meet the standard is not intended.

221-2.14.2.2 Refractory Anchoring. To withstand shock and vibration, all areas of refractory shall be anchored or held in position (as shown on applicable drawings) by one of the following methods:

- a. Brick Bolts - applicable to firebrick laid 4-1/2 inches thick and to burner tile.
- b. Anchor Strips - applicable to castable refractory and plastic refractory.
- c. Boiler Tubes - as an example, superheater screen tubes, rear wall tubes, sidewall tubes, generating bank tubes, and curtain wall tubes retain adjacent refractory.
- d. Relatively small areas of castable refractory and plastic refractory may be keyed in by cutting back the sides of adjacent brickwork.
- e. Where other methods are inadequate, nichrome wire may be used to anchor small areas of castable refractory.

NOTE

Nichrome wire shall be considered an anchoring device, not reinforcement. Also, nichrome wire shall not be used with plastic refractory, because it interferes with proper pounding of the plastic.

221-2.14.2.3 Sustained High Furnace Temperature. Refractory materials obtained from the Naval Supply System have been tested and selected to provide a margin of safety relative to the maximum temperature attainable in areas where they are designated on refractory arrangement drawings. Approved refractory can probably not be damaged by overheating in a properly maintained and operated boiler. If it is apparent to forces afloat that inferior material is being received or installed, the circumstances should be reported to NSWCCD-SSSES for further investigation.

221-2.14.2.4 Rapid Changes in Temperature. The ability to withstand sudden temperature changes is a factor in selecting the refractories for naval boiler use. Rapid changes in temperature can be reduced to a minimum, however, by proper boiler operation. Never form steam in a cold boiler any faster than necessary. Refractories

previously baked out and fired are more sensitive to rapid cooling than to rapid heating. When securing a boiler, do not continue to run blowers or leave registers open or partly open. Close up boilers as tightly as possible and let the furnace cool slowly. Emergencies may arise, however, that require that these precautions be ignored. The brickwork will probably stand the abuse, but its life may be shortened; and if such practice is continued it could bring on furnace problems and necessitate repairs.

221-2.14.2.5 Minimum Cooldown prior to FDB Testing. The following are requirements for minimum cooldown time for main boiler refractory prior to testing forced draft blower speed limiting governors. If urgent time limitations do not exist, the cooldown time shall be a minimum of 24 hours after securing with burner air registers closed. The minimum cooldown time can be reduced to 6 to 8 hours only if the following conditions are met:

1. Urgent time limitations exist for completion of testing.
2. Main boiler firing rate during previous 24 hours must not have exceeded 30 percent of the full power steaming rate.
3. Furnace refractory must not be glowing upon securing of fires.
4. Burner air registers are left open to establish a natural draft in boiler and permit a gradual cooldown of the refractory.

221-2.14.2.6 Slag Formation From Seawater in Fuel Oil. The presence of even a small amount of seawater in fuel oil is highly detrimental to refractories and is one of the major causes of excessive slag accumulation on firesides. The Engineer Officer shall ensure elimination of all seawater from fuel oil. Refer to NSTM Chapter 541, Ship Fuel and Fuel Systems.

221-2.14.2.7 Fireside Cleaning Debris. Debris removed when firesides are cleaned shall be carefully swept from the furnace. The presence of this refuse on refractories lowers their melting point and contributes to slag formation. After sweeping the furnace, clean the refuse from expansion joints so the brickwork can expand freely when heated. Hard slag shall not be chipped from the refractory except where it interferes on burner throat rings or where accumulation on a floor causes carbon accumulation there. If excessive carbon deposits are found on burner tips and diffusers and if excessive slag is found on the burner throat rings, attention shall be given to the cleanliness and alignment of burner components to determine if corrective measures are necessary.

221-2.14.3 TYPES OF REFRACTORY AND INSULATING MATERIALS. The following refractory materials are stocked in the Navy Supply System and are approved for use as shown on applicable refractory arrangement drawings. Refer to [Appendix A](#) for stock numbers. Other material shall not be used except in an emergency.

221-2.14.3.1 Firebrick. MIL-B-15606 grade A is the type most generally used and shown on refractory arrangement drawings. MIL-B-15606 grade B has a slightly lower maximum use temperature, is less resistant to slag attack, but is equivalent to grade A in other respects. Grade A firebrick shall be the only firebrick used in furnace areas. Grade A and B firebrick are equally suitable for use in superheater cavities of D-type boilers. Firebrick has relatively poor insulation value, less than 1/10 that of insulation block, MIL-I-PRF-2819. The purpose of firebrick is to provide structural stability and protect backup insulation from maximum temperatures, flame erosion, slag attack, and rapid temperature change.

NOTE

Firebrick shall not be substituted if drawings specify insulating brick: both heat loss and casing temperature would increase.

221-2.14.3.2 Refractory Mortar MIL-M-15842. Class 1 mortar is shipped in dry form and requires mixing with water before use. Class 1 mortar is preferred in general use. Class 2 mortar is furnished ready mixed but may require mixing with additional water to obtain the proper consistency. Class 2 mortar shall be used when laying MIL-B-16305 class B insulating brick because this type of brick absorbs moisture from class I mortar so quickly that properly thin joints cannot be obtained easily. Both types of mortar are air-setting; that is, they develop strength after drying without being heated. The primary purpose of mortar is to seal joints in brickwork or tile installations and to cushion the pieces against concentrated stresses, rather than to cement the pieces together.

221-2.14.3.3 Burner Tile. Refer to MIL-B-15606 grade A for material and properties and NAVSEA drawing. 803-1385708 for shape and dimensions. Tile is available in various sizes and shapes for specific burner types. Tile can be used only with the specific burner type for which it was designed.

221-2.14.3.4 Castable Fireclay Refractory MIL-C-717. This item is about equal to firebrick in maximum use temperature, but is usually less durable because of lower strength. It contains a hydraulic setting binder and develops strength without heating in a manner resembling concrete. It is preferred to plastic refractory for small repairs or where standard size brick or tile cannot be used. Performance is sensitive to installation technique and anchoring. It is installed by casting, tamping, or ramming, depending on circumstances. Large areas, such as the complete burner front, require use of a suitable forms. Refer to the Main Boiler Repair and Overhaul Manual for details.

221-2.14.3.5 Plastic Fireclay Refractory MIL-P-15731. This material is weaker and shrinks slightly more than castable refractory. It develops strength only after heating at about 1,095° C (2,000° F) or higher; therefore, plastic refractory use shall be avoided at low temperature areas. Its performance is sensitive to installation technique and anchoring.

221-2.14.3.6 Silicon Carbide Baffle Tile MIL-B-20215. This tile is made of silicon carbide and characterized by high strength, good dimensional stability and resistance to rapid temperature change, and low insulating value. Baffle tile is available in several sizes and is shaped to fit between tubes having certain common tube spacings.

221-2.14.3.7 Insulating Brick. Two types are commonly used in naval boilers. MIL-B-16008 brick has better insulating value but less strength and high temperature capability than MIL-B-16305 class B brick. The insulating value of both types is intermediate between that of firebrick and insulation block.

- a. MIL-B-16008 - used only for backup insulation behind firebrick, plastic, or castable refractory.
- b. MIL-B-16305 Class B - used only as a gasside layer at lower temperature areas of D-type boilers, such as at the main generating blank areas and behind tangent sidewall and roof tubes.

221-2.14.3.8 Insulation Block MIL-I-PRF-2819, Class 3. Insulation block is used as the first layer on the inside of inner casings and is capable of withstanding surface temperatures up to 815° C (1,500° F) when protected by other refractory from gas erosion and slag attack. Its physical strength is relatively low but adequate for the intended use. Its insulating value is much greater than that of other furnace lining components.

221-2.14.3.9 Castable Insulation MIL-C-19794. This castable material has a unique combination of good insulating value and moderate temperature resistance, but it is weak. It is an approved substitute for insulating brick and insulating block (but not for insulating block only) in certain boiler walls, as noted on refractory arrangement drawings. It is unsuitable for use in a wall previously provided with 2-inch thick insulation block, in floors, or as a gasside layer. Its advantage is the speed and economy of installing it since hand cutting the insulation for brick bolts is eliminated.

WARNING

Ceramic fibers are suspected animal carcinogens. The strict handling and personnel exposure guidance given in the Main Boiler Repair and Overhaul Manual, NAVSEA S9221-C1-GTP-020, Appendix 10A, and NSTM Chapter 635 shall be followed.

221-2.14.3.10 Ceramic Fiber Insulating Board (Millboard). Ceramic fiber insulating board is composed of ceramic fibers and binders, and formed into sheets typically 1/4 and 1/2 inch thick. It has very good thermal insulation properties but requires protection from direct exposure to combustion gases. It is a convenient substitute for insulating cement (MIL-C-2861) between the boiler inner casing and the insulation block (MIL-I-PRF-2819).

221-2.14.3.11 Insulating Cement MIL-C-2861. Insulating cement is composed of mineral wool fibers and clay binder. The cement is used as insulating space filler used between the insulation block and the casing in certain boiler classes (as shown on applicable drawings) and to fill voids in the insulation block layer such as at missing corners or at cut-outs for anchor devices. It also provides a straight backing for insulation block where minor casing warping has occurred and in certain other machinery insulation arrangements.

221-2.14.3.12 Ceramic Fiber Mixes and Ceramic Fiber Rope.

- a. Ceramic fiber mixes, such as Fiberfrax FC-25 Tamping Mix, are wet tamping mixes composed of bulk ceramic fibers and high temperature inorganic binders. A combination of strength, low heat transfer, and resistance to thermal shock give these mixes ideal properties for exposure to rugged, high temperature environments. Ceramic fiber mixes are used to fill expansion joints and are installed as packing between superheater tubes at casing penetrations. The surface of superheater tubes in contact with Fiberfrax shall be painted with two coats of heat resistant aluminum paint (refer to [Appendix A](#)). Fiberfrax shall be installed as close to light-off as possible to minimize corrosion of tubes.
- b. Ceramic fiber rope such as Fiberfrax rope is a high temperature, twisted roping composed of extra long fibers. It possesses the same thermal and chemical properties as the bulk ceramic fibers in the ceramic fiber mixes.
- c. Either the ceramic fiber mixes or ceramic fiber ropes can be used to repair cracks in deteriorated or failed refractory. Cracks up to 3/4 inch can be packed with these materials. These cracks are normally found on boiler fronts in areas such as between burner tile and adjacent refractory. They are also found at junctions of sidewall/rearwall, sidewall/roof and in refractory linings behind the sidewall or rearwall tubes. These materials can be packed in openings between burner tiles that result from dimensional discrepancies. Openings ranging in width between 1/4 inch and 3/4 inch may be packed with these materials between the tile joints. Joints smaller than 1/4 inch are to be filled with refractory mortar, MIL-M-15842. NSWCCD-SSSES is to be consulted if gaps greater than 3/4 inch exist.

221-2.14.3.13 CERAMIC FIBER PUMPABLE INSULATION MATERIAL.

- a. To affect repairs and correcting voids behind brickwork where the brick wall is otherwise sound, pumpable ceramics fiber insulation material is sometimes used.
- b. One type of pumpable ceramics fiber insulation is Thermal Ceramics Kaowool Pumpable XTP insulation material. It is a mixture of Kaowool ceramic fibers dispersed in a high-temperature binder. This mix produces a stable high-temperature insulation which can be placed by forced pumping.
- c. Thermal Ceramics Kaowool Pumpable XTP insulation material has been installed on LHA-1/LHD-1 Class ships boilers to repair missing insulation board material between the generating bank rear wall bricks and rear wall inner casing.
- d. Thermal Ceramics Kaowool Pumpable XTP insulation material can be used in hot or cold repairs. The Kaowool pumpable XTP will air dry over time. However, at unit operating temperatures, the drying is rapid while still allowing time for the Thermal Ceramics Kaowool pumpable XTP, under force, to seek out all voids. Thermal Ceramics Kaowool pumpable XTP offers good insulating properties, good strength and vibration resistance.
- e. Thermal Ceramics Kaowool Pumpable XTP is a high-strength premium mixture of Kaowool ceramic fibers dispersed in a high-temperature binder. It comes in 5 gallon buckets.

NOTE

Product containers should be kept sealed to avoid hardening. Kaowool Pumpable must be protected from freezing.

- f. Installation information. Kaowool Pumpable is installed under pressure using pumping equipment such as the Kaowool Diaphragm Pump.
- g. Removal Information. Ceramic fiber material, particularly after exposure to high temperature furnace conditions, is considered a health hazard. Even in applications where protected by brickwork (as described in [paragraph c](#) above), the following precautions must be heeded.

WARNING

Ceramic fibers are suspect animal carcinogens. The strict handling and personnel exposure guidance given in the Main Boiler Repair and Overhaul Manual, NAVSEA S9221-C1-GTP-020, Appendix 10A, and NSTM Chapter 635 shall be followed.

221-2.14.4 ANCHOR DEVICES. Refer to the Main Boiler Repair and Overhaul Manual for detailed instructions and drawings of anchors. These exist in several forms to accommodate various, specific, anchoring requirements. In general, the following requirements apply:

- a. Anchor bolts and retainers for firebrick and burner tile shall be as shown in the above reference and NAVSEA drawing 803-1385785. Only one of the two anchor bolt slots in 9-inch long brick need be used. In some instances, as shown on applicable refractory arrangement drawings, the two end slots on 13-9/16 inch long brick should be used. Brick bolt retainers shall be welded to the inner casing by ring fillet welds, not merely by tack welds.

- b. Anchors for castable or plastic refractory shall be of the pennant type or a modification thereof to suit conditions. At furnace areas the unsupported end of the anchor shall extend 1/2 to 1 inch from the gasside surface of the refractory. The anchors may be cut or compressed slightly in length by bending to suit conditions. For large areas anchors should be spaced about 10 to 12 inches apart, but optimum spacing is influenced by configuration. If the pennant type is unavailable, brick or burner tile anchors may be used in emergency situations to anchor castable or plastic refractory.

221-2.14.5 INSPECTION AND MAINTENANCE OF REFRACTORY. Refer to the Boiler Inspection Manual for detailed procedures. Refractory installations will occasionally require minor repairs. Effective preventive maintenance during routine inspection periods can prevent extensive damage to refractories and other boiler components.

1. Open mortar joints between brick or tile can allow heat penetration, which causes cracks resulting from unequal expansion strains. When open joints are found they shall be filled, not merely covered over with mortar.
2. Expansion joints backed by split firebrick in the furnace area shall be cleaned of debris, unless doing so would break away the brick corners. Expansion joints previously filled with ceramic fiber material shall not be cleaned out unless the fiber material needs to be replaced. Expansion joints considered to be excessively wide may be loosely but completely filled with a ceramic fiber product such as Fiberfrax FC-25. Refer to the NAVSEA refractory installation drawing applicable to each boiler design for location and size of expansion joints.
3. Inspect the refractory behind any 1/4-inch or larger gaps between wall tubes.
4. Inspect burner throat openings for:
 - a. Thin peels or projections large enough to interfere with airflow. Such projections shall be broken away. A thin slag coating on throat surfaces is not harmful.
 - b. Radical differences in the amount or color of the slag or in the color of the refractory surface at different areas around the refractory cone. The refractory cone and areas in the burner wake shall be free of carbon. Carbon deposits and differences in slag color and amount are caused by improper burner settings, mis-aligned burner components, or mis-aligned throat refractory. The specific cause shall be identified and appropriate correction made.
 - c. Cracks (1/16 inch wide or larger) in a plane parallel to the front casing are likely to cause the refractory to break away; renewal of the affected area should be considered at a future availability. Radial cracks act as self made expansion spaces and usually are not harmful unless they are associated with cracks parallel to the front casing.
 - d. Spalling of the refractory to a depth greater than 1 inch over a significant area warrants repair or renewal of the refractory burner opening.
 - e. Throat surfaces should be straight or nearly so. Throat openings should be concentric, within 1/8 inch, with the metal throat ring and diffuser. The shape and form of the throat is important in the installation of any fuel oil burner register. Refractory throats shall be installed concentric with the metal throat rings and concentric with the axis of the atomizer. The angles should be straight, true surfaces. The angle of the refractory rings shall begin as close to the furnace edge of the metal register throat rings as practical and still protect the latter from excessive oxidation or actual flame erosion. Flat, straight runs of refractory at register throats tend to raise draft losses and reduce net efficiencies. VP burner systems have metal convergent throats instead of refractory throats.
 - f. Check gas baffles and corbels to determine that they are essentially gastight or serving their intended purpose. Superheater gas baffles shall be within 1 inch of the height specified. Greater tolerance is satisfactory

if the superheater outlet temperature is satisfactory. Spalling of corbel brick corners is not harmful, provided the corbel still serves its sealing purpose. Some surface peeling of castable refractory is normal and tolerable at seals along the top of furnace rear walls in certain D-type boilers. If the seal is not gastight, however, castable refractory shall be added to maintain the seal.

5. LHA-1/LHD-1 Class Furnace Coping Brick Wall. Several LHD-1 Class vessels (LHD-1, 3 - 5) have replaced castable refractory lower header rear, side and frontwall copings with more easily removed, or "portable", firebrick walls. These portable brick (MIL-B-15606 grade A) walls prevent tube damage during castable coping removals, and make removal for five year inspections a less time consuming and labor intensive task. Portable coping walls should be installed, inspected and repaired in accordance with NAVSEA drawing 221-8283469. It is normal during inspection to find that the anchored cap brick has moved (up to 3/4 -inch) away from furnace circuit tubes. If this occurs, do not pack the gap with Fiberfrax. Simply slide the cap brick back in its original position in contact with adjacent tubes.

221-2.14.6 REPAIRS TO REFRACTORY INSTALLATION. Refer to the Main Boiler Repair and Overhaul Manual for detailed procedures. When renewal of any substantial area of refractory is planned, renewal shall be made as shown on the applicable refractory arrangement drawing. Any repair material shall be suitably anchored if it is to be durable.

- a. The firebrick layer will function adequately even though as much as 1-1/2 inches of an original 4-1/2-inch thickness (or about 1 inch of an original 2-1/2 inch thickness) may be lost by shagging or spalling. Since the insulating value of firebrick is relatively low compared to that of backup insulation, such loss has no significant effect on heat transfer through the wall. Broken corners or spalls less than 1 inch deep and small surface cracks are of no consequence. A long, deep, structural crack about 1/8 inch wide may occur as a self made expansion joint. This, by itself, is no basis for renewal. Cracks that are dark in the interior are not closing and should be filled with mortar if they are not over 1/4-inch wide. Wider cracks should be filled with ceramic fiber mix or rope.
- b. Plastic and castable refractories are naturally lower in strength than firebrick. These materials can often be gouged and caused to crumble when abraded by a metal tool, depending on the force applied. Such efforts serve no useful purpose unless there is visual evidence of reduction in thickness by the boiler environment.
- c. When castable or plastic refractory is repaired, the entire thickness of that refractory at the repair area shall be replaced. A new layer of plastic or castable refractory applied over old refractory will not adhere.
- d. When brickwork in the lower part of a wall is renewed, the top course of brickwork in the repair area cannot be anchored or easily replaced. That top course of brick shall be replaced with castable or plastic refractory, suitably anchored.
- e. If a gap larger than 1/4-inch exists between any two sidewall tubes in a D-type boiler and the refractory behind the gap shows significant deterioration, the space behind that gap shall be filled with either a ceramic fiber mix or a ceramic fiber rope.
- f. An individual burner tile piece can be replaced by a new tile or by castable or plastic refractory. Use care when removing the old tile piece, to avoid damaging or mis-aligning the adjacent tile.
 1. Before inserting a new tile and its anchor bolt, remove mortar from abutting surfaces of the old tile to facilitate fitting the new. Mortar shall be used between old and new tile surfaces. Cone surfaces of new and old tile should be even within 1/16-inch.
 2. When using castable or plastic refractory, do not use a tile anchor bolt. Use two to four anchor devices per tile being replaced, depending on the size tile involved. Castable refractory, if used, shall be mixed to a stiff plaster consistency to prevent slumping. The throat surface shall be contoured even with the tile throat.

- g. Replacing an individual pair of superheater screen baffle tiles requires replacing additional tiles at the involved tube space, between the void and normal gas passage area. If the repair area is in an upper baffle, removing tile support lugs below the baffle is also necessary. Cut the lugs off at the involved tube space(s), leaving a short (about 1/16-inch wide) stub on the tube wall. After installing replacement tile, attach retaining lugs to the stubs of former lugs, using the welding procedure given on the refractory arrangement drawing applicable to the boiler.
- h. The mere presence of molten slag on the refractory is not a sound basis for refractory renewal; the thickness of the refractory remaining or other factors should govern the need for renewal. Slagging is a slow, progressive action that is accelerated by oils having high ash content and by full power operation. Slag does not form on refractories when distillate fuel is burned unless there is heavy and prolonged seawater contamination of the oil. Slag accumulations cannot be avoided when burning NSFO because it contains varying quantities of slag forming elements. Mixtures of distillate fuel and NSFO may result in slagging, depending on the proportions of the mixture and the duration of burning.

221-2.14.7 CURING REFRACTORY. Castable refractories require air curing, while plastic refractories require baking out. Firebrick and other refractory components may be baked out or fired when convenient.

- a. Castable refractory should air cure for two days or more before the boiler is lighted off. Longer curing time is not harmful. Lighting fires in a boiler with newly installed castable refractory after an air cure of only one day is prohibited without NSWCCD-SSES LCEM approval because the normal strength of the material would not be obtained. Refer to [Section 4](#), Operation, for detailed operation and light-off procedures.
- b. Large areas of plastic refractory shall be baked out within one to two days after installation to minimize shrinkage; otherwise, plastic refractory should be kept covered with moist rags or other steps taken to prevent drying. This does not apply to small areas such as at peepholes. Except in an emergency, plastic refractory shall not be installed unless steam is available on the ship (or motor-driven blowers are fitted), thereby permitting the blowers to operate and raising steam within a reasonable period of time. Castable refractory shall be used if the boiler cannot be lighted off within the required time.
- c. Superheaters on all boiler types shall be protected while baking out. For integral-superheater D-type boilers establish steam flow through the superheater by means of connections to the auxiliary steam and exhaust.
- d. Large areas of newly installed plastic refractory (such as burner openings or header protection) require slow baking out. Light-off one burner with the smallest capacity sprayer plate available for about 1 hour. Then, slowly increase the boiler firing rate so that boiler operating pressure is maintained for some 3 to 4 additional hours. The plastic refractory will probably be adequately dried by that time, but will have very little strength. To develop strength, the furnace temperature shall be gradually increased to the maximum obtainable under the steaming conditions for which the boiler is being used. Final firing at boiler full power rating is desirable, if permitted by steaming conditions.
- e. Small areas of plastic refractory (such as at a peephole) and any brickwork area need not be baked out as slowly. However, unnecessarily rapid raising of steam or advancement to full power shall be avoided during the first firing of newly installed refractory.
- f. Firing of the boiler at the maximum practical temperature shall be continued for a period of several hours to develop bonding in the plastic. If time is available after baking out is completed, and the brickwork has cooled sufficiently, it is advisable to open the furnace and inspect the settings.

221-2.14.8 HANDLING AND STORAGE OF REFRACTORY. Refractory bricks are packed in cartons for convenient storage and handling. All refractory materials shall be stored in a weatherproof enclosure or compartment protected from seawater spray or accidental flooding. Insulating brick, insulating block, and material in bags

are especially sensitive to moisture. Castable refractory in damaged or previously opened bags will absorb moisture from the atmosphere and deteriorate or harden. If a bag of castable refractory contains hard clustered lumps the entire contents shall be discarded. Plastic refractory requires only protection from drying out before installation and may be used as long as it is workable, regardless of age. Plastic refractory that has dried to the extent that it is not adequately workable shall be discarded, since re-mixing dried plastic refractory with additional water is likely to result in poor service. Plastic refractory and class 2 refractory mortars are subject to freezing. If frozen, the material shall be slowly and completely thawed before use.

221-2.15 SLIDING FEET.

221-2.15.1 Boiler foundation sliding feet shall have movement indicators installed, except as noted in [paragraph 221-2.15.2](#). The Main Boiler Repair and Overhaul Manual illustrates a typical installation. The sliding foot movement indicators shall be inspected before light-off, during boiler warm-up and after the boiler is on the line, to verify that movement of the water drum and lower headers is not impeded by defective sliding feet. This should be done monthly near the time the sliding feet are lubricated under PMS. The purpose of the inspection is to identify frozen sliding feet, not to compare the actual movement readings with the design readings.

221-2.15.2 SLIDING FEET WITHOUT MOVEMENT INDICATORS. In exceptional cases where the configuration of the sliding feet, casing, and foundation prevent installation of movement indicators, movement verification shall be made during each lubrication required by PMS. If the casing, skirts, or foundations crack or distort, movement should be verified at the earliest opportunity. Inspecting the saddle base plate and chock facing at the movement area will normally reveal an indication of foot movement (such as fresh grease in the movement area, lack of dust or dirt in the movement area, and a gap between a raised area of grease and the saddle).

221-2.15.3 LUBRICATION OF SLIDING FEET. Sliding feet, saddles, and foundations shall be inspected, cleaned, and greased according to PMS. Sliding feet shall be greased using the high temperature grease identified in [Appendix A](#). Acceptance of grease by the sliding foot shall be verified by observing grease exiting any edge of the foot. Sliding feet enclosed by the air casing shall have flexible tubing grease connections leading outside the casing to facilitate periodic greasing. If stainless steel braided tetrafluoroethylene (Teflon) hoses are being used for grease piping, these shall be inspected during the annual fireside inspection for signs of breakage, bulging, or other signs of braid failure. Other requirements for this type of hose, which are called out in NAVSEA S6430-AE-TED-010, such as tagging and periodic hydrostatic tests, are not applicable to these hoses when used as grease piping. The sliding foot chock facing and saddle base plate mating surfaces and exposed edges shall not be painted.

NOTE

Ships equipped with leaded bronze (Lubrite) permanently lubricated chock facings shall not be lubricated or repaired as described in [paragraphs 221-2.15.3 and 221-2.15.4](#). Once (Lubrite) lubricated chock facings are greased continue to grease.

221-2.15.4 REPAIR OF SLIDING FEET. The following policy governs repair and maintenance of main boiler sliding feet:

- a. A boiler with sliding feet that do not show movement shall be secured for repair.

- b. The initial repair attempt shall be by the solvent soak, flush, and grease procedures described in the Main Boiler Repair and Overhaul Manual.
- c. If soaking fails to allow positive injection of grease on a ship in the operating cycle, but the foot shows movement; the foot shall be considered functional. The ship should continue to periodically verify movement and flush the foot in an attempt to get the foot to accept grease.
- d. If soaking fails to allow positive injection of grease on a ship in availability, or if movement cannot be verified at the subsequent boiler light-off, the sliding foot assembly shall be repaired using the guidance of the main boiler repair and overhaul manual with bolting make-up accomplished according to NAVSEA drawing 810-2145500.
- e. Do not repair functioning sliding feet by jacking, solely, to restore or establish compliance with the standard drawing requirements.

To ensure that sliding feet remain functional after extended idle periods, accomplish the following at the first light-off of a boiler which has been idle for more than two months:

- 1. Verify that all sliding feet accept grease before light-off.
- 2. Verify that all sliding feet have moved during boiler warm-up and record results in the engineering log.

221-2.16 HYDROSTATIC TESTS.

221-2.16.1 OBJECT OF HYDROSTATIC TESTS. The object of boiler hydrostatic tests is to prove either the tightness of all parts of the boiler or the strength of the boiler and its parts. The tests apply to and include the entire boiler pressure vessel, including the first or most proximate valve on each connecting line to the boiler. This valve may be any one of the following: safety, bottom blow, surface blow, main steam stop, auxiliary steam stop, superheater protection steam inlet and outlet, chemical feed, vent, direct and remote water gauge, pressure and temperature gauge, drain or feed valve. Piping on opposite sides of these valves is discussed in NSTM Chapter 505. In some situations only a specific boiler area (such as the superheater) is isolated following repair and tested separately. NDE of a weld or weld repair of a boiler pressure vessel (boundaries previously described) does not take the place of a hydrostatic test. Non-destructive examination does not prove the adequacy of pressure vessel welds or materials.

NOTE

Hydrostatic test pressures for a particular boiler can be determined by reference to the design and operating data listed in the boiler technical manual.

221-2.16.1.1 DISASSEMBLY AND REASSEMBLY OF FLANGED JOINTS IN THE BOILER PRESSURE VESSEL PIPING (UP TO 3/4 NPS). Operational test per NSTM Chapter 505 can be substituted for 100% maximum operating pressure hydrostatic test, provided proper selection of component parts and controlled assembly is verified, and the joint can be safely re-torqued when the boiler is hot. Operational test cannot be substituted if the flange was machined prior to gasket replacement.

221-2.16.2 HYDROSTATIC TEST REQUIREMENTS. Each boiler hydrostatic test pressure has a definite purpose. Testing too often or at pressures higher than required to prove the test objective will increase the risk of damage to the boiler and injury to personnel. Experience indicates that careful planning is necessary to properly schedule a boiler hydrostatic test so that all components and fittings composing the boiler pressure vessel are in

a proper state of repair to satisfy the test objective without necessity for repeat tests. Planning which results in subjecting an already tested boiler to hydrostatic test pressures for the sole purpose of testing adjacent boiler systems is to be avoided. Boiler hydrostatic tests shall be applied as follows. This information is also shown in [Table 221-2-5](#) and graphically in [Figure 221-2-8](#).

221-2.16.3 PREPARATION FOR HYDROSTATIC TEST. The following paragraphs describe the requirements for boiler flushing and close-up, blanking and gagging of valves, and water conditions.

221-2.16.3.1 Boiler Flush. Flush out the boiler with feedwater or potable water using a hose at a pressure of approximately 50 psig. Steam and water drums, gauge glass through drum penetrations, and all tubes and headers should be flushed out to remove all loose deposits.

221-2.16.3.2 Boiler Close-up. A careful examination of the boiler shall be made to ensure no tools are left in the boiler. The Engineer Officer should ensure that all tubes are free and clear of obstructions particularly after girth baffles have been removed for tube work and drum access has been uncontrolled. This can be done by running a rubber hose through each tube. When waterjet cleaning is performed at the end of availability it fulfills this requirement. Ensure that all gasket, handhole and manhole surfaces are clean and remake all joints. Ensure that all removed handhole plates and opened manways are remade properly. The gasket seating surfaces must be cleaned and new gaskets installed. Refer to [paragraphs 221-2.11.3 through 221-2.11.5](#) and the Main Boiler Repair and Overhaul Manual for information concerning handhole and manhole plate installation and gasket compression. All steam and water drum mechanical joints, flange bolts, and nuts should be set up properly to ensure that drum internals are properly secured and that pipe joints do not leak.

221-2.16.3.3 Safety Valve Gags and Blanks. Blank or gag all safety valves when the boiler is subjected to hydrostatic test pressures above operating pressure. To minimize bent valve stems, it is recommended that the valves be blanked off rather than gagged for hydrostatic tests above 100 percent operating pressure. Blanking is required for 150 percent design tests. When gagging safety valves, take care not to set up on gags to the extent that valve stems are bent by over tightening. In most cases, gags placed hand tight are satisfactory. Under no circumstances shall the safety valves of a boiler be lifted by hydrostatic pressure. Testing of safety valves with steam is required if safety valve gags are used. If valves are not gagged and hydrostatic pressure inadvertently lifts a valve, then testing with steam is required. A determination as to whether or not a valve is lifted by hydrostatic pressure shall be made by visual observation where possible. If an unexplained sudden drop in test pressure is noted or if test pressure cannot be maintained and there is no other evidence of leakage, it should be assumed that a safety valve has lifted.

221-2.16.3.4 Valve Closures and Blanks. Before applying a hydrostatic test, close all connections on the boiler except the air vent, direct reading water gauge, test pressure gauge, and valves in the line through which pressure is to be applied.

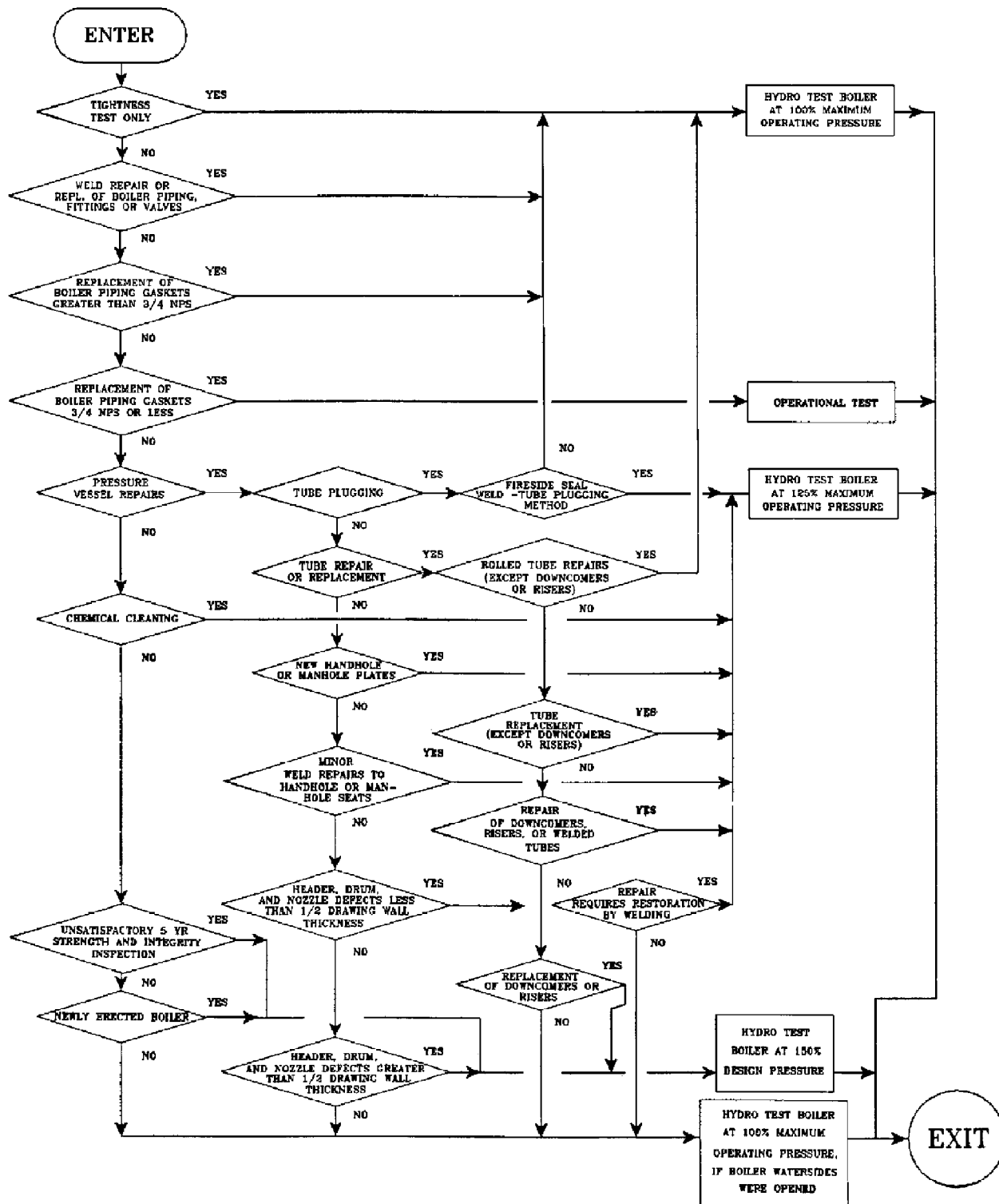


Figure 221-2-8. Logic Chart for Boiler Hydrostatic Test

NOTE

Make sure root and cut-out valves to the remote water level indicators and automatic boiler control transmitters are secured and equalizing valves are open.

When applying a 150 percent hydrostatic test, the direct reading water gauge connections shall be shut; safety valves and boiler blow valves shall be removed and blanked. All blank flanges used to blank off any opening in the boiler, including temporarily cut large tubes or piping, shall be sized (including thickness) according to NAVSEA drawing 845-4612172.

221-2.16.3.5 Water Conditions. Refer to [Table 221-2-1](#) to determine the amount of water required for hydrostatic tests. Hydrazine/morpholine treated water remaining from lay-up cannot be used for hydrostatic testing because of the danger of spray leakage at higher test pressures. The water shall be heated to between 20° C and 50° C (70° F and 120° F). The danger in using hot feedwater for hydrostatic tests is that water spraying from leaks will flash into steam and injure personnel. Safety restrictions stipulate that 50° C (120° F) is the maximum safe temperature for exposure of personnel to inadvertent contact with leaking water. Methods to properly heat water for hydrostatic tests include:

1. Warm the feed water in the deaerating feed tank (DFT) with steam.
2. Use an independent mixing tank to heat the water before filling the boiler.

221-2.16.3.6 Sodium Nitrite Amount. When using method 1 above, omit the addition of sodium nitrite to avoid excess concentration of this chemical in the boiler. Also omit the addition of sodium nitrite if:

- a. The hydrostatic test is to be applied within 36 hours of securing from EDTA cleaning.
- b. The hydrostatic test is to be applied during sodium nitrite wet lay-up.
- c. Sodium nitrite is not authorized for use in hydrostatic test water on ships using chelant or Carbohydrazide treatment unless the ship is in an industrial repair period.

221-2.16.4 SAFETY PRECAUTIONS FOR HYDROSTATIC TESTS. The following safety precautions shall be observed during all hydrostatic tests.

221-2.16.4.1 Steam Stop Valves. Necessary precautions shall be taken to ensure that there is no leak past the main or auxiliary steam stop valves.

221-2.16.4.2 Compressed Air Buildup. Compression of trapped air within the boiler during hydrostatic test pressure buildup can lead to an extremely dangerous situation and may prevent achieving the required pressure. Compression of trapped air could result in extensive damage and possible personnel injury in the event of a pressure part failure.

Table 221-2-5. Boiler Hydrostatic Test

Step	Test	When Required
1	100 percent maximum steady state operating pressure (as defined in paragraph 221-1.1.1.k).	Inspection for valve and fitting tightness and gasket tightness after handhole and manhole repairs; tube seat tightness for all rolled, re-rolled, or welded tubes including large diameter tubes and support tubes; and tube joint tightness after tube plugging (other than when the fireside seal welding method has been used). Flange sealing after weld repair to raised face of flange. Weld repair or replacement of boiler pressure vessel piping, fittings or valves. Disassembly and re-assembly of flanged joints in boiler pressure vessel piping over 3/4 NPS.
2	125 percent maximum steady state operating pressure.	After tube replacements including rolled or welded economizer, superheater, and superheater support tubes, but not large diameter tubes; seal welding and repairs to seal welds on large diameter tubes; repairs to welded tube joints; chemical cleaning; minor weld repairs to headers, drums, and nozzles including defects of 1/2 or less of drawing wall thickness; minor weld repairs to handhole or manhole seats; installing new handhole or manhole plates; and tube plugging (when the fireside seal welding method has been used).
		NOTE Attachment welds to the vessel surface DO NOT require hydro if no repair below base metal surface has been made.
3	150 percent boiler design pressure.	After erection of new boilers, major weld repairs to headers, drum and nozzle involving defects of more than 1/2 of drawing wall thickness; renewal of large diameter tubes.

221-2.16.5. HYDROSTATIC TEST PROCEDURES. The following paragraphs give procedures for the application of hydrostatic tests.

221-2.16.5.1 Filling Boiler. When filling the boiler, the GIS safety valve system shall be flushed to ensure lines are free of dirt and debris. Reconnect the lines using the GIS Safety Valve Technical Manual S6435-Q1-MMO-010 for guidance. The GIS Safety Valve System shall be vented in accordance with EOSS. The boiler shall be completely filled with heated water and entirely free of air before pressure is applied. Air is removed by keeping vent valve(s) open until water flows from vents. The boiler metal temperature shall not fall below 70° F during the hydrostatic test. Hydrostatic tests performed by depot level activities shall be conducted using feed quality water per NSTM Chapter 220, Volume 2, treated with sodium nitrite. Refer to [paragraph 221-2.3.1](#) for sodium nitrite mixing, disposal and flushing instructions. Hydrostatic tests performed by ship's force shall be conducted using feedwater (untreated or treated with sodium nitrite) meeting the requirements of NSTM Chapter 220, Volume 2. However, if sufficient feedwater is not available, ship's force may use fresh water. If fresh water is used, the boiler must be flushed with feedwater prior to light-off. For ships using chelant or Carbohydrazide treatment, sodium nitrite is not added to the hydrostatic test water for hydrostatic tests performed by ships' force unless the ship is in an industrial repair period. If sodium nitrite is used in the hydrostatic test water, the hydrostatic test water must be dumped and the boiler must be flushed prior to light-off.

221-2.16.5.2 Hydrostatic Test Equipment.

CAUTION

The main feed pump shall not be used for hydrostatic testing except in emergencies when an operable test pump is not available. In that event, the

Caution - precedes

use of the main feed pump shall be limited to the 100 percent maximum steady state operating pressure hydrostatic test. Use of the main feed pump or emergency feed pump should be restricted to filling the boiler with water.

A typical hydrostatic test pump arrangement is shown in [Figure 221-2-9](#). The hydrostatic test pump and fittings shall comply with the following as a minimum:

- a. The pump shall be of a type specifically designed for hydrostatic testing and capable of attaining the maximum test pressure to applied to a boiler component (150% of economizer design). Most ships have been initially outfitted with portable pneumatically driven pumps as required by the later revisions of the boiler specification (MIL-B-18381). Replacement of the initially outfitted pumps has resulted in various types and models throughout the fleet. In some instances, electrically driven pumps have been substituted. These are usually mounted in a central location and piped to several spaces. Special higher capacity pumps are also used at depot level activities and these are sometimes electrically driven. Regardless of the type of pump used, precautions shall be taken to avoid rapid raising of hydrostatic test pressure and to avoid over pressurizing the boiler.

WARNING

Observe electrical safety precautions when using electric equipment. Electrical equipment shall be properly grounded.

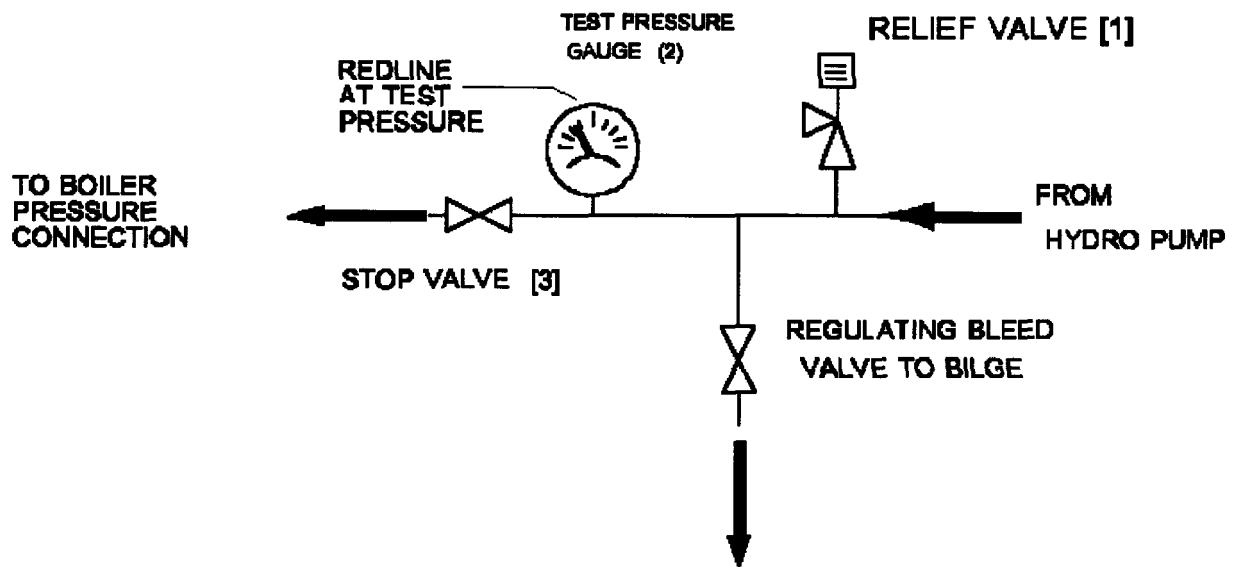
- b. Ship's force or Industrial Maintenance Activity (IMA) personnel should use pneumatically driven pumps. Use of electric hydrostatic test pumps by ship's force or IMA personnel is not recommended due to the potential electrical shock hazard. In general, pneumatic equipment and tools should be used instead of the electric counterparts when working in a machinery space, especially in areas where water is likely to be present (e.g. near a boiler undergoing maintenance such as draining, hydrostatic testing, etc., and in bilge areas). If an electrically driven pump is used, particular attention shall be devoted to locating the pump in an area that minimizes electrical shock hazard. In addition to the requirement that electrical equipment be properly grounded, the use of ground fault circuit interrupters (GFCIs) is highly recommended.
- c. All hoses and fittings shall meet either military specifications or the Society of Automotive Engineers (SAE) specification if purchased from an outside vendor. Components which are not meant for high pressure service (such as a copper pipe or tubing, brass or forged bronze fittings, etc.) are not suitable for hydrostatic testing service. Using a magnet to determine if the materials are ferritic is not a gage of suitability for service since many, if not most, high pressure fittings are made of non-ferritic alloys. Flanged components, for the most part, have pressure ratings stamped on the flange edges. Other components generally have some type of marking indicating a specification number (military or commercial), a manufacturer's part number, a symbol, a material type or pressure rating. These will require verification against the specification or manufacturer's literature. All defective components shall either be replaced with equivalent components or repaired.
- d. A minimum of one method of manual over pressure protection shall be provided for every hydrostatic test and at least one means of backup over pressure protection is required (manual or by relief valve). Boiler maintenance manuals specify that a safety relief valve similar to Sprague part number 005-023A-3 should be installed.
- e. Portable hydrostatic test hoses shall have a tag attached to them with the words **For Use With Hydrostatic Test Pump Only**. These hoses generally have a rubber or polymer protective sheathing as the outer layer. To minimize chafing of the outside of the hose, metal tags attached with wire should not be used. A plastic tag attached with plastic electrical cable ties is recommended. A metal sleeve or ferrule stamped with the part number and rated, working or burst pressure of the hose assembly is usually integrally attached to one end of

the hose assembly at time of manufacture. If a replacement hose has been obtained and this information is not present, attach an additional tag with this information to the hose assembly prior to placing it in service.

- f. The hydrostatic test pump and related accessories should be covered and stored in a cool dry area.

221-2.16.5.3 Raising Pressure. Pressure shall be increased slowly and applied carefully to avoid exceeding the test pressure. A boiler shall not be tested to a higher pressure than required by the test objective. The pressure to be applied shall not exceed 1-1/2 times the boiler design pressure under any circumstances. However, test pump relief valves should be set as shown in [Figure 221-2-9](#).

221-2.16.5.4 Monitoring Pressure. An operator shall be stationed at the regulating valve and pressure gauge during the entire test to monitor and regulate hydrostatic test pressure to prevent over-pressurization. The bilge line should be used to regulate the boiler pressure by bleeding excess supply to the bilge. The stop valve can be used if a drop test is to be performed.



NOTES

1. MAXIMUM SETTING OF RELIEF VALVE IS:

A. 155% BOILER DESIGN PRESSURE, OR

B. 155% ECONOMIZER DESIGN PRESSURE. ECONOMIZER SHALL BE ISOLATED IF HYDROSTATIC TEST PRESSURE GREATER THAN 150% BOILER DESIGN PRESSURE IS TO BE PROVIDED.

2. USE A GAUGE WITH A PRESSURE RANGE APPROXIMATELY DOUBLE THE TEST PRESSURE (E.G., USE A 2,000 PSIG GAUGE FOR 1,000 PSIG HYDROSTATIC TEST). ENSURE THAT THE GAUGE CARRIES A CURRENT CALIBRATION STICKER.

3. THIS VALVE SHALL BE OPEN WHILE THE BOILER IS UNDER PRESSURE. THE VALVE MAY ONLY BE CLOSED TO SET THE RELIEF VALVE WITH NO PRESSURE ON THE BOILER.

Figure 221-2-9. Typical Piping Arrangement for Boiler Hydrostatic Testing

221-2.16.5.5 Duration of Hydrostatic Test. The test pressure shall be maintained at least 15 minutes before beginning the inspection of pressure parts to minimize personnel exposure to boiler component failure or sudden leakage. The test shall last just long enough to accomplish the inspection.

221-2.16.5.6 Sequence of Hydrostatic Tests. If the boiler is to be inspected at pressures higher than the 100 percent maximum steady state operating pressure, the highest pressure shall be applied first. For the type and level of test required, refer to [paragraph 221-2.16.2](#) and [Figure 221-2-8](#). The tightness test (100 percent maximum steady state operating pressure) shall always be applied last. Inspection of all boiler joints and fittings should be conducted during this tightness test.

CAUTION

During the hydrostatic test of the boiler, the desuperheater shall, be filled with water and pressurized along with the boiler to prevent exceeding the design pressure of the assembly. This requires that any shutoff valve between the superheater outlet and the desuperheater inlet be open during the test.

221-2.16.5.7 Desuperheater Hydrostatic Tests. Desuperheaters within the steam or water drum shall be hydrostatically tested (to 150 psig or the maximum operating differential pressure for the assembly, whichever is higher) for tightness at the joint or tube seats when the assembly is installed in the boiler. They shall be tested to 150 percent of the desuperheater design unit pressure (350 psig if data is unavailable) to check assembly tightness with the unit removed from the boiler and following repairs (including tube plugging).

221-2.16.5.8 Economizer Hydrostatic Tests. If a test of economizer at 150 percent of design pressure is to be conducted, the economizer shall be isolated to prevent application of an unnecessary pressure on the boiler. To verify tightness of the remade blanked joint between economizer and boiler, an additional test at 100 percent boiler operating pressure is required (after the 150 percent test) if the economizer has been isolated. The 125 percent and 100 percent tests of the economizer shall be based on boiler operating pressure.

CAUTION

Do not enter the boiler during the 150 percent hydrostatic test.

221-2.16.5.9 150 Percent Hydrostatic Test. While under 150 percent hydrostatic test pressure, the boiler shall be subjected to an external visual examination to detect structural defects such as gross leakage, bulges, or distortions or cracks in welds, nozzle connections, and renewed or repaired pressure parts. Sufficient casing panels shall be removed to permit the visual examination. Inspection of all boiler joints and fittings shall not be conducted during this test. Upon completion of the 150 percent hydrostatic test, a close visual examination of the boiler from the outside and inside shall be made of welds, nozzles, connections, and reworked or repaired pressure parts.

221-2.16.5.10 Individual Tube Hydrostatic Tests. These tests are done with either the hydrotest tool (Hydro-Pro, Inc. San Jose, CA) or standard test plugs designed for 1, 1-1/2 and 2-inch tubes. Individual 1 and 2-inch tube hydrostatic tests with the Hydrotest tool are done to test previously leaking tubes after re-expansion (rolling) without completely filling the boiler with water, or to identify leaking tubes after an unsuccessful full boiler hydrostatic test. Standard test plugs are only capable of testing the tube itself and not the tube-to-drum or header rolled joint. In either case individual tube hydrostatic testing does not replace the full boiler 125% strength test required for new tube installations. The Hydrotest tool is not authorized for use on auxiliary or waste heat boilers.

221-2.16.6 HYDROSTATIC TEST ACCEPTANCE CRITERIA. Hydrostatic test acceptance criteria and related repair guidance are given in the following paragraphs.

221-2.16.6.1 Tube Joint Leakage. The first hydrostatic test of newly installed rolled tubes is at 125 percent, and if dry, followed by the 100 percent test to confirm tightness. Tubes leaking at the 125 percent test shall be re-rolled. Each subsequent hydrostatic test of the rolled joint is at 100 percent. If the joint is not absolutely dry, it should be re-rolled using only the proper equipment and re-tested at 100 percent hydrostatic test pressure for 15 minutes after which joint tightness shall be re-evaluated. After two re-rolls, the joint may be considered acceptable if dampness but not leakage (that is, weep, spray, or trickle) is present at the joint, providing the inspector verifies all of the following conditions:

- a. Reviews records of the affected tube hole measurements and finds they are within allowable tolerances.
- b. Examines tube rolling equipment and confirms that the proper equipment was used.
- c. Confirms proper method of installation.
- d. Confirms hydrostatic test method is satisfactory (time/temperature conditions).

NOTE

Hand re-rolling of leaking tube seats is recommended. Machine re-rolling can cause additional adjacent tubes to begin leaking due to excessive force being exerted. Failure to attain a completely dry seat after re-rolling is generally an indication of a defective tube seat.

- e. In general it is felt that only a few tubes will indicate dampness after rolling. If more than 10 percent of newly installed tubes are affected, NSWCCD-SSES LCEM should be consulted for further guidance.
- f. Old tube joints (that is, other than newly installed) need only satisfy the 100 percent hydrostatic test for leakage. Dampness (that is, a slight ring around a rolled tube joint) with no weep, spray or trickle is not considered to be a leaking joint.

221-2.16.6.2 Failed Tube Location. Most failed tubes can be identified from access areas located throughout the boiler. Inline tube arrangements provide the easiest inspection capability. Where staggered tube arrangements exist, tubes may be temporarily spread to permit inspection of tubes located deep in the tube bank. Every effort should be made to identify the failed tube by visual inspection during the hydrostatic test. Various procedures exist for locating failed tubes when visual inspection capability is limited, including installation of temporary plugs in individual tubes and either pressure or vacuum testing of isolated tubes. Isolating tubes with plugs will not, however, aid in locating leakage at tube-to-tube sheet joints. This type of examination during a hydrostatic test of the boiler (or portion, if a particular circuit can be isolated) or by specially designed fixtures capable of testing an individual joint in conjunction with the tube (refer to [paragraph 221-2.16.5.10](#)). In case of rolled tubes, if the leaking joint(s) cannot be isolated, a nest of tubes in the general area where leakage is noted shall be re-rolled.

221-2.16.6.3 Tube Joint Leak Repairs. Tubes that leak should be renewed, plugged or replaced with blind nipples. If plugs or blind nipples are installed, the tubes should be renewed as availability permits or whenever the number of plugged tubes reaches the limits specified in [paragraph 221-2.8.5](#).

221-2.16.6.4 Valve and Fitting Leakage. If pressure loss is high and only slight leakage exists through the tube joints and gaskets, the loss is due to leaky valve(s) or fitting(s) and these should be overhauled as necessary. Refer to NSTM Chapter 505.

221-2.16.6.5 Gasket Leakage. Continued gasket leakage can cause damage to the seating surfaces, making follow-on repairs more expensive. The leakage criteria for boiler handholes and manholes at the 100 percent maximum steady state operating hydrostatic test pressure are as follows:

1. For operating ships, the leakage rate is, preferably, zero, but shall not exceed five drops per minute.
2. For ships in an availability that includes a boiler overhaul, the leakage rate for repaired or resurfaced handhole and manhole seats shall be zero (bone dry).

221-2.16.6.6 Gasket Replacement. Upon completion of a 150 percent hydrostatic test, all boiler manhole gaskets shall be replaced. Newly renewed handhole gaskets do not have to be replaced following a 150 % (boiler design pressure) hydrostatic test, provided that the gasket sets in a fully recessed seat of at least 3/32-inch depth that supports the periphery of the gasket 360 degrees around its perimeter. Handhole gaskets shall be renewed following the second 150% hydrotest; refer to [paragraph 221-2.11.3, step 10](#).

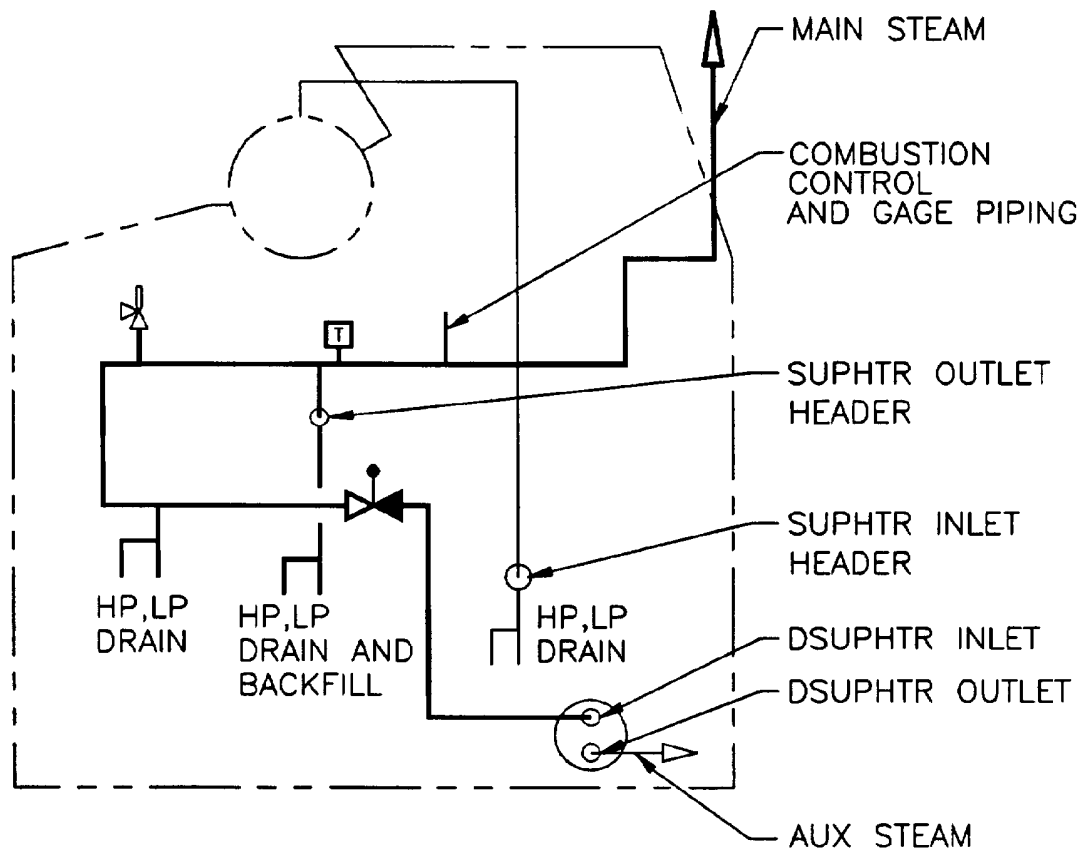
221-2.17 MATERIAL IDENTIFICATION AND CONTROL (MIC) OF BOILER PIPING SYSTEM.

221-2.17.1 GENERAL. Boiler external piping, including superheater outlet and superheater drain piping, is considered part of the boiler system. See [Figure 221-2-10](#). The boiler isolation valves, (first valves off the boiler) are included in this definition for some purposes such as hydrotesting. The main steam piping and HP drain system Material Identification and Control (MIC) level I requirements of Material Control Standard (NAVSEA 0948-LP-045-7010) do apply to boiler external piping, as follows:

Piping from the superheater outlet to the desuperheater inlet and to the main steam stop is level I providing the operating temperature exceeds 775° F. MIC level I control is also required for superheater outlet header drain piping operating above 775° F. The boiler isolation valves to these systems are considered MIC level I for Navy maintenance and overhaul work. MIC level I fasteners and weld filler metal must be used at the non-level I interfaces with this piping.

221-2.17.2 BOILER MATERIAL EXEMPT FROM MIC LEVEL I. The boiler proper, supplied under MIL-B-18381, including superheater tubes and headers are exempt from MIC level I. Safety valves are also excluded. Superheater nozzles or water drum nozzles (at desuperheater inlet) that are replaced, and not procured from the boiler manufacturer, shall be procured to level I standards. Consult NSWCCD-SSSES concerning Soot blower heads, companion flanges and inlet orifice plates. Superheater inlet and intermediate header drains, are exempt from level I requirements. A Controlled Industrial Material (CIM) program based on NAVSEA Instruction 4855.30 is necessary and sufficient for this piping.

221-2.17.3 MAINTENANCE AND CONSTRUCTION BOUNDARIES. The preceding policy applies to piping replacement and repair work done under Navy maintenance programs. Different boundaries may apply during construction based on the suppliers/shipbuilders Q.A. program and contractual considerations.



1. **BOILER EXTERNAL PIPING IS PIPING FROM BOILER NOZZLE-TO-BOILER NOZZLE, OR BOILER NOZZLE UP TO THE FIRST ISOLATION VALVE. BOILER ISOLATION VALVES THAT INTERFACE THE MIC LEVEL I PIPING SHOWN ABOVE AND THE SHIPS' MAIN STEAM AND HP DRAIN SYSTEMS ARE CONSIDERED LEVEL I FOR NAVY MAINTENANCE WORK.**
2. **MIC LEVEL I BOILER EXTERNAL PIPING CONNECTS THE SUPERHEATER OUTLET TO THE DESUPERHEATER INLET AND THE MAIN STEAM STOP VALVE.**
3. **REFER TO NAVSEA 0948-LP-045-7010 FOR MIC LEVEL I BOUNDARY INFORMATION FOR SYSTEMS OTHER THAN BOILER EXTERNAL PIPING.**
4. **THE BOILER AND SUPERHEATER SAFETY VALVE ARE EXCLUDED FROM MIC LEVEL I.**
5. **SUPERHEATER INTERMEDIATE HEADER DRAINS ARE EXCLUDED FROM MIC LEVEL I.**
6. **MIC LEVEL I FASTENERS OR FILLER METAL TO BE USED AT NON-LEVEL I INTERFACE.**

LEGEND






	MIC LEVEL I		STOPCHECK VALVE (LOCKED OPEN)
	NOT MIC LEVEL I		SUPERHEATER SAFETY VALVE
	THERMOWELL		

Figure 221-2-10. MIC Level I Boundary Diagram for Typical Boiler External Piping

SECTION 3

MAIN PROPULSION BOILER ACCESSORIES

NOTE

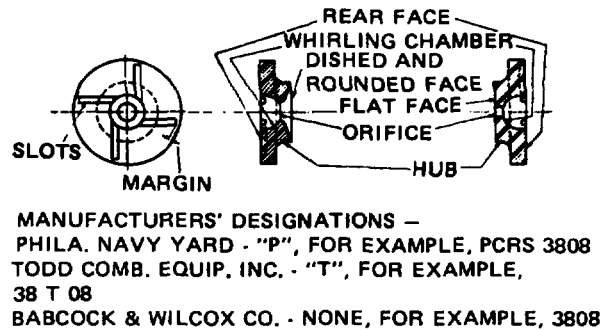
Operation of the boiler and its accessories is covered in [Section 4](#). This section covers the description, inspection, testing, maintenance, repair, and stowage of the boiler accessories.

Preventive maintenance shall be according to Maintenance Requirement Cards (MRCs) of the Planned Maintenance System (PMS).

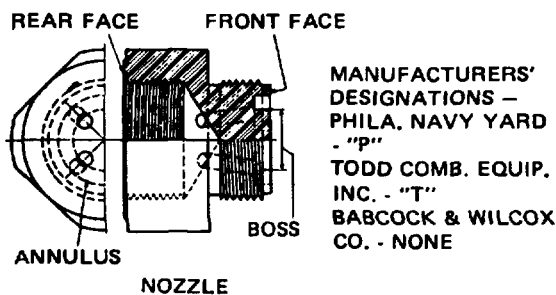
221-3.1 OIL BURNERS.

221-3.1.1 GENERAL. The two main components of an oil burner are the atomizer assembly and the air register assembly. The atomizer divides the fuel oil into very fine particles; the air register admits combustion air to the furnace and promotes mixing of the air and the fuel oil spray. Burners also include various valves, fittings, connections, and (on most installations) safety shutoff devices, which prevent oil spillage when an atomizer assembly is removed from a burner while the burner root valve is still open. The major burner components are discussed in the following paragraphs.

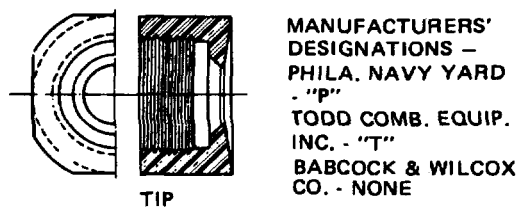
221-3.1.2 ATOMIZER ASSEMBLIES. An atomizer assembly, usually referred to as an atomizer, consists basically of a handle, a barrel, and the atomizer parts themselves. When the term burner barrel is used, it refers to the atomizer assembly without the sprayer plate(s) or without cartridge assemblies for vented plunger burners. Different types of atomizers require different arrangements of these parts. Typical arrangements of atomizer assemblies are shown in [Figures 221-3-1](#) through [221-3-4](#). Factors affecting the character of atomization, including capacity, spray angle, and particle fineness, are primarily determined by the size and proportions of passages in the atomizer parts. They are also determined by fuel oil viscosity, atomizing steam pressure, steam dryness, and oil pressure.



SPRAYER PLATE



NOZZLE



TIP

NOTES:

1. THERE IS STAMPED ON EACH PART TO IDENTIFY THE MANUFACTURER, THE DESIGNATION LISTED ABOVE.
2. 'CRS' ON PHILADELPHIA MANUFACTURED SPRAYER PLATES IS THE ABBREVIATION FOR CORROSION RESISTING STEEL.

Figure 221-3-1. Straight Mechanical Atomizer Tip Components

221-3.1.3 ATOMIZER TYPES. The types of atomizers used on Naval ships are straight mechanical, steam, and vented plunger, as described below.

- a. **Straight Mechanical Type.** In this type, the fuel oil is atomized by mechanical means - using orificies and whirling to form a spray. Varying the supply fuel oil pressure and changing sprayer plate sizes controls the firing rate of this type burner.
- b. **Steam Type.** In this type, steam is used to break up the oil into minute particles and to project a cone shaped spray of oil particles into the furnace.
- c. **Vented Plunger Type.** This atomizer is designed to permit wide range operation using the straight mechanical pressure atomization principle without the need to change sprayer plate sizes.

221-3.1.3.1 Straight Mechanical Atomizers. Straight mechanical atomizers (Figure 221-3-1) consist of the following parts:

- a. Tip. This part serves to center the sprayer plate whirling chamber on the atomizer nozzle boss and to hold the sprayer plate face tightly against the front face of the atomizer nozzles, preventing passage of oil into the whirling chamber anywhere except through the slots of the sprayer plate.
- b. Nozzle. This part serves to lead the oil from the atomizer barrel into the slots of the sprayer plate. The nozzle has a 1/2-inch diameter boss and has four oil lead holes.
- c. Sprayer Plate. The sprayer plate transforms solid streams of oil under high pressure into a cone of fine, fog-like particles. Two types of sprayer plates are in common use.
 1. Standard. The standard plate may have either a dished and rounded or a flat face and is made with three, four, or six slots depending upon the drill size and ratio of the sprayer plate. Four and six slot plates are most common.
 2. Standard High Capacity. The high capacity sprayer plate is similar to the standard sprayer plate except that the whirling chamber diameter is larger. All high capacity sprayer plates are dished and rounded and most of them have six slots (a few very large sizes have eight slots).

221-3.1.3.2 Steam Atomizers. Three basic types of steam atomizers are used in the fleet today; the B&W Racer, and the Todd NAV-JET and the CE (Figure 221-3-3).

1. In the B&W Racer and Todd NAV-JET steam atomizer, steam is supplied through the inner tube of the atomizer to the steam ports of the sprayer plate. Oil is delivered to the sprayer plate oil ports through the annulus formed between the inner and outer atomizer tubes. Each steam port meets with an oil port and the mixture of oil and steam exits from a common hole. Four to eight such exit ports are inclined at an angle around the axis of the sprayer plate.
2. In the CE atomizer, the oil is supplied through the inner tube and atomized by steam from the outer tube in an internal mixing sprayer plate.

221-3.1.3.3 Vented Plunger Atomizers. In vented plunger atomizers, oil flows down the atomizer barrel (around the atomizer cartridge) and enters the whirl chamber through tangential holes drilled around its circumference. The piston in the whirl chamber is spring-loaded and is moved to cover or uncover the tangential holes in the whirl chamber by varying the oil supply pressure.

Increasing oil pressure moves the piston to uncover more holes and increase oil rate; decreasing oil pressure does the opposite. Good atomization is achieved at all firing rates by the high pressure drop through the tangential holes (maintained by varying the tangential hole flow area). A hole is drilled through the length of the piston to vent the spring chamber to the furnace, allowing the spring to be compressed. This is possible due to the air core formed in the whirl chamber by the whirling oil. Any oil leakage along the piston into the spring chamber is vented into the furnace in the same manner. See Figure 221-3-4.

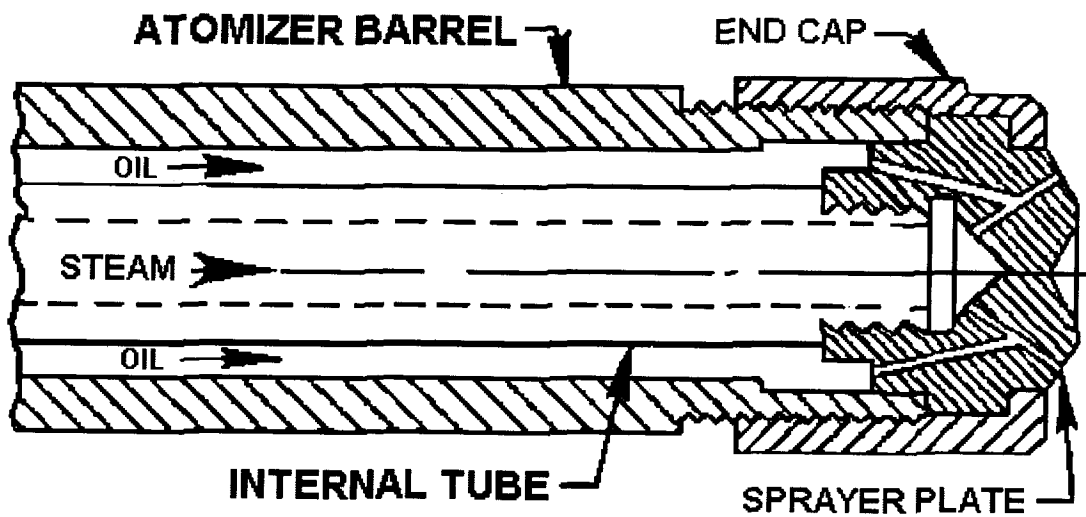


Figure 221-3-2. Steam Atomizer - B&W Racer/TCI NAV-JET

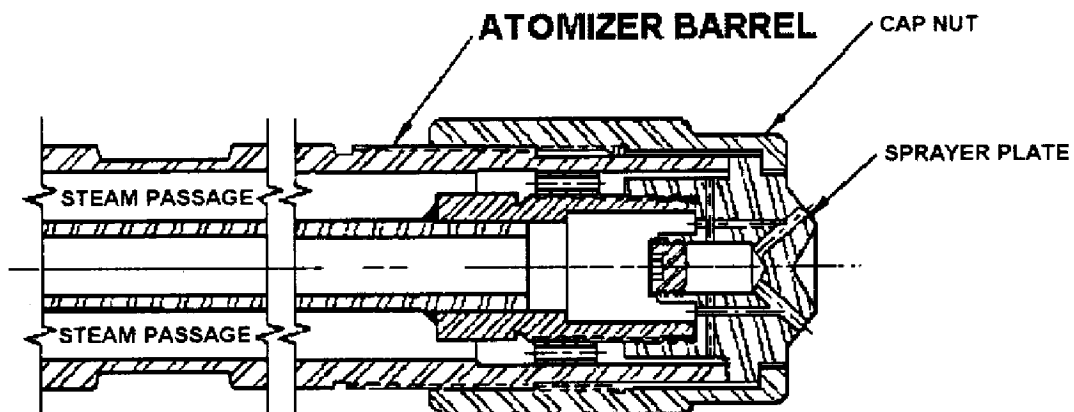


Figure 221-3-3. Steam Atomizer Combustion Engineering

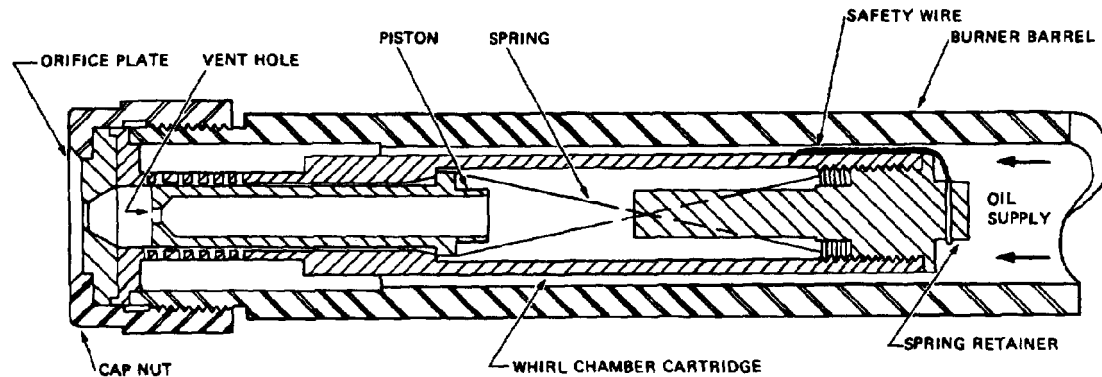


Figure 221-3-4. Vented Plunger Atomizer

221-3.1.4 BURNER BARRELS. The minimum number of usable burner barrels aboard ship shall be 250% of installed burner registers. The minimum recommended number of usable burner barrels in a machinery room is 200% of installed burner registers in the machinery room. For example, on a ship with two machinery rooms with two boilers per space and five burners per boiler (totaling four boilers and 20 installed registers), the minimum required amount of usable burner barrels aboard ship is 50. The corresponding recommended amount of usable burner barrels in the machinery rooms is 20 per space or 10 per boiler. Keeping a 200% quantity of burner barrels in the space enables a complete change out of burners in the event of gross fuel oil contamination and associated clogging of the atomizers.

221-3.1.5 ATOMIZER AND SPRAYER PLATES. The burner manufacturer supplies the first sets of atomizers and sprayer plates for any installation. Ships shall order replacements from the stock system using the nomenclature and national stock number shown in their Allowance Parts List (APL). Sprayer plates now in use are fabricated from either 18-percent chromium, 8 percent nickel, 0.25 percent selenium alloy (corrosion-resisting steel, grade 7, FED Spec QQ-S763), or case hardened high-carbon tool steel. The nozzle and tip are manufactured of case hardened tool steel or other suitably heat-treated special steel. The ship shall have the following minimum number of sprayer plates in the fire or main machinery room.

1. Light-off plates (if different from full power or intermediate plates) - two per boiler.
2. Full power plates (Steam Atomizer and Straight Mechanical Systems) three per burner.
3. Overload plates (Steam Atomizer (in some installations) and Straight Mechanical Systems) - two per burner (usually in custody of the Engineering Officer).

NOTE

In steam atomizer systems having one size for both full power and overload, the in space quantity shall be three per burner.

4. Intermediate range plates (straight mechanical systems) - three each size per burner.
5. Vented Plunger Atomizer Cartridges - three per burner.
6. EDTA Cleaning Sprayer Plates (If different from other sprayer plates) four plates per ship for two, three and four boiler ships, eight plates per ship for eight boiler ships.

221-3.1.6 CARE OF ATOMIZERS. As far as possible, operating personnel shall maintain the atomizers in their original mechanical condition and polished finish. The importance of proper care and cleanliness of the atomizer parts cannot be overemphasized. They are frequently ruined because personnel do not understand the importance of fineness of atomization and do not appreciate how easily careless handling may ruin an atomizer. The following instructions shall be observed in the operation and maintenance of the atomizers.

221-3.1.6.1 Inspection of Atomizers Under no circumstances shall operating personnel make any changes in dimensions of atomizers or otherwise tamper with them. Slight variations from a set standard have a noticeable effect on results. Where a number of atomizers are used in a boiler, it is essential for proper operation that they all produce uniform sprays. It is not only necessary that the various oil passages be made to size but that they retain their original manufactured finish and be free from blemishes. The Engineer Officer shall make frequent inspections to ensure that sprayer plates and nozzles are in good condition. Inspection should include checking oil and (if applicable) steam orifice holes of sprayer plates with a Go/No-Go gauge. Gauges are shown for 1,200 psig boilers on Naval Sea Systems Command (NAVSEA) drawing 250-4692835 and for 600 psig boilers on drawing 250- 5274181. Refer to PMS for ships not covered by these drawings. This gauge shall be individually packaged with a certification that verifies proper sizing of orifices, and manufactured to wire drill sizes. Penetration into the orifice by the smaller end (green color) of the gauge indicates the orifice is larger than the minimum required size (acceptable), and lack of penetration by the smaller end indicates the orifice is undersized and the plate shall be discarded. Lack of penetration by the larger end (red color) of the gauge indicates the orifice is smaller than the maximum required size (acceptable) while penetration by the larger end indicates the orifice is over-sized and the plate shall be discarded. Some gages are available in the stock system. Refer to [Appendix A](#). They may also be procured from Van Keuren Precision Products., 470 Old Evans Road, Evans, GA 30809 by specifying the hole or orifice size and requesting a certificate verifying orifice sizes for each gauge desired.

221-3.1.6.2 Cleaning Atomizers.

1. Steel wire or steel tools shall not be used for cleaning sprayer plates, nozzles, or other atomizer parts.
2. Atomizers firing distillate fuel, when withdrawn from burners, shall not be cleaned by blowing through them with steam or compressed air. Unless the atomizer barrels shall be immediately put into service again with clean sprayer plates, allow the withdrawn atomizer barrels to cool at the burner bench for 15 minutes.

NOTE

Burner atomizer assembly cleaning brackets have either been removed or have had the air/steam supply disconnected from them. For brackets still installed, there shall be no hard piped air/steam supply connected to them. Drain piping from brackets still installed (and at locations where cleaning brackets have been removed) shall be disconnected if routed to a drain collection system (such as the oily waste system) and the collection system piping shall be capped. Burner cleaning brackets may be retained for potential future use in hydrostatically testing burner atomizer assemblies.

3. After this cooling period remove the atomizer tip components (sprayer plates, orifice plates, adaptor plates, nozzles, cartridges, etc.) and place them in a pan of fuel to soak.
4. After the parts have soaked in fuel oil until the carbon has become soft, they should be cleaned. The slots in the sprayer plates and the supply holes in the nozzles may be cleaned with match-sticks copper wire or soft copper tubing flattened to form a tool, without danger of damaging the parts. Properly fitted wooden cleaning sticks may be used for cleaning and polishing the orifices and whirling chambers of sprayer plates, the annular grooves of the nozzles, and the faces of all parts. When polishing, use only a light lubricating oil; never use emery or any substance that will cut the metal.
5. After the atomizer parts have been cleaned, they should be wiped with light lubricating oil to minimize the possibility of rusting. Atomizer parts should never be stored in heavy lubricating oil.
6. If a sprayer plate fails to give an even and finely atomized spray after being carefully cleaned, it should be discarded.

221-3.1.6.3 Assembly of Atomizers. In assembling atomizers, care shall be taken not to over tighten the tips. For straight mechanical atomizers, permanent deformation of the sprayer plate at the outer edge of the face and on the area of overlap of the sprayer plate and the nozzle boss can occur. Repeated over-tightening will undercut the sprayer plate to such an extent that oil leaks into the whirling chamber without traversing the slots, with consequent drooling, smoking, and carbon formation.

221-3.1.6.4 Changing Atomizers. Atomizers should be changed once a week provided the following precautions and guidelines are practiced:

1. Maintain satisfactory Bottom Sediment and Water (BS&W) levels in fuel tanks to prevent atomizer nozzle blockage due to fuel oil contamination, as specified in NSTM Chapter 541, Ship Fuel and Fuel Systems.
2. Observe the flame condition of each atomizer to ensure proper combustion. Replace any suspect atomizers.
3. Pull one atomizer per boiler, once each day. If the condition of this sample atomizer and BS&W and flame conditions, per [steps 1 and 2](#) above, are satisfactory, no further action is necessary.
4. Atomizers not removed immediately upon securing the fuel oil supply to that atomizer (due to maneuvering situations) shall be removed as soon as possible. In particular, vented-plunger atomizers shall always be removed immediately to prevent varnishing, which could hinder the movement of the piston. This should not be a problem in maneuvering at sea when all burners can remain in at all times .
5. If a smoking condition exists that is not attributable to incorrect air supply, pull atomizers from the boiler one by one to find the faulty atomizer.
6. Change all atomizers before arrival in-port or after an extended in-port steaming period.
7. When steaming in port, pull one atomizer daily and follow [step 3](#). Be particularly alert for signs of poor combustion during this period, since soot blowing is normally curtailed and boiler firesides, especially the economizer area, may be affected.

221-3.1.6.5 Overhaul of Atomizers. When corrective maintenance of atomizers is necessary due to observed oil leakage or failed hydrostatic test, they shall be carefully dismantled at the burner cleaning bench. All seals shall be replaced. Only fluorocarbon elastomer (Viton) O-rings in accordance with AMS 7259 shall be used. Check all atomizer parts for presence of foreign materials (such as grit, rust particles, etc.) and pieces of deteriorated gaskets or seals. Clean out all plugged openings. Burner barrel nozzle bodies (for straight mechanical atomization) that have become nicked or scored shall be replaced. Bushings that slide into safety shutoff device seals shall be lightly sanded with emery and crocus cloth to remove small nicks. Bushings that are damaged severely enough to cause leakage shall be replaced along with cut and nicked seals. As atomizers are reassembled they should be checked for uniform length, and great care should be taken to engage all threaded parts correctly. Failure to maintain correct lengths in all atomizers for a particular boiler will result in faulty burner operation. During overhaul of atomizers at repair facilities, internal tubes must be disassembled from the heads (handles) and accurately measured. The internal tubes shall be within $+1/64$, $-1/32$ inch of the applicable manufacturing drawing length. If not, the internal tubes must be replaced. If circumstances dictate the measurement can be done on assembled atomizers (not preferred), the same tolerance must be applied to the overall length per the applicable manufacturer's drawing. The internal tube must be replaced (except on CE burner guns) if the overall length is not within tolerance. The criteria for shipboard evaluation of atomizer length are given in [paragraph 221-3.1.7.4](#). Completely reassembled and rebuilt atomizers and those suspected of leaking shall be hydrostatically tested according to [Appendix G](#). The burner barrels shall be tested by repair activities including RMCs, shipyards, and Type Commander (TYCOM) authorized ships, which include tenders, repair ships, and aircraft carriers. Main boiler burner barrels shall be tested for tightness to 400 $+5/-0$ psig using a blank atomizer tip or a tip with the openings brazed. If weld repairs to pressure containing parts have been made, or if pressure containing parts have been renewed with components not previously strength tested, a strength and integrity test of 525 $+5/-0$ psig, or to the system relief valve setting, whichever is greater, shall be made. Periodic hydrostatic testing of atomizers is required in accordance with PMS MIP scheduling.

221-3.1.6.6 Stowage, Makeup, and Installation of Atomizers. Proper atomizer stowage is important for maintaining atomizer machined edges and threads. Stowage racks shall be installed in the vicinity of the burner atomizer bench. Before placing cleaned atomizers in the stowage rack, loosely thread the cap nut or tip onto the end of the atomizer to prevent damage to the nozzle and threads. Before placing an atomizer in any burner, including the light-off burner, and when changing atomizers in a steaming boiler, it is the responsibility of the top watch to check the atomizer for tightness and proper makeup. Whenever possible, the top watch should also look through the boiler peep sights or sight glasses to ensure that newly installed and cut-in atomizers are firing properly. The flame pattern is indicative of proper installation. These vital functions should not be delegated to inexperienced personnel. For straight mechanical atomizers, a recommended method for preventing reverse or backward installation of sprayer plates and orifice plates in atomizers is to take an old discarded nozzle, sprayer plate,

orifice plate, and cap nut, and tack weld them, in proper installed sequence, on the edge of the burner bench, to provide a visual guide for personnel in making up an atomizer. An improperly made up atomizer, when placed in a burner and pressurized, can cause a boiler explosion.

221-3.1.7 REGISTERS. When open, air registers direct airflow from the double front into and around the stream of fog-like oil particles produced by the atomizer. When closed, they prevent air from entering the furnace. Present air registers consist of two principal parts: the diffuser and the airfoils. Use of two separate air streams, one through the diffuser and a second through the foils airfoils, has permitted greatly increased capacity and flexibility over conical registers. The diffuser provides primary mixing of the droplets with air and prevents blowing of the flame from the atomizer; the air foils guide the major quantity of air to mix with oil particles after they leave the diffuser and to envelop the flame. In the Combustion Engineering (Wallsend) register design air foils are not used. Instead, a converging diverging Venturi nozzle is used to promote mixing of combustion air and the oil fog. It has been necessary on some boilers to install air baffles between the casings to achieve equal air flow to burners of this type; refer to [paragraph 221-2.13.3](#).

221-3.1.7.1 Types of Registers.

1. Radial Vane. Wedge shaped vanes form the entering side of the burner throat. See [Figure 221-3-5](#).
2. Cylindrical Doors. Rectangular curved doors surround the burner throat. See [Figure 221-3-6](#).
3. Cylindrical Sleeve. A cylindrical sleeve surrounding the burner is moved in or out to control air flow. See [Figure 221-3-7](#).

221-3.1.7.2 Inspection. To ensure proper working order, all parts of the register should be checked before operation of any new installation of air registers, after having been disassembled, and at frequent inspection intervals. Register air doors should be examined periodically and warped doors should be straightened or replaced. Doors should be checked to ensure that all close completely when the air door handle is turned to the closed position.

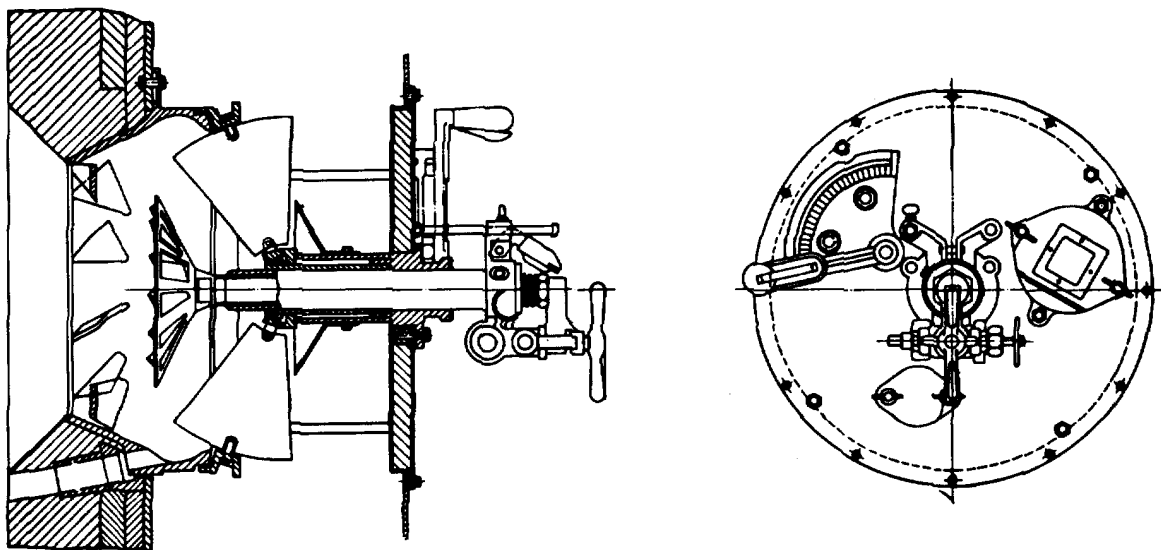


Figure 221-3-5. Radial Vane Register

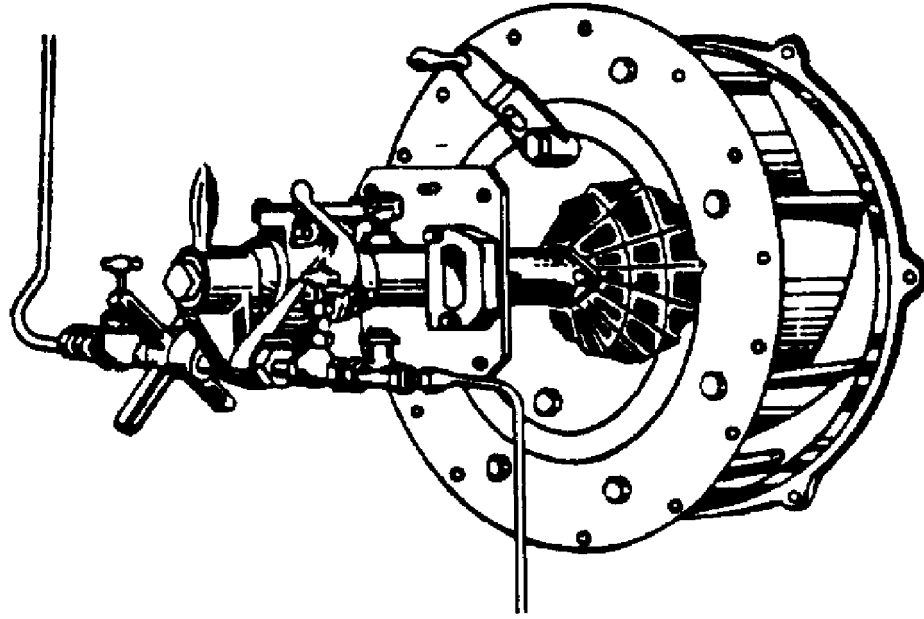


Figure 221-3-6. Cylindrical Door Register

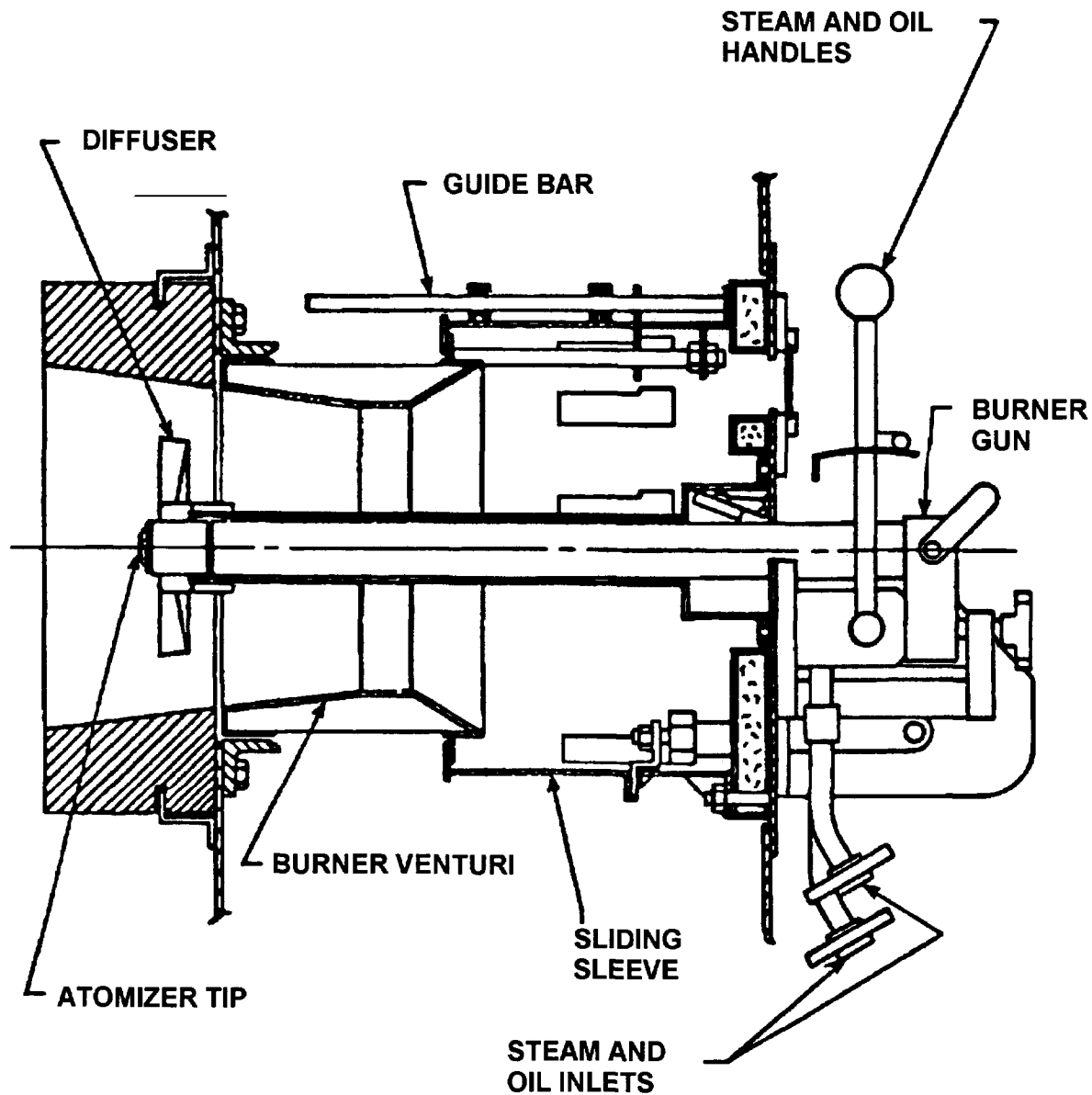


Figure 221-3-7. Cylindrical Sleeve Register

221-3.1.7.3 Cleaning of Air Foil Surfaces. Air foil surfaces (blades of bladed cones, air scoops, or air doors) and diffusers shall be maintained free of oil, carbon, and dirt. Air slots in the impellers should be entirely clear and free of encumbrances.

221-3.1.7.4 Burner Settings.

1. The atomizer setting (or tip protrusion) is the relationship between the atomizer and the diffuser. The withdrawal setting is the relationship between the diffuser and the throat ring. The atomizer and withdrawal settings should be checked and adjusted, if necessary, according to the Boiler Technical Manual. All atomizers should be measured aboard ship for overall length prior to setting tip protrusion on a boiler. The measured atomizer length must be $+1/64$, $- 1/32$ of the design drawing length shown in volume II of the applicable boiler

technical manual. An atomizer of median length (the length where half those measured are greater; the other half lesser in length) should be used when setting tip protrusion.

NOTE

If atomizers exceed $+ 1/64$, $-1/32$, but are all of the same length ($\pm 1/16$ inch) they may be used as a boiler set as long as a temporary minor DFS is received by the ship. Criteria for shop overhaul of atomizers is given in paragraph 221-3.1.6.5.

2. The atomizer barrel shall be centered at both ends of the jacket tube within the tolerances provided for by the centering method. A drooping atomizer, not concentric with the jacket tube, may cause impingement and should be corrected by checking and repairing centering lugs in tube at the furnace end. On B&W burners make sure atomizer weld lugs and regulating rod (Jacket Tube) dimensions are within allowable manufacturing tolerances.

NOTE

For good combustion, it is extremely important to ensure that the atomizer is concentric with the diffuser, which in turn shall be concentric with the refractory throat within tolerances allowed by the design drawings.

3. Register distance pieces should be marked so that the position of the atomizer-distance piece assembly with reference to the burner throat (withdrawal setting) can be determined from the fireroom, where the design allows for such an external verification. On some registers, a pipe sleeve is installed on the spindle on which the safety shutoff rides, holding the distance piece in a fixed position. Specific instructions provided in the applicable main boiler technical manual should be closely followed.
4. To ensure that diffuser mounting screws and nuts do not vibrate loose and affect burner settings when installing diffusers, use either lockwashers or locking nuts where possible.

221-3.1.7.5 Diffusers. Diffusers heavily clogged with carbon or improperly machined, especially in vane openings, can cause improper combustion and vibration. All diffusers installed in a boiler shall be identical and machined to the same tolerances. This shall be a furnace inspection item.

WARNING

Boilers using burners without safety shut-off devices shall display the following WARNING label on the boiler fronts to reduce the chance of accidental admission of fuel into the operating spaces: Ensure that both the fuel oil supply header valve and the manifold valve are closed before attempting to remove the atomizer assembly.

221-3.1.8 SAFETY SHUTOFF DEVICE. This device is provided on most fuel oil burner fronts to accept and position the atomizer. Its safety function is to prevent personnel from accidentally cutting in fuel to a burner that does not have an atomizer in place, and to prevent uncoupling a fuel pressurized atomizer (which could lead to fuel spraying around the burner front, creating a fire hazard). Safety shutoff devices shall be checked for tightness prior to light-off. Safety shutoff devices are not designed for zero leakage under all conditions. Table 221-3-1 summarizes the leakage requirements for the safety shutoff device and the manifold root valve. Excessive leakage shall be repaired as practicable by dismantling the shutoff device to replace seals and Viton O-rings, and examine internal parts for scoring. Rebuilding of safety shut-off devices shall be accomplished when leakage is evident. Do not place the clevis (vise handle) of a Todd type safety shutoff device in an upward position after the atomizer is withdrawn. A typical safety shutoff valve for dual cutoff (oil and steam) is shown in Figure 221-3-8.

221-3.1.9 BURNER LEAD PIPING. Fuel oil and steam burner lead piping from the supply manifold to the burner safety shutoff device or burner, and any oil return flow piping to the return manifold (if applicable), shall be made up from seamless carbon steel tube and pipe whenever renewal is required. Piping shall be renewed when ultrasonic inspection indicates remaining wall thickness is less than NSTM Chapter 505 requirement for fuel oil systems. Further requirements are given below:

- a. Steam atomization and vented plunger atomizer systems shall use 0.840 inch outside diameter (od) by 0.120 inch MIL, type D, MIL-P-24691 seamless pipe.
- b. The 300 psig straight mechanical burner systems shall use 0.540 inch od by 0.049 inch MW MIL-P-24691 seamless pipe for flexibility and reasonable service life.

Table 221-3-1. Safety Shut-Off Device And Manifold Root Valve Leakage Requirements

COMPONENT	TYPE OF LEAKAGE	LEAKAGE LIMIT
FUEL OIL MANIFOLD ROOT VALVE	THROUGH SEAT (PMS CHECK)	ZERO LEAKAGE ALLOWED
FUEL OIL MANIFOLD ROOT VALVE	EXTERNAL PACKING GLAND	
SAFETY SHUT-OFF DEVICE OIL VALVE	THROUGH SEAT (PMS CHECK)	NO CONSTANT STREAM SPRAY, OR ATOMIZATION MAXIMUM LEAKAGE 8 OUNCES PER HOUR (80 DROPS PER MINUTE NO CONSTANT STREAM, SPRAY OR ATOMIZATION.
SAFETY SHUT-OFF DEVICE OIL BALL CHECK (IF APPLICABLE)	EXTERNAL WITH BURNER REMOVED (PMS CHECK)	
STEAM MANIFOLD ROOT VALVE	THROUGH SEAT (PMS CHECK)	10 CC PER HOUR (4 DROPS PER MINUTE)
SAFETY SHUT-OFF DEVICE STEAM VALVE	THROUGH SEAT (PMS CHECK)	8 OUNCES PER HOUR (80 DROPS PER MINUTE)
SAFETY SHUT-OFF DEVICE STEAM BALL CHECK (IF APPLICABLE)	EXTERNAL WITH BURNER REMOVED (PMS CHECK)	8 OUNCE PER HOUR (80 DROPS PER MINUTE)
BURNER (BURNER FIRING OR SECURED; ATOMIZER INSTALLED OR REMOVED, AS APPLICABLE)	EXTERNAL OIL LEAKAGE WITH BOILER FIRING: Todd Safety Shut Off Device (LCC-19)	ZERO LEAKAGE
	B & W Safety Shut Off Device	ZERO LEAKAGE
	Wallsend Safety Shut Off Device (LHA/LHD Class)	10 DROPS PER MINUTE (SEE NOTE BELOW)
<p>NOTE: Wallsend burners installed on LHA/LHD class rely on a plug valve and pre-formed packing insert to prevent internal leakage past the plug and external leakage via the valve stem and packing gland nut. The continuing problem with the design is that the packing compression required to prevent external leakage is greater than that necessary to prevent internal leakage. Leakage rates were significantly reduced but not eliminated with the development and installation of SCD 70242/MACHALT 624. In service Wallsend burners have acceptable leakage criteria of 10 drops per minute. Burners which exceed this criterion shall be secured and repaired.</p>		

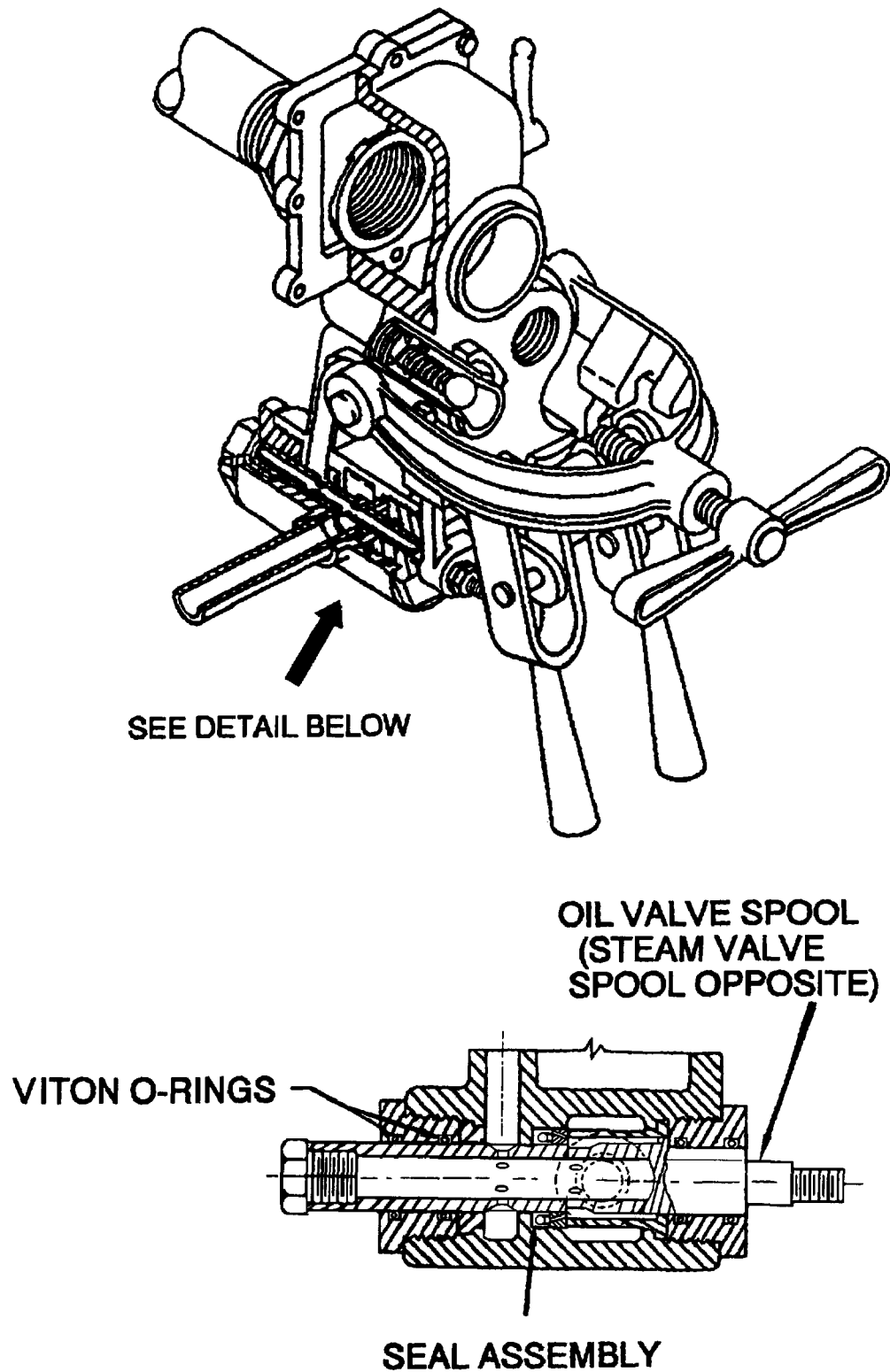


Figure 221-3-8. Safety Shut-off Device

- c. Minimum bending radius shall be five times the tube/pipe diameter according to MIL-STD-1627. Any required joints shall be socket welded; number of welds shall be minimized. Piping elbows shall not be used in the piping run from the safety shut-off device flange to the manifold root valve flange.
- d. Where lead piping exhibits excessive vibration during boiler operation, dampers (in the form of brackets or heavy rubber snubbers) shall be installed.
- e. Paint fuel oil leads according to procedures in NSTM Chapter 631 Preservation of Ships in Service.

221-3.1.9.1 Insulation. Burner lead fuel oil piping shall not be insulated. The steam atomization burner lead pipe shall be insulated and lagged with epoxy coating (preferred) or metal shielding. Flanges and other fittings in the steam lead piping shall be insulated with removable pads. Refer to [Table 221-3-2](#). The following procedure shall be used for the epoxy coating:

1. Remove all previous insulation and paint the steam atomization piping with two coats of heat resistant aluminum paint (Refer to [Appendix A](#)).
2. Insulate the steam atomization pipe from atomizing steam header to burner safety shut-off device according to the procedure in NSTM Chapter 635, Thermal, Fire, and Acoustic Insulation, or MIL-STD-769 using A-A-52569 tubular calcium silicate.
3. Fill in all areas and gaps not covered by the insulation with insulating felt (fiberglass), MIL-I-16411, Type 2.
4. Caulk around all locations where metal would come in contact with the epoxy coating with silicone rubber sealer, MIL-A-46106 Grade 1, Type 1 (Dow Silastic RTV-732 or General Electric TRV-102). (Refer to [Appendix A](#).) This includes, including piping termination points and any metal protrusions through the insulation. The silicone rubber provides flexibility for expansion that prevents an oil entry point at the metal-to-epoxy interface. [Figure 221-3-9](#) shows how the silicone rubber should be applied to the insulation at the metal interface.
5. Ensure all insulated surfaces are allowed to thoroughly dry before applying the epoxy coating.

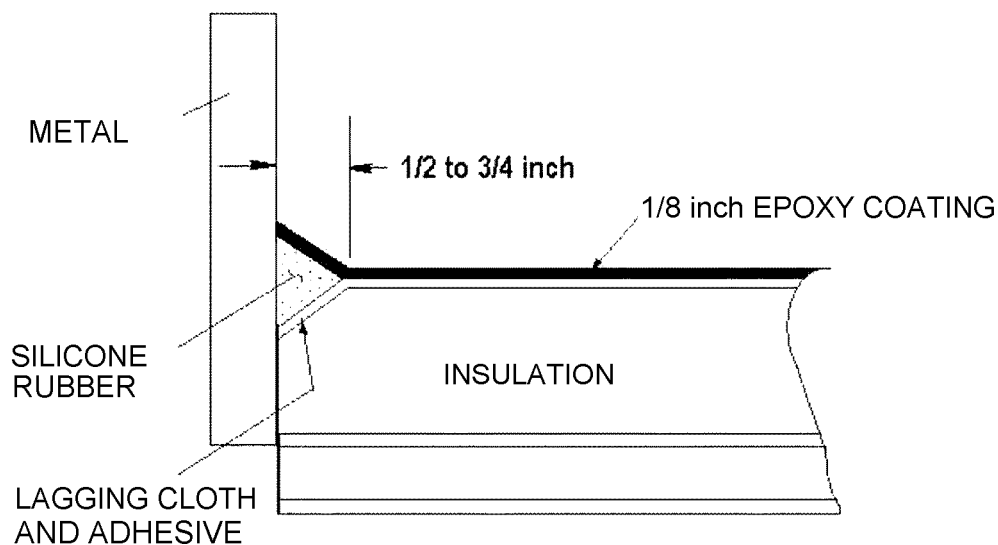


Figure 221-3-9. Silicone Rubber Caulking of Steam Atomization Piping Insulation

NOTE

If burner lead piping is flanged, and arrangement permits, remove it from the boiler for shop installation of the epoxy resin and hardener. This will ensure all of the insulated surfaces are covered with the epoxy which is especially important to prevent fuel oil soaking.

6. Apply epoxy resin and hardener to insulated piping. Ensure silicone rubber is covered with epoxy coating. Resin thickness shall be approximately 1/8 inch. Follow manufacturer's instructions. Feather all edges from minimum 1/8 inch thickness down to 0 inch and to within 1/2 inch of burner lead flanges. For ease of mixing and application, mix in small quantities and initially apply by hand or with small pointed trowel. Rubber gloves are required. Pot life of 1 gallon mass is 5 hours.
7. Allow 15 hours curing time.
8. If desired, paint the epoxy coating with fire retardant paint, designated MCU 2100 Type II or VI, (Refer to [Appendix A](#)). The lagging should be sanded to a smooth finish before painting to eliminate sharp edges and pockets.
9. The epoxy coating shall be installed by intermediate and depot level activities only. Ship's force is not authorized to install the epoxy, but can perform routine repairs, such as applying epoxy to surfaces where the epoxy coating has been perforated.

NOTE

Do not cover strainer caps or valves in the piping system. The insulation and epoxy resin shall be installed to permit removal of strainer for PMS and removal of valve internals for repair.

Table 221-3-2. Burner Lead Piping Insulation Requirements

COMPONENT	MANUFACTURER	REQUIREMENTS
FUEL OIL PIPE	ALL	DO NOT INSULATE
STEAM PIPE	ALL	INSULATE & EPOXY COAT OR INSTALL METAL JACKET
MANIFOLD VALVES	ALL	DO NOT INSULATE (NOTE: SPRAY SHIELDS REQUIRED FUEL OIL VALVE PACKING GLANDS)
FUEL LEAD FLANGE JOINTS	ALL	DO NOT INSULATE (NOTE: FLANGE SHIELDS REQUIRED)
STEAM LEAD FLANGE JOINTS AT HEADER AND SAFETY SHUT-OFF DEVICE	ALL	INSULATE WITH REMOVABLE PADS (REFER TO ^{NOTE 1})
STEAM STRAINERS, STEAM LEAD CHECK VALVES, NO. 1 BURNER LEAD ATOMIZING AIR CHECK VALVE	ALL	INSULATE WITH REMOVABLE PADS (REFER TO ^{NOTE 1})
LONG PIPE NIPPLES BTWN SAFETY SHUT-OFF DEVICE AND STEAM FLANGE	B&W RACER, WALLSEND	INSULATE & EPOXY COAT, OR INSTALL METAL JACKET, OR INSULATE WITH PADS (REFER TO ^{NOTE 1})

^{NOTE 1} Fabricate pads with insulating felt (fiberglass) MIL-I-16411, Type II, of thickness required by MIL-STD-769. For the pad external lagging cloth, (top cover and ends) the preferred material is silicone rubber coated glass fabric (The aluminized Mylar type not required.), as specified in footnotes of Table of MIL-STD-769. For the internal lagging cloth, which will bear against the hot surface, use cloths as specified by MIL-STD-769, for the service temperature. Shut-off devices which are in close proximity between steam and oil flanges may prevent insulating the steam flange to the full thickness required IAW MIL-STD-769. Customized pads of reduced thickness shall be fabricated in order to insulate the steam flange in this case.

221-3.1.9.2 Removal, Replacement, and Inspection.

1. To facilitate burner removal from the boiler front, all lead piping shall be flange-connected at burner end and manifold end.

2. During availabilities, burner lead piping with threaded connections; couplings or elbows and union fittings shall be replaced according to NAVSEA drawing 803-5959293. Flanged connections require flange shields.
3. Flexibility in burner lead arrangement (to facilitate diffuser withdrawal) is required only for old design 300 psig straight mechanical burner systems. Steam atomizers and vented plunger atomizers do not require diffuser withdrawal for idle burners. Extensive tests in these systems have proven that withdrawal barely reduces the temperature of diffusers of idle burners in a steaming boiler.
4. During each boiler overhaul burner lead piping shall be carefully examined and hydrostatically or ultrasonically tested according to PMS.

221-3.1.10 REFRACTORY THROATS. The purpose of the refractory furnace opening ring, or throat, of any fuel oil burner register is to hold the air closely around the flame, at the same time assisting combustion by its heating effect. Vented plunger burner systems have converging throats only so the refractory throat opening is contiguous with the front wall refractory in this case.

NOTE

It is extremely important for good combustion to ensure that the atomizer is concentric with the diffuser which in turn shall be concentric with the throat to within required tolerances.

221-3.2 SAFETY VALVES.

221-3.2.1 REQUIREMENTS. The requirements of a safety valve are that the valve open fully at the popping pressure without excessive preliminary simmering, that it remain open until the reseating pressure is reached, that it close tightly without chattering, and that it remain tight when closed.

221-3.2.2 TYPES OF SAFETY VALVES. Two types of safety valves are used on Naval boilers: steam drum and superheater outlet. All steam drum safety valves in service are spring loaded, including nozzle reaction, and huddling chamber and remote-pilot-operated types. The types of superheater outlet safety valves in service are drum-pilot-operated, remote-pilot-operated, and spring-loaded.

221-3.2.3 STEAM DRUM SAFETY VALVES. The types of steam drum safety valves are described in the following paragraphs.

221-3.2.3.1 Nozzle Reaction Safety Valve. An understanding of the basic design elements and forces involved in the operation of a safety valve will facilitate proper adjustments while testing the nozzle reaction valve. The basic design features of a typical nozzle reaction safety valve are illustrated in [Figure 221-3-10](#). The pressure-containing parts are the nozzle and the disc insert. The boiler pressure enters the inlet and is contained by the seat surface formed by the top of the nozzle and the disc insert. The disc insert is held in place against the nozzle seat and the boiler pressure by the spring load. The spring load is transmitted to the disc insert through the spindle. The spindle is guided and held in alignment with the disc insert by the guide bearing, the guide, and the disc holder. Two other design elements, which constitute operating control parts, are the guide (adjusting) ring and the nozzle ring. The safety valve operates as follows:

1. As boiler pressure rises, the upward force of the steam pressure on the disc insert will increase until it balances the downward spring load at the set pressure of the valve. At this pressure, a small amount of steam

will escape through the seats, as illustrated in [Figure 221-3-11](#). The valve opening is produced by two stages of reaction, working together to produce a continuous pop, as described in the following paragraphs.

2. First, the escaping steam strikes the lower (nozzle) ring and changes direction ([Figure 221-3-12](#)). The resulting reactive force pushes the disc up, giving the pop action. The disc then rises to moderate lift.
3. After the valve has popped to a moderate lift, the escaping steam begins to react against the upper (guide) ring ([Figure 221-3-12](#)). The reaction of the deflected steam pushes upward against the under side of the disc, lifting it still higher. In this way, the valve attains a full lift. The valve will require a 3 percent accumulation of pressure above lifting pressure to reach full discharge capacity.
4. As can be seen from [Figure 221-3-11](#), the initial lifting force at the opening is affected by the position of the nozzle ring in relation to the valve seat. The final lifting force, which brings the valve to full lift, is controlled by the position of the guide ring ([Figure 221-3-12](#)).

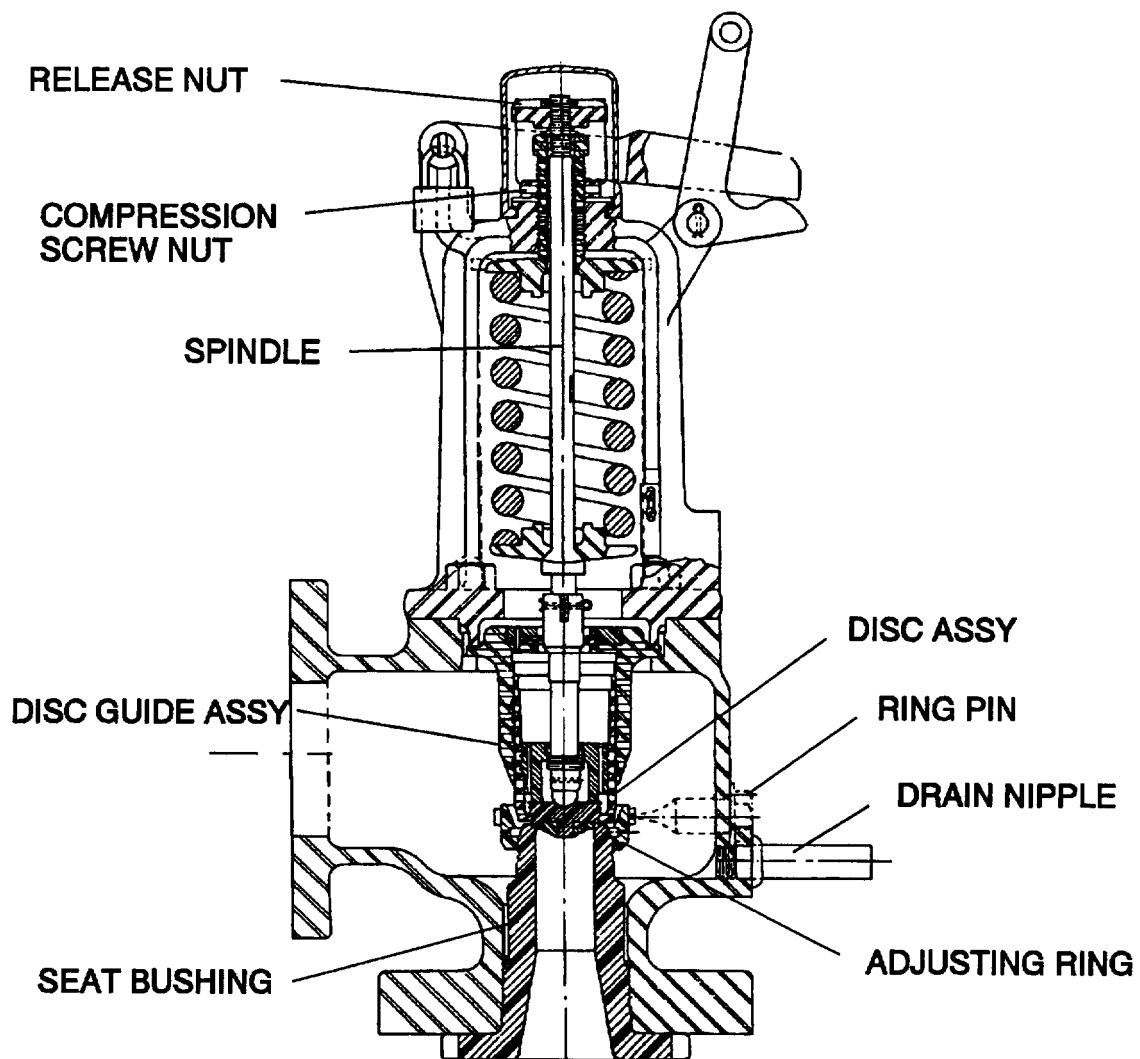


Figure 221-3-10. Typical Nozzle Reaction Safety Valve

5. With decreasing pressure, the disc and holder will drop closer to the seat and will then snap to the closed position as the reactive lifting force is lost.

6. The guide ring is the principal blowdown control ring. Blowdown is the difference between the steam pressure at which the valve opens (popping pressure) and the steam pressure at which it closes (reseating pressure). Turning the guide ring to the right raises it and thereby shortens the blowdown. Turning the guide ring to the left lowers it and thereby lengthens the blowdown. The nozzle ring principally controls the sharpness of the valve opening and closing. The nozzle ring, if properly set upon first installation, should require no further adjustment in service. However, if proper functioning of the valve cannot be obtained by movement of the guide ring, resetting of the nozzle ring may be necessary. Directions for resetting the nozzle ring as given in the manufacturer's instruction book should be followed.
7. Since both rings affect the forces that cause the valve to operate, the rings shall be correctly positioned with respect to each other for best performance.
8. For example, if the nozzle ring position is too high, resistance at closing will build up and prevent the valve from a snap closing action, such that it hangs at closing and may have a longer blowdown than desired. If the nozzle ring is too low, it will result in simmer or warn before the actual popping of the valve. Positioning the guide ring too high can keep the valve from attaining full lift, and cause the closing to be indistinct and dragged out. Setting the guide ring too low will cause too long a blowdown.

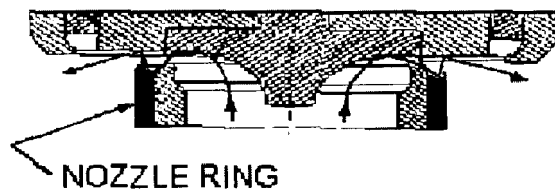


Figure 221-3-11. Safety Valve Nozzle Ring

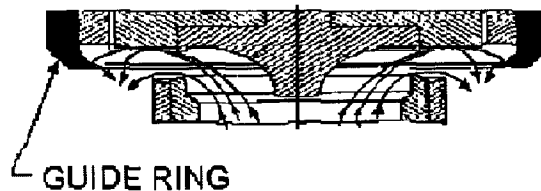


Figure 221-3-12. Safety Valve Guide Ring

221-3.2.3.2 Huddling Chamber Safety Valve. In the huddling chamber safety valve, the static pressure acting on the area of the disc causes initial opening (Figure 221-3-13). As the valve opens, the huddling chamber between the seat and a restricting orifice fills with steam, which builds up a static pressure on the extension of the disc. This temporary pressure increases the upward load against the spring, thereby causing the disc to lift higher or pop; after a predetermined drop in pressure (blowdown), the valve closes with a slight snap. The valve requires a 3 percent accumulation of pressure above lifting pressure to reach full discharge capacity. Blowdown adjustment is accomplished by raising or lowering an adjusting ring which shapes the huddling chamber. Raising this adjusting ring, which is attached to the seat bushing (nozzle), increases the blowdown; lowering it decreases the blowdown.

221-3.2.4 SUPERHEATER OUTLET SAFETY VALVES. Where simple spring-loaded safety valves are used, they are practically identical in construction to drum valves, except that special materials are used for the higher temperatures. Special superheater safety valve systems are outlined in the following paragraphs.

221-3.2.5 PILOT-OPERATED SAFETY VALVE SYSTEM. All pilot-operated safety valve systems consist of a combination of two valves; the pilot valve and the pilot-operated superheater outlet valve. These systems are commonly used because the popping pressure and blowdown of the simple spring-loaded superheater outlet safety valve will vary if boiler superheated steam temperature changes. Pilot-operated systems are not affected by changes in superheated steam temperature because the pilots operate under constant temperature conditions. There are two types of drum-pilot-operated safety valve systems and a remote-pilot-operated safety valve sys-

tem.

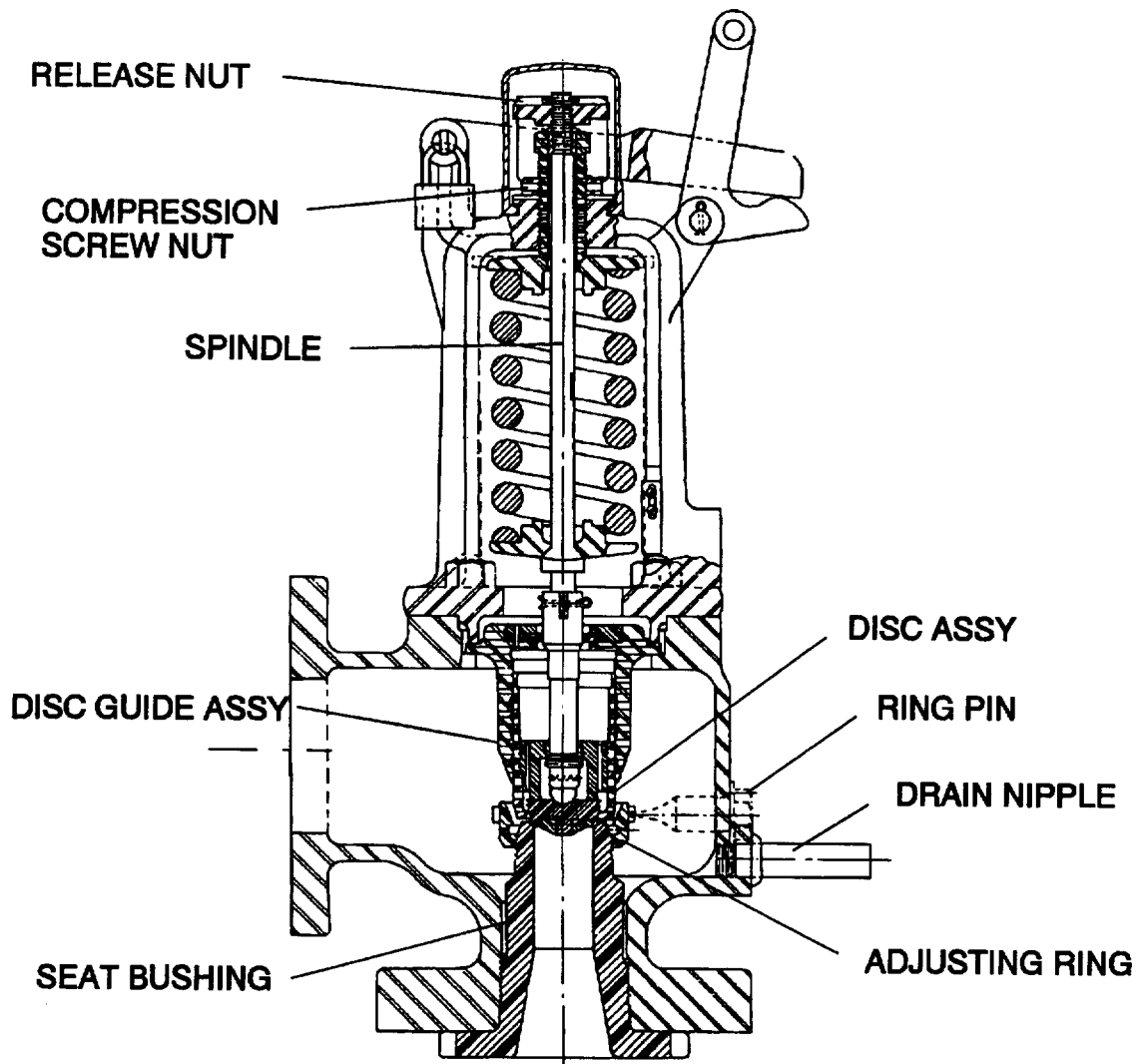


Figure 221-3-13. Huddling Chamber Type Safety Valve

221-3.2.5.1 Drum-Pilot-Operated, Spring-Loaded, Superheater Safety Valve System. The pilot valve is normally of small size and limited capacity and is used to actuate the superheater outlet valve by means of pilot valve body pressure acting on a piston and cylinder in the superheater outlet valve ([Figure 221-3-14](#)). This pressure is transmitted to the superheater unloading valve by an actuating line connected to a flanged opening in the pilot valve body. Operation is as follows:

1. The pilot valve is mounted on the boiler drum; the spring-loaded pilot operated valve is mounted on the superheater outlet line. The superheater valve includes a piston and cylinder-lifting mechanism as an integral part of a regular spring-loaded safety valve.

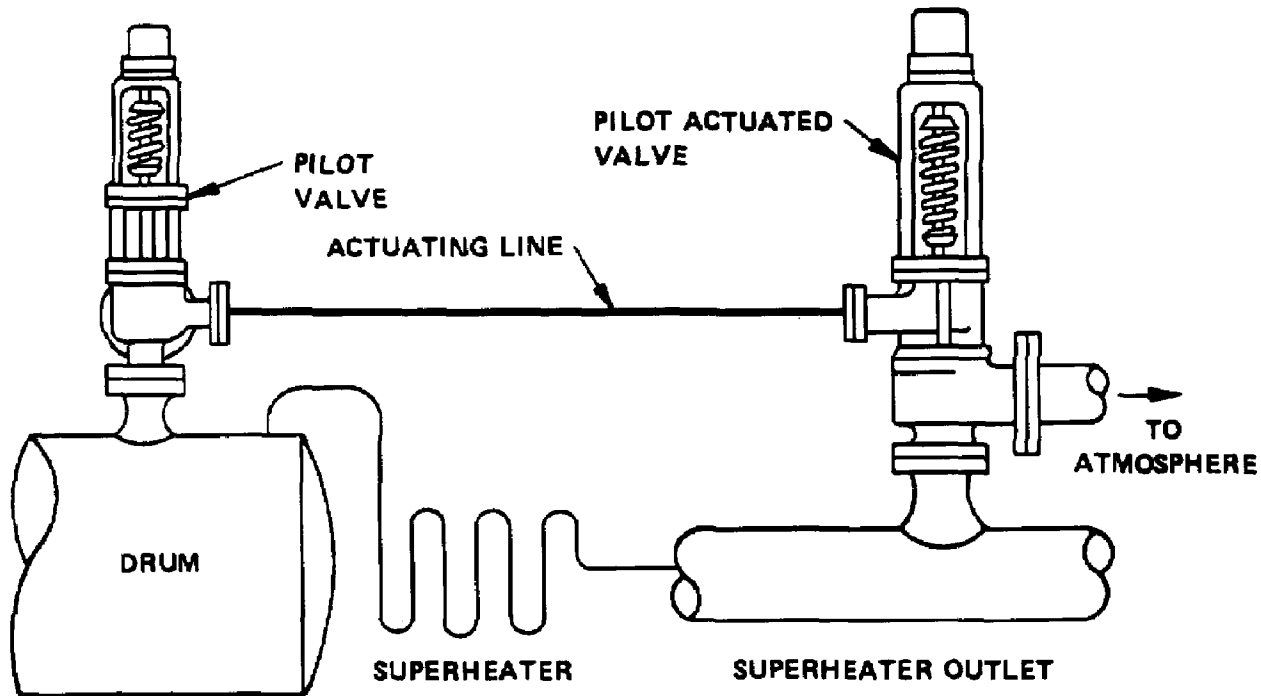


Figure 221-3-14. Drum Piloted Operated, Spring Loaded, Superheater Safety Valve System.

2. When the pilot valve pops, steam pressure from the body of the pilot valve acts through the actuating line to impose pressure on the lower face of the piston in the superheater valve. This steam pressure is sufficient to overcome the spring load of the unloading valve and lift the valve instantly to full capacity.
3. During normal boiler operation, the control of the combination pressure relieving system is completely actuated from the pilot valve both as to opening pressure and as to closing pressure.
4. The superheater valve is normally set as a conventional spring-loaded valve for relief protection. In this way, the spring-loading of the superheater valve is such that its operation is completely controlled by the pilot, but in the unlikely event of actuating line failure, the superheater valve will perform as a conventional spring-loaded valve.

221-3.2.5.2 Drum-Pilot-Operated, Pressure-Loaded, Superheater Safety Valve System. The pressure-pilot-operated superheater outlet valve assembly was developed for superheat control boilers. This design consists of a pilot valve which is basically a small drum safety valve with a vent in the valve body to which the superheater valve is connected by an actuating line. When the pilot valve lifts, the backpressure caused by steam flow through the escapement piping is transmitted by way of the actuating line to a cylinder on the superheater safety valve. The superheater safety valve is held shut by bleeding steam from the superheater through a small hole to a chamber above the superheater safety valve disk. The cross-sectional area of the side of the disk exposed to the steam pressure in the chamber is greater than the cross-sectional area of the nozzle under the disk, which is also exposed to the superheated steam pressure. The imbalance in forces resulting from the difference in cross-sectional areas exposed to superheated steam pressure holds the superheater valve closed until the drum pilot actuator lifts. When the pilot valve lifts, the steam pressure transmitted to the cylinder on the superheater valve actuates a mechanism, which vents the steam from the chamber over the superheater safety valve disk. The pressure under the disk opens the superheater safety valve. When the pilot closes, pressure in the pilot valve body and actuating line returns to atmospheric, closing the cylinder actuated vent on the superheater valve. With the vent closed, superheated steam entering the chamber above the disk increases chamber pressure quickly to provide sharp clean closing of the superheater safety valve.

221-3.2.5.3 Remote-Pilot-Operated, Superheater Safety Valve System. This system consists of two major components, the superheater outlet safety valve itself and the hydraulic pilot unit. Piping connects the pilot unit to

the boiler and to the superheater outlet valve. This piping allows the pilot to sense boiler pressure, receive boiler water for hydraulic functions, and open or close the superheater outlet valve. The pilot unit is assembled on a heavy metal backing plate and enclosed in a cabinet, which is mounted in a convenient location in the fireroom. Unlike a conventional steam drum pilot valve, it does not function as a relief valve since it does not exhaust steam. Rather, its sole function is to control the superheater outlet safety valve by hydraulically loading or unloading the valve disc in response to steam drum pressure. Boiler water pressure holds the safety valve closed during normal boiler operation. When the pilot valve set pressure is reached, the pilot unit acts to vent the water pressure in the safety valve allowing the steam pressure to open the superheater outlet valve. A schematic arrangement of this system is shown in [Figure 221-3-15](#).

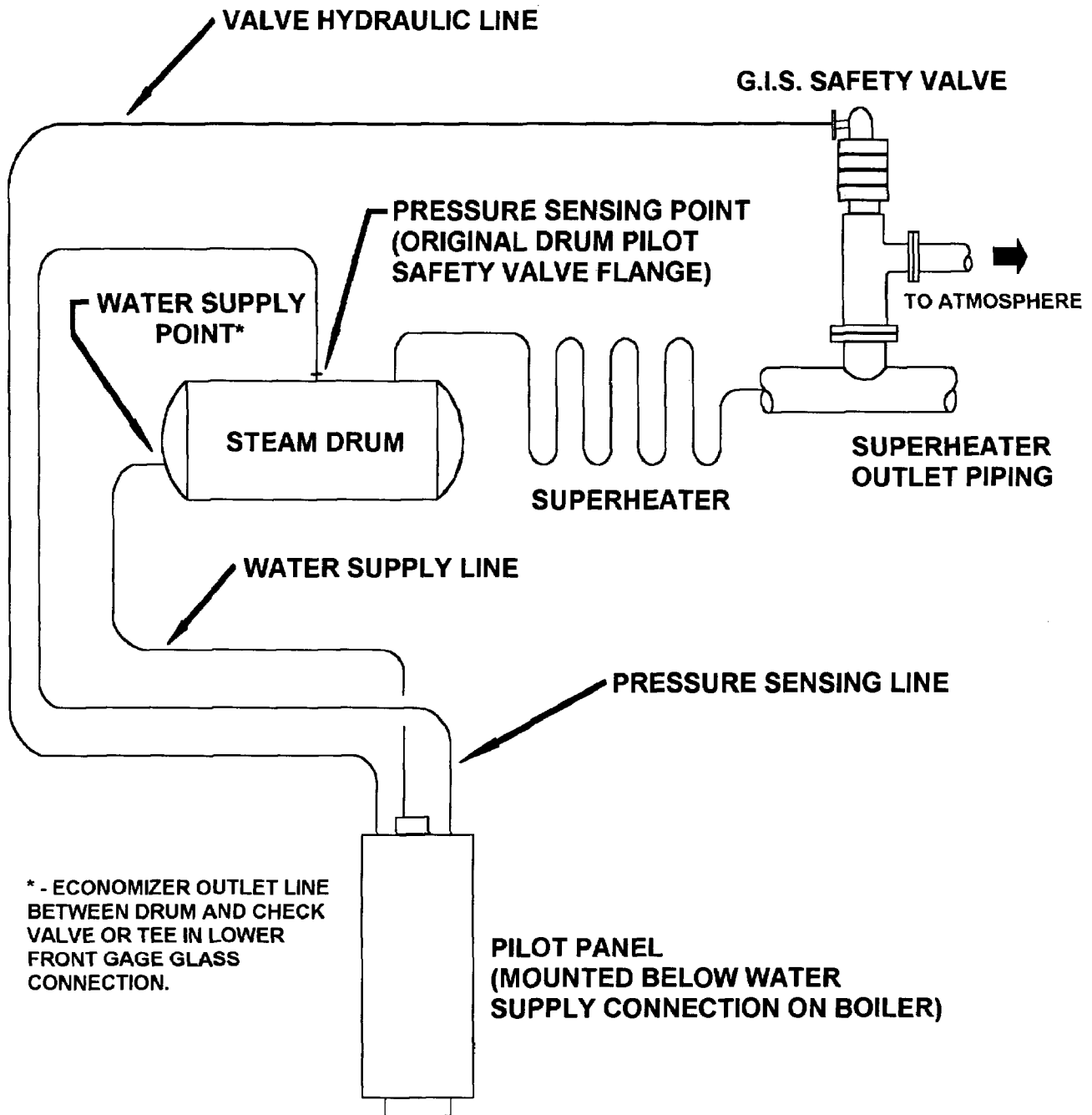


Figure 221-3-15. Remote Pilot-Operated Superheater Safety Valve System.

221-3.2.5.4 Pilot-Operated Drum Safety Valve System. This system consists of two major components a G.I.S. drum safety valve and a hydraulic pilot panel assembly. A hydraulic line runs from the G.I.S. drum Safety valve to the drum pilot panel. The pressure sensing and water supply lines for the drum valve are connected by tees to the existing lines of the G.I.S. Superheater valve for the boiler. Operation and maintenance is similar to that of the remote-pilot superheater valve system; refer to [paragraph 221-3.2.5.3](#).

221-3.2.6 SAFETY VALVE TESTING REQUIREMENTS. Boiler safety valves are to be tested by steam to determine correct operation at preset pressures as follows:

NOTE

The Engineering Officer, or designated test leader, will ensure test personnel are fully briefed on standard EOCC and procedures in the event of a tube, piping or pressure vessel failure when testing safety valves. This includes ensuring personnel are stationed at the superheater safety valve unloader lever, if installed, or hand easing gear operating wheel locations and are briefed, and prepared, to lift safety valves if ordered to relieve pressure to zero and to secure fires.

1. All safety valves of each boiler shall be tested 18 month intervals according to PMS.
2. After each boiler hydrostatic test, each gagged safety valve of the boiler shall be tested.
3. Safety valves shall be tested when they have been removed and replaced on a boiler for any reason such as boiler 150 percent hydrostatic test or when they have been reworked. In the latter instance, the reworked safety valve and all lower set safety valves on the boiler shall be tested after having been gagged. Pilot-operated spring-loaded superheater safety valves should usually be tested in conjunction with the drum pilot actuator according to [paragraph 221-3.2.10.1](#).
4. Safety valves which are accidentally lifted by water during boiler hydrostatic tests shall be tested.

NOTE

Testing of GIS valves when gags are installed in the Pilot Panel is not required.

221-3.2.6.1 Pressure Gauge Calibration for Safety Valve Setting. All safety valves installed on a boiler shall be set utilizing the drum pressure gauge installed on that boiler. The pressure gauge used shall have been calibrated within the past twelve months. Safety valve tests are not required when a new or re-calibrated boiler pressure gauge is installed. For information on calibration of gauges, refer to [paragraphs 221-3.6.2 through 221-3.6.2.2](#), and NSTM Chapter 504, Pressure, Temperature, and Other Mechanical and Electromechanical Measuring Instruments, paying particular attention to hydrostatic leg corrections.

221-3.2.6.2 Boiler Operation During Testing and Setting. Complete securing of the boiler and all burners shall be avoided during testing and steam setting of installed safety valves. Whenever possible the boiler shall be put on the line to the extent that it is supplying steam to auxiliary machinery such as blowers and feed pumps, or to a turbo-generator during safety valve tests. Safety valve tests with closed main and auxiliary stops shall be avoided. One burner shall be used to bring the boiler to line pressure and to operate the steam equipment. A second burner shall be used to assist in raising the boiler to over pressure to lift the safety valves. The second burner shall be secured immediately following lift, and fuel oil pressure to the first burner is to be reduced without extinguishing its fire. The primary consideration is to avoid several cycles of completely securing fires and lighting off a hot boiler. Under some circumstances such cycling can result in flareback or furnace- explosions. In most boiler designs, placing the boiler on line also assists in maintaining satisfactory steam flow through the superheater.

221-3.2.6.3 Controlling Excessive Steam Pressure During High Drum Safety Valve Lift Testing. Two burners shall be used, as described in [paragraph 221-3.2.6.2](#), when raising steam pressure to lift safety valves, and EABC should be placed in one knob control. If the high drum safety valve fails to lift after exceeding lifting pressure

plus allowable tolerance, a burner should be immediately secured and EABC should be reduced to minimum. In the unlikely event that steam pressure continues to rise or does not fall, secure fires and lift the superheater safety valve unloader lever, if installed, or hand easing gear to reduce steam drum pressure to at least 200 psig below operating pressure.

NOTE

When applicable EOCC specifies lifting safety valves by hand, gagged GIS safety valves can be lifted with hand easing gear in the event that a casualty occurs during safety valve testing. Refer to [paragraph 221-3.2.9](#).

221-3.2.6.4 Safety Valve Setting. Developments in boiler design require the use of different types of safety valves, with different procedures for setting these valves. It is therefore impractical to formulate one set of rules that would apply to all types of valves. The settings for safety valves of all ships are included in PMS and Main Boiler Technical Manuals. Safety valve settings shall not be increased or decreased without written approval of NAVSEA. After settings are made, all valve cap assemblies shall be locked with a padlock to prevent unauthorized changing of settings. Adjusting ring plugs shall also be locked or lead wire sealed. In the case of GIS valve, the cabinet and the self contained mechanical gag on the superheater outlet safety valve shall be locked. Locks and lead seals should not be removed until just prior to setting the valve and by specific direction of the Engineering Officer. Valves found with locks and seals missing must be retested unless circumstances of removal can be established and the integrity of the settings positively assured. In such cases, locks and seals shall be restored only with the approval of the Engineering Officer.

221-3.2.7 PRESSURE TOLERANCES. Inexperienced personnel shall not be allowed to set boiler safety valves by steam. Tests and adjustments shall be carried out strictly as set forth. Simmering of safety valves within 1 percent of the popping pressure is to be expected after a period of service. As long as a valve does not simmer at the boiler operating pressure, however, no corrective measure need be taken. The following lift pressure tolerances and blowdown ranges shall be used for setting all safety valves by steam, provided that a differential of at least 5 psi is maintained between the actual settings of the drum pilot valve and the lowest set drum valve for any boiler having valves of that type:

a. Lift Pressure Tolerances.

1. 325 psig boiler drum pressure and below (300 psig nominal standard safety valves and less) - tolerance plus or minus 3 psig.
2. 326 to 710 psig boiler drum pressure (600 psig nominal standard safety valves) - tolerance plus or minus 5 psig.
3. 711 to 1,410 psig boiler drum pressure (1,500 psig nominal standard safety valves) - tolerance plus or minus 10 psig.

b. Blowdown. A blowdown range between 3 and 6 percent of actual safety valve lift (popping) pressure is acceptable, providing the boiler valves reseal in proper sequential order, that is, on pilot action, drum valves reseal before superheater valves. Drum valves do not have to reseal in sequence. Additionally, no valves shall reseal below operating pressure. Attempting to achieve too fine a blowdown setting in individual safety valve can lead to repeated lift tests which break down the finely honed surfaces of valve discs and nozzles (seats).

221-3.2.8 GAGGING. Gags shall not be placed on safety valves when the boiler is cold except before hydrostatic test. Thermal expansion of safety valves spindles, as the boiler temperature rises from cold to hot, will result in severe over gagging stress on the spindle if the gags are applied when the boiler and valves are cold. Gags shall not be placed on a steaming (warm-up status) boiler until the boiler pressure is 100 to 200 psi below the lowest safety valve setting, or 75 percent of the working pressure, whichever is higher. On remotepilot operated GIS systems, gagging each hydraulic pilot unit (at the panel) also gags the superheater outlet safety valve. The self-contained mechanical gag on the superheater outlet safety valve is used only when the boiler is hydrostatically tested with the hydraulic pilot unit removed from the boiler.

221-3.2.9 HAND EASING GEAR DISENGAGEMENT DURING TESTING. When valves are gagged for testing as discussed in [paragraph 221-3.2.8](#), remove lifting gear from all non-GIS safety valves. The GIS safety valve hand easing gear is unaffected by the gags installed in the pilot panel. This allows lifting of GIS safety valves via hand easing gear with gags installed.

221-3.2.10 INSTRUCTIONS FOR TESTING, SETTING, AND ADJUSTING SAFETY VALVES. Procedures for setting and adjusting safety valves and for controlling blowdown are described in the following paragraphs. If the safety valves of any boiler cannot be adjusted to lift within the prescribed range, the boiler shall not be used for steaming until the fault has been corrected. Refer to PMS for specific procedures for safety valve setting. Each individual valve of each boiler shall be lifted by steam and reset if at variance with the authorized popping and reseating pressures. Between pops, drop the pressure to operating pressure. Because the temper of the superheater valve spring (where applicable) is affected by temperature, complete cool down of the valve between blowdowns (at least 30 minutes) is necessary. With increasing temperature, valve blowdown tends to decrease. Blowdown is shortened about 1/2 percent for each 55° C (100° F) rise in temperature of the spring. If resetting of the spring-loaded superheater outlet valve without the recommended cool-down is necessary, the above rate of compensation of blowdown should be employed. For a final approval test, the superheater valve shall be popped only in conjunction with the pilot valve.

NOTE

To maintain good seating surfaces and optimize valve performance, popping of the valves should be kept to a minimum. If the valve does not respond to adjustments as described here or in the Boiler Technical Manual, NSWCCD-SSES should be notified and, if required requested to assist.

221-3.2.10.1 Drum-Pilot-Operated, Spring-Loaded Superheater Valve.

1. The steam temperature at the valve during testing will affect the operating characteristics of the valve. For example, higher temperatures will cause blowdown to shorten compared to valve performance at lower temperatures. In addition, temperature variation will affect the repeatability of the popping point of the valve.
2. Since the steam temperature at the superheater outlet may vary during valve testing periods (due to changing flow condition), it is important to make every effort to maintain temperatures at a consistent level. If temperature variations occur, the valve operating characteristics should be observed and, when determining acceptable valve performance, allowances shall be made for these temperature variations.
3. The principal objective of the superheater valve test is to obtain sharp opening and closing within the allowable blowdown range, since the superheater valve is operated by the drum pilot during regular boiler operation.
4. The successful performance of the pilot-operated valve system depends on the combined operation of the drum pilot valve and the superheater outlet valve. Therefore, the final readings of pop and reseal pressures should be obtained when testing the two valves in combination. The superheater safety valve is designed to operate as a spring-loaded valve should the drum pilot actuator valve fail.
5. When making the initial installation, after rework, after removal and installation, and after lift by hydrostatic pressure, the valve shall be lift-tested and set separately and then be lifted in conjunction with the pilot safety valve. At other safety valve lift test periods, when the separate spring-loaded superheater safety valve does not come under the conditions above, it is lift-tested only in conjunction with pilot valve. Lift tests made in conjunction with the pilot valve satisfactorily prove the superheater valve operation after gagging for a steam test of the drum valves.

221-3.2.10.2 Pop Pressure Adjustment of Drum-Pilot Actuator, Drum Safety Valves, and Spring-Loaded Superheater Valves. Since valves are operating on saturated steam, there will be a noticeable difference in the noise level and sharpness of operation compared with superheater outlet valve. Opening, blowing, and closing action, although clean, will not be as sharp nor produce as high a noise level as with superheater outlet valves. This is especially true of the pilot valve. Close observation of pilot valve operating characteristics is necessary in order to make correct adjustment. Procedures are as follows:

1. Remove lifting gear (lever pin padlock, forked lever pin, forked lever, cap setscrew and cap) to expose the adjusting bolt. Raise the boiler pressure until the valve pops or until the allowable boiler pressure limit is reached. If the boiler pressure allowable limit is reached and the valve has not popped, lower the boiler steam pressure sufficiently to allow resetting the popping pressure (about 10 percent is usually sufficient). Adjust popping pressure according to [Figure 221-3-16](#). When proper pressure has been obtained, make sure that the adjusting bolt locknut is tight.
2. Changing the popping pressure tends to alter the blowdown adjustment as follows: raising the pressure lengthens the blowdown, and lowering the pressure shortens the blowdown. A slight change of popping pressure generally does not require readjustment of blowdown.

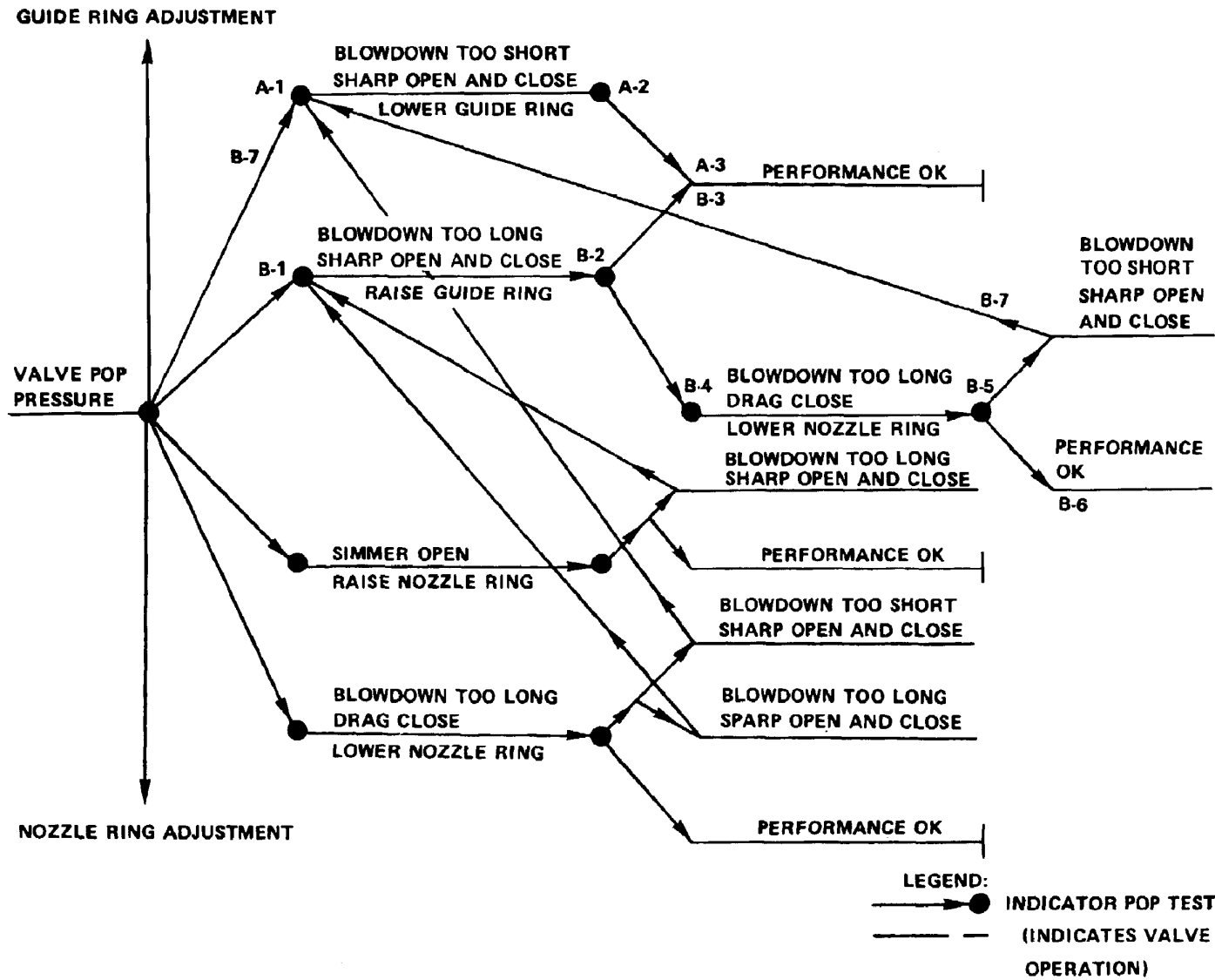


Figure 221-3-16. Safety Valve Adjustment Diagram.

221-3.2.10.3 Control of Blowdown in Nozzle Reaction Valves. The guide ring and the nozzle ring are the operational control parts of the valve, and the location of these rings is of primary importance in proper performance. Location reference points and the meaning of the established ring settings are illustrated in [Figure 221-3-17](#). Adjustment procedures are as follows:

1. The zero location of the guide ring and the nozzle ring is at the plane of the lower face of the disc holder. The nozzle ring is, therefore, at zero location when it has been raised until it touches the disc holder. The movement of the nozzle ring shall be downward and, therefore, all locations of this ring will be minus. The guide ring zero location is established by placing it even with the plane of the lower face of the disc holder. Upward movement of the guide ring from the location is plus and downward movement is minus.
2. The guide and nozzle rings are adjusted by engaging the notches of the ring (by means of a screwdriver or other similar tool) and moving the ring in the desired direction on the thread. The amount of movement is controlled by counting the notches. Thus, moving the guide ring five notches in the upward direction from zero location will give a location of +5, while moving it in the downward direction from zero location a total of five notches will give a location of -5. Moving the nozzle ring from zero location a total of 10 notches will give a location of -10.
3. For adjustment of safety valves that have not been removed from the boiler for rework (and the ring adjustment has not been disturbed), the guide ring should normally be used as the principal means of adjusting blowdown. Turning the guide ring to the right raises it (plus direction) and thereby reduces lifting force, shortening blowdown. Turning the guide ring to the left (minus direction) lowers it, increasing the lifting force and increasing blowdown. Procedures are as follows:
 - a. The nozzle ring which is intended primarily to cause the valve to pop sharply (eliminate simmer or warn) normally need not be adjusted as long as valve action is satisfactory.
 - b. Between test pops, adjustments to the guide ring should not be greater than five notches in either direction. After each adjustment, always replace and tighten the setscrew being careful that its point engages a notch and does not rest on the top of a tooth.

WARNING

When the nozzle ring is adjusted with pressure on the boiler, the valve should be gagged as a safety precaution.

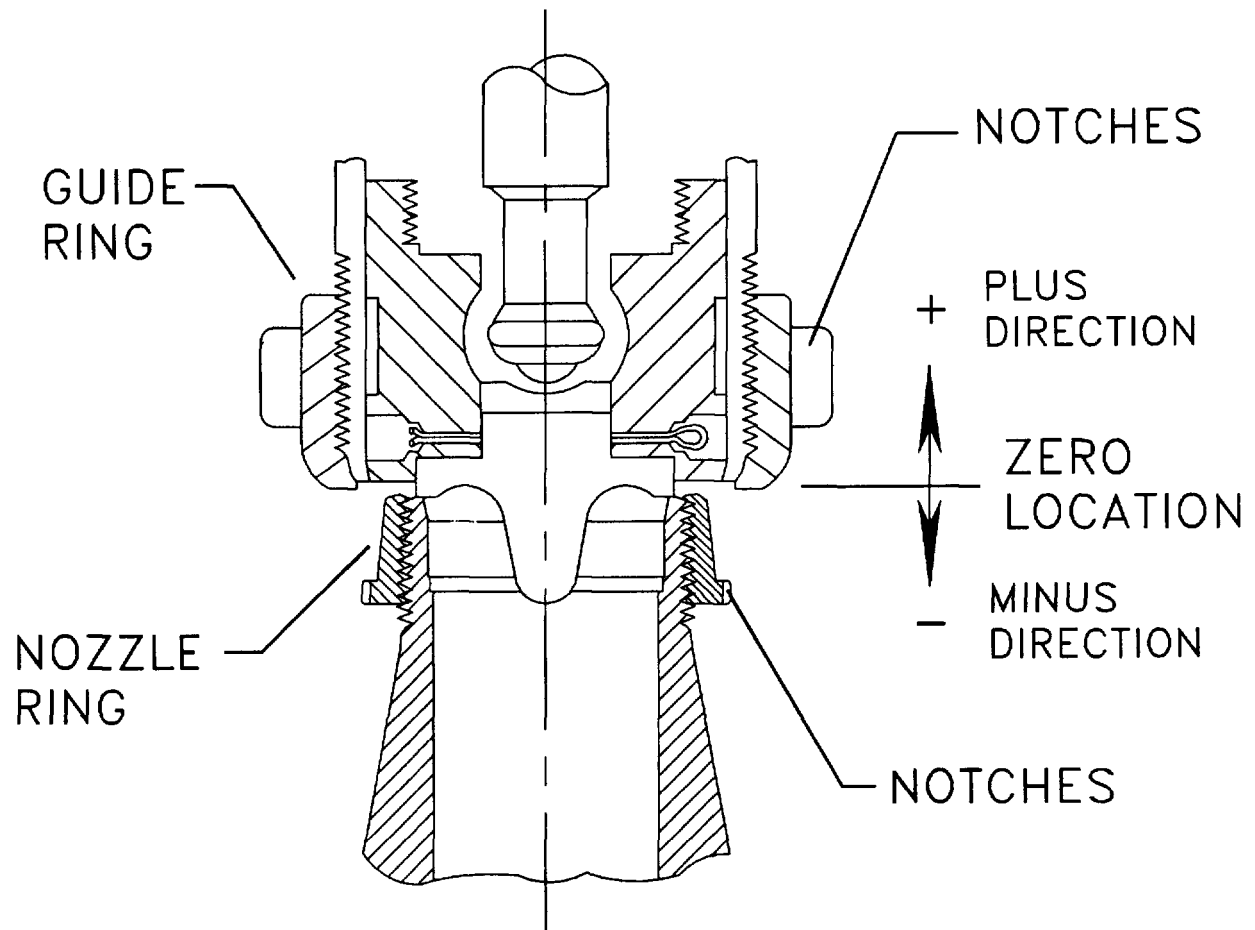


Figure 221-3-17. Nozzle and Guide Ring Adjustment

- c. If the guide ring is raised too high, in attempting to shorten the blowdown, it will become ineffective and further upward adjustment will not affect valve operation. The maximum position of the guide ring ordinarily should not exceed +20. If blowdown requires further adjustment, the nozzle ring may be used as long as valve operation continues to be satisfactory. When the nozzle ring is adjusted, movement between pops should be limited to one notch at a time as it is very sensitive to movement. Turning the nozzle ring to the right raises it and causes the valve to pop more sharply. If it is adjusted too high, it will cause the valve to hang at the reseating point before closing. This movement will also increase blowdown.
- d. Turning the nozzle ring to the left lowers it, reduces popping action, and generally reduces blowdown. A record of adjustment should always be kept when setting valves, to follow valve action and allow return to the starting point if necessary.
- e. Always take full advantage of allowed tolerances for set pressure and blowdown. Try to achieve correct operation with the minimum number of test pops to reduce wear on seating surfaces.

221-3.2.10.4 General Adjustment Procedure. If satisfactory operation cannot be achieved by adjustment of the guide ring, or for valves that have been removed from the boiler and reworked, or for new valves, the general adjustment procedure is as follows:

1. Starting from the zero position, adjust rings to the settings given in [Table 221-3-3](#).
2. Pop the valve and record the lifting and reseating pressures.

3. If the blowdown is extremely long, use the nozzle ring to reduce blowdown. Turn the nozzle ring clockwise to the left (lower it), one notch at a time as needed, until the valve begins to lose its good lift characteristic.
4. Raise the nozzle ring one or two notches to return the good lift characteristics and lock in place with the set-screw.
5. Use the guide ring as required to further adjust the blowdown. Turning the ring to the right raises the ring and shortens blowdown, turning to the left lowers it and increases blowdown.

NOTE

During the following sequences of adjusting the valve, it may be necessary to make minor adjustments to the set pressure. On other examples follow indicated paths and instructions.

221-3.2.10.5 Safety Valve Adjustment Diagram. [Figure 221-3-16](#) illustrates safety valve adjustment by diagramming the test and adjustment sequence used in setting nozzle reaction safety valves. It shows various alternatives in performance characteristics and corrective steps to obtain proper performance. The diagram illustrates the testing of a safety valve in good mechanical condition (undamaged by foreign material and unaffected by installation conditions). If the valve being adjusted displays leakage, erratic -popping and closing, or excessive simmer during testing and does not respond to adjustments, it should be checked for mechanical damage or friction resulting from installation strains. The diagram gives a step-by-step sequence of tests and results, following the paths indicated by the arrows, as shown in the following examples:

a. Example 1:

1. A-1 Pop the valve. The blowdown is too short but the valve opens and closes sharply. Adjust the guide ring downward (approximately 5 to 10 notches) to increase the blowdown. Follow the path to A-2.
2. A-2 Pop the valve. Check the response to adjustment. If the blowdown is still too short, adjust the guide ring downward to increase the blowdown. Repeat until performance is satisfactory.
3. A-3 Performance is within specification.

b. Example 2:

1. B-1 Pop the valve. The blowdown is too long but the valve opens and closes sharply. Adjust the guide ring upward to shorten the blowdown. Follow the path to B-2.
2. B-2 Pop the valve. Check the response to adjustment. If the blowdown is still too long, adjust the guide ring upward until condition B-3 or B-4 is reached.
3. B-3 Performance is within specification, or;
4. B-4 Blowdown is still too long but the valve drops in lift and drags to low lift close. Adjust the nozzle ring to a lower position (one or two notches at a time). Follow the path to B-5.
5. B-5 Pop the valve. Check the response to adjustment. If drag close, adjust the nozzle ring downward to improve valve closing action until condition B-6 or B-7 is reached.
6. B-6 Performance is within specification, or;
7. B-7 Valve opens and closes sharply, but blowdown is now too short. Return to Setting A-1 (Example 1) and proceed as shown.

WARNING

When a huddling chamber safety valve adjusting ring is adjusted with pressure on the boiler, the valve should be gagged as a safety precaution.

221-3.2.10.6 Control of Blowdown Huddling Chamber Valves. The adjusting ring position controls valve blowdown. Turning the adjusting ring to the right (counter-clockwise) raises it, increases lifting force and lengthens the blowdown. Turning the adjusting ring to the left (clockwise) lowers it, decreases lifting force and shortens the blowdown. Ring adjustments are made as follows:

1. Remove the ring pin. Engage the notches in the ring with a screwdriver and move the ring in the desired direction on the thread. The amount of movement is measured by counting the notches.
2. Between test pops, the adjusting ring should not be moved more than five notches in either direction. After each adjustment, always replace and tighten the ring pin, being careful that its point engages a notch and does not bear against a tooth.
3. Always, take full advantage of allowed tolerances for set pressure and blowdown. Try to achieve correct operation with the minimum number of test pops to reduce wear on seating surfaces.
4. On a repaired valve where the ring setting before rework is not known, the initial test should be conducted with the adjusting ring two turns down from the zero position. The adjusting ring is in zero position when it has been raised to contact the disk holder.

Table 221-3-3. Safety Valve Adjustments

Valve	Nozzle Ring	Guide Ring
<p style="text-align: center;">NOTE</p> <p>Starting from the zero position described in paragraph 221-3.2.10.3 and Figure 221-3-17, adjust rings to the following settings</p>		
Crosby		
Pilot (HNP-F) 1,200 psi	-10 ^{N 1}	+10 ^{N 2}
Drum (HN-H) 1,200 psi	10 ^{N 1}	10 ^{N 2}
SH(HNB-P) 1,200 psi	10 ^{N 1}	-20 ^{N 2}
Pilot (HNP-F) 600 psi	-7 ^{N 1}	+10 ^{N 2}
Drum (HN-H) 600 psi	-7 ^{N 1}	+10 ^{N 2}
SH (HNB-H) 600 psi	-7 ^{N 1}	-20 ^{N 2}
Dresser (Consolidated) (Manning)		
Pilot 1711P & 1711PT (2-Ring)	-14 ^{N 3}	0 ²
Pilot 1711P (3-Ring)	+3 ^{N 3}	+30 ^{N 4}
<p style="text-align: center;">NOTE</p> <p>The third ring, the trim ring, shall be raised one turn up from ports being just closed position. Ports will be 1/3 to 1/2 open when ring is in correct position.</p>		
Pilot (1531P)	-1 3/4 ^{T 5}	N/A
Drum (1553)	2 ^{T 5}	N/A
Drum (1556)	-2 ^{T 5}	N/A

N = NOTCHES

T = TURNS

¹Zero reference point for all Crosby valve nozzle rings is the top edge of the nozzle ring level with the lower edge of the disc holder.

²Zero reference point for all Crosby valve guide rings and the 1711P (2-Ring) guide ring is the bottom edge of the guide ring level with the lower edge of the disc holder.

³Zero reference point for the 1711P (2-Ring and 3-Ring) nozzle ring is the top edge of the nozzle ring level with the seat. This must be set before assembly of the valve. If, after the valve is assembled, the ring position becomes unknown, zero reference point can be relocated by raising the nozzle ring until it makes contact with the disc holder, then lowering the ring seven notches.

⁴1711P (3-Ring) guide ring has a 30 degree bevel on its lower edge. The zero reference point is the ID of the bevel of the guide ring even with the lower edge of the disc holder.

⁵Zero reference points for the 1531P, 1553, and 1556 nozzle rings are determined by raising the nozzle ring until it makes contact with the disc holder.

221-3.2.10.7 Adjusting Remote-Pilot-Operated Safety Valves. There are only two adjustments normally made on the remote-pilot-operated safety valve: bleeding trapped air from the system and setting popping pressure. Blowdown is factory set between 3 and 6 percent of lift pressure, and is not adjustable. Adjustments are made as follows:

1. Bleed air from the system by using the purge fittings on the filter canister and safety valve when boiler pressure reaches 100 psig.

2. Adjust popping pressure by loosening the lock ring and turning the 11/16-inch hex bolt. Retighten the lock ring.
3. Do not make any other adjustments.

221-3.2.10.8 Duplicate Safety Valve Settings. Some boiler designs are peculiar in that the pilot-operated spring-loaded superheater safety valve and the lower drum safety valve have identical lift settings. When tested independently, this could cause confusion in gagging valves and the consequent lift required following gag removal. To eliminate confusion, use the following procedure:

1. Gag all valves except the superheater safety valve.
2. Set the superheater valve, preferably to minus tolerance.
3. Gag the superheater valve carefully and test the drum valves in succession (in order of descending set pressure)
4. Set the drum valve with the lowest set pressure, preferably to plus tolerance.
5. Remove the gag from the drum pilot valve.
6. Test and set the pilot valve.
7. Remove the gag from the superheater valve.
8. Test pop the pilot-superheater valves in combination.

NOTE

It is preferred that the superheater safety valve on independent spring action lift within the negative tolerance from its nominal set pressure and that the lowest set drum valve lift within the positive tolerance. However, this preference is not a requirement. Follow-on lifts and adjustments accomplished only to achieve the preferred tolerances is not authorized.

221-3.2.10.9 Testing of Superheater Valve Unnecessary. The above procedure eliminates the necessity for subsequent testing of the superheater valve on its own spring action following gag removal. Note also that pilot-operated spring-loaded superheater safety valves are not lift-tested separately (refer to [steps 1](#) and [2](#)), unless they are initially installed, reworked, removed from and reinstalled on boiler, or lifted by hydrostatic pressure.

221-3.2.11 SAFETY VALVE LEAKAGE. One of the most common problems encountered with spring-loaded safety valves is leakage past the valve's seating surfaces. Because of the hard metallic seating surfaces and the relatively low seating forces, some leakage will always be present at full boiler pressure. As valves are degraded by time and numerous pops, the leakage rate of the valve will increase. When valves have been degraded by wear, and leakage becomes excessive, seating surfaces should be examined. This examination can be deferred until availability permits and remedial action can be taken as necessary. In general, safety valve leakage, although a nuisance, is not grounds for curtailing boiler operation. At present, the only criterion available for determining whether safety valve leakage has reached a point requiring repair action is evidence of a steady plume of steam (3 feet long in calm air) emitting from the exhaust line at the stack. For most types of safety valves, to identify which safety valve on a steaming boiler is leaking excessively, carefully place a cool, flat knife blade between the lowest coils of each valve's spring. The leaking valve will leave excessive moisture beads on the knife. Wear insulated gloves to avoid possible skin contact with invisible superheated steam vapor at spring-loaded superheater valves. A mirror may replace the knife.

GIS type valves have an allowable leakage from the pilot or three way valve, provided the safety valves have no visible signs of simmering and the bottom of the filter canister is not hot to the touch at least one hour after setting or adjusting safety valves. Schedule repair if leakage exceeds 10 drops per minute, the safety valves experience simmering or the filter canister is hot to the touch.

221-3.2.12 MAINTENANCE. Maintenance procedures described in the following paragraphs are to be followed exactly to ensure optimum operation of safety valves. In general, safety valves shall not be touched as long as their operation is satisfactory, because disturbing or altering internal parts often results in valves giving unsatisfactory service. This is particularly true if work is done by one not thoroughly familiar with proper repair methods. Instructions for the care, operation, and maintenance of valves will be found in the Boiler Technical Manual.

221-3.2.12.1 Criteria for Repairs. Safety valves that have been removed from the boiler to a depot activity for repair shall be tested with steam at the repair activity for steam tightness and popping pressure. Acceptance criteria for the tightness test are given in the Main Boiler Safety Valve Repair Guide, and may be used for both 600 psig and 1,200 psig safety valves. When the valves are installed on-line and set at the required settings there should no plume visible at the stack or any visible or audible leakage at the valves. Slight leakage from valve drains is not grounds for rejection. In the event valves do not meet these criteria, after having passed shop steam leakage tests, the following areas should be checked:

- a. Seating surfaces may have been damaged during setting on the boiler.
- b. The hand easing gear may be restricted from expanding with the boilers due to an obstruction or interference and is causing a strain on the valve(s).
- c. Safety valve escape piping or actuating line may be causing strain on the safety valve body.

221-3.2.12.2 Removal of Escapement or Actuating Piping. Ship's personnel should not remove escapement or actuating piping on a pressurized boiler. If a piping problem is suspected, NSWCCD-SSES assistance should be requested. Guidelines for examination of safety valve related piping are contained in NSTM Chapter 505.

NOTE

Refer to the Main Boiler Safety Valve Repair Guide and the Boiler Technical Manual for specific repair procedures.

221-3.2.12.3 Repairs. For satisfactory operation of safety valves it is important that essential original dimensions be retained. Grinding in and subsequent adjustment of valve parts should therefore be kept to minimum and worn out parts should be replaced. Continued unsatisfactory operation in service usually indicates that essential dimensional details have undergone a change from the original design; clearance has been modified because of repeated grindings and, as a result, correction to other parts has been omitted. For the guidance of older ships not having specific instructions for maintenance of safety valves, and ships in which installed safety valves do not fall in the categories outlined, general instructions are given below. See [Figure 221-3-18](#).

1. The grinding in of a safety valve, even where the amount of metal removed is small, involves a departure from design dimensions. Although success in eliminating leaks often follows first grinding, it is not safe to assume that further grinding will effectively remedy subsequent leaks.
2. Small metal templates made by the valve manufacturer should be carried on board for each set of safety valves for use in gagging the correct dimensions or clearances of the valves and valve seats when grinding in.

3. Although various brands of safety valves differ in detail, the valve shown in [Figure 221-3-18](#) illustrates the operating principles common to all.
4. When a safety valve is repeatedly ground in, or when a cut is taken on the valve disc or valve seat, metal is removed from the seating surfaces WW of either the valve disc or the valve seat. This procedure alters the vertical position of the disc and changes important dimensions, unless steps are taken to counteract the effects of the cut on the valve seat or disc.
5. For example, referring to [Figure 221-3-18](#), if 0.005 inch is removed (vertically) from WW of the disc, an equal amount of material should be removed from the surfaces at BB and CC so that there is no change in the original dimensions of X.

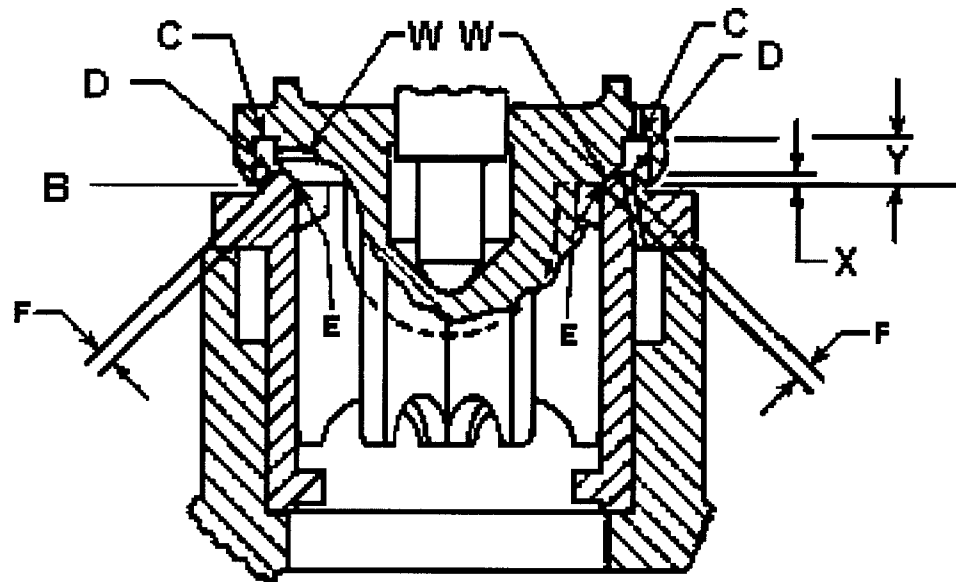


Figure 221-3-18. Safety Valve Grinding Repairs.

6. Likewise, should the cut be taken from WW of the seat, a cut should be taken off the horizontal shoulder DD to keep the dimensions on F as originally designed. This is an important feature of some types of valves.
7. Any chamfer existing at EE should be restored after taking off the cut from WW.

221-3.2.12.4 Safety Valve Preservatives. To provide adequate protection against corrosion formation, the external surfaces of safety valve bodies, bonnets, caps, yokes, and flanges shall be painted with two coats of heat resistant paint (refer to [Appendix A](#)). Safety valve springs, spindles (stems), and adjusting screws shall not be painted.

221-3.2.13 HAND EASING GEAR. Safety valve hand easing gear was originally designed to ensure that safety valve internals were still free without over pressurizing the boiler to lift them by steam. Subsequent modifications were introduced to use this mechanism for relieving boiler pressure in an emergency. This dual purpose is unique to the Navy. Neither the safety valve nor the hand easing gear is designed to support the compression of the safety valve spring as boiler pressure is diminished. In addition, the cam-operated systems open the valves in sequence and hold them open until the highest set valve is opened. This procedure takes so much time that the water level cannot be maintained if firing the boiler is continued and pressure is lost if firing is discontinued. Consequently, cam operated hand easing gear should only be activated with all cables connected, during a casualty severe enough to justify the potential damage to the valves and hand easing gear.

221-3.2.13.1 Inspection and Maintenance. Every 18 months according to PMS, hand easing gear should be cleaned, lubricated and checked for adjustment to ensure that the system will open the valves in an emergency.

- a. Spring Loaded Valves. This check should be done without actually opening the valves, by removing the forked lever as the slack is taken up to each valve. Observe the sequence of lift, travel and snap back action of the safety valve lever arms. On ships equipped with cam operated hand easing gear the adjustment of cable travel shall be verified by actually lifting the valve as required. Cable travel shall be verified after certain work is done to ensure that the cam follower travel is sufficient to open the valve and compensate for cable stretch, but not enough that the cam box is jammed, preventing further forward rotation of the cams. This test shall be accomplished after the hand easing gear has been replaced or adjusted, when the safety valve is replaced or when work is done on the safety valve which could change the end point of lever arm travel. This test should only be accomplished on one valve at a time on the valves requiring it, and shall not be attempted unless boiler pressure on the valve is within 100 psig of the lift set pressure. Care shall be taken to ensure adequate steam flow through the superheater during the test.
- b. GIS Valves. Periodic lubrication of the 3-way valves in the GIS safety valve panels with high temperature lithium grease is required. This maintenance requires permission of the Engineering officer.

221-3.2.13.2 Hand Easing Gear Cam Follower Adjustment. In making preliminary cam follower adjustments on a cold boiler, the lever arm travel can be determined by backing off the spindle nut from its properly adjusted position. With the spindle nut temporarily located in the position it would occupy if the valve were lifted, check the travel of the lever arm as follows: With the cable clevis and snap back spring disconnected from the lever arm, measure and record the travel of the clevis pin hole in the lever arm between snap back position and its position with the lever arm lifted until either the spindle nut or the lever arm stop nut is engaged. After taking this measurement, return and lock the spindle nut in its properly adjusted position and reconnect the snap back spring and cable clevis to the lever arm. For boilers with shielded cables between the cam box and the safety valves, adjust the cable sheath adjustment nuts at each end of the cable sheath to vary cam follower travel. Note that the cam follower end point of travel in the cam box is determined by the diameter of the cam and is not subject to adjustment. Changes in travel are reflected by changes in the point where the cam picks up the follower.

221-3.3 SOOT BLOWERS.

NOTE

For soot blower operation, refer to [paragraphs 221-4.16 through 221-4.16.5](#).

221-3.3.1 TYPES OF SOOT BLOWERS. Soot blowers now in service may be classified into two general types, rotary and stationary.

221-3.3.1.1 Rotary. This type of soot blower has multi-nozzle elements. The soot blower head steam valve is actuated and the element is rotated by a crank, an endless chain, or an air or electric motor. Steam is admitted from the head into an element, which incorporates uniformly spaced nozzles. A typical rotary soot blower is illustrated in [Figure 221-3-19](#).

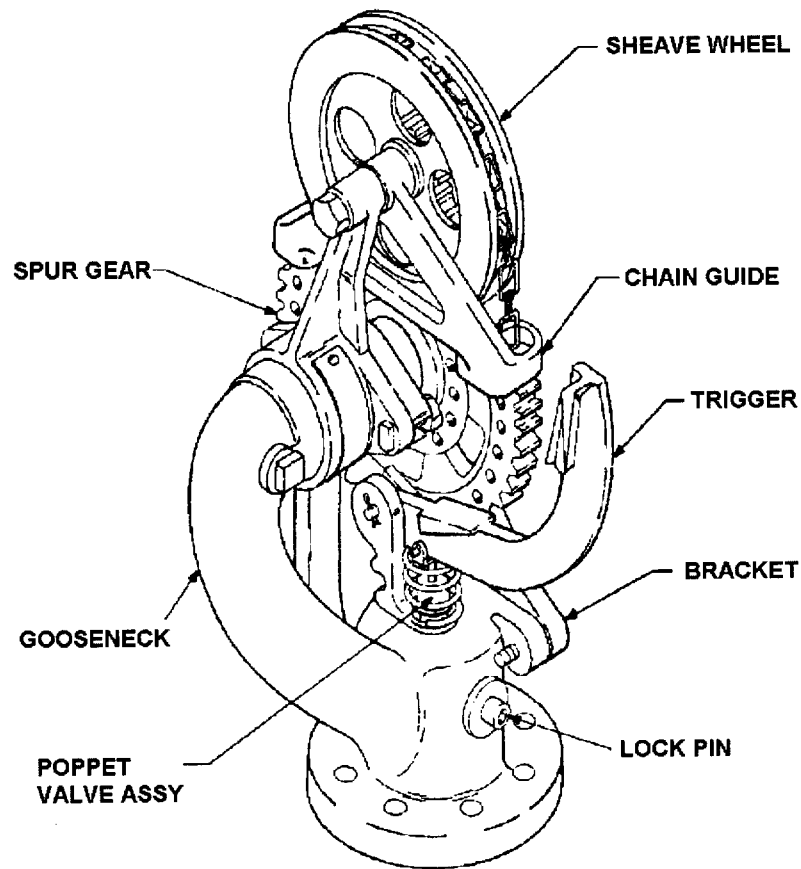


Figure 221-3-19. Typical Rotary Soot Blower

221-3.3.1.2 Stationary. This type of soot blower usually has one or two rows of nozzles directed to the area immediately above the water drum or directly below the steam drum in D-type boilers. Steam is admitted for a short duration, normally 15 seconds, by a manually or power actuated stop valve.

221-3.3.2 CONSTRUCTION OF SOOT BLOWER ELEMENTS. Practically all soot blower elements are fabricated from 1-1/2 or 2 NPS tubing with venturi nozzles placed equidistantly along one or both sides. The soot blower specification (MIL-B-1947) requires that nozzle spacing shall be no greater than every third tube if the axis of the element is at right angles to the axis of the tubes, or no greater than 3 inches if parallel to the tubes. For right angle arrangements, the element should be positioned to direct steam between tubes, to prevent steam impingement. The metals used in soot blower elements differ with relation to the gas temperature to which they are exposed; the elements, therefore, are not interchangeable although of identical size and nozzle spacing. If soot blowers are disassembled, particular care shall be taken to ensure that each element is reinstalled with its proper unit.

221-3.3.3 SOOT BLOWER BEARINGS. Soot blower elements of rotary and stationary types are supported by bearings spaced in the generating bank. During generating bank renewals, these bearings shall be inspected and, if in poor condition, renewed with the new generating bank tubes. Replacement bearing material shall be 25-percent Cr, 20-percent Ni or 25-percent Cr, 12-percent Ni.

221-3.3.4 STEAM PRESSURE. For best results in cleaning, the steam pressure in the soot blower head shall be as specified in the applicable boiler or soot blower technical manuals or drawings. If no designated pressure can be found, this pressure should be approximately 300 psig for rotary types and 150 psig for stationary types. The allowable tolerance setting for each type unit above is plus or minus 25 psi. Should fireside inspections

reveal unsatisfactory soot accumulations, minus tolerance settings in soot blower heads shall be raised to plus settings. This pressure can be checked by temporarily installing a pressure gauge at the connection provided on the head or at the element flange. If pressure adjustment is necessary, applicable manuals or drawings should be consulted. Some soot blowers are pressure-adjusted by means of an orifice in the companion flange, some by an adjustable orifice inside the head, and some by valve spring adjustment. When conducting a PMS test or adjusting the soot blower head blowing pressure, the connecting tubing for the pressure gauge shall have a fixed loop with a water leg carried within the loop to prevent rupturing the gauge and to prevent personnel injury.

221-3.3.5 PIPING WARMUP. Sufficient time shall be allowed for gradual and thorough warm-up of the steam lines before steam is admitted to the soot blowers. If this is not done piping may be subjected to thermal shock, inducing excessive thermal stresses which, in turn, could result in piping failure.

221-3.3.6 INSPECTION. Compliance with the following instructions will help to keep the soot blowers in proper operating condition.

221-3.3.6.1 Piping. Inspect the soot blower supply piping and drains to ensure that installation is according to NAVSHIPS drawing 804-841336. If the soot blower piping is not as shown in the drawing, it should be altered when repair or renewal of the piping becomes necessary. The visual inspection and ultrasonic testing of soot blower piping shall be accomplished during every CNO scheduled depot level overhaul/availability (PMA) or when damage is experienced or integrity is suspected whichever occurs first. When overhauls and availabilities are canceled or scheduled beyond the established phased maintenance period, the time between inspections shall not exceed 60 months for main propulsion boilers. The time between auxiliary and waste heat boiler soot blower piping inspections shall not exceed the maximum Strength and Integrity Inspection time limit as defined in [paragraph 221-5.4.2](#). The examination shall include piping from the steam root valves to the soot blower flanges, including the entire drainage system down to the reservoir and last drain valve. Tests must be conducted and results must be reported as specified in Section 505 of the General Specifications for Overhaul. (GSO.) The UT report and associated detailed sketches must be in accordance with NAVSEA S9221-D2-MMA-010 Appendix D. Piping must be replaced when it is equal to or below the minimum allowable thickness specified in NSTM Chapter 505 or analysis of thickness data indicates it will drop to the minimum allowed, due to continuing deterioration, before the next availability. Insulation must be removed from the soot blower piping for a thorough visual inspection for external corrosion, and properly reinstalled.

221-3.3.6.2 Heads (Goosenecks). The soot blower heads shall be ultrasonically tested to coincide with the Boiler Strength and integrity Inspection (refer to [paragraph 221-2.1.2.5](#)), or when damage is experienced or integrity is suspected, whichever occurs first. Head thickness is measured using pulse echo type of ultrasonic equipment with A-scan and fingertip transducers suitable for curved surfaces. Heads with remaining thickness less than 50 percent of the original thickness specified on applicable drawings shall be replaced.

NOTE

Replace all aluminum soot blower head reaction plates with ductile iron ASTM A536-77 Grade 80-55-06.

NOTE

In the past, aluminum packing glands have been mistakenly supplied for Copes-Vulcan soot blower heads. Any aluminum packing glands must be replaced with steel glands prior to placing the soot blowers in operation.

221-3.3.6.3 Elements. Soot blower elements shall be securely attached to the head. If a coupling attachment is used, ensure at least 1/2-inch thread engagement at each end and firm seating of coupling set screws. If the element and head extension piece are each screwed into flanges and the flanges bolted together, ensure 1/2-inch thread engagement and firm setting of screws. In addition to either system, screwed connections are to be tack

welded in at least three locations around the periphery. All elements shall be checked during each major overhaul for material condition and sizing of all element nozzles as follows:

1. Do not substitute elements of different material than specified, nor substitute nozzles of different size than original nozzles. In no case shall nozzles less than 3/16-inch diameter ever be used, as serious over pressurization may occur at the soot blower head. Use of original equipment manufacturer elements provides the greatest assurance of satisfactory element material and nozzle dimensions.
2. At the first test of a new element, compare the head blow pressure with past MRC recorded tests. Any substantial increase in blowing pressures not attributable to adjustment of head control devices shall be cause for removal and examination of the element.
3. If binding is experienced on an element that is rotated through 360 degrees, a change in the idle position on the element may be made from time to time to close the valve at different element nozzle positions. On units that are rotated through 360 degrees, the element should be rotated relative to the swivel tube as specified in the soot blower instruction book.

NOTE

All rotary and stationary soot blowers, except rotary soot blowers in the main generating bank that have been permanently removed, shall be kept in operating condition. NSWCCD-SSS approval is required to blank soot blowers.

221-3.3.6.4 Operating Mechanism. All moving parts in the soot blower heads shall be inspected regularly to ensure proper operation as follows:

1. Check packing glands for steam leaks, and adjust as required. Ease of operation should be assured at all times.
2. Observe that element steam valves have reseated properly and are not being held open by a failure to return the operating mechanism to the closed position after blowing tubes. Very fine hairline cracks found in Stellite valve seating surfaces (discs and seats) are usually characteristic of Stellite overlays and do not necessarily denote that repairs are necessary. Deeper cracks or "wiredrawn" grooves require repair.
3. Inspect soot blower blowing arcs and element fore and aft positions during each fireside inspection according to PMS.

WARNING

Do not inspect for seat leaks by removing the plugs in the soot blower heads and pressurizing the system.

4. Frequent inspections shall be made to ensure that the check valve installed in the scavenging air connection on the soot blower head remains clean and free from corrosion, corrosion products, or other foreign material which could prevent its proper operation. This connection supplies air to the soot blower element, preventing combustion gases from backing up into the soot blower heads to piping where the sulfur content of the gases combined with moisture could cause serious acid corrosion. Each check valve should be disassembled as often as experience shows necessary to ensure its proper operation. Check valves must be installed in accordance with manufacturer's recommendations.

221-3.3.7 BILGE DRAIN VALVE. The bilge drain valve in the soot blower piping shall be left open when soot blowers are secured. When preparing to blow tubes, ensure that the bilge drain is open sufficiently to expel all condensate from the system. Open the soot blower steam root valve far enough to establish flow. When all condensate is expelled, close the bilge drain. The bilge drain valve is designed to provide continuous drainage when the valve is closed by means of an internal drain hole drilled in the body or seat of the valve. The hole should be sized to provide approximately 100 to 140 lbs/hr. flow, or 1/16-inch diameter (whichever is larger). According to NAVSHIPS drawing 804-841336, drain holes are normally 1/8-inch for 600 psig or lower and 1/16-inch

for systems above 600 psig. If steam flow stops when the valve is closed, the valve should be inspected for possible blockage of the drain hole. After securing soot blowers, the bilge drain shall be opened.

NOTE

Failure to thoroughly drain supply piping of condensate when cutting in steam can cause thermal shock damage to piping, soot blower heads and soot blower elements.

221-3.3.8 DRAIN ORIFICE. If a drain orifice is installed in the soot blower drain piping to the HP drain main, ensure the drain valves to the drain main are opened. The bilge drain shall be used to drain and warm up the soot blower supply system, and the drain orifice shall be used to ensure continuous drainage during system operation.

221-3.4 WATER LEVEL INDICATORS.

221-3.4.1 GENERAL. The actual water level in a boiler is determined by means of gauge glasses and remote water level indicators. It is important, therefore, that these instruments be correctly installed and kept in proper operating condition.

221-3.4.2 GAUGE GLASSES. Three types of gauge glasses, also known as boiler water gages, are used on main propulsion boilers. They are supplied by either Yarway (TYCO Industries/Penberthy) or Jerguson Gage and Valve Division (Clark-Reliance Corp.). A typical arrangement is shown in [Figure 221-3-20](#). Consult applicable boiler technical manual for more detailed information. The three types are described below:

- a. Yarway Water Gage Assembly, 18" visibility, continuous vision type, Figures 4150, Mod 4159 and 4190, 750 psi design pressure. Current drawing: 024-021729.
- b. Jerguson 18" Type A Class I Boiler Water Gage, 700 Psi design (Note: 700 Psi is a reference to the pressure category under MIL-G-16356). Current drawing: E-287-CD1340. The E-287 can be rated to 900 psi design pressure. The E-287 is available in the following frame assembly numbers: A-15112, A-16217 and A-26033. Frame assembly no. A-26033 is a complete frame assembly designed to replace the Yarway water gage discussed above. It is sized to fit between the 25-7/16" gasket surface-to-gasket surface of the Yarway upper and lower valves. It is also drilled and tapped for the Yarway illuminator assembly.
- c. Yarway Continuous Vision Water Gage, 18" visibility, 2,500 psi design, Figure no. 4198. Current drawing: 024-021755. The 2,500 psi gauge is limited to 1,500 psi pressure due to the rating of the glass. This gauge is primarily used on 1,200 psi boilers and on catapult accumulators.

NOTE

In the current fleet, only the LPD-1 Class B&W boilers were originally equipped with Jerguson water gauges. All other boilers that have Jerguson E-287 frames installed have received them from supply as a replacement for Yarway 750 psi gauges. This has resulted in the potential for mixed gauge types in machinery spaces and inadequate logistics and documentation support for the Jerguson gauges. Once installed the Jerguson gauge must be maintained using procedures and parts intended for gauges of that type and manufacture. Spring cone washers, bolting, studs and other OEM parts should not be intermixed between manufacturers. Yarway parts and maintenance documentation must be used for the shut-off valves, where the original valves have been retained. Rebuilding kits

(containing size 7 glass, gaskets and mica) conforming to MIL-G-16356 are suitable for both the Yarway and Jerguson gauges discussed above in a. and b. A different kit with special molded graphite and aluminum gaskets is necessary for the Yarway 2,500 psi gauge. Refer to additional information on gasket materials in paragraph 221-3.4.2.7.

221-3.4.2.1 Gauge Glass Scale. Each gauge glass shall have a scale showing the location of normal water level by the letter N and marked with 1/2-inch increments the entire visible length. Each 1-inch mark shall be numbered.

221-3.4.2.2 Inspection. Particular attention should be given to the condition of the mica sheets; as long as mica sheets are not extensively cracked and delaminated they should remain serviceable. A red haze or rust deposit is allowable on the mica as long as the water level is readable. If a band of deposits is formed around the normal water level, and this band can be mistaken for the water level, replace the mica.

NOTE

Yarway 2,500 psig gauge glass cutout valves shall be checked- quarterly for backing out of the valve yoke hexagon bushing, which would release steam from the drum into the fireroom. Tack welding of the bushing to the valve body shall be on two opposite sides of the bushing hex.

221-3.4.2.3 Glass. Care shall be taken to ensure that only glass of proper quality and dimensions is used in gauge glasses, that the glass is correctly fitted into place, and that gauge glass fittings are examined frequently and kept in proper order. Note that the occurrence of some bubbles in the glass is common, and may be acceptable. However, the glass shall contain no more than 12 air bubbles with a maximum allowed bubble diameter of 0.031 inches. Bubbles shall not be located in any pattern that could cause false indication of water level.

221-3.4.2.4 Mica. Deteriorated mica should be renewed at first opportunity to avoid rapid fogging of the gauge glass. In addition, the cracked mica might be mistaken for the water level. When installing new mica sheets, always confirm that the gasket is installed between the mica and the gauge glass body. Incorrect installation (gasket between mica and glass) will cause deterioration of glass facing. Mica shall not be removed from packaging material until ready for placement in the glass holder.

NOTE

Total thickness of Mica shall be 0.009 inches minimum. The mica can be provided in one or two pieces. If it is in two pieces, both pieces shall be installed back to back, with the thicker piece in contact with the steam and water.

221-3.4.2.5 Cap Screws. During inspections and in assembly of water level gauge glasses, cracked spring cone washers should be noted and replaced with spares. Cap screws shall not be over-torqued because washers may crack and thread stripping may result.

NOTE

Cracked spring cone washers on Yarway 2,500 psig gauge glasses shall not be replaced individually. The entire cap screw and spring cone washer assembly shall be replaced.

221-3.4.2.6 Thread Protrusion. Uniform loading on gauge glass assemblies is important to allow correct seating of the gasket and to prevent fracture of the glass. The Bellville type spring cone washers used on gauge glasses aid in establishing even loading. Fasteners must never be over tightened in an attempt to meet thread protrusion criteria. It is sufficient for the stud or bolt end to be flush with the top of the nut except in cases where the last thread is chamfered, rounded or otherwise imperfect. In this case the end thread must protrude beyond the nut. This is to ensure that all the threads within the nut are fully formed. Typically studs or bolts are sized by the manufacturers to extend 2 to 2-1/2 threads beyond the nut. This is based on their recommended gasket thicknesses and tolerances for stud length. It is not required to maintain this thread exposure on in-service gauges. Completely rebuilt gauges (when fasteners are renewed) should have a minimum of two threads protruding on all fasteners. When there is a problem with inadequate thread protrusion, in addition to confirming correct length of studs and bolts, check for the following:

- a. Yarway 750 Psi Water Gauges - Some Yarway frame bodies have been modified by repair activities by drilling and tapping the threaded holes completely through the chamber body. This allows the studs to be screwed in beyond the normal design point. Longer studs (longer than the 2-5/8" length stocked in Navy supply) must be used to correct this condition. A new uniform stud length should be established so that all studs are interchangeable regardless of position, and the length should allow for 2 to 2-1/2 threads protrusion beyond the nut. Use of thicker spring cone washers (or extra washers) will also affect thread protrusion. An earlier version of the gauge used thicker washers and had longer studs. If the original washers are used with the current 2-5/8" long studs about two threads will be lost.
- b. Jerguson A-287 Water Gauges - There are two stud lengths used on these Jerguson frame assemblies. Longer 5-3/4" studs are used at the corner positions of each segment where the cover thickness is greater. Gauges have come from the factory with some of the shorter studs installed at the corners. If this is the case, 5-3/4" long studs should be installed. This is done by grinding off the tack weld, centering the new stud in the frame and re-applying the tack weld. When properly positioned the stud should extend 2-5/8" from each side of the chamber.

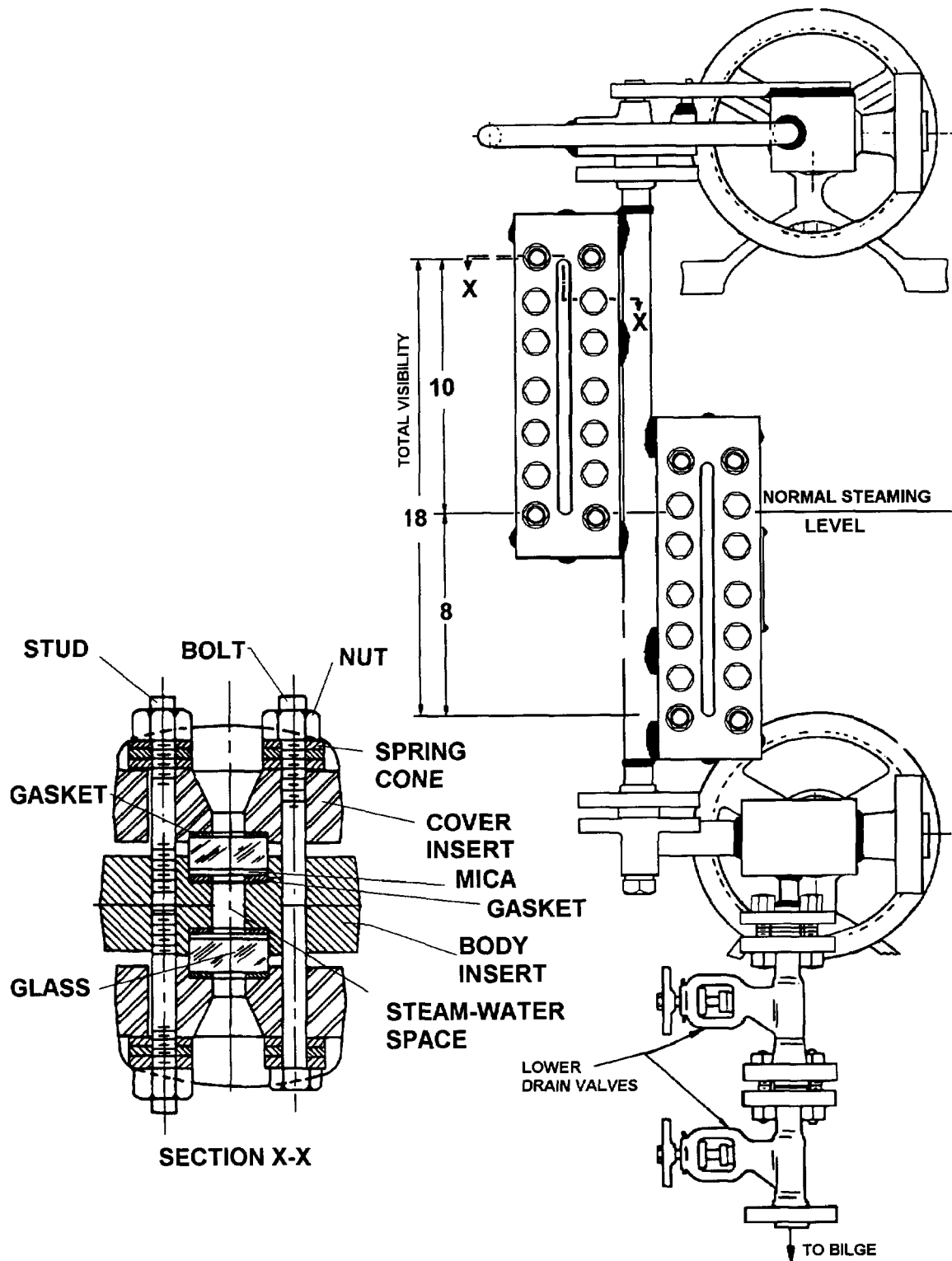


Figure 221-3-20. Typical Arrangement of Gauge Glass (Yarway Shown)

221-3.4.2.7 Pressure Sealing Gaskets and Cushion Gaskets. Historically the sealing gasket used between the chamber and the mica (pressure side of the glass) and the cushion gasket used on the cover side were made of a special grade of asbestos sheet material. Pressure sealing gaskets provided by the manufacturers have traditionally been 1/32" thick. The cushion or cover gasket specified for Yarway gauges (except 2,500 psi) is also 1/32" thick, while Jerguson Gage uses a 1/16" thick cushion gasket. Both manufacturers have replaced asbestos sealing gaskets with reinforced graphite material.

NOTE

When both 1/32" and 1/16" gaskets are supplied in a kit, the 1/32" thick gasket must be used on the pressure side. When both reinforced graphite and composition gaskets are provided in a kit, the graphite gasket must be used on the pressure side and the composition gasket as the cover or cushion gasket.

Jerguson cushion gaskets are made of a non-asbestos composition material. Currently the MIL-G-16356 repair kits provided under NSN 6680-00-049-8008 include two 1/16" thick gaskets of a non-asbestos composition material. Use of the thicker MIL-G-16356 kit gaskets will result in less thread protrusion (about one thread). The Allowance Parts List (APL) for the Yarway gauges notes that there is a separate NSN available for the Yarway 1/32" gasket that can be substituted. Unfortunately, this gasket is asbestos and should no longer be used (refer to [paragraph 221-3.4.2.8](#)). There is currently no NSN for a 1/32" thick non-asbestos gasket, but these gaskets are readily available commercially. Asbestos precautions should always be used when handling and working with gauge glass gasket materials. Particular care should be taken when scraping off residual gasket materials that are not clearly graphite. (Graphite gaskets are silver black and soft; asbestos gaskets are harder and usually grey or tan in color.) While the original equipment manufacturers have not supplied asbestos for many years, alternate suppliers, and suppliers of the MIL SPEC kits have provided asbestos until recently. "Klinger Seal C-4400", Garlock "IFG5500" and Armstrong TN-9005 are markings that will be seen on non-asbestos composition gaskets that may be supplied. Many NSNs in the supply system for gauge glass gaskets contain asbestos, as the policy had been to use existing stock until exhausted. Gauge assembly procedures should be modified when graphite gaskets are used; refer to [paragraph 221-3.4.2.9](#).

221-3.4.2.8 Removing Asbestos Gaskets. The asbestos in gauge glass gaskets is bound in an elastomer compound and should not pose a health hazard under normally handling conditions. A hazard would arise if the gaskets are subjected to mechanical actions that would cause the fibers to be released. Removal of old gaskets does present a problem since the gaskets on occasion bake on, and when this occurs, cannot be removed without mechanical scraping. Since there are proven graphite and composition non-asbestos alternatives available the use of asbestos gaskets should be discontinued to avoid asbestos hazard control issues that are difficult to deal with in operating machinery spaces.

CAUTION

When an existing gasket cannot be confirmed as non-asbestos, and cannot be removed intact, refer to NSTM Chapter 078 paragraph 9.3.2 for appropriate precautions, asbestos hazard control and disposal requirements. Any suspected asbestos containing gaskets and remnants must be wet prior to scraping. A sharp brass scraper is the best tool to separate the gasket from the gauge body without causing abrasion and further deterioration. Wire brushing, power tools and compressed air should never be used.

221-3.4.2.9 Glass, Mica and Gasket Renewal. Complete illustrated procedures for renewal are provided below. The first step is to inspect gaskets and cushions to be removed. If they can be confirmed as non-asbestos continue to remove old glass, mica shield and gaskets. If the gaskets and cushions are asbestos refer to [paragraph 221-3.4.2.8](#). Clean gasket seating surfaces with approved scraping tool (manufacturer's tool or tool made from brass shim stock) and solvents if necessary. Abrasives and tools that can gouge the seating surface shall not be used. If the gauge has just been removed from a steaming boiler it is easier to remove residue from composition gaskets while the frame is still warm. Provisions should be taken to prevent burns when doing so. The following information discusses both graphite and composition non-asbestos gaskets. The reassembly procedures are outlined below for Jerguson gauges and both type Yarway gauges.

a. Yarway 750 psig Gauge Assembly.

1. Verify Removal of all gasket residues. Be careful not to damage the seating surface if tools are used to scrape out the remaining gasket. It is not good practice to polish the gasket seating surface. A seat with a rough "as machined finish" is best for graphite gaskets ($R_a=400$).
2. Inspect the contents of the kit for damage. Graphite gaskets, if provided, are more easily damaged by bending and impact. Molykote Z powder (SAE-AMS-M-7866) can be applied to composition gaskets when they are included to prevent them from adhering to the frame during service. Two gaskets are provided in kits, one for the pressure side (mica/glass), the other for the cover or cushion side. Refer to [paragraph 221-3.4.2.7](#) above for more information on gaskets.
3. Insert the pressure side gasket in the gauge chamber recess, Then add the mica, glass and second gasket (cushion or cover gasket) on top.
4. Bend the spacer strips around the glass at each curved end. Make sure the glass is centered so that it uniformly clears the sides of the recess and cannot contact metal.
5. Position cover over glass and cushion gasket.
6. Apply molybdenum disulfide anti-seize compound to all threads. Place three spring cone washers on each of the four corner studs as shown in [Figure 221-3-21](#), and draw up finger tight.

CAUTION

Spring cones must be stacked as illustrated. Make sure spring cones are the correct diameter and thickness for the gauge as shown.

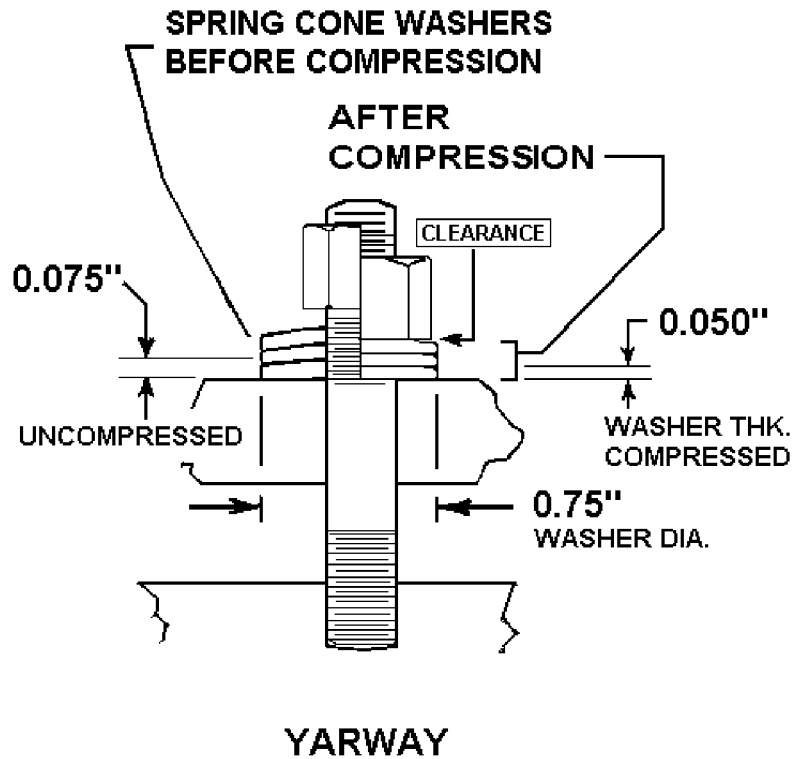


Figure 221-3-21. Arrangement of Yarway Spring Cone Washers

7. Check to make sure glass is still properly centered and gasket correctly seated.
8. Repeat the procedure ([steps 2](#) through [7](#)) for the other side of the frame.
9. With end nuts hand tight, carefully turn the gauge on its side and install the 7/16 inch bolts with three spring cone washers on each side. Nuts should be turned until finger tight.
10. Tighten bolts one flat at a time, using the sequence shown in [Figure 221-3-22](#), until the bolts (nos. 1 to 10) have been tightened a total of 4 flats.

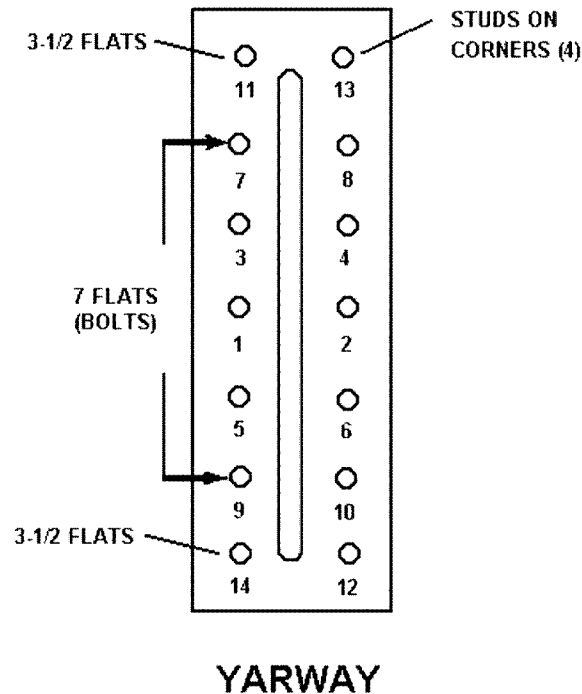


Figure 221-3-22. Yarway 750 Psi Gauge Tightening Sequence.

Continue the sequence one flat at a time, but now include the four end studs (nos. 11 to 14) for a total of 4 more flats; finish with an additional 1/2 flat rotation on each end stud.

11. Check for full compression of the spring cone washers. Do not tighten beyond the fully compressed point. Spring cone washers should not be compressed more than 90% of their uncompressed thickness. A slight clearance (sheet paper thickness) should remain where shown in [Figure 221-3-21](#). If doubt exists, retighten each fastener in sequence using a torque wrench to 45 ft-lbs.

NOTE

Instead of counting flats, all tightening can be done using a torque wrench. A five step (15 - 20 - 25 -35 -45 ft-lb) sequence should be used for composition gaskets. Reduce the torque requirements by at least 5 ft-lbs when graphite gaskets are used. A 10 - 15 - 20 - 30 -40 ft-lb) sequence should be used.

12. No hot torquing should be done with graphite gaskets. If slight gasket leakage or a loosening of the bolts is detected in service, re-torque cold to 50 ft-lbs max. After re-torquing, observe for excessive flow of graphite gaskets into the glass viewing area.
 13. Add illuminator to gauge body.
 14. Connect illuminator power supply.
- b. Jerguson E-287 Assembly Procedure.
1. Verify Removal of all gasket residues. Be careful not to damage the seating surface if tools are used to scrape out the remaining gasket. It is not good practice to polish the gasket seating surface. A seat with a rough "as machined finish" is best for graphite gaskets ($R_a=400$).
 2. Inspect the contents of the kit for damage. Graphite gaskets, if provided, are more easily damaged by bending and impact. Molykote Z powder (SAE-AMS-M-7866) can be applied to composition gaskets

when they are included to prevent them from adhering to the frame during service. Two gaskets are provided in kits, one for the pressure side (mica/glass), the other for the cover or cushion side. Refer to [paragraph 221-3.4.2.7](#) above for more information on gaskets.

3. Insert the pressure side gasket in the gauge chamber recess, Then add the mica, glass and second gasket (cushion or cover gasket) on top.
4. Bend the spacer strips around the glass at each curved end. Make sure the glass is centered so that it uniformly clears the sides of the recess and cannot contact metal.
5. Position cover over glass and cushion gasket.
6. Apply molybdenum disulfide anti-seize compound to all threads. Place the four spring cone washers on each stud as shown in [Figure 221-3-23](#) and draw up fingertight.

CAUTION

Spring cone washers must be stacked as illustrated. Make sure spring cones are the correct diameter and thickness for the gauge as shown.

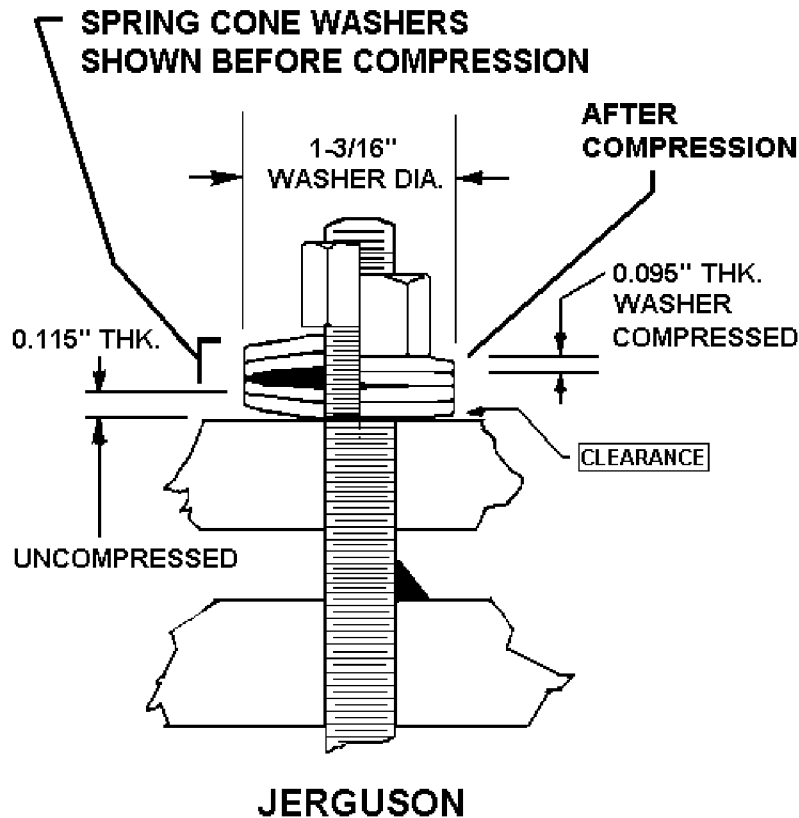


Figure 221-3-23. Jerguson Spring Cone Washer Arrangement

7. Check to make sure glass is still properly centered and gasket correctly seated.
8. Tighten studs one flat at a time, using the sequence shown in [Figure 221-3-24](#), until the studs have been tightened a total of 5 flats.
9. Check for full compression of the spring cone washers. Do not tighten beyond the fully compressed point. Spring cone washers should not be compressed more than 90% of their uncompressed thickness. A slight

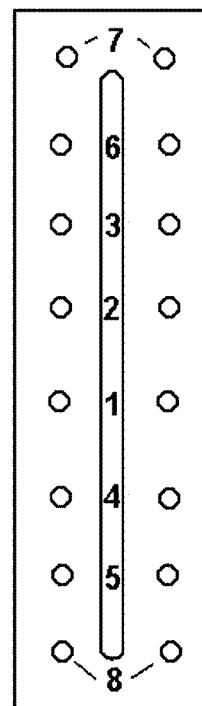
clearance (sheet paper thickness) should remain where shown in [Figure 221-3-23](#). If doubt exists, retighten each stud in sequence using a torque wrench to 55 ft-lbs.

NOTE

Instead of counting flats, all tightening can be done using a torque wrench. A five step (10 - 20 - 30 - 40 - 55 ft-lbs) sequence should be used for composition gaskets. Reduce the torque requirements by at least 5 ft-lbs when graphite gaskets are used. A 10 - 15 - 25 - 35 - 50 ft-lb) sequence should be used.

10. No hot torquing should be done with graphite gaskets. If slight gasket leakage or a loosening of the nuts is detected in service, re-torque cold to 60 ft-lbs max. After re-torquing, observe for excessive flow of the graphite gaskets into the glass viewing area.
11. Add illuminator to gauge body.
12. Connect illuminator power supply.

**ALL STUDS
5 FLATS**



JERGUSON E-287

Figure 221-3-24. Jerguson E-287 Gauge Tightening Sequence

c. Yarway 2,500 psig Gauge Assembly.

1. Install new mica and graphite gasket assembly, registering the gasket in the body groove. It is important that all contacting surfaces of mica, gaskets, glass and gage body be clean and free from dirt particles.
2. Install new glass with end tapes to center the glass in the gage body recess.
3. Press new cover gasket in recess on cover.
4. Using guide pins previously installed (in place of the top two cap screw assemblies during disassembly), register the cover on the body.
5. Inspect cap screws and install the two center cap screws. Tighten ¼ turn to hold cover in place and prevent its weight from resting on glass or tape. Guide pins at top can now be removed.

6. Install remaining cap screws and partially tighten gradually and uniformly all cap screws, starting at the center and moving criss-cross towards end of cover. Continue to tighten until all cap screw collars are pulled down to body.

WARNING

Do not attempt to tighten further. If leakage persists, the problem is with gasket fit-up.

7. Add illuminator assembly to gauge body.
8. Connect illuminator power supply.

221-3.4.2.10 Gauge Glass Lighting. An illuminator assembly designed by Yarway, and supplied with the gage glass assembly, is used to provide "back-lighting" to each gauge section. These illuminators are wired to the ships emergency lighting circuit. The interior of the illuminator is painted white to maximize reflectivity and should be cleaned or repainted periodically. A typical Yarway illuminator, shown in [Figure 221-3-25](#), has provisions for both 115 vac primary and 12 vdc relay battle lantern operation as described below. Materials needed to support gauge glass lights can be found in [Appendix A](#).

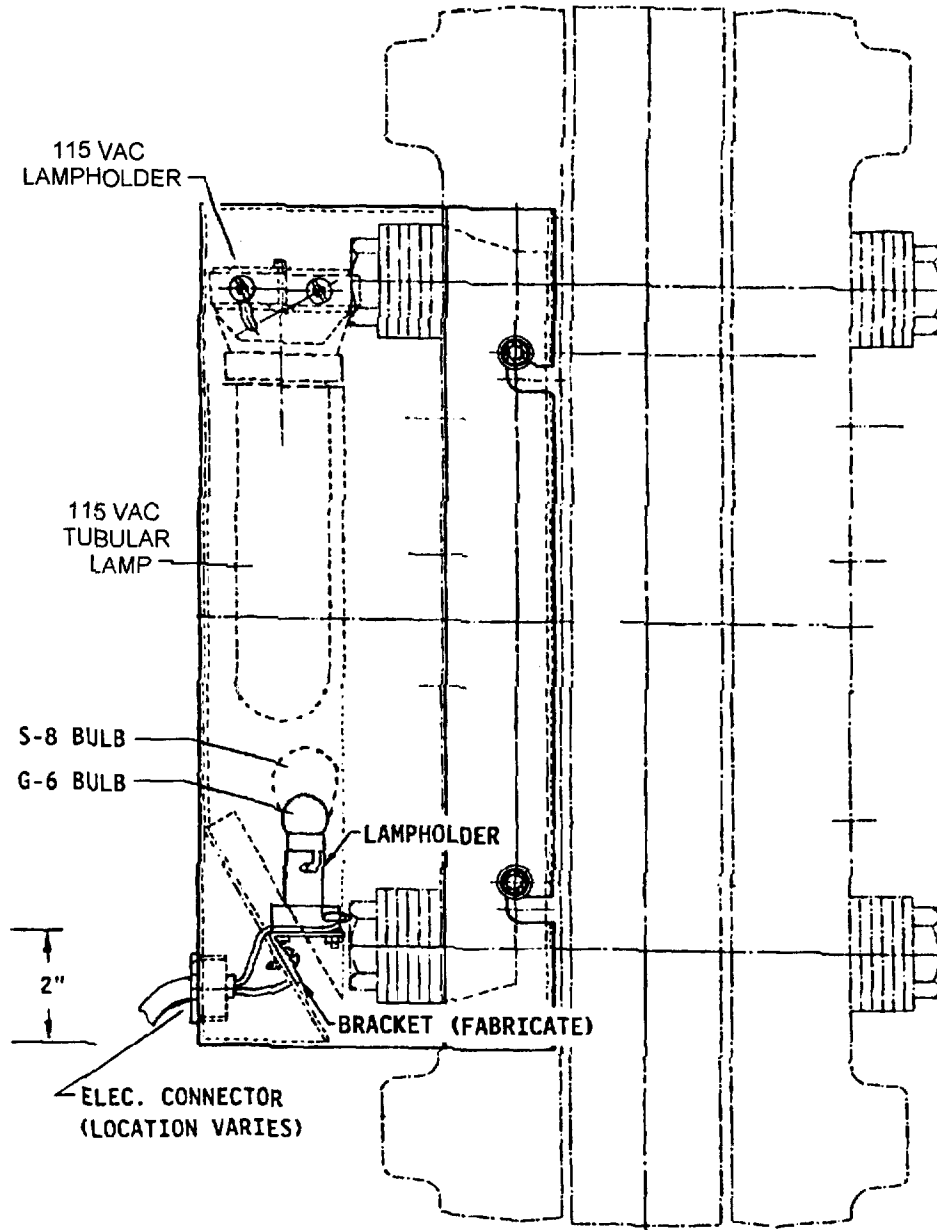


Figure 221-3.25. Gauge Glass Lighting Arrangement

221-3.4.2.10.1 Primary Lighting. A 40w tubular incandescent lamp and UL-STD-496 (Navy Supplement) lampholder provide the primary (115vac) light source.

221-3.4.2.10.2 Emergency Lighting. In accordance with the specifications for shipbuilding, relay operated battle lanterns (MIL-F-16377/53A Symbol 101.2) must be provided for illuminating main boiler gauge glasses. The lantern battery power provides back-up protection when the ship's emergency lighting circuit power is lost. It was found that water level was difficult to view when the lantern was just directed at the water gauge glass. A method modifying the relay lanterns was developed to remotely power a bulb located inside the illuminator. This arrangement shown as method H-10-D on NAVSEA Std. drawing 803-5184170 provides "back-lighting" similar to the primary arrangement. Specifications and NSNs shown on the std. drawing are not current; refer to

[Appendix A](#). One relay lantern must be used for each illuminator on the gauge glass. Relay lantern batteries (ANSI-C18.1) must be checked at least monthly. If a lantern is located where temperatures are consistently higher than 90 degree F weekly, testing is required.

221-3.4.2.11 Stowage. In stowing gauge glasses, care shall be exercised to prevent scratching the fine polish by contact with iron or steel.

221-3.4.2.12 Gauge Glass Chain-Operated Valve. For installations not incorporating sheave-wheels where it is not possible to remotely shut the gauge glass valves, replace valves as part of a documented alteration process, with sheave-wheel operated valves or use valve stem kits to allow chain operation. Chains on valves are required to permit remote closing of gauge cutoff valves should the gauge be damaged. Sheave-wheel operation is preferred.

221-3.4.3 REMOTE WATER LEVEL INDICATORS (RWLI'S). To enable boiler operators to observe the steam drum water level from their watch stations, RWLI's are installed. The majority of ships have two RWLI's that are designated primary and secondary indicators. The primary- indicator activates high and low level alarms and generates an electrical signal proportional to the water level. This signal provides the input for repeater indicators located in the enclosed operating space, engine room, main control, or central control.

221-3.4.3.1 RWLI System. In a typical RWLI system, the sensing line that connects the upper steam drum and the high pressure side of the indicator contains a reservoir (reference chamber), and is called the high pressure leg. The hydraulic pressure in this leg remains constant. The other sensing line connects between the lower steam drum and the low pressure side of the indicator and is called the low pressure leg. The hydraulic pressure in this sensing line varies as the water level in the drum. The pressure difference between the high pressure leg and the low pressure leg is the sensed differential pressure. See [Figure 221-3-26](#) which shows a Barton RWLI arrangement. Other than the RWLI itself, the elements consist of the following:

- a. Reservoir (reference chamber) is connected to the upper steam drum connection and provides a constant hydraulic head to the high pressure side of the indicator. A constant water level shall be maintained inside the reservoir to enable the indicator to operate properly.
- b. Sediment Chambers are installed in the high and low pressure legs and provide a location for dirt, sludge, and other foreign matter to collect and prevent it from contaminating the indicator. The sediment chambers shall be blown down periodically according to the existing MRC, and during initial and normal start-up procedures.
- c. Shutoff-Equalizing Manifold provides a means for equalizing the pressures in the sensing lines to the indicator during performance checks, start-up, shutdown and blowdown to prevent excessive pressure and temperature from reaching the indicator and rupturing the HP or LP bellows due to an extreme imbalance of pressure.

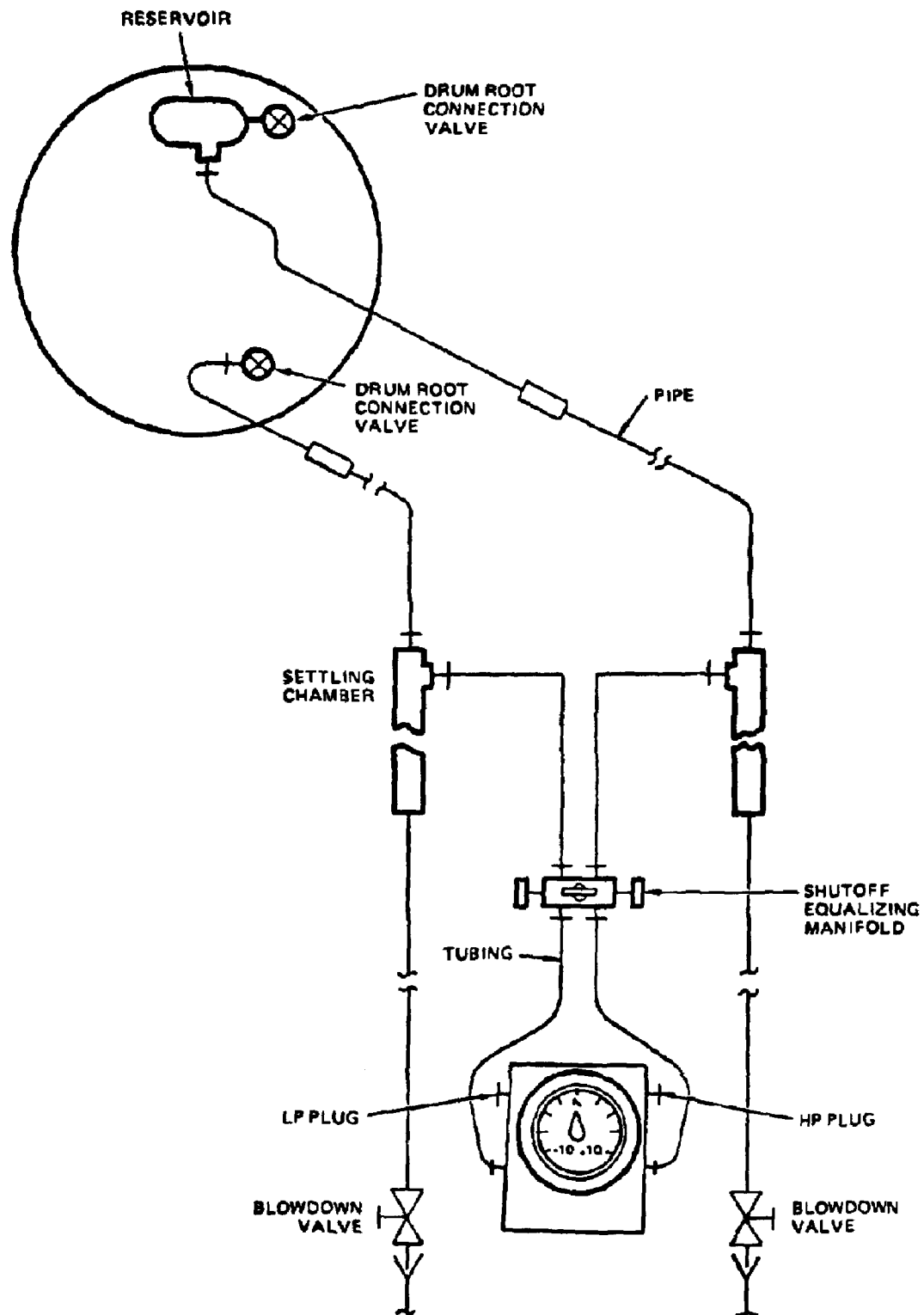


Figure 221-3-26. Barton Remote Water Level Indicator Installation

221-3.4.3.2 Descriptions of RWLI Components. There are two types of remote water level indicators used within the basic system described above. The older system is based on the Barton Model 385/S888 differential pressure/dial indicator unit. The newer electronic system uses a SMAR LD301 transmitter and a Weschler type BG-241 digital meter. Refer to [paragraphs 221-3.4.3.3 and 221-3.4.3.4](#) below.

221-3.4.3.3 General. The Barton remote water level indicator consists of three major components: the differential pressure unit (DPU), the dial indicator movement (with associated high and low limit switches), and the electronic transmitter (with associated power supply). These components are combined in a single instrument in which the indicator movement and electronic circuits are housed.

221-3.4.3.3.1 Differential Pressure Unit. Two interconnected bellow assemblies are mounted in separate pressure chambers on opposite sides of a center plate. Both the bellows and the center plate are filled with clean, non-corrosive turbine oil. During operation, differential pressure in the two pressure chambers causes movement of the bellows assembly. This movement is converted to rotary motion by the torque tube assembly that drives the dial indicator pointer, electronic transmitter and high and low limit switches.

221-3.4.3.3.2 Dial Indicator Movement. The DPU torque tube output shaft is mechanically connected and provides drive to a combined differential drive arm and switch-actuating cam in the indicator movement and switch assembly. Mechanical adjustments enable precise calibration of the pointer movement so that the measured pressure differential is accurately indicated on the front panel scale plate. The switch-actuating cam activates the high and low water level alarms.

221-3.4.3.3.3 Electronic Transmitter. The electronic transmitter transmits a signal proportional to the boiler drum water level. The transmitter input is provided by the torque tube output shaft, using a flexure wire, cantilever beam, strain gauges, and an electronic circuit. The shaft rotation is converted to a 4 to 20 milliamper (mA) signal that is used to drive the indicators.

221-3.4.3.3.4 Operation. During operations pressure is applied to the high and low pressure chambers surrounding the bellows of the differential pressure unit. Any difference in pressure between the high and low pressure chambers which is generated by the hydrostatic head of the boiler drum water level causes the bellows to move until the spring effect of the differential pressure unit balances out the pressure forces applied. The linear motion of the bellows is transmitted as a rotary motion through a torque tube assembly into the indicator case to drive the indicator pointer, provide input to the electronic transmitter, and actuate the low and high alarm switches. Once in operation, the instrument continuously indicates the drum level and activates appropriate alarm signal circuits without further operator intervention. The only additional operating procedure recommended is the adjustment of a pulsation dampener to increase or decrease instrument response time. The pulsation dampener included as part of the DPU assembly enables operator control of the instrument response time so that the effects of sloshing water in the drum can be prevented from adversely affecting the indicator readings.

221-3.4.3.3.5 Maintenance. RWLI system maintenance consists of blowing down the sensing lines, testing the indicator for proper performance and cleaning the instrument. Troubleshooting entails determining if the instrument is actually malfunctioning and then isolating the malfunction to a particular replaceable component or assembly. Instrument repair consists entirely of component and assembly replacement procedures. Refer to NAVSEA S9221-BS-MMO-010 and the applicable MRCs for detailed procedures.

NOTE

To ensure accurate operation of the indicator and switches, all piping connections in the system shall be free of leaks. Since the differential pressures measured are small, even a small leak in the system can cause a large indicator error.

221-3.4.3.4 Electronic Remote Water Level Indicator. The electronic remote water level indicator consists of two basic components a differential pressure transmitter and a NEMA enclosure that serves as a meter box or alarm cabinet; see [Figure 221-3-27](#). These components are inter-connected by a single twisted pair power cable.

All other connections to the system are made at the cabinet by Amphenol connectors to existing power, alarm and repeater cables. A more detailed functional description of the system follows:

221-3.4.3.4.1 Electronic Transmitter. The SMAR model LD301-D2 electronic transmitter measures differential pressure to determine boiler level. The differential pressure transmitter has two sensing inputs and is designed to measure the pressure difference between the two inputs. The differential pressure transmitter utilizes high (HP) and low (LP) pressure sensing taps. The HP line consists of a constant level reservoir located above the maximum gauge glass level. The LP line is connected to the boiler drum below the lowest gauge glass level. The HP leg acts as a constant and does not change as boiler water level changes. The LP leg varies as boiler water level changes with load. (NOTE: the HP and LP sensing taps and water leg system described previously is the same as was used with the Barton or Yarway RWLI systems. The new electronic system components begin with the rigid mount manifold Hex HM 53-55) . The SMAR transmitter utilizes capacitive plates which are directly affected by differential pressure. This change is detected by an on-board electronics section which produces a linear 4 to 20 mA output based on the maximum to minimum differential pressure. The electronics section is fitted with a central processing unit (CPU) microchip and internal memory chips. The CPU performs numerous functions some of which are signal scaling, signal processing, and continuous internal diagnostics. The memory is used for CPU operation, and calibration storage on a non volatile EEPROM. The transmitter can be programmed in three ways: locally with magnetic screwdriver, and remotely using a hand held calibrator or laptop computer. The remote method of calibration relies on digital communication between the transmitter and the remote device. The digital communication can take place over the same two output wires that carry the 4-20 mA signal. The computer method is the only method recommended for ships force; a lap top computer has been supplied to each ship's automatic boiler control technician for use in calibrating the electronic transmitters. The transmitters are also equipped with local indication via liquid crystal display. This indicator can display any 2 selectable variables within the transmitter. The measured variable in user selected units (water level from -10 to +10 inches) and transmitter's output in mA have been selected for display on the rum level electronic transmitter.

221-3.4.3.4.2 Meter/electronics Enclosure. The meter mounted on the enclosure (cabinet) and the power supply located inside are described below:

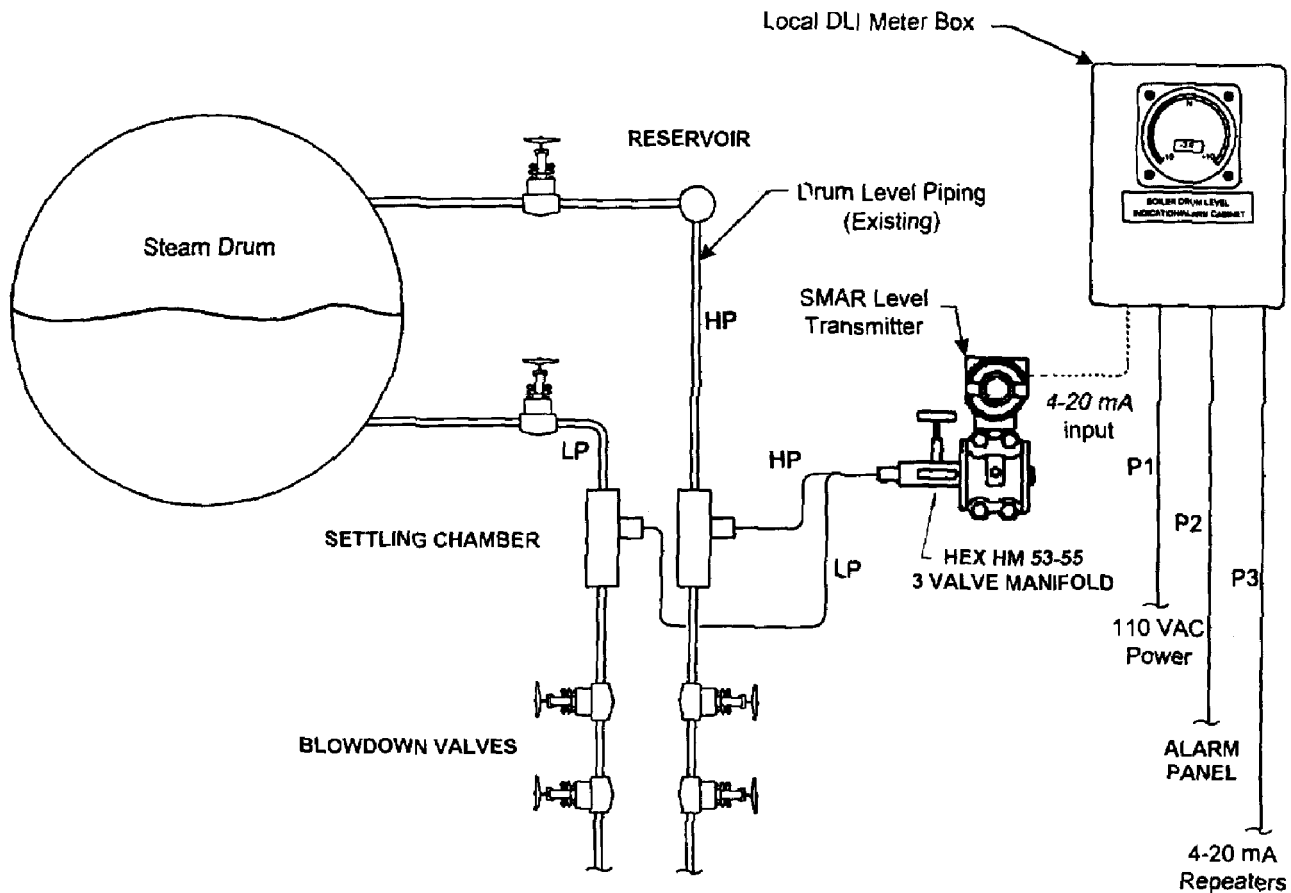


Figure 221-3-27. Electronic Remote Water Level Indicator Installation.

- a. **Indicating Meter.** The Weschler Instruments model BG-241 is a 4-1/2 inch square bargraph indicating meter that has a 101 circular arc bar display and a 3-1/2 inch digit LED digital display. The circular graph and LED display are powered by 120 vac. The input power is internally fused to protect the circuit boards from transient spikes and power surges. The unit contains two C form alarm relays: one for low alarm and one for high alarm. The unit is fully configurable by the operator via a jumper and pushbuttons located under the meter faceplate. All field wire connections are made via the externally threaded (10-32 UNF) posts on the back of the meter.
- b. **28 vdc Power Supply.** An Abbott Electronics model AW20S/28-A-ER power supply is located inside the electronics enclosure to provide power to the drum level indicating transmitter (SMAR model LD301-D2). The power supply shares 120 vac input power with the indicating meter. Its function is to provide 28 vdc loop power to the SMAR transmitter. The SMAR transmitter develops a 4 to 20 mA output signal which is applied to the indicating meter. The power supply is 3 inches high by 2.5 inches wide by 7/8 inch deep. It provides a maximum current of 0.71 amps @ 28 vdc (a total of 20 watts of power). The unit is mounted onto the enclosure mounting plate from the underside with four 4-40 UNF screws. The electrical connections are made via a 9 pin "D" sub-connector. This is similar to a computer serial port connector. The opposite ends of the connections are terminated at terminal boards 1 and 2 also inside the enclosure.

221-3.5 SMOKE INDICATORS.

NOTE

Several ship classes are equipped with the Boiler Combustion Monitoring System (BCMS). See the BCMS technical manual NAVSEA S9221-DT-MMO-010 for detailed information.

221-3.5.1 TYPES. Smoke indicators are installed to provide a means of detecting smoke density in the uptake of a boiler. There are two types in service on Naval boilers:

- a. Visual
- b. Visual-Photoelectric.

221-3.5.2 VISUAL TYPE. The arrangement of the visual smoke detector elements enables the operator to observe the smoke as it passes through the uptake or stack. A lamp unit provides a source of illumination across the uptake and acts as a seal so that the furnace gases cannot escape into the fireroom. A reflecting unit houses a mirror that reflects the light or smoke image down to the vision unit and also acts as a seal against the furnace gases on its side of the uptake. A vision unit transmits the visual smoke image or density from the reflecting unit to the operator.

221-3.5.2.1 Adjustment. The angles of the periscope mirrors in the reflecting unit and vision unit shall be adjusted, using set screws provided for that purpose, to obtain a centered view of the lamp.

221-3.5.2.2 Maintenance. The only maintenance required is periodic cleaning of lenses and mirrors as necessary, and replacement of the lamp when it burns out.

221-3.5.3 VISUAL-PHOTOELECTRIC TYPE. The visual-photoelectric smoke indicator provides a direct visual means at the firing platform for detecting smoke density, combined with electronic means to indicate smoke density and color (black or white) at the boiler operating console.

NOTE

The white smoke feature of this unit was removed from this unit due to safety concerns during calibration (letter NSWCCD-SSES 9221 Ser 377F/2319 of Dec. 20, 1996 applies).

The white smoke feature was removed permanently. The visual part of the indicator is a mirror periscope arrangement. The electronic part of the indicator is composed of photo-cells, an amplifier cabinet, and read-out devices. The components are positioned across the boiler uptake region above the economizer.

221-3.5.3.1 Components. The indicator consists of a lamp which provides a source of illumination for the photocells and mirrors, a reflecting unit which houses the density photocells and a reflecting mirror, a white smoke unit which houses the photocells used in the detection of white smoke, an amplifier cabinet which receives the signals from the photocells and provides the information display, a voltage regulator to provide regulated power to the lamp unit and amplifier cabinet, and a vision unit which transmits the visual smoke image or density from the reflecting unit to the boiler technician. A pressurized lens cleaner manifold cabinet and pushbutton station to

clean lenses was originally included. This system was ineffective and has been removed or not maintained. The smoke indicator arrangement also includes damper units, which allow the boiler technician to have a positive means of preventing stack gases from escaping from the uptake into the engineering space during maintenance, and an auxiliary panel that duplicates the information displayed on the face of the amplifier cabinet. In addition, there is a scavenging air system installed to keep lenses clean.

221-3.5.3.2 Operation. There is no step-by-step procedure for operating the smoke indicator; it is basically self-operating. The meter and indicating lights will indicate boiler smoke conditions on a continuous basis.

221-3.5.3.3 Maintenance. The recommended maintenance schedule is shown in [Table 221-3-4](#). The most common causes of trouble are misalignment, dirty lenses, broken connections, or soot collections blocking pipes or nipples. The scavenging air system should normally assure that the smoke indicator lenses remain clean indefinitely. However, lenses should be spot-checked frequently for cleanliness during operation, and hand cleaned as needed if there is reason to suspect dirty lenses. Evidence of dirty lenses is as follows:

1. Gradually or suddenly higher readings of smoke density on the amplifying cabinet meter at similar combustion conditions.
2. Inability to get a zero or near zero reading on amplifying cabinet meter when operating with a clear stack.
3. An obviously dirty lens is seen through the vision unit.

Table 221-3-4. Recommended Maintenance Schedule, Photoelectric Smoke Indicators

Operation	Daily	Weekly	Monthly	Annually
Clean:				
4" Pipe Nipples			X	
Water Strainers				
Angular Air Holes				X
Spray Nozzles				X
Air Filter	X (Blowdown)			
Check:				
Lenses	X (Hand clean if necessary)			
Light Source			X	
Panel Lights			X	
Soot Leaks-				
Stack MTD			X	
Units				
Pressure Gauges		X		
Solenoid Action	X			
Auxiliary Panel Tracking			X	
Wiring & Piping				X
Scavenging Air Piping			(Check for soot)	

221-3.5.3.4 Lens Cleaning. Refer to the Boiler Technical Manual for procedures for cleaning lenses. Disassembly and hand cleaning is required.

221-3.5.3.5 Indicator Lights. The smoke indicator is equipped with a colorzoned meter and indicator lights colored to correspond to the meter zones. The indicator lights will come on at the meter position indicated by the two red pointers on the face of the meter on cabinets with API meters. These pointers can be adjusted to other positions by the two small brass screwdriver slotted studs, which protrude from the rear of the meter barrel just below the meter terminals. On cabinets with Simpson meters, the pointers are adjusted by the knobs provided on the meter case. If the operating zones are to be determined by the indicator lights only, then the zones can be varied by adjusting the red pointers.

221-3.5.3.6 Bulb Replacement.

1. All indicating lights with legends are of the push to test type, and burned out bulbs can be easily located. Relamping is accomplished by pressing the small chrome tab at the right hand edge of each light to open the indicating light. Old bulbs may then be pulled out and new ones inserted.
2. The main light source bulb, located in the lamp unit, is rated for 10,000 hours. Refer to the Boiler Technical Manual for instructions on bulb replacement.

NOTE

Lamps may fail more frequently if ambient temperature is too high. If so, insert extra insulation between boiler and lamp unit.

221-3.5.3.7 Visual Operation. If for any reason it becomes necessary to remove the amplifier cabinet from the circuit, it is still possible to operate the smoke indicator visually by connecting plugs P-9 and P-10 together instead of to the cabinet; this connection will energize the lamp unit directly from the voltage regulator. There is no danger of making an improper connection, since P-9 and P-10 will only connect to each other or to their proper receptacles in the cabinet.

221-3.5.3.8 Calibration. Calibration of this system may be accomplished with the boiler either on or off the line. The most accurate calibration can be made when the boiler is on the line and the stack mounted units are hot and the amplifier cabinet has been warmed up for about 1 hour. The white smoke unit is not to be used and must not be calibrated. Refer to the Boiler Technical Manual or Wager manual for calibration procedures.

221-3.6 MISCELLANEOUS FITTINGS.

WARNING

No attempt shall be made to modify or adjust thermometers other than by shifting the scale or dial to improve their accuracy. These thermometers shall NOT be removed from their fittings while the boiler is under pressure.

221-3.6.1 THERMOMETERS. There are several different types of instruments used for measuring temperature on Naval boilers:

- a. Bimetallic

- b. Gas Filled
- c. Mercury Filled
- d. Liquid in Glass
- e. Resistance Temperature Detector (RTD)
- f. Peened Thermocouples
- g. Pyrometers.

221-3.6.1.1 Bimetallic Thermometers. Temperature indicators on boiler systems, other than superheated steam, shall be primarily bimetallic type thermometers. Where bimetallic designs are not interchangeable with the liquid-in-glass designs, a locally mounted, remote reading, gas-filled system thermometer shall be installed. Refer to NSTM Chapter 504.

221-3.6.1.2 Gas Filled Thermometers. Superheater outlet steam temperature gauges shall be locally mounted, remote-reading, gas-filled system thermometer types or remote-reading, gas-filled system types having a small sensing bulb and a capillary not exceeding 40 feet in length. If capillary length would exceed 40 feet, an electrical temperature indicating system shall be used.

221-3.6.1.3 Mercury Filled Thermometer. All older design mercury type thermometers and remote reading, mercury-filled types should be replaced whenever possible.

221-3.6.1.4 Liquid-In-Glass Thermometers. Many older designs featured a connection for liquid-in-glass thermometers. This type thermometer should be replaced by a locally mounted, remote-reading, gas-filled system thermometer.

221-3.6.1.5 Resistance Temperature Detector (RTD) Thermometer. Another type indicator with limited use is known as an RTD system. Unless the thermocouple installed with this system is compatible with the thermowell, the system will be inaccurate.

221-3.6.1.6 Peened Thermocouples. Installation of peened thermocouples or clamped thermocouples on the pipe according to NSTM Chapter 504, provides an additional method of checking thermometer accuracy.

WARNING

In entering the uptake for inspection or cleaning, care shall be taken not to damage pyrometer units, which project into the uptake.

221-3.6.1.7 Pyrometers. If uptake pyrometers are installed, the bulbs extending into the gas passage should be kept clean to ensure accurate reading. The pyrometer may be calibrated by submerging the bulb in boiling water. The dial can be rotated to indicate a temperature of 100° C (212° F) under this condition. When replacing the unit after calibration, ensure that it is inserted at the same location in the uptake.

221-3.6.1.8 Calibration. Thermometer calibration shall be according to instructions listed in NSTM Chapter 504. Whenever possible, calibration should be accomplished at repair activity instrument shops.

221-3.6.2 PRESSURE GAUGES. Pressure gauges on all boilers should be calibrated to agree as closely as possible, with special attention given to their accuracy in the working pressure range.

221-3.6.2.1 Calibration. Pressure gauge calibration shall be according to instructions listed in NSTM Chapter 504. Whenever possible, calibration should be accomplished at repair activity instrument shops.

221-3.6.2.2 Hydrostatic Corrections. In calibrating pressure gauges on boilers, the hydrostatic leg in the gauge piping should be compensated for in setting the gauge hands. This compensation may be based on 2 feet of water being equivalent to 1 psi pressure. Thus, in the case of the steam drum, if the centerline of the gauge is 10 vertical feet below the point of connection to the steam drum, the pressure hand should be set to show 5 psi less than the actual pressure at the location of the gauge, in order to show the actual pressure in the steam drum.

221-3.6.3. DRAFT GAUGES. The function of the draft gauge is to measure the pressure of combustion air between the casings at the burner front.

Newer draft gauges are of the electronic type. Electronic gauges consist of an electronic “smart” pressure transmitter and one or two digital electronic indicators. The electronic transmitter is of the same type as is used in the ABC system and auxiliary steam plant controls. As with the older mechanical gauges, the electronic transmitter is directly connected to the pressure source (windbox pressure). The transmitter sends an electronic signal that is proportional to the measured pressure to one or more electronic indicators. The indicators can be either a circular bargraph with digital numerical display or a vertical bargraph with digital numerical display. One indicator is located in the firing aisle as with the mechanical draft gauges and one or more indicators can be located in the EOS or other remote locations.

221-3.6.3.1 Operation. When placing the air pressure gauge or electronic transmitter in service after a long idle period or overhaul, vent the lines to atmosphere first. This will blow out any condensate which has collected in the lines.

WARNING

Verify the gauge or electronic transmitter is out of service before blowing back lines to prevent rupture of gauge diaphragms or possible damage to electronic transmitter.

221-3.6.3.2 Maintenance.

- a. Electronic Indicator Maintenance. Maintenance checks for electronic windbox pressure indicators are similar to those for the mechanical indicators. The following checks are recommended:
 1. Check the calibration of the electronic windbox pressure transmitter annually or at any time that readings are suspect. The local and remote electronic indicators, whether of the circular or vertical type, also have calibration features and should be checked if they do not correspond to the local transmitter indication or their operation is otherwise suspect.

2. The sensing line to the electronic transmitter should be checked with the same frequency and under the same conditions as the gauge connection to the mechanical type draft gauge. The sensing line should be disconnected at the input to the electronic transmitter if it is necessary to check the line for obstructions.

SECTION 4

MAIN PROPULSION BOILER OPERATION

221-4.1 FIREROOM OPERATION.

WARNING

Personnel performing boiler maintenance and boiler light-off, standing watch, and working in boiler/fireroom spaces during boiler operations shall wear fire retardant engineering coveralls to provide flash and fire protection in addition to any specialized protective devices or clothing outlined in the boiler procedures.

NOTE

Information given in this section supports and supplements the Engineering Operational Sequencing System (EOSS) . EOSS comprises Engineering Operational Procedures (EOP) and Engineering Operational Casualty Control (EOCC). Operators shall always comply with EOSS where installed.

This section is written for D-type boilers, but applies in general to all boiler types. , The correct Boiler Technical Manuals and EOSS procedures must be consulted if specific operating information is sought on other boiler designs.

221-4.1.1 PERSONNEL COMPETENCY. Every member of the fireroom watch shall be a Personnel Qualified Standards (PQS) watchstander and become thoroughly acquainted with every detail of the fireroom installation. Personnel shall understand the operation and purpose of the equipment under their control.

221-4.1.2 CONTROL OF STEAM PLANT WATER CHEMISTRY. The methods, precautions, and procedure to follow in controlling water chemistry in the steam plant are contained in NSTM Chapter 220, Volume 2, Boiler Water/Feedwater Test and Treatment, and shall be strictly adhered to.

221-4.1.3 PLANT EFFICIENCY. To determine the combination of boilers and burners to be used, the Engineer Officer should select the combination that gives the greatest plant efficiency with due regard to providing for safety and military requisites.

221-4.1.4 ECONOMY. Most ships have sufficient data available from trials or from previous operations to determine the most economical operating condition for steady steaming. The number of boilers should be selected so that the resulting combustion rate and the number of auxiliaries used will give the highest possible plant efficiency. Curves of boiler efficiency versus combustion rate will show when a boiler is operated at its most efficient combustion rate.

221-4.1.5 FORCED DRAFT BLOWERS. Whenever possible, the number of blowers in operation should be kept to a minimum. It may be more economical to run one at or near its designed full speed than to run two or

more at lower speed. Consult the applicable technical manuals to determine the steam consumption of the blower turbines at various speeds and select the most economical machinery alignment.

221-4.1.6 MAXIMUM PRESSURE. The maximum pressure at which a boiler may be operated, except when testing safety valves, shall not exceed the 100 percent boiler maximum steady-state operating pressure (120 percent rate) . This pressure may be found in the Boiler Technical Manual.

221-4.1.7 LOW STEAM PRESSURE. During steady-state operation steam pressure, should not be allowed to drop below normal operating pressure when the boiler is on line. Loss of steam pressure indicates a casualty. Follow procedures in EOCC or NSTM Chapter 079, Volume 3, Damage Control - Engineering Casualty Control, as applicable, until normal operation can be resumed.

221-4.1.8 CONTROL OF BOILERS. All ships are equipped with automatic controls and wide-range burners that reduce the need for frequent atomizer changes.

221-4.1.9 PARALLELING BOILERS. Under ordinary conditions the steam load should be divided among all boilers in use. Before any boiler is cut in on the main steam line, it should first be cut in on the auxiliary steam line. In addition, any combination of boilers connected to a common main steam line should also be connected to a common auxiliary steam line. That is, if two boilers in the same fireroom furnish steam to the main steam line, the valve in the auxiliary steam line between those two boilers should be open; similarly, if the cross-connection valve in the main steam line between port and starboard engines or between forward and aft engine rooms is open, the corresponding cross-connection valve in the auxiliary steam line should be open. The cross-connection valve in the auxiliary steam line should be opened before the cross-connection valve in the main steam line.

221-4.2 SAFETY PRECAUTIONS

221-4.2.1 This section of the manual supplements safety precautions contained in the text so that personnel can be alerted to unsafe conditions, both during operation and repair, take necessary action and preventive measures to avoid in jury, and return to safe operation.

221-4.2.2 BOILER PURGE. Furnace purge is an airflow through the boiler firesides that continues long enough to clear the furnace and uptake of explosive vapors. To accomplish this, 5 volumetric air changes of the combined volumes of the boiler furnace, uptake, and smoke pipe associated with each boiler are required. This “5 volume” air change is the standard on which all purge requirements are based. Because of differences in boiler size, uptake system, fan size and output, each boiler requires a different purge time. These times have been calculated and, together with wind box pressure as an index of airflow, have been issued to all ships, printed on metal plates that shall be installed in clear view of the operator. In addition, this information is contained in [Appendix H](#). The proper minimum purge time is listed adjacent to the pressure. The pressure is measured, and the boiler is purged, with all burner registers open. If the pressure falls between listed values, use the purge time corresponding to the next lower pressure. Minimum times are based on the assumption that there is no unburned fuel in the furnace. If unburned fuel is present, it shall be removed before starting the purge.

NOTE

The boiler windbox draft gage reading is affected by the fireroom ambient space pressure. If imbalance in the fireroom exhaust and supply fans causes a partial

vacuum in the space the draft gage will indicate a draft through the boiler higher than actual during purge and initial light-off. Ships' force should attempt to minimize any partial space vacuum by balancing ventilation. To assure adequate boiler purge, purge times shall be determined either:

- a. Using the differential pressure indicator installed across the burner register air flow transmitter taps (if installed)
- b. Using the boiler draft gauge, with the light-off fan running, but with all space ventilation momentarily secured. Once purge time is determined, space ventilation can be reactivated.

221-4.2.3 LIGHT-OFF FANS. The principal hazards in using light-off fans (or port use blowers) exist when main forced-draft blowers are started. If the light-off fan has been secured but its discharge damper or shutter is not manually locked in the closed position, as the main forced draft builds up, the light-off blower can reverse in operation, overspeed, and tear apart, sometimes violently, resulting in hazardous flying debris. To prevent this, starting, securing, and locking shutter operations shall be carried out following EOSS instructions (where installed), and these operations shall be logged.

221-4.2.4 HAZARDS. Before working with combustible fuels or high pressures and temperatures, operating personnel should familiarize themselves with safety precautions relevant to these situations. Hazards related to the use of combustible fuels include:

- a. Oil leaks
- b. Unburned oil accumulations in boiler
- c. Oil in bilges
- d. Any type of ignition source (such as naked electric lights, potential electrical shorts and exposed electric motor commutators)

221-4.2.5 OIL LEAKS. Be careful to ensure absolute tightness in the fuel oil system. Any spilled oil shall be wiped up immediately. Be sure that the lighting off torch pot does not leak. Also, do not fill the lighting off torch pot so full that the oil spills when the torch is dipped. Firing oil burners should not leak externally during boiler operation. External leaks shall be corrected at the first opportunity consistent with the ship's operational commitments.

221-4.2.6 UNBURNED OIL ACCUMULATIONS IN BOILER. Take every precaution to prevent unburned oil from collecting in the furnace, since hot refractory gasifies the oil and can cause a violent explosion. Proper precautions will eliminate such dangers. Do not assume that the furnace purge period will eliminate unburned fuel collected in the furnace, especially after an unsuccessful burner light-off attempt in a boiler that is hot from previous steaming, or in a boiler in which burner fires have been suddenly extinguished. An unsuccessful light-off attempt can put unburned fuel into a furnace, and this shall be removed before another light off attempt is made. The furnace should be inspected with a boiler inspection device (BID) and the Boiler Combustion Monitoring System (BCMS) with light source (if installed) to verify that the furnace floor is clear of unburned fuel before inserting the torch.

NOTE

Presently, the only authorized main propulsion boiler BIDs are either the sectional BID manufactured by Lenox Instrument or the original Navy design BID (which has been manufactured at a number of different Regional Maintenance Centers (RMC) throughout the years). The Navy BIDs are slowly being phased out and will be replaced with the new sectional BID. BID technical information, including operating procedures can be found in NAVSEA technical manual S9221-E6-MMA-010 (for the Navy BIDs) or the Lenox operating manual for the new sectional Bids. Each main space shall be required to maintain one (BID), electrical power cord (with electrical safety check tag), power pack and spare bulb. Ship's force should report any problems related to the BID and BCMS operation, maintenance and repair parts availability to the appropriate RMC and NSWCCD-SSES Code 922 for resolution.

The presence of visible wet spots, the smell of fuel, the fogging of the inspection device, or the presence of white or black smoke indicates unburned fuel. Fuel can leak into the bottoms of air-encased boilers undetected until a serious fire in the casing results. Prevent this by frequently inspecting casing bottoms.

221-4.2.7 OIL COLLECTIONS IN BILGES. Do not allow fuel oil to accumulate in the bilges. In addition, take particular care to guard against accumulation in drip pans, under pumps, and on floor plates. If major fuel oil leakage occurs in the fireroom at any time, take immediate action to shut the quick closing valves and stop the oil pump. Dispose of any oil leakage according to NSTM Chapter 593, Pollution Control.

221-4.3 PRECAUTIONS BEFORE BOILER LIGHT-OFF

221-4.3.1 General. The following are general steps in lighting off and placing oil-fired boilers in operation. Where EOSS is not installed, the ship's force should establish lighting off schedules that integrate these general steps with other applicable evolutions.

1. The Duty Engineer shall review the engineer's standing and light-off orders.
2. The Duty Engineer shall inspect all propulsion spaces and verify equipment status.
3. Be sure that stack covers have been removed.
4. Be sure that bilge, drip pans, deck, and boiler fronts are free of oil.
5. Be sure that- deck plates, handrails, and ladder treads are in place and secured.
6. Be sure that power panels are energized.
7. Check firefighting and damage control equipment to ensure they have been maintained according to PMS.
8. Be sure that communication circuits are operable and equipment is available.
9. Be sure that all alarms are tested and operational.
10. Be sure that all gauges are in place and not overdue for calibration.
11. Be sure that all locks and lock wire seals are in place.
12. Inspect for, and remove all fire hazards from spaces. Stow equipment not in use.
13. Conduct a caution and danger tag audit throughout the engineering spaces.

221-4.3.2 FUEL OIL SYSTEM.

1. Inspect and clean fuel oil strainers (system not pressurized).

NOTE

If the ship has Fire Safe Fuel Oil Strainers installed according to NAVSEA dwg. 803-5001048, they are to be examined externally only. Inspect and clean these strainers annually according to PMS.

2. Be sure that all fuel oil tanks are at the proper level.
3. Test fuel oil service tanks for bottom sediment and water (BS&W) according to NSTM Chapter 541, Petroleum Fuel Stowage, Use, and Testing. Strip as required.
4. Be sure that all flange shields are in place.
5. Before igniting distillate fuel onboard ship, take extreme precautions to prevent fuel from being spilled or sprayed onto lagging or floor plates. It is also extremely dangerous to attempt a boiler light-off when distillate fuel is in the bilges or the burner drip pans. No attempt to light-off shall be made if any of the foregoing conditions exist.

221-4.3.3 LUBE OIL SYSTEM.

1. Take lube oil samples and ensure that sumps are at the proper operating level on all main and auxiliary equipment.
2. Be sure that lube oil filters and strainers are clean.
3. Be sure that all flange shields are in place.

221-4.3.4. COOLING WATER SYSTEMS.

1. Be sure that auxiliary equipment cooling water strainers are clean.
2. Align the auxiliary machinery cooling water system and start the auxiliary machinery cooling water pump.

221-4.3.5 FEEDWATER SYSTEM.

1. Chemically test reserve feedwater tanks according to NSTM Chapter 220, Volume 2.
2. Chemically test boiler water before lighting off except when the boiler has been freshly filled and treated.
3. Be sure that feedwater tanks are at the proper level.

221-4.3.6 STEAM PIPING SYSTEMS.

1. Be sure that all valve wheels are installed and that remote operators are installed and operational.
2. Before light-off, warm up cold steam piping by cycling and seating lightly all valves and warm up or bypass valves in the following systems as applicable:
 - a. Main steam

- b. Auxiliary steam
 - c. Auxiliary exhaust
3. Unseat all valve bonnet and steam drain valves to the bilge, and fresh-water drain main to ensure proper drainage.

221-4.3.7 DFT OPERATION. Operate equipment as follows to warmup and recirculate the deaerating feed tanks (DFT)

- 1. Place the auxiliary gland exhaust condenser serving the DFT in operation.
- 2. Place the applicable steam reducer (augmenter) in operation for DFT operation.
- 3. Align the DFT for recirculation and warmup.

221-4.3.8 BOILER.

- 1. Be sure that burner atomizers are clean and assembled.

CAUTION

Do not lift safety valves.

- 2. Inspect the boiler safety valve hand-easing gear to ensure that cables are attached to lifting arms and can move freely.
- 3. Be sure that boiler desuperheater inlet valves on boilers are locked open.
- 4. Inspect boiler(s) furnace and remove all traces of raw fuel.
- 5. Prepare boilers under dry lay-up for light-off according to [paragraphs 221-2.3.3.1](#) and [221-2.3.3.2](#). Refer to NSTM Chapter 220 for the preparation for light-off steps required after wet lay-up.

221-4.4 PREPARATION FOR LIGHT-OFF

221-4.4.1 FUEL OIL SUPPLY. Align the fuel oil system for proper operation. Fuel oil pressure adequate for light-off shall be provided according to EOSS, where installed, or the applicable technical manual.

221-4.4.2 COMBUSTION AIR SUPPLY. On ships equipped with motor driven forced draft blowers, light-off is accomplished at low speed or at low airflows regulated by inlet vanes. Electric light-off fans, on ships so equipped, shall be used in all normal (non-emergency) light-offs except on aircraft carriers, -until steam from the boiler being lighted off is available to drive the steam-driven blowers. On aircraft carriers, the steam FDB shall be used if normal pressure supply steam is available. If an electric blower is not available, the next preferred method of light-off is with a steam forced draft blower fed by steam from another operating boiler. A third option is to light off with a turbine driven blower, fed by shore steam, if pressure is sufficient and if the steam chemistry meets the requirements of NSTM 220.

CAUTION

Ensure that the water level in the steam drum is in sight at all times.

221-4.4.3 FEEDWATER SUPPLY. Ensure that the feed system is aligned to deliver water to the boiler. Before boiler light-off the water level gauge glass shall be checked by lowering and raising the water level to ensure that these actions reflect a corresponding change in the gauge indication. This will also ensure that the economizer is full of water.

221-4.4.4 LIGHT-OFF BURNER. Except in emergencies, a firing rate not to exceed 5 percent is required to prevent damage to the superheater and furnace refractory. A sprayer plate of the smallest capacity available shall be used. For wide range burners, light-off oil pressure shall be used with the designated burner light-off sprayer plate.

221-4.4.5 LIGHTING OFF TORCH. A torch suitable for use in boilers is shown in [Figure 221-4-1](#). The torch shall protrude sufficiently into the furnace so that the flame from the torch is within the atomized fuel cone produced by the atomizer. The optimum torch length will vary with boiler type, but will be such that the torch protrudes at least 18 inches into the furnace from the inner surface of the front wall (refer to [Appendix B](#))

221-4.4.5.1 Lighting Off Torch Pot. A suitable lighting off torch pot can be made by welding a 7 inch square by 1/4-inch thick plate over one end of an 18 inch length of 4-inch iron pipe. A cover can be fitted at the other end, arranged so that it can be closed when the lighting off torch is inserted after use. The pot should be welded or bolted to a structural member of the floor grates in front of each boiler. Means for draining oil should be provided.



Figure 221-4-1. Burner Light-off Torch

221-4.4.5.2 Boiler Igniter System (BIS). Several ships have a BIS installed as an alternate to torch light-off. The BIS provides a safe and reliable way to light the No. 1 burner using a high-energy spark igniter. The BIS eliminates the need for torch light-off, but torch pots and torches shall be maintained in the space in case of igniter system failure. A Programmable Logic controller (PLC) located in both the EOS and at the burnerman's console allows the operator to safely and easily verify light-off permissives such as purging the boiler, steam/air atomization and fuel pressures. BIS adds two PLCs, an igniter with retract assembly, electric actuated fuel oil control valve, differential pressure transmitter, pressure switch, and dedicated power system. Refer to BIS Technical Manual NAVSEA S9221-DW-MMA-010 for detailed information.

221-4.5 BOILER LIGHT-OFF.

WARNING

Initial burner light-off is a two man procedure, requiring one man to operate the burner fuel oil supply manifold valve, and one man to insert the lighting off torch, open the safety shut-off device/atomizer valve, and operate the air register.

221-4.5.1 The different types of burners in Naval service are described in [paragraphs 221-3.1.3 through 221-3.1.3.3](#). The sequence of events during a conventional torch light-off is shown in [Figure 221-4-2](#). Procedures to follow in case of unsuccessful ignition are outlined in [paragraph 221-4.5.8](#). Light-off procedures vary and will be outlined according to the type of atomization used, as follows:

- a. Straight mechanical burner light-off procedures.
- b. Additional guidance for light-off of:
 1. Steam atomizing burners using ship's steam.
 2. Steam atomizing burners using compressed air.
 3. Steam atomizing burners using mechanical atomization.
 4. Steam atomizing burners shifting from compressed air to steam.
- c. Subsequent burner light-off.

NOTE

In the following light-off procedures the number 1 burner is the light-off burner. Ships shall use their designated light-off burner if different from the number 1 burner.

221-4.5.2 STRAIGHT MECHANICAL BURNER LIGHT-OFF PROCEDURE. The following procedure pertains to straight mechanical burners, including those with vented plungers. The procedure also applies to steam atomizers, with additional guidance provided in [paragraphs 221-4.5.3 through 221-4.5.6](#). The steps in [Figure 221-4-2](#) are described more fully as follows:

1. Be sure that all fuel oil manifold (root) and safety shutoff devices/atomizer valves are closed. (step 1)
2. Be sure that the fuel oil manifold recirculation valve is cracked open. (step 2)
3. Insert a clean atomizer with a lighting-off sprayer plate in the number 1 burner. (step 3)
4. Inspect the boiler furnace for evidence of unburned fuel with a BID (refer to [paragraph 221-4.2.6](#)) . The presence of visible oil, vapors, or white or black smoke is a sign of unburned fuel. (step 4)

CAUTION

The furnace should not be purged until all traces of unburned fuel have been removed. Raw fuel on the furnace floor cannot be removed by purging; access to the furnace floor is required to remove all remaining oil.

A clear stack condition shall be maintained during purge.

5. Purge the boiler according to the posted purge table or [Appendix H](#). Refer to [paragraph 221-4.2.2](#) for additional discussion regarding boiler purge. (step 5)

NOTE

Purging and preparing the boiler front for lighting fires should be completed simultaneously. If necessary, continue to purge until boiler front preparations are

complete. If fires are not lighted within 5 minutes of completing the purge, the boiler shall be purged again. The 5 minute period begins when all registers except number 1 are closed.

It is good engineering practice to periodically observe the periscope during purge. This is especially important before light off of a hot boiler.

6. Close all burner air registers except number 1. (step 6)
7. Adjust the combustion air and fuel oil pressure for lighting fires. (step 7)
8. Close the number 1 air register. (step 8)

WARNING

The torch man shall wear fire-retardant engineering coveralls, eye shield, and gloves. When lighting fires, stand well clear of the burner air register and the lighting off port to avoid injury in case of flareback.

9. Ignite the lighting off torch. (step 9)
10. Loosen the wing nut and open the lighting off port cover, insert the lighted torch into the lighting off port, close the lighting off port cover, and tighten the wing nut; verify visually that the torch remains lighted. (step 10)
11. Open the number 1 burner fuel oil safety shutoff device/atomizer valve to the fully open position. (step 11)

NOTE

The man handling the burner air register shall coordinate with the man at the burner fuel oil supply manifold valves and perform [steps 12 through 14](#) in rapid succession.

12. Open the number 1 burner manifold valve 1/2 turn. (step 12)
13. Observe the furnace through the number 1 burner observation port for ignition. (step 13)

CAUTION

If ignition fails to occur within 2 to 3 seconds, shut the burner fuel oil supply manifold valve and safety shutoff device/atomizer valve. Ensure that the fuel oil manifold recirculating valve remains open. Before making any further attempt to relight fires, proceed according to [paragraph 221-4.5.8](#).

NOTE

On ships with air registers incorporating air doors that block vision of the furnace, difficulty may be experienced in determining (by audible or visual means) when ignition has occurred. In these cases, air register should be opened 3 seconds after opening the fuel oil supply manifold valve to confirm ignition. If no flame is present the fuel oil supply manifold valve shall be secured immediately. If a flame is present continue with [step 14](#) below.

14. When ignition is successful, open the number 1 burner air register and observe the furnace through the number 1 burner observation port. Quickly flick the burner air register handle to the shut position, then to the fully open position to ensure the flame is brought close to the atomizer tip. (step 14)

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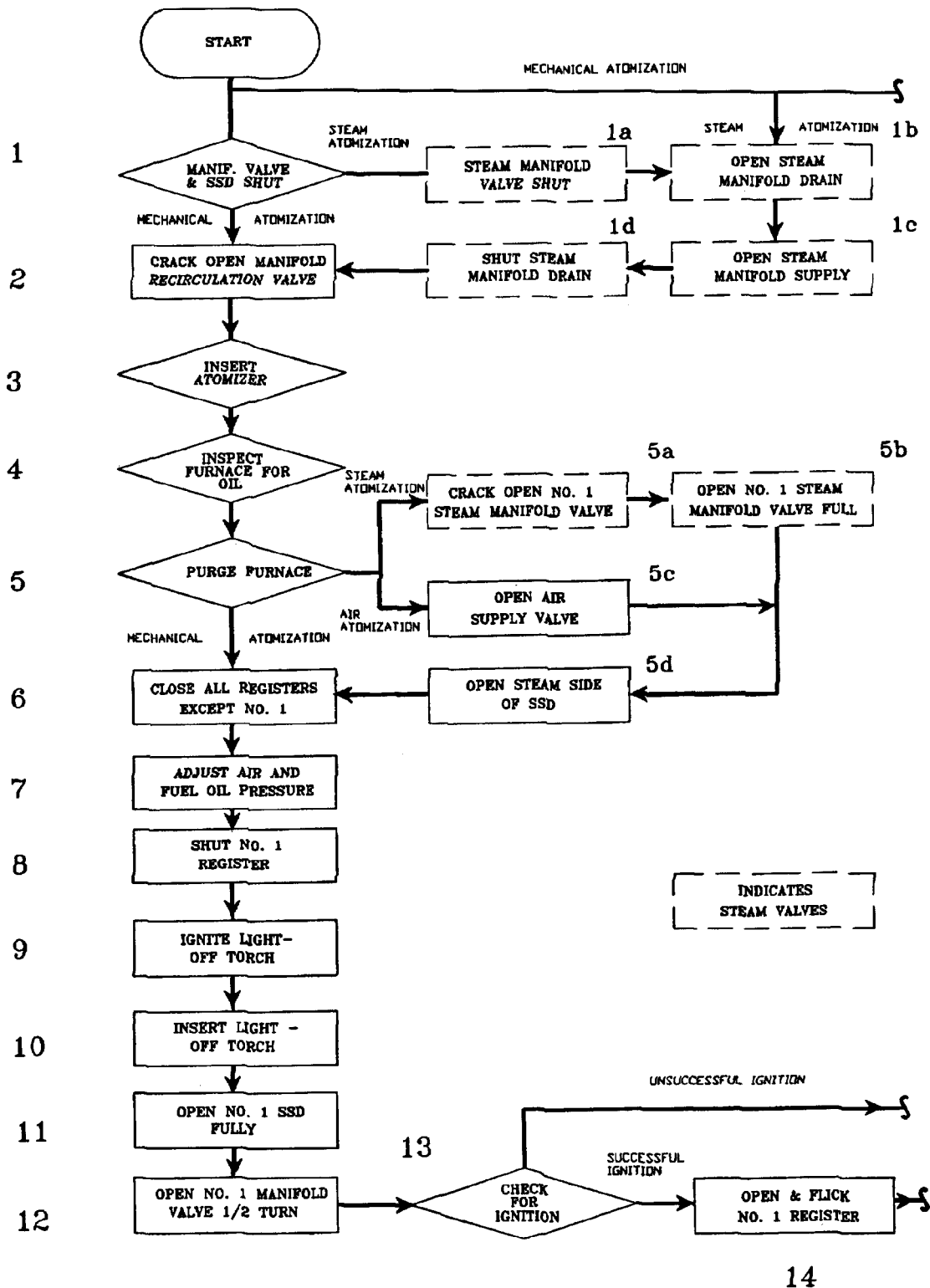


Figure 221-4-2. Logic Chart for Boiler Light-off (Sheet 1 of 2)

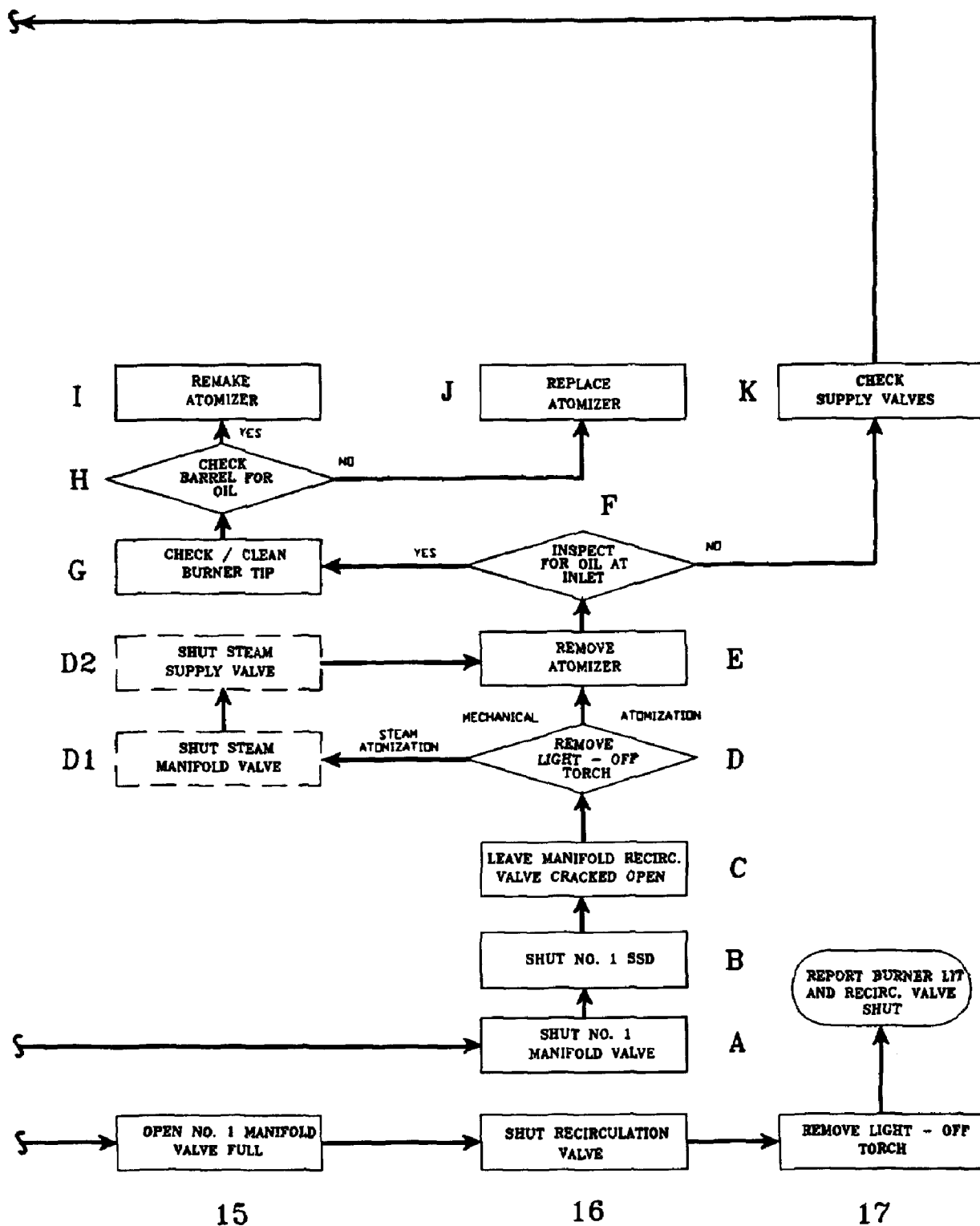


Figure 221-4-2. Logic Chart for Boiler Light-off (Sheet 2 of 2)

NOTE

Flicking the air register is not required for certain atomizers such as the CE/Wallsend, where the flame does not return to the atomizer tip.

15. Check the flames stability and open the number 1 burner fuel oil supply manifold valve to the fully open position. (step 15)
16. Slowly shut the fuel oil manifold recirculating valve. (step 16)

WARNING

Stand well clear of the light-off port while removing the torch.

17. Loosen the wing nut and open the lighting off port cover, withdraw the torch, close the lighting off port cover, and tighten the wing nut; extinguish the torch. (step 17)

CAUTION

A clear stack condition shall be maintained after ignition.

18. Notify the Boiler Technician of the Watch (BTOW) and the console operator that ignition has occurred and that the burner manifold recirculating valve is shut. Verify that the fuel oil manifold pressure is within the required range for raising steam.

NOTE

Shore steam is not approved as a source for steam atomization because of its poor quality (that is, a temperature at or below saturation with large amounts of condensate and pressure fluctuations).

221-4.5.3 STEAM ATOMIZING BURNERS USING SHIP'S STEAM. All steam atomization burner systems shall use ship's 150 psig auxiliary steam for normal lightoff. After steam has been cut into the atomizing steam system, precautions shall be taken to ensure that the steam lines are thoroughly drained of condensate at the atomizing steam header before the atomizing steam is cut into an individual burner atomizer. If a 150 psig in-line desuperheater is installed., steam in the temperature range from 200° C (390° F) to the maximum limits discussed in [paragraph 221-4.6](#) should be discharged. Ensure that the in-line desuperheater is properly adjusted and that the feed regulating valve is not leaking. Operators shall be alert for possible degradation in flame condition. A sputtering, unstable flame may indicate excessive moisture in the atomizing steam. If, after investigation, a minimum temperature of 200° C (390° F) cannot be obtained, operation at 190° C (370° F) is permissible. Refer to [paragraph 221-4.6](#) for additional guidelines for steam atomization systems. The procedures in [paragraph 221-4.5.2](#) also apply to lighting off steam atomizing burners, with the following additional steps. See [Figure 221-4-2](#) for a graphic representation of steam atomizing burner light-off.

CAUTION

Be sure that sufficient steam pressure and drainage is maintained as long as fires are lighted.

1. Be sure that all burner atomizing steam manifold valves are shut. (step 1a)
2. Open the atomizing steam manifold drain valve to the LP funnel drain. (step 1b)
3. Open the root steam supply valve to the atomizing steam manifold. (step 1c)

4. When all condensate has been expelled, close the atomizing steam manifold drain valve to the LP funnel drain, then open the HP System valve for constant drainage through the orifice. (step 1d)
5. Crack open the number 1 burner steam manifold valve (step 5a)
6. Open the steam side of the safety shutoff device on the number 1 burner. (step 5d)
7. Allow steam to blow through the atomizer for 3 to 5 minutes. Then open the number 1 burner steam manifold valve fully. (step 5b)

221-4.5.4 STEAM ATOMIZING BURNERS USING COMPRESSED AIR. If ship's steam is not available, use compressed air at 85 to 150 psig for atomization. One burner on each boiler should be equipped with a compressed air hose connection on the steam supply line. The procedures in [paragraphs 221-4.5.2](#) and [221-4.5.3](#) apply with the following exceptions. See [Figure 221-4-2](#) for a graphic representation of these steps.

1. Open the air supply valve (step 5c)
2. Open the steam side of the safety shutoff device and allow air to blow through for 3 to 5 minutes (step 5d)

221-4.5.5 STEAM ATOMIZING BURNERS - LIGHT-OFF WITH MECHANICAL ATOMIZATION. In the event that an emergency requires lighting off with a mechanical sprayer plate and subsequently shifting to ship's steam, the procedures in the operation section of the applicable Boiler Technical Manual shall be used as guidelines.

221-4.5.6 STEAM ATOMIZING BURNERS - SHIFTING FROM COMPRESSED AIR TO STEAM. During the initial phase of boiler light-off, an atomizer equipped with a standard full-power steam atomizing sprayer plate will normally be used as the light-off burner to raise steam pressure. The procedure to shift from compressed air atomization to ship's steam is as follows:

1. Be sure that fuel oil manifold valves and safety shutoff devices to burners not in operation are shut.
2. Be sure that all steam manifold valves are shut.
3. Crack open the atomizing steam manifold drain valve to the LP funnel drain.
4. Open the root steam supply valve to the steam manifold.
5. When all condensate has been expelled, shut the atomizing steam manifold drain valve to the LP funnel, then open the HP system valve for constant drainage through the orifice.
6. Insert a clean atomizer with steaming size sprayer plate into the number 2 burner.
7. Open the number 2 burner steam manifold valve and the steam side of the safety shutoff device.

NOTE

Atomizing steam shall be according to [paragraph 221-4.5.3](#).

8. Allow steam to blow through the atomizer for 3 to 5 minutes.
9. Verify that the combustion air and fuel oil header pressure are adjusted for lighting off the additional burner.
10. Open the oil side of the safety shutoff device on the number 2 burner.

NOTE

The person handling the burner air register shall coordinate with the person at the burner fuel oil manifold valves and perform [steps 11](#) and [12](#) in quick succession.

11. Open the number 2 burner fuel oil manifold valve 1/2 turn.

CAUTION

If ignition fails to occur within seconds, shut the number 2 burner fuel oil manifold valve, atomizing steam manifold valve, and safety shut-off device. Shut the number 2 burner air register, and remove the atomizer.

12. Immediately open the number 2 burner air register and observe the furnace through the number 2 burner observation port. When ignition is successful, proceed as follows:
 - a. Quickly flick the burner air register handle to the shut position and then to the fully open position to ensure that the flame is brought close to the atomizer tip.

NOTE

Flicking the air register is not required for certain atomizers such as CE/Wallsend, where the flame does not return to the atomizer tip.

- b. Check the stability of the flame and open the number 2 burner fuel oil manifold valve to the fully open position.
13. If ignition does not occur within seconds, immediately proceed as follows:
 - a. Shut the number 2 burner fuel oil manifold valve.
 - b. Shut the number 2 burner safety shutoff device.
 - c. Shut the number 2 burner steam manifold valve.
 - d. Shut the number 2 burner air register.
 - e. Remove the number 2 atomizer assembly from the boiler front and inspect for evidence of oil having entered the atomizer head.
 - f. Reassemble or replace the burner atomizer and proceed with the second light-off attempt; repeat [steps 1 through 11](#).
14. If ignition of the number 2 burner is successful, secure the number 1 burner and air atomization; proceed as follows:
 - a. Shut the number 1 burner fuel oil manifold valve.
 - b. Shut the number 1 burner safety shutoff device.
 - c. Shut the number 1 burner air register.
 - d. Shut the air supply valve on the low-pressure air line adjacent to the boiler front.
 - e. Disconnect the air atomization hose and remove the atomizer from the number 1 burner.

CAUTION

Excessive firing rates before the boiler is up to pressure, can damage the superheater and furnace refractory. Do not exceed established limits for the firing rate after light-off while raising steam pressure.

221-4.5.7 SUBSEQUENT BURNER LIGHT-OFF. When the operation of the first burner has stabilized and good combustion with a clear stack has been achieved, an adjacent burner may be lighted off as follows:

1. For straight mechanical burners, including vented plunger, open the safety shutoff device/atomizing valve.
2. For steam atomizers, open the steam side of the safety shutoff device, open the steam manifold valve, and allow steam to blow through the atomizer for 30 to 60 seconds. Then open the oil side of the safety shutoff device.
3. Open the fuel oil manifold valve 1/2 turn.

4. Open the burner air register and verify proper ignition. Quickly flick the oncoming burner air register handle to the shut position, then to the fully open position to bring the flame closer to the tip of the atomizer.
5. Open the fuel oil manifold valve fully.

CAUTION

Do not attempt a second light-off until the cause of the first, unsuccessful light-off attempt has been corrected.

NOTE

On ships where the arrangement of burners is such that burner lightoff can be adequately observed by the root valve operator for every burner on each boiler, exemptions from the two-man rule (after fires have been initially lighted and the boiler is on the line) may be requested from NSWCCD-SSES.

221-4.5.8 IGNITION UNSUCCESSFUL. Notify the console operator and BTOW that ignition has not been successful. See [Figure 221-4-2](#), for a graphic representation of the following additional steps if ignition is not successful within seconds:

1. Shut the number 1 burner fuel oil manifold valve. (step A)
2. Shut the number 1 burner safety shutoff device/atomizer valve. (step B)
3. Be sure that the fuel oil manifold recirculating valve remains cracked open. (step C)

WARNING

Stand well clear of the lighting-off port while removing the torch.

4. Open the lighting-off port cover, remove the torch, shut the lighting-off port cover, and tighten the wing nut; extinguish the torch. (step D)
5. Shut the number 1 burner steam manifold valve. (step D1, for steam atomizing burners only)
6. Shut the steam supply valve. (step D2, for steam atomizing burners only).
7. Remove the burner atomizer assembly from the boiler front. (step E)
8. Inspect for evidence that oil has entered the atomizer head. (step F)
 - a. When signs of oil are visible, proceed as follows:
 - (1) Remove the atomizer tip assembly and confirm proper burner makeup. (step G)
 - (2) Place the burner barrel in the vertical position with the nozzle end down. (step H)
 - (3) If oil comes out the nozzle end, remake the atomizer. (step I)
 - (4) If no oil comes out the nozzle end, makeup a different atomizer and put aside the questionable atomizer for further inspection. (step J)
 - b. When no signs of oil are visible, inspect all burner valves to determine the reason for lack of oil flow. (step K)

NOTE

When ordered, the next light-off attempt can be made by repeating [steps 1 through 18](#) of paragraph 221-4.5.2.

221-4.5.9 LIGHTING FIRES WITH BOILER IGNITER SYSTEM (BIS) (AIR AND STEAM ATOMIZATION).

CAUTION

Do not insert atomizer into the burner until it has been inspected by the space supervisor.

NOTE

Lighting off with the Boiler Igniter System requires that the fuel oil supply pressure (75-100 psig) be adjusted for lighting fires.

Lighting off with the Boiler Igniter System requires that the air atomizing pressure (85-150 psig) be adjusted for lighting fires. It is advisable for air pressure to exceed fuel pressure when attempting light-off.

Lighting off with the Boiler Igniter System requires that the steam atomizing pressure (135-150 psig) be adjusted for lighting fires.

1. Verify that the control indication LED 8 is green at the location of operation (EOS or LOCAL).
2. When notified, open all burner air registers in preparation for purging boiler.
3. When notified, shut all burner air registers except No. 1.
4. Verify with console operator, purge process is complete and the combustion air pressure is adjusted for lighting fires.
5. Shut No. 1 burner air register.
6. Verify Ignition ready LED is green.

WARNING

When lighting fires, stand well clear of the burner register and lighting-off port to avoid injury in case of boiler explosion.

7. Open No. 1 burner fuel oil safety shutoff device.
8. Open No. 1 burner fuel oil supply manifold valve.

CAUTION

If ignition is not verified immediately upon opening the air register, shut burner fuel oil supply manifold valve and safety shut-off device, air supply valves and burner atomizing steam/air at safety shut-off device. Ensure fuel oil manifold recirculating valve remains cracked open. Before making any further attempt to light fires, proceed as follows: Remove burner atomizer assembly from the boiler and determine the cause of ignition failure. Stop the port use fan, inspect the furnace for unburned fuel and remove all traces of unburned fuel.

WARNING

A potentially explosive situation is deemed to exist after generating white smoke for more than one minute. A potentially explosive situation is deemed to exist after generating heavy black smoke for more than two minutes.

9. The EOS/LOCAL operator will press "Ignite" button (PB3), which will automatically start the arc timer (5 seconds) and spark the igniter.
10. Open No. 1 burner air register and observe furnace through No. 1 burner observation port. Verify ignition by pressing "ACKNOWLEDGE" pushbutton (PB4) at location of operation (LOCAL or EOS).
 - a. When ignition is successful, proceed as follows:
 - (1) Verify electrically actuated fuel oil control valve is open, Fuel Oil Valve Position LED 7 is green.
 - (2) Slowly shut fuel oil manifold recirculating valve.
 - (3) Place No. 1 burner order reply switch to the "ON" position.
 - (4) Notify console operator and space supervisor that ignition has occurred and fuel oil manifold recirculating valve is shut and verify fuel oil manifold pressure.
 - (5) Verify furnace/stack conditions on BCMS monitor with BCO in EOS. Verify stack condition with direct reading periscope.

NOTE

When using Atomizing Steam, shut atomizing steam drains to waste water drain main.

- b. If ignition does not occur, immediately proceed as follows:
 - (1) Verify electrically actuated fuel oil control valve is closed, Fuel Oil Valve Position LED 7 is red.
 - (2) Shut No. 1 burner fuel oil supply manifold valve.
 - (3) Shut No. 1 burner fuel oil safety shutoff device.
 - (4) Shut No. 1 burner air register.
 - (5) Ensure fuel oil manifold recirculating valve remains cracked open.
 - (6) Shut No. 1 burner atomizing steam/air safety shutoff device.
 - (7) Shut No. 1 burner low-pressure air supply valve.

NOTE

When using Atomizing Steam, Shut No. 1 burner atomizing steam manifold valve.

- (8) Press Start/Stop/Reset button (PB1) to reset Boiler Igniter System controller (SSR LED1 should turn Green).
- (9) Report to console operator that ignition has not been successful.
- c. Remove burner atomizer assembly from boiler front and inspect for evidence of oil having entered the atomizer head:
 1. When signs of oil are visible, proceed as follows:
 - a. Remove the atomizer tip assembly and confirm proper burner makeup.
 - b. Place the burner barrel in the vertical position with the nozzle end down.

- c. If oil comes out the nozzle end, remake atomizer.
 - d. If no oil comes out the nozzle end, make up a different atomizer and put aside the questionable atomizer for further inspection.
2. When no signs of oil are visible, inspect safety shutoff device and all burner valves to determine reason for lack of oil flow.

CAUTION

A timed purge of the furnace shall not be accomplished nor shall a second light-off be attempted until the furnace has been inspected for unburned fuel and all traces of unburned fuel have been removed.

- d. Inspect furnace for unburned fuel using boiler inspection device (CP NO. BID).
 - 1. If unburned fuel is observed and boiler is cold, open furnace and remove all traces of unburned fuel.
 - 2. If unburned fuel is observed and steam has formed in the boiler, notify the space supervisor and perform the following steps:
 - a. If auxiliary steam is available, open boiler air casing steam smothering valve.
 - b. Remove locking device and shut boiler air casing steam smothering test connection valve.
 - c. When air casing fills with steam, open lower two air registers to admit steam to furnace.
 - d. After injecting steam for 30 minutes, shut boiler air casing steam smothering valve.
 - e. Open boiler air casing steam smothering test connection valve and install locking device.
 - f. Open all air registers and purge furnace.
 - g. Allow boiler to cool and remove all traces of unburned fuel.
 - 3. Report to space supervisor when all traces of unburned fuel have been removed.

221-4.6 STEAM ATOMIZATION SYSTEM REQUIREMENTS.

221-4.6.1 IN-LINE DESUPERHEATER SYSTEMS. (Atomizing steam systems with steam temperature regulated by an in-line desuperheater.) The desired range for atomizing temperature is 200° C to 210° C (390° to 410° F) at the outlet of the in-line desuperheater. The presence of water in saturated atomizing steam can cause unstable performance and has been linked with several boiler explosions. There is no effective means in the fireroom to determine steam moisture content. By maintaining 200° C to 210° C (390° F to 410° F) at the outlet of the in-line desuperheater, 13° C to 24° C (24° F to 44° F) of superheat is established in the atomizing steam piping system. This ensures that the in-line desuperheater is functioning properly and that the steam is not being flooded with water. When the piping downstream of the in-line desuperheater is properly insulated, and the system is properly drained before light-off, this level of superheat will ensure stable performance of the steam atomizer at all plant operating conditions. If the atomizing steam system is supplied by an in-line desuperheater that does not have to maintain a maximum 410 degree F or less to protect copper piping in the 50 psi steam system, then the maximum allowable steam temperature shall be 475 degree F.

221-4.6.2 SYSTEMS WITHOUT IN-LINE DESUPERHEATERS. (Systems without in-line desuperheaters, or in which the atomizing steam is teed off upstream of the in-line desuperheater; see [Figure 221-4-3.](#)) The maximum allowable steam temperature shall be 525 degrees F or less for these systems. However, consideration must be given to the material composition of bronze safety shut-off devices exposed to 325 degree F temperatures. Todd Combustion (TCI) devices are found in the fleet with the following bronze compositions:

Original (1993) and earlier: Fed. Spec. QQ-C-390B, alloy C90300; nominal 88% copper, 8% tin and 4% zinc.

Upgraded (1994) and later: ASTM B-61 alloy C92200; nominal 88% copper, 6% tin, 1.5% lead and 4.5% zinc.

CAUTION

Ships using Todd Combustion (TCI) safety shut-off devices of the original bronze alloy that regularly experience operating temperatures above 475 degrees F, shall verify temperatures at the burner front using a recently calibrated thermometer. If temperatures exceed 475 degrees F, the safety shut-off devices shall be upgraded to the newer Todd steam bronze alloy, which has a service limit of 550 degrees F, or steel.

221-4.6.3 SATURATED ATOMIZING STEAM. Tests of steam atomizers using saturated atomizing steam, with a wide range of moisture contents revealed:

1. A large amount of heat is transferred in the atomizer barrel between the atomizing steam and the fuel oil. The magnitude of this heat transfer is such that the atomizing steam at the sprayer plate is always saturated, regardless of the degree of superheat at the entrance of the barrel.
2. Steam atomizer performance degrades to unsafe conditions as the atomizing steam gains moisture at saturation temperature. The most critical operating condition is at minimum supply oil pressure (35 to 40 psig). At this point, the steam as it enters the safety shutoff device shall be at least 80 percent quality at saturation temperature (80-percent steam by weight, 20-percent water by weight) in order to ensure stable operation of the atomizer. For higher moisture contents, the fires may become unstable and may be lost. At higher oil pressures, more moisture in the steam can be tolerated.
3. Other effects that accompany the gain in moisture in atomizing steam at saturated temperature include:
 - a. The oil capacity of the atomizer will increase by as much as 20 percent.

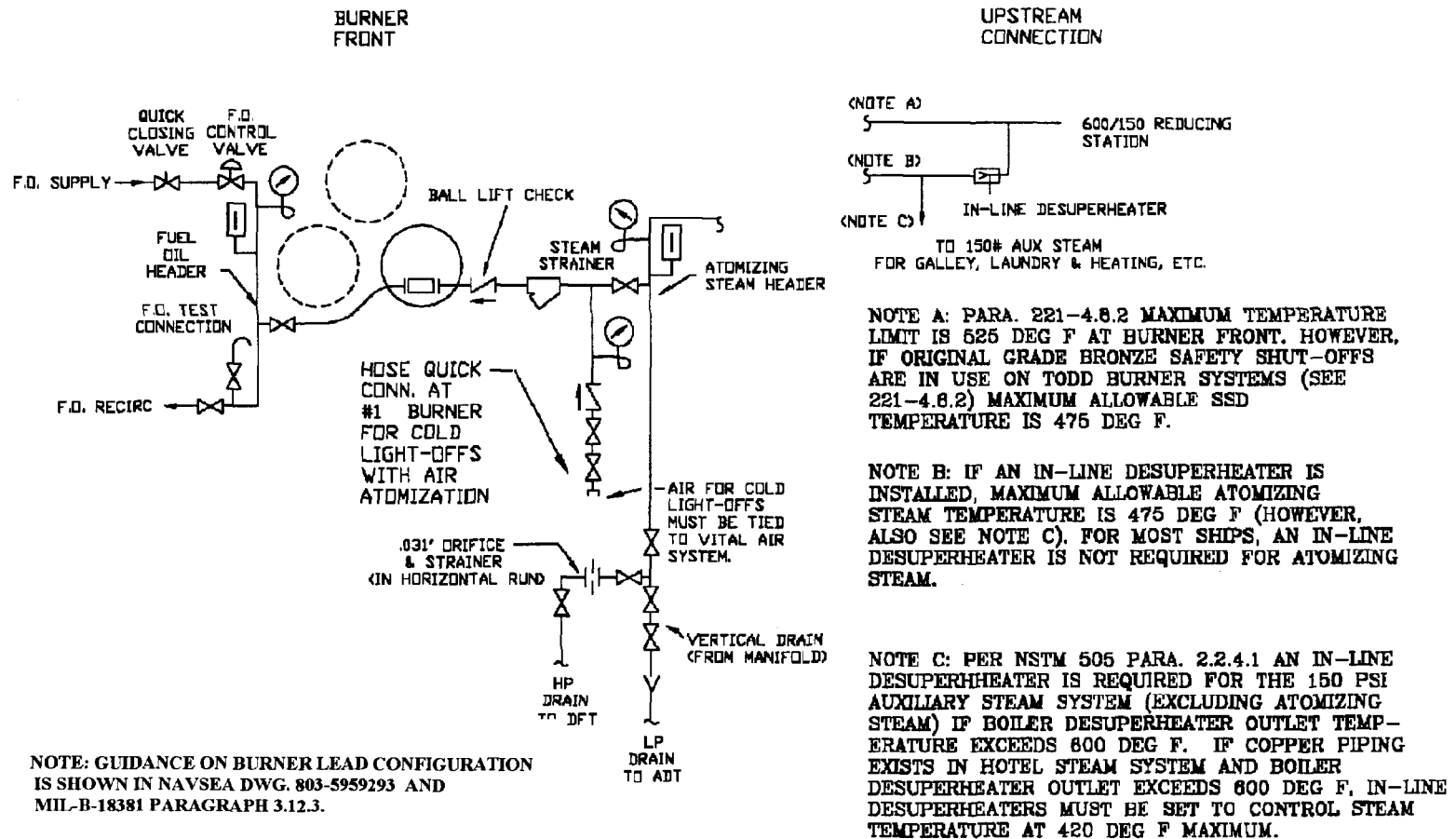


Figure 221-4-3. Fuel and Atomizing Steam Piping Schematic

- b. The atomizing steam flow increases by as much as 200 percent.

221-4.6.3.1 System Discrepancies. Tests have shown that it is impossible to maintain flame stability with atomizing steam below saturation temperature. This discrepancy is almost always due to instrumentation problems. Either pressure or temperature instrumentation is out of calibration or installed improperly, or the pressure and temperature sensors are widely separated in the piping system. The only other system discrepancy that could cause subsaturated temperatures is flooding of the piping by the in-line desuperheater water valve. Flashing steam at the header funnel drain is not in itself proof that the fluid in the header is steam.

221-4.6.4 LOW ATOMIZING STEAM TEMPERATURE PROBLEMS. Ships may experience difficulty in maintaining atomizing steam temperature at or above 180° C (370° F) at the in-line desuperheater outlet, at some plant operating conditions, even though the in-line desuperheater is operating properly, and the piping system is well insulated and free of water. The heat content of steam that produces superheat above the saturation temperature (sensible heat) is very small in comparison to the heat content required to make steam at saturation temperature (latent heat) . For example, for steam at 150 psig, 188° C (370° F) (4° F of superheat) a heat transfer of only 2.5 BTUs per pound of steam will reduce the steam to its saturation temperature of 185° C (366° F) . However, a heat loss of 857 BTUs per pound of steam is required to condense the saturated steam to water. Therefore, steam loses its superheat readily in flowing through a piping system, but once saturated, the steam accumulates moisture very gradually.

221-4.6.4.1 Additional Potential Deficiencies. Excluding system deficiencies (refer to [paragraphs 221-4.6.5.1 through 221-4.6.5.6](#)), low atomizing steam temperature can be due to plant load or measurement location. Atomizing steam temperature is usually lowest at low plant loads, typically during light-off after the single burner being fired has been shifted from air atomization to steam atomization. Three factors combine to cause atomizing steam temperature to be lower under these conditions:

- a. Boiler Desuperheater Outlet Temperature The boiler's desuperheater outlet temperature is at its minimum at low boiler rates, when auxiliary steam flow is minimal. Reduction of temperature at the boiler desuperheater outlet has a corresponding effect on the temperatures downstream of the reducer. On some ship classes, the resulting temperatures at the outlet of the reducer will be close to, or in, the required range for atomizing steam, without any desuperheating being required. Due to heat loss occurring in the piping systems, it is not surprising that temperatures can be reduced to below 188° C (370° F). As long as pressure stays at 150 psig temperature should not go below 366° F; pressure will probably drop.
- b. Low Atomizing Steam Flow With one burner firing, the atomizing steam flow is at its lowest value. The rate of heat loss from the piping is relatively constant, for all steam flows. Therefore, with one burner firing the greatest heat loss per pound of steam occurs.
- c. Effect of Measurement Location The effect of sensible heat loss is very pronounced on atomizing steam temperature, as measured at the steam header at the boiler front. If 188° C (370° F) is being held at the in-line desuperheater outlet, the heat loss in a 10-foot length of piping, with 2-1/2 inches of lagging; could be sufficient to reduce the steam temperature to saturation (A typical single burner steam flow of 120 pounds per hour has been used) . Therefore, ships will often measure saturation temperature at the steam header at the boiler front, even though the steam is superheated at the outlet of the in-line desuperheater. If there is no instrumentation that can be monitored at the in-line desuperheater outlet, the ship cannot determine whether or not the 188° C (370° F) minimum requirement is being met.

221-4.6.5 VALIDATION OF SYSTEM PERFORMANCE FOR SATURATED STEAM TEMPERATURE. Ships that have low atomizing steam temperature problems, shall take the following steps to validate the atomizing steam system as safe for operation at saturated conditions. [Figure 221-4-4](#) shows saturation temperature versus atomizing steam pressure.

- 1. Validate instrumentation used for measuring atomizing steam temperature.
- 2. Ensure that atomizing steam quality at the burner front will be 80 percent or greater (80-percent steam by

weight, 20-percent water by weight) at all plant operating loads. This involves checks of the piping configuration, pipe lagging, in-line desuperheater, system drains and also an analysis of system heat loss.

3. Monitoring of atomizer performance under lowest steam temperature conditions.

NOTE

Appendix J provides a detailed checklist that can be used to systematically evaluate the atomizing steam piping system.

221-4.6.5.1 Instrumentation Validation. On ships which do not have a temperature monitor at the in-line desuperheater outlet, every attempt should be made to measure the temperature at this location to determine if 188° C (370° F) or greater is being maintained. As a temporary monitor, ships should arrange to have a well insulated, peened thermocouple attached to the external pipe wall, with a digital readout. If this monitor does prove that 188° C (370° F) is being maintained, the ship should request the installation of a bulb type bimetallic thermometer in a thermowell. It should be installed just downstream of the temperature sensor that feeds back to the in-line desuperheater controller.

221-4.6.5.1.1 Every effort should be made to ensure that accurate pressure and temperature readings are obtained. All pressure and temperature indicators shall be calibrated by approved procedures before an evaluation of atomizing steam temperature. Ships should attempt to measure pressure and temperature at approximately the same location and should submit a request to move instrumentation when the distance between the nearest pressure and temperature monitors exceeds 50 feet. All temperature indicators should be installed with a thermowell which extends at least midway across the inside diameter of the pipe. The thermometer bulb should extend to the bottom of the well.

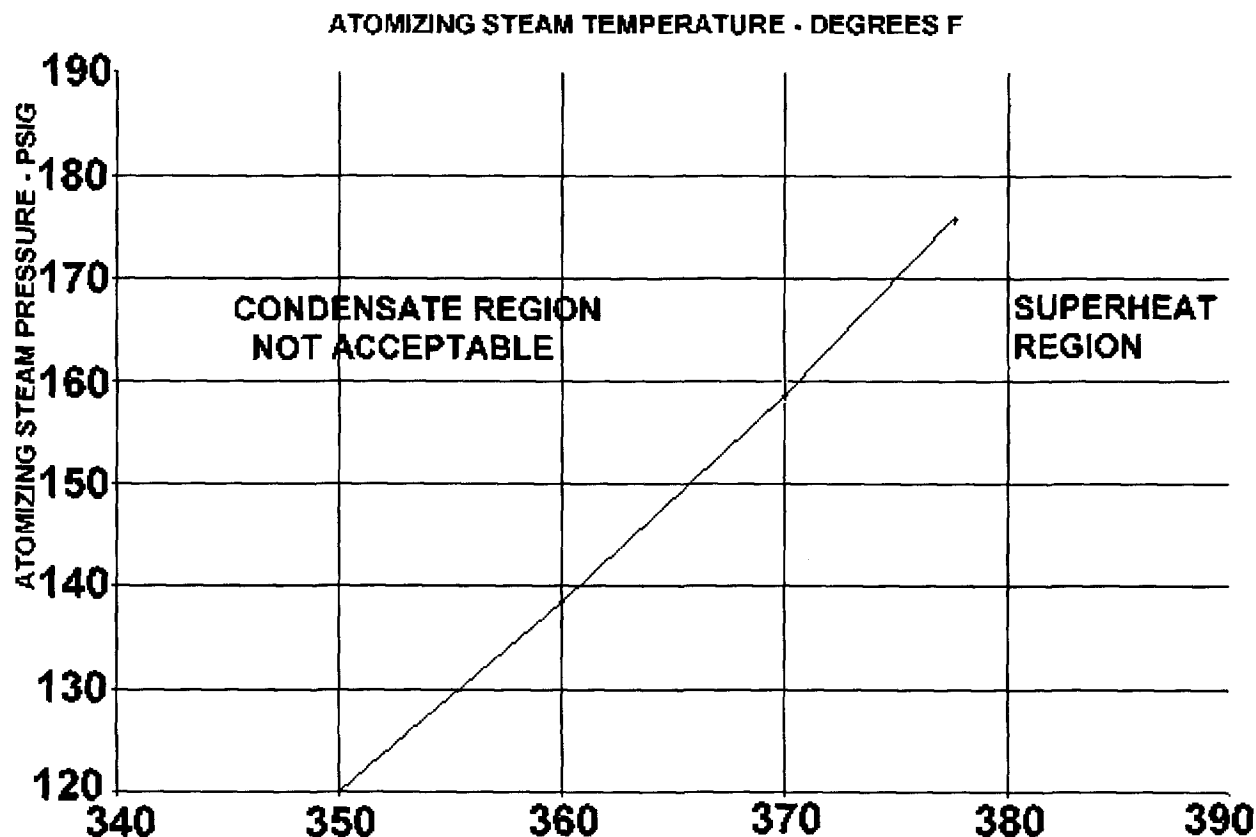


Figure 221-4-4. Temperature - Pressure Curve of Atomization Steam

221-4.6.5.1.2 Data to be used in the evaluation of atomizing steam temperature shall be obtained at stabilized pressure and temperature conditions. Pressure downstream of the reducer should be constant, and if the pressure has changed recently, time should be allowed for the temperature reading to stabilize.

221-4.6.5.2 Piping Configuration Checks. The atomizing steam piping should tie in to the 150 psi piping at a point downstream of the temperature sensor for the in-line desuperheater controller. The piping should exit either from the top or the side of the 150 psi line. The atomizing steam piping should follow a continuous downward slope from the 150 psi system connection to the burner front header. No un-drainable loops should exist in the piping run.

221-4.6.5.3 Piping Insulation Checks. Every effort should be made to completely insulate the piping system according to [paragraph 221-3.1.9.1](#). The piping up-stream of the 150 psi system, all the way back to the boiler's desuperheater outlet, should be checked as well, since heat loss in this line will affect temperatures downstream of the 600/150 psi reducer. In the 1/2 to 1-1/2-inch pipe size range, MIL-STD-769 requires insulation thickness to be 1-1/2 inches for pipe surface temperatures up to 197° C (389° F), and 2-1/2 inches for temperatures greater than 197° C (389° F). Insulation on the atomizing steam piping should be 2-1/2 inches thick, since at higher plant loads the piping surface temperature will probably exceed 197° C (389° F). If a steam separator is installed, it should be insulated with a thickness of 3 inches.

221-4.6.5.4 In-Line Desuperheater Checks. The following checks should be accomplished on the in-line desuperheater:

- a. Water Valve Hydrostatic Test It is essential that the water supply valve be hydrostatically tested in the fully closed position, and then stroked to verify full range operation, and that it is not sticking.
- b. Sensor Location The preferred temperature sensor location is 30 to 40 feet downstream of the in-line desuperheater, but in no case should the distance be less than 20 feet nor more than 50 feet.
- c. Desuperheater Nozzles The desuperheater nozzles should be inspected according to PMS and the applicable technical manual to verify that they are not plugged. Also, if an atomizing steam connection is supplied to the nozzle block, this line should always be used when the in-line desuperheater is in service.
- d. Temperature Controller Temperature controller calibration should be verified. The controller should be set to maintain temperature between 188° C and 210° C (390° F and 410° F).
- e. Operational Checks With the in-line desuperheater in service, verify that the water valve is regulating water flow when the steam temperature is greater than 188° C (390° F). If the steam temperature is less than 188° C (390° F), the water valve should stay in the fully closed position. Also, verify that the 600/150 psi reducer and 1,200/600 psi reducer (if applicable) are not cycling.

NOTE

The in-line desuperheater should not be secured at all plant loads because steam temperature is low at low plant loads. At elevated plant loads the 150 psi steam temperature will increase. The in-line desuperheater is required to maintain 150 psi steam temperature less than 213° C (415° F) in order to protect downstream copper piping that is installed in the laundry and hotel steam systems.

221-4.6.5.5 System Drain Checks. The following system drains should be checked:

- a. Atomizing Steam Header. The atomizing steam header should have two drains, a warmup funnel drain (or bilge drain) and an orifice drain connected to the HP drain system. The orifice should be 0.031 inches in diameter and should be installed with a strainer to prevent clogging.
- b. Steam Separator. The steam separator (if installed) should have an HP drain connection with orifice. This drain shall always be in service when the system is operating.

- c. HP Drain Independence. All HP drains shall be independent with their own orifices. It is not permissible to tie together the steam separator and header drains, nor to tie drains from two boilers together.
- d. HP Drain Overload. Boiler operators should be alert for signs of HP drain overload caused by oversized/eroded orifices. If the HP drain main relief valve lifts frequently, the system orifices should be inspected.

221-4.6.5.6 Piping Heat Loss Evaluation. The ship shall evaluate their atomizing steam piping system, utilizing [Appendix J](#), to verify that with a single burner, the heat loss is not sufficient to reduce steam quality to 80 percent. If all the answers to the questions in [Appendix J](#) are yes or not applicable (except question number 1), then the steam atomizer can be safely operated using saturated atomizing steam after successful operational test (refer to [paragraph 221-4.6.5.7](#)). If any of the answers are no (except question number 1), the ship shall describe in detail the nature of the discrepancy and request technical assistance in resolving the problem.

221-4.6.5.7 Operational Verification. During initial operation with saturated atomizing steam, great care should be taken to observe flame patterns to verify that they are stable. When the water content of atomizing steam is excessive, the flames will sputter. Tests have shown that slugs of water actually block the flow of fuel oil. In extreme cases, the oil flow will be momentarily reduced to zero. Therefore, any tendency for the flame size or intensity to oscillate should be regarded as indicating excessive moisture in the atomizing steam.

221-4.7 RAISING PRESSURE.

221-4.7.1 FIRING RATES. A boiler firing rate in the range of 2 to 5 percent full power shall not be exceeded until the boiler is on the line unless a higher light-off and pressure raising cycle firing rate is authorized. When the boiler is cold, the elapsed time required to bring it to operating pressure shall be from 1-1/2 to 6 hours. The elapsed time for lighting off from a steam blanket shall be from 45 minutes to 3 hours.

NOTE

Light-off times for Boilers having larger water volumes (i.e. LHA, 2% light-off rate) shall be at the high end of the range while the smaller boiler (i.e. LPD) light-off times may be at the lower end of the range. Applicable boiler EOSS should be consulted for specific times and maximum fuel oil pressure allowances. The boiler heat-up rate should be controlled by regulating the superheater protection steam and fuel oil pressure. Securing fires to achieve slower heat-up rates is not permitted.

CAUTION

When securing electric light-off fans and shifting to the on-coming forced-draft blower, always lock the damper or shutters of the secured light-off fan (port use blower) in the closed position.

221-4.7.2 D-TYPE BOILERS. In a D-type boiler with an integral superheater, an excessive firing rate before steam is formed and flow is established can damage the superheater. The superheater shall be protected whether superheater protection steam (SHPS) is available or not.

221-4.7.2.1 Superheater Protection Steam (SHPS) Available. Superheater protection steam shall be properly applied, when authorized and available, to provide a positive steam flow through the superheater. SHPS is taken from the 150 psig auxiliary steam system. Personnel should be sure that the superheater is properly drained and

is allowed to drain, as condensate is formed when the initial protective steam contacts the relatively cold superheater tubes and headers. Proper draining is being accomplished when hot steam exits the superheater drains when they are cracked open. The following procedures shall be used to raise steam when SHPS is available:

1. Before lighting the first burner, open the SHPS outlet line to the auxiliary exhaust line, if installed, and then open the protection steam connection to the boiler. If not installed, the superheater outlet header vents and drains shall be opened to establish a positive flow through the superheater. Standard size high pressure (HP) traps or orifices (Refer to [Appendix A](#)) will not clear out initial condensate from superheater headers, nor will they clear out condensate formed in the superheater during 150 psig steam blanket lay-up; therefore, low pressure (LP) or bilge drains shall be used to clear out this condensate at light-off. When boilers are equipped with a larger steam blanket orifice plate (Such as the 0.070-inch used on CV's - Refer to [Appendix A](#)) drains shall be shifted in accordance with EOSS procedures.
2. A relief valve is installed in the bleeder line to protect the auxiliary exhaust line from excessive pressure when using the bleeder pipe. A bleeder valve is installed upstream of the relief valve to permit throttling of the protection steam. Adjusting this valve regulates the time required to raise steam pressure.
3. A pressure gauge is installed between the bleeder valve and the relief valve. When throttling the bleeder valve, maintain downstream pressure on the pressure gauge at authorized ranges.
4. Shut the protection steam line valve(s) to the boiler when the boiler begins to generate its own steam, as evidenced by an increase in steam drum pressure above the pressure of the protection steam supply.
5. The SHPS outlet line connection to the auxiliary exhaust system shall not be closed until the desuperheater is cut into the line and sufficient steam flow is established. Steam flow is considered sufficient when a main feed pump is operating.
6. Unauthorized changes to bleeder pipe size and to installed valves, as well as pressure irregularities in the auxiliary exhaust system, will affect the downstream pressure.
7. When this system is designed for remote bleeder system operation, at the console booth for example, the remote gear shall be attached to the bleeder valve and the pressure gauge shall be led to the remote site.
8. The bleeder system should never be completely closed off throughout the light-off cycle until the auxiliary steam stop is opened. Posting instructions based on proper operation of the bleeder system in individual ship installations is recommended.
9. The steam temperature at the superheater outlet shall be monitored to ensure that the temperature does not rise excessively.
10. Monitor the steam gauge to be sure that it registers pressure.
11. Monitor the water level in the water gauges, since the level rises from expansion when the water in the boilers is heated. The water level shall be monitored at all times during boiler operation.
12. Check water gauge operation by blowing down the gauge glass at approximately 100 to 200 psig steam drum pressure and whenever there is any question about the level.
13. When the boiler pressure reaches 160 psig, shift drains to the HP drain main.
14. When the boiler pressure reaches 200 to 400 psig, place the boiler on the line.

NOTE

If adequate drainage cannot be accomplished, or 150 psig steam quality is unsatisfactory during the initial pressure-raising cycle, the use of SHPS shall be discontinued and the superheater drains (and vents) opened.

221-4.7.2.2 Superheater Protection Steam (SHPS) Not Available. If no SHPS is available, the elapsed time to bring a boiler to operating pressure shall be increased. A minimum time of 3 hours is recommended. The procedures shall be as follows:

1. Open steam drum and superheater outlet header air vents and superheater drains.
2. When steam is formed, shut the steam drum air vent.

CAUTION

Steam flow shall be provided through the superheater at all times when fires are lighted.

3. Open the SHPS bleeder valve. The valve shall be opened sufficiently to ensure adequate flow through the superheater.
4. Follow [steps 3](#) and [5](#) through [14](#) of paragraph 221-4.7.2.1. [Step 13](#) must be modified to require shifting of drains to the HP drain system at 50 psig. On CV's with steam blanket orifice plates, the drains are shifted to the steam blanket orifice system at 50 psig and shifted again at 160 psig to the standard 0.020 orifice HP drain system.

221-4.8 CUTTING IN AND PARALLELING BOILERS.

CAUTION

When securing electric light-off fans and shifting to an oncoming forced-draft blower, always lock the damper or shutters of the secured light-off fan in the closed position.

221-4.8.1 WARMING UP STEAM LINES. If the main and auxiliary steam lines to which the boiler is to be connected are cold, the lines should be thoroughly warmed by using bypass valves (if fitted) or by cracking the boiler main and auxiliary steam stop valves. Watch the steam lines during the process and set up on any leaky joints. Watch the slip joints or other steam line expansion provisions to see if they are free. Use the steam line drains to drain all condensate thoroughly from steam lines.

221-4.8.2 D-TYPE BOILERS. Thoroughly drain steam lines on the oncoming boiler. At operating pressure, open the superheater outlet valve bypass or crack open the superheater outlet valve. Then, slowly open the superheater outlet valve fully. When the superheater outlet valve has been opened wide, secure the bleeder connection to the auxiliary exhaust line.

221-4.9 SUPERHEAT TEMPERATURE

221-4.9.1 CONTROL OF SUPERHEAT. Superheat control is not provided on D-type boilers, where the superheater outlet temperature varies with load; it usually increases with increased load, except on recent designs, where the temperature peaks at about 65 percent of full power rate.

221-4.9.2 HIGH SUPERHEATER OUTLET TEMPERATURE. Superheater outlet steam temperature can be higher, or indicate higher than normal for the following reasons, which are listed in approximate order of frequency:

- a. Faulty temperature indicators
- b. High levels of excess air
- c. Improperly installed furnace gas baffles
- d. Incorrect fuel oil burner settings and alignment
- e. Improper automatic combustion control adjustments
- f. Damaged fuel oil burner sprayer plates
- g. Leaking fuel oil atomizers
- h. Incorrect burner sequence and mixed sprayer plates
- i. Leaky desuperheater
- j. Low feedwater temperature
- k. Dirty economizer firesides
- l. Low boiler steam pressure
- m. Gas-side or fireside restrictions
- n. Low steam flow.

221-4.9.3 LOW SUPERHEATER OUTLET TEMPERATURE. Superheater steam temperature can be lower than normal if the following conditions are present:

- a. Drum pressure is carried too high.
- b. Feedwater temperature is too high.
- c. Wrong burner combination
- d. Levels of excess air too low or much too high.
- e. Excess moisture carryover.
- f. Superheater tubes fouled either on the steam side or firesides.
- g. Improper gas baffles and improper bypass areas.

221-4.9.4 CARRYOVER. The superheater temperature will drop and recover if the boiler is foaming because of high total solids or improper chemical treatment. The temperature drops increase as the total solids in the boiler water increase. Priming due to a high water level or rapid excursions in water level will cause the superheater temperature to drop suddenly and recover. To correct this situation, follow the casualty control procedures in NSTM Chapter 220, Volume 2.

221-4.9.5 TEMPERATURE LIMITS. Nominal superheater outlet temperature limits for typical main propulsion boilers are as follows for steady state operation:

- a. 1,200 PSI - 950° F +25/-0
- b. 600 PSI - 850° F +25/-0

The maximum allowable temperature limit during transients (limited to 15 minutes during any 1 hour) at the superheater outlet is usually 25° F degrees higher. It should be noted that the maximum temperature limits are not so much boiler dependent as they are turbine dependent. Propulsion turbine manuals usually specify maximum time that a turbine may operate at a given temperature. These time limitations are cumulative-; that is, the time accumulates over the life of the turbine. Consult boiler and main turbine technical manuals for specific limits for specific plants. For example, for one particular boiler/turbine combination the maximum steady state temperature was determined to be 1,000° F with a maximum limit during transients (limited to 15 minutes during any one-hour) of 1,020° F.

221-4.10 STEADY-STATE OPERATION

221-4.10.1 MAINTAINING STEADY-STATE CONDITIONS. The combustion rate is fairly constant when cruising and when operating in port. Very slight variation in steam demand is the rule under such circumstances. The fireroom crew shall make every effort to attain steady-state conditions on as many of the boilers being used as possible by proceeding as follows:

1. Regulate blowers to the proper air pressure and keep the pressure steady as long as the number of burners or the oil pressure does not change.
2. Maintain constant water level.
3. Keep atomizers clean. (refer to [paragraph 221-3.1.6.2](#))
4. Maintain constant steam drum or superheater outlet pressure, as applicable.
5. The engine room or fireroom crew, according to location of the equipment, should maintain a constant feed pressure and feedwater temperature.

221-4.10.2 PRECAUTIONS AGAINST EXCESSIVE EVAPORATION RATE. NSWCCD-SSES has established the sizes of sprayer plates to be used for each boiler installation, including a size of sufficient capacity for boiler overload steaming rates. Sprayer plates larger than the sizes listed in the applicable Boiler Technical Manual shall not be used. Except in an emergency, a boiler should not be steamed to a rating higher than that required to obtain full ship power with all boilers in use. To do so may adversely affect water circulation, with subsequent warping or failure of tubes. Guard against overloading a boiler, particularly when steaming on less than a full complement of boilers. Within design limits the amount of steam that can be supplied from a natural circulation boiler is generally limited by circulation failure, steam quality, blower capacity, decreased combustion efficiency, and other factors such as casing strength.

221-4.10.3 REDUCE DEMANDS FOR STEAM IF PRESSURE DROPS. When operating at high steaming rates, if the steam pressure drops for any reason and the boiler does not recover steam pressure, reduce demands for steam until the pressure begins to build up. Otherwise, blowers, pumps, and other auxiliaries that depend on an increasing steam supply will run slower instead of faster. Ships have been brought to a full stop, with all fires cut out automatically; because steam was bled from the system by keeping main engine throttles open too wide.

221-4.11 VARIABLE LOAD OPERATION.

221-4.11.1 CHANGES IN LOAD. An increase or decrease in load with a specified number of boilers can be managed in three ways: by increasing or decreasing the oil pressure with each variation in the load, by increasing or decreasing the number of atomizers in use, or by changing sprayer plates.

1. Straight mechanical burners produce optimum efficiencies at firing rates on the order of 2/3 to 3/4 their capacities. For this reason straight mechanical systems are normally operated at 150 to 300 psig, preferably at the higher pressures. It is preferable, therefore, to use a smaller number of burners at high rates per boiler.
2. Withdrawal of diffusers is not required, since tests have indicated that diffusers of idle burners in a steaming boiler are not significantly cooled.
3. With wide range steam atomizer and vented plunger burner systems it should be possible to operate with all burners firing for most underway conditions. It is strongly recommended that all burners be fired down to 30 percent boiler load, or lower if possible, since this will prolong diffuser life. It is permissible to secure burners when required for efficiency reasons (refer to [paragraphs 221-4.1.3](#) and [221-4.1.4](#)) and when the ship has excess steaming capacity on-line to support special operations.

NOTE

The atomizers of secured burners (both mechanical and steam atomizers) in operating boilers shall be removed unless essential for maneuvering situations. Failure to do this with vented plunger atomizers can cause heavy varnishing of the atomizer cartridge and can cause the piston to seize, rendering the cartridge inoperative. With steam atomizers, sprayer plates left in idle boilers have been known to fracture due to thermal shock, even though steam was left on for cooling. Also, the steam, which must be left on for cooling of idle steam atomizers can cause corrosive condensation in the boiler and wastes feedwater.

221-4.11.1.1 Oil Pressure Changes. Within the range of good atomization, the increase in capacity obtained through the increase of oil pressure is very nearly proportional to the square root of the pressure. Increasing oil pressure requires additional air pressure because of an increase in the quantity of oil being burned.

NOTE

A corresponding increase in air pressure shall always precede an increase in rate of combustion, and a decrease in air pressure shall always follow a decrease in rate of combustion.

221-4.11.1.2 Air Pressure Changes. Every change in boiler load (fuel rate) requires a change in combustion air supply pressure. Failure to increase the air pressure when increasing the load will quickly cause the boiler to pant and produce heavy smoke. If, when the load is reduced, the blower is not slowed down a corresponding amount, a large amount of excess air will be introduced. This will not lead to such obvious results, but it can lead to dangerous white smoke conditions and reduce the efficiency of the boiler considerably.

221-4.11.1.3 Burner Changes. A numerical or alphabetical sequence should be followed when cutting in numbered burners; in securing, the reverse order should be followed. If burners are not numbered, light-off the burner farthest away from the superheater first, and then light-off additional burners in the sequence also of greatest dis-

tance from the superheater. Optimum numbers of registers to use, as well as preferred sizes of sprayer plates, have been determined for all boilers and are included in the Boiler Technical Manual.

NOTE

Cut in and secure fuel to individual atomizers using root valves. The safety shut-off device is used for this purpose in casualty situations only.

221-4.11.1.4 Lighting Additional Burners. Torch Use. When additional atomizers are lighted in Navy design boilers, the atomizers may be safely lighted from the flame of adjacent atomizers in operation because of the close spacing of atomizers. On non-naval boilers, where the boilers have widely spaced burners, a torch is sometimes used to light additional burners if experience indicates the furnace draft does not extinguish the torch. No matter how hot the furnace may be, if all burners are temporarily secured, do not attempt to relight from the incandescent brickwork. The most serious accidents result from this practice.

NOTE

When using more than one atomizer, select the combination of size and number of burners that give the highest fireroom efficiency for the particular installation. Select size on the basis of capacity at about 225 psig oil pressure for straight mechanical fuel systems.

221-4.11.1.5 Sprayer Plate Changes. Changing sprayer plate sizes should be governed by the following considerations:

- a. Sprayer plates larger than the size allowed for the ship shall not be used.
- b. Sprayer plate combinations of dissimilar sizes or ratios shall never be used in a boiler at the same time. Changes in steam pressure and temperature shall be taken care of by varying the number of burners, the oil pressure, and, if necessary, the size plates used in the boiler.
3. Under special circumstances, particularly at low steaming rates during maneuvering conditions, when time is not available for a complete change of plates, it may be necessary temporarily to use a smaller plate in one burner to keep from losing fires or from dropping oil pressures unduly low. Such plates shall be removed from the boiler immediately thereafter.

221-4.12 CONTROL OF FUEL.

221-4.12.1 RANGE OF OIL SUPPLY. The amount of steam that can be supplied by oil fired boilers aboard Naval ships ranges from the amount obtainable with one burner fitted with the smallest atomizer to the amount obtained using the full battery of boilers with all burners fitted with atomizers of largest size. The parameters that can be adjusted to achieve the variation in oil combustion rate necessary to cover this range in steam demand are as follows:

- a. Size of sprayer plate used.
- b. Number of atomizers used per boiler.
- c. Oil pressure.

- d. Number of boilers used.
- e. Number and speed (air pressure) of blowers used.

221-4.12.2 SPRAYER PLATE CAPACITIES. Individual Boiler Technical Manuals contain pressure capacity curves for atomizer sprayer plates.

221-4.12.3 FUEL OILS. The standard fuel oil being used in Naval boilers is Diesel Fuel Marine (DFM) purchased to MIL-DTL-16884L (NATO F-76). It may sometimes become necessary to burn other fuels because of supply problems, emergencies, or wartime conditions. A list of alternative fuels, with JP-5 as first preference, can be found in NSTM Chapter 541. If it becomes necessary to burn a residual fuel such as Naval Special Fuel Oil (NSFO), heating is mandatory to reduce the viscosity for atomization. Depending upon the grade and sea temperature, these fuels also may have to be heated in their tanks so that pumps can handle the oil at full capacity. Refer to [Appendix I](#).

NOTE

The vented plunger wide range mechanical burner system should not be fired with NSFO.

221-4.12.4 FUEL OIL PIPING SYSTEMS. Pumps shall be operated as necessary to meet requirements and operating conditions. In most cases (excluding carriers) the capacity of one fuel oil service pump inadequate to meet the maximum fuel demand of all boilers in a particular machinery or fireroom space. For temperature limits in fuel piping systems, refer to NSTM Chapter 541.

221-4.12.4.1 Fuel Oil Control Valves. An ABC type fuel oil control valve is the only type valve that should be used to regulate fuel flow to the burners. ABC fuel oil control valves are superior to micrometer valves for fuel flow control. Micrometer valves are obsolete and shall not be used in new design, or when valve replacement is necessary. An ABC-type fuel oil control valve with proper modifications, including pneumatic connections, can be manually operated to control fuel flow for boilers that are not equipped with ABC. A backup ABC type fuel control valve shall normally be placed in a bypass line around the primary fuel control valve with shutoff valves on either side of the backup valve to isolate it. The preferred position for fuel oil control valves is a vertical position in a horizontal run of pipe, to avoid fuel leakage. Any vent or bleed-off line shall be piped to contaminated fuel tanks; it shall not be piped to burner drip pans. Using globe valves as manual fuel control valves is not authorized.

221-4.12.4.2 Fuel Oil Accumulators. A steady oil pressure is essential to good combustion. Screw-type pumps experienced very little trouble from fluctuating pressures. Some ship classes use fuel oil accumulators in the fuel supply line to maintain fuel pressure during momentary loss of electric service pumps due to pump start-up, shutdown or speed change.

221-4.12.4.3 Dual Fuel Oil Piping Systems. On those ships with dual fuel oil service piping systems installed in one space, some conditions, such as combat, or replenishment at sea, may require that both pumps be operated simultaneously, with each pump discharging independently to a boiler. In this situation, however, or any other (except as listed below), there shall be no more than one service tank on suction at any time. The second service tank shall be retained as a standby tank. The only exception is those ships like aircraft carriers that have

four tanks per space. In carriers, separate service tanks, service pumps, and piping normally serve each of the two boilers. The remaining two service tanks are retained on standby. Refer to NSTM Chapter 541, for tank settling, stripping, and sampling requirements.

221-4.12.4.4 Standby Fuel Oil Pump. In any of the above cases the Engineer Officer shall ensure that the standby pump is ready for starting and operating with a minimum of valve realignment.

221-4.12.4.5 Fuel Oil Strainers. Since clean oil passages in the atomizers are essential for good atomization, inspect and clean strainers according to NSTM Chapter 541.

221-4.13 CONTROL OF AIR.

221-4.13.1 SOURCE OF AIR. The air necessary for combustion of fuel oil in a naval boiler furnace is provided by electric or steam driven blowers.

A boiler is under forced draft when pressure higher than that of the outside air is maintained in the inner-casing space surrounding the burners.

221-4.13.2 METHODS OF CONTROL. The air supply for an oil-fired boiler is controlled in three ways, as follows:

- a. Number of air registers opened
- b. Amount each register is opened

NOTE

Once the setting for a D-20/D-21 air register is established, it is not varied during operation.

- c. Increase or decrease in air pressure.

221-4.13.2.1 Number of Air Registers Open. In the operation of an oil-fired boiler, only the air registers of the atomizers in use shall be opened. All other registers shall be kept closed to prevent excess air from entering the furnace.

221-4.13.2.2 Cracking Idle Registers. On fuel oil burners in which warping and burning of burner register parts has occurred, the practice is to permit a slight amount of air to leak through dead registers to protect them from the extreme heat of the furnace, even though this brings about a small sacrifice in efficiency. A register shut tight could become red hot, with consequent distortion of the metal when it cools. With burners used on air-encased boilers, cracking the registers is necessary.

221-4.13.2.3 Amount of Register Opening. Under normal conditions registers are either closed or wide open, and air-flow is controlled by adjusting air pressure.

NOTE

LPD Class ships operate with air register doors half open after a stable flame pattern is observed. This permits a 10% reduction in Forced Draft Blower speed during high power steaming. Stops are installed on the operating quadrant to secure the operating handle at the half-open position.

221-4.13.2.4 Control of Air Pressure. Combustion air pressure is controlled as follows:

1. Steam-Driven Blower. The speed of the fan is controlled by a throttle valve at the steam inlet.
2. Motor-Driven Blowers. There are three different types of motor drives:
 - a. Single constant speed. Pressure is controlled by some combination of radial vanes or dampers at either the inlet or the outlet.
 - b. Multiple constant speed. Same as above, with an increase in efficiency at low speed and low powers.
 - c. Variable-speed motors.

221-4.13.3 VISUAL INDICATIONS. The appearance of the flame, presence of white or black smoke, and soot or carbon deposits can indicate improper amounts of combustion air, as described in the following paragraphs.

221-4.13.3.1 Appearance of the Flame. A study of the appearance of the flame in conjunction with the stack is a good visual guide to high furnace efficiency. Flame characteristics are listed below:

1. If the flame is incandescent white and the furnace walls are clearly discernible through it, considerable excess air is present.
2. As the percentage of excess air is reduced, the color of the flame at the rear of the furnace becomes a pale yellow, then yellowish orange and orange red. In general, with a well-designed installation in good condition and operating with a minimum of excess air, the end of the flame farthest from the atomizers is a yellowish orange or golden shade. The gases of combustion are colorless, and seams in the brick are just discernible.
3. At very high rates of combustion, when the flame completely fills the furnace, very high furnace temperatures preclude these colors. An incandescent and dazzlingly white flame indicates excess air, but a reduction in this excess is indicated in the furnace only when the intensity of the white flame softens. Water in the oil or a leaky tube will also cause a dazzling, white flame.
4. Sputtering indicates the presence of considerable water in the fuel oil.

221-4.13.3.2 Stack Condition. Maintain a clean stack when distillate fuel is being burned. Fireroom personnel shall reduce the supply of air until a light brown haze is emitted from the stack. The air supply should then be increased immediately until a clear smokepipe is produced. The clear smokepipe condition should then be maintained for efficient burning. A perfectly clear smokepipe, however, is deceiving; it could mean only a small amount of excess air or as much as 300 percent excess air. A clear smokepipe is ideal when gas analysis at the same time shows high CO₂, very low O₂, and no CO; for example, 14.7-percent CO₂, 1.8-percent O₂, 0-percent CO. When NSFO is burned, a light-brown haze shall be maintained unless smokeless operation is required.

221-4.13.3.3 Causes of Smoke. The presence of smoke does not always mean insufficient air or high CO. Poor atomization, a poor mixture of air and oil, or unconsumed oil striking cooler surfaces frequently causes smoke, even when the air supplied for combustion is far in excess of that required. Such defects shall be eliminated

before proper oil and air regulation can be attempted and before the smoke can be used to indicate the amount of excess air being supplied. If one or two atomizers are dirty, for example, streaks of dense oil enter the furnace and pass out the funnel partially consumed, causing black smoke, even though there may be a very high percentage of excess air. A trained eye can often tell the difference between black smoke from this cause and from other causes, because it is generally more irregular and streaked than that due to lack of air. Refer to [paragraph 221-4.18.8](#) for a discussion of white smoke and guidance on casualty control.

221-4.13.3.4 Smoke Indicators. Smoke periscopes have been installed on boilers to provide a means by which operating personnel in the fireroom can see the smoke conditions in the uptakes. If the light in the periscope is clear and unobstructed there is no smoke but there may be excess air. If it is just slightly dimmed (hazy) and the furnace also indicates good combustion, the air supply is about right for the most economical operation. Increasing degrees of black smoke indicate the need for more air. If the smoke indicator shows entirely black, a large amount of either black smoke or white smoke is indicated, since both will obscure the bulb and differentiate between black and white smoke. Refer to [paragraphs 221-3.5](#) through [221-3.5.3.8](#) for details.

221-4.13.3.5 Soot and Carbon Deposits. Deposits in the boiler may be caused by insufficient air for combustion, poor atomizers, too viscous fuel oil, improperly adjusted fuel atomizers, or contaminated oil.

221-4.13.3.6 Heavy Soot on Tubes. Heavy deposits of soot on tubes always accompany heavy smoking, no matter what kind of oil is used, and are a sign of incomplete combustion.

221-4.13.3.7 Carbon Deposits. Deposits of hard carbon on tubes and on the furnace sides and bottom are caused by oil striking the tubes or the brick before it has had time to burn. This is caused by defects in design and operation. With faulty operation, the causes are the same as those that produce excessive soot and smoke; that is, the failure to obtain an intimate mixture of entering air and oil at the register. This is most often caused by improper location of atomizing tips. It sometimes results when excess air enters around the cone of oil, cooling the flame so that combustion is not obtained until the spray has passed some distance back in the furnace. As a result, the particles of oil forming the outer surface of the oil cone strike the furnace bottom, sidewalls, or tubes near the front of the furnace and are thus cooled below ignition temperature. The heat causes the hydrocarbons to coke, and coke adheres to the surfaces as a solid mass. A similar action occurs when the amount of air is insufficient for complete combustion. If carbon forms on the tubes or furnace walls, burners shall be carefully checked to ensure that the atomizers are in the position prescribed in the technical manual for the particular installation.

221-4.13.3.8 Carbon on Burner Openings. If carbon collects on the edges of the furnace opening, the atomizers have been drawn too far back in the registers or, as is often the case, the furnace opening is irregular, because of patched refractory and the projection of refractory into the cone of oil. Air-centrifuging the flame by nearly closing the air doors while maintaining relatively high air pressure causes carbon deposits of this nature. Avoid undue throttling of register air doors, especially during port operation. In extreme cases carbon deposits could be sufficient to intercept particles of atomized oil and cause them to pass backward and downward into the double front as oil drips, creating a fire hazard.

221-4.13.3.9 Carbon on Atomizer Tips. Carbon on atomizer tips may be a sign that the tips are improperly located. If the atomizer is inserted too far, an eddy forms in the entering air currents. A fine fog of oil is drawn back behind the face of the tip and is deposited back on the atomizer pipe (this is an extreme case where the atomizer has been inserted several inches beyond the proper point). In extreme cases, jets of ragged flame are also drawn back by this eddy, sometimes, completely hiding the tip from view.

221-4.14 WATER LEVEL CONTROL

CAUTION

Whenever the boiler water level drops or rises completely out of sight in the gauge glasses, immediate steps shall be taken to secure the boiler. Refer to paragraphs 221-4.18.16 through 221-4.18.16.2 for specific actions to be taken for high and low water.

NOTE

When feedwater is being supplied manually to a steaming boiler, the boiler technician assigned to the feed check shall have no duty other than maintaining proper water level.

221-4.14.1 NORMAL WATER LEVEL. As a rule, the designed normal water level is at the center of the drum, but there are a number of exceptions to this rule. The Engineer Officer should therefore ascertain from the ship's drawings the location of the designed normal water level for the boilers under his care and the location of this level with respect to the center of the gauge glasses. This should be marked on the gauge glasses to guide the boiler room crew. If the water level is not clearly marked on the ship's drawings, NSWCCD-SSES should be consulted.

221-4.14.2 WATER LEVEL INDICATORS. Water gauge glasses and remote water level indicators are provided for reading the water level in a boiler. These instruments shall be installed correctly and maintained in proper operating condition. Refer to operating and maintenance instructions in paragraphs 221-3.4 through 221-3.4.3.4.2. If the upper and lower connections between the water gauge and the steam drum are closed or even partially blocked, as by a piece of scale, the water level indicated will be false. Installation of unauthorized orifice restrictions or snubbers of any sort, such as copper washers or copper coins, are prohibited.

221-4.14.2.1 Gauge Glass Blowdown. The water level gauge should be blown to clear any obstruction and to remove debris from the mica. The gauge shall be blown twice; first, with the upper cutout valve shut and the lower cutout valve open, and again with the upper cutout valve open and the lower cutout valve shut. After blowdown, take care to open both valves wide and to ensure that the water level indicated is accurate. If there is any doubt about the accuracy of the water level in the gauge when the boiler is on line, blow the gauge down immediately. After blowdown, if return of the water level in the glass is sluggish, determine the cause and correct at once.

221-4.14.2.2 Shrink and Swell. During maneuvering, the water level will appear to rise (swell) under constant feed as the steam flow rate from the boiler is increased, and conversely to drop (shrink) when the rate is decreased. The terms swell and shrink indicate a change in water level resulting from a change in steam flow or firing rate without any change in the amount of water in the boiler. This change in water level occurs because steam bubbles below the water surface occupy a larger volume at high evaporation rates than at low evaporation rates. If water transformed into steam is not replaced by a higher rate of feeding, the level will fall rapidly. Water flow into the boiler shall correspond to steam outflow. If the feed is decreased when the swell occurs, the level will momentarily rise and then may fall dangerously low. Similarly, the water level will momentarily fall when the firing rate is decreased and then rise rapidly unless the rate of feeding is decreased. The check man shall learn by experience to anticipate these changes so that the water level does not drop from sight when the rate decreases,

or rise to a level that may cause carryover when it increases. Maintaining an apparent constant water level under these conditions (with manual control) is the criterion of efficient water tending and requires the utmost vigilance.

221-4.15 ELECTRONIC AUTOMATIC BOILER CONTROL (EABC) SYSTEMS.

221-4.15.1 TYPES. EABC Systems consist of automatic combustion controls (ACC), automatic feedwater controls (FWC), main feed pump controls (FPC), and recirculation controls (RCC) . Refer to NSTM Chapter 225, as well as, individual ship EABC System manuals and on-line verification (OLV) procedures (If applicable) for specific details on these systems.

221-4.15.2 PURPOSE AND FUNCTION OF ACC. The purpose of the ACC System is to maintain a predetermined steam pressure as measured at the steam drum, at the superheater outlet, or in the common steam lines of the boilers in a fireroom. This is accomplished by automatic regulation and by proportioning the fuel oil and the combustion air supplied to the boiler to correspond to the momentary steaming rate or to changes in the steaming rate. With an increase in steam demand, steam pressure tends to drop, causing controls to increase the firing rate to restore the pressure to its desired value. The ACC System operates in the reverse mode if the steam demand decreases.

221-4.15.3 AUTOMATIC FEED WATER CONTROL. The primary function of the automatic feedwater control (FWC) system is to maintain normal boiler water level set-point within ± 1 inch at all boiler loads. The FWC System measures steam flow, feedwater flow, and boiler drum water level. The FWC System utilizes this information to position the main feedwater-regulating valve to maintain normal boiler drum water level. The three-element FWC System is designed to modify the setpoint during normal boiler operations to compensate for the effects of boiler water shrink and swell (one system per boiler)

221-4.15.4 MAIN FEED PUMP CONTROL. The Main Feed Pump Control (FPC) system maintains constant main feed pump discharge pressure and ensures that sufficient feedwater flow is available to support all boiler loads with minimal pressure deviations. The FPC System measures the main feed pump discharge pressure at a common header point and positions each pump speed control valve to maintain desired header pressure setpoint (one system per boiler)

221-4.15.5 MAIN FEED PUMP RECIRCULATION CONTROL. The Recirculation Control (RCC) System measures the flow of each main feed pump and positions the RCC valve (either open or closed) to maintain minimum flow through each pump at low end. The RCC System maintains sufficient flow through the feed pumps at low loading levels to ensure no pump damage will occur from overheating (one system per main feed pump)

221-4.15.6 ADVANTAGES. EABC System offers the following distinct advantages over manual control:

- a. Ability to continue steaming the boiler when the fireroom becomes uninhabitable
- b. Fewer operating personnel
- c. More efficient boiler operation under all conditions
- d. Better steam pressure regulation
- e. Reduced likelihood of producing excessive superheater outlet steam temperatures because of high excess air.

221-4.15.7 OPERATION. Ships equipped with an EABC System shall use the controls at all times while steaming. Manual operation at the control panel (remote manual) should be used when lighting off and securing the boiler. The EABC System should be cut out and local manual control used only when required to maintain equipment or train personnel.

221-4.15.8 CONTROL TRANSFER. Casualty conditions may necessitate transfer of the entire control system or a part of the system to remote manual or local manual operation. To ensure competence in this type of operation, sufficient time should be taken to train and drill each watch in transfer procedures and manual operation of the boiler and associated equipment.

221-4.15.9 PERSONNEL RESPONSIBILITIES. While in automatic or remote manual operation, ships with combustion controls shall have an operator stationed at the control panel at all times to observe operation of the controls and to operate the boiler when it becomes necessary to switch to remote manual operation. While in remote manual operation, with the ship undergoing rapid maneuvering, it may be necessary to station a second operator at the control panel to assist in operating the boiler. The operator will also observe the water level on the gauge glass or on the remote water level indicator, observe control system operation, and operate the Man-Auto control station if it becomes necessary to switch to remote manual operation.

221-4.15.9.1 Calibration. The EABC System shall be maintained in optimum operating condition. Accurate calibration is required before the controls are considered satisfactory. The appropriate technical manual or PMS shall be consulted for calibration data.

221-4.15.9.2 Faulty Operation. While in automatic operation, if the boiler cannot be controlled satisfactorily (as evidenced by smoke or excessive fluctuation of steam pressure while maneuvering), the combustion controls shall be switched from automatic to remote manual and the boiler operated manually from the control panel or console. While in remote manual, if the boiler cannot be operated satisfactorily, operation shall be shifted to the boiler front where the boiler shall be operated manually until combustion controls are repaired. If the water level cannot be maintained (or if it continually fluctuates) while on automatic regulation, the control system shall be switched from automatic to remote manual and operated manually from the control panel. While in remote manual, if the water level still cannot be maintained, the feed check station shall be manned and the water level controlled by operating the feed check valve manually. The automatic control system shall be repaired and placed in service promptly.

221-4.15.10 MAINTENANCE. The control equipment shall be adjusted and serviced periodically and regularly to prevent failure or impairment of equipment. Air lines shall be kept free of oil and water, and air filters kept clean.

221-4.15.11 FEEDWATER CONTROL SYSTEM. Two types of automatic feedwater control are in use on boilers:

- a. Single element
- b. Three element

221-4.15.11.1 Single-Element Control Systems. These control systems have a control element that depends only on the water level in the V2M auxiliary boiler steam drum. They have several inherent disadvantages:

- a. The chief reliance for maintaining proper water level remains in the feed control valve.
- b. They maintain the water level within reasonably close limits under steady steaming and under all other conditions except hotel load changes. However, load, shrink and swell changes are small and controls recover quickly.
- c. They will not, and should not, be expected to hold the water level exactly at the design water level during hotel load changes, since they depend on a variance from the design level to operate the control valve and tend to carry an increasingly lower water level as the steaming rate is increased and an increasingly higher water level as it is decreased. This variation in water level is generally within acceptable limits.
- d. They tend to act in the wrong direction during load changes. On an upward load change, when the level has swelled, the control system first tends to reduce water flow when an increase will soon be necessary to provide the additional steam. The reverse is true for a downward load change.
- e. If they are not in service constantly, they shall be operated in full control of boilers for a reasonable period each day to ensure that they will be operable when cut in. Control elements mounted on the steam drum shall be cut in at all times and shall be blown down regularly according to instructions in the manufacturer's instruction book.

211-4.15.11.2 Three-Element Control Systems. The three-element control systems control water level by combining the influences of steam flow, feedwater flow, and water level. Measuring the steam flow immediately and accurately indicates a change in boiler steam demand and begins to position the regulating valve in the direction desired. By measuring feedwater flow, a balance can be maintained between steam taken out and water brought in. Measuring the water level resets the level at the design point and corrects any deficiencies in the measurement of steam and feedwater flow. Refer to NSTM Chapter 225 for a more complete description of three-element feedwater control systems.

221-4.16 SOOT BLOWER OPERATION.

NOTE

All rotary and stationary soot blowers shall be kept in operating condition. NSWCCD-SSS LCEM approval is required to blank soot blowers. Main generating bank soot blowers have been permanently removed on some classes after testing indicated they were not required when operating with distillate fuel.

221-4.16.1 PERMISSION TO BLOW TUBES. Permission shall be requested of the Officer of the Deck (OOD) and granted before starting to blow soot from boiler tubes. At sea, the OOD can often set the best possible ship's course so that soot from the stacks will clear the topside decks and equipment. Notify the OOD when soot blowing has been completed. All in-port soot blowing shall be carried out strictly according to local port regulations and standing orders.

221-4.16.2 FREQUENCY OF BLOWING TUBES. The frequencies listed below reflect the results of the latest available information:

1. When burning distillate fuel, blow tubes:
 - a. In all steaming boilers at least once each week while under way, in port, or at anchor.
 - b. After leaving or just before entering port.

- c. When practical, just after making heavy smoke from any cause (such as lighting off or casualty)
- d. Should periodic fireside inspection reveal excessive soot deposits in boilers, especially in the economizer area (provided fuel oil burner settings and equipment are satisfactory, and the boiler exit stack has not emitted haze or dark smoke for extended periods of steaming), the soot blowing for that ship shall be increased in frequency to once daily at sea and once daily in port (subject to local port regulations). Should the next inspection again reveal excessive deposits, soot blowing shall be increased to twice a day at sea. The in-port cycle shall not be increased further. Inspection of soot blowing elements shall be initiated, and blowing pressures at soot blower heads shall be checked. Prolonged in-port low steaming rates and low firing rates will produce increased soot deposits, especially in the economizer area, regardless of any measures taken.

CAUTION

It is realized that local port regulations will prohibit operation of soot blowers in most instances. This does not mean that the need to blow tubes during extended periods of low steaming rate operation does not exist. Ships whose operating profile includes extended in-port steaming must make sure all combustion and atomizing steam quality issues are resolved prior to deployment. Increases in stack gas temperature (where equipped) and wind-box pressure levels over anticipated values for a given steaming rate can be an indicator of soot accumulation on firesides. A decline in economizer outlet water temperature (where equipped) from anticipated values for a given steaming rate may also be an indicator. It is not advisable to steam a boiler at low rates, even one with no known combustion problems, more than 500 hours without getting underway for the purpose of standard operation of soot blowers.

- 2. When blowing tubes, consider the effect on the upper decks. More frequent use of soot blowers results in less smoke and soot topside.
- 3. Rotate manual steam soot blower elements at a rate of 10 to 15 seconds per 90 degrees of rotation, making from one to three complete traverses with each element, depending on the condition of boiler firesides.
- 4. Whenever practical, shortly before burners are secured, clean the boiler firesides of accumulated soot with steam soot blowers. Steam soot blowers shall be used only while fires are lighted. It is good practice to blow tubes before building up for a full power or economy run.

221-4.16.3 SEQUENCE OF BLOWING TUBES. To ensure maximum efficiency of soot blowing operation, blow the economizer soot blowers initially after thoroughly draining the supply steam system of condensate. This will clear the economizer area of any soot that has collected since the last tube blowing operation. Following this, the regular sequence of blowing all soot blowers, from the generating bank and upward, as outlined in the applicable Boiler Technical Manual, should be followed. The economizer soot blowers used in the initial phase of the sequence shall be blown at the end of the operation. All soot blowers should be labeled for proper identification. Renumbering soot blowers because of the elimination of retractable units in the superheater cavity area for some boilers is not recommended because of the possible confusion resulting when using boiler drawings and manuals. If stationary soot blowers have been added to a boiler, they should be labeled by alphabetical prefix in sequence (for example, 2A, 3A).

221-4.16.4 FORCED DRAFT DURING SOOT BLOWING. Before actuating the first soot blower in sequence, increase the boiler forced draft 2 to 3 inches so that soot dislodged by soot blowers will be carried clear of the boiler and up into the uptake and smoke pipe. Restore the draft to the required setting after securing the last soot blower.

221-4.16.5 BOILER FIRING RATE DURING BLOWING. Soot blowing shall begin when boilers are at a firing rate of 50 percent or greater when the ship is underway, so the action of blowing steam will not affect the stability of the burner fires. Burner fire stability shall be closely checked when soot blowing occurs during in-port operation or when anchored.

221-4.17 BOILER BLOWDOWN.

221-4.17.1 PURPOSE OF BLOWDOWNS. Impurities will eventually contaminate the boiler water, entering either with the feedwater, which may have picked up impurities in the feed system, or with the makeup feedwater. Impurities are also generated by the chemical treatment of the boiler water and by corrosion products formed within the boiler proper. Since the boiler may be thought of as a highly efficient evaporator, almost every impurity that enters from these sources will remain in the boiler unless means are provided to rid the boiler of them. The nature of the impurities is either to form scum, which will float on the surface of the water in the steam drum, or to form sludge, which will settle at the lower boiler parts, like headers and water drums. The general objectives and procedures for blowdown are listed in [Table 221-4-1](#).

Table 221-4-1. Objectives And Procedures For Using Blowdown

Conditions	Action	Remarks
Emptying boiler	Use of water and header bottom blows, and superheater drains.	Boiler cold. Refer to paragraph 221-2.2 .
Priming and foaming	Use surface blow.	Boiler steaming.
Sludge removal	Use bottom and waterwall header blows.	Boiler secured and no longer generating steam.
Excess Chemicals and salinity	Use surface blow if steaming, drain bottom blow if not.	Carry water level above normal for duration of blow.
High water	Use surface blow.	None.

221-4.17.2 SURFACE AND BOTTOM BLOW PROCEDURE. Requirements and procedures for surface and bottom blow are contained in NSTM chapter 220, Volume 2.

221-4.17.3 BOILER BLOWDOWN SYSTEM VALVE LEAKAGE. Boiler Blow Systems are designed for full boiler pressure. Boiler blow valve seat leakage is undesirable and should be corrected at the earliest opportunity, but is not restrictive to boiler operation.

- a. According to NSTM Chapter 505, Piping Systems, new and overhauled boiler blow valves have an allowable maximum seat leakage rate of 15 ml/hr. Therefore, zero leakage in all cases cannot be expected. Consequently, the boiler blow system may become pressurized. However, this does not impose a restriction to boiler operation unless continuous flow overboard is occurring as explained below.

- b. A continuous flow overboard condition can be identified by and external piping temperature at a location one to two feet upstream of the overboard guarding valve being three-Celsius degrees (five Fahrenheit degrees), or more, above ambient temperature. This temperature should be measured with all valves closed when the boiler blow system is in a stabilized temperature condition, at least 24 hours after boiler blowdown system has been operated. The procedure for measuring temperature is similar to existing PMS for testing boiler blow valves for internal seat leakage and using local ambient temperature in the immediate vicinity of the overboard-guarding valve.
- c. A restriction to boiler operation is imposed when all valves in the boiler blow system (boiler blow, guarding, overboard valves) are leaking to the point that flow overboard is occurring. This restriction is necessary due to the uncontrolled loss of boiler water treatment chemicals and the impact on make-up feedwater. Any external steam leakage from the system, i.e. piping flanges, valve packing, is also boiler restrictive until corrected.

221-4.18. CASUALTIES.

221-4.18.1 ENGINEERING CASUALTY CONTROL. This section supplements the procedures specified in NSTM Chapter 079, Volume 3, and EOCC.

221-4.18.2 EFFECT OF GUNFIRE AND BOMBING. During gunfire or bombing, the partial vacuum created at the draft blower intake could cause a boiler flareback. Blowers may be adversely affected by the shock, and their operation should be watched. In addition, boiler walls and the fuel oil piping may be damaged. During gunfire or bombing personnel should be especially alert to guard against injury and to detect any change in the operation of equipment.

221-4.18.3 CASUALTY CONTROL DRILLS. When a casualty drill requires that the boiler be secured, repeat (piggyback) drills should be conducted using only the light-off burner to minimize the amount of unburned fuel that drains into the furnace. After one repeat (piggy back) drill, an additional drill on the same boiler should not be conducted until the boiler is at line pressure, the main steam stop valve is open, and the boiler control systems are operating fully, automatically.

221-4.18.4 BOILER EXPLOSIONS. Ignition of combustible fuel-air mixtures in a boiler may be either controlled (burning fuel at a determined rate at or near the atomizer tip) or uncontrolled (explosion) . In an explosion an accumulated combustible mixture ignites almost instantaneously, creating a force that exceeds the yield strength of the boiler furnace, casing, or uptake, causing structural damage. Symptoms or indications are a sudden loud explosion in the boiler furnace or uptakes. The basic cause of all boiler explosions is the accumulation of unburned fuel or combustible vapors at some point in the system. Since fuel burns only when certain mixes with air (oxygen) are achieved and when a certain temperature is reached, any condition that delays achieving the proper mix and temperature creates the danger of explosion, because unburned fuel accumulates during the delay. This fuel may then burn later, uncontrollably and explosively. The causes of such accumulations of unburned fuel or combustible vapors are:

- a. Improper balance of fuel and air at the atomizer.
- b. Improperly assembled atomizer.
- c. Failure to secure the fuel supply to atomizers promptly when fires are extinguished.
- d. Leaking burner valves.
- e. Wet atomizing steam.

- f. Failure to follow proper light-off procedures.
- g. Repeated unsuccessful light-off attempts.
- h. Failure to purge the furnace properly, including furnace, boiler, and uptake areas.
- i. Excess or insufficient combustion air supply.
- j. Failure to open air register immediately after burner ignition.
- k. Inadequate soot blowing, which results in economizer gas-side restrictions.

221-4.18.5 BOILER INTEGRITY INSPECTION. Additionally, boiler explosion is the rapid ignition or detonation of volatile fuel-air mixture at the burner atomizer tip. This blast extinguishes the atomizer fire and causes furnace gas and flame to rush through the burner air register and light-off port. Experienced personnel should inspect the boiler carefully after such events to determine boiler integrity, and to determine whether there was any damage.

221-4.18.6 PRECAUTIONS TO PREVENT EXPLOSIONS AND FLAREBACKS. The most common incident noted in boiler explosion and flareback reports is an attempt to relight a burner in a hot boiler after fires have been completely extinguished. The explosion or flareback occurs at the time of the attempted relight because unburned fuel in a vaporized state has accumulated in a hot boiler and has not been completely and thoroughly removed or purged from the furnace and uptake. If an accumulation of fuel is determined or suspected to be in the furnace, do not continue to light-off. If the boiler is cold, the unburned fuel presents no immediate explosive hazard, but shall be removed before lighting fires. Purging will not reduce the chance of a flareback or boiler explosion if raw fuel, even in minimal quantities, is present in the furnace or if fuel oil continues to leak into the furnace. Almost all boiler explosions can be avoided if operators pay close attention to the danger signs (that is, one or more unsuccessful attempts to light fires, sputtering fires or fires going out, irregular or streaked black smoke, fogging of the BID, fuel vapors coming from the light-off port, very heavy black smoke uncorrected by fuel air adjustments, and white smoke). Whenever a burner is secured, the atomizer shall be removed from the boiler as soon as possible. In all cases, whenever the initial burner is to be placed in operation, a clear stack shall be verified and the furnace shall be inspected with a BID before beginning the purge to determine if vapors or wet spots exist. Fires should be lighted as soon as possible following completion of the purge. If fires are not lighted within 5 minutes after completing the purge, the boiler shall be purged again. After igniting each burner, check for the proper flame pattern and a clear stack. Should these observations indicate an abnormality, take corrective action before continuing the procedure.

221-4.18.7 LOSS OF CONTROL AIR. In the event of control air failure with ACC, shift to local manual operation at the boiler front to bring the boiler to the required firing rate. Shift back to automatic operation as soon as control air is available. In case the valve operator diaphragm or the control air supply to the FWC fails, transfer feedwater regulation of these boilers promptly to local-manual operation using either the manual check valve or the operating handwheel or jack installed on the feed regulator valve. An air lock system is provided for a safe transition from automatic to local manual control within minimal change machinery plant operation. Refer to NSTM Chapter 225 for a detailed description of the air supply and air lock systems.

WARNING

Do not adjust fuel oil header pressure as a means of clearing white smoke.

221-4.18.8 WHITE SMOKE. A potentially explosive situation exists after white smoke is generated. Therefore, avoid smoking white; correct a white smoke condition as soon as possible, particularly under cold boiler conditions, by adjusting the forced-draft blower speed and vane position. Take care to ensure that water vapor is not mistaken for white smoke. If unable to correct the white smoke condition within 1 minute of its detection, secure the boiler and take appropriate action to eliminate the explosive condition. Good judgment, however, calls for securing the boiler immediately on detecting white smoke, rather than attempting to correct the condition, if any of the following conditions exist:

- a. Commencement time of white smoke is unknown.
- b. White smoke is extremely heavy.
- c. Initial corrective action is ineffective.
- d. The boiler is not on the line.

221-4.18.9 BLACK SMOKE. The presence of carbon particles in the boiler exit gases appears as black smoke. For light to moderate levels, this will be the only condition existing and will not present an explosion hazard. Although the condition should be corrected, there is no necessity for securing the boiler. However, if smoke is very heavy, the possibility exists that raw fuel is also being deposited in the boiler. Heavy black smoke can be caused by: atomizer oil leakage, failure of atomizer parts, very poor boiler draft during light-off or extremely deficient combustion air flow at all other times. Boiler operators should recognize the difficulty in judging the explosive potential of black smoke and firebox conditions. Some level of black smoke may be unavoidable during cold boiler light-off or at the highest boiler rates if combustion air supply is marginal. However, the boiler should be secured after two minutes of heavy black smoke. After the boiler is secured, an inspection must be immediately made for unburned fuel oil accumulations. Steam smothering should be actuated if any accumulations are found.

- 1. The following condition can be used to judge the severity of black smoke. If the smoke at the stack exit or in the periscope approaches 100 percent solid black appearance and the smoke severity does not decrease upon attempts to correct the combustion air flow levels, then heavy black smoke exists.
- 2. These other conditions may accompany heavy black smoke:
 - a. Flame appearance is unusual, particularly showing a streaked appearance.
 - b. Smoke is pouring from the light-off port, idle burners, or other casing joints.
 - c. The smoke conditions onsets suddenly, when it was previously satisfactory.
 - d. The burner flame, or raw oil, appears to be coming back into the air casing.
 - e. A floor fire exists on the furnace deck.

221-4.18.10 FUEL ACCUMULATION IN FURNACE. Apply the following procedures when fuel has accumulated in the furnace of a hot or cold boiler. Refer also to [Table 221-4-2](#).

- 1. When the fuel accumulated in the furnace burns while the burners are lighted, the following procedures apply:
 - a. Reduce the boiler firing rate.
 - b. Secure all but one lower burner and allow the accumulated fuel to burn out.
 - c. Determine the cause of fuel accumulation, correct, and fire the boiler as necessary.

NOTE

If residual fire shows no sign of burning out, the one lower burner may be leaking. Light-off a different lower burner, and remove the first burner and inspect for signs of leakage.

2. When accumulated fuel continues to burn after burners have been secured, the following procedures apply:
 - a. Open 1 lower air register to admit combustion air.
 - b. Stop forced-draft blowers.
 - c. Allow the fire to burn itself out.
 - d. Inspect the furnace for evidence of unburned fuel.
3. When an accumulation of fuel does not continue to burn in the furnace of a hot boiler after the burners are secured, the following procedures apply:
 - a. Do not admit air to the furnace.
 - b. Stop forced-draft blowers.
 - c. Close all air registers tightly.
 - d. Activate the boiler air casing steam smothering system.
 - e. When the air casing has filled with steam, open the two lower air registers to admit steam into the furnace for 30 minutes. After 30 minutes, secure the steam-smothering, purge the furnace, and close all air registers.
 - f. After actuating the steam-smothering system on some boilers, it can be difficult to determine when the air casing has filled with steam. On all boilers, if steam is not observed in the casing view ports within 5 minutes after the system is activated, ensure proper system alignment by unseating the test connection valve. If steam is emitted from the test connection valve, assume that the casing has filled with steam and open the lower two air registers.
 - g. Allow the boiler to cool to ambient temperature before entering the furnace to clean out the accumulated fuel. Do not attempt to relight fires until the accumulated fuel is removed.

CAUTION

In boiler furnaces having refractory decks, pay particular attention to accumulated fuel that may have seeped through expansion joints and collected in the brick pan.

4. When an accumulation of fuel oil is observed in the furnace of a cold boiler, open the furnace and remove all the fuel.

221-4.18.11 OIL FIRES. An oil fire may be caused by the ignition of oil or oil vapor in any place where oil is allowed to collect. The fireroom crew shall be drilled to handle the oil fire promptly and efficiently. An oil fire assumes serious proportions in a matter of minutes. The Engineer Officer shall ensure that standard firefighting equipment is available and ready for use in all oil-burning firerooms. The firefighting procedures and equipment shall be as specified in NSTM Chapter 555, Shipboard Firefighting, and [Table 221-4-2](#).

221-4.18.12 OIL IN BOILER WATER. Contaminated drain inspection tanks shall be observed at frequent intervals and at least once each hour on systems where drains are recovered. When oil film or cloudiness is observed, the drains shall be shifted to the bilge or contaminated drain collecting tank and a search begun to

determine the source of the leak. In case of cloudiness, take drain samples of the diverted inspection drain tank. Keep the inspection tank clean, so that contamination can be seen easily.

221-4.18.12.1 Source of Contamination. When oil is detected in the water level gauge glasses of the condensers, DFT, freshwater drain tank, or boiler, the feed system has been contaminated. Refer to NSTM Chapter 220 for correcting feed system contamination. Immediate action should be taken to determine the source of contamination, first by sampling drains that may be contaminated with fuel oil, such as fireroom funnel drains, and then checking sources of possible lubricating oil contamination such as leaking condensate pump gear seals, contaminated open engine room funnel drains, excessive accumulations of oil bilge water leaking directly into the freshwater drain tank or condensate system, or ineffective or defective LP turbine deflector seals.

When oil contamination is seen only in the boiler water level gauge glasses or on boiler watersides during internal inspection, industrial contamination could be the cause, but only if detected immediately following tube renewal work; refer to [Appendix E](#).

221-4.18.12.2 Stopping Contamination. Stop further contamination of the feed system if this is at all possible without securing the propulsion plant affected.

221-4.18.12.3 Type of Contamination.

1. If the contaminant is distillate fuel or lubricating oil and the source of contamination has been corrected, the boiler or boilers may continue to be steamed. The risk of failure is only slightly greater than that which existed before contamination by the fuel or lubricating oil. Reducing the firing rate of the boilers will reduce the risk of failure. If the boiler is known to be free of waterside deposits, however, the operation of the boiler need not be restricted. While the boiler is steaming, determine the extent of oil contamination by taking samples of water from the economizer outlet header and boiler drums. Blow down the boiler frequently, using the surface blow connection. Maintain boiler water chemical limits according to NSTM Chapter 220, Volume 2. The boilers affected should be rescheduled for early inspection and cleaning.

Table 221-4-2. Summary Of Firefighting Procedures For Boilers

Type of Fire	Action
Casing	Secure fires and blowers. Use boiler casing steam smothering followed by foam application, if required.
Economizer	Secure fires and blowers and close all air registers. Maintain water/steam flow. Attack fire with water through the smoke periscope or an uptake access above the economizer. After wetting as thoroughly as possibly this means, use soot blowers to assist with steam from below. (Premature use of soot blowers will simply stir up more soot and may create an explosive mixture.)
Furnace Fire	
(a) Accumulation of fuel on the firebox floor burns while burners are lit.	Reduce firing rate, secure all but one lower burner and allow the floor burns while burners are lit. accumulated fuel to burn out. Determine cause of the fuel accumulation, correct and fire the boiler as required.
(b) Accumulated fuel continues to burn in the firebox after burners have been secured.	Allow the fire to burn out. Stop forced draft blowers. Open on lower air register to admit combustion air to the firebox fire. After the fire has burned out, inspect the firebox. If no unburned fuel remains, the boiler may purged and fire relighted.
(c) If an accumulation of fuel in the firebox or a hot boiler does not continue to burn after burners are secured, the fuel will vaporize causing a potentially explosive situation	Do not admit air to the firebox, stop forced draft blowers and close all air registers tightly. Activate the steam smothering system. When the air casing fills with steam, open lower two air registers to admit steam to the fire box. After 30 minutes, secure steam smothering and purge the firebox. Allow the boiler to cool to ambient temperature before entering the firebox to clean out fuel accumulation- Do not attempt to relight fires until accumulated fuel is removed

2. If the contaminant is residual fuel oil, when the source of further contamination is stopped the boiler or boilers affected should be scheduled for securing as soon as possible (within 2 hours) unless the ship's operating situation will not permit outage.

NOTE

Operation with residual fuel or fuels with residual content like NSFO would not occur without a special conversion effort; refer to [Appendix I](#). It is highly unlikely residual fuel oil contamination will normally be a consideration.

In no case should the boiler be fired at high rates unless absolutely necessary when residual fuel contamination is suspected. While the boiler is steaming, determine the extent of oil contamination by taking samples of the boiler from the economizer outlet header and boiler drums. Blow down the boiler using the surface blow connection until the oil is removed. Maintain boiler water chemical limits according to NSTM Chapter 220, Volume 2.

3. If the contaminant is lubricating oil and the source of contamination cannot be stopped even though it is known, steaming the boilers may be continued. Dump the LP drain tank to the bilge or contaminated drain tank until the drains are free of oil accumulation. Reduce the rate of oil leaking into the turbine by throttling or stopping the gland exhaust blower (if installed) and by raising the gland sealing pressure. If operational conditions and commitments permit, reduce the boiler firing rate until the extent of the feed system contamination can be determined. Contamination is evaluated by inspecting the gauge glass and sampling the water from the DFT and boiler. If samples show only a film of oil, resume normal firing rates. Blow down the boiler frequently, using the surface blow connection. Maintain boiler water chemical limits according to NSTM Chapter 220, Volume 2. Reschedule the boilers affected for early inspection and cleaning, and correct the cause of oil contamination as soon as possible.

221-4.18.13 **WATER IN FUEL OIL.** Water contamination tests for fuel oil storage and service tanks and procedures for cleaning such contaminated tanks are covered in NSTM Chapter 541, and shipboard PMS procedures. The procedure outlined therein shall be carried out to ensure reliable and safe boiler operating conditions.

221-4.18.14 **BRICKWORK FAILURE.** When it is suspected or known that refractory has fallen from furnace walls, curtail boiler operation or limit the firing rate to prevent damage to the boiler casing. Secure burners adjacent to the damaged area and monitor the casing for hot spots.

221-4.18.15 **PANTING AND VIBRATION OF THE BOILER.** If undue panting or vibration occurs, make an effort to determine its cause and, if practical, to correct it. The strongest refractory will not withstand continuous and heavy vibration indefinitely. This is especially true of plastic or castable settings, such as burner fronts. Panting is usually attributable to one of the following causes:

- a. Deficiency of combustion air.
- b. Very high excess air.
- c. Poor air-oil intermixture.

NOTE

Poor air-oil intermixture may be caused by improper register settings, dirty or clogged sprayer plates, improper atomizer withdrawal, or severe warping of burner parts. If the difficulty cannot be corrected by the ship's force, NSWCCD-SSSES shall be advised and given all pertinent information available that may aid in determining corrective measures.

221-4.18.16 **WATER LEVEL CASUALTIES.** Whenever high or low water level alarms sound, or water goes out of sight (high or low) in the gauge glass, secure the boiler and perform the following:

1. In the event of high water, blow the boiler down (by way of the surface blow valve) until the water level is approximately at the normal level. If the water level goes out of sight high before fires are secured, do not relight fires. Carryover and superheater contamination may have occurred; test drains.
2. In the event of low water, the boiler shall remain secured pending boiler inspection, proceed as follows.
 - a. Do not attempt to restore the water level by increasing the supply of feedwater.
 - b. Lift the boiler safety valves by hand to reduce the steam drum pressure to approximately 200 psi below operating pressure.
 - c. Allow the boiler to cool to approximately ambient temperature. Open and inspect boiler firesides for damage. Inspect for boiler tube distortion, serious steam or water leaks, ruptured tubes, brickwork destruction, or warping of boiler casings. Closely inspect the upper portions of the tubes, which may have been water-starved for bulges, blisters, cracks, discoloration, or any other unusual condition.
 - d. Apply a 100-percent hydrostatic test according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#).
 - e. If boiler fires are secured before the water level is out of sight, low in the gauge glass, the casualty is restorable and there is no requirement to carry out the procedures described in the last two paragraphs above. If the boiler water level falls out of sight in the gauge glass after fires have been secured, the water level can be restored to normal or light-off level as soon as the cause has been determined and corrected.

221-4.18.16.1 High Water Level. If the water level is too high, priming or carryover will occur. This is especially true when the steam demand is high and fluctuating rapidly.

221-4.18.16.2 Low Water Level. When a boiler is operating with insufficient water to absorb furnace heat, warping of the boiler casing, distortion of boiler heating surfaces, destruction of boiler brickwork, serious steam and water leaks, and danger of tube failure are certain to result. In taking remedial action the following shall be considered:

1. In the event of low water, make no attempt to restore the normal water level by increasing the supply of feed-water. This will allow the boiler to cool gradually, and any parts that may have become overheated will be subjected to an annealing process that will minimize possible damage to the boiler pressure parts.
2. Ordinarily, a drop in steam pressure is caused by an increase in steam use, and the natural tendency is to counteract it by cutting in more burners or by accelerating the fires. If the drop in pressure is caused by low water, accelerating the combustion will result in serious boiler damage and possibly in injury to personnel. On boilers with automatic controls in automatic operation, the boiler controls will react to increase the firing rate to restore the lost pressure. It is critical that the operator be aware if water level is low so that he can counteract this response. Always bear in mind that a fall in pressure may indicate low water. When any pronounced or unusual fall in steam pressure occurs, the reason for which is not apparent, the level of water in gauge glasses shall be checked before additional burners are cut in or fires accelerated.

221-4.18.17 PRESSURE PART RUPTURE. Whenever a tube rupture or serious steam leak occurs in a boiler, prompt action is required to prevent serious injury to personnel, to reduce boiler damage to a minimum, and to isolate the effect of the casualty so the ship can continue steaming. Secure the affected boiler and shut stops. Lift the safety valve by hand to relieve steam pressure and to minimize steam and water leakage, lifting them in normal sequence with the superheater safety valve (if installed) first. When the nature of the failure is unknown, lifting the safety valve is the safest procedure to follow. If a crack in the header or drum or a serious handhole or manhole leak is suspected as the source, the steam pressure in the boiler should be relieved as soon as possible by lifting safety valves by hand.

WARNING

Ship's force should conduct emergency egress and Emergency Escape Breathing Device (EEBD) training in accordance with NSTM 077 (3.4.5.3) and NSTM 079 (46.11.5). Personnel must be trained in advance to find a safe escape route from their watch station, even in total darkness.

If evacuation becomes necessary and personnel are in the Enclosed Operating Space (EOS), don EEBD, secure plant, Ensure EOS doors are shut prior to opening the scuttle then immediately evacuate through scuttle in overhead of EOS. Muster in repair 5 and report to locker leader status of the main space and source of steam leak if known.

Avoid areas where steam leaks are thought to exist.

To avoid a chimney effect, when evacuating a main machinery space that has been filled with live steam, ensure all personnel are inside the escape trunk

Warning - precedes

or enclosed operating station with the door/scuttle secured before opening the upper door/scuttle. At no time should both the lower and upper doors be opened simultaneously.

221-4.18.18 GAUGE GLASS FAILURE. Should a water gauge glass on a steaming boiler experience a glass failure (crack or damage) or leak to the point of forming steam vapor, every effort should be made to secure the gauge glass by shutting the chain-operated cutout valves. The boiler shall normally be taken off the line. If an emergency situation warrants consideration of further steaming of the affected boiler, it shall be done on the basis of continued safe operation of the remote water level indicator and the combustion control feedwater regulator. In this mode load change, demands on the affected boiler shall be held to a minimum.

221-4.18.19 BOILER WATER LEAKAGE. Symptoms of boiler water leakage include excessive feedwater consumption or a continuous decrease in boiler water conductivity, chloride, phosphate, and alkalinity when no blowdowns or chemical injections are performed. If carryover is not occurring, and all chemicals are being lost simultaneously, then leakage is occurring. A leaking boiler can be a precursor to a ruptured tube or a serious steam leak which has a high risk of serious injury to personnel.

- a. Ships force should understand all the symptoms of boiler water leakage as outlined in NSTM Chapter 220, paragraph 220-23.77.1.
- b. The immediate action for a leaking boiler is to inject chemicals as necessary to keep alkalinity and phosphate within limits and then to immediately secure the boiler.
- c. The only exception to securing the boiler is if the Commanding Officer directs continued steaming due to the operational situation.
- d. If continued operation of a leaking boiler is necessary due to the operational situation, the firing rate shall be minimized. No maintenance of any kind will be conducted on a leaking boiler. No drills will be conducted on a steam plant that has a leaking boiler. If continued operation of a leaking boiler is necessary, the ship shall provide a detailed message report within 24 hours to the TYCOM with an information copy to the ISIC, RMC, NAVSEA (05Z23), and NSWCCD-SSS (922). The report shall indicate the symptoms, the probable cause, and what action the ship has taken to reduce the stress on the boiler (reduction of firing rate, etc. as discussed above), and to reduce the risk to personnel (refer to [paragraph 221-4.18.17](#)).

221-4.19 LOSS OF BOILER FIRES.

The two most common causes of loss of boiler fires are water in the fuel oil, and loss of fuel pressure due to loss of fuel oil service pump suction. Other possible causes are severe burner problems, wet atomizing steam, or extremely high excess air. An explosion hazard is created by loss of fires because fuel may continue to be admitted, unburned, into the furnace and then ignite in an uncontrolled manner. Upon loss of fires the boiler must be immediately secured. If unburned fuel accumulations are observed the steam smothering system must be actuated.

221-4.20 SECURING BOILERS.

NOTE

Whenever a boiler is to be secured, including when burner fires are lost or secured, boiler stops shall be shut when burner fires are extinguished.

221-4.20.1 EMERGENCY BOILER SECURING. In an emergency, a boiler can be shut down quickly by tripping the boiler fuel supply quick-closing valve. After tripping this valve, shut the burner safety shutoff devices/atomizer valves, crack open the fuel oil manifold recirculating valve, and shut the burner fuel oil and atomizing steam (if applicable) manifold valves. Visually verify that fires are out and shut all air registers. (If a residual fire is present, proceed according to [paragraph 221-4.20.3](#).) Remove atomizers from burners. Stop the fuel oil service pump (unless it is supplying fuel to another boiler on the line)

221-4.20.2 GENERAL STEPS IN CUTTING OUT AND SECURING. This paragraph provides the general procedure for cutting out and securing an oil-fired boiler when burning distillate fuel.

1. Blow tubes with steam soot blowers if practical.
2. Sample, test, and chemically treat the boiler according to NSTM Chapter 220, Volume 2.
3. Before securing the last burner on the last boiler on the ship (or in the propulsion group), raise the water level to plus 8 inches.
4. When steam is no longer required, secure burners according to the following procedures:
 - a. Shut the burner fuel oil manifold valve.
 - b. Open the fuel oil manifold recirculation valve when securing the last burner in the boiler.
 - c. Shut the burner atomizing steam manifold valve (if applicable).
 - d. Shut the safety shutoff device/atomizer valve.
 - e. Shut the burner air register.
 - f. Remove atomizers from the burner.
 - g. When the last burner is secured, visually verify that fires are out.
 - h. If residual fire is present, proceed according to [paragraph 221-4.20.3](#).
5. When the last boiler in a space is secured, stop the fuel oil service pump according to EOSS or the applicable technical manual.
6. All atomizers shall be removed from registers as soon as possible after the burner is secured. Intense heat from the furnace rapidly carbonizes the oil remaining in tips and may cause the expanding oil to drip down the boiler front. Carbonization is injurious, and plugs sprayer tips, making them difficult to clean. Clean atomizers and stow according to with [paragraphs 221-3.1.6.2](#) and [221-3.1.6.6](#).
7. Supply combustion air until all burners are cut out; then the blower may be stopped. Run a blower long enough after shutting off the oil supply to ensure that residual fires burn out and that the furnace has been cleared of all gases.
8. Tightly close air doors on the boiler front and other openings to the furnace when all atomizers have been extinguished and all blowers have been secured to prevent the entry of air into the heated interior. Sudden cooling will cause serious damage to the hot refractory lining of the furnace.
9. When a boiler is being secured, the bleed connection to the auxiliary exhaust shall be opened before the main stop (superheater outlet) valve is closed, and it shall remain open until the boiler ceases generating steam from residual heat within the boiler. This point can be ascertained when the boiler pressure drops approximately 200 to 300 psi below operating pressure.

NOTE

Refer to [paragraph 221-2.14.2.4](#) for precautions for cooldown of refractory.

10. Shut boiler steam stops.
11. After securing other than the last boiler, raise the water level to plus 8 inches. Do not secure the feed system while the boiler is still generating steam. Carefully watch the hot well or feed tank level until all boilers being secured have completed this operation. After hard steaming it may be necessary occasionally to pump additional water into the boiler to maintain the desired water level, because the intense heat of brick walls may continue to form steam.
12. Bottom blow the boiler according to NSTM Chapter 220, Volume 2.
13. When flushing and pumping out bilges, follow the instructions of NSTM Chapter 593.
14. Clean out the oil accumulation in all drip pans and wipe up floor plates before the watch leaves the fireroom. Clean out any oil accumulations in the bottom of air casings and drips on inner fronts of all air-encased boilers.
15. Put on the stack cover when all boilers connecting with that stack have been secured.
16. When boilers have been secured and the space is on cold iron or otherwise not manned, oil should be drained from torch pots.

221-4.20.3 RESIDUAL FIRES. Residual fires, by themselves, are not casualties. They may occur when securing burners according to casualty control procedures or as a result of mechanical problems in the fuel oil service system, specifically leaking through of valves in the burner supply system. A residual fire is defined as the presence of fire at the burner tips or on the firebox deck that is caused by fuel leaking into the boiler after burner safety shut-off devices and manifold valves have been secured. When residual fires are present, take the following action:

1. Ensure that burner safety shut-off devices and manifold valves have been secured and the recirculating valve is open.
2. Leave a lower air register open to allow fires to burn out.

NOTE

If a candling atomizer is observed, do not wait for it to burn out before withdrawing atomizers. Also, do not wait for residual fire on the floor to burn out before withdrawing atomizers. Proceed with [step 3](#) immediately.

3. Remove the atomizers from the boiler. Snuff out any flame at the burner tip before draining oil from atomizers.
4. Visually verify when the residual fire goes out.
5. If residual fires are not the result of the securing procedures, effect repairs before re-lighting fires.

SECTION 5

AUXILIARY BOILERS

221-5.1 INTRODUCTION.

NOTE

The auxiliary boiler operating guidance given in this Section supports and supplements the Engineering Operational Sequencing System (EOSS). Operators shall always comply with EOSS - where installed. Preventive maintenance shall be according to Maintenance Requirement Cards (MRC's) of the Planned Maintenance System (PMS).

221-5.1.1 DEFINITION. The term auxiliary boilers is used in this section to define a category of small boilers that supply steam for distilling plants, space heating, oil heating, water heating, galley, and laundry. These boilers are equipped with all auxiliaries, accessories, and controls to form a complete system. The D-type are arranged to operate as a self-contained steam generating plant. The waste heat boilers receive their heat input from the exhaust gases of an associated gas turbine generator set (GTGS) and therefore have no combustion chamber and fuel burning capability. In addition to the requirements contained in this section, some requirements in the foregoing sections concerning main propulsion boilers also apply to auxiliary boilers. Information in Section 5 is not intended to apply to re-boilers.

221-5.1.2 TYPES OF AUXILIARY BOILERS. Auxiliary boilers are divided into the following types:

- a. Watertube natural-circulation boilers.
- b. Waste heat boilers.

NOTE

These boiler types generate saturated steam only; there is no superheater, desuperheater, or economizer.

221-5.1.3 PACKAGE BOILER EQUIPMENT. Auxiliary boilers are usually self-contained or packaged, except for waste heat boilers, and are supplied with integral fuel and feedwater pumps, a forced-draft fan, and all necessary controls.

221-5.1.4 AUXILIARY EQUIPMENT INSPECTION. In addition to the inspections of the boiler proper, discussed in [paragraphs 221-5.4.1](#) and [221-5.4.2](#), the integral auxiliary equipment shall be inspected concurrently. Auxiliary equipment inspection should include feedwater and fuel oil service systems and pumps, deaerating feed systems, condensate coolers, control condensers and control systems.

221-5.2 AUXILIARY BOILER DESCRIPTIONS AND COMPONENTS.

221-5.2.1 WATERTUBE NATURAL-CIRCULATION BOILERS. Most of these boilers are small versions of D-type main propulsion boilers and consist of a steam drum and a water drum connected by a bank of generat-

ing tubes. The two drums are also connected by a row of water tubes that form a water-cooled sidewall opposite the tube bank. The water-wall tubes pass beneath a refractory furnace floor, up the sidewall, and across the furnace roof before they enter the steam drum. No downcomer tubes are provided in the LSD-41 Class design. In these boilers the rearmost generating bank tubes act as downcomers to supply water to the remaining generating bank and furnace tubes by way of the water drum. Cross-sectional views of a typical watertube natural circulation auxiliary boiler are shown in [Figure 221-5-1](#). A typical arrangement of steam drum internal fittings is shown in [Figure 221-5-2](#).

221-5.2.2 WASTE HEAT BOILERS. The two types of waste heat boilers used in naval service are:

- a. Horizontal straight tube, forced-circulation (CG-47).
- b. Horizontal coils, forced-circulation (DD-963 and DDG-993 class).

221-5.2.2.1 PRINCIPLES OF OPERATION. Both types of waste heat boilers operate on the same principle. The exhaust gases of the GTGS are used as the heat source to generate steam. The waste heat boiler system, illustrated in [Figure 221-5-3](#), includes the following basic modules: steam drum, steam generator, condenser, control panel, and feed pump. CG-47 Class are also provided with deaerating feed systems.

221-5.2.2.2 STEAM DRUM. The steam drum module is made up of a steam drum, circulating water pump, and accessories, with connections for circulating pump suction and saturated steam outlet. The steam drum internals consist of a turbo or cyclone steam/water separator. [Figure 221-5-4](#) shows the turbo steam/water separator installed on CG 47 Class ships.

221-5.2.2.3 STEAM GENERATOR. The steam generating module is located in the gas turbine generator exhaust ducting. The construction of this module is similar to a typical steel finned tube, single-bank economizer. The steel fins, shaped as a continuous spiral, are welded to the outer diameter of the element tubing. Water enters the inlet header through two circulating feed pipes at the bottom of the unit. The water flows upward through the element circuits to the outlet header. The flow continues through a circulating return line to the steam drum. See [Figure 221-5-5](#).

221-5.2.2.4 CONDENSER. The condenser module consists of the control condenser and condensate return line. The control condenser is either a shell and U-tube or titanium flat plate heat exchanger. The inlet-outlet channel is bolted to the shell flange and has affixed to it the channel flathead and seawater inlet and outlet connections. The condensate return line is bolted to the bottom of the condenser. It consists of isolation valves, strainer, impulse-type steam trap, and the sensor for the sea water control valve.

221-5.2.2.5 CONTROL PANEL. The boiler control system is a relay logic system. The boiler control system controls either automatically or manually the following equipment: feed pump, circulation pump, main steam stop valve, and main steam dump valve. In addition to controlling this equipment, the boiler control system annunciates, by way of light indications and an audible alarm, a number of alarm conditions associated with boiler operations.

221-5.2.2.6 FEED PUMP. The boiler feed pump is a horizontal, close-coupled, single stage centrifugal pump.

221-5.3 OPERATION OF AUXILIARY BOILERS.

221-5.3.1 Since design and methods of operation of auxiliary boilers differ widely from main propulsion boilers, some of the preceding main boiler sections of this manual do not completely apply to auxiliary boilers. It is mandatory, however, that the ship's auxiliary boiler operating personnel acquire thorough knowledge of the principles of combustion, boiler maintenance practices, and safety precautions in sections 2, 3, and 4 of this chapter and use the applicable information in connection with operating the auxiliary boilers. The wide variations in the design of auxiliary boilers and their auxiliaries, accessories, and controls render it impractical to prepare general operating and maintenance instructions for all types in use. To provide specific information for each type of boiler, therefore, the Naval Sea Systems Command (NAVSEA) requires that a description of the boiler and all auxiliaries and complete instructions for installation, operation, and maintenance be included in the manufacturer's technical manual. Each ship equipped with auxiliary boilers should have on board at least two copies of the applicable technical manuals. The ship's force should use the technical manuals for detailed information on construction, operation, and maintenance of auxiliary boilers.

NOTE

In addition to all general safety precautions applicable to auxiliary boilers, the space in which the boiler is located shall be well ventilated at all times to prevent such conditions as a rise in ambient temperature, an accumulation of toxic flue gases, and the possible starvation of the burner-blower for the combustion air supply.

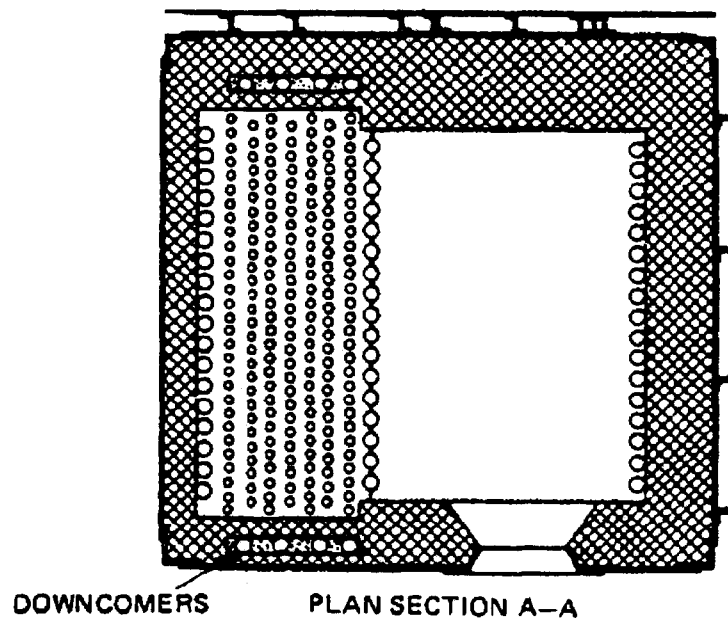
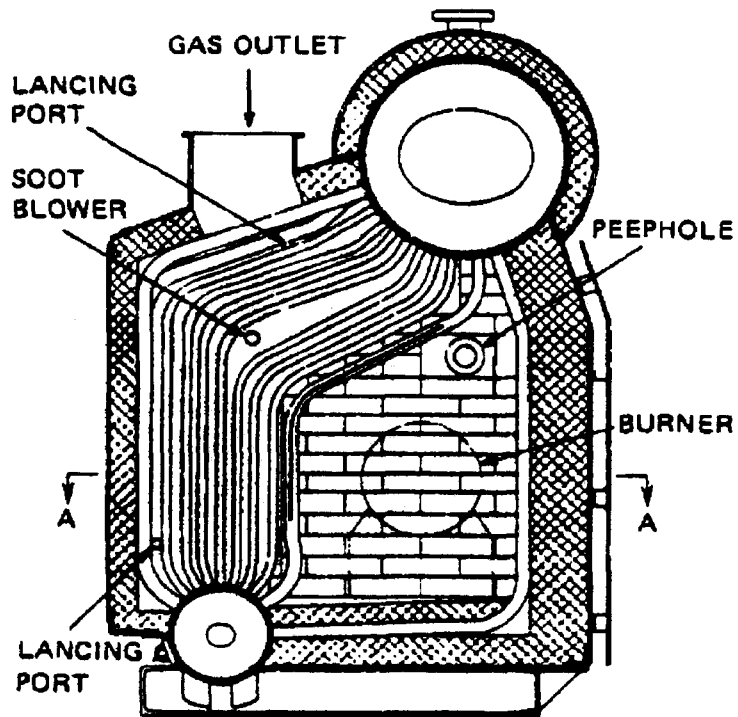


Figure 221-5-1. Typical Watertube Natural-Circulation Boiler

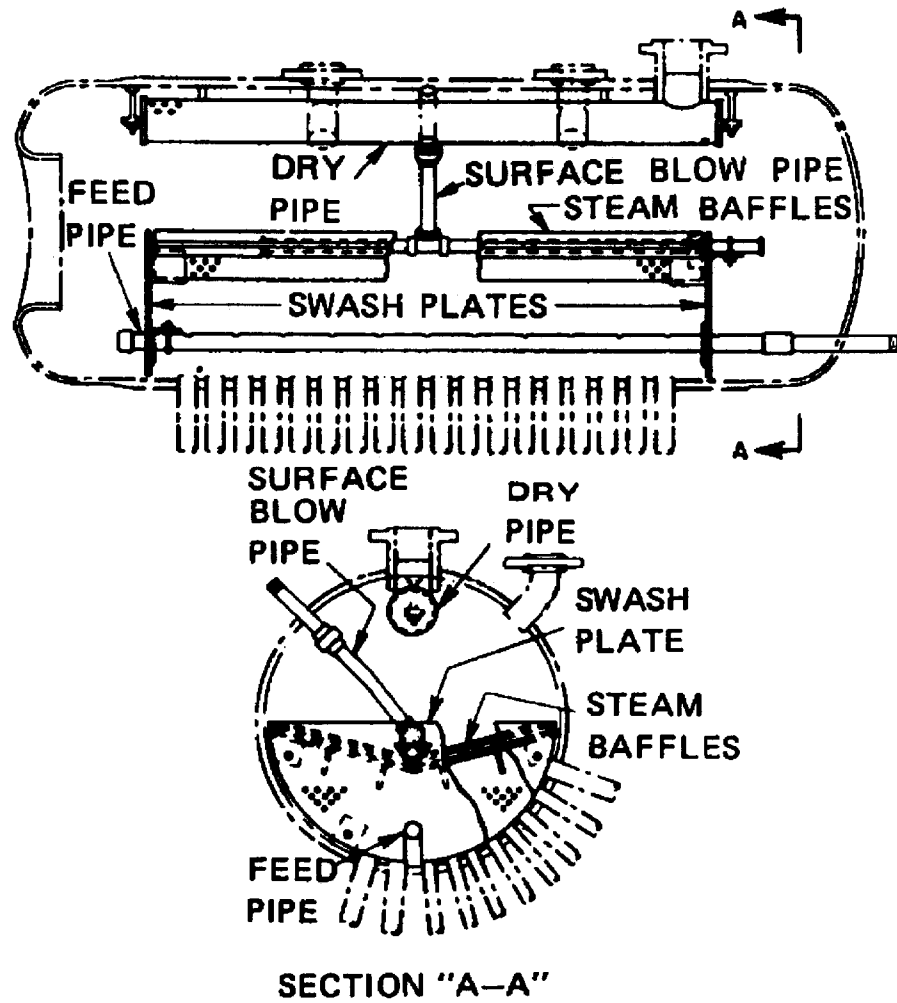


Figure 221-5-2. Typical Steam Drum Internal Fittings

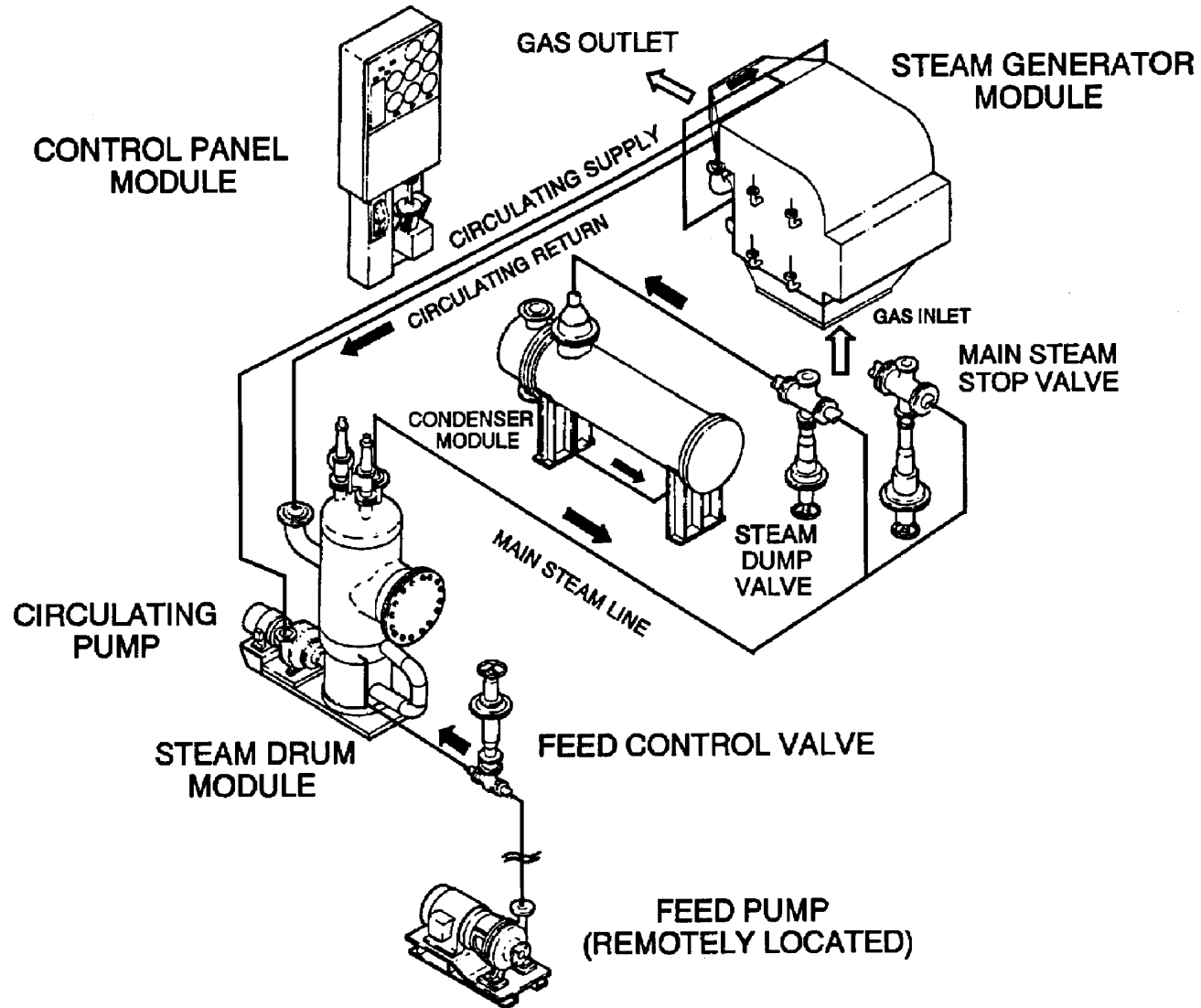


Figure 221-5-3. Isometric of Typical Waste Heat Boiler System

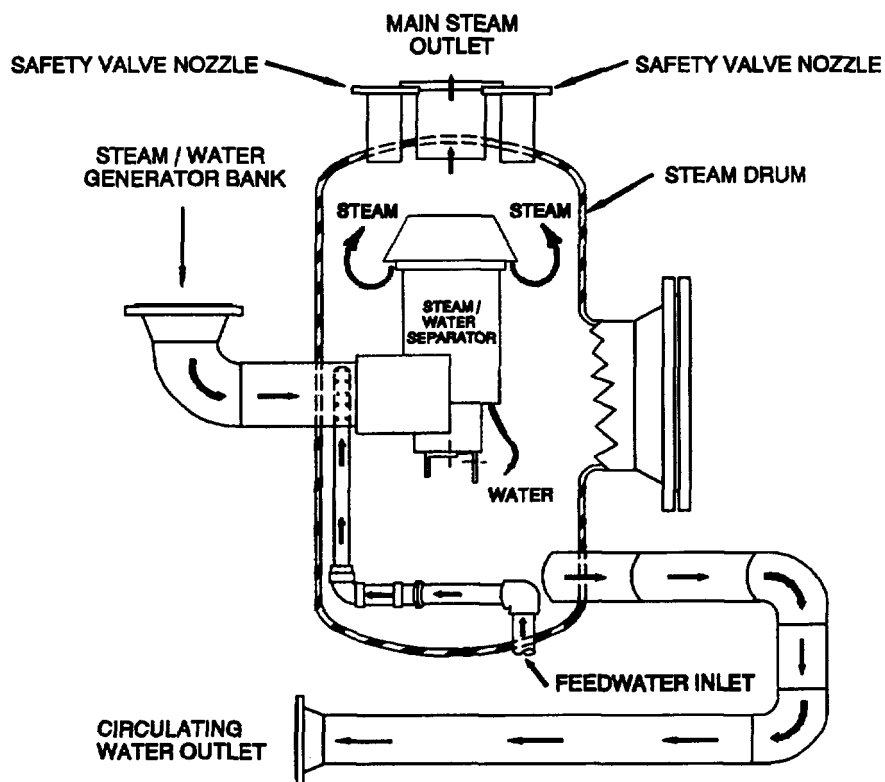


Figure 221-5-4. Steam Drum of Typical Waste Heat Boiler

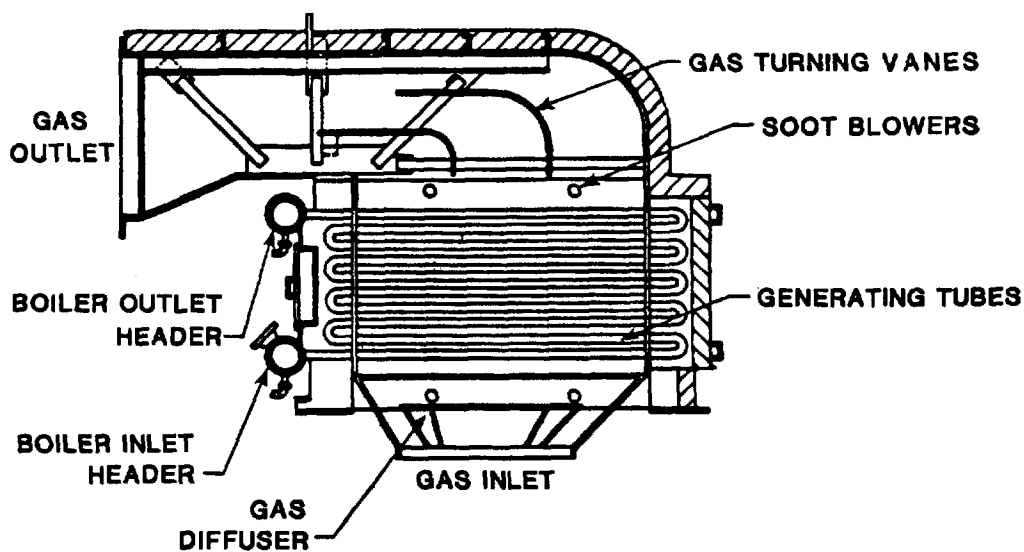


Figure 221-5-5. Steam Generator of Typical Waste Heat Boiler

221-5.3.2 PRECAUTIONS AND CONTROL OF BOILER WATER. Auxiliary boilers shall be maintained within the prescribed limits and conditions listed in NSTM Chapter 220, Volume 2, Boiler Water/Feedwater- Test and Treatment.

221-5.3.3 SURFACE AND BOTTOM BLOWDOWNS. Follow the procedures of NSTM Chapter 220, Volume 2, for surface and bottom blowdowns. Auxiliary boilers shall be given a bottom blow whenever it is secured for more than 2 hours unless the boiler is to be dumped. Bottom blowdown is also required weekly (no more than 168 steaming hours) when continuously steamed; and daily (no more than 24 hours) when the boiler water sample contains sediment. Surface blowdown (if provided) shall be performed when results of water chemistry tests indicate it is required.

221-5.3.4 BOILER OPERATION AND ROTATION. In two boiler installations when one boiler shall be operated continually above rated capacity, operate the second boiler. From the standpoint of performance and economy, it is better to operate two boilers at 2/3 load each than to operate one boiler at 120 percent capacity. Rotate use of auxiliary boilers every 300 steaming hours, if not more frequently.

221-5.3.5 WATCHSTANDING FOR AUXILIARY BOILERS. Continuous watchstanding is not required on auxiliary boilers arranged for fully automatic or semi-automatic operation, provided the space watchstander makes periodic inspections and all safety devices are in operation. Continuous watch is required during manual operation. If it should become necessary for any reason to leave unattended a boiler arranged for manual operation (even for a brief period of time), the boiler shall be secured.

221-5.3.6 CHECKS FOR AUTOMATIC BOILERS. The following are checks to be accomplished for all auxiliary boilers equipped for fully- or semi-automatic operation:

a. Accomplish each watch:

1. Observe the performance of the boiler auxiliaries.
2. Observe the boiler or separator water level and all pressure and temperature readings to ascertain that performance is normal. Verify boiler or separator level in both the direct reading gage and RWLI if installed.
3. Visually inspect the fuel oil, electrical, water, and steam systems for loose and leaky connections.
4. Observe flame pattern for proper combustion and atomization.

NOTE

The frequency of periodic inspections should be increased if the boiler is in deficient material condition or if it has features that warrant inspection that is more frequent.

b Accomplish daily:

1. Inspect waste heat boiler casing for development of exhaust gas leakage at all casing joints and inlet and outlet ducting joints. Secure boiler if exhaust gas leakage is excessive.
2. Inspect the boiler auxiliaries. Check the boiler control panel for worn, loose, and burned relay contacts.
3. Inspect soot blower drain valve discharge for moisture or steam indicating root valve leak-by.
4. Inspect steam smothering tell tale discharge for moisture or steam indicating actuating valve leak-by.

c. Accomplish quarterly and following depot level availabilities:

1. Lower the boiler water level to the low water cutoff point and check to determine that the cutoff control is working properly. Ensure that the water level does not go out of sight in the gauge glass.
2. Secure fuel oil to the burner. Verify that the flame failure safety device is functioning properly.
3. Allow steam pressure to build up. Check operation of the pressure limit control.

221-5.3.7 WATERTUBE NATURAL-CIRCULATION. The procedures for operating will depend on the type of controls provided, as follows:

- a. Manual Control. The operating procedures will be essentially the same as for Main Propulsion Boilers in [Section 4](#).
- b. Automatic Control. These boilers operate, shutdown, and start-up automatically, except if shutdown is due to flame failure, when manual reset is required.
- c. Semi-automatic Control. These boilers will operate automatically within the limit settings. Once the boiler shuts down for any reason it requires a manual restart.

NOTE

The wide variety in design of boilers and controls makes it impractical to prepare general instructions for all types. Refer to the Boiler Technical Manual for specific instructions and procedures.

221-5.3.8 WASTE HEAT. The waste heat boiler has only one normal mode of operation. This is an automatic mode in which the steam stop valve, circulating pump, and feed pump controls are actuated in response to the GTGS run signal. Independent manual controls for each of the five control functions are provided for equipment checkout, test, or in the event of equipment failure, each pneumatic diaphragm valve is fitted with a manual handwheel operator. Selector switches are provided for the main steam stop valve, circulating pump, and feed pump for AUTO, ON, and OFF mode of operation. Refer to the Boiler Technical Manual for detailed instructions and procedures for start-up, shutdown, dry operation, and emergencies. CG-47 Class waste heat boilers can be operated dry for an unlimited time period. DD-963/DDG-993 Class waste heat boilers with stainless coils installed can be operated for unlimited time periods up to a maximum GTG gas outlet temperature of 800° F (427° C). When the gas outlet temperature is above 800° F (427° C), dry running operation cannot exceed two hours. Prior to operating waste heat boilers dry, the boiler should be dumped and flushed with feed water. If operating schedule does not permit securing the generator to dump and flush the boiler, the boiler blowdown valves and vents should be opened to drain the steam generator rapidly. DD-963/DDG-993 and CG-47 Class boilers should not be hot started. GTG should be secured and the boiler should be allowed to cool for 4 hours prior to injecting cold feed water into the coil. CG-47 Class boilers are provided with an emergency capability to hot start the boiler without securing the generator. This procedure shall only be used for emergency purposes and not utilized during routine operation and drills.

221-5.4 AUXILIARY AND WASTE HEAT BOILER INSPECTION.

221-5.4.1 GENERAL REQUIREMENTS. All auxiliary boilers shall be carefully examined whenever they are opened for cleaning, maintenance, or overhaul and the conditions found shall be described in the boiler water chemistry log and engineering log. Operating ships should not open boilers for routine inspections more often than necessary; therefore, all inspections and routine maintenance actions requiring boiler disassembly shall be scheduled to coincide with required periodic inspections. All auxiliary boilers are subject to the following periodic inspections:

- a. TYCOM (Routine) Inspection. Firesides and watersides of all auxiliary boilers shall be inspected every 18 months according to OPNAVINST 9220.3. This inspection shall be performed by a certified Steam Generating Plant Inspector (SGPI). This inspection will be documented in BIRMIS. Refer to [paragraph 221-5.4.3](#) for Ship's Pre-inspection Checklist for Routine Inspections of D-type auxiliary boilers and [221-5.4.4](#) for Ship's Pre-inspection Checklist for Routine Inspections of waste heat boilers.
- b. Boiler Overhaul/Availability Related Inspections. Overhaul and availability related inspections include Pre-overhaul or Pre-availability Inspections (Pre-SOI/Pre-SAI), Start of Overhaul or Availability Inspections (SOI/SAI) and Completion of Overhaul or Availability Inspections (COI/CAI). Pre-overhaul and Pre-availability Inspections may be accomplished whenever major boiler work requiring early definition is probable. For natural circulation auxiliary boilers and waste heat recovery boilers, SOI/SAI inspections must be conducted by

the boiler LCEM (NSWCCD-SSES) Code 922 inspector, along with the TYCOM SGPI, and repair activity personnel whenever major boiler work is planned or performed. Participation of LCEM in other inspections is dependent on circumstances and fleet policy.

All overhaul and availability related inspections shall be documented in BIRMIS. Refer to [paragraph 221-5.4.5](#) for a Checklist of auxiliary boiler SOI/SAI preparations; the waste heat boiler SOI/SAI checklist is provided in [paragraph 221-5.4.6](#).

Pre-overhaul Tests and Inspections (POT&I) may be accomplished whenever major boiler work requiring pre-overhaul definition is required.

- a. Routine and Overhaul/Availability related inspections shall be documented in BIRMIS.
- b. All auxiliary boiler and waste heat recovery boiler overhaul related inspections must be conducted by the NSWCCD-SSES inspector along with the designated SGPI and repair activity personnel whenever major boiler overhauls are planned or performed.

221-5.4.2 AUXILIARY BOILER STRENGTH AND INTEGRITY INSPECTIONS. Auxiliary boilers must be inspected for strength and integrity of pressure parts. The inspection should be arranged to coincide with CNO scheduled availabilities or routine inspections. Every effort shall be made to conduct this inspection within five years, not to exceed 6 years, of the last five year strength and integrity inspection. Should visual and NDE indicate questionable areas, repairs shall be accomplished in accordance with NAVSEA S9221-C1-GTP-010 or NAVSEA S9086-RK-STM-010/Chapter 505 for piping systems. A final hydrostatic test of the repair must be applied according to [paragraph 221-2.16](#) through [221-2.16.6.6](#). The estimated initial boiler light-off date following the inspection shall be the documented completion of the strength and integrity inspection and documented in BIRMIS. All pressure piping inspections and NDE shall coincide with the strength and integrity inspections and be documented in BIRMIS. Unless otherwise directed by the inspecting activity, the following preparation and inspection requirements for the auxiliary boiler types based on ship class apply:

- a. **Watertube Natural Circulation.** Remove all drum and header manhole and handhole plates and all steam drum internals. Remove insulation to expose steam drum nozzles steam supply piping to soot blower, feed and blowdown piping to first flange or valve, and gage glass and level transmitter surfaces. A close visual inspection from the outside and inside shall be made of all welds, nozzle connections, and drum and header surfaces. A NDE (UT) shall be conducted on all pressure vessels piping to include all soot blower, vents, drains, and sensing piping to the first valve and bottom blow piping to the outlet at ships hull.
- b. **Waste Heat Boilers (DD-963/DD-993 Class).** Remove steam generator header casing access doors and insulation from the steam drum to expose nozzle connections and external surfaces of the headers and steam drum. A close visual inspection of outside and accessible inside surfaces of all welds and nozzle connections shall be made. Perform a fiber-optic inspection of the steam generating bank tubes to inspect internal surfaces. An NDE (UT) shall be performed on the steam drum lower head, upper separator cyclone section opposite the steam inlet piping, and all steam separator pressure piping to include gage glass, level transmitter piping, feed piping to the first valve, soot blower piping to casing penetrations, recirculating pump suction and discharge piping, and separator and header blowdown piping to the ship's hull.
- c. **Waste Heat Boilers (CG-47 Class).** Remove header lagging pads, front and the rear return bend access doors, and gas side access door to expose header nozzle and external pressure part surfaces. A close visual inspection from the inside and outside shall be made of all header welds and nozzle connections. Remove steam drum manway, cyclone separator and perform a close visual inspection of the steam drum internal surface and steam drum internals. Perform a fiber-optic inspection of the steam generating bank tubes to determine internal surface condition. Remove exterior insulation of the steam drum and attached pressure piping including blowdown piping soot blower, steam inlet, steam outlet piping, feed and recirculating piping out to first valve, condenser drum and header connections To determine condition of drum surfaces and attached

pressure piping NDE (UT) pressure vessel and piping areas in accordance with NAVSEA T9074-AS-GIB-010/271 and NSTM Chapter 505. A NDE (UT) shall be performed on the steam separator pressure piping to include gage glass, level transmitter piping, soot blower piping to element casing penetration, and separator and header blowdown piping to the ship's hull.

221-5.4.3 SHIPS'S PRE-INSPECTION CHECKLIST FOR UP-COMING ROUTINE (LSD-41-52 Class) AUXILIARY BOILER INSPECTION BY U.S. NAVY STEAM GENERATING PLANT INSPECTOR (SGPI).

- a. Purpose. The primary purpose of this Pre-Inspection checklist is to provide ships force and the SGPI's with Pre-Inspection requirements for up-coming auxiliary boiler routine inspections.
- b. Checklist. Ship's Force shall conduct testing of safety devices listed in the Boiler Inspection Manual, S9221-D2-MMA-010 and the ships PMS/EOSS and prepare the auxiliary boiler for the routine inspection in accordance with the Boiler Inspection Manual, S9221-D2-MMA-010, and as follows:
 1. Conduct outer casing leakage inspection by hand soap film techniques before the start of routine boiler inspection per [paragraph 221-2.13.7](#). Mark all leaks clearly on the casing. Provide a casing map to the designated SGPI for determining the extent of casing removal required. The map consists of external casing drawings from NAVSEA S9517-AT-MMA-010 V2M 125 PSI Auxiliary Boiler Technical Manual for LSD 41 through 52 Class Ships.
 2. Prior to opening the boiler watersides, conduct a pre-inspection hydrostatic test at 100 percent maximum steady state operating pressure according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#). Contact the local SGPI to witness the hydrostatic test.
 3. The following items shall be conducted by ships force and witnessed by the designated SGPI inspector:
 - a. Conduct safety valve hand easing gear check.
 - b. Make keys available for all oil lab inspection items and prepare oil lad for inspection using check list outline in the Boiler Inspection Manual, S9221-D2-MMA-010.
 - c. Demonstrate the operation of all final control elements and safety devices in accordance with PMS/EOSS.
 - d. Demonstrate the Boiler Inspection Device (BID).
 4. After completion of hydrostatic testing, secure, wire shut, and tag DO NOT OPEN appropriate valves according to current OPNAV tag-out instructions.
 5. Drain and dry out boiler, blow piping, header drains and any other piping systems that may permit entry of water into the boiler. Open the boiler watersides as follows:
 - a. Open steam drum manway plate.
 - b. Remove all handhole plates from the lower water drum header.
 6. Remove the steam drum all apron plates. Carefully match mark all removed drum internals with their position in the steam drum to ensure proper reinstallation. Stow nuts, bolts, washers and other small parts in a container outside the drum to prevent them from being lost in the boiler.
 7. Dry out the boiler water sides, using the hot air lay-up method per [paragraph 221-5.6.2.2](#). Install temporary closures over handholes and manway to maintain hot air lay-up until preparations for entering the boiler begin.
 8. Install temporary closures over, nozzle openings, handholes, and the other bored openings whenever practicable to prevent entry of industrial debris and foreign objects.

NOTE

It is not necessary to mechanically clean (wire brush) or water-jet the waterside surfaces to be inspected for an 18 month inspection. The need for cleaning will be determined by the inspection results.

9. Remove generating bank outer and inner access doors. Remove only bolted panels; not permanent panels.
10. Provide access to the furnace through the rear access door opening. Remove the boiler uptake access plate leading to the air sides. Remove the boiler smokepipe access door leading to the gas sides.
11. Open and dry out Feed/Drain Tank.
12. Remove Force Draft Blower plenum chamber access plate.
13. Ensure that the boiler is gas free and gas free certificate is signed, dated and posted in accordance with NAVSEA S6470-AA-SAF-010, Naval Maritime Facility Confined Space Program manual prior to the scheduled arrival time of the inspector. The certificate is to include both firesides and the watersides.
14. Ensure fuel oil atomizer assemblies are disassembled for inspection and an inventory of the atomizers and burner barrels is conducted. Compare the quantity to the requirements of [paragraphs 221-3.1.4 and 221-3.1.5](#), and procure more atomizers if necessary.
15. Have the following special tools available for the inspector to use: Go-No-Go gages, gage or scale for measuring burner tip nut protrusion, diffuser withdrawal, ignitor setting, concentricity of diffuser and bladed cone, refractory cone angle template, and any other tools that ships force normally uses in conducting its own boiler inspections.
16. Provide the last six months of boiler water and feed water logs while plant was in operation for review by the inspector. Have the boiler data sheets filled out and corrections made to the boiler technical data report that may be required. Also, provide copies of:
 - a. Boiler tube renewal sheets.
 - b. Most recent boiler inspection report.
 - c. Boiler CASREP summaries and all current boiler DFS's.
 - d. Results of the most recent nondestructive testing (NDE) tube evaluation.
 - e. Record of the boiler work performed since the last availability.
 - f. Boiler operating records for the last 6 months.
 - g. Machinery Plant Water Treatment Log package for the last 6 months of operation.
 - h. Hydrostatic test data for all burner barrels.
 - i. Provide certificates for personnel who have completed the Auxiliary Boiler Course (J-651-0457).
 - j. Results of soot blower head blowing pressure tests.
 - k. All outstanding maintenance actions not covered by OPNAV 4790/2K forms recorded in the ship's Current Ship's Maintenance Project (CSMP).

NOTE

Ship's force shall provide the inspector with a list of known deficiencies and problems not covered in the CSMP.

17. Have the most recent NDE UT results for the soot blower heads, soot blower piping system and the bottom blow piping for review by the inspector. Ensure that ultrasonic test results meet the following periodicity requirements:
 - a. Soot Blower Heads (Copes Vulcan) 10 years, (120M).

- b. Soot Blower Piping not to exceed 60 months.
- c. Boiler (Carbon Steel) Surface and Bottom Blow Piping 5 to 6 years, should be scheduled to coincide with the 5 Year Strength and Integrity Inspection.
- d. Monel Surface and Bottom Blow Piping system 10 years (120M).

NOTE

The piping wall thickness replacement criteria for boiler bottom blow piping is in NSTM Chapter 505 - Piping (NAVSEA S9086- RK-STM-010/CH-505). The minimum boiler bottom blow piping wall thickness criteria for pressurization, and the soot blower and high pressure steam drain piping replacement criteria are also in NSTM Chapter 505 Piping.

NOTE

When the designated SGPI (SGPI assigned to perform the routine inspection) is not on-site, contact the local Steam Generating Plant Inspector's (SGPI) office for assistance.

When the designated SGPI (SGPI assigned to perform the routine inspection) is not on-site, contact the local Steam Generating Plant Inspector's (SGPI) office for assistance

221-5.4.4 SHIP'S PRE-INSPECTION CHECKLIST FOR UP-COMING WASTE HEAT BOILER INSPECTION BY U.S. NAVY STEAM GENERATING PLANT INSPECTOR (SGPI).

- a. Purpose. The primary purpose of this Pre-Inspection checklist is to provide ships force and the SGPI's with Pre-Inspection requirements for up-coming Waste Heat boiler routine inspections.
- b. Checklist. Ship's Force shall prepare the Waste Heat boiler for the routine inspection in accordance with the Boiler Inspection Manual, S9221-D2-MMA-010, and as follows:
 - 1. Conduct outer casing leakage inspection using hand and soap film techniques before the start of routine boiler inspection per [paragraph 221-2.13.7](#). Mark all leaks clearly on the casing. Provide a casing map to the designated SGPI for determining the extent of casing removal required. The map consists of external casing drawings from the applicable Waste Heat Boiler Technical Manual.
 - 2. Secure the Gas Turbine Generator (GTG) and waste heat boiler
 - 3. Prior to opening the boiler watersides, conduct a pre-inspection hydrostatic test at 100 percent maximum steady state operating pressure according to [paragraphs 221-2.16 through 221-2.16.6.6](#). Contact the local SGPI to witness the hydrostatic test.
 - 4. The following items shall be conducted by ships force and witnessed by the designated SGPI inspector:
 - a. Conduct safety valve hand easing gear check.
 - b. Make keys available for all oil lab inspection items.
 - c. Demonstrate the operation of all final control elements and safety devices in accordance with PMS/EOSS.
 - 5. After completion of hydrostatic testing, secure, wire shut, and tag DO NOT OPEN appropriate valves according to current OPNAV tag-out instructions.
 - 6. Prior to placing boiler in dry lay up, flush the water sides with feed quality water. Completely dry out the boiler before inspection by dry firing and/or blowing out individual tubes or circuits with air.

7. Drain and dry out boiler, blow piping, header drains and any other piping systems that may permit entry of water into the boiler. Open the boiler watersides as follows:
 - a. Remove internal cyclone separator unless otherwise directed by the inspector. (CG-47 Class) Stow nuts, bolts, washers and other small parts in a container outside the drum to prevent them from being lost in the boiler.
 - b. Remove the insulation louvers and remove two handhole plates from each end adjacent to the drain lines and one from the center of the inlet and outlet headers (CG-47 Class).
 - c. Install temporary closures over tube holes, nozzle openings, manways, handholes, and the other bored openings whenever practicable to prevent entry of industrial debris and foreign objects, and to maintain hot air lay-up until preparations for entering the boiler begin.
8. Remove the two return bend access doors located between the headers.
9. Remove the gas inlet and gas outlet ducting manway and access doors for gas-side inspection (CG-47 Class).
10. Remove the inspection opening on the deaerating feed tank. Completely dry out the internal surfaces and place under dry desiccant lay up. Inspect spray and jet nozzle settings in accordance with PMS (CG-47 Class).
11. Remove the handhole plate/inspection flange on the steam separator (DD-963 Class).
12. Remove the inner and outer casing access doors and a minimum of six finger plugs on the inlet header (DD-963/DDG-993 Class).
13. Remove the gas inlet access door and a minimum of six finger plugs on the outlet header (DD-963/DDG-993 Class).
14. On DD-963 Class ships with lagging installed on the outside of the steam generating bank casing, remove sufficient section of the lagging pads to permit inspection of the access doors, side panel casing joints and the top cover casing joint. Lagging pads shall not be reinstalled until after the operational inspection is accomplished by the SGPI.
15. Remove the feed tank manhole from one tank for inspection of internal surfaces. Ships force shall verify tank is gas free prior to actually entering the tank for inspection or preservation.
16. Prior to conducting the gas side inspection verify the Gas Turbine Generator has been tagged out at the Local Control Panel and at the Electric Plant Control Equipment panel in CCS.
17. Ensure that the boiler is gas free and gas free certificate is signed, dated and posted in accordance with NAVSEA S6470-AA-SAF-010, Navy Maritime Confined Space Program, prior to the scheduled arrival time of the inspector. The certificate is to include both firesides and the watersides.
18. Provide the last six months of boiler water and feed water logs while plant was in operation for review by the inspector. Have the boiler data sheets filled out and corrections made to the boiler technical data report that may be required. Also, provide copies of:
 - a. Boiler tube renewal sheets.
 - b. Most recent boiler inspection report.
 - c. Boiler CASREP summaries and all current boiler DFS's.
 - d. Results of the most recent nondestructive testing (NDE) tube evaluation.
 - e. Record of the boiler work performed since the last availability.
 - f. Boiler operating records for the last 6 months.
 - g. Machinery Plant Water Treatment Log package for the last 6 months of operation.
 - h. Provide certificates for personnel who have completed the WHB B/W F/W Course (A-652-0188).
 - i. All outstanding maintenance actions not covered by OPNAV 4790/2K forms recorded in the ship's Current Ship's Maintenance Project (CSMP).

NOTE

Ship's force shall provide the inspector with a list of known deficiencies and problems not covered in the CSMP.

19. Have the most recent NDE UT soot blower piping system and the bottom blow piping for review by the inspector.

NOTE

The piping wall thickness replacement criteria for boiler bottom blow piping is in NSTM Chapter 505 - Piping (NAVSEA S9086-RK-STM-010/CH-505). The minimum boiler bottom blow piping wall thickness criteria for pressurization, and the soot blower and high pressure steam drain piping replacement criteria are also in NSTM Chapter 505 Piping.

20. When the designated SGPI (SGPI assigned to perform the routine inspection) is not on-site, contact the local Steam Generating Plant Inspector's (SGPI) office for assistance.

221-5.4.5 PREPARATION FOR START OF OVERHAUL (SOI) OR START OF AVAILABILITY INSPECTION (SAI) FOR D-TYPE AUXILIARY BOILERS. The following procedures should be used to prepare the LSD 41-52 Class auxiliary boilers for the SOI/SAI. The SOI/SAI and Strength and Integrity Inspection are a joint inspection by NSWCCD-SSES, the overhauling activity, RMC SGPI and ship personnel:

1. Conduct outer casing leakage inspection using hand and soap film techniques before overhaul or availability per [paragraph 221-2.13.7](#). Mark all leaks clearly on the casing. Provide a casing map to the inspection team for determining the extent of casing removal required. The map consists of external casing drawings from NAVSEA S9517-AT-MMA-010, the V2M 125 PSI Auxiliary Boiler Technical Manual.
2. Prior to opening the boiler watersides, conduct a pre-inspection hydrostatic test at 100 percent maximum steady state operating pressure according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#).
3. The following actions shall be taken by ships force and witnessed by the designated SGPI inspector:
 - a. Conduct safety valve hand easing gear check.
 - b. Make keys available for all oil lab inspection items and prepare oil lab for inspection using checklist outlined in the Boiler inspection Manual, NAVSEA S9221-D2-MMA-010.
 - c. Demonstrate the operation of all final control elements and safety devices in accordance with PMS/EOSS.
 - d. Demonstrate
 - d. Demonstrate the Boiler Inspection Device (BID).
4. After completion of hydrostatic testing, secure, wire shut, and tag "Do Not Open" appropriate valves according to current OPNAV tag-out instructions.
5. Drain and dry-out the boiler, blow piping, header drains and any other piping systems that may permit entry of water into the boiler. Open the boiler watersides by removing all handhole and manway plates from drums and headers. Clean plates and the header and drum manway and handhole plate seating surfaces. Standard Item 009-62 will be accomplished on seats that were found leaking during the Pre-SAI hydrostatic test.
6. Dry out the boiler watersides, using the hot air lay-up method per [paragraph 221-2.3.3.1](#). Install temporary closures over handholes and manway and nozzle openings to maintain hot air lay-up until preparation for entering the boiler begin. This will also prevent debris and foreign objects from entering the watersides.
7. Ensure that the boiler is gas free and a gas free certificate is signed, dated and posted in accordance with

NAVSEA Technical Manual S6470-AA-SAF-010, Naval Maritime Facility Confined Space Program manual, prior to scheduled arrival of the inspector. The certificate is to include both firesides and watersides.

8. Remove all steam drum internals. Carefully match mark the internals with their position in the steam drum to ensure proper reinstallation. Stow nuts, bolts, washers and other small parts in a container outside the drum to prevent them from being lost in the boiler.
9. Open boiler fire sides, water sides, gas sides and air sides.
10. Provide access to the furnace through the rear access door opening. Remove the boiler uptake access plate leading to the air sides. Remove the boiler smokepipe access door leading to the gas sides.
11. Remove generating bank outer and inner access doors. Remove only bolted panels; not permanent panels.
12. Remove water drum coping pour and power wire brush clean tubes in this area.

NOTE

Do not remove the side wall coping pour.

13. Clean boiler fire sides (side wall, screen wall and generating bank tubes) to include all accessible areas of the smoke pipe.
14. Water jet clean water sides using water treated with sodium nitrite.
15. Wire brush clean all piping systems and welded joints. Accomplish all require piping UT inspection.
16. Remove the burner air register and burner inner casing air flow baffles.
17. Open the feed drain tank and ensure tank is drained and cleaned out.
18. UT inspection of all 1-1/2" screen wall tubes and the floor tubes at the water drum end that were embedded in the castable refractory pour will be accomplish at the discretion of the NSWCCD-SSES inspector.
19. Remove Force Draft Blower plenum chamber access plate.
20. Mechanically clean stack, rain gutters and expansion joints. Do not waterwash without NSWCCD-SSES approval.
21. Ensure fuel oil atomizer assemblies are disassembled for inspection and an inventory of the atomizers and burner barrels is conducted. Compare the quantity to the requirements of [paragraphs 221-3.1.4 and 221-3.1.5](#), and procure more atomizers if necessary.
22. Have the following special tools available for the inspector to use: Go-No-Go gages, gage or scale for measuring burner tip nut protrusion, diffuser withdrawal, igniter setting, concentricity of diffuser and bladed cone, refractory cone angle template, and any other tools that ships force normally uses in conducting its own boiler inspections.
23. Provide the last six months of boiler water and feed water logs while plant was in operation for review by the inspector. Have the boiler data sheets filled out and corrections made to the boiler technical data report that may be required. Also, provide copies of:
 - a. Boiler tube renewal sheets
 - b. Most recent boiler inspection report.
 - c. Boiler CASREP summaries and all current boiler DFS's.
 - d. Results of the most recent nondestructive testing (NDE) tube evaluation.
 - e. Record of the boiler work performed since the last availability.
 - f. Boiler operating records for the last 6 months.

- g. Machinery Plant Water Treatment Log package for the last 6 months of operation.
 - h. Hydrostatic test data for all burner barrels.
 - i. Provide certificates for personnel who have completed the Auxiliary Boiler Course (J-651-0457).
 - j. Results of soot blower head blowing pressure tests.
 - k. All outstanding maintenance actions not covered by OPNAV 4790/2K forms recorded in the ship's Current Ship's Maintenance Project (CSMP).
24. The following piping systems will require lagging removal, removal of all piping support hangers, power wire brush cleaning of piping systems and accomplish UT inspection:

NOTE

Do not remove the lagging and insulation from the steam drum.

- a. Soot blower head and soot blower piping.
- b. Bottom blow piping and surface blow piping from the steam drum and water drum to the ship shell discharge blow piping (carbon steel and Monel piping systems).
- c. Aux steam piping to the Aux steam stop valve.
- d. Boiler sample cooler piping from the water drum to the cooler.
- e. Steam drum, steam gage and vent line connections out to the first valve.
- f. Steam drum nozzle connections (safety valves, gage glass, feed pipe, surface blow, soot blower and the water drum bottom blow nozzle).
- g. Boiler sensing lines (high and low legs) piping systems.
- h. Chemical injection tank and piping system from the boiler to the tank.
- i. Feed water supply piping from the feed regulator valve back to the boiler.
- j. Burner fuel and steam leads.

221-5.4.6 PREPARATION FOR START OF OVERHAUL INSPECTION (SOI) OR START OF AVAILABILITY INSPECTION (SAI) FOR WASTE HEAT BOILERS. The following procedures should be used to prepare the waste heat boilers for SOI/SAI inspection. The SOI/SAI and Strength and Integrity Inspection is a joint inspection by NSWCCD-SSES, the overhauling activity, RMC SGPI and ship personnel. Preparations are as follows:

- 1. Conduct outer casing leakage inspection using hand and soap film techniques before the start of SOI/SAI per [paragraph 221-2.13.7](#). Mark all leaks clearly on the casing. Provide a casing map to the inspection team for determining the extent of casing removal required. The map consists of external casing drawings from the applicable waste heat boiler technical manual.
- 2. Secure the Gas Turbine Generator (GTG) and waste heat boiler.
- 3. Prior to opening the boiler watersides, conduct a pre-inspection hydrostatic test at 100 percent maximum steady state operating pressure according to [paragraphs 221-2.16](#) through [221-2.16.6.6](#).
- 4. The following actions shall be taken by ships force and witnessed by the designated SGPI inspector:
 - a. Conduct safety valve hand easing gear check.
 - b. Make keys available for all oil lab inspection items and prepare oil lab for inspection using checklist outlined in the Boiler inspection Manual, NAVSEA S9221-D2-MMA-010.

- c. Conduct steam testing per Boiler Inspection manual (NAVSEA S9221-D2-MMA-010) Check-off sheet Figure 11-2.
5. After completion of hydrostatic testing, secure, wire shut, and tag “Do Not Open” appropriate valves according to current OPNAV tag-out instructions.
6. Prior to placing boiler in dry lay-up, flush the watersides with feed quality water. Completely dry out the boiler before inspection by dry firing and/or blowing out individual tubes or circuits with air.
7. Drain and dry out boiler, blow piping, header drains and any other piping systems that may permit entry of water into the boiler.
8. Remove insulation pads from inlet and outlet headers, access doors and steam drum manway opening.
9. Install temporary closures over nozzle openings, manways, handholes, and the other bored openings whenever practicable to prevent debris and foreign objects from entering the boiler and to maintain lay-up until ready to enter the boiler.
10. Remove the gas inlet and gas outlet ducting manway plate and access doors for gasside inspection.
11. Remove the inspection opening on the dearating feed tank. Completely dry out the internal surfaces and place under dry desiccant lay up. Inspect spray and jet nozzle settings in accordance with PMS. Open reserve feed tank.
12. Open steam drum. Remove internal cyclone separator. Allow for replacing O-ring seal upon re-installation.
13. Remove all headers and steam drum handhole and manway plates. Clean plates and header and drum manway and handhole seating surfaces. Measure suspect or leaking seats in accordance with Chapter 221 and NAVSEA Standard Item 009-62.
14. Mechanically clean all exposed waterside areas for inspection.
15. Prior to conducting the gasside inspection verify the gas turbine generator has been tagged out at the local control panel and that the electric plant control equipment panel in CCS.
16. Ensure that the boiler is gas free and a gas free certificate is signed, dated and posted in accordance with NAVSEA Technical Manual S6470-AA-SAF-010, Naval Maritime Facility Confined Space Program manual, prior to scheduled arrival of the inspector. The certificate is to include both firesides and watersides.
17. Provide the last six months of boiler water and feed water logs while plant was in operation for review by the inspector. Have the boiler data sheets filled out and corrections made to the boiler technical data report that may be required. Also, provide copies of:
 - a. Boiler tube renewal sheets.
 - b. Most recent boiler inspection report.
 - c. Boiler CASREP summaries and all current boiler DFS's.
 - d. Results of the most recent nondestructive testing (NDE) tube evaluation.
 - e. Record of the boiler work performed since the last availability.
 - f. Boiler operating records for the last 6 months.
 - g. Machinery Plant Water Treatment Log package for the last 6 months of operation.
 - h. Provide certificates for personnel who have completed the Auxiliary Boiler Course (J-651-0457).
 - i. All outstanding maintenance actions not covered by OPNAV 4790/2K forms recorded in the ship's Current Ship's Maintenance Project (CSMP).
18. The following piping systems will require insulation removal, removal of all piping support hangers, power wire brush cleaning of piping systems and accomplish UT inspection:

- a. Soot blower piping from root valve to WHB connection, including drain pipe section.
- b. Bottom and surface blow drain piping from headers and drum connection to overboard hull connection.

NOTE

Do not paint or re-insulate the Monel pipe sections.

- c. Steam outlet piping from the steam drum outlet to soot blower root valve, dump valve and to outer manual stop valve. This will include all pipe connections for gage, vent and steam blanket piping out to the first valve.
- d. Steam outlet piping from dump valve to control condenser inlet. This will include vent and drain piping.

NOTE

If plate type condenser installed, remove insulation from condensate discharge piping from the condenser to the cut-out valves. If shell and tube type condenser is installed, remove insulation from condenser shell, vent, drains and discharge piping out to the first cut-out valve.

- e. Recirculating pipe from steam drum connection to inlet header connection flanges. This will include vent, gauge, sample line and drain piping out to the cut-out valve.
- f. Steam pipe from outlet header connection to steam drum inlet nozzle to include vent and drain pipe out to cut out valve.
- g. Feed pipe from deck penetration to steam drum nozzle connection.
- h. Remove insulation from shore steam moisture separator in No. 2 ER.
- i. Steam drum shell to include all nozzle connections.

221-5.4.7 SOI/SAI INSPECTION AREAS. The Start of Availability Inspection (SAI) or Start of Overhaul Inspection (SOI) will be conducted using the inspection areas outlined in the Boiler Inspection Manual NAVSEA S9221-D2-MMA-010 Chapter 11 for auxiliary boilers. Inspectors will address need for acid cleaning if a determination was not made previously.

a. Watertube Natural Circulation.

- 1. Remove one screen tube and two generating bank tubes, 2/3 furnace depth, for analysis to determine if the boiler requires acid cleaning because of hard waterside deposits. This sampling of tubes, are undertaken at the discretion of the NSWCCD-SSES inspector per [paragraphs 221-2.4.3.16](#) and [221-2.4.4.4](#).
- 2. Forward deposit thickness data and analysis to the Carderock Division of the Naval Surface Warfare Center (NSWCCD-SSES Code 922/Phila. site). Use [Figure 221-5-6](#) for guidance for acid cleaning. Obtain NSWCCD-SSES LCEM approval before acid cleaning the boiler. If acid cleaning is required and authorized perform according to MIL-STD-796 or MIL-STD-1607, as applicable. In unusual cases where acid cleaning is performed after SOI/SAI, re-inspect the boiler watersides for defects.

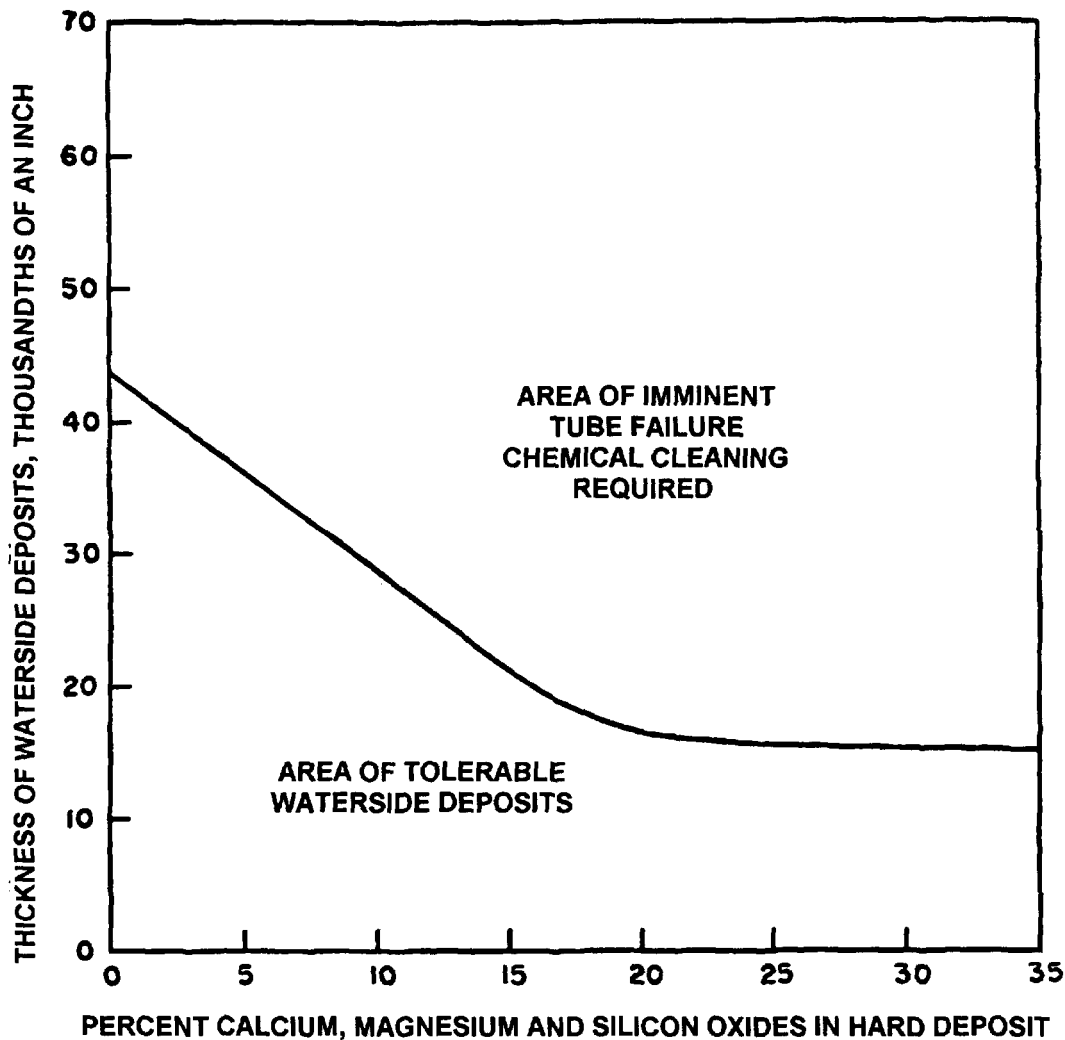


Figure 221-5-6. Guidelines for Chemically Cleaning Watertube Natural Circulation Auxiliary Boilers

b. Waste Heat Boilers. In addition to the inspection areas covered within Chapter 11 of the Boiler Inspection Manual, NAVSEA S9221-D2-MMA-010, the following inspections/checks shall be made:

1. Inspect condition of generating bank waterside surfaces with fiberoptics. Determine need for chemical cleaning in accordance with [paragraph 221-5.5.3](#).
2. Perform visual inspection of gas side surfaces. Check condition of soot blower elements on CG-47 Class.
3. Check condition of casings and inspect condition of tube sheets and covers. Inspect condition of soot seals in accordance with [paragraph 221-5.5.3](#).
4. Perform visual inspection of steam drum waterside surfaces. On CG-47 Class check condition of steam separator O-ring seal. If O-ring is missing, unbolt the separator and inspect the steam inlet pipe and gland plate for erosion.
5. Inspect condition of exhaust gas inlet and outlet ducting, control condensers, condensate coolers, control systems, feedwater, blowdown, and steam piping, and feed systems.
6. Inspect shell condition and atomizing steam valve on CG-47 class deaerating feed tanks. Inspect the condensate spray nozzle.

221-5.4.8 INDUSTRIAL SUPPORT VISIT (ISV). One or more ISV's may be required when extensive pressure part repairs are performed. The requirements for these visits and their approximate times will be determined at the SOI/SAI.

221-5.4.9 COMPLETION OF OVERHAUL/AVAILABILITY INSPECTION (COI/CAI). The COI/CAI should be started when approximately 90 percent of all boiler work has been completed. Specific inspection requirements are as follows:

- a. Tube renewals, pressure part repairs, and refractory renewals/repairs should be completed.
- b. Boiler uptake and casing repairs should be completed and outer casing insulation and covers installed. Uptakes are to be open for the inspection.
- c. About 90 percent of all boiler appurtenances and external systems should be installed.
- d. Steam drum internals should be installed with the steam drum open for inspection.
- e. The furnace access door (if provided) should be open or the burner register removed.
- f. Provide additional boiler access as required and listed by the inspecting activity in the SOI/SAI report.

221-5.4.10 BOILER INSPECTION AND REPAIR MANAGEMENT INFORMATION SYSTEM (BIRMIS). To enhance the value of auxiliary boiler inspections, the Boiler Inspection and Repair Management Information System (BIRMIS) forms is used to maintain inspection results. Specific forms available for each of the following type boilers shall be used by inspectors to input results into the system: Natural circulation D-type auxiliary boilers, CG-47 waste heat and, DD-963/DDG-993 waste heat boilers.

221-5.4.11 PIPING RENEWAL CRITERIA. The minimum allowable wall thickness for soot blower and bottom piping on 150 psi auxiliary and waste heat boiler systems shall be 0.070 inches. The 0.070-inch minimum shall also be used for other 150 psi auxiliary and WHB boiler pressure vessel piping up to 2-1/2 nps. For pipe 3 nps and above, renewal shall be required when original (nominal) wall thickness is reduced below 50 percent.

221-5.5 MAINTENANCE OF AUXILIARY BOILERS.

221-5.5.1 Personnel in charge of operating an auxiliary boiler should be thoroughly familiar with the boiler and all support systems. Satisfactory sustained operation of the boiler depends on proper care and on accomplishing all required maintenance. Specific attention should be paid to maintaining automatic controls and safety devices in proper operating condition. Undetected failure of these devices may lead to a major casualty, damage to equipment, and injury to personnel. Maintenance is essential as outlined in sections 2 and 3 for main boilers, with differences as outlined in the following paragraphs.

221-5.5.2 WATERTUBE NATURAL-CIRCULATION. Inspect and maintain these boilers as follows:

1. Inspect watersides as required under [paragraph 221-5.4](#). If inspection indicates the need for waterside cleaning, use one of the following methods for the removal of soft waterside deposits, as described in [paragraphs 221-2.6.4](#), and [221-2.6.6](#) through [221-2.6.6.5](#).
 - a. High pressure water-jet (preferred).
 - b. Power driven wire brush.
2. If hard deposits are present and acid cleaning is necessary, refer to [paragraph 221-5.4.7](#) for requirements.
3. Inspect firesides as required under paragraph 221-5.4. If inspection indicates the need, firesides should be mechanically cleaned. Removal of soot deposits from tube banks can be accomplished with the use of an air lance similar to [Figure 221-5-7](#). The length of this lance will depend on the space constraints around the boiler. Access is gained by removing the inner and outer generating bank access doors and from the furnace if necessary ([Figure 221-5-1](#)). Most boilers have baffle plates located near the gas outlet to retard gas flow for better heat transfer. Soot deposits may accumulate more readily in this area, in which case these plates shall be

removed for easier access to the tubes. Begin cleaning at the top of the boiler and work down. The lance should be inserted between staggered tube banks first by one diagonal and then the other. The soot will accumulate on the furnace floor where it can be swept up or vacuumed. Water wash only if necessary and only with NSWCCD-SSES approval.

4. On single cased boilers, particular attention should be paid to casing joints, which should be kept tight since soot and gas will leak into the engine room spaces. Combustion gases are toxic, and leakage will impair the effectiveness of the air purge cycle, which is timed to eliminate the hazards of a gas-side explosion.
5. Foundation sliding feet for thermal expansion are provided on all water tube natural circulation boilers. Sliding feet are provided with slotted or oversized holes to permit expansion. Visually inspect for structural damage or casing cracks in the sliding feet area at every fireside inspection. There are no provisions installed or requirements for lubrication. There are no requirements for the installation of movement indicators on auxiliary boiler sliding feet.
6. Handhole and manhole seat maintenance on water tube natural circulation auxiliary boilers should be accomplished according to [paragraphs 221-2.11.2 through 221-2.11.4](#). Minimum hand hole seat thickness for all water tube natural circulation auxiliary boiler headers and drums is 0.250 inches.

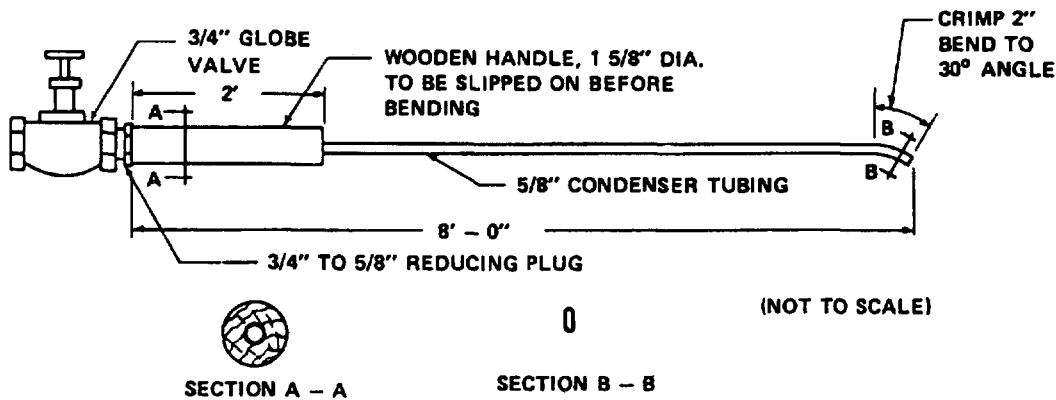


Figure 221-5-7. Typical Air Lance

221-5.5.3 WASTE HEAT. Inspect and maintain these boilers as follows:

1. The circulating pump has a mechanical gland seal that requires occasional maintenance. Note leakage and, if excessive, renew the seal. Refer to the Boiler Technical Manual for guidance.
2. The CG 47 Class has an O-ring at the inlet to the turboseparator that requires occasional renewal, as indicated by an increase in moisture carryover. An increase in separator moisture carryover will be apparent when operating two waste heat boilers. The boiler with a high moisture carryover rate will experience a continuous drop in the boiler water alkalinity, phosphate, and chloride levels while the boiler with a lower carryover rate will increase in chemical levels. This O-ring shall be inspected during ship's force and routine inspections by removing the gland plate and verifying the O-ring is in place. Renew the O-ring, if there is any question about its condition, and tighten the gland plate.
3. Waste heat boiler gas side and waterside inspections are conducted in accordance with PMS. Conduct a gas side inspection of casing joints and bolted access doors before shutting down the SSGTG to identify casing leaks. CG-47 class generating tube packing glands can be inspected through the small vestibule cover inspection doors or by removing the vestibule cover. Some packing leakage in the vestibule area can be expected and repacking should not be required unless significant external leakage is evident past the vestibule cover gasketed joints into the machinery space. Repair and replacement of vestibule cover gaskets should be accomplished to eliminate or reduce external gas leakage prior to attempting to repack the tube glands. Gland repacking and replacement should be accomplished at the depot level and not by ships force due to time consuming and difficult gland removal process.

4. Handhole seats on CG-47 Class waste heat boilers should be maintained according to [paragraphs 221-2.11.2](#) and [221-2.11.3](#). Minimum hand hole seat thickness is 0.250 inches. DD-963/DDG-993 class waste heat boiler headers are provided with threaded finger plugs. Only copper gaskets should be used on the finger plugs. A high temperature thread lubricant should be applied to plug threads prior to installation. Finger plugs shall be torqued to 130 ft-lbs to seat the copper gaskets. Use of excessive torque can result in header damage.

WARNING

Chemical cleaning of stainless steel alloy coils with hydrochloric acid is not permitted. Hydrochloric acid will induce stress corrosion cracking of the tube metal, and may cause eventual tube failure.

5. NSWCCD-SSES LCEM approval shall be obtained before chemical cleaning watersides. Determination and approval to acid clean waste heat boilers is made by NSWCCD-SSES based on the results of a visual boiler inspection by a local SGPI confirming heavy waterside deposit buildup present and a review of operational data. Visual inspection with borescope or fiberoptics should include an inspection of inlet and outlet header and the steam separator watersides. Requirement for chemical cleaning will also be indicated if chemical hideout, as confirmed in accordance with NSTM 220, is being experienced. Chemical hideout in waste heat boilers is caused by either heavy waterside deposit build-up in the generating bank or dry out of one or more tube circuits or coils due to insufficient circulation flow. Low circulation flow through the generating bank may be caused by reduced circulating pump capacity, discharge gate valve blockage, partially restricted tube coil, or presence of a gas lane across the top of the tube coil (DD-963/DDG-993 Class). Prior to requesting chemical cleaning authorization, the local inspector should investigate possible causes of boiler tube dryout if chemical hideout is being experienced. The prescribed cleaning methods are provided in [Appendix D](#) and as follows:
 - a. CG-47 Class boilers - The generating tube bank cannot be mechanically cleaned. Deposits can only be removed by chemical cleaning utilizing hydrochloric acid (MIL-STD-796) or sulfamic-citric acid (MIL-STD-1607) methods. Refer to [Appendix D](#) for explicit chemical cleaning procedures.
 - b. DD-963/DDG-993 Class boilers - The generating tube coil cannot be mechanically cleaned. Coils fabricated of stainless steel alloy shall be cleaned utilizing sulfamic- citric acid (MIL-STD-1607) only. Refer to [Appendix D](#) for explicit chemical cleaning procedures.
6. CG-47 Class waste heat boilers are provided with foundation sliding feet for thermal expansion. Visually inspect for structural damage, casing cracks, and correct foundation bolt installation. Lubrication fittings or movement indicators are not required.

221-5.5.4 TUBE PLUGGING LIMITATIONS. Tube plugging limitations for various auxiliary boilers are as follows:

- a. Waste Heat Boilers - DD-963/DDG-993 Class.
 1. Consecos. When six tubes have been plugged in a Consecos waste heat boiler, replacement of the tube coil should be scheduled for next availability or overhaul. More than six tubes may be plugged between the time the sixth tube failed and the scheduled tube coil replacement provided the ship's steam demands can be met. As long as the total number of tubes plugged in any two boilers on the ship does not exceed twelve, shipboard steam requirements at all ambient conditions can be met. Procedures for plugging boiler tubes are provided in the waste heat auxiliary boiler technical manual, NAVSEA S9517-AS-OMI-010.
 2. Combustion Engineering When either two complete circuits or 20 individual tube elements have been plugged or jumpered, replacement of the failed tube elements or complete generating bank tube elements replacement should be scheduled for the next availability or overhaul. More than two complete circuits or 20 tube elements may be taken out of service between the time twenty tubes have been taken out of service and the scheduled tube repairs provided the ships steam demands can be met. As long as the total number of tubes taken out of service in any two boilers aboard ship does not exceed 40, and shipboard steam requirements at all ambient conditions can be met. Procedures for plugging tube circuits, jumpering tube elements, and replacing tube elements are provided in the technical manual. NAVSEA S9237-AA-MMA010/01A. and S9237-AA-MMA-A10 . When placing a complete circuit that has been plugged back

in service, only the tube that has failed or been damaged requires replacement or jumpering. A failure in the upper or lower tube element will require replacement of this element to restore the circuit to operation. In these tubes, the short section of tube between the header and tube sheet may be replaced without replacing the complete element if the failure is in this section. Replacement of the remaining tubes in the circuit is not required unless removal is needed to improve access to the lower or upper tube. Tube circuit plugging in excess of the limitations above must be authorized by NAVSEA.

b. Water Tube Auxiliary Boilers.

1. Generating Bank Tubes. Up to 10% of the installed generating bank tubes may be plugged provided a complete lane of more than three tubes wide is not created.

Refer to [paragraph 221-2.8.4](#) for general plugging guidance.

2. Furnace Rear and Sidewall Tubes. Refer to [paragraph 221-2.8.5.2](#).

221-5.6 AUXILIARY BOILER LAY-UP.

221-5.6.1 As with main propulsion boilers, the prevention of corrosion in auxiliary boiler watersides, often caused by exposure to the atmosphere, is of major concern when securing. The requirements of [paragraphs 221-2.3](#) through [paragraph 221-2.3.3](#), therefore, also apply to auxiliary boilers. The Oil King shall log the lay-up status of the auxiliary boiler daily on the boiler water chemistry worksheet/log. Factors such as duration of lay-up, availability of required equipment, and type of repair work that will be performed should be considered when choosing the type of lay-up to be used. The applicability of the lay-up methods to the various types of auxiliary boilers is given in [Table 221-5-1](#).

221-5.6.2 DRY METHODS. Dry methods include desiccant and hot air lay-ups. The procedures for preparing for dry lay-up shall be according to [paragraph 221-2.3.2](#), with the exceptions listed below. These procedures shall be used whenever a boiler is to be emptied, even if hot air or desiccant is not going to be applied (such as for boiler repair).

Table 221-5-1. Applicability Of Lay-Up Methods To Auxiliary Boilers

	Waste Heat Boilers	Watertube Natural Circulation Boilers
Dry Lay-up		
Desiccant	A ¹	A
Hot air	A	A
Wet Lay-up		
Steam blanket	A	A
Nitrogen blanket	A	A
Hot deaerated fill	A ²	N/A
Hydrazine	A	A
Sodium nitrite	A	A

^AApplicable

¹Not applicable to DD-963/DDG-993 class waste heat boilers with carbon-molybdenum coils. Applicable to separators only on DD-963/DDG-993 class waste heat boilers with stainless steel coils since stainless steel is less susceptible to atmospheric corrosion.

²Applicable to waste heat boilers with operable deaerating feed tanks.

^{N/A}Not applicable

NOTE

On ships using chelant treatment ensure that flushing of the waste heat boiler to remove sodium nitrite does not cause flush water to enter the condensate systems. Sodium nitrite, is chemically incompatible with hydrazine and will also affect boiler water chemistry control upon light-off. Hydrazine lay-up is to be accomplished by a repair activity only.

1. Auxiliary boiler water is treated with 2 pounds of sodium nitrite for each 100 gallons of boiler water volume at steaming level.
2. Just after the boiler has been secured, add the sodium nitrite, already in solution, to the chemical injection tank and then fill the boiler to the top of the gauge glass with the injection tank aligned to the system.
3. The use of sodium nitrite as a rinse prior to dry lay-up is not required for waste heat boilers. However, waste heat boiler watersides should be thoroughly dried after the boiler is drained, via use of a portable heater or running the gas turbine for 10 minutes, prior to placing under dry lay-up.

NOTE

Sodium nitrite is an oxidizing agent that may support combustion. Exercise caution in stowing and using this chemical for storage and handling precautions, refer to NSTM Chapter 670, Stowage, Handling, and Disposal of Hazardous General Use Consumables.

221-5.6.2.1 Desiccant. The procedures, materials, lost lay-up, time limit, disposal, safety precautions, and preparation for light-off requirements listed in [paragraph 221.2.3.3.2](#) apply. Refer to [Table 221-5-2](#) for the amount of desiccant to be added to auxiliary boilers. The following additional requirements for auxiliary boilers apply:

- a. DD-963/DDG-993 Class. Desiccant lay-up is applicable to DD-963/DDG-993 class waste heat boilers with stainless steel coils installed. Desiccant is placed in the steam separators with humidity indicator cards and the stainless coils are thoroughly dried and then closed. The boiler should be drained while it is still warm. Hand-hole plates or inspection plugs on the generating bank headers and steam separator should be removed. All circuits and coils should be blown out with air to prevent pockets of water. Inspect to ensure that no water is left in the headers or steam separator. If necessary, heat should be applied to thoroughly dry the generating bank. Heat may be applied in two ways:
 1. Circulate hot air from a portable heater through the individual circuits of the generating bank.
 2. Run the gas turbine for 30 minutes (applying external heat will dry tubes). Refer to [Table 221-5-2](#) for the amount of desiccant to be added to waste heat boilers.
- b. CG-47 Class. Desiccant is installed in the steam generating bank headers and the steam separator. The boiler should be drained and dried out as indicated above for the DD-963/DDG-933 Class waste heat boilers.

221-5.6.2.2 Hot Air. Hot air lay-up is used in all types of auxiliary boilers. The procedures, lost lay-up, time limit, disposal, safety precautions and preparation for light-off requirements listed in [paragraph 221-2.3.3](#) apply. The equipment and material listed in [paragraph 221-2.3.3.1](#) also apply with the following exceptions:

- a. Electric blower: centrifugal, direct drive, 440 volts, 3 phase with totally enclosed fan cooled (TEFC) motor, 240 cfm at 4 inch S.P. capacity for all applications.

- b. Electric heater: 440 volts, 3 phase, 10 KW capacity.

221-5.6.2.3 HOT AIR ENTRY AND EXIT POINTS. Hot air entry and exit points should be according to the following:

- a. Watertube Natural-Circulation. Hot air should be introduced to the firesides by the furnace access door or through a burner register. The hot air exits up the stack. Hot air enters the watersides by way of the water drum or header, or the lower waterwall (if installed). Air exits from the steam drum manhole or the upper waterwall (if installed).
- b. Waste Heat. Gas side hot air should be introduced under the steam generator module and exit up the stack. Waterside hot air circulation should be as follows:
 - 1. CG-47 Class. Waterside hot air should be introduced into two to four of the inlet header handholes of the steam generator and exit through the steam separator manway access. Install 6-inch reducer in the steam drum manway access.
 - 2. DD-963/DDG-993 Class. Waterside hot air should be introduced to the steam generator outlet connection (4-inch NPS flange connection) and the steam separator steam inlet connection (4-inch NPS flange) and exit through the steam separator handhole plate. Requires removal of the 4-inch NPS flanged pipe section between the coil outlet and the steam separator. Provide exit for air through the steam separator access opening.

221-5.6.3 WET METHODS. Wet lay-up methods include steam blanket, nitrogen blanket, hot deaerated fill, hydrazine/morpholine, and sodium nitrite. These methods are described below.

221-5.6.3.1 STEAM BLANKET. Steam blanket lay-up is applicable to all types of auxiliary and waste heat boilers. The procedures, materials, lost lay-up, time limit, disposal, safety precautions, and preparation for light-off requirements listed for main boilers apply refer to [paragraph 221-2.3.1](#) with the following exceptions:

CAUTION

No. 3 waste heat boilers on DD-963/DDG-993/CG-47 class ships are susceptible to freezing and tube damage during extremely cold weather. Dry lay-up is required for No. 3 waste heat boiler in periods when outside temperatures are expected to be extremely cold to prevent boiler freeze up.

- a. A steam supply from another boiler or shore steam up to a maximum of the boiler operating pressure is required.
- b. Do not add feedwater to the secured boiler.
- c. The steam blanket method on waste heat boilers (CG-47 class) is automatic any time the boiler is shut down, providing there is steam pressure on the steam main. When the boiler is shut down and the steam pressure falls below 50 psig, the steam blanketing system reducing valve opens to maintain a steam blanket pressure of 15 to 50 psig. The operator should check the drum pressure gauge and separator or steam drum water level hourly. Steam drum water level shall be maintained between normal and plus 2 inches using the surface blow. The DD-963 Class requires manual opening of steam blanket valves.

- d. The boiler shall have been steamed for at least one hour just prior to securing. Requirement for the feedwater dissolved oxygen level to be within limits per NSTM 220 only applies to ships with DFTs installed (CG-47 Class).

221-5.6.3.2 NITROGEN BLANKET. A nitrogen blanket may be used for all types of auxiliary boilers. The procedures, materials, lost lay-up, time limit, disposal, safety precautions, and preparation for light-off requirements listed main boilers apply refer to [paragraph 221-2.3.1](#) with the following exceptions:

- a. Do not add feedwater to the secured boiler.
- b. For forced-circulation auxiliary boilers the nitrogen pressure is applied at the washout inlet connection.

221-5.6.3.3 HOT DEAERATED FILL. Hot deaerated fill can be used in waste heat boilers with operating deaerating feed tanks. The procedures, materials, lost lay-up, time limit, disposal, safety precautions, and preparation for light-off requirements listed main boilers apply refer to [paragraph 221-2.3.1](#) with the following exceptions:

- a. When securing, after performing the required blowdown, allow the boiler pressure to reduce to the DFT pressure.
- b. Fill the boiler with deaerated feedwater to overflow at vent.
- c. Secure the vent valve.
- d. Manually close the feed valves at the inlet to the steam separator to prevent boiler drain down.
- e. Maintain a positive pressure, not to exceed the boiler operating pressure, using the feedwater pump or a head tank.

Table 221-5-2. Desiccant Required For Lay-Up

Hull No.	Auxiliary Boiler Water Capacity, gal	Desiccant Required, lb
CG-47	110 (drum)	2
	190 (generator)	4 (2/header)
DD-963	100	2
LSD-41	470	8

NOTE

Desiccant does not apply to the generator on the DD-963 Class waste heat boiler.

221-5.6.3.4 HYDRAZINE/MORPHOLINE. This method is applicable to all types of auxiliary and waste heat boilers but is to be utilized by industrial activities only. Follow main boiler for lay-up procedures and precautions with the exception of the following provisions:

- a. Prepare sufficient hydrazine/morpholine treated water to fill the boiler and provide a reservoir; approximately double the steaming volume plus 50 to 100 gallons.
- b. Maintain a positive pressure not in excess of the boiler operating pressure.

221-5.6.3.5 SODIUM NITRITE. This method is applicable for all auxiliary boilers. The procedures, materials, lost lay-up, time limit, disposal, safety precautions, and preparation for light-off requirements listed in main boiler procedures (refer to [paragraph 221-2.3](#) apply with the following exceptions:

- a. Prepare sufficient sodium nitrite solution to fill the boiler and provide a reservoir, approximately double the steaming volume plus 50 to 100 gallons. Dissolve 1 pound of sodium nitrite per 100 gallons of feedwater required in a pierside tank or ship's feed tank. Mixing is accomplished by dissolving the sodium nitrite in feed quality water (10 pounds will dissolve in 2 gallons of water), and then adding the dissolved chemicals to the feedwater in the tank. The tank is then recirculated for 30 minutes to mix the solution.
- b. A head tank is the easiest and the preferred method of maintaining positive pressure. If a head tank method is used, locate and pipe the head tank above the highest boiler vent.
- c. Fill the boiler with sodium nitrite solution and maintain pressure by using a head tank or feed pump.

NOTE

On ships using chelant treatment ensure that flushing of the waste heat boiler to remove sodium nitrite does not cause any flush water to enter condensate systems. Sodium nitrite is chemically incompatible with hydrazine and will also affect boiler water chemistry control upon light-off. Hydrazine lay-up is to be accomplished by a repair activity only.

221-5.7 BURNERS.

221-5.7.1 STEAM ATOMIZING BURNERS (CONSTANT ATOMIZING STEAM PRESSURE). Oil burners used on auxiliary boilers are the steam-atomizing type. These burners are essentially the same as the main boiler oil burners, and are similar to the Y-jet burner. They use atomizing steam at a constant pressure, and varying fuel pressures with varying loads. A typical arrangement of a steam atomizer burner is shown in [Figure 221-5-8](#).

221-5.7.2 BURNER MAINTENANCE REQUIREMENTS. Watertube auxiliary boiler burners and safety shut off devices (where provided) shall be maintained in accordance with PMS and [paragraphs 221-3.1.6 through 221-3.1.8](#) with the following exceptions:

1. Atomizers shall be removed and inspected weekly and after securing the boiler. Observe flame condition after boiler light-off and once an hour thereafter. If flame condition indicates that problem with combustion or atomization exists, secure the boiler and clean and inspect the atomizer.
2. Atomizers shall be inspected and hydrostatic tested every 18 months in accordance with PMS. Hydrostatic tests at 200 psi (oil side) 150 psi (steam side) operating pressure shall be accomplished as indicated in [Appendix G](#).
3. Auxiliary boilers safety shut-off devices are provided with spring loaded ball check valves. Safety shut-off device ball valves shall be tested for tightness in accordance with PMS. The allowable leakage past the fuel side ball check when pressurized to 200 psig is 8 ounces per hour (80 drops per minute) with no constant spray or atomization. Fuel oil supply solenoid valve leakage shall be checked at every light-off by observing fuel oil supply pressure (main) and checking for main tip leakage during the pre purge period. Fuel oil pressure build-up at the main burner during light-off may indicate the supply solenoid valves are leaking by. No leakage is allowed past these solenoids when closed. Fuel oil or steam leakage from a safety shut-off device or coupling with an atomizer installed is not allowed while the boiler is operating.

4. Burner fuel oil and atomizing steam leads shall be fabricated from SCH 80 carbon steel piping whenever renewal is required. Leads shall be hard piped to the safety shut-off device after the correct burner settings were established. Fuel oil piping shall not be lagged. Atomizing steam piping located below the register centerline shall be lagged with epoxy coating as detailed in [paragraph 221-3.1.9.1](#).

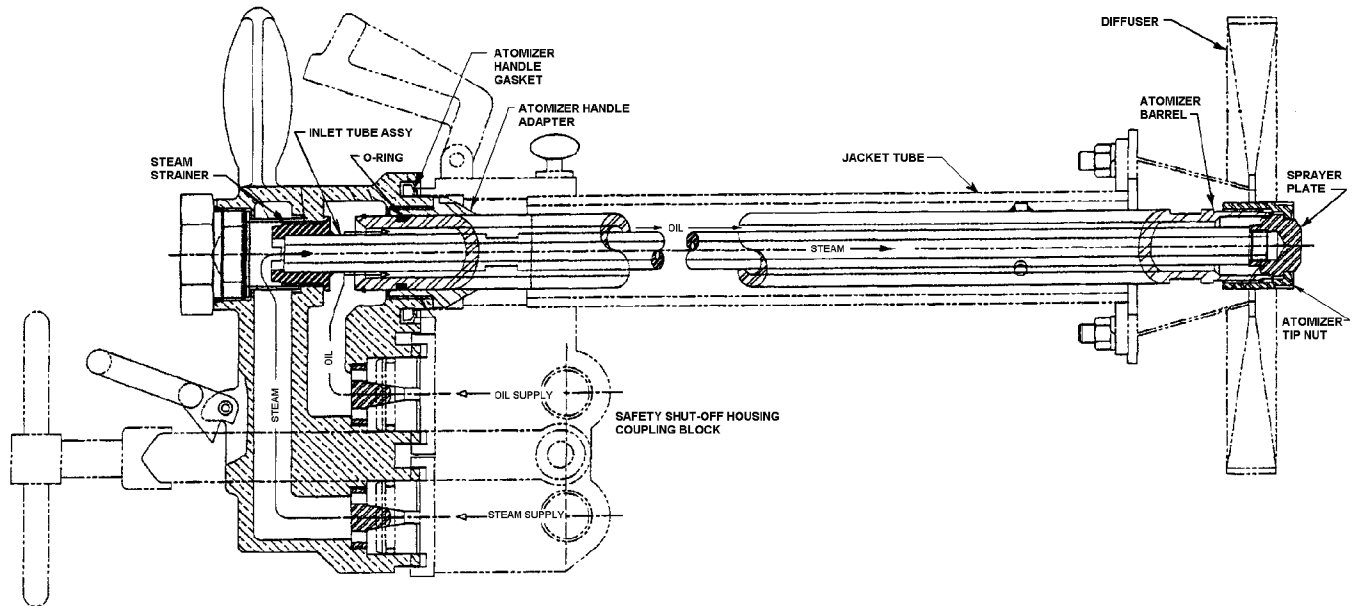


Figure 221-5-8. Typical Burner and Steam Atomizer Assembly

221-5.7.3 ATOMIZER ON-BOARD ALLOWANCES. The minimum number of complete atomizers including tip nuts required in the machinery room is two for each auxiliary boiler. Four sprayer plates or four complete sets of atomizer tip components are also required in the machinery room for each auxiliary boiler. Burner vise for disassembly of atomizers shall be provided. One set of all wrenches required to disassemble the atomizer or remove the sprayer plates shall be available in each machinery room with an auxiliary boiler installed. Atomizers shall be stored in suitable storage racks.

221-5.8 CONTROLS FOR 150 PSI V2M WATERTUBE AUXILIARY BOILERS.

221-5.8.1 BURNER MANAGEMENT SYSTEM (BMS) FLAME SAFEGUARD. There is one burner solenoid valve for the main flame. The valve is operated by the BMS flame safeguard control to open or close at specified times during the ignition cycle or during operation. The flame scanner monitors the furnace to detect the presence of flame. When the high energy igniter is energized, if the flame scanner detects a flame within 15 seconds the main burner solenoid valve opens. If no flames are present during the light-off or normal operation, the boiler will shut down and sound an alarm. After such shut downs, the controls must be reset by boiler operator to restart the boiler. The BMS cabinet utilizes NSN MIL-SPEC Potter Brumfield Corp. 110 VAC AC electrical relays and Agastat Corp. 110 VAC electrical timing relays for Pre-ignition purge, Igniter and pilot burner on, Main burner on, Run mode, Post ignition Purge alarms and shut-down. During the RUN MODE the General Regulator Corp. pneumatic combustion controls operate the boiler fuel and air.

- a. **Light-off Permissives.** The following permissives must be met in order for operator to press BOILER START pushbutton:
 1. Fuel oil Supply Pressure. Fuel oil pump energized with fuel oil supply pressure above 160 psig.
 2. Steam drum Pressure below 115 psig.

3. Atomizing Steam Pressure above 80 psig.
 4. Control Air supply Pressure above 60 psig and 15 psig.
 5. Steam Drum water level above -4 inches.
 6. Absence of Flame in Furnace.
 7. FDB Damper at minimum position.
 8. FDB Running.
- b. Cold Check. Secure fuel oil supply to boiler to prevent actual boiler light-off. With STANDBY light lit on BMS cabinet, press BOILER START pushbutton. FDB vane Actuator should go to MAX position and conduct a boiler PRE-IGNITION PURGE for 1 minute. FDB Damper should then go to MIN position, fuel oil solenoid valve should open and igniter should energize. After 15 seconds BMS should go into an ignition failure POST IGNITION PURGE for 1 minute and then into STANDBY mode. If BMS does not perform properly refer to Troubleshooting chapter of V2M Boiler BMS, Combustion and Feedwater Controls Technical Manual. valve should open and igniter should energize. After 15 seconds BMS should go into an ignition failure POST IGNITION PURGE for 1 minute and then into STANDBY mode. If BMS does not perform properly refer to Troubleshooting chapter of V2M Boiler BMS, Combustion and Feedwater Controls Technical Manual.
- c. Hot Check. Start boiler fuel oil and feedwater pumps and Forced Draft Blower (FDB). Ensure all boiler light-off permissives in above paragraph 5-8.1a are met. Open fuel oil supply to boiler. With STANDBY light lit on BMS Cabinet, press BOILER START pushbutton.
1. FDB Damper Actuator should go to MAX position and conduct a boiler purge for 1 minute.
 2. FDB Damper should then go to MIN position, fuel oil solenoid valve should open and igniter should energize.
 3. If ignition is successful Main Burner solenoid valve should then open as indicated by MAIN BURNER ON light on BMS cabinet. After one minute BMS will release control of combustion to general regulator Corp. pneumatic automatic combustion controls and RUN MODE light should energize on BMS cabinet. Operator should now have control of combustion with Boiler Master auto/manual control station in Remote-Manual Mode.
 4. If BMS does not perform properly refer to Troubleshooting Chapter of Ships V2M Boiler BMS, Combustion and Feedwater Controls Technical Manual (S9221-DJ-MMO-010).
- d. Casualty Conditions. If the following casualties occur the boiler fuel oil pump will secure automatically and Post Ignition Purge will be conducted. Also, an audible alarm will occur. The BMS provide first annunciation; i.e., only the first casualty that caused shutdown will illuminate.
1. Pre-Ignition Fire. When flame scanner detects a flame in the furnace prior to start.
 2. Flame failure. When the flame scanner does not sense a flame during light-off and when boiler is on-line.
 3. Low Atomizing Steam Pressure. When atomizing steam pressure drops below minimum setting of 80 psig.
 4. Low Fuel Oil Supply Pressure. When fuel oil supply pressure drops below minimum setting of 160 psig.

221-5.8.2 COMBUSTION CONTROL. A pneumatic steam pressure transmitter (SPT) directly senses boiler steam drum outlet pressure and transmits a 3-15 psig signal proportional to steam pressure to the General Regulator Model 55 steam pressure controller (SPC) via a pneumatic Auto/Manual Control Station. The firing rate is determined by the SPC. These units operate the fuel oil control valve via a pneumatic Fuel Oil Characterizing Relay to modulate fuel and FDB air damper actuator for air. The control setpoint is steam pressure. All auxiliary boilers are controlled by the steam pressure controller "master demand" signal which is proportional to steam pressure. Both fuel and air are driven by this master demand signal. The BMS prevents these signals from reaching the final control elements until in the RUN MODE for 1 minute via 3-way solenoid valves on operator con-

trol panel. Water tube auxiliary boilers have the fuel and air driven together pneumatically with air bias capability of FDB damper via a separate pneumatic Fuel/Air Ratio Relay on boiler control panel. The relationship between the fuel and air is predetermined and incorporated into the fuel oil characterizing relay to achieve up to full load without smoking or supplying too much excess air. The proper fuel vs. air adjustments should be documented in the V2M Boiler BMS, Combustion and Feedwater Control System technical manual.

- a. Pre Light-Off Cold Check. If possible, install a jumper wire inside the BMS cabinet to energize the RUN MODE relay.
 1. Observe pneumatic input gauge to FDB Damper actuator and operation of drive lever and associated linkage. Ensure there is no binding and damper moves from minimum to maximum position.
 2. With FDB damper at 50 percent position, rotate Fuel/Air relay from minimum to maximum position. Verify FDB Damper position goes above and below 50 percent.
 3. Observe input and output pneumatic gauge on fuel oil characterizing relay. Ensure proper outputs per V2M Boiler BMS, Combustion and Feedwater Controls technical manual. If possible, check operation of the fuel oil control valve. Recirculate fuel oil and confirm that the fuel oil header return pressure gauge goes from minimum to maximum header pressure when the auto/manual control station is changed from 0 to 100 percent.
 4. Open SPC Cabinet. Check for proper proportional band and reset settings on SPC. Observe input/output pneumatic gauges for proper operation of High and Low limit relays.
- b. Boiler Light-Off. Combustion Control is conducted in Remote-Manual Mode until steam drum pressure is above Setpoint. When SPC starts to unload, switch Boiler Master auto/manual control Station to Automatic Mode transfer knob.
- c. Boiler Hot check. If unable to conduct above combustion cold check, observe operation of boiler combustion controls after BMS switched to RUN MODE. With Boiler Master auto/manual control station in Remote-Manual mode, slowly bring steam pressure up to Setpoint.
 1. Observe operation of FDB Damper actuator/linkage and check for proper operation with no binding of linkage.
 2. Check pneumatic input/output gauges on fuel characterizing relay along with proper operation of fuel oil control valve as verified by fuel oil header pressure. During boiler light-off verify proper fuel oil header pressure from minimum to maximum. There should be no signs of White or Black smoke from stack. If there is, adjust Fuel/Air Ratio Relay on operator control panel accordingly to attain clear stack.
 3. If combustion control is not operating properly, refer to troubleshooting section of Ships V2M Boiler BMS, Combustion and feedwater Controls technical manual.

221-5.8.3 STEAM PRESSURE CONTROL. A Moore Products Model 173 pneumatic Steam Pressure Transmitter (SPT) directly senses steam drum pressure outlet pressure and sends a 3-15 psig pneumatic signal to the steam pressure control Cabinet. This signal goes to the proportional plus reset pneumatic General Regulator Corp Model 55 Steam Pressure Controller (SPC). When boiler is operating satisfactorily for 1 minute in the RUN MODE, the BMS will release control to the SPC. The SPC will automatically modulate fuel and air via the fuel oil control valve and FDB damper to maintain boiler drum pressure at Setpoint of 125 psi for V2M boilers. Proper calibration of the fuel oil characterizing relay and FDB damper actuator will ensure a clear stack from minimum to maximum boiler load. If stack is not clear, the Fuel/Air Ration Relay can be adjusted to bias the damper to attain a clear stack. The BMS will shut down the boiler on a high-pressure signal, and conduct a Post Ignition Purge. The Operator will have to restart the boiler by depressing the Boiler Start pushbutton.

221-5.8.4 FEEDWATER REGULATION. Watertube V2M boilers have a pneumatic single element feedwater level control system. An ITT Barton model 284 pneumatic differential pressure (level) transmitter sends a 3-15 psig signal proportional to steam drum water level to the Drum level Control cabinet. This signal is inputted to the General Regulator Corp. model 55 proportional plus reset feedwater level controller and low water cutout pressure switch. The controller output goes to a General Regulator auto/manual control station and then onto a valve positioner on the diaphragm operated Feedwater Control Valve. The auto/manual control station enables Remote-Manual control of steam drum water level. Additionally, an ITT Barton model 385 differential pressure indicator/alarm provide local water level indicator is provided for local and remote drum water level indication, and also a secondary boiler shutdown for low water level.

221-5.8.5 FUEL CHARACTERIZATION. Watertube V2M boiler systems characterize fuel via a pneumatic fuel oil characterizing relay with integral input and output cams. Inspect cams, springs and rollers. The characterizing relay sends a control air signal to General Regulator force balance fuel oil control valve to regulate fuel oil header return pressure according to boiler load.

221-5.8.6 FINAL CONTROL ELEMENTS. Blower damper actuators/linkages, force balance fuel oil control valves, and diaphragm operated feedwater level control valves should be stroked pneumatically from the Boiler Master and Feedwater Level auto/manual control stations. The Boiler Master auto/manual control station can only take Remote-Manual control when BMS is in RUN MODE. Refer to above [paragraph 221-5.8.2](#). Check for full range of motion within the calibrated range. Check for binding, restrictions, leaks, and uniformity of motion.

221-5.8.7 SUPPORTING EQUIPMENT. Verify FDB, Boiler Fuel Oil Pump, and Boiler Feed Pump motor controller operation. Secure electricity and look inside the motor controllers for poor wiring and/or corrosion. Verify all pumps put out required flows and pressures. Verify all indicators and gauges function properly.

221-5.8.8 BOILER SHUTDOWN. The boiler will shutdown under the following conditions:

- a. No flame detected.
- b. Low atomizing steam pressure.
- c. Low fuel oil supply pressure.
- d. High Steam Pressure.
- e. Low water.
- f. Electrical failure.
- g. Low control air pressure.

221-5.8.9 EVALUATION. To evaluate the BMS and Combustion and feedwater automatic controls during operation, observe the light-off, modulation, and shutdown operations. Certain conditions can be simulated to monitor the response of the control system.

- a. Light-off Sequence. If the auxiliary boiler cannot light off by the boiler operator pressing the BOILER START pushbutton the BMS must be repaired by use of the Troubleshooting procedures. Troubleshooting can become very difficult and often requires a thorough understanding of the electrical and mechanical control system configurations. The most common light-off impediment is failure to meet all the light-off permissives. The boiler inspector should concentrate on the safety aspects of the boiler control. Proper purge periods should

be verified with dampers open and windbox pressure measured. Fuel solenoid valve action should be verified at the specified times. Fuel should cease to enter the furnace immediately upon solenoid closure. Main burner fuel should not go to the burner until a pilot flame is detected.

- b. Low Water cutout. With the boiler on-line, lower the water level by controlling the feedwater control valve or by using blowdown. The boiler level should shutdown.

CAUTION

Do not allow the water level to go out of sight in the gauge glass.

- c. Flame Failure. Simulate flame failure by removing the flame scanner and covering. Verify that the fuel solenoid closes, fires are extinguished and a post purge are automatically accomplished.
- d. High Steam Pressure. V2M boiler can be shut down automatically on high steam pressure by taking Remote-Manual control of the firing rate and slowly raising steam pressure with Boiler Master auto/manual control station. The boiler should shut-down before the first safety valve pops.

221-5.9 WASTE HEAT BOILER CONTROLS.

Procedures for normal and manual starts, and other operating features of waste heat boilers are discussed below. Refer to the Waste Heat Boiler and DFT Electronic Control Technical Manuals for detailed operating procedures.

221-5.9.1 AUTOMATIC OPERATION NORMAL START. Automatic operation is the normal mode for operating waste heat boilers. Normal start-up would be with the system under a steam blanket. When the ship service GTGS is started with the boiler emergency stop reset, the following actions occur:

1. The feed pump and circulating pump start.
2. The steam dump valve opens.
3. Water expands rapidly in the boiler and is dumped to the control condenser.
4. After a timed interval the steam dump valve returns to modulating.
5. After a timed interval the boiler is stable and the main steam stop valve opens, allowing steam to the ship's steam main.

221-5.9.2 WATER LEVEL CONTROL. Some waste heat boilers have an electronic steam separator water level transmitter which transmits a 4.20 mA signal representing water level to a Fairmount automatic FAC2000 multi-loop digital controller. The FAC2000 has software that controls water level by sending a 4-20 mA signal to current pneumatic (I/P) valve positioner. The FAC2000 also transmits 4-20 mA analog output signal for the RWLI meter and digital outputs for high and low water level alarm activation on ICSM alarm panel. Most waste heat boilers still have Leslie pilots for water level control and ITT Barton 385 transmitters for RWLI and high/low water level activation.

221-5.9.3 GTGS SHUT DOWN. When the GTGS is shut down, the feed pump and circulating pump stop, and the main steam stop valve closes. The steam dump valve continues to dump steam until the boiler pressure falls

below 100 psig. The boiler pressure continues to fall to 15 psig when steam from the steam main keeps the boiler under a steam blanket. For a normal start after dry operation, shut down the GTGS and allow it to cool for 2 hours before starting.

221-5.9.4 MANUAL START. A manual start after dry operation is not routine and should be used only if absolutely necessary. For a manual start, perform the following:

1. Close the circulating pump discharge valve (an orifice in the valve provides minimum flow).
2. Start the GTGS. The boiler will sequence.
3. After a timed interval the steam dump valve will modulate.
4. At this time fully open the circulating pump discharge valve.

221-5.10 MAIN STEAM STOP AND DUMP VALVES.

The main steam stop and main steam dump valves are very similar and are shown in [Figure 221-5-9](#). The main steam stop valve will close when the control air fails, and the steam dump valve will open. These valves are controlled by mechanical pilots that employ a constant supply of clean air at steady pressure to produce a variable output in response to a pressure change on the pilot diaphragm. The output is used to operate the diaphragm control valve controlling service flow.

221-5.11 CIRCULATING AND FEED PUMPS.

The boiler circulating pump is used to control boiler water flow. A typical centrifugal pump is shown in [Figure 221-5-10](#). This pump has a special gland arrangement. Refer to the Boiler Technical Manual for gland details. The boiler feed pump is similar to the circulating pump except for gland details.

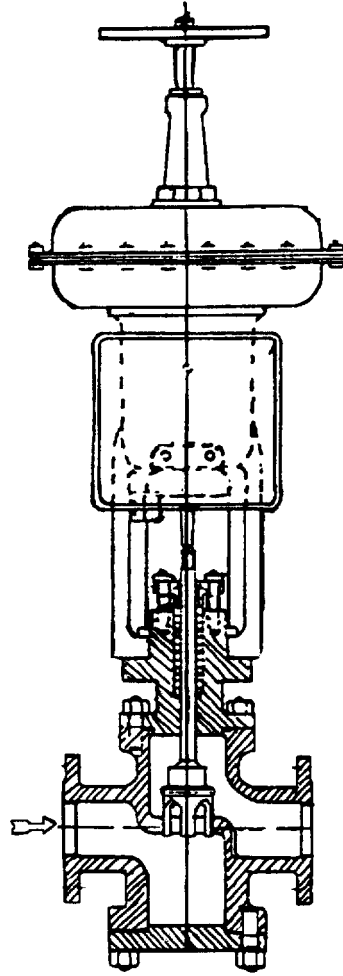


Figure 221-5-9. Typical Main Steam Stop or Dump Valve

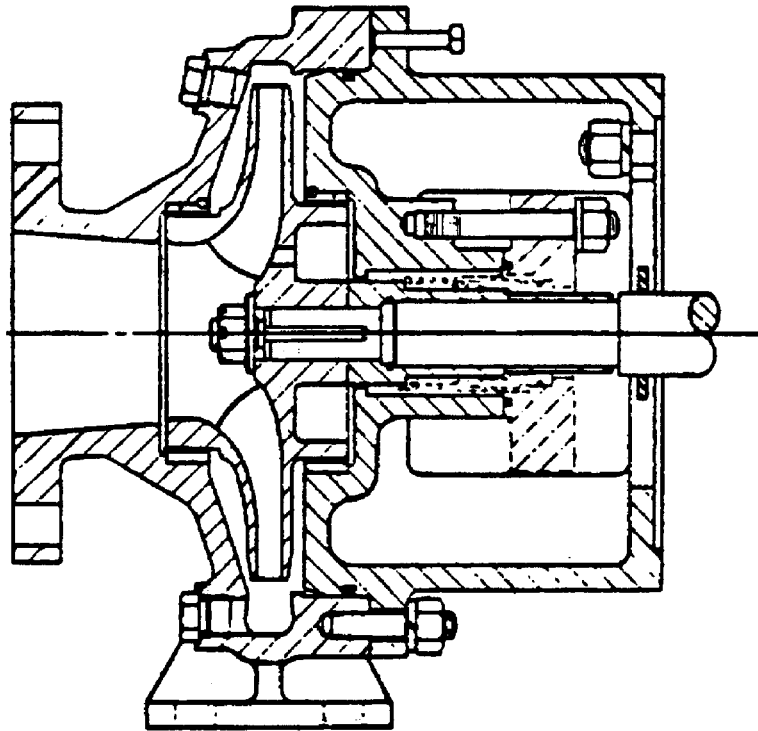


Figure 221-5-10. Typical Circulating or Feed Pump Details

221-5.12 AUXILIARY BOILER ACCESSORIES.

221-5.12.1 SOOT BLOWERS. Soot blowers are installed only on watertube natural-circulation and waste heat boilers. In general, the requirements for soot blowing are the same as those outlined in [paragraphs 221-3.3 through 221-3.3.8](#) and [221-4.16 through 221-4.16.5](#) for main boilers with the following exceptions.

- a. **Watertube Natural Circulation.** For these boilers the soot blower installation usually consists of a manual chain operated, rotary soot blower. Head pressure is maintained at 80 to 100 psig. Before rotating the soot blower make sure the steam line is properly drained. Increase the draft before blowing soot so that the soot blower will not smother the fire. Use the soot blower only when the fire is lit, and never allow steam to blow when the element is not in motion.
- b. **Waste Heat.** On both horizontal and coil designs the soot blowing element is stationary; in one case horizontal and in the other vertical. The steam inlet valves are manual stop valves. When the generating bank is blown steam is applied at approximately 100 psig. Soot blowing shall be kept in proper sequence so that soot will be swept progressively toward the exhaust gas outlet. Soot should be blown every 24 hours; also, after start-up and before placing the boiler in dry operation. As in all soot blowing operations, make sure the steam supply line is drained.

221-5.12.2 WATER GAUGES. Water gauges on auxiliary boilers are similar to those used on main boilers with the following differences:

- a. They are usually of the reflex type on watertube natural circulation and waste heat boilers; that is, they are viewed from one-side only. They are also rated at a much lower design pressure than main boilers. Mica is not installed between the glass and the boiler water.
- b. Lamps shall be mounted to the side of reflex gauge glasses and behind transparent type gauge glasses for illumination. Emergency lighting for gauge glass illumination is not required for auxiliary boilers.

221-5.12.3 REMOTE WATER LEVEL INDICATORS (RWLI's). RWLI's are installed on all watertube natural circulation and all waste heat boilers. Refer to [paragraphs 221-3.4.3](#) through [221-3.4.3.4](#) and the Boiler Technical Manual for guidance.

221-5.12.4 SAFETY VALVES. Most steam safety valves on auxiliary boilers are of the nozzle reaction type. Refer to the Boiler Technical Manual and [paragraphs 221-3.2](#) through [221-3.2.12.2](#) for guidance. Auxiliary boiler safety valves should be steam tested on the boiler to determine correct operation at present pressures as follows:

1. All safety valves of each auxiliary boiler shall be tested at 18 month intervals in accordance with PMS.
2. After each hydrostatic test when the safety valves have been gagged.
3. Safety valves shall be tested when they have been removed and replaced on an auxiliary boiler for any reason.
4. Safety valves which have been accidentally lifted by water during boiler hydrostatic tests.

Each safety valve installed shall be lifted by steam and reset if at variance with authorized popping and reseating pressures. Refer to boiler technical manuals and [paragraph 3.2.7](#) for pressures and setting tolerances. Auxiliary boiler safety valve cap assemblies shall be locked to prevent changes to settings, unless they are not equipped for locking, in which case they shall be lead wire sealed. Adjusting ring plugs shall also be locked or lead wire sealed.

221-5.12.5 FUEL OIL HOSES AND FITTINGS. The use of flexible hose type connections in any part of the fuel oil service system subject to fuel oil service pressure is prohibited.

221-5.13 HYDROSTATIC TEST OF AUXILIARY AND WASTE HEAT BOILERS.

221-5.13.1 GENERAL. Auxiliary boiler hydrostatic test requirements are identified in this Section. Refer to the main boiler hydrostatic test information located in [paragraphs 221-2.16.6](#) through [221-2.16.6.6](#), and [Table 221-2-5](#), for additional details on safety precautions, test objectives, test preparation and methods of testing.

221-5.13.2 DEFINITIONS. Definitions of auxiliary boiler design and operation pressure conditions are as follows:

1. Auxiliary Boiler Operating Pressure. Auxiliary Boiler Operating Pressure is the highest operating pressure of the auxiliary boiler components during normal operation. For oil fired auxiliary boiler with an automatic recycle control system (LSD-41 Class), the maximum operating pressure will be the high pressure cutout switch setting. For waste heat boilers the maximum operating pressure of the steam separator/drum is 110 psi.
2. Auxiliary Boiler Design Pressure. Design pressure or maximum allowable working pressure is specified by the boiler manufacturer. Most oil fired auxiliary boilers and the CG-47 Class waste heat boilers have a design pressure of 150 psi. The DD-963/993 class waste heat boiler design pressure is 130 psi.

221-5.13.3 HYDROSTATIC TEST REQUIREMENTS. Each boiler hydrostatic test pressure has a definite purpose and shall be applied as follows:

1. 100 Percent of Maximum Operating Pressure. (As defined in [paragraph 221-5-13.2](#)). Required after boiler has been opened for inspections to check for manhole, handhole, and finger plug, and fitting tightness. Also required for inspection of valve and fitting tightness, gasket tightness after handhole or manhole repair, tube seat tightness for all rolled or re-rolled joints, and tube joint tightness after tube plugging (other than welded in tube plugs on DD-963/DDG-993 Class or any auxiliary boiler with seal welded fireside tube plugs). Required after replacement of boiler vent, drain and other pipe sections installed between the boiler pressure vessel and the first valve, blowdown piping, soot blower piping and welded valves. This includes circulation piping installed between the generating bank and separators and the piping attached to separators on waste heat boilers up to the first valve.
2. 100 Percent of Maximum Operating Pressure. (As defined in [paragraph 221-5-13.2](#)). Required after boiler has been opened for inspections to check for manhole, handhole, and finger plug, and fitting tightness. Also required for inspection of valve and fitting tightness, gasket tightness after handhole or manhole repair, tube seat tightness for all rolled or re-rolled joints, and tube joint tightness after tube plugging (other than welded in tube plugs on DD-963/DDG-993 Class or any auxiliary boiler with seal welded fireside tube plugs). Required after replacement of boiler vent, drain and other pipe sections installed between the boiler pressure vessel and the first valve, blowdown piping, soot blower piping and welded valves. This includes circulation piping installed between the generating bank and separators and the piping attached to separators on waste heat boilers up to the first valve.
3. 125 Percent of Maximum Operating Pressure. This test is required after tube replacement, including rolled or welded waste heat boiler generating bank tubes, repairs to welded tube joints on waste heat boiler generating banks, chemical cleaning, minor weld repairs to drums and headers involving defects of less than 1/2 of original wall thickness, minor weld repairs to handhole, finger plug, or manhole seats, installation of new handhole or manway plates or finger plugs, and following welded in tube plugs on DD-963/DDG-993 Class waste heat boilers and when the fireside seal welding plug method is used on any auxiliary boiler.
4. 150 Percent of Boiler Design Pressure. Required after erection of new boilers or on replacement of waste heat boiler coils, after replacement of headers, major weld repairs to headers, drums, and separators, replacement of drum, header, or steam separator nozzles, plug/tube bosses, or inlet piping, replacement of stem separator sections after disassembly for repairs or inspection. This test is also required after repairs to header or drum defects that are 1/2 or more than the original wall thickness.

221-5.13.4 PREPARATION FOR HYDROSTATIC TEST. Requirements for boiler close-up specified in [paragraph 221-2.16.3.2](#) apply to auxiliary and waste heat auxiliary boilers. The following paragraphs describe the requirements for boiler flush, gagging of safety valves, and water conditions.

- a. Boiler Flush. When the boiler has been open for inspection prior to conducting the hydrostatic test, the boiler shall be flushed with feedwater or potable water using a hose at a pressure of approximately 50 psi. Steam, water drums and steam separators, gauge glass, RWLI, and blowdown nozzles, headers, tubes, and individual tube circuits and coils shall be flushed out of remove loose deposits. On DD-963 and DDG-993 Class waste heat boilers do not allow water to drain from the finger plugs in the inlet header into the boiler casing. Boilers shall be dumped and flushed with feedwater two times if potable water was used for flushing the waterside or hydrostatic tests. To dump and flush a waste heat boiler the following procedure should be used:

1. Completely fill waste heat boiler with feedwater using the boiler feed pump until water flows from the vents. While the feed pump is operating, operate the boiler circulating pump when the separator water level is above minus 4 inches.
 2. Drain feed water from the boiler by opening the header and separator blowdown valves and draining the boiler to the bilge.
- b. **Safety Valve Gags and Blanks.** Blank or gag all safety valves when boilers are subjected to test pressures above the maximum boiler operating pressure. Safety valves shall be removed and blanked for 150 percent design test to minimize bent valve stems. When gagging safety valves take care not to set up on gags to the extent that valve stems are bent by over tightening. Testing of the safety valves with steam on the boiler is required after safety valves have been gagged.
- c. **Valve Closures and Blanks.** Before applying a hydrostatic test, close all connections on the boiler except for the air vent, direct water level gage, test pressure gages, and valves in the line through which pressure is to be applied. When applying a 150 percent design pressure hydrostatic test close the direct water level gage and remove and blank the safety valves. When conducting 150 percent of design tests on waste heat boilers, the components being tested shall be blanked off or isolated from boiler components not being tested. For example: when applying a 150 percent design hydrostatic test to a waste heat boiler steam generating bank, blank the header inlet and outlet flange connections. When applying a 150 percent design hydrostatic test to the waste heat boiler separator, blank the recirculating pump suction flange and the steam inlet flange at the separator.
- d. **Water Condition and Quantity Requirements.** Refer to [Table 221-2-1](#) to determine the amount of feedwater required to hydrostatic test the boiler. Feedwater temperature shall be between 20° C to 50° C (70° F to 120° F). If necessary, feedwater can be heated in the feedwater/drain collection tank by admitting condensate drains to the tank. Feedwater used for hydrostatic tests shall be treated with sodium nitrite except in the following cases:
1. Hydrostatic test prior to chemical cleaning.
 2. Hydrostatic tests conducted within 24 hours of operating the boiler.
 3. Hydrostatic tests conducted while the boiler is under sodium nitrite lay-up or when boiler is to be placed under sodium nitrite lay-up.
 4. Hydrostatic test conducted on stainless DD-963 or DDG-993 Class steam generating banks.

NOTE

Sodium nitrite should be added to the hydrostatic test water if the steam separator is being hydrostatically tested with the steam generating bank. Do not add sodium nitrite for the close out hydrostatic test. Sodium nitrite is not compatible with chelant treatment systems.

5. Hydrostatic tests conducted by ships force on DD-963, DD-993, or CG-47 Class waste heat boilers.

221-5.13.5 HYDROSTATIC TEST PROCEDURES. The following paragraphs give procedures for the application of hydrostatic tests:

- a. **Filling the Boiler.** Refer to [paragraph 221-2.16.5.1](#) for guidance on filling the boiler.
- b. **Hydrostatic Test Pumps.** Test pressures for operating pressure and 125 percent of operating pressure may be applied using the boiler feed pump. 150 percent of design pressure hydrostatic tests shall be applied by a

pneumatic operated hydrostatic test pump. A standard hydrostatic test pump piping arrangement is shown in [Figure 221-2-9](#). The hydrostatic test pump and fittings shall comply with the requirements specified in [paragraph 221-2.16.5.2](#).

- c. Raising Pressure. Pressure shall be raised slowly to avoid exceeding the test pressure. When conducting an operating pressure hydrostatic test raise pressure by operating the feed pump and throttling the feedwater control valve or stop check valve.
- d. Monitoring Pressure. An operator shall be stationed at the test pump regulating valve or feedwater control valve during the entire test to monitor and regulate test pressure to prevent over pressurization. Blowdown drain to the bilge or boiler vent valve should be used to regulate pressure if necessary. The stop valve should be closed if a drop test is to be performed.
- e. Duration of Hydrostatic Tests. The test pressure shall be maintained at least 15 minutes before beginning the inspection to minimize exposure to sudden leakage. Test should last just long enough to accomplish the inspection. On stainless DD-963 and DDG-993 Class waste heat boiler coils the test shall be maintained for 30 minutes to inspect tube and weld leaks.
- f. Inspection Requirements. Sufficient casing panels or access doors shall be removed to allow inspection of tube joints, header welds, and flange joints. While under pressure (including 150 percent of design) the boiler shall be carefully inspected for leaks. An operating pressure hydrostatic test shall always be applied last. Inspection of all boiler joints and fittings should be conducted during this test.

221-5.13.6 HYDROSTATIC TEST ACCEPTANCE CRITERIA. Acceptance Criteria for auxiliary boilers are provided in the following paragraphs. Acceptance criteria for water auxiliary boiler rolled tube joints is provided in [paragraphs 221-2.16.6.1](#) through [221-2.16.6.3](#).

221-5.13.7 WASTE HEAT BOILER FAILED TUBE LOCATION. Whenever possible try to identify the failed tube location during the hydrostatic test. If the leaking tube cannot be identified, use the vacuum leak detector and test plugs to identify the leaking tube coil or tube circuit.

221-5.13.8 VALVE AND FITTING LEAKAGE. During all hydrostatic tests soot blower and steam piping drains shall be opened to check for valve leak by. Inspect drain piping outlets for leaky valves or fittings.

221-5.13.9 GASKET LEAKAGE. Leakage criteria for boiler handholes, manholes, finger plugs, and flange joints are as follows during a 100 percent hydrostatic test:

- a. For operating ships the allowable handhole or manhole leakage rate is 3 to 5 drops per minute.
- b. For ships in a availability that includes a boiler overhaul, the leakage rate for handhole and manhole seats shall be zero.
- c. Finger plug gasket allowable leakage is zero. Copper gaskets should be replaced when leakage is present. High temperature anti-seize compound shall be used on finger plug threads. Initial torque for finger plugs is 130 ft-lbs. Finger plugs may be re-torqued to 155 ft-lbs to stop leakage.
- d. Flange joint allowable leakage is zero. Gaskets shall be replaced when leakage is present.

221-5.13.10 GASKET REPLACEMENT. After a 150 percent design pressure hydrostatic test, only replace gaskets that leak during the follow on 100 percent hydrostatic test.

APPENDIX A

LIST OF FREQUENTLY USED MATERIALS FOR BOILER MAINTENANCE

Table 221-A-1. List Of Frequently Used Materials For Boiler Maintenance

Nomenclature	Specification or Standard Drawing	Stock Number	Pt.No./Size	Reference Paragraph
BOILER LAYUP				
Nitrogen, technical	BB-N-411	01-028-9402		221-2.3.1
Sodium nitrite	Tech. Grade	6810-00-270-3254	O-C-265	221-2.3.3
Light, Portable, watertight and explosion proof	MIL-F-16377/52	6230-00-701-2947	100w	221-2.3.3
	MIL-F-16377/51	6230-00-283-9671	25w	
	MIL-F-16377/49	6230-00-244-3996	8w	
Desiccant, Activated	MIL-D-3464 Type I	6850-00-264-6572 (150 bags of 16 units)		221-2.3.3.2
Indicator card, humidity		6685-00-752-8240	MS-20003	221-2.3.3.2
Blowers and Heaters, Hot Air Lay-up, Type IV	Table 221-2-3	AEL 2-92001569 ¹		221-2.3.3.1
Heater		4410-01-145-6414		
Blower		4410-01-145-6416		
Relay, fan interlock		4140-01-142-1225		
Hose, air duct	MIL-PRF-62028D	4720-00-540-2600	4 inch Dia.	
		4720-00-882-5624	6 inch Dia	
		4720-00-419-0483	8 inch Dia x 25'	
CASINGS				
Sealing compound		8030-00-407-7604	Prestite 589.1	221-2.13.5
Bead strip			Hi-temp	
Paint, Aluminum heat resistant	TT-P-28 Type L	8010-00-664-7468 (1 qt.)		221-3.1.9.1
		8010-00-815-2692 (1 gal.)		221-3.2.12.4
		8010-00-857-1938		
Gasket, Flat	803-841624	5330-01-171-4028	1-in.	221-2.13.5
	HH-P-31	5330-01-171-4029	1-1/4	
		5330-01-171-4030	1-1/2	
		5330-01-171-4031	2-in.	
		5330-01-171-4033	3-in.	
Gasket, Tadpole	803-841624	5330-01-207-0619	1-3/8	
		5330-01-210-0534	1-7/8	
		5330-01-210-0533	2-3/8	
COVERALLS , Fire retardant		(See AEL2330075145 2330075146 2330075147 for NSNs)		
DRUMS AND HEADERS				
Plugs, Plastic for tube holes	NAS847	5340-01-114-0206	F-17	221-2.9.7.2

Table 221-A-1. List Of Frequently Used Materials For Boiler Maintenance -

Continued

Nomenclature	Specification or Standard Drawing	Stock Number	Pt.No./Size	Reference Paragraph
Gasket, Metallic spiral wound, manhole 3/4 inch wide	M5501/7-	5340-01-039-0334 5340-01-043-7078 5340-01-165-1159 5340-00-286-3506 5340-01-194-3200 5340-01-194-3201	F-18 F-19 F-21 F-24 F-25 F-27	
Gasket, Metallic spiral wound, handhole	MIL-G-15342 Class 2	5330-01-379-5982	MH12	221-2.11.5
	MIL-G-15342 Class 1, Series 1200-920 deg F	5330-01-394-9922 5330-01-394-9926 5330-01-394-9929 5330-01-394-9928	B&W 40J FW-637 FW-71 1 ² CE-23/FW-30 ²	221-2.11.5
Gasket, Metallic spiral wound, handhole	Class 1 Series 600-850 deg F	5330-01-392-5158 5330-01-394-9919 5330-01-394-9932 5330-01-394-9921 5330-01-392-3346 5330-01-394-9924 5330-01-394-9920 5330-01-394-9918	CE-29 CE-33 CE-21 ² CE-24 ² CE-27 ² CE-28 ² CE-30 ² MH06	
Gasket, Metallic spiral wound, manhole, aux.-blrs. 1/2-inch wide graphite filler (alternate) 15/16-inch wide mica-graphite filler	MIL-G-15342 Class 2	5330-01-394-9918		
	Commercial- Flexitallic ³ , Inc.	5330-01-373-3045	3171200	
FIRESIDE CLEANING Vacuum Cleaner, industrial	AEL 2-920014001	7910-00-267-1205		221-2.7.6
GAUGE GLASS LIGHTING Lampholder, 115v Lamp, 40 watt. 120v type 40T-10-IF Lampholder. 12vdc	UL STD-496 (970) MS15551-2	6250-00-939-8126 6240-00-846-9815 6250-00-071-6902 ⁴	P/N 1761-06 301151 2423/30DC (76568)	221-3.4.2.10.1 221-3.4.2.10.1 221-3.4.2.10.2
Lamp, S-8 (alternate) Lamp, G-6	MS-15569-3	6240-00-982-5636 6240-00-797-4370	1612 82	221-3.4.2.10.2 221-3.4.2.10.2
INSULATING MATERIALS Brick, Insulating High temperature	MIL-B-16008	9350-00-229-4185 9350-00-274-3832 9350-00-229-4187	1.25 2.0 2.5 2.5(arch)	221.2.14.3.7

Table 221-A-1. List Of Frequently Used Materials For Boiler Maintenance -

Continued

Nomenclature	Specification or Standard Drawing	Stock Number	Pt.No./Size	Reference Paragraph
Brick, Insulating	MIL-B-16305	9350-00-229-4214 9350-00-229-42 16 9350-00-229-4217	1.25 2.0 2.5	221.2.14.3.7
	Class B	9350-00-229-42 15 9350-00-229-4218 9350-00-229-4219 9350-00-247-0551	1.25 2.0 2.5 2.5(special)	
Castable Insulation	MIL-C-19794	9350-00-558-0457 (50 lb.) ⁵		221.2.14.3.9
Block, Insulation	MIL-PRF-2819			221-2.14.3.8
Cement, Insulation high temperature	MIL-C-2861	5640-00-272-2995		221-2-14.3.11
Board, Insulating ceramic fiber (2)	Kaowool ² M-board Cera-form ²	5640-01-074-7875 (36 X 24) 5640-01-080-8383 (36X 24)	1/2 in. 1/4 in.	221-2.14.3.10
Encapsulant, asbestos	Polaproof Firegard/ Polaprime II ²	Non-Stock. A product of 3E Corp., P.O. Box 392 890 Glen Ave., Moorestown, NJ 08057 (Phone (609) 866-7600)		221-2.13.6.1
Expanded Perlite Tamping mix, ceramic fiber ⁶	Sproule WR-1200 ² FC-25FP ²	Non-Stock 9350-00-789-1749 (50 lb.)		221-.2.13.6.2 221-2.14.3.13
Rope, Ceramic fiber ⁶	Fiberfrax ²	5330-00-872-6982 (10 lb.)	1 in.	221-2.14.3.13
SLIDING FEET Lubrication grease, high temperature	MIL-L-15719	9150-01-080-9652 (14 oz. cart.)		221-2.15.3
SPARE TUBE PRESERVATION Tube Preservative Type P-2. soft film	MIL-PRF-16173 Class I Grade 2	8030-00-244-1297 8030-00-244-1298	1 gal. 5 gal.	221-2.10
Tube Preservative, Type P-3, water Displacing, soft Film, low VOC	MIL-PRF-16173 Class II, Grade 3	8030-01-396-5748 8030-01-347-0971	1 gal. 5 gal.	221-2.10
SPRAYER PLATES Go No-go gages ⁷ CAGE: 62679	250-4692835 (1200 psi) 250-5274181 (600 psi)	5220-01-169-3938 5520-01-334-7716 5220-01-125-1774 5220-01-281-0240 5220-01-285-0333	VK-13 VK-19 VK-20 VK-21 VK-22	221-3.1.6.1

Table 221-A-1. List Of Frequently Used Materials For Boiler Maintenance -

Continued

Nomenclature	Specification or Standard Drawing	Stock Number	Pt.No./Size	Reference Paragraph
		5220-01-285-0334	VK-23	
		5220-01-285-0335	VK-24	
		5220-01-191-4973	VK-25	
		5220-01-191-4970	VK-27	
		5220-01-191-4971	VK-30	
		-	VK-33	
		5220-01-127-1146	VK-34	
		5220-01-125-1802	VK-36	
		5220-01-125-1803	VK-37	
		5220-01-281-0241	VK-38	
		5220-01-218-2622	VK-50	
		5220-01-218-2623	VK-53	
		-	VK-54	
		5220-01-446-1400	VK-55	
		5220-01-262-5971	VK-56	
		5220-01-317-8821	VK-61	
		5220-01-329-7477	VK-62	
		5220-01-258-8417	VK-63	
		-	VK-104	
		5220-01-446-1405	VK-105	
		5220-01-446-1408	VK-106	
		5220-01-446-1410	VK-108	
		5220-01-446-1412	VK-109	
STEAM ATOMIZATION PIPING				
Epoxy coating		8010-01-008-0836 (3 gal.) ⁸		221-3.1.9.1
Paint, Fire retardant	MCU-2100 Type ² II OR IV	Non-Stock. A Product of Steelcote Mfg., St. Louis, MO 63103-2990 (Phone: 1-800-7370282)		221-3.1.9.1
Domed strainer/orifice, 150 psi, 1/2 nps	MS18301-05/11 MS18301-11 (strainer)	4730-00-216-6146 4730-00-432-1293	0.031	221-4.5.3 221-4.5.6 221-4.6.5.5
Domed strainer/orifice, 150 psi, 3/4 nps	MS183301-06/12 MS183301-12 (strainer/gasket)	4730-00-216-6132 4730-00-216-6231	0.031	
Silicone rubber RTV	MIL-A-46106 Gr. 1, Type I	8040-01-331-7466 (5 oz.) 8040-01-010-8758 (12 oz.)		221-3.1.9.1
SUPERHEATER DRAINS				
Domed strainer/orifice, 1,200 psi,	MS18301-07/15 MS18301-07/15L1 ⁹	4730-01-054-3762 4730-01-238-0126	0.036 0.036	221-4.7.2.1

Table 221-A-1. List Of Frequently Used Materials For Boiler Maintenance -

Continued

Nomenclature	Specification or Standard Drawing	Stock Number	Pt.No./Size	Reference Paragraph
combatants, 1/2 nps	MS18301-07	4730-00-216-6155 (strainer/gasket)	0.036	
Domed strainer/ orifice, 1200 psi combatants, 3/4 nps	MS18301-08/16	4730-01-037-5036		
Domed strainer/ orifice, 1200 psi CV's, 1/2nps	MS18301-07/01	4730-00-217-7462	0.020	
	MS18301-07/01L1 ⁹	4730-01-094-3226	0.020	
	MS18301- ¹⁰	¹⁰	0.070	
Domed strainer/ orifice, 1200 psi CV's, 3/4 nps	MS18301-07	4730-00-216-6155 (strainer/gasket)		
	MS18301-08/02	4730-00-217-7443	0.020	
	MS18301-08/012L1 ⁹	4730-01-094-3225	0.020	
	MS18301- ¹⁰	¹⁰	0.070	
Domed strainer/orifice, 600 psi, 1/2 nps	MS18301-08	4730-00-217-7487 (strainer/gasket)		
	MS18301-09/03	4730-00-216-6152	0.031	
Domed strainer/orifice, 600 psi, 3/4 nps	MS18301-09	4730-00-215-8601 (strainer/gasket)		
	MS18301-10/04	4730-00-216-6151	0.031	
	MS18301-10	4730-00-216-6173 (strainer/gasket)		
WATERSIDE CLEANING - BOILING OUT (FOR EDTA Refer to TABLE 221-C-3)				
Sodium Metasilicate	A-A-1818 Ty2 ASTM D-537	6810-00-664-7062 (100 lb.)		221.E.1.1
Wetting Agent	-	7930-00-282-9699		221.E.1.1
Trisodium Phosphate (TSP)	0-S-642 Type-I			221.E.1.1

¹Applicable to LHD 1 Class. For smaller applications (Types I, II and III) refer to [Table 221-2-3](#). Note make sure blower back pressure requirement of 4" static pressure is observed when selecting blowers.

²No current USN fleet applications.

³Mention of trade names or commercial products does not indicate that the Naval Sea Systems Command necessarily considers these products superior to others.

⁴NSN in "V", terminal status.

⁵Refer to boiler APLs and NAVSEA refractory drawings for insulating block NSN's.

⁶Materials containing Refractory Ceramic Fiber (RCF) must be handled in accordance with the procedures of Appendix 10A of NAVSEA S9221-C1-GTP-020 to minimize adverse health effects.

⁷Available commercially from Van Keuren Co. Framingham MA 01702; tel: 1-800-825-4272

⁸Kit consisting of 2 gal hardener and 1 gal epoxy resin.

⁹"L1" following the MIL STD dash number indicates MIC level I. HP drain orifice plates need not be level I on fossil fired surface ships if they are procured to MIL STD MS-18301 (SHIPS) requirements.

¹⁰The 0.070 steam blanket orifice plate is not stocked. It can be ordered commercially or a smaller plate shown above (correct NPS size) can be drilled out.

APPENDIX B

LIGHT-OFF TORCHES

221-B.1 DETERMINING LIGHT-OFF TORCH LENGTH.

221-B.1.1 Main Boiler Torches. Table 221-B-1 provides a torch length that will ensure a torch flame will reach an atomizing fuel spray pattern in front of a burner diffuser. The torch lengths shown in Table 221-B-1 will permit a successful initial burner light-off if proper light-off procedures are followed.

Length calculations are based on the following assumptions:

- The light-off port opening is located midway-between the light-off burner and the adjacent burner.
- Maximum and minimum atomization fuel oil spray patterns are utilized.
- The flame at the end of the light-off torch is taken as a point source (a good flame is at least approximately 1 ft. in length)

221-B.1.2 Auxiliary Boiler Emergency Light-off Torch. The torch length (Figure 221-B-2) for emergency light-off on LSD-41 Class, V2M, 125 psi, auxiliary boilers shall be 3'-2". Torch light-off is a last resort emergency procedure applicable only to boilers equipped with high energy igniters; refer to the boiler technical manual (NAVSEA S9517-AT-MMO-010) for the torch light-off procedure.

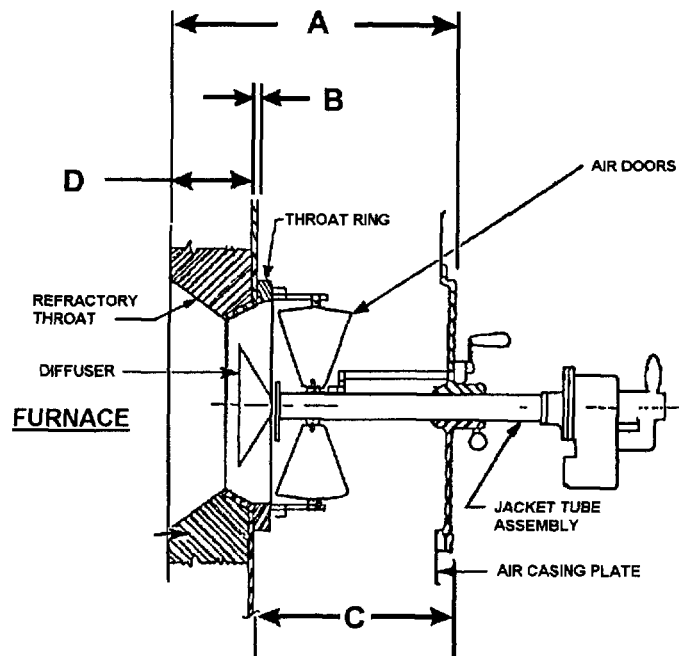


Figure 221-B-1. Burner Dimension Locations

221-B.2 EXISTING TORCHES

221-B-2.1 This Appendix should be used as a guide to the fabrication of new torches as required. Ships should not discard existing torches that permit successful initial burner light-off just because they are non-conforming lengths. If new torches are required, continue to fabricate in accordance with [paragraph 221-4.4.5](#), using lengths shown in [Table 221-B-1](#).

Table 221-B-1. Required Torch Lengths for Various Main Boiler Registers.

BURNER TYPE	MANUFAC- TURER	DIMENSIONS (See Figure 221-B-1)				FLAME PATTERN DISTANCE	"A" DIMEN- SION + 18"	TORCH LENGTH (Figure 221-B-2)
		A	B	C	D			
D-17	TODD	31-3/8	1/4	24-3/8	6-3/4	18"	49-3/8"	4'-1"
D-20	TODD	25	1/4	18	6-3/4	18"	43"	3'-7"
3M	B&W	24-1/4	3/8	17-1/8	6-3/4	18"	42-1/4"	3'-6"
3M	B&W	27-5/8	3/8	20-1/2	6-3/4	18"	45-5/8"	3'-9"
3M	B&W	31-3/8	3/8	25-1/4	6-3/4	18"	49-3/8"	4'-1"
LVC-4M/ LVS-4M	TODD inc. NAV- JET	28-3/32	1/4	21-3/32	6-3/4	18"	46-3/32	3'-10"
LVC-4M	TODD	26-1/2	1/4	19-1/2	6-3/4	18"	44-1/2	3'-8"
C.E.	C.E.	39-1/8	1/4	32-1/8	6-3/4	18"	57-1/8	4'-9"

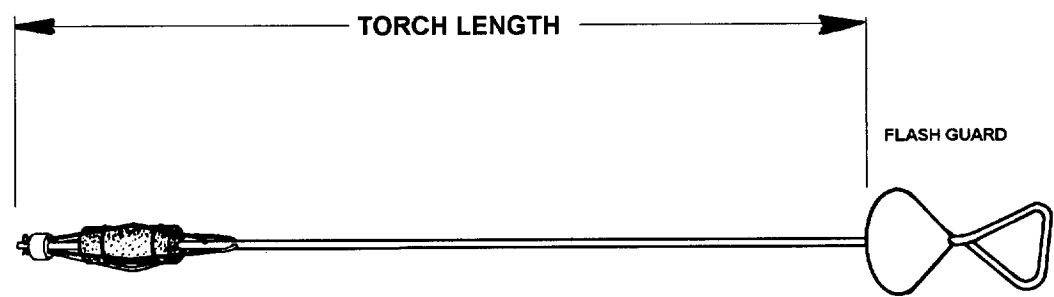


Figure 221-B-2. Measuring Torch Length.

APPENDIX C

EDTA BOILER WATERSIDE CLEANING METHOD

221-C.1 DESCRIPTION.

221-C.1.1 GENERAL. This method involves treating the boiler with a 1-percent solution of EDTA and steaming the boiler at 240 psig plus or minus 10 psig for 4 hours, dumping and flushing the boiler and then inspecting the boiler.

NOTE

If EDTA cleaning is accomplished in port, the cleaning effluent shall be neutralized before overboard discharge. Overboard discharge without neutralization is permissible at sea. Refer to [paragraph 221-C.3.7](#) for neutralization procedures. Refer to NSTM Chapter 593, pollution Control, for in-port disposal requirements.

221-C.1.2 APPLICATION. EDTA (ethylene-diamine-tetraacetate) boiler waterside cleaning method is used as an alternative to water-jet and wire brush cleaning methods of main propulsion boiler waterside soft deposit removal. EDTA cleaning can be accomplished before boiler inspections, and may be used any time boiler waterside soft deposit removal is required.

221-C.1.3 MATERIALS REQUIRED. The following materials are required to accomplish EDTA boiler cleaning:

- a. EDTA, MIL-T-24494. Quantities per [Table 221-C-1](#).
- b. Mixing tank with spigot, 30-gallon, plastic or steel. EDTA reacts with aluminum; therefore, do not use an aluminum tank.
- c. Rubber or plastic hose (3/4 inch in diameter) with hose clamps to reach from mixing tank to boiler.
- d. Portable pump (not required for gravity feed).
- e. Stirrer (broom handle).

221-C.2 SAFETY, HANDLING, AND STORAGE.

- a. Properties of EDTA. The dry powdered material is irritating to the eyes, nose, and respiratory- tract.
- b. Safety Precautions. While handling and mixing EDTA the following protective equipment shall be worn:
 1. Goggles
 2. Rubber gloves
 3. Rubber apron
 4. Dust mask.
- c. First Aid. In case of contact with skin, flush with plenty of water. If eyes are affected, flush with running

water for at least 15 minutes and report to sick bay immediately thereafter. If EDTA solution is swallowed, induce vomiting immediately by giving two glasses of water and sticking finger down throat, and report to sick bay immediately.

- d. Stowage. EDTA should be stowed in a dry, ventilated place. Containers should be kept closed and plainly labeled.
- e. Spill Cleanup. When dry EDTA is spilled, sweep up and place in dry container for disposal. For small (less than 1 gallon) wet spills, wash to bilge with water; for larger wet spills, wash to bilge with water, and neutralize with citric acid (1-pound citric acid per gallon of concentrated EDTA solution spilled). Dispose of bilge water according to NSTM Chapter 593.

221-C.3 PREPARATION.

1. Boiler to be cleaned shall be at zero psig.
2. Provide feedwater at the mixing tank.
3. Connect hosing, mixing tank and pump. The hosing, tank, and pump shall be flushed with feedwater before connecting to boiler. If mixing tank can be located higher than the steam drum the solution can be gravity fed.

Table 221-C-1. Pounds Of EDTA Required To Clean One Boiler (By Ship)

POUNDS OF EDTA	SHIPS
100	EX-FF-1038, EX-FF-1052 Class
125	AFS-1, T-AFS-3, AS-39, AS-40, LPD-7 thru LPD-10, LPD-13, LPD-15, EX-LPD-14, LPD-15, EX-LSD-38.
150	T-AE-26, AE-32 thru T-AE-35, T-AFS-5, T-AFS-7, LCC-19, LCC-20.
200	CV-67.
225	CV-63
275	LHA-1, LHA-4, LHA-5, LHD-1-7

4. Connect hosing to boiler vent. This connection may require removing a valve and preparing a flanged inlet pipe.
5. If boiler is empty, fill with feedwater to bottom of gauge glass, do not treat. If boiler is filled and treated, do not dump. Adjust boiler water level to the bottom of gauge glass. Cleaning with EDTA can be accomplished with or without boiler water treatment chemicals in the boiler water. A freshly filled boiler shall be lit-off within 24 hours of filling. The boiler should be lit-off as soon as possible, but not more than 4 hours after injection of EDTA.

221-C.3.1 CHEMICAL ADDITION. Use the following procedures:

1. Add feedwater to the mixing tank.
2. Add EDTA to the feedwater by mixing 50 pounds of EDTA with 25 gallons of feedwater. Mix with wooden stirrer.

CAUTION

EDTA forms an alkaline solution. Personnel mixing solution shall wear rubber gloves, rubber apron, safety goggles, and dust mask. If solution is splashed in eyes or on skin, wash with copious amounts of water. Flush with potable water for 15 minutes while lifting upper and lower lids. Seek medical attention immediately.

3. Pump or gravity drain EDTA and feedwater solution into the boiler. Superheater drain should be open to allow for pressure release.
4. Repeat injections until the amount indicated in [Table 221-C-1](#) is injected.
5. Flush tank, hoses, and pump with feedwater.
6. Disassemble injection equipment. Prepare boiler for steaming.

221-C.3.2 PLANT ALIGNMENT DURING EDTA CLEANING. The preferred method for plant alignment is to steam only the boiler being cleaned in a given plant. This reduces the possibility of contamination of the adjacent boiler with EDTA solution in the event of a desuperheater leak or other cross contamination condition. If cross contamination occurs, the adjacent boiler will exhibit high phosphate, conductivity, pH/alkalinity and chloride, and will require treatment per NSTM Chapter 220, Volume 2, Boiler Water/Feedwater-Test and Treatment. The source of cross contamination shall be identified and corrected. Before adding EDTA to the boiler, remove drum level transmitters and remote water level indicators from service to preclude sludge accumulation in sensing lines. Proceed as follows:

1. Open manifold equalizer valve.
2. Close manifold shutoff valves.
3. Close root valves on steam drum.

221-C.3.3 BOILER OPERATION DURING EDTA CLEANING. The following steaming procedure shall be followed:

1. When other boiler(s) in the space is (are) secured:
 - a. Light-off according to Engineering Operation Sequencing System (EOSS) ship's light-off checklist except:
 - (1) Ships equipped with NAVJET and Racer burners shall use sprayer plate 4-51-57-55-80, NSN 9C 4520-01-069-3261 throughout the cleaning.
 - (2) Ships equipped with CE/Wallsend burners shall use sprayer plate 5X-80-43-43-78, NSN 9C 4530-01-047-0608 throughout the cleaning.
 - (3) Ships equipped with straight mechanical, return flow, and variable steam pressure burners shall use the light-off plate throughout the cleaning.
 - b. Starting the main feed pump may require opening the overload nozzles and manually jacking open the governor valve. The main steam stop shall be open. Do not operate the feed pump on bypass. Leave the overload nozzles open to take some of the steam load and provide maximum pump discharge pressure. If main feed pump operation is not possible, use emergency feed pump for this operation.
 - c. Bleed steam to auxiliary exhaust. The atmosphere dump valve will eventually open.

- d. Adjust oil pressure and bleed steam to maintain 240 plus or minus 10 psi steam drum pressure. Open superheater drains if required to maintain steam drum pressure. Do not exceed 250 psi.
 - e. Feed water to boiler as required to maintain normal water level.
 - f. The cleaning solution will give off a volatile component during the first hour of cleaning. This will cause an increase in the salinity indicator readings where the steam is used; however, no harmful effects will occur.
2. When other boiler(s) in the space is (are) on the line, the above procedures apply except for the following:
 - a. Steam stops and bypass valves on the boiler being cleaned cannot be opened.
 - b. The boiler pressure will be controlled by adjusting firing rate, normal bleed off to auxiliary exhaust, and opening superheater vents and drains.

NOTE

Maintenance of steaming pressure at 240 plus or minus 10 psi during cleaning is critical to ensuring maximum cleaning effectiveness without causing breakdown of EDTA to volatile compounds which raise steam/condensate pH and conductivity. This phenomenon does not affect adjacent boiler water pH/alkalinity, conductivity, or chloride, because these compounds are volatilized in the boiler.

3. Secure boiler 4 hours after reaching 240 psig.
4. After the boiler has been secured, it shall be dumped hot. This ensures that iron deposits which were removed during the cleaning do not come out of solution in the form of iron oxide rust which can coat waterside surfaces and cause post-cleaning chemical hideout to occur. Do not treat with sodium nitrite before dumping. EDTA is an excellent passivator and coats waterside surfaces with protective magnetite during the cleaning.

NOTE

If EDTA cleaning is being accomplished in-port, neutralize the cleaning effluent according to [paragraph 221-C.3.7](#), and dispose of bilge water according to NSTM Chapter 593. Neutralization may also be used at sea to preclude iron oxide rust from depositing on bilge surfaces.

221-C.3.4 POST-EDTA CLEANING FLUSHING. After the boiler is dumped it shall be filled and dumped a minimum of two times with feedwater allowing a 15-minute soak between filling and dumping. This ensures adequate flushing of EDTA solution from boiler circuits to help preclude post-cleaning boiler pH/alkalinity problems.

NOTE

Post-cleaning inspection, hydrostatic testing, and light-off should be accomplished as soon as possible after dumping (normally within 36 hours of securing from cleaning). The boiler should then be steamed at a low firing rate (less than 50 percent) for at least 72 hours to ensure stable chemistry control before steaming at high rate. The boiler shall be steamed before wet lay-up. If timely steaming is not possible, the boiler shall be placed in dry lay-up.

221-C.3.5 POST-EDTA CLEANING BOILER INSPECTION. Open and inspect according to [paragraph 221-2.5.5](#). Post-cleaning inspection shall include:

- a. Opening of steam drum and inspection of representative sample of screen wall tubes. Removal of one girth plate should be sufficient to accomplish this.
- b. Removal of sufficient handhole plates from headers to allow for inspection of tube ends and removal of sludge from headers and lower tube ends.
- c. Opening and inspection of water drum and lower tube ends. Remove loose deposits and debris from tube ends and water drum. This may require removal of desuperheater.
- d. Loosely adhering soft deposits should be removed from tube ends with bristle brush or rag. Industrial vacuum cleaner should be used to remove debris from drums and headers.
- e. Inspect the boiler for the presence of deposits and for indications of corrosion. Record all findings. If an adherent deposit remains, the boiler shall be cleaned using EDTA, water-jet, wire brush, or hydrochloric/sulfamic acid as conditions dictate.
- f. Before closing the boiler and conducting hydrostatic testing, flush all accessible surfaces (including gauge glass through the drum penetrations) with strong stream of feedwater using 1-1/2-inch hose and nozzle, if available, to ensure removal of all debris and to reduce post-cleaning chemistry control problems. The hose and nozzle shall be free of salt water.

221-C.3.6 BOILER OPERATION/CHEMISTRY CONTROL FOLLOWING EDTA CLEANING. After freshly filling the boiler, treat with disodium phosphate (DSP) only [do not treat with trisodium phosphate (TSP)] according to NSTM Chapter 220, Volume 2. After the boiler is on the line, test and treat per NSTM Chapter 220, Volume 2, as conditions indicate. Additional blowdowns during the first 168 steaming hours following an EDTA cleaning are required. Conduct a 10 percent surface blowdown every 24 hours. A bottom blowdown shall be performed at least every 72 hours, and preferably every 48 hours if possible.

NOTE

The mechanical cleaning hours are to be zeroed if the inspection shows the cleaning was successful. The chemical cleaning hours are not zeroed since complete removals of hard deposits are not achieved by the EDTA procedure. EDTA cleaning is not considered an alternative to acid cleaning.

Return drum level transmitter and remote water level indicators to service as follows:

1. Open root valves on steam drum.
2. When boiler has reached 200 psig after initial light-off, blowdown sediment chambers using normal blowdown procedures.

CAUTION

Do not allow hot fluid to reach differential pressure units.

3. Open manifold valves when sensing lines and sediment chambers have cooled to ambient temperature.
4. Close manifold equalizer valve.
5. Proper operation of Deaerating Feed Tanks (DFT's), and Remote Water Level Indicators (RWLI's) will occur when boiler operating pressure is reached and sensing lines and reference chambers are filled with condensate.

221-C.3.7 EDTA CLEANING EFFLUENT NEUTRALIZATION PROCEDURE. This procedure provides a method for neutralizing EDTA cleaning effluent in ship's bilge thus facilitating in-port disposal. Do not add citric acid to the boiler for neutralization.

a. Material Required:

1. Anhydrous citric acid in 50-pound paper drums. Commercial Item Description, A-A-59147, Citric Acid, Technical Quantity depends on the amount of EDTA used (refer to [Table 221-C-2](#). Stirrer (broom handle).
2. Stirrer (broom handle).
3. Mixing tank with spigot, 30 gallon capacity.
4. Plastic hose 3/4-inch in diameter.

b. Safety, Handling, and Storage:

Table 221-C-2. Citric Acid Requirements

POUNDS OF EDTA USED FOR CLEANING	POUNDS OF CITRIC ACID FOR NEUTRALIZATION
75	25
100	35
125	45
200	70
225	80
275	100

1. Properties of citric acid. The dry powered material is irritating to the eyes, nose, respiratory tract, and skin. In concentrated solution, it neutralizes the alkali of skin tissues, and contact can cause severe irritation. Prolonged contact with skin may cause ulcers.
2. Safety Precautions. Both citric acid and trisodium phosphate are potentially hazardous chemicals which should be handled with care. Personnel handling and mixing these chemicals shall wear the following protective equipment:
 - (a) Goggles
 - (b) Rubber gloves
 - (c) Rubber apron
 - (d) Dust mask
3. First Aid Treatment. Citric Acid Treatment and Antidotes. In case of contact with acid, flush the skin immediately with plenty of water and remove all affected clothing. If the eyes are affected, flush with running water for at least 15 minutes and report to the sick bay immediately thereafter. If acid has been swallowed, drink a teaspoonful or more of magnesia, chalk whiting, or small pieces of soap softened in water, several glasses of milk, or several egg whites in milk under doctor's direction.
4. Stowage. Citric acid should be stowed in a dry, ventilated place. Containers should be kept closed and plainly labeled.

c. Spill and Cleanup Procedures:

1. When dry citric acid is spilled, sweep up and place in dry container for disposal (closed plastic bag is acceptable). It is important that the chemical always be kept dry when not in use.
2. For small (less than 1 gallon) wet spills of citric acid, wash to bilge with water. For large wet spills of citric acid, neutralize with trisodium phosphate, 1 pound of trisodium phosphate per 2 pounds of citric acid spilled, rinse to bilge with water, and Dispose of according to NSTM Chapter 593.

d. Preparation:

1. Locate the plastic mixing tank near boiler gravity drain discharge.
 2. Attach a piece of plastic hose so that the citric acid will discharge in the same bilge compartment as the spent EDTA cleaning solution.
 3. Add 20 gallons of hot water between 50° C and 75° C (120° F and 170° F) to the plastic tank.
 4. Determine the quantity of citric acid required (refer to [Table 221-C-2](#)).
 5. Slowly add the citric acid to the mixing tank, stirring continuously. Continue stirring for 5 minutes after chemical addition is complete to ensure that the citric acid is completely dissolved. The solution will be clear when mixing is complete.
 6. Fill the mixing tank to the 30-gallon mark.
 7. Determine the citric acid feed rate necessary to evenly treat the boiler effluent with citric acid by dividing the 25 gallons of citric acid solution needed by the boiler drainage time in minutes.
- e. Procedure:
1. Drain the EDTA cleaning solution from the boiler while allowing the citric acid solution to run into the boiler effluent at the treatment rate determined in [paragraph 221-C.3.7, step d7](#) such that the citric acid solution is mixed evenly with the EDTA solution being drained from the boiler.
 2. Secure the citric acid feed after 25 gallons have been mixed with boiler effluent.
 3. Add 25 gallons of water to the remaining 5-gallons citric acid solution to make a diluted citric acid solution.
 4. After the boiler has completely drained, fill the boiler for the first flush.
 5. Drain the boiler while adding the 30 gallons of diluted citric acid solution to the boiler effluent.
 6. The solution in the bilge may be disposed of according to NSTM Chapter 593.

221-C.4 SUPPLY SUPPORT INFORMATION FOR EDTA BOILER CLEANING/POST CLEANING/CITRIC ACID NEUTRALIZATION

221-C.4.1 The materials and safety equipment required to perform cleaning, post-cleaning and citric acid neutralization is contained in [Table 221-C-3](#).

Table 221-C-3. Edta Boiler Cleaning/Post-Cleaning/Citric Acid Neutralization

a. Materials:		NSN
Item		
EDTA-MIL-T-24494 (25 lb. drum)		6810-01-109-3911
Citric Acid-A-A-59147 (50 lb. drum)		6810-00-141-2942
Trisodium Phosphate Dodecahydrate O-S-642 Type II (25 lb. drum)		6810-01-082-5415
Mixing Tanks with Spigot (30 Gallon)		4940-01-130-0017
Pump, Eastern Magnetic Drive MD-80		
b. Safety Equipment:		
Item		
Face shield		4240-00-542-2048
Rubber gloves		8415-00-266-8677
Rubber apron		8415-00-082-6108
Dust mask		4240-00-629-8199
Goggles		4240-00-190-6432

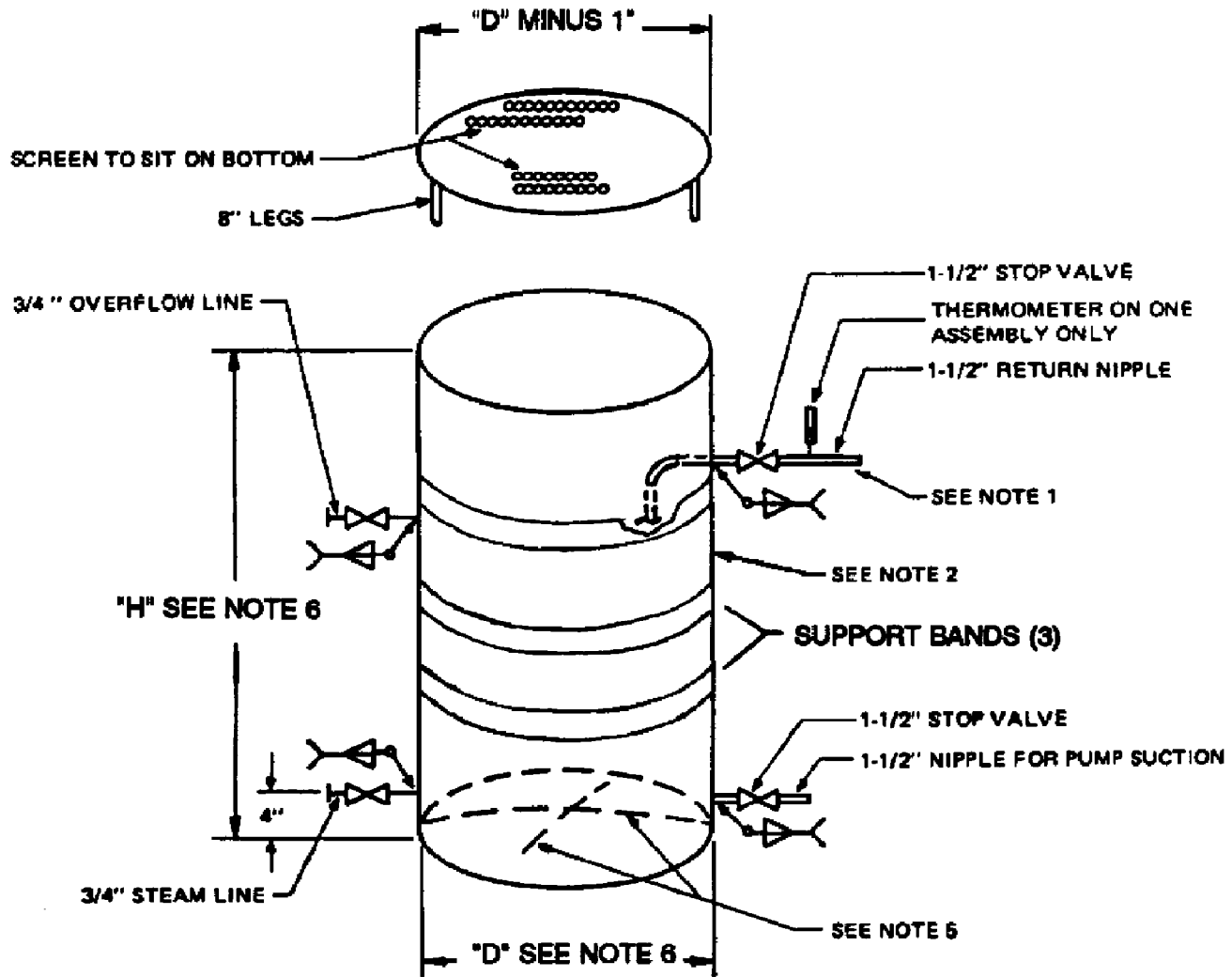
APPENDIX D**CHEMICAL CLEANING PROCEDURES FOR WASTE HEAT BOILERS
CHEMICAL CLEANING PROCEDURE STAINLESS STEEL COIL WASTE HEAT BOILERS
(DD-963/993 CLASS)****SECTION D-1****SULFAMIC-CITRIC ACID METHOD****221-D.1 GENERAL.**

221-D.1.1 The following procedure is to be used with MIL-STD-1607, Chemical Cleaning of Main and Auxiliary Boilers (Sulfamic-Citric Acid Method), for the chemical cleaning of the stainless steel coils in waste heat boilers on SPRUANCE and KIDD class destroyers. If the steam separators also require cleaning, blank off the separator from the coil and clean each component separately using identical proportions of required chemicals.

221-D.1.2 A chemist and safety officer shall oversee the entire cleaning process including mixing, chemical injection, circulation, flushing and disposal of descalant and subsequent solutions.

221-D.2 EQUIPMENT REQUIRED.

- a. Mixing Tank. Approximately 500 gallon capacity, fabricated of mild steel with appropriate inlet and outlet fittings, shown in [Figure 221-D-1](#).
- b. Acid Pump. Centrifugal type, acid resistant, 30 gallons per minute against a 20-foot static head.
- c. Hose. 1-1/2" ID, acid resistant, suitable for continuous service with 10% sulfamic-citric acid, rated at 150 psi.
- d. Valves. 1-1/2 connections, mild steel, gate or globe.
- e. Heating Coil (Optional). Mild steel fabrication, with appropriate valves and fittings enabling introduction and discharge of steam safely.
- f. Pyrometer. Portable, 0-250° F range.
- g. Chemical goggles. Clear, rubber framed.
- h. Rubber Gloves. Acid resistant.
- i. Rubber Apron.
- j. Faceshield.
- k. Rubber Boots.
- l. Assorted Non-sparking Tools. Including hammers, wrenches and screwdrivers, tools for repairing acid cleaning equipment.



REF: SH 13202671

NOTES:

1. INSTALL THREE ASSEMBLIES IN TANK TO CONNECT RETURN LINES.
2. USE 12 GAUGE STEEL FOR TANK.
3. USE ALL HIGH PRESSURE FITTINGS
4. INSTALL 4 x 1/4 INCH SUPPORT BANDS AROUND TOP, CENTER AND BOTTOM OF MIXING TANK.
5. CONCAVE BOTTOM 4 INCHES FOR STRENGTH.
6. COMPUTE "H" AND "D" DIMENSIONS TO SUIT 300 OR 500 GAL CAPACITIES REQUIRED BY PROCEDURES.

Figure 221-D-1. Acid Cleaning Tank

221-D.3 CLEANING CHEMICALS REQUIRED.

- a. Boiler Scale Removing Compound. Military Specification MIL-B-24155.
- b. Copper Complexer. Diethylthiourea (DETU), packaged separately in the boiler scale removing compound container.
- c. Spill Absorbent. Sodium bicarbonate, anhydrous, technical grade, Federal Specification A A 59563.
- d. Nitrogen Gas. Oil-free conforming to class 1 of Federal Specification A A 59503 90-100 PSI.
- e. Feedwater. In accordance with- NSTM 220 Vol. 2.

WARNING

Sulfamic-citric acids may cause chemical burns if they come into contact with skin or eyes. DETU, a suspect carcinogen, is also considered as a moderate irritants to the skin and eyes. Personnel handling this material shall wear rubber gloves, chemical workers goggles or plastic face shields, rubber aprons and boots.

In case of skin contact, the affect area shall be thoroughly flushed with fresh water. If any acid gets into the eyes, allow fresh water to flow into the opened eyes for 15 minutes and get immediate medical attention.

No smoking, burning or welding is permitted in the vicinity of the acid tank, engine room and vent discharge while the cleaning is in progress. Non-sparking tools shall be used.

Sodium bicarbonate shall be used in cases of acid spills.

221-D.4 SOLUTIONS REQUIRED.

- a. Descalant Solution. The following shall be added to 300 gallons of feedwater in the mixing tank:
 - 1. Boiler Scale Removing Compound (MIL-B-24155) - 10% by weight, 300 pounds per 300 gallons feedwater.
 - 2. Corrosion Inhibitor Diethylthiourea (DETU)-provided as part of the boiler scale removing compound container.

221-D.5 BOILER AND PIPING SYSTEM PREPARATION.

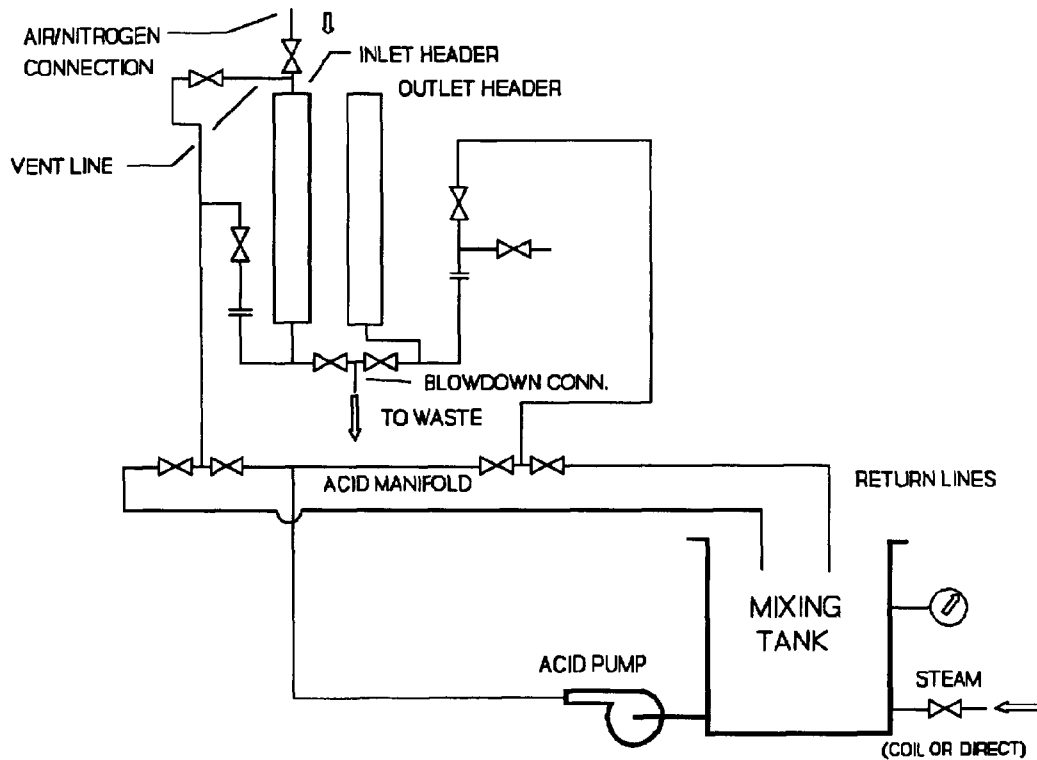
NOTE

If visual inspection of watersides reveals the presence of preservative or oil, the boiler shall be boiled out prior to chemical cleaning in accordance with NSTM 221 Boil Out Procedure ([Appendix E](#)).

WARNING

Mild steel shall be used for all valves, fittings, piping, pumps and tanks. No copper material shall be used. Ship's pumps SHALL NOT be used to pump acid.

1. Break flange to inlet and outlet header.
2. Remove all restrictor plugs from inlet header and replace with outlet header type finger plugs.
3. Locate a 500 gallon mixing tank in an open area outside on deck or pier. Mixing tank shall not be located in machinery spaces. Restrict area to essential personnel and post signs stating **NO SMOKING, OPEN FLAMES OR HOT WORK** at the tank and at the boiler.
4. Provide valves and hoses/piping to allow circulation of the acid to and from the headers as required in the cleaning procedure. A typical arrangement is shown in [Figure 221-D-2](#).
5. Provide 100 psi steam at the mixing tank.
6. Provide a valved high pressure air/nitrogen supply line (90-100 psi) to the inlet header vent.
7. Connect valved line to the inlet header and outlet header blowdown lines to serve as blow out points for solutions in the dead ends.
8. Perform a successful 150 psi hydrostatic test on the entire system (hoses and fittings included).



NOTES

1. GENERATING COIL/TUBE BANK NOT SHOWN.
2. SUPPLY AND RETURN 1-1/2-INCH ACID HOSES MUST BE PIPED DIRECTLY TO INLET AND OUTLET HEADER FLANGES FITTED WITH 1-1/2-INCH HOSE CONNECTIONS.
3. BLOWDOWN PIPING TO WASTE SHOULD BE CONNECTED TO 3/4-INCH FLANGED ACID CLEANING CONNECTIONS ON INLET AND OUTLET HEADER PIPING FOR DD-963/993 CLASS.

Figure 221-D-2. Waste Heat Boiler Chemical Cleaning Piping Schematic for DD-963/993 Class

221-D.6 PREHEAT PROCEDURE.

1. Fill the mixing tank with 300 gallons of feedwater. Heat to 180° F and maintain with steam via heating coil or by adding steam through drain connection on tank. The heating coil shall be of mild steel fabrication. If a heating coil is not used, a valved tee should be used for steam addition and mixing tank draining.
2. Fill the WHB coil with the hot water through the outlet header flange connection and return to the tank from the inlet header vent. Then reverse flow and enter hot water at inlet header flange and return to tank from the outlet header flange.
3. Circulate for 15-30 minutes, until the WHB coil is heated to 170 - 180° F. Insure the coil is hot from bottom to top by measuring tube metal temperature with a pyrometer on unfinned tube sections adjacent to the inlet header (not the header itself).

221-D.7 ACID CLEANING CYCLE PROCEDURES.

1. Secure preheat circulation. Leave the hot water in the coil until the acid is mixed.
2. In the mixing tank, prepare 300 gallons of descalant solutions.

WARNING

Scale removing compound shall be added only upon completion of filling mixing tank with feedwater. DO NOT add water to acid. Fill mixing tank with feedwater first, then add acid.

3. Preheat descalant solution to 170-180° F. **DO NOT EXCEED 180° F.**
4. Dump the preheat water from the entire system (coil, feed and return lines). Refer to [step 6](#) for system alignment for disposal. When empty, fill the coil with the descalant solution through the outlet header flange connection and return to the tank via the inlet header vent. When the coil is full, as indicated by a return at the tank, continue to circulate for 10 minutes.
5. The acid shall remain in the coil for 7 hours total time. During each hour, the acid shall be circulated for 20 minutes. During outlet to inlet header recirculation, return from header via the top vent for 10 minutes and bottom inlet flange for 10 minutes. During inlet to outlet header recirculation, return from outlet header flange for all 20 minutes. Maintain 170-180° F by heating the descalant solution during the circulation as required. Ensure that proper temperature is maintained by verifying with pyrometer during the circulations.
6. At the end of the last circulation, align the system for disposal of the descalant solution. Dispose of the spent acid in accordance with local regulations and NSTM 593. Dispose of remaining descalant solution in mixing tank prior to emptying coil, feed and return lines. Blow the descalant solution out of the coil with air or oil-free nitrogen at 90-100 psi. Assure the coil is empty by blowing out each circuit in the following order:
 1. Outlet header flange connection.
 2. Outlet header blowdown connection.
 3. Inlet header flange connection.
 4. Inlet header blowdown connection.
 5. Repeat the cycle until all of the circuits are empty.

221-D.8 WATER RINSE PROCEDURES.

1. Flush the tank with feed quality water. Dispose of this water in accordance with local regulations and NSTM 593. Add 300 gallons of feedwater and heat to 170-180° F.
2. Fill the coil with the hot water through the outlet header flange connection and return to the tank via the inlet header vent.
3. When the coil is full, continue to circulate for 20 minutes adding steam as required to maintain 170-180° F. During the last 10 minutes, reverse flow to enter the inlet header flange and return via the outlet header flange.
4. Blow the hot water out of the coil in the same manner as the descalant solution.
5. Dispose of this water and repeat the water rinse with fresh feedwater.
6. Immediately following the second water rinse, open the coil by removing all finger plugs, blanks and temporary connections in order to ensure a good dry out.

221-D.9 POST CLEANING.

1. Conduct a post cleaning inspection of watersides to determine the effectiveness of the cleaning.

NOTE

Based on this post cleaning inspection, verify cleaning effectiveness in removing adherent deposits. If appreciable adherent deposits remain, a repetitive cleaning **SHALL NOT** be conducted without notification to and authorization from the Life Cycle Manager (LCM).

2. Conduct all hydrostatic tests with water containing sodium nitrite (1 lb/100 gal).
3. During initial light-off and for the first 96 hours of steaming blowdown the separator and the headers after on the line, every eight steaming hours and after securing.

221-D.10 GENERAL NOTES.**a. Safety:**

1. Operators handling the chemicals or mixing solutions shall wear face shield, chemical workers goggles, rubber gloves, apron and boots.
2. Any chemical or solution in the eyes shall require copious flushing with water for at least 15 minutes followed by immediate medical attention. Raise eyelids during water wash.
3. Any chemicals on skin shall be flushed with water. If itching or rash occurs seek medical attention.
4. Sodium carbonate shall be available to neutralize spills.
5. No smoking, burning, or welding is permitted in the engine room or in the vicinity of the acid tanks and vent discharge while the cleaning is in progress. Non-sparking tools shall be used.
6. Adequately tie down and secure all hoses to prevent movement during operation.

- b. Records.** Maintain a log of the cleaning operations containing a description of all operations with the time of start and finish, amounts of chemicals and temperatures during all phases of the cleaning process.

- c. Disposal. Dispose of all solutions in accordance with local regulations and NSTM 593.
- d. Long lines may require more than 300 gallons of solution to fill the coil and provide a sump solution. In such cases, increase the amount of chemical proportionately (100 lb scale removing compound per 100 gallons feedwater).

SECTION D-2**CHEMICAL CLEANING PROCEDURE CARBON-MOLYBDENUM OR CHROME-MOLYBDENUM ALLOY WASTE HEAT BOILERS HYDROCHLORIC ACID METHOD****221-D.11 GENERAL.**

221-D.11.1 HYDROCHLORIC ACID METHOD OF CLEANING CARBON-MOLYBDENUM OR CHROME-MOLYBDENUM ALLOY WASTE HEAT BOILERS. This procedure is to be used with MIL-STD-796, Chemical Cleaning of Main and Auxiliary Boilers (Hydrochloric Acid Method), for the chemical cleaning of the carbon/ molybdenum and the chrome-molybdenum alloy steel generating tube bank in the waste heat boilers on SPRUANCE (DD-963) Class destroyers and Aegis (CG-47) Class cruisers. If the steam separators also require cleaning, blank off the separator from the coil and clean each component separately using identical proportions of required chemicals.

221-D.11.2 SAFETY OBSERVERS. A chemist and safety officer shall oversee the entire cleaning process including mixing, chemical injection, circulation, flushing and disposal of descalant and subsequent solutions.

221-D.12 EQUIPMENT REQUIRED.

- a. Mixing Tank. Approximately 500 gallon capacity, fabricated of mild steel with appropriate inlet and outlet fittings, shown in [Figure 221-D-1](#).
- b. Acid Pump. Centrifugal type, acid resistant, 50 gallons per minute with 20-50 psig discharge pressure.
- c. Hose. 1-1/2" ID, acid resistant, suitable for continuous service with 10% sulfamic-citric acid, rated at 150 psi.
- d. Valves. 1-1/2" connections, mild steel, gate or globe.
- e. Heating Coil (Optional). Mild steel fabrication, with appropriate valves and fittings enabling introduction and discharge of steam safely.
- f. Pyrometer. Portable, 0-250° F range.
- g. Chemical Goggles. Clear, rubber framed.
- h. Rubber Gloves. Acid resistant.
- i. Rubber Apron.
- j. Face shield.
- k. Rubber Boots.
- l. Assorted Non-sparking Tools. Including hammers, wrenches and screwdrivers, tools for repairing acid cleaning equipment.

221-D.13 CLEANING CHEMICALS REQUIRED.

- a. Hydrochloric Acid. (20 Degree Baume), Federal Specification (ASTM-E-1146).
- b. Corrosion Inhibitor. Rodine 213 or Military Specification MIL-I-17433, must be compatible with hydrochloric acid.
- c. Wetting Agent. Non-ionic detergent, Military Specification MIL-D-16791.
- d. Ammonium Bilfluoride. Technical grade, commercially available.
- e. Copper Complexer. Diethylthiourea (DETU), technical grade, commercially available.
- f. Sodium Nitrite. Technical grade, NSN 6810-00-270-3254.
- g. Disodium Phosphate. Federal Specification O-S-639.
- h. Monosodium Phosphate. American Water Works Assoc. (AWWA) ANSI/AWWA 504.
- i. Spill Absorbent. Sodium carbonate, anhydrous, technical grade, A A 59563.
- j. Nitrogen Gas. Oil-free conforming to class 1 of A A 59503 90-100 PSI.
- k. Feedwater. In accordance with NSTM 220 Vol 2.

WARNING

Hydrochloric acid can cause chemical burns if it comes into contact with skin or eyes. Also, Rodine 213 and DETU (a suspect carcinogen) are considered as moderate irritants to skin and eyes. Personnel handling these materials shall wear rubber gloves, goggles, face shields, rubber aprons and boots.

In case of skin contact, the affected area shall be thoroughly flushed with fresh water. If any acid gets into eyes, allow fresh water to flow into the opened eyes for 15 minutes and get immediate medical attention.

No smoking, burning or welding is permitted in the vicinity of the acid tank, engine room or vent discharge while the cleaning is in progress. Non-sparking tools shall be used.

Sodium carbonate shall be used to neutralize spills.

221-D.14 SOLUTIONS REQUIRED.

WARNING

Concentrated acid must be slowly added to water, otherwise a violent reaction will occur.

- a. Descalant Solution. The following chemicals shall be added to 300 gallons of feedwater in the mixing tank to provide the specified percent solution:
 1. Hydrochloric Acid. 20 Degree Baume (ASTM-E-1146) - 5% by weight, 45 gallons per 300 gallons feedwater.
 2. Rodine. 213 (MIL-I-17433) - 0.2% by volume, 0.5 gallons per 300 gallons feedwater.
 3. Wetting agent. (MIL-D-16791) - 0.1% by weight, 36 ounces per 300 gallons feedwater.
 4. Ammonium Bifluoride. 1.4% weight, 35 pounds per 300 gallons feedwater.
 5. Diethylthiourea (DETU). 1.0% by weight, 25 pounds per 300 gallon feedwater.
- b. Mild Acid Rinse Solution. The following chemicals shall be added to 250 gallons of feedwater in the mixing tank:
 1. Hydrochloric Acid. , 20 Degree Baume (ASTM-E-1146) - 0.2% by volume, 0.5 gallons per 250 feedwater.
 2. Rodine 213. (MIL-I-17433) - 0.004% by volume, 1.3 ounces per 250 gallon feedwater.
- c. Passivating Solution. The following chemicals shall be added to 250 gallon of feedwater in the mixing tank:
 1. Sodium Nitrite. - 0.5% by weight, 10 pounds per 250 gallons feedwater.
 2. Disodium Phosphate. (O-S-639) - 0.25% by weight, 5 pounds per 250 gallons feedwater.
 3. Monosodium Phosphate. American Water Works Assoc. (AWWA) ANSI/AWWA 504 - 0.25% by weight, 5 pounds per 250 gallons feedwater.

221-D.15 BOILER AND PIPING SYSTEM PREPARATION.

NOTE

If visual inspection of watersides reveals the presence of preservative or oil, the waste heat boiler shall be boiled out prior to chemical cleaning in accordance with NSTM CH 221 Boil Out Procedure ([Appendix E](#)).

WARNING

Mild steel shall be used for all valves, fittings, piping, pumps and tanks. No copper material shall be used. Ship's pumps SHALL NOT be used to pump acid.

1. Break flange to inlet and outlet header on DD-963/DDG-993 class waste heat boilers. Blank inlet and outlet header circulation water supply and return flange connection on CG-47 waste heat boilers.
2. Locate a 500 gallon mixing tank in an open area outside on deck or pier. Mixing tank shall not be located in machinery spaces. Restrict area to essential personnel and post signs stating **"NO SMOKING, OPEN FLAMES OR HOT WORK"** at the tank and at the boiler.
3. Provide valves and hoses/piping to allow circulation of the acid to and from the headers as required in the cleaning procedure. The necessary arrangement for DD-963/DDG-993 class waste heat boilers are shown in [Figure 221-D-2](#). For CG-47 class waste heat boilers, use existing 1-1/2 inch chemical cleaning connections provided on inlet and outlet headers.

4. Provide 100 psi steam at the mixing tank.
5. Provide a valved high pressure air/nitrogen supply line (90-100 psi) to the inlet header vent.
6. Connect valved line to the inlet header and outlet header blowdown lines to serve as blow out points for solutions in the dead ends.
7. Perform a successful hydrostatic test on the entire system (hoses and fittings included) at maximum available acid pump discharge pressure.
8. Install stack cover to prevent heat loss from tube bank.

221-D.16 PREHEAT PROCEDURE.

1. Fill the mixing tank with 300 gallons of feedwater. Heat to 170° F and maintain with steam via heating coil or by adding steam through drain connection on tank. The heating coil shall be of mild steel fabrication. If a heating coil is not used, a valved tee should be used for steam addition and mixing tank draining.
2. Fill the WHB coil with the hot water through the inlet header flange connection and return to the tank from the inlet header vent.
3. Circulate for 15-30 minutes, until the WHB coil is heated to 170-180° F. Verify by checking tube metal temperature of tube ends entering the outlet header with a pyrometer.

221-D.17 ACID CLEANING CYCLE PROCEDURES.

1. Secure preheat circulation. Leave the hot water in the coil until the acid is mixed.
2. In the mixing tank, prepare 300 gallons of descalant solutions.

WARNING

Hydrochloric acid shall be added only upon completion of filling mixing tank with feedwater.

DO NOT add water to acid. Filling mixing tank with feedwater first, then add acid.

Mixing tank may become HOT after the addition of acid.

3. Preheat descalant solution to 160-170° F. **DO NOT EXCEED 170° F.**
4. Dump the preheat water from the entire system (coil, feed and return lines) . Refer to [step 6](#) for system alignment for disposal. When empty, fill the coil with the descalant solution through the inlet header connection and return to the tank via the outlet header. When the coil is full, as indicated by a return at the tank, continue to circulate for 10 minutes.
5. The acid shall remain in the coil for 7 hours total time. During each hour, the acid shall be circulated 10 minutes. Maintain 160-170° F by heating the descalant solution during the circulations as required. Ensure that proper temperature is maintained by verifying with pyrometer during the circulations.

For CG-47 class waste heat boilers, alternate circulation flow of descalant solution through inlet then outlet header as follows:

1st: In the outlet header flange, return via the inlet header vent.

2nd: In the inlet header flange, return via the outlet header flange.

3rd: In the inlet header vent, return via the outlet header flange.

4th: In the outlet header flange, return via the inlet header flange.

5th: In the outlet header flange, return via the inlet header flange.

6th: In the inlet header flange, return via the outlet header flange.

For CG-47 class waste heat boilers, alternate circulation flow of descalant solution through inlet then outlet header.

6. At the end of the last circulation, align the system for disposal of the descalant solution. Dispose of the spent acid in accordance with local regulations and NSTM 593. Dispose of remaining descalant solution in mixing tank prior to emptying coil, feed and return lines. Blow the descalant solution out of the coil with air or oil-free nitrogen at 90-100 psi. Assure the coil is empty by blowing out each circuit in the following order:

221-D.18 WATER RINSE PROCEDURES:

1. Flush the tank with water. Dispose of this water in accordance with local regulations and NSTM 593. Add 300 gallons of feedwater and heat to 150-160° F. This rinse water shall not be used for mild acid rinse.
2. Fill the coil with the hot water through the outlet header flange connection and return to the tank via the inlet header vent.
3. When the coil is full, continue to circulate for 20 minutes adding steam as required to maintain 150-160° F. During the last 10 minutes, reverse flow to enter the inlet header flange and return via the outlet header flange.
4. Blow the hot water out of the coil in the same manner as the descalant solution.

221.D.19 MILD ACID RINSE PROCEDURE.

1. Prepare 250 gallons of mild acid rinse (Ph 2) solution in the mixing tank.

WARNING

Acid shall be added only upon completion of filling mixing tank with feed-water.

DO NOT add water to acid. Fill the mixing tank with feedwater first, then add acid.

Mixing tank may become HOT after addition of acid.

2. Preheat mild acid solution to 150-160° F with steam.
3. Fill the coil with the mild acid solution through the inlet header connection and return to the tank via the outlet header.
4. When the coil is full, continue to circulate for 20 minutes adding steam as required to maintain 150-160° F. During the last 10 minutes, reverse the flow to enter the inlet header flange and return via the outlet header flange.

5. Blow the mild acid solution out of the coil in the same manner as the descalant solution.

221-D.20 PASSIVATING SOLUTION PROCEDURE.

1. Rinse the mixing tank with feedwater. Dispose of this flush water in accordance with local regulations and NSTM 593.
2. Prepare 250 gallons of passivating solution in mixing tank. Add chemicals to water to avoid caking and ensure chemicals are completely dissolved.
3. Fill the coil with the passivating solution through the outlet header flange connection and return via the inlet header vent.
4. When the coil is full, continue to circulate for 20 minutes adding steam as required to maintain 150-160° F. During the last 10 minutes, reverse the flow to enter the outlet header flange and return via the inlet header.
5. Blow the passivating solution out of the coil in the same manner as the descalant solution, except that oil-free high pressure air (90-100 psi) may be used.
6. Immediately, open the coil by removing all blanks and temporary connections in order to ensure a good dry out.

221-D.21 POST CLEANING.

1. Conduct a post cleaning inspection of watersides to determine the effectiveness of the cleaning.

NOTE

Based on this post cleaning inspection, verify cleaning effectiveness in removing adherent deposits. If appreciable adherent deposits remain, a repetitive cleaning **SHALL NOT** be conducted without notification to and authorization from the Life Cycle Engineering Manager (LCEM).

2. Flush tubes with high velocity feedwater containing sodium nitrite (1 lb/100 gal) to remove residual deposits if present. Flush each tube individually.
3. Conduct all hydrostatic tests with water containing sodium nitrite (1 lb/100 gal)
4. During initial light-off and for the first 96 hours of steaming, blowdown the separator and the headers after on the line, every eight steaming hours and after securing.

221-D.22 GENERAL NOTES.

a. Safety:

1. Operators handling the chemicals or mixing solutions shall wear face shield, chemical workers goggles, rubber gloves, apron and boots.
2. Any chemical or solution in the eyes shall require copious flushing with water for at least 15 minutes followed by immediate medical attention. Raise eyelids during water wash.
3. Any chemicals on skin shall be flushed with water. If itching or rash occurs seek medical attention.
4. Sodium carbonate shall be available to neutralize spills.

5. No smoking, burning, or welding is permitted in the engine-room or in the vicinity of the acid tanks and vent discharge while the cleaning is in progress. Non-sparking tools shall be used.
 6. Adequately tie down and secure all hoses to prevent movement during operation.
- b. Records. Maintain a log of the cleaning operation that contains the following:
1. Description of all operations, time of start and finish, amounts of chemicals and temperatures.
 2. Initial acid concentrations entering the coil and the temperature.
 3. Hourly record of the acid concentration and the temperature during circulations.
- c. Disposal. Dispose of all solutions in accordance with local regulations and NSTM 593.
- d. Hose Length. Long lines may require more than 300 gallons of solution to fill the coil and provide a sump solution. In such cases, increase the amount of chemical proportionately (14 gallons of hydrochloric acid descalant solution per 100 gallons feedwater).

APPENDIX E

BOILING OUT

221-E.1 GENERAL.

221-E.1.1 NORMAL BOIL-OUT. The standard boil-out procedure described here should be used when normal boil-out is required. If deposits are hard and baked-on the tube surfaces, a special degreasing procedure can be performed before the standard boil-out procedure; contact NSWCCD-SSES CODE 614 for guidance. The standard procedure is for boiling out both the boiler and economizer together. When major boiler tube renewal has been accomplished exclusive of the economizer, however, boil-out of the boiler only can be performed. A procedure for boiling out the superheater is described in [paragraphs 221-E.3 through 221-E.3.5](#). Refer to [paragraphs 221-2.6.8 through 221-2.6.11](#) for information concerning inspection of the boiler for oil contamination and evaluation of inspection results.

221-E.2 STANDARD BOIL-OUT PROCEDURE FOR BOILER AND ECONOMIZER.

This procedure employs a nominal 3.0 percent solution of trisodium phosphate and sodium metasilicate containing 0.1 percent by volume of a nonionic wetting agent to remove organic contaminants from the boiler watersides. Some variations in the boil-out procedure may be required depending on boiler conditions, piping arrangement, and available equipment. If inspection of the boiler reveals a heavy accumulation of soft waterside deposits, mechanical cleaning of tubes before attempting boil-out shall be accomplished. For an effective boil-out, the chemicals shall be completely dissolved and the solution temperature maintained in the range of 150° C to 165° C (300° F to 325° F) during the boil-out.

WARNING

Trisodium phosphate and sodium metasilicate are highly alkaline chemicals that can cause burns to the skin and eyes. Affected personnel shall flush the skin with large amounts of water; for eyes, flush with potable water for at least 15 minutes, lifting upper and lower lids, and obtain immediate medical attention. Use of dust mask, face shield, chemical worker's goggles, rubber gloves and rubber apron is mandatory when handling these chemicals and the wetting agent.

221-E.2.1 CHEMICALS REQUIRED. For each 1,000 gallons of feedwater used, the chemicals listed below are required. (Refer to [Appendix A](#) for stock numbers). Water capacity is to be calculated based on the volume of the completely filled boiler and economizer.

- a. 120 pounds of anhydrous trisodium phosphate (TSP)
- b. 120 pounds of sodium metasilicate
- c. Two quarts of non-ionic wetting agent.

NOTE

If sodium metasilicate is unavailable, boil-out may be accomplished using only TSP and -the wetting agent. In this case, use 200 pounds of TSP and 2 quarts of wetting agent per 1,000 gallons. TSP boil-out formulation may be less effective than TSP/metasilicate.

221-E.2.2 EQUIPMENT AND SERVICES REQUIRED. The following equipment is used for both standard boil-out and degreasing. See [Figure 221-E-1](#) for the equipment arrangement.

- Chemical mixing tank (1,500 gallon capacity with heating coil) located on pier.
- Emergency feed pump or portable pump with sufficient capacity and head to pump the hot alkaline boil-out solution into the boiler and economizer at a rate of 50 to 100 gpm.
- Steam source at 75 to 150 psig.
- Steam hoses (1-1/2 or 2 inch) of sufficient length to connect the steam source to the bottom blow hose connection and to the chemical mixing tank.

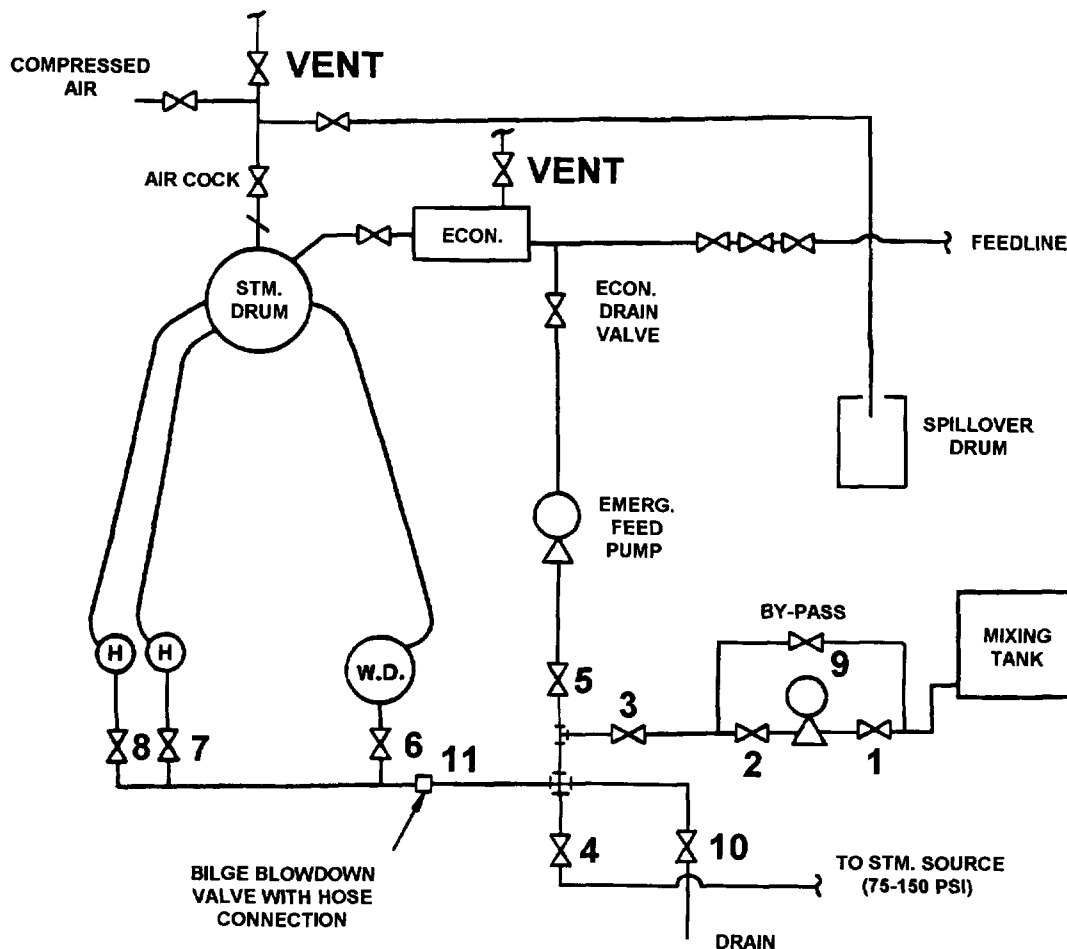


Figure 221-E-1. Piping Diagram for Boiling-out Boiler and Economizer

221-E.2.3 BOILER AND PIPING SYSTEM PREPARATION. Numbers in parenthesis refer to fittings shown on [Figure 221-E-1](#).

1. Connect a 1-1/2 or 2--inch pipe cross to the hose connection on the boiler bottom blow system valve (11). Attach the steam supply with valve (4) to 1 cross opening. Attach the drain line with valve (10) to another cross opening. Attach a tee with 2-valves (3 and 5) to the remaining cross opening. Connect hoses from the suction side of the emergency feed pump or portable pump to valve (5) and from the pump discharge to the economizer inlet header drain valve. If the economizer inlet header has no drain valve, connect the hose to the vent. Connect hoses from the discharge side of the portable mixing tank pump to valve (3) and from the pump suction to the mixing tank. Provide a bypass with required valves (1, 2 and 9) around the portable pump. Provide steam supply to the chemical mixing tank.
2. At the boiler air cock, connect a 1/2-inch hose or tubing and run it to the spillover tank. Also, connect a compressed air line with a valve as shown on [Figure 221-E-1](#) to the steam drum and economizer.

WARNING

Adequately tie down and secure all steam and rubber hoses to prevent movement during operation.

3. Install a metal blank in the feed line at the economizer inlet at the last flange before inlet header to isolate the unit from the feed system.

NOTE

Feedline valves are not to be used for blanking purposes.

4. Blank-off the superheater inlet with a wooden or rubber plug in the steam drum, and secure the valve at the outlet. Fill the superheater with feedwater and maintain full during boil-out.
5. Remove girth baffles or apron plates in the steam drum to allow circulation of the boil-out solution through all tubes. The baffles or plates can be loosely stacked in the steam drum for cleaning or completely removed from the boiler and cleaned separately with boil-out solution. The latter may prove most effective for cleaning all internals if heavy deposits are present, since obstructed sections of the internals may not be reached for effective cleaning by the boil-out solution if the internals are stacked in the drum. If desuperheater and feed lines shall be removed to accomplish the above, the desuperheater drum connections should be blanked off before boil out.
6. Close the boiler and hydrostatically test at 150 psig.

221-E.2.4 BOIL-OUT PROCEDURE. See [Figure 221-E-1](#).

1. After a successful hydrostatic test, open the air cock and valve (10). Allow the water level to drop to mid-point on the sight glass. Secure valve (10).
2. Transfer approximately 1,000 gallons of the water remaining in the boiler to the mixing tank. This can be accomplished by applying oil free air at approximately 50 psig to the boiler air cock. The protection steam source can also be employed to force water from the boiler. With protection steam, the air cock shall be closed. Ensure that the water is transferred to the mixing tank through the bypass around the pump. This shall be accomplished by closing valves (1) and (2) and opening valve (9). When approximately 1,000 gallons of water have been transferred, close valve (9).
3. Heat the water in the mixing tank to $70^{\circ}\text{C} \pm 6^{\circ}\text{C}$ ($160^{\circ}\text{F} \pm 10^{\circ}\text{F}$). Add the required amounts of chemicals and ensure that they are dissolved. The wetting agent shall be added last to prevent excessive foaming.
4. Open valves (1, 2, 3, 6, 7, 8, and 11). Verify that valves (4 and 5) are secured. Pump the solution into the boiler. When the mixing tank is empty, close valves (3, 7, and 8). Close the air cock and economizer vents.
5. Open valve (5) and start the emergency feed pump or portable pump. Re-circulate the solution from the gen-

erating bank to the economizer for 10 minutes. Close valve (6), open valve (7), and re-circulate for 5 minutes; then secure valve (7), open valve (8), and re-circulate for 5 minutes.

6. Secure the emergency feed pump or portable pump, close valve (5), and open valves (6 and 7). Crack open the valve on the air cock vent to vent air. Open valve (4) to inject steam into the boiler through valves (6, 7, and 8). When the boil-out solution reaches about 150° C (300° F) at 50 psig, close the vent valve, if open, and crack open the spillover line valve to permit oil which has risen to the highest areas during heating to drain to the spillover tank.
7. Close steam valve (4), the air cock valve, and the spillover valve. Open valve (5) and light-off the emergency feed pump or portable pump. Recirculate the boil-out solution for 1/2 hour through the boiler and economizer. Secure the pump and valve (5). Crack open the air cock valve.
8. Open valves (4 and 11) and inject steam into the boiler for 1 hour. Close valve (6) so that steam is directed through valves (7 and 8). Continue injecting steam for 1/2 hour. Make certain the pressure is maintained between 50 and 100 psig. Close valve (4) (steam) and open valve (6)
9. Close the air cock and open valve (5). Start the emergency feed pump. Recirculate the solution through the boiler and economizer for 1/2 hour. Throttle the spillover valve to allow a slight run-off into the spillover tank while the steam supply is open to the boiler. This is necessary to avoid recontamination of circuits by oil. Secure the spill-over valve when steam is not in use.
10. Continue to boil-out as described in [steps 8 and 9](#) for 20 hours from the time the solution temperature in the boiler reached 150° C (300° F) at 50 psig.
11. Dump the solution by applying air pressure. Disposal shall be according to NSTM Chapter 593, Pollution Control. Do not pump the hot solution to the bilges.
12. Fill the boiler and economizer with hot feedwater, about 60° C (140° F). Using the emergency feed pump or portable pump, recirculate the water through the boiler and economizer for 1/2 hour.
13. Dump the boiler and refill it with hot, 60° C (140° F) feedwater. Recirculate the water for an additional 1/2-hour and dump. Take a sample of the effluent and add a few drops of phenolphthalein indicator. If a pink color appears, continue the flushing operations until the rinse solution is neutral (no pink color) to the indicator.
14. Open the boiler for inspection.
15. Dump the superheater and obtain a water sample and test as in step 13. Continue to refill and dump the superheater until the rinse solution is neutral.

221-E.2.5 ALTERNATIVE MIXING PROCEDURE. Dissolving chemicals in the steam drum is no longer permitted. If the ship's force is performing the boil-out and the 1,500 gallon mixing tank is unavailable, the use of trisodium phosphate and wetting agent (without sodium metasilicate) is permissible, although cleaning time may be extended. The 30-gallon plastic mixing tank described in the EDTA waterside cleaning procedure of [Appendix C](#) can be used to dissolve the trisodium phosphate. Batches to trisodium phosphate shall contain no more than 45 pounds of trisodium phosphate per 25 gallons of water. After completely dissolving each batch of the chemical, the tank solution is fed by gravity using a rubber hose connected to the boiler air cock and introduced in to the steam drum. Add the wetting agent to the first trisodium phosphate has been introduced, disconnect the hose and plastic mixing tank. Inject steam into the boiler through the bottom blow system. Proceed with steps 5 through 13.

221-E.2.6 INSPECTION AND ADDITIONAL CLEANING PROCEDURE.

1. Open the boiler and flush out the tubes, drums, (including gauge glass through drum penetrations) and headers with a high velocity stream of feedwater before the watersides have had time to dry.
2. After the flush and dry out, inspect the waterside surfaces including the steam drum, water drum, headers and tubes. Determine the necessity for mechanically cleaning tubes based on the extent of waterside deposits present. Remove any oil traces in the drums or headers by wiping with Turkish toweling or absorbent rags.

3. If inspection reveals the boiler watersides have not been satisfactorily cleaned, the boil-out procedure shall be repeated.

221-E.3 BOIL-OUT PROCEDURE FOR SUPERHEATER.

This procedure may be required when severe oil contamination of the boiler has occurred for a prolonged period. If tube deposits are thick, mechanical cleaning of the tubes shall be performed before boil-out where accessible. Some types of superheaters with sharp tube bends cannot be mechanically cleaned. Superheater boil-out is accomplished by circulation of a 95° C to 100° C (200° F to 210° F) trisodium phosphate and sodium metasilicate solution through the superheater for a 12-hour period to remove organic tube deposits. The superheater unit is not actually filled with the solution and then boiled as is the case with the boiler since the small size of the unit would cause excessive boil-off of the solution, resulting in an ineffective cleaning.

WARNING

Trisodium phosphate and sodium metasilicate are highly alkaline materials that can burn the skin and eyes. Affected personnel shall flush the skin with large amounts of water; for eyes, flush with potable water for at least 15 minutes and obtain immediate medical attention. Use of dust mask, face shield, chemical worker's goggles, rubber gloves and rubber apron is mandatory when handling these chemicals and the wetting agent.

221-E.3.1 CHEMICAL REQUIRED. For each 100 gallons of feedwater required to completely fill the superheater, add the following chemicals. (Refer to [Appendix A](#) for stock numbers.)

- a. Twelve pounds of anhydrous trisodium phosphate
- b. Twelve pounds of sodium metasilicate
- c. One-half pint of non-ionic wetting agent.

221-E.3.2 EQUIPMENT AND SERVICES REQUIRED. See [Figure 221-E-2](#).

- a. Mixing tank of approximately 100-gallon capacity. Two 50-gallon drums connected by a pipe at the bottom can be used.
- b. Pump with sufficient capacity to pump the hot alkaline solution into the superheater at a rate of 50 to 100 gpm.
- c. Steam source at 50 to 100 psig.
- d. Steam hose (1-inch) of sufficient length to connect the steam source to the mixing tank and the superheater outlet (only if vertical type superheater is to be cleaned)
- e. Reinforced rubber hose or steam hose (1-1/2 inch) capable of withstanding circulation of 95° C to 100° C (200° F to 210° F) alkaline solution. Sufficient length is required to connect the mixing tank to the inlet superheater header and outlet superheater header back to the mixing tank.
- f. Heating coil fabricated from 20 feet of 3/4-inch copper tubing for insertion in mixing tank.

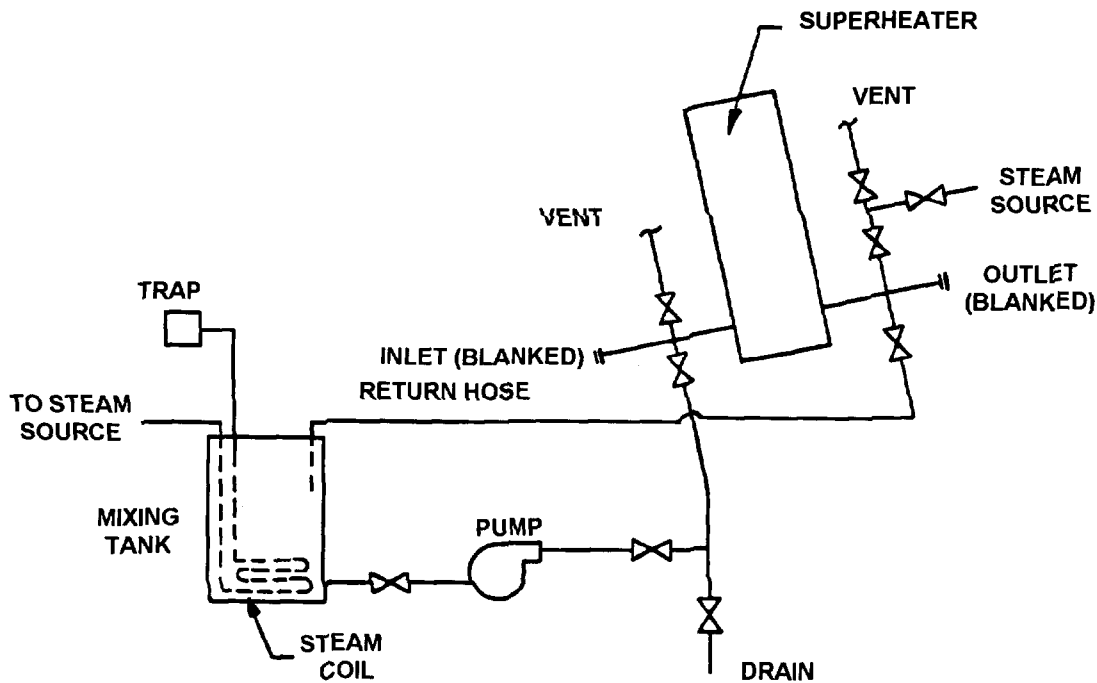


Figure 221-E-2. Piping Arrangement for Horizontal Superheater Boil-out

221-E.3.3 SUPERHEATER AND PIPING SYSTEM PREPARATION. See [Figure 221-E-2](#).

1. Isolate the superheater by installing an expandable pipe plug at the steam drum outlet and securing the main steam stop with a downstream telltale drain open.
2. Connect hoses between the mixing tank, pump, and superheater as shown.

WARNING

Adequately tie down and secure all hoses to prevent movement during operations.

3. Perform a hydrostatic test at 100 psig.

221-E.3.4 SUPERHEATER BOIL-OUT PROCEDURE. See [Figure 221-E-2](#).

1. Fill the superheater with 95° C to 100° C (200° F to 210° F) feedwater.

NOTE

Difficulties can be encountered in completely filling vertical superheaters. To alleviate the problem, supply steam to the superheater for 1/2 hour to vent the air. **After securing the steam, immediately fill the superheater with hot feedwater.**

2. Add feedwater to the clean mixing tank to approximately 1/3 capacity. Circulate the feedwater through the superheater and back to the tank.
3. Slowly add the required amounts of chemicals to the mixing tank while the water is circulating through the tank. Break up any caked chemicals into small pieces before adding them to the water. After the chemicals are completely in solution, add the prescribed amounts of wetting agent. Adding the detergent last will prevent excessive foaming.
4. After the addition of all chemicals, continue to recirculate for 1/2 hour. Heat the solution with the steam coil in the mixing tank during recirculation.
5. Continue the cleaning operation for 12 hours. Recirculate for 1/2 hour at hourly intervals.
6. Comply with local, state, and federal pollution laws when disposing of expended chemicals.
7. Refill the superheater with feedwater and recirculate for 1/2 hour. Discharge flush water.
8. Apply 2 additional fills of feedwater to the superheater and recirculate for 1/2 hour each. Check the effluent of the third flush with phenolphthalein. If the water turns pink with this indicator, continue to flush until the water is neutral to phenolphthalein (no color)

NOTE

For vertical superheaters, dump the boil-out solution and rinse water by applying steam pressure to obtain a more complete flush of the system.

221-E.3.5 FINAL INSPECTION AND CLEANING. Open the superheater steamsides after final flush and inspect the header and tube surfaces. Flush with a high velocity stream of feedwater if excessive deposits are present.

APPENDIX F**WATER-WASHING OF BOILER FIRESIDES****221-F.1 GENERAL.****NOTE**

This procedure shall only be accomplished after approval by the NSWCCD-SSES.

221-F.1.1 CONSIDERATIONS. When waterwashing, consideration should be given to the following:

- a. Only areas of gross contamination should be waterwashed.
- b. There should be sufficient fresh water available.
- c. All electrical equipment around or under the boiler should be protected.
- d. The combination of soot and water forms acid which is corrosive to drums and tubes. Successful waterwashing requires the removal of all deposits from tubes, headers, and drums. After waterwashing, the boiler shall be lighted off immediately to dry out the brickwork and any moist areas, as described in [paragraph 221-F.5.2](#).

221-F.1.2 METHOD OF WATERWASHING. Waterwashing shall be accomplished with a water-jet machine using freshwater at 500-5,000 psig as needed.

CAUTION

Sodium nitrite should not be added to the water since it can form toxic fumes hazardous to personnel when in contact with fireside deposits.

221-F.2 PREPARATIONS FOR WATERWASHING.

1. Open or remove access doors and panels to provide access to the firesides and drainage from around drums and headers; the furnace should be drained by means of a drain hole in the furnace floor, if installed. It may be desirable to loosen rather than remove certain panels, to reduce splashing adjacent machinery or personnel. Line up a bilge and stripping pump or portable bilge pump for pumping the waste water into the contaminated oil tank or other receiving tank for disposal according to NSTM Chapter 593, Pollution Control.
2. A 3-degree list shall be placed on the ship in the direction of the side of the boiler with the access panels removed or in the direction of the deck drain, to allow for controlled drainage of the wash water.
3. Install canvas, plastic or rubberized sheeting (similar to Herculite) shields or gutters where practical to reduce wetting the refractories or boiler. When washing an economizer, installing canvas under the economizer and directing the water through the side casings can protect the boiler.
4. Refractory corbels at the water drums should be protected as much as possible to prevent water from flowing between the corbel and the drum. Silicone Rubber (RTV) may be applied to seal the expansion joints, void or cracked areas prior to water washing and then removed upon completion. A typical rubber-gasketed drain pan

is shown in [Figure 221-F-1](#). The pan slides into place between the top of the corbel and the bottom of the first row of tubes where they enter the water drum. Three large C clamps are used to secure the pan in place with one at each end of the pan and one in the center. The gasket shall be tight against the water drum to prevent leakage. A 1-1/2-inch hose is then connected to a nipple brazed to the center of the pan, and the hose is led outside the furnace to the bilge and stripping pump. Wastewater is pumped into the contaminated oil tank or container for disposal.

5. Personnel using the water-jet machine shall be provided with gloves, goggles, slickers, respiratory masks for toxic dusts, and other such equipment as advisable to avoid being injured with high- pressure water and to prevent any possible toxic effects of the waste water. Personnel qualifications for Water-jet cleaning, discussed in [paragraph 221-2.6.4](#), are applicable for all cleaning applications including fireside cleaning.
6. Provide litmus paper for testing the waste water for acidity. Acid from scale or soot turns litmus paper red. Continue flushing until litmus paper indicates neutral wastewater.
7. Rig plastic, rubberized sheeting (Herculite) or canvas over electrical equipment and machinery likely to be splashed during water washing.

221-F.3 WATERWASHING SEQUENCE.

Unless the boiler is adequately protected, everything below the point of initial washing should be thoroughly water washed to prevent the possibility of acid corrosion. Start at the top and systematically work down to the furnace.

221-F.4 INDIVIDUAL COMPONENTS.

The following paragraphs give instructions for washing individual boiler components or areas.

221-F.4.1 ECONOMIZERS. When economizers are to be washed, apply the waterwash at 500 to 5,000 psig as needed over the top of the tubes, until the economizer surfaces are clean. Repeat the washing until satisfactory cleanliness has been obtained throughout the economizer.

221-F.4.2 SUPERHEATERS. Apply the water-wash at 500 to 5,000 psig as needed to various parts of the superheater from the furnace superheater cavity, or from the casings when doors or access panels are removed.

221-F.4.3 GENERATING TUBES. Apply the water wash at 500 to 5,000 psig as needed to the various parts of the bank. Access may be had from inside the furnace, from the end casings when doors or panels are removed, and from the outer side of the banks.

221-F.4.4 SIDE AND REAR WATERWALL FURNACE TUBES. Side and rear waterwall furnace tubes shall not be water-washed.

221-F.5 POST-WASHING PROCEDURES.

The following paragraphs apply after boilers have been water washed.

221-F.5.1 CHECK FOR ACIDITY. After washing is completed, check the water drained off from the boiler with litmus paper. Wash down portions of the casing and bilges where wash water has drained to clear off acidic water accumulations.

221-F.5.2 DRYING THE BOILER.

1. Immediately upon completion of water washing, carefully drain all excess water from the boiler and remove scale deposits on drums, in casing corners, and on refractories. Close up the boiler and prepare for and light-off using the smallest sprayer plate and minimum fuel pressure. After fires are lighted, maintain minimum firing rate for 2 hours and secure fires for a period of not less than 2 hours to allow the moisture in the refractories to evaporate. This total 4-hour period may be sequenced into 15-minute intervals of light off time and 15 minutes of secured time.
2. During the drying out period, use superheater protection steam and drains to ensure a flow through the superheater at all times. The main and auxiliary steam stops shall not be opened. If the boiler pressure builds up to line pressure, open the superheater protection steam valve and the drain valves farther to lower steam pressure.
3. After the drying out period, the boiler shall be allowed to cool sufficiently to allow the boiler to be opened for inspection of the refractories. Particular attention should be given to the refractory corbels and for any signs of shrinkage or damage caused by too rapid evaporation of the water. Several bricks should be removed to check the dryness of the floor. Subsequently, when firing the boiler while underway, a close watch should be kept to ensure that no damage has been done to the refractories. After the inspection has been completed and the furnace shows no signs of brickwork damage, the boiler shall either be placed in a dry lay-up status or lighted-off and placed on the line. Test the water according to NSTM Chapter 220, Volume 2, Boiler Water/Feedwater Test and Treatment.

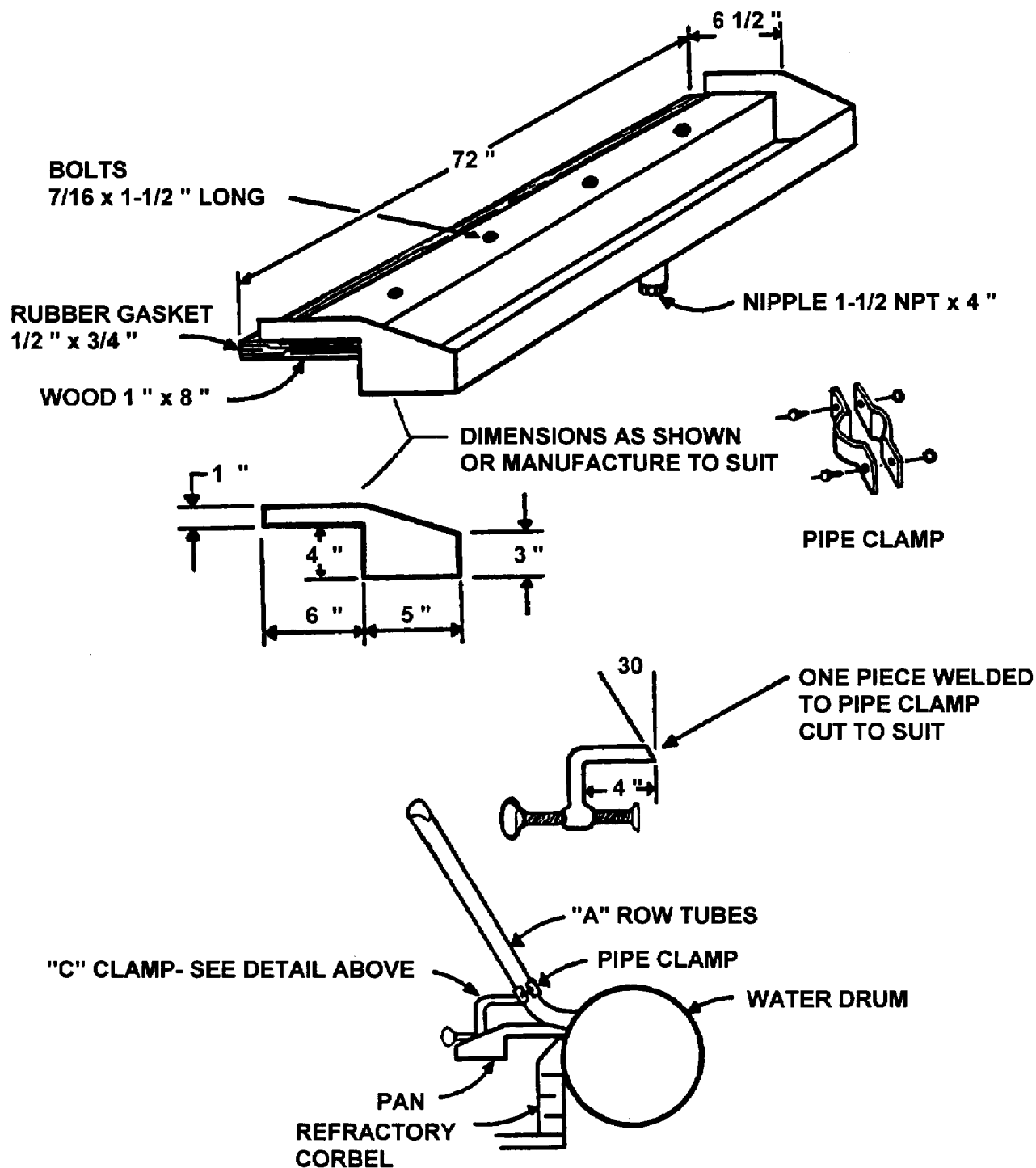


Figure 221-F-1. Drain Pan

APPENDIX G

BURNER BARREL HYDROSTATIC TEST

221-G.1 GENERAL

221-G.1.1 PROCEDURES FOR HYDROSTATIC TEST OF BURNER BARRELS. The following paragraphs describe in detail the burner barrel hydrostatic test. Read paragraphs and observe all safety precautions before proceeding with the actual procedures.

221-G.1.2 DESCRIPTION OF HYDROSTATIC TEST BENCH. See [Figure 221-G-1](#). All parts shall be permanently mounted on the test bench. As discussed in [paragraph 221-3.1.2](#), when the term burner barrel is used, it refers to the atomizer assembly without the sprayer plate(s) or without cartridge assemblies for vented plunger burners. Water shall be used as the test medium.

221-G.1.3 PIPE SIZES AND FITTING REQUIREMENTS. Use CRES (stainless steel) tubing and fittings to prevent introducing corrosion products into tested burner barrel assemblies. Tubing from the water tank to the suction side of the hydrostatic pump will be 1/2-inch stainless steel, and tubing from the discharge side of the hydrostatic pump to the drain (f-5 of [Figure 221-G-1](#)) will be 1/4-inch stainless steel.

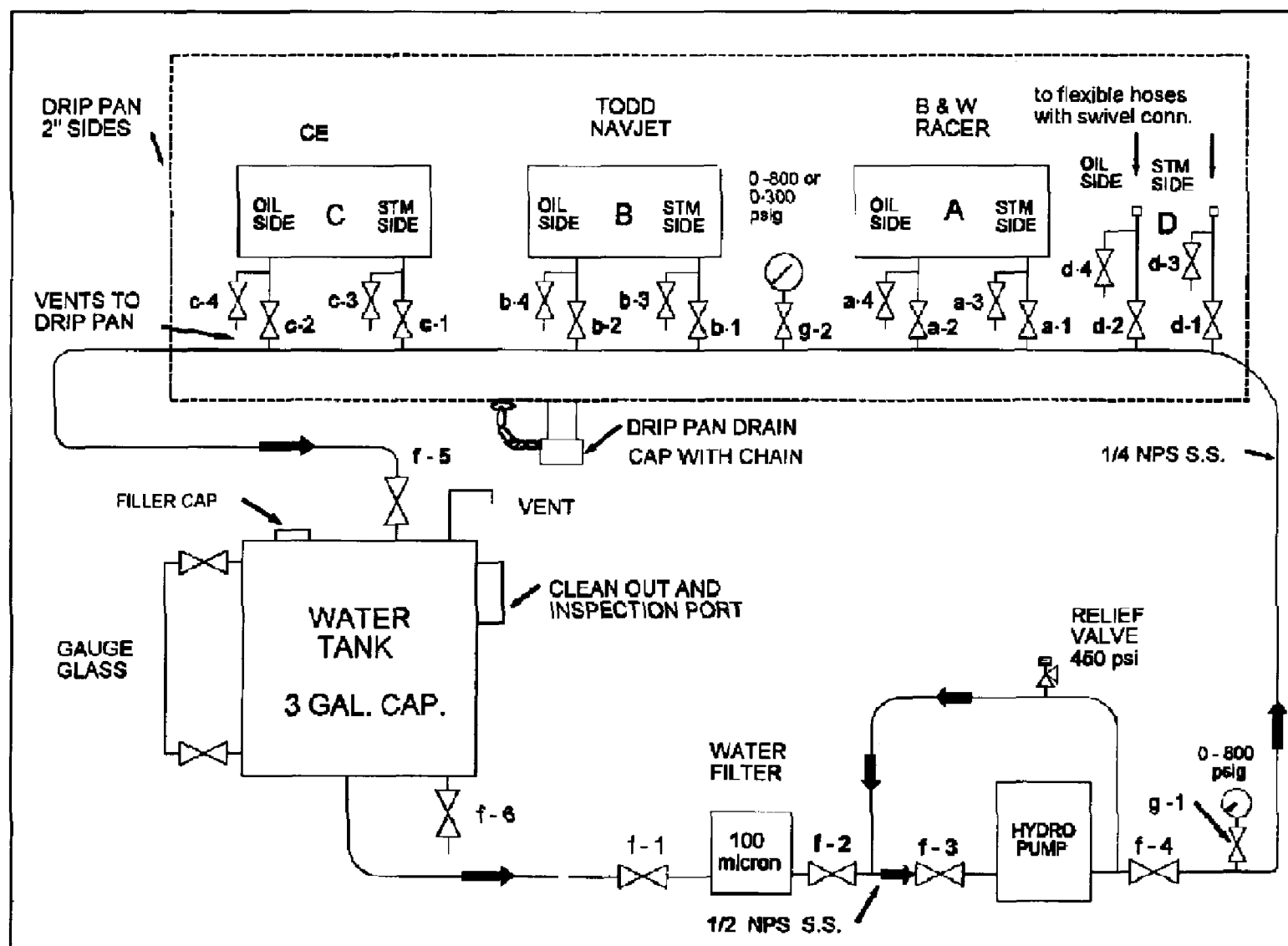


Figure 221-G-1. Burner Barrel Test Bench Schematic

221-G.1.4 TEST GAUGES. Three test gauges (Two with a 0 to 800 psig range and one with a 0 to 300 psig, range, graduated in 10 pound increments and a maximum error of 10 psig) are required. To prevent damage to the gauges from sudden pressure changes, gauge snubbers shall be installed. The gauges shall be calibrated every 6 months or when calibration is suspected. Calibration shall be according to NSTM Chapter 504.

221-G.1.5 HYDROSTATIC TEST PUMP. The pump shall be of the type covered in Section P of Navy main boiler technical manuals. The test pump shall be a Sprague Products Model S-440, series model S216C-10, or the equivalent. The relief valve shall be a Sprague 200 to 4,000 psig valve, manufacturer's part number 005-023C-3, or the equivalent. Some hydrostatic test pump repair parts are available in the Navy supply system; refer to 46469 . . . series APLs.

221-G.1.6 STRAINER. There shall be a 100 micron strainer installed in the pump suction piping. The strainer shall be a NUPRO Company model SS-8TF2-140 or equivalent. It is imperative that the strainer mesh be no finer, since that might impede the gravity feed from the water tank.

221-G.1.7 SAFETY SHUTOFF DEVICE. The Intermediate Maintenance Activity Repair Officer shall make the final determination of the type of burner safety shutoff devices permanently mounted on the test stand. Consideration should be given to the number of each type of burner the repair activity is asked to test. A permanent safety shut-off device installation shall, however, include at least three of the following:

- a. Babcock & Wilcox 350-psi Racer
- b. Combustion Engineering 350-psi Wallsend
- c. NAV-JET (same as some VP with Todd burners)
- d. Babcock & Wilcox Mechanical
- e. Single port Todd (CV-67 only)

221-G.1.8 DRIP PAN. The drip pan shall be constructed with a minimum sidewall of at least 2 inches and shall extend under all four burner stations. The purpose of the drip pan is to collect the water from the burner tip during venting and disassembly procedures. It shall have a drain complete with threaded cap and chain attached to the drip pan to facilitate draining the drip pan.

221-G.1.9 FLEXIBLE HOSES. Flexible hoses shall be used for safety shut-off devices that are not permanently mounted on the test stand. Flexible hoses shall be equipped with suitable plugs to be installed in the ends of the hoses when that station is not in use. The flexible hoses shall be Aeroquip FC-300 1/4 inch or equivalent, with 2,000 psig minimum burst pressure and 8,000 psig maximum burst pressure.

221-G.2 BOILER HYDROSTATIC TEST BENCH MAINTENANCE.

For hydrostatic test pump maintenance and recommended periodicity, refer to Section P of a main boiler technical manual and the manufacturer's maintenance instructions for the pump installed. Requirements for periodic system maintenance are given in the following paragraphs.

221-G.2.1 INITIAL CONSTRUCTION/INSTALLATION.

1. Flush the system to ensure that there is no welding slag or debris in the system.
2. Calibrate two 0 to 800 psig test gauges and one 0-300 psig gauge according to NSTM Chapter 504.
3. With the two 0-800 psig gauge installed hydrostatically test the system to 135 percent of normal operating pressure (540 +7 -0 psig) according to NSTM Chapter 505. The relief valve shall be readjusted to accomplish this test.

221-G.2.2 FIVE-YEAR PERIODS. Hydrostatically test the system to 135 percent of normal operating pressure (540 +7 -0 psig) according to NSTM Chapter 505. The relief valve shall be readjusted to accomplish this test.

221-G.2.3 SEMI-ANNUALLY.

1. Hydrostatically test the system to 100 percent normal operating pressure (400 +5 -0 psig), and inspect the system for leaks.
2. The relief valve shall be tested to lift at 450 +5/-0 psig (oil side pressure). The setting will be readjusted by personnel conducting steamside or auxiliary boiler atomizer testing in accordance with [paragraph 221-G.6](#) and [paragraph 221-G.7](#) as required.
3. Calibrate the gauges according to NSTM Chapter 504.
4. Drain and flush the entire water system. Open, inspect, and clean out the water tank. Open, inspect, and clean or replace the filter. Refill the system with fresh water.

221-G.2.4 DAILY. When system will not be used daily, drain system. Inspect system for corrosion prior to refilling. Refill prior to use.

NOTE

Burner barrel hydrostatic tests shall be accomplished only at an authorized test facility. The Work Center Supervisor shall witness and approve the test of each atomizer. Supervisors unfamiliar with fuel oil burners operation shall consult with ships force or local SGPI for assistance prior to witnessing testing.

221-G.3 BURNER BARREL HYDROSTATIC TEST - GENERAL.

This procedure provides guidance to authorized repair facilities for hydrostatically testing fuel oil burner barrels. The objective of the test is to ensure that the burner barrel tightness and integrity has been restored following overhaul of the atomizer assembly. Conduct this test at intervals specified on the ships' boiler Maintenance Index Page.

221-G.3.1 EQUIPMENT. The following test equipment is required:

1. One 6 inch straight edge
2. One hydrostatic test bench (see [Figure 221-G-1](#))
3. Rags
4. Eye shield

221-G.3.2 REPORTING REQUIREMENTS. Two copies of the test report (as shown in [Figure 221-G-2](#)) shall be completed, one to be retained by the test facility and the other retained by the ship until the next hydrostatic test report on the individual burner barrel is received.

WARNING

All personnel conducting the hydrostatic test shall wear eye shields to avoid injury in case of a spray of high-pressure water.

221-G.3.3 TEST PROCEDURE. Burner barrel hydrostatic test procedures are described in the following paragraphs.

221-G.4 SAFETY SHUTOFF DEVICE.

1. Ensure that the safety shutoff device matches the burner barrel to be tested. If the burner barrel is not compatible with the permanently mounted safety shutoff devices on the test bench, a compatible safety shutoff device shall be provided by the ship and connected to the flexible hoses (Figure 221-G-1) on hydrostatic test station D. Safety shut-off device suitable for testing auxiliary boiler NAV-JET atomizers (LSD-41Class) is available under NSN 4530-01-349-7635.
2. Inspect the burner head and ensure that it is in good condition. If seating surfaces are scarred or gouged, repair or replace the safety shutoff device.

221-G.5 TEST SETUP.

1. Each burner barrel delivered to the authorized test facility shall be permanently marked, using a die stamp, by the test facility or the ship submitting the burners to ensure that each burner barrel is properly tested and to allow each hydrostatic test report to be tracked with each burner barrel.
2. Visually inspect the following seating surfaces on burner barrel ends as applicable:
 - a. Outer barrel end
 - b. Inner barrel end
 - c. Blank sprayer plate seating surfaces for outer barrel, inner barrel and tip nut.
 - d. Burner tip nut or blank tip nut.
3. Inspect burner barrel length.
4. Remove gouges, scratches, nicks, and other defects from machined surfaces by hand lapping. Refer to manufacturer's drawing for design tolerances on burner barrel being tested. Do not remove more than 1/64th of an inch from the design barrel length. In situations where barrels cannot be replaced, which require more machining than 1/64th of an inch, contact NSWCCD-SSES for an analysis of the specific tolerances of the burner design as they relate to burner settings as maintaining seal integrity.

Assemble the burner barrel with a blank sprayer plate or blank burner tip.

NOTE

Teflon tape is not authorized for use with Combustion Engineering 350 psi floating outer barrel designs. Previously, when hydrostatically testing Combustion Engineering 350 psi welded outer barrel steam burner barrel designs, Teflon tape was used to provide a positive seal between the burner barrel and the tip nut.

221-G.6 HYDROSTATIC TEST OF BURNER BARREL - FUEL SIDE.

1. With the burner barrel installed in the appropriate station, ensure correct system alignment. Refer to hydrostatic test bench schematic (Figure 221-G-1). Make sure the correct range pressure gauge is installed at location g-2.
2. Example: With the burner barrel to be tested installed in station A:
 - a. Ensure that the following valves are closed: f-5, f-6, d-1, d-2, d-3, d-4, c-1, c-2, c-3, c-4, b-1, b-2, b-3, b-4, a-1, a-4, a-3 (a-3 for straight mechanical burner system)
 - b. Ensure that the following valves are open: f-1, f-2, f-3, f-4, g-1, g-2, a-2, a-3 (a-3 for steam atomization burner system)
3. Ensure that the water level in the water tank is at the top of the sight glass.
4. Open valve f-5 two turns.
5. Ensure that the hydrostatic pump air regulator compression screw is backed out completely and the air cut-out valve to the pump is closed. Line up low pressure (LP) air to the pump and ensure that there is sufficient LP air available. Normally 75 psig will be sufficient.
6. Open the LP air inlet valve to the pump. Slowly turn the compression screw of the air regulator clockwise to admit air to the pump. Establish a minimum water flow through the pump to purge the system of air.
7. Loosen the tip nut sufficiently to bleed air out of the burner barrel. As soon as the air is expelled from the burner barrel tighten the tip nut. Wipe up any water spilled when venting the burner barrel.

NOTE

If specially ported blanks are used venting can be accomplished by opening the applicable valve instead of loosening the tip nut.

8. Close drain valve f-5 after all air is purged from the system.

CAUTION

Maintain a close watch on the hydrostatic pump discharge gauge (g-1). NEVER EXCEED FUEL OIL SERVICE PRESSURE (NORMALLY 400 +5 -0 psig).

9. Slowly increase the pump discharge pressure by turning the air regulator compression screw clockwise. As the pressure increases, monitor the burner head, barrel, and vent for leaks. If any leaks are detected, determine location and immediately secure the pump and close the station valve (a-2). If no leaks are detected continue the remainder of the test. If water is leaking from the vent it indicates inner leakage, and the burner barrel shall be disassembled and inspected. If leaks are detected, determine the location and enter it into the test report.

NOTE

Erratic bouncing of the gauge needle above the anticipated pressure indicates there is air in the system and the system shall again be purged of air.

10. Slowly increase the pressure to 400 +5 -0 psig. (200 +5, -0 for auxiliary boilers) Secure the air supply to the hydrostatic pump and close discharge valve f-4. The pressure should remain at 400 +5 -0 psig for a minimum of 5 minutes with no pressure drop allowed.

NOTE

Leakage through the relief valve or system valves will cause a drop in pressure.

11. After completion of the 5 minute test period, slowly crack open drain valve f-5 to bleed off the system pressure. After system pressure reaches zero, close station valve (a-2). Loosen the tip nut and the burner yoke to drain the water from the burner barrel into the drip pan. Wipe up any water spilled when draining the burner barrel.
12. Using compressed air and/or rags, remove all residual moisture from burner barrel inner and outer surfaces. To prevent corrosion, store barrels in a dry environment with a light coating of DFM or lightweight machine oil. Do not use heavier oils such as lube oil, which may clog burner tips. Burner cap nuts or thread caps should be installed on barrels to protect threads during storage.

Hydrostatic Test of Burner Barrel

Ship Name and Hull No.

Work Center

Test Date

Burner Type

Burner #

Supply Port	Test Pressure	Pressure Requirements	Test Conditions	Test
Fuel Side	_____	400 +5-0 psig	No Leakage (200 psig Aux. Blrs.)	5 Minute Minimum
Steam Side	_____	150 +2-0 psig	No Leakage	5 Minute Minimum

COMMENTS: Test Results; Corrective Action Required/Taken

Work Center Supervisor

Test Bench Operator

Testing Facility

Two copies of this report shall be completely filled out. One copy is to be retained at the test facility and one copy is to be given to the ship. The test report shall be retained until the next time the burner barrel is hydrostatically tested and the new test report is received.

Figure 221-G-2. Test Report Form

221-G.7 HYDROSTATIC TEST OF BURNER BARREL - STEAM SIDE (If Applicable).**NOTE**

The purpose of this test is to prove the tightness of mechanical joints only. It is not meant to be a strength test. If any repairs are performed on the steam side, hydrostatic tests of the steam and fuel oil sides shall be performed.

1. With the burner barrel installed in the appropriate station, ensure correct system alignment. Refer to hydrostatic test bench schematic (Figure 221-G-1). The relief valve shall be readjusted to lift at 165 +5/-0 psig. Install the 0-200 psig gauge in the g-2 location.
2. Example: With the burner barrel to be tested installed in station A:
 - a. Ensure that the following valves are closed: f-5, f-6, d-1, d-2, d-3, d-4, c-1, c-2, c-3, c-4, b-1, b-2, b-3, b-4, a-2, a-3.
 - b. Ensure that the following valves are open: f-1, f-2, f-3, f-4, g-1, g-2, a-1, a-4.
3. Ensure that the water level in the water tank is at the top of the sight glass.
4. Open valve f-5 two turns.
5. Ensure that the hydrostatic pump air regulator compression screw is backed out completely and the air cut-out valve to the pump is closed. Line up LP air to the pump and ensure that there is sufficient LP air available. Normally 75 psig will be sufficient.
6. Open the LP air inlet valve to the pump. Slowly turn the compression screw of the air regulator clockwise to admit air to the pump. Establish a minimum water flow through the pump to purge the system of air.
7. Loosen the tip nut sufficiently to bleed air out of the burner barrel. As soon as the air is expelled from the burner barrel, tighten the tip nut. Wipe up any water spilled when venting the burner barrel.
8. Close drain valve f-5 after all air is purged from the system.

CAUTION

Maintain a close watch on the hydrostatic pump discharge gauge (g-1). NEVER EXCEED STEAM ATOMIZATION PRESSURE NORMALLY 135 TO 150 psig).

9. Slowly increase the pump discharge pressure by turning the air regulator compression screw clockwise. As the pressure increases, monitor the burner safety shut-off device, barrel, and vents to drip pan for leaks. If any leaks are detected, determine location and immediately secure the pump and close the station valve (a-1). If no leaks are detected continue the remainder of the test. If water is leaking from the vent, it indicates inner leakage, and the burner barrel shall be disassembled and inspected. If leaks are detected determine the location and enter it into the test report.

NOTE

Erratic bouncing of the gauge needle above the anticipated pressure indicates there is air in the system and the system shall again be purged of air.

10. Slowly increase the pressure to 150 +2 -0 psig. Secure the air supply to the hydrostatic pump and close discharge valve f-4. The pressure should remain at 150 +2 -0 psig for a minimum of 5 minutes with no pressure drop allowed.

NOTE

Leakage through the relief valve or system valves will cause a drop in pressure.

11. After completion of the 5 minute period, slowly crack open drain valve f-5 enough to bleed off the system pressure. After system pressure reaches zero, close the station valve (a-1) . Loosen the tip nut and the burner yoke to drain the water from the burner barrel into the drip pan. Wipe up any water spilled when draining the burner barrel.
12. Using compressed air and/or rags, remove all residual moisture from burner barrel inner and outer surfaces. To prevent corrosion, store barrels in a dry environment with a light coating of DFM or light weight machine oil. Do not use heavier oils such as lube oil which may clog burner tips. Burner cap nuts or thread caps should be installed on barrels to protect threads during storage.

APPENDIX H

BOILER AIR PURGE DATA

Table 221-H-1. Boiler Air Purge Data

Ships	Windbox Pressure (Inches Water)	Purge Time (Minutes)
T-AE-26	5	1-1/2
	2	2
	1/2	4
	1/4	6
	< 1-4	10
T-AE-32-35	AUTOMATED	
T-AFS-5, 7	7	3/4
	3	1
	1	2
	1/4	5
	< 1/4	10
AS-39-40	6-1/2	3/4
	3	1
	1	2
	1/4	5
	<1/4	10
CV-63, 67	28	1
	12-1/2	2
	3	3
	1/2	8
	1/4	10
	< 1/4	15
EX-FF-1038	17	1/2
	8	1
	2	3
	1/4	5
	< 1/4	10
EX-FF-1052	26	1/2
	11-1/2	3/4
	3	1
	1/2	3
	1/4	5
	< 1/4	10
LCC-19, 20	8-1/2	3/4
	4	1
	1/4	5
	< 1/4	10

Boiler Air Purge Data - Continued

Ships	Windbox Pressure (Inches Water)	Purge Time (Minutes)
LHA-1, 4, 5 LHD-1-7	25	1/2
	11-1/2	3/4
	3	2
	1/2	4
	1/4	5
	< 1/4	10
LKA-113-117	Automated	
LPD-7-10, 13, 15 EX-LPD-14	11	1/2
	6	1
	1-1/2	2
	1/4	5
	< 1/4	10
EX-LSD-38	10-1/2	1/2
	5	1
	1-1/2	2
	1/4	5
	< 1/4	10

NOTE

Times are based on the assumption that a forced draft blower or light-off fan is in operation providing pressure to the boiler. Refer to [paragraph 221-4.2.2](#). If a forced draft blower is not available, the purge time shall be at least 20 minutes when a positive windbox pressure is not indicated.

APPENDIX I

BURNING NAVY SPECIAL FUEL OIL

221-I.1 TEMPERATURE AND VISCOSITY.

NOTE

The information given in this section supports and supplements the Engineering Operational Sequencing System (EOSS). EOSS does not cover abnormal operation of boilers with NSFO. Operators shall always comply with EOSS where installed.

221-I.1.1 The information provided in the following paragraphs describes in detail how to burn special fuel oil.

1. Viscosity. Navy Special Fuel Oil (NSFO) is a residual fuel of much higher viscosity than distillate fuel. When NSFO is burned, it shall be heated to reduce its viscosity (thus increasing fluidity). This is necessary to provide adequate fineness of atomization. With oils that are extremely viscous at low temperatures, some heating is necessary so that pumps can handle the oil at full capacity. See NSTM Chapter 541, Petroleum Fuel Stowage, Use, and Testing.
2. Optimum Burning Temperature. Optimum burning temperature is that temperature which gives an acceptable fuel oil viscosity. Viscosity is measured in units of Saybolt Universal Seconds (SUS) or Saybolt Furol Seconds (SFS). NSTM chapter 541 provides a chart for converting between these two viscosity units. For NSFO the optimum burning temperature is that which gives a viscosity of 100 to 135 SUS, depending on the type of atomization employed. This temperature may be determined accurately with the viscosity temperature charts in NSTM 541, once the viscosity of oil is measured at a standard temperature (usually 50 ° C (122° F)). If viscosity is reported in SFS's, there is a convenient rule of thumb for finding the optimum burning temperature, in units of degrees Fahrenheit:
 - a. OPTIMUM BURNING TEMP. (in deg. F) = viscosity (in SFS's at 122° F) plus 115° F. FOR EXAMPLE: Fuel oil is received with a viscosity of 20 Saybolt Furol Seconds at 122° F, the correct burning temperature is:

$$20^{\circ} \text{ F} + 115^{\circ} \text{ F} = 135^{\circ} \text{ F}$$
 - b. TYPICAL BURNING TEMPERATURES. It should be noted that optimum fuel temperatures vary from batch to batch depending upon the origin of both the crude and the refinery which produced the final product, typical burning temperature are:
 - (1) Navy Special (Commercial #5) 160° F
 - (2) Navy Heavy (Commercial #6) 200° F

221-I.2 TEMPERATURE LIMITATIONS.

Overheating NSFO will result in lower efficiency, a greater tendency toward formation of atomized deposits, and an increased tendency toward pulsation. In addition, higher fuel temperatures increase the possibility of heater fouling. Under heating will result in poorer atomization, a longer flame, a greater air pressure requirement, increased stack solids, and increased fireside deposits. These factors lower the overall efficiency. The applicable Boiler Technical Manual should be checked for correct viscosity.

221-I.3 OPERATIONAL FACTORS.

1. Types of Atomization. Mechanical or steam atomization is presently used to break up the oil mass of NSFO into fine particles for combustion. Using mechanical atomization with most sprayer plates, proper atomization will result with nearly all grades of fuel oil at the proper viscosity (135 SUS) when oil pressures between 125 and 300 psig are used. In special instances pressures lower than 125 psig may be used, but such pressures shall generally not be used unless they are specified in the Boiler Technical Manual or by NAVSEA in special instructions.

NOTE

Vented plunger wide range mechanical systems should not be fired with NSFO fuel oil.

With steam atomization, a variable supply oil pressure (from a minimum of 35 psig up to a maximum of 350 psig at the manifold) is used with the same size wide range sprayer plate. The atomizing steam assists or causes atomization of the fuel oil at the low operation rates where oil pressure in the range of 30 to 100 psig is insufficient to produce adequate mechanical atomization. The method by which the atomizing steam assists atomization of the fuel oil is different amongst manufacturers. The most widely used type constant steam pressure burners, NAVJET (TODD) and RACER (B&W) use common interchangeable sprayer plates. An oil viscosity of 100 SUS should be maintained for all steam atomization systems.

2. Cutting Out and Securing Burners. The procedure for cutting out and securing when burning NSFO is the same as for distillate fuel except for the following additions:
 - a. When the fuel flow is reduced, decrease the steam supply to the oil heater to prevent excessive heating and carbonizing of the oil.
 - b. When all atomizers have been cut out, shut off steam supply to the oil heaters.
3. Changing and Cleaning Atomizers. Changing and cleaning mechanical burner atomizers in ships burning NSFO is normally done each steaming 4-hour watch. This practice is not necessary with steam atomizing burners.

APPENDIX J

CHECKLIST FOR VALIDATION OF ATOMIZING STEAM SYSTEM FOR OPERATION WITH SATURATED ATOMIZING STEAM

Table 221-J-1 CHECKLISTS

221-J.1 INSTRUMENTATION CHECKS	YES	NO	N/A
a. Is there a temperature indicator at the in-line desuperheater outlet?			
1. If YES, use this temperature indicator in the evaluation of atomizing steam temperature.			
2. If NO, arrange for the installation of a temperature indicator at this location, before the evaluation of atomizing steam temperature. For temporary installations a well-insulated thermocouple, peened to the outside of the pipe wall can be used, along with a digital readout. However, the ship should submit an AER for a permanent installation of a bulb type bimetallic thermometer, installed in a thermowell.			
b. Have pressure and temperature indicators been calibrated within 6 months of the atomizing steam temperature evaluation?			
1. If NO, attempt to have calibration performed before the evaluation.			
c. Are the pressure and temperature indicators within 50 feet of each other in the piping system, with no major restrictions in between?			
d. Is the temperature indicator installed in a thermowell, which extends at least halfway across the pipe ID.			
e. Does the thermometer bulb extend to the bottom of the thermowell?			
NOTE If using temporary instrumentation, as described in (a), answer N/A to questions (d) and (e).			
f. Has the temperature data been obtained at times when the 150 psig steam pressure is stable (not cycling)?			
221-J.2 PIPING CONFIGURATION CHECKS	YES	NO	N/A
a. Does the atomizing steam piping tie in at a point downstream of the temperature sensor for the in-line desuperheater temperature controller?			
b. Does the pipe exit from either the top or side of the 150 psi line?			
c. Is the piping run from the 150 psi line to the burner front free of un-drainable loops or pockets?			
221-J.3 PIPE LAGGING CHECKS	YES	NO	N/A
a. Is piping upstream of the in-line desuperheater properly lagged, all the way back to the boiler's desuperheater outlet?			
b. Are the following minimum lagging thicknesses installed, as indicated, throughout the atomizing steam piping system?			
1. Piping run from 150 psi main to burner front - At least 1-1/2 inches thick.			
2. Header-At least 1-1/2 inches thick for 1 or 1-1/2 inch pipe sizes, and 2-1/2 inches thick for larger pipe sizes.			
3. Burner leads-At least 1-1/2 inches thick.			
4. Steam separator (if installed) - At least 3 inches thick.			
5. Steam separator bypass - At least 1-1/2 inches thick.			

Table 221-J-1 CHECKLISTS - Continued

NOTE			
These are minimum values. A thickness of 2-1/2 inches is preferred over 1-1/2 inches, and may be required by MIL-STD-769 if temperatures exceed 389 7deg;F.			
221-J.4 IN-LINE DESUPERHEATER CHECKS	YES	NO	N/A
a. Has the in-line desuperheater water valve been hydrotested, and does it shut tight with no leakage?			
b. Does the in-line desuperheater water valve stroke full range, without sticking?			
c. Has the in-line desuperheater temperature controller been calibrated within the last 6 months?			
1. If NO, attempt to calibrate before proceeding with the atomizing steam temperature evaluation.			
d. Is the in-line desuperheater temperature setpoint between 390° and 410° F?			
e. Is the temperature sensor for the in-line desuperheater at least 20-feet downstream of the desuperheater?			
f. Has the in-line desuperheater nozzle block been inspected, and are all nozzles open?			
g. If the in-line desuperheater has an atomizing steam supply to the nozzle block, is this steam always used when the unit is in operation?			
h. When the atomizing steam temperature is less than 390° does the in-line desuperheater controller hold the water valve in the fully closed position?			
221-J.5 SYSTEM DRAIN CHECKS	YES	NO	N/A
a. Does the atomizing steam header have two drains (a warmup funnel drain, or bilge drain, and an orifice drain connected to the HP drain system)?			
b. Is the header HP drain orifice 0.031 inches ± 0.005 inches in diameter?			
c. Does the steam separator (if installed) have an orifice HP drain connection?			
d. Are all HP drains independent, with their own orifices?			
e. Does each HP drain orifice have a cone strainer installed?			
221-J.6 PIPING HEAT LOSS EVALUATION	YES	NO	N/A
a. Atomizer steam hole size designation: _____			
NOTE			
-----For NAVJET and Racer atomizers, this is a drill size. For CE/Wallsend atomizers, this is the steam hole diameter in thousandths of an inch.			
b. Steam hole diameter: _____ inches.			
Example for CE: A size 59 equates to 0.059 inches in diameter. For NAVJET and Racer atomizers, use the size scale on Figure 221-J-1 to determine the steam hole diameter.			
c. Steam flow per steam hole: _____ Pounds per hour.			
Obtain from Figure 221-J-11, at the steam hole diameter.			
d. Number of steam holes per sprayer plate: _____.			
e. Total steam flow for one atomizer: _____ pounds per hour.			
Multiply (c) by (d).			
f. Feet of lagged pipe required to reduce steam quality to 80 percent: _____ feet.			
Obtain from Figure 221-J-2, at the steam flow from (e). Use the curve for nominal pipe size and lagging thickness which applies.			
g. Actual length of atomizing steam piping: _____ feet.			

Table 221-J-1 CHECKLISTS - Continued

h. Steam quality loss due to heat loss through lagging:_____ percent. Divide (g) by (f). Then multiply by 20 percent.			
i. Square feet of un-lagged pipe area required to reduce steam quality to 80 percent:_____ square feet. Obtain from Figure 221-J-3 , at the steam flow from (e). Use the curve for nominal pipe size which applies.			
j. Estimate area of un-lagged surface area in atomizing steam piping system:_____ square feet.			
k. Steam quality loss due to heat loss from un-lagged pipe:_____ percent. Divide (j) by (i). Then multiply by 20 percent.			
l. Total loss in steam quality:_____ percent. Add (l) and (k).			
m. Estimated steam quality at the burner front: percent. Subtract (l) from 100 percent.			
n. Is (m) greater than or equal to 80 percent?			

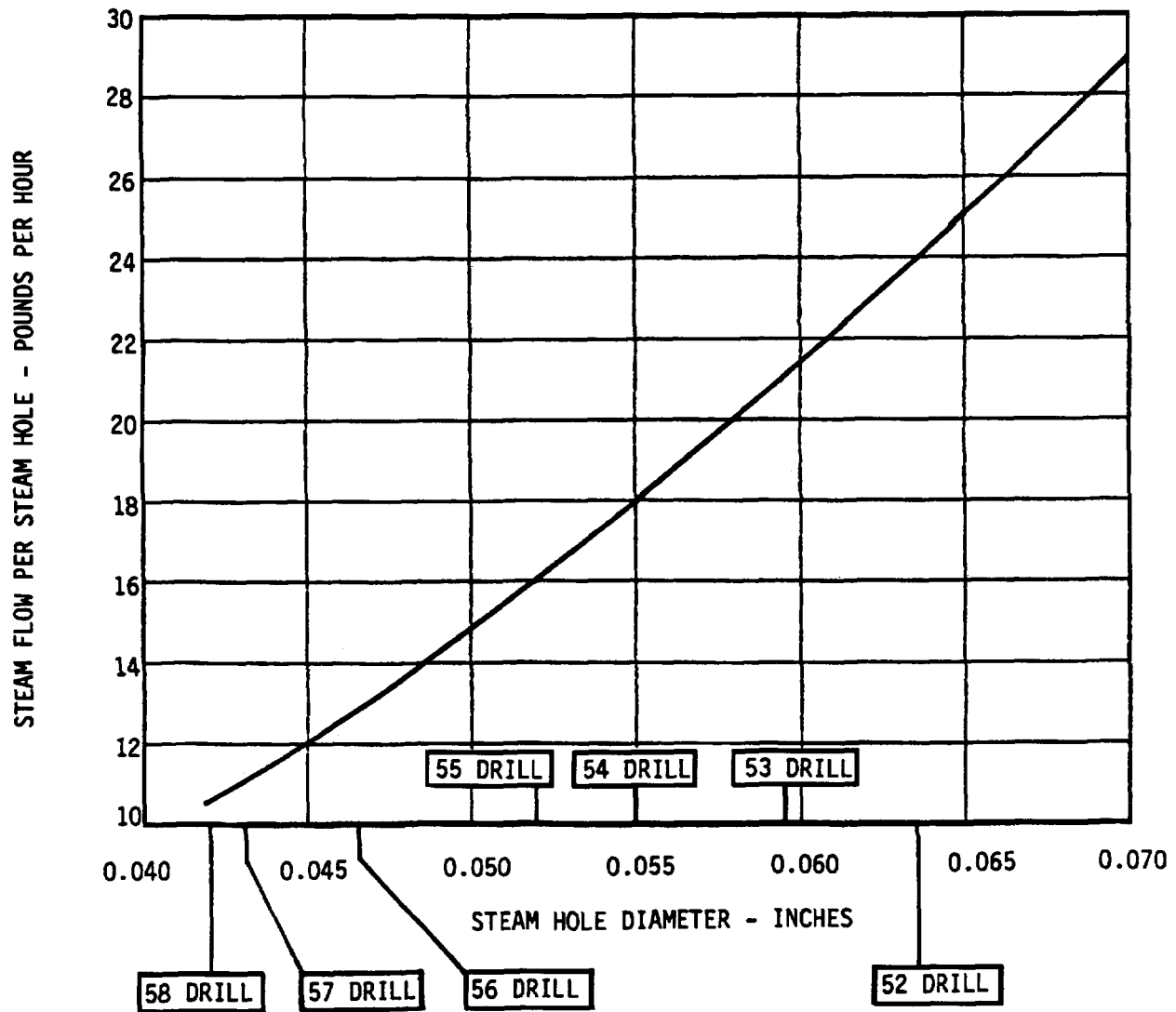


Figure 221-J-1. Steam Flow Per Steam Hole Versus Steam Hole Diameter

**INSULATED PIPE LENGTH
WHICH WILL REDUCE STEAM
TO 80% QUALITY - FEET**

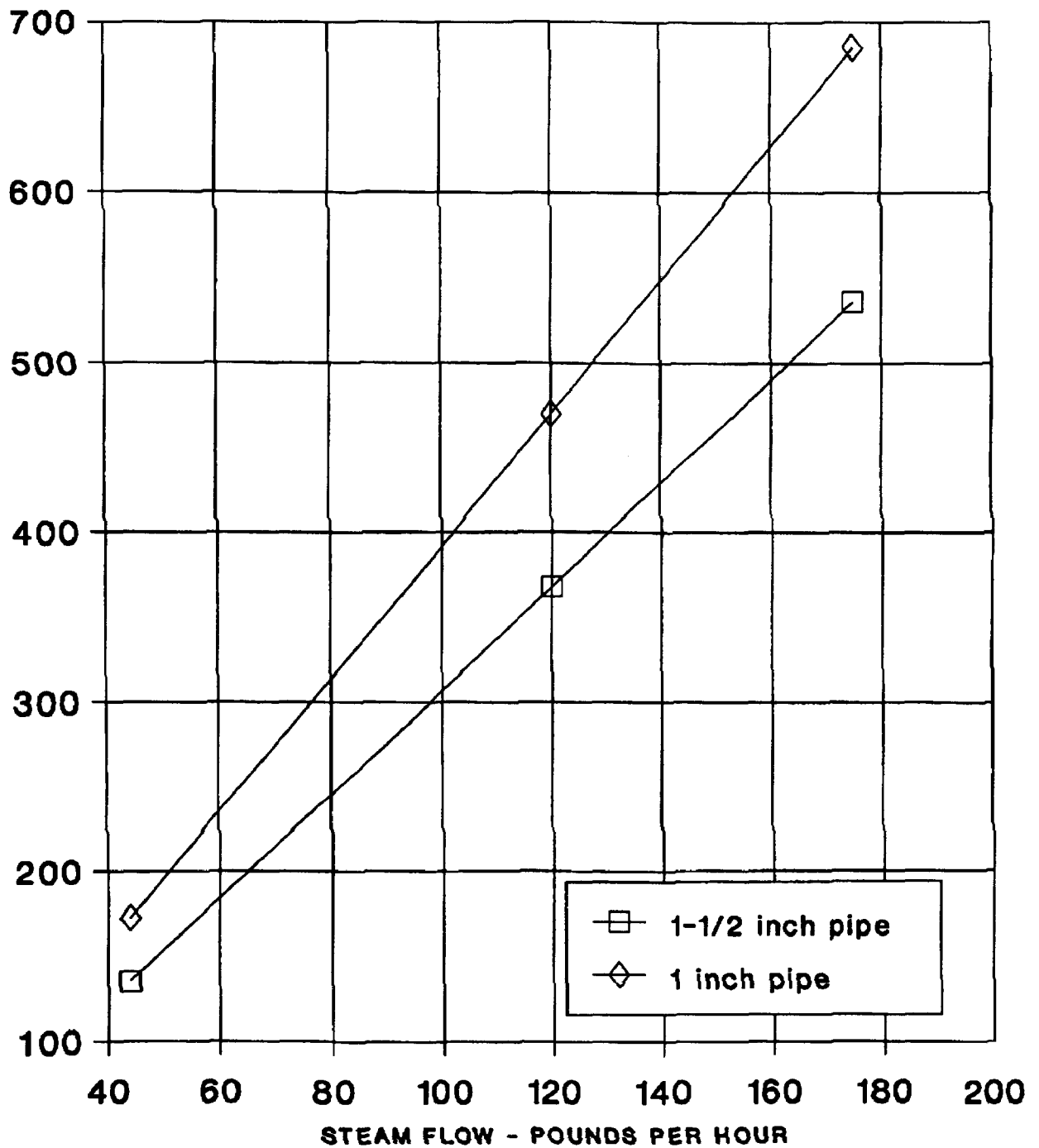


Figure 221-J-2. Insulated Piping Length which will Reduce Steam to 80 Percent Quality Versus Steam Flow

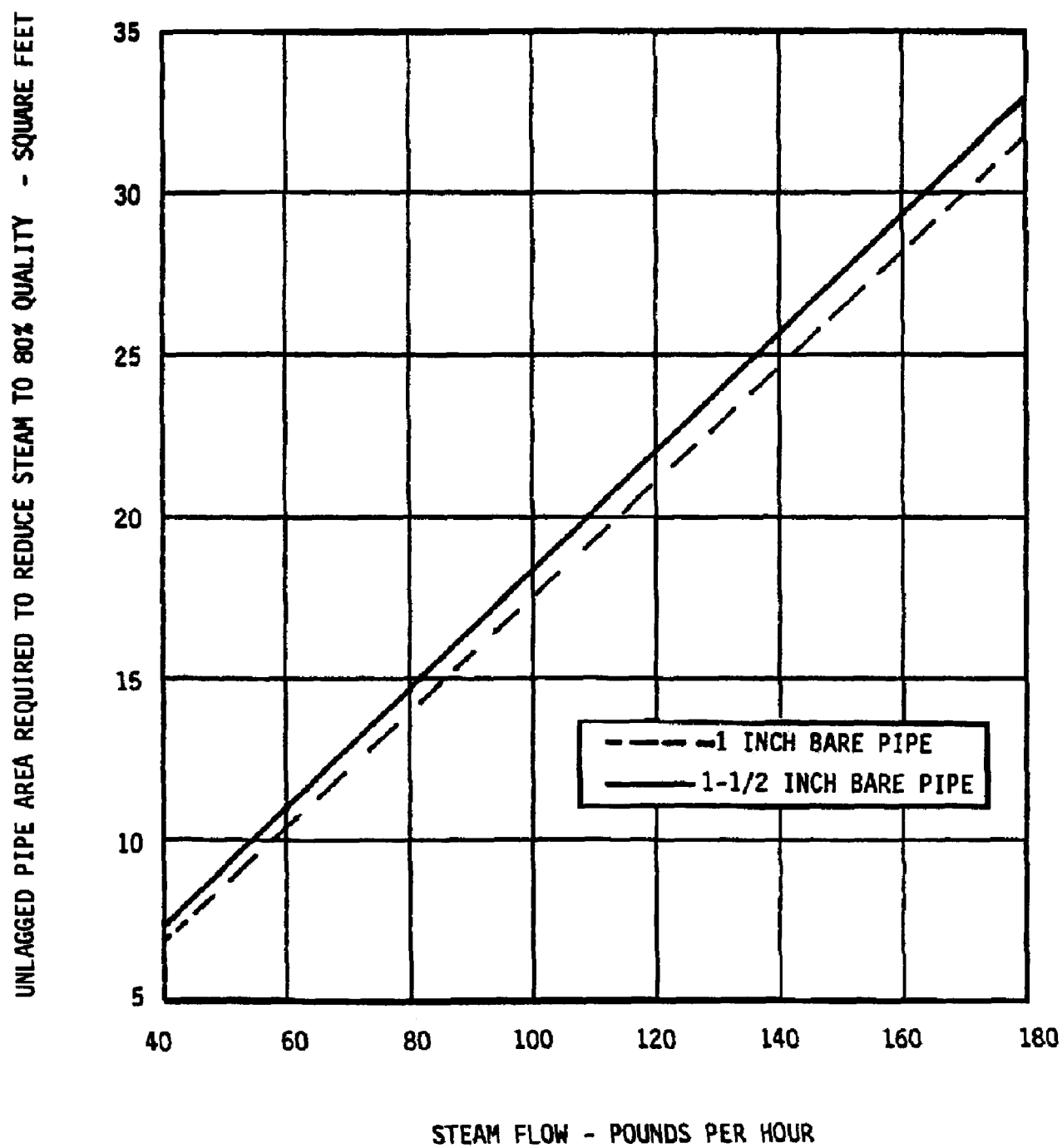


Figure 221-J-3. Un-lagged Pipe Area Required to Reduce Steam to 80 Percent Quality Versus Steam

APPENDIX K

SHIP'S FORCE QUICK REFERENCE OF RESPONSIBILITIES

The intent of this Appendix is to provide ship's force with a Ready Reference Summary to assist them with Inspection Scheduling, Maintenance Documentation requirements, Maintenance items Requiring NAVSEA/TYCOM Approval, Shipboard Material Inspection Items and Pre-Operational Checklist and Operational Requirements.

Table 221-K-1. Boiler Inspection Scheduling and Preparation

Paragraph Number	Paragraph Title	Description
221-2.1.2.2	TYCOM (Routine) Inspection	Both firesides and watersides shall be inspected every 18 months. To provide scheduling flexibility, this inspection may be performed as early as 12 months or as late as 24 months after the previous inspection.
221-2.1.2.4	Unscheduled Inspection	Requirements for Unscheduled Inspection
221-2.1.2.8	Boiler Maintenance Inspection	A boiler inspection by a Steam Generating Plant Inspector (SGPI) or NSWCCD inspector is required whenever major boiler work is accomplished.
221-2.1.2.3	TYCOM (Routine) Inspection Main boilers	Pre-Inspection requirements for up coming main boiler routine inspections.
221-5.4.3	TYCOM (Routine) Inspection Auxiliary boilers	Pre-Inspection requirements for up coming auxiliary boiler routine inspections.
221-5.4.4	TYCOM (Routine) Inspection Waste Heat Boilers	Pre-Inspection requirements for up coming waste Heat boiler routine inspections.

Table 221-K-2. Maintenance Documentation

Paragraph Number	Paragraph Title	Description
221-2.4.5	Ship's Force Responsibilities During Overhaul	The ship's force shall document the status of boiler lay-up in the boiler water chemistry worksheet/log daily.
221-2.8.5	Tube Plugging Limitations	Requirements to maintain tube plugging and renewal documentation (main and aux. boilers).
221-4.18.19	Boiler Water Leakage	Requirements for leaking boiler operational message report.
221-5.6.1	Auxiliary Boiler Lay-up	Requirements for documenting lay-up status.

Table 221-K-3. Maintenance Items Requiring NAVSEA or TYCOM Approval

Paragraph Number	Paragraph Title	Description
221-2.6.4	High Pressure Waterjet Cleaning	Approval shall be requested from NSWCCD-SSES LCEM.
221-2.7.4	Inspection and Cleaning Procedures	Waterwashing or water-jetting of boiler firesides is prohibited without prior NSWCCD-SSES approval.
221-2.8.5	Tube Plugging Limitations	Limitations and approval requirements for tube plugging (main and aux. boilers).
221-3.1.7.4	Burner Settings	Policy regarding DFS for atomizer length.
221-3.3.6.3	Soot Blower Elements	NSWCCD-SSES approval is required to blank soot blowers.

Table 221-K-3. Maintenance Items Requiring NAVSEA or TYCOM Approval

- Continued

Paragraph Number	Paragraph Title	Description
221-5.5.2	Watertube Natural Circulation	Waterwash only if necessary and only with NSWCCD-SSES approval.
221-5-4.7	Waste Heat Boiler Chemical Cleaning	NSWCCD-SSES LCEM approval shall be obtained before acid cleaning watersides.

Table 221-K-4. Shipboard Material Inspection

Paragraph Number	Paragraph Title	Description
221-2.11.5.2	Boiler Gasket Inspection	Ship's force receipt inspection of manhole and handhole spiral wound gaskets.
221-2.1.1	Boiler Care	General requirement for Engineering Officer to monitor boiler conditions.
221-2.5.1	Importance of Waterside Cleanliness	Engineering Officer ensures that the watersides of boilers are maintained free from scale, oil, or accumulations of sediment. Failure to do so may result in tube failures.
221-2.16.3.2	Boiler Close-up	Engineering Officer assures boiler is suitable for close up.
221-3.1.6.1 221-3.1.7.4	Inspection of Atomizers	Engineering Officer requirement for inspection of burner atomizers, sprayer plates and tip components.
221-3.2.6.4	Safety Valve Setting	Specific direction by Engineering Officer required for removal of locks and lead seals prior to safety valve testing; policy for missing seals restoration.
221-3.2.13.1	Inspection and Maintenance - GIS Valves	Lubrication of the 3-way valves in the GIS safety valve panels requires permission of the Engineering Officer.

Table 221-K-5. Pre-Operational Checklists and Operational Requirements

Paragraph Number	Paragraph Title	Description
221-2.15.1	Sliding feet	Sliding feed movement indicators should be observed at least monthly during boiler light-off.
221-3.2.6	Safety Valve Testing Requirements	The Engineering Office or designated test leader will ensure test personnel are fully briefed on standard casualty procedures prior to testing safety valves.
221-4.3	Precautions Before Boiler Light-off	General Checklist to follow prior to boiler operation.
221-4.12.4.4	Standby Fuel Oil Pump	Engineering Officer shall ensure that the standby pump is ready for starting and operating with a minimum of valve realignment.
221-4.14.1	Normal Water Level	The Engineer Officer should verify correct marking of gauge glass normal water level.
221-4.18.11	Oil Fires	General requirement for availability of firefighting equipment.
221-4.18.17	Pressure Part Rupture	Summary of safety precautions applicable to boiler pressure parts.

APPENDIX L**TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT (TMDER)****NOTE**

Ships, training activities, supply points, depots, Naval Shipyards, and Supervisors of Shipbuilding are requested to arrange for the maximum practical use and evaluation of NAVSEA technical manuals. All errors, omissions, discrepancies, and suggestions for improvement to NAVSEA technical manuals shall be reported to the Commander, NAVSURFWARCENDIV, 4363 Missile Way, Port Hueneme, CA 93043-4307 on NAVSEA/ SPAWAR Technical Manual Deficiency/Evaluation Report (TMDER), NAVSEA Form 4160/1. To facilitate such reporting, print, complete, and mail NAVSEA Form 4160/1 below or submit TMDERS at web site <https://nsdsa2.phdnswc.navy.mil/tmder/tmder.htm>. All feedback comments shall be thoroughly investigated and originators will be advised of action resulting therefrom.

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