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NAVAL SHIPS TECHNICAL MANUAL

CHAPTER 9560

BOILER WATER/FEEDWATER TEST AND TREATMENT



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NAVAL SHIPS TECHNICAL MANUAL

CHAPTER 9560 – BOILER WATER/TEST AND TREATMENT

February 1969 Edition

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Part 1. Introduction

9560.1 PURPOSE OF CHAPTER 9560

This section presents water treatment in such a way that Naval personnel will be thoroughly familiar with it. A description of the shipboard water cycle is followed by the principles of boiler water and feedwater treatment, and a discussion and application of these principles to the treatment of Naval feedwater and boiler water. Also included in this section are illustrations and descriptions of the special apparatus and equipment needed in Naval vessels. Careful study of this chapter and compliance with its provisions should enable the ship's personnel to maintain the watersides of all boilers in practically new condition. The action required for any unusual condition not covered herein should be determined by the knowledge acquired from the study of this chapter. In any case of doubt or in cases not specifically covered in this chapter, the Naval Ship Systems Command should be advised and instructions requested.

9560.2 PURPOSE OF BOILER WATER TREATMENT

Boiler water treatment prevents the formation of scale on the waterside of the boiler, reduces corrosion of boiler metal to a minimum, and ensures the absence of foaming under all conditions of operation. The careless application of water treatment chemical or blowdown, will result in unsatisfactory boiler protection.

9560.3 UNITS FOR REPORTING WATER ANALYSIS

The standard system for reporting the results of water analyses adopted by the Navy is in either parts per million (ppm) or equivalents per million (epm). Both are weight-per-weight units. Thus one part per million equals one weight of substance dissolved in one million one weights of solution. One ppm may represent either one pound of salt dissolved in one million pounds of water, or one gram of salt dissolved in one million grams of water. Similarly, one equivalent per million equals one unit equivalent weight of substance per million unit weights of solution.

9560.4 TEST RECORDS-WATER TREATMENT LOGS

There are four types of water treatment logs. They are:

1. Feedwater log NAVSHIPS 9560/4 for feedwater
2. Boiler water treatment log-Navy boiler compound, NAVSHIPS 9560/1 for 600 psi boilers and below
3. Boiler water treatment log-Low phosphate treatment, NAVSHIPS 9560/3 for 1200 psi boilers
4. Boiler water treatment log-High phosphate treatment, NAVSHIPS 9560/2 for ships with diatomite feedwater filters.

Ships shall employ the feedwater log and the appropriate boiler water treatment log. Ships should prepare such additional test sheets as are necessary for entering results of other tests. Forms 9560/1 (FSN 0105-637-0000), 9560/2 (FSN 0105-637-1000) 9560/3 (FSN 0105-637-2000), 9560/4 (FSN 0105-637-3000) are available from Navy Supply Center, Norfolk, Charleston, Oakland, and San Diego and Naval Supply Depot, Newport in accordance with NAVSANDA Publication 2002, Section II.

Part 2. Shipboard Water Cycle

9560.11 GENERAL

A familiarity with the shipboard water cycle will help personnel to understand the treatment of boiler feedwater and boiler water. Of basic importance is the fact that whether water is evaporated, diluted, or chemically treated, all shipboard water originally comes from the sea and therefore retains sea salts as the major contaminants. The shipboard water cycle in figure 9560-1 and its relation to the treatment of boiler feedwater and boiler water can best be understood by examining the feedwater phase, the boiler phase, and the steam condensate phase.

Sea water supplied to the shipboard cycle is a stable and uniform solution of about 35,000 parts per million (ppm) of mixed sea salts. The common components of sea water are listed in table 1.

Table I

Component	PPM
Sodium Chloride (NaCl)	24,500
Magnesium Chloride (MgCl ₂)	5,200
Sodium Sulfate (Na ₂ /SO ₄)	4,000
Calcium Chloride (CaCl ₂)	1,100
Sodium Bicarbonate (NaHCO ₃)	200
TOTAL	35,000

The calcium and magnesium are scale formers because they yield compounds of low solubility at high temperature and high pH (alkali content).

9560.12 MAKEUP BOILER FEEDWATER

Sea water enters the shipboard water cycle through a steamheated evaporator which evaporates one-third to one-half of the sea water to essentially salt-free vapor and sends the remainder overboard with the concentrated salts. The vapor is converted back into liquid water (distillate) by

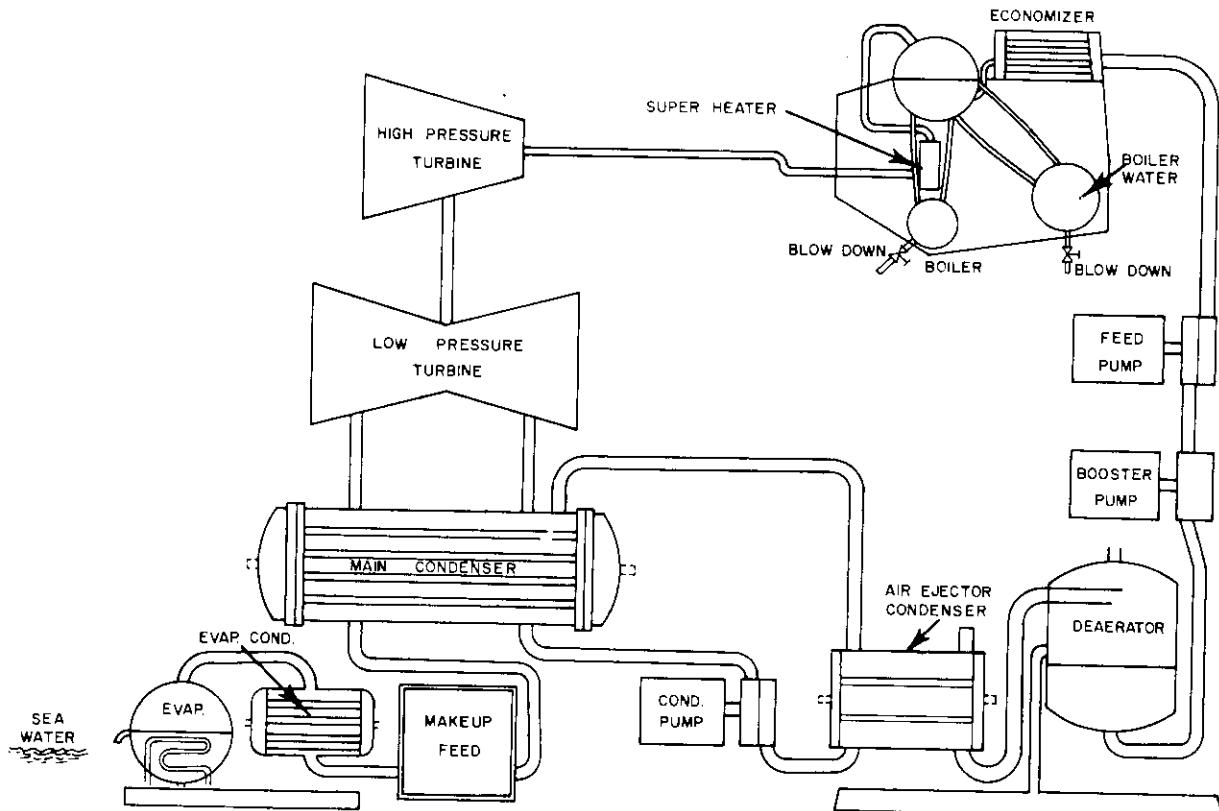


Figure 9560-1. Shipboard water cycle.

passing it into the evaporator condenser where it flows over tubes filled with relatively cool sea water. From the evaporator condenser, the distillate flows into the makeup feedwater tank. Actually the distillate is not pure water, but is diluted sea water containing about 1.75 ppm of sea salts.

9560.13 BOILER FEEDWATER

Boiler feedwater, the first component of the water cycle proper, combines makeup feedwater with steam condensate. Condensate is obtained from water which is boiled to steam in the boiler and is then relieved by contacting sea-water-cooled tubes in the main condenser. Boiler feedwater resembles makeup feedwater but may contain corrosion products from the steam lines and condensate lines, sea salts from the condenser tubes, dissolved solids and gases carried over from the boiler, and oil from fuel oil heaters.

Feedwater will usually contain from 1.7 to 3.5 ppm of dissolved solids of which sea salts are the major components. Poor quality feedwater may contain many times as much dissolved solids as the aforementioned quantity.

9560.14 DEAERATED BOILER FEEDWATER

Deaerated boiler feedwater is the same as the feedwater previously described except that most of the gases have been removed in the feedwater heater or deaerator either by heating the water or by heating it and then blowing steam through it. The dissolved solids content remains essentially the same as before the treatment.

9560.15 BOILER WATER

The boiler is an oil-heated pressure vessel designed to evaporate water to steam at an extremely high rate so that the steam can be used for operating machinery and heating. Reduced to the essential parts, the shipboard boiler consists of a large horizontal upper cylinder (steam drum), several horizontal lower cylinders (water drums and headers), and a number of small diameter (1-inch to 4-inch) nearly vertical tubes which connect the drums and surround the furnace fire.

When the furnace is lighted, heated water rises to the steam drum through the hotter fire-row tubes and returns to the water drum and headers via the more distant and therefore cooler tubes (downcomers). At the boiling temperature, steam collects in the upper part of the steam drum and increases in pressure to the operating pressure of the power plant. The steam at the operating pressure of the power plant is either passed through a nest of tubes exposed to the furnace gases (superheater) to increase its heat content (energy) or passed directly to the steam line as wet (saturated) steam, depending on the operating conditions.

The steam passes through the propulsion machinery, consisting of turbines or reciprocating engines, various pumps and auxiliaries. Eventually, the steam returns to the condenser where it recycles to the boiler.

Since the boiler does not have a continuous overboard drain, like the sea water evaporator, it traps or concentrates all types of solid matter introduced with the feedwater.

This concentration alone is such a serious problem that personnel should always remember that no water is so pure that it will not eventually cause solid concentration in a boiler.

9560.16 STEAM AND CONDENSATE

Just as evaporator distillate is dilute sea water, so steam condensate is basically a mixture of dilute boiler water and dilute sea water. However, steam condensate usually has no more than 3.5 ppm of dissolved solids. Steam condensate may pick up salts from sea water, leaks in the condenser and oil from fuel-oil heaters, and the returning of such water to the boiler can lead to serious waterside problems.

Part 3. Principles of Boiler Water Treatment

9560.21 NEED FOR BOILER WATER TREATMENT

Boiler water treatment is necessary because some salts are dissolved in all waters. The salts dissolved in boiler water could include those derived from sea water by evaporator carryover and condenser leakage, those corroded from piping and tanks, those dissolved from filter media; from the coatings and interior of piping and tanks, treatment chemicals and the various combinations that result from such mixtures. Some of these salts are corrosive, some are scale-forming, and some combat the objectionable properties of the first two classes. Any type of boiler water treatment must be intelligently applied with a knowledge of the desired results and the methods of obtaining these results.

9560.22 PROCESS OF SCALE FORMATION

Salt scale is formed from the water directly in place on the heated metal part by crystallization processes induced by temperature changes. The solubility of salts in water varies with temperature of the water. Some salts are more soluble in cold water than in hot water (negative solubility), while the solubility of other salts increases as the temperature of the water increases. The salts that are more soluble in cold water (negatively soluble) form boiler scale. These negatively soluble, scale-forming salts are relatively soluble in the cooler parts of the boiler, but in the boiler tubes, where the temperature is much higher, the saturation point may be reached although the actual concentration is low.

When a steam bubble is formed on the evaporative water surface, the salts in the water are forced into an envelope of water closely surrounding the bubble. Since salts do not evaporate, they remain in the water. Where the steam bubble, the water, and the tube surface touch each other, an irregular, circular-like line on the metal surface is formed. Crystals of scale-forming salts will be deposited on this line because it is the hottest point of the system. In this area, the solubility of the scale-forming salts will be the lowest and the quantity of these salts will be the highest. As the steam bubble leaves the metal surface, a ring of small scale crystals will be left to mark the location where the bubble was formed.

Because of their method of formation, scales have definite crystalline microstructures with crystals usually growing at right angles to the metal surface. Most scales are hard, dense and adherent, but some are soft and nonadherent. Figure 9560-2 shows the general appearance of typical scale. The method of formation and the resulting microstructure determine whether or not a deposit is scale. As previously mentioned, calcium and magnesium are the principal scale formers in the shipboard water system.

With the separation of successive steam bubbles, the many rings of scale crystals become interlaced and the individual crystals increase in size. This is the manner in which true scale grows. It is possible, however, under conditions to be discussed later, for suspended matter to settle from the boiler water and bake onto the evaporative surfaces. Although the effects of such deposits may be the same as scale, the deposits should be recognized as baked sludges, not scales.

9560.23 EFFECTS OF SCALE

A layer of scale on the waterside surface prevents normal heat transfer through the tube wall to the boiler water and thereby increases the temperature of the tube metal to the extent that wasting away from oxidation on the fireside and heat blistering and rupture from internal pressure may occur. A very thin layer of scale is sufficient to raise the tube-wall temperature enough to cause failure.

9560.24 SCALE-FORMING SALTS

Normally, calcium sulfate is the only scale-forming salt of serious importance in naval boilers. Calcium sulfate is

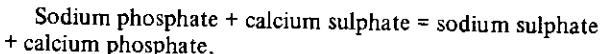


Figure 9560.2. General appearance of typical scale.

soluble to the extent of over 1,500 ppm in boiler feedwater but is virtually insoluble at the temperatures existing in boiler tubes, so that in the absence of proper treatment, almost all of the calcium sulfate fed to the boilers will be deposited as scale. Calcium sulfate scale is so hard and tightly adherent that it is virtually impossible to remove it by mechanical cleaning. Silicates form hard, glass-like scales. Their occurrence usually is evidence of unusual feedwater conditions such as may be caused by the use of cement wash for coating feed bottoms, the use of shore water for makeup feedwater or the malfunctioning of oil-removal filters on ships equipped with reciprocating engines permitting the filter aid to enter the feedwater. Calcium carbonate and magnesium hydroxide occasionally occur in boiler scale but the solubility of these salts is so low at all temperatures that they are not of serious concern since they are a normal constituent of the boiler sludge. Properly prepared naval boiler feedwater is so pure and water treatment techniques are so effective that the occurrence of scale is very rare, and its presence should be the reason for a prompt investigation of the conditions which permitted its formation.

9560.25 PREVENTION OF BOILER SCALE

Boiler scale prevention is relatively simple. It involves adding to the water disodium phosphate (Na_2HPO_4) and a highly soluble alkaline chemical such as soda ash (sodium carbonate, Na_2CO_3) or caustic soda (sodium hydroxide, NaOH) which will react with scale-forming calcium sulfate to form highly soluble sodium sulfate and a relatively harmless sludge consisting of calcium phosphate. The reaction is:



When the ratio of hardness to alkalinity in the feedwater differs widely from that existing in sea water, as is the case when shore water is used, the completion of these reactions may yield intolerably high boiler water alkalinitiess. It is always necessary to have an excess of the conditioning chemical present to insure that the chemical reactions will be complete. The presence of an excess also provides protection against any unexpected entry of scale-forming salts.

9560.26 BAKED SLUDGE

Sludges are sedimentary deposits of insoluble matter in the boiler water. Consequently, a certain amount of sludge is inevitable in every boiler because of the concentration phenomenon. Dirt, rust, insoluble products of evaporation or of water treatment, and oil all fall into this class. Since a sludge simply settles out or floats out of the water on the insides of tubes and drums, the deposit does not have a uniform microstructure, except stratification. Sludge may be a fine powdery mass or a conglomeration of many-sized particles. Most sludges originally are soft, or at least non-adherent, but they tend to become hard persistent deposits if allowed to remain on the boiler surfaces. Figure 9560-3 shows a typical sludge in a 2-inch boiler tube. Such sludges usually collect in the lower part of the boiler because they are heavy. They tend to concentrate and bake onto fire-row tubes because of the rapid evaporation at these points.

Heavy films of metal oxide or water-treatment sludges reduce heat transfer in water-wall and fire-row tubes to the extent that sludge baking and heat blistering occur. Baked sludge is difficult to remove by mechanical means and is not disintegrated by treatment chemicals. Excessive accumulation of sludge indicates that blowdown has been inadequate. The presence of sea water resulting from excessive condenser tube leakage is a common cause of heavy sludging. The products of corrosion of condensers and feed piping systems also contribute to excessive boiler sludging.

9560.27 PROCESS OF CORROSION

1. **Corrosion Deposits and High Temperature Oxide.** Corrosion deposits, like scales, form directly in place, but they are formed by reaction of the metal with the water, as in rusting. High temperature oxide, sometimes called mill scale because it resembles the surface of newly rolled steel, is a special type of corrosion product which results from reaction of hot metal with water or air.

2. **Electrolytic Corrosion (Pitting).** All corrosion is electrolytic in nature; however, the term is usually applied to local effects like the pit shown in figure 9560-4 and the scab shown in figure 9560-5. It is possible for a tube to be completely sound except for one or two such pits. For a number of reasons, anodic and cathodic areas exist even in the most perfectly formed metal tubes. When exposed



Figure 9560-3. Typical sludge in a 2-inch boiler tube.

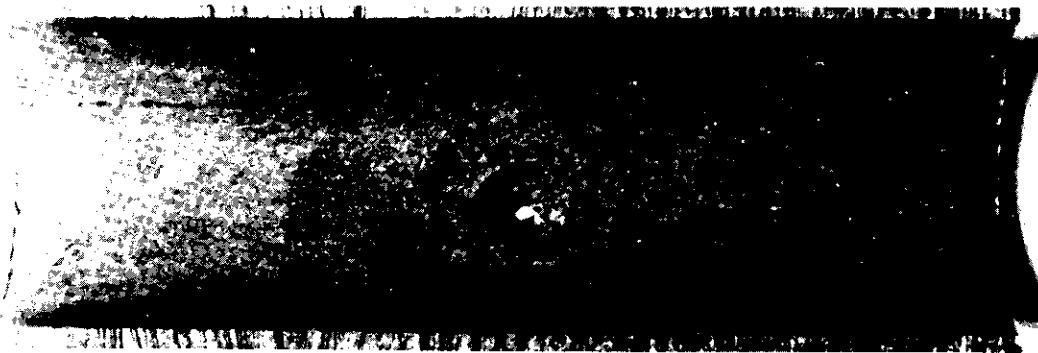


Figure 9560-4. Oxygen Pit.

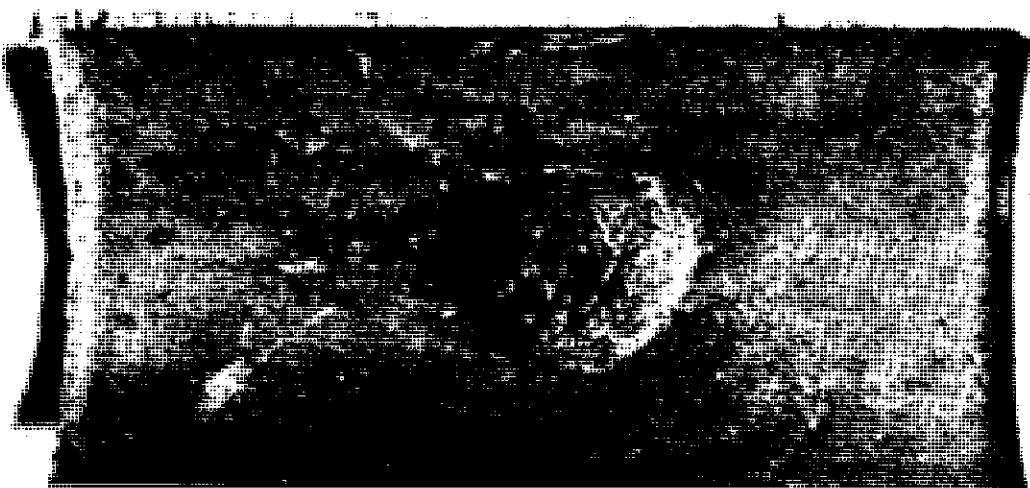


Figure 9560-5. Oxygen Scab.

to a conducting medium (electrolyte) such as boiler water, iron goes into solution.

3. General Corrosion. Under certain conditions, the water in contact with the tube metal is corrosive enough so that there is general metal loss over the entire tube area. However, this phenomenon rarely occurs in Naval boilers.

4. Corrosion of Boiler Watersides. Corrosion of boiler watersides is a special case of electrolytic corrosion. Iron in contact with water tends to go into solution, as has been previously mentioned. This effect cannot be prevented completely, but it can be reduced to a tolerable minimum. This can be accomplished by simultaneously keeping boiler-water conditions in the prescribed range and eliminating dissolved oxygen from the feedwater and boiler water. The importance of these factors is elaborated below.

9560.28 EFFECT OF LOW ALKALINITY

Acid corrosion that is caused by low alkalinity will cause general wastage of the waterside surfaces and may be accompanied by localized pitting.

9560.29 EFFECT OF EXCESSIVE ALKALINITY

If the boiler water alkalinity is too high, strong caustic concentrations may develop in the film in contact with the evaporative surfaces. Such strong caustic solutions will then penetrate cracks in the protective film and react with the tube metal.

This process can cause severe furrowing and grooving in fire-row and studwall tubes where high evaporation rates establish a local, high concentration alkaline film. Thus it can be seen that the proper treatment is a choice of a mean between two extremes.

9560.30 EFFECT OF DISSOLVED OXYGEN

Dissolved oxygen causes localized electrolytic corrosion. Oxygen corrosion can be identified by the occurrence of scattered, localized pits and the absence of general corrosion in the intervening areas. Oxygen pitting is accelerated by increase in temperature, dissolved oxygen, and acidity (decrease in alkalinity). The normal introduction of feedwater to the top drum of a steaming boiler usually reduces the dissolved oxygen to a tolerable residual, since the evolved steam scrubs the dissolved gases away, but there is considerable evidence that traces of oxygen can cause serious pitting of fire-row or stud-wall tubes or in other relatively hot portions of the boilers. Economizers, which operate at low temperatures and can provide no escape for the dissolved oxygen, are particularly vulnerable to dissolved-oxygen corrosion.

9560.31 SOURCES OF DISSOLVED OXYGEN

Aerated feedwater is one of the principal sources of oxygen contamination of boiler water. Atmospheric oxygen is also drawn into a boiler which is secured at steaming level and permitted to cool. Air will dissolve readily in feedwater and, if not removed by the condensers or deaerating feed tanks, will pass on to the economizer and generating-tube nest. It is imperative that the dissolved-oxygen content of the feedwater be reduced to the lowest possible level before it leaves the deaerating feed tank, and that the feedwater be protected against air from leaking in during its travel through the suction lines. It is also imperative to secure a boiler to prevent oxygen from entering the boiler while it is cooling and while it is cold. Securing procedures should be as outlined in chapter 9510.

9560.32 PROCESS OF DEAERATION

Modern methods of deaeration take advantage of the solubility characteristics of gases. The solubility of oxygen increases with an increase in the pressure of the oxygen-bearing atmosphere above the water, and decreases with an increase in the temperature of the water. The solubility of oxygen in water at various temperatures and pressures is illustrated in figure 9560-6. This figure illustrates that at reduced pressures, the solubility of oxygen decreases rapidly with an increase in temperature and reaches zero at the temperature corresponding to the boiling point.

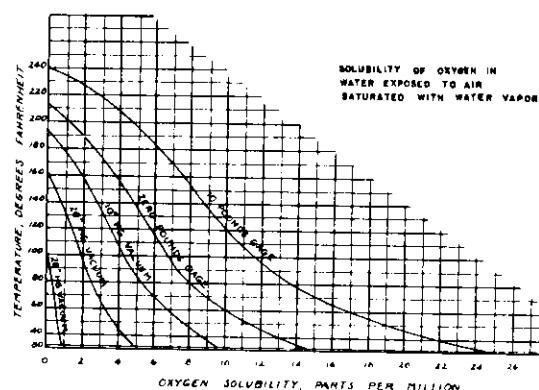


Figure 9560-6.

The deaeration process simply removes gases from the feedwater by either heating to reduce solubility, applying vacuum to reduce solubility and remove gases, or scrubbing with steam to remove the gases mechanically. The three basic mechanical deaeration systems (feedwater heater systems) are the open feedwater heater, the semiclosed feedwater heater, and the pressure-closed deaerator. These systems are diagrammed in figure 9560-7. All deaeration systems must be operated carefully and checked regularly if dissolved oxygen in the feedwater is to be minimized. The deaerating principles of the several systems are discussed below.

1. **In the open feedwater system**, vacuum is obtained in the condenser with a steam-powered air ejector (aspirator principle). The low pressure reduces the solubility of the gases which pass out of the ejector. From the condenser, the water flows to an open tank where it is kept hot to minimize solution of gases. The air-ejecting, low-pressure condenser is common to all of the three systems.

The efficiency of the open feedwater system depends on maintenance of the condenser vacuum by air ejection and the extent of open feed tank heating. Low feed tank temperature is the principal source of trouble.

2. **The semiclosed feedwater system** introduces less air than the open system because it has centrifugal pumps instead of reciprocating wet air pumps, and because it uses a surge tank floating on the line instead of an open feedwater tank through which all of the water flows. The surge tank has a constant overflow near the expected water level to remove the surface layer continuously and thereby to minimize the introduction of aerated surface water to the feedwater line. The purpose of the surge tank is defeated if water is not overflowed from this point continuously by adding makeup feedwater to level out feedwater demands. Low surge tanks temperature has the same effect as low open tank temperature.

3. **In the pressure-closed deaerating system**, a spray type deaerator is substituted for the feed or surge tank. Hot feedwater from the condenser is sprayed into the deaerator shell through a number of spring loaded atomizing valves. Simultaneously, exhaust steam is blown through the spray to sweep the gases out of the vent.

The primary step in deaeration, therefore, is to raise the temperature of the feedwater to the boiling point corresponding to the deaerating feed tank pressure. This renders the oxygen insoluble, but the problem of purging the water of the last traces of oxygen and transporting the air-free water to the boiler without reaeration remains. The feedwater systems used for solving these problems are discussed in detail in Chapter 9562.

9560.33 NATURE OF CARRYOVER

In addition to the prevention of scale and corrosion, the third principal object of boiler-water treatment is the prevention of such abnormal boiling conditions as priming or foaming. The greater the amount of dissolved solids in a water, the greater will be the tendency of the water to foam or froth when it is boiled violently. Solids will accumulate in the surface layer and will stabilize bubble formation so that the bubbles pile up instead of bursting. If these stabilizing forces are great enough, no amount of steam space above the liquid surface will prevent foam from carrying

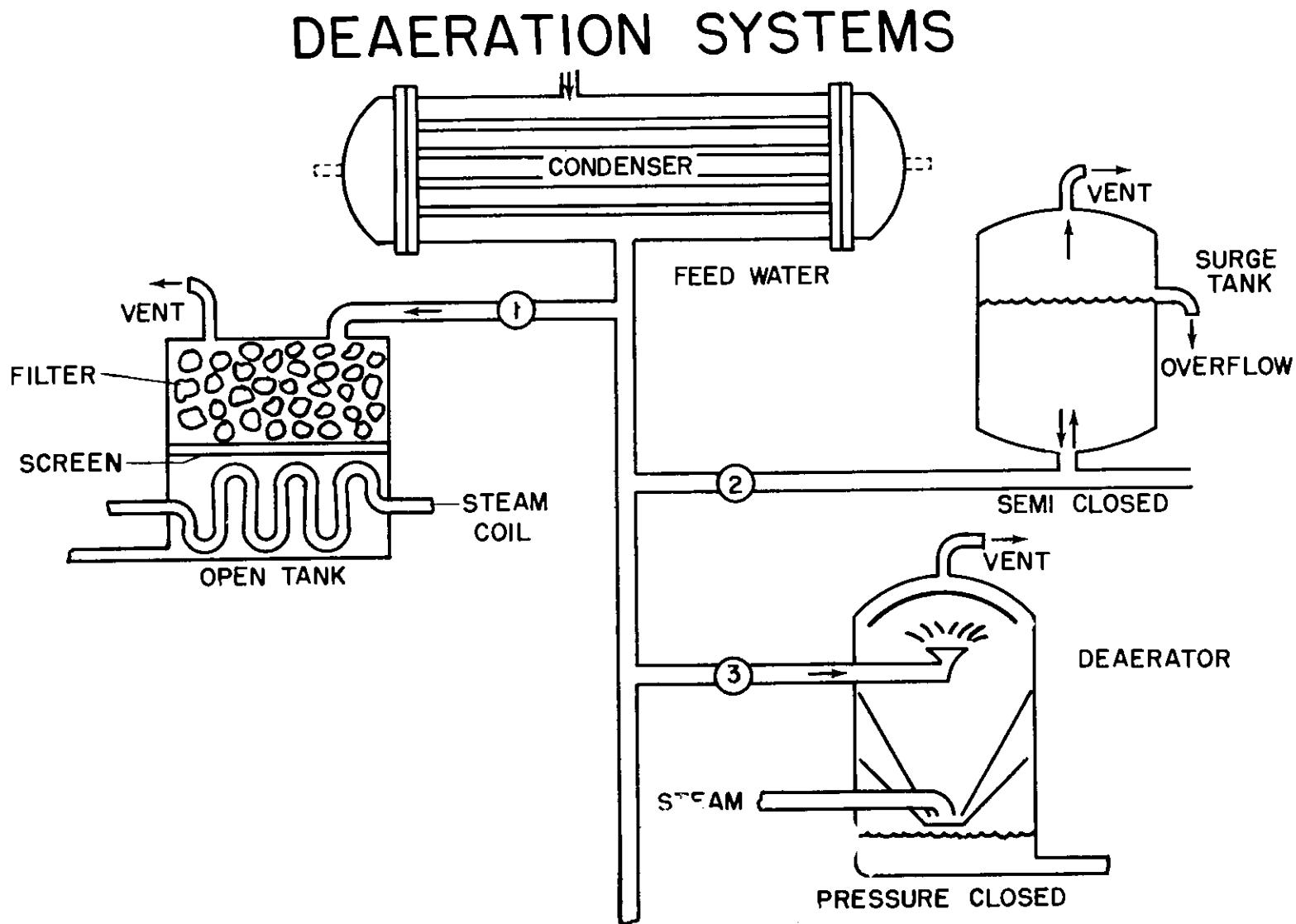


Figure 9560-7.

over into the steam line. The boiling over of a coffeepot is an everyday example of this phenomenon.

If the amount of suspended matter is considerable, any foam which forms is stabilized by the small particles and the film thickness, so that the steam bubbles fail to break before entering the dry pipe. Small particles of water then will be carried along with the steam; the process is called carryover. Excessive alkalinity will also cause the boiler water to foam and to carryover. Carryover causes wet steam and objectionable deposits in the steam lines, superheaters, and turbines. Figure 9560-8 illustrates the effects of carryover in a superheater line.

Priming is a violent type of carryover caused by erratic firing, carrying boiler water level too high, very rapid increases in steam withdrawal, and rough weather, so that large quantities of water be thrown into the steam space as though small intermittent explosions were occurring. Large amounts of water then will be carried into the dry pipe.

Foaming can generally be controlled by reducing the amount of dissolved and suspended solids in the boiler water; however, priming is a mechanical matter.

Part 4. Care of Feedwater and Makeup Feedwater

9560.41 SEA WATER DISTILLATE

All water used for boiler-feed purposes contains some undesirable impurities. It is impossible to make evaporator distillate free from all impurities. The distillate from shipboard evaporators will normally contain less than 0.065 ppm of chloride. Associated with these chlorides are smaller amounts of all the other salts found in sea water. All of these impurities enter the boiler with the makeup feedwater.

9560.42 ELECTRICAL SALINITY INDICATORS

Electrical conductivity meters, or salinity indicators, are installed in virtually all naval vessels. Their operation is based upon the fact that the electrical resistance of a water solution varies with the amount of ionized salts dis-

solved in it. This resistance and the corresponding meter indication vary both with the temperature and the ionized salt concentration of the water flowing through the cell. Temperature compensation is provided to eliminate the temperature effects. The compensator must be set at a value corresponding to the temperature of the solution being measured. This compensation is accomplished manually in the older types of indicators and automatically in the newer types of indicators. Power factor type meters are used to eliminate the effects of line voltage fluctuations. Salinity indicators are most sensitive at low ionized salt concentrations. The salinity indicators should be operated and checked as recommended in chapter 9650 and in the manufacturer's instruction book supplied with the equipment. To further ensure that the salinity equipment is operating properly, the maintenance schedule set forth in the maintenance requirement cards (MRC) must be followed. The results obtained with the indicator may be compared with the corresponding chloride titrations (methods for determining the concentration of a substance in solution). The dials of salinity indicators are calibrated in grains of sea salt per gallon and ppm of chloride. To convert the dial reading for checking against results obtained from chloride titration multiply by the factor 0.261; e.g., grains of sea salt per gallon (meter reading) X 0.261 = ppm, chloride. For example, titration of a sample which the indicator shows to have 0.60 grain of sea salt per gallon should give a result of approximately 0.15 ppm of chloride. Tables II and III will assist the operator in making necessary conversion for checking the values read from the salinity indicator against the values in the chloride test and vice versa.

9560.43 UNDESIRABILITY OF SHORE WATER

All shore waters contain varying amounts of contaminating salts, depending on the character of the rocks, sand, and earth over which they have flowed and on the extent and nature of municipal treatment to which they have been subjected. The impurity content of shore water will always



Figure 9560-8. Super Steamside Deposit.

TABLE II

Grains of sea salt per gallon:	Equivalents per million chloride:	Grains of sea salt per gallon:	Equivalents per million chloride:
0.1	0.026	1.3	0.339
.2	.052	1.4	.365
.25	.065	1.5	.392
.3	.078	1.6	.418
.4	.101	1.7	.444
.5	.130	1.8	.470
.6	.157	1.9	.496
.7	.183	2.0	.522
.8	.209	3.0	.783
.9	.235	4.0	1.044
1.0	.261	5.0	1.305
1.1	.287	10.0	2.610
1.2	.313		

TABLE III

Equivalents per million chloride:	Grains of sea salt per gallon:	Equivalents per million chloride:	Grains of sea salt per gallon:
0.01	0.038	0.29	1.111
.02	.077	.30	1.149
.03	.115	.31	1.187
.04	.153	.32	1.226
.05	.192	.33	1.264
.06	.230	.34	1.302
.07	.268	.35	1.340
.08	.306	.36	1.379
.09	.345	.37	1.417
.10	.383	.38	1.455
.11	.421	.39	1.494
.12	.460	.40	1.532
.13	.498	.41	1.570
.14	.536	.42	1.609
.15	.574	.43	1.647
.16	.613	.44	1.685
.17	.651	.45	1.724
.18	.689	.46	1.762
.19	.728	.47	1.800
.20	.766	.48	1.838
.21	.804	.49	1.877
.22	.843	.50	1.915
.23	.881	.60	2.298
.24	.919	.70	2.681
.25	.958	.80	3.064
.26	.996	.90	3.447
.27	1.034	1.00	3.830
.28	1.072	1.5	5.745
		2.0	7.660
		2.5	9.575

be higher and, more important, will be chemically and proportionately different from that of the sea water distillate which naval water treatment is designed to control. Water received from shore should not be used in the boilers (except in emergency) without first being evaporated in the ship's distilling plant. Consult chapter 9580 for discussion of conditions under which the ship's distilling plant may be used for evaporating shore water and operating precautions to be taken under these circumstances. If necessary to use shore water without distillation, the water should be tested and only a neutral water, low in hardness, should be accepted for temporary use during the emergency. A neutral

water is one which is colorless with phenolphthalein indicator and green with methyl purple indicator. The evaporation of shore water, to obtain satisfactory feedwater for the boilers, may result in depositing on the evaporator tubes an extremely hard scale different from that resulting from evaporation of sea water. For the use of shore source distillate, refer to article 9560.92.

9560.44 PROTECTION OF FEEDWATER

Feedwater shall be maintained as free from impurities as possible. This requirement involves careful attention to the

entire plant through which the water passes, either in the form of steam or as water, for, even though evaporator distillate quality is excellent at the time of entry into the system, by the time it is used as makeup feed, it may absorb impurities from the various parts of the installation.

9560.45 SOURCES OF SALT WATER CONTAMINATION

The most prolific source of contamination of the water in naval boilers is salt water leakage into the feedwater system. The principal parts of the system where this leakage may occur are listed below:

1. Condensers: main, auxiliary, and T-G set.
2. Salt-water-cooled air-ejector condensers.
3. Distilling plants.
4. Salt-water-cooled gland-exhaust condensers.
5. Leaky bottom-blow valves on idle boilers.
6. Leaky feed suction and drain lines which run through bilges.
7. Leaky seams and rivets in reserve feed tanks.

9560.46 CONDENSATE CHLORIDE

Condensers are the most common source of salt water leakage into the feedwater system. Particular attention should be given to detect leakage of salt water into the freshwater side of condensers. In most naval installations, the condensate consistently contains less than 0.05 ppm of chloride. Any consistent increase above this value is a definite indication of a leak. When a leak is detected, it should be corrected as soon as operating conditions will permit dismantling the unit affected. Attention is directed to appropriate parts of chapter 9460 for operation and maintenance of condensers.

9560.47 EFFECT OF CARRYOVER ON CONDENSATE CHLORIDE

Whenever the condensate from any condenser shows the presence of chloride to be above the usual operating value, it is well to check the steam from the boilers by testing a sample of water from one of the steam drain lines. The results of the steam-condensate analyses will indicate whether or not there is any carryover of boiler water in sufficient quantity to give more than normal chloride readings in the condensate. Sudden large increases in ship speed may cause carryover from the boilers. The effect of this carryover on the chloride in the condensate will be more pronounced the higher the chloride content of the boiler water.

9560.48 FINDING SOURCE OF CHLORIDE CONTAMINATION

It is of the greatest importance that any unusual rise in the chloride content in the feed tanks, feedwater, or boilers be investigated at once and the source of the leakage found and corrected. To locate these sources, test the feedwater from different units in the system, and where possible cut out the elements one at a time until the source of contamination is located. A test for chloride in the feedwater should be made each time one of the elements is cut out. Before making a test, the plant should be allowed to operate for several minutes without this element in commission so that the chloride concentration of the feedwater due to that element may have time to be diluted with salt-free water. The

methods of testing the condensers to locate a leak are described in chapter 9460.

9560.49 LEAKING EVAPORATOR TUBES

Leaky evaporator tubes occasionally are responsible for salting up the feed system and for causing excessive sludging in the boiler water. The salting-up usually occurs after the distilling plant has been secured, when a leak in the first-effect evaporator tube nest will permit salt water to enter the first-effect tube-nest drains and eventually some part of the system. Therefore, tube-nest drains should be tested for salinity upon starting up the distilling plant. It is possible, through faulty evaporator operation, to permit the level of the brine in the shells to rise to the point where salt water backs up through the first-effect tube-nest vent line, thus contaminating the drains. The first-effect tube-nest drain line should be secured during all periods when the distilling plants are idle.

9560.50 LEAKING SUCTION LINES IN BILGES

The system may be salted up by leaky feed suction lines which run through the bilges. Such leaks will also be responsible for some loss of makeup feedwater. Periodic tests of feed-suction lines should be made, as very often leaks will exist which are responsible not only for a loss of feedwater but for loss of pumping efficiency when the lines are being used.

9560.51 SALT WATER AND FEEDWATER CROSS-CONNECTIONS PROHIBITED

No cross-connection shall be permitted between salt water and feedwater piping.

9560.52 ELIMINATION OF AIR IN FEEDWATER

For reasons made clear in part 3, it is imperative that all possible precautions be taken to eliminate dissolved air from the boiler feedwater in order to reduce corrosion of boilers and, particularly, of economizers. Elimination consists in correcting all possible sources of air leakage into the feed system and of maintaining the efficiency of the deaerating equipment. A list of precautions is given in Chap. 9562 for each type of boiler feedwater system.

9560.53 ELIMINATION OF OIL AND GREASE IN FEEDWATER

The presence of oil and grease in the feedwater and in the boilers is not a frequent occurrence in naval installations. The following precautions should be effective in preventing any oil from reaching the boilers:

1. No oil shall be used for the internal lubrication of the steam cylinders or valve chests of any reciprocating machinery. Saturated steam provides enough water of condensation to give the necessary lubrication, and in superheated steam units the metals used are designed to operate satisfactorily without lubrication. The use of a pure mineral oil may be authorized by the command in special cases only. Only a light, smooth coating of petrolatum shall be applied to the inside of cylinders at specified inspections.

2. Very little lubrication of rods is necessary and this lubrication shall be kept at a minimum by the use of small quantities of mineral oil at each application. With reciprocating engines using forced lubrication, the oil from

such as crossheads and guides should be prevented from splashing on the piston rods or valve stems.

3. When filters or grease extractors are fitted, they always should be used and kept in efficient condition.

4. Filtering material should be cleaned or renewed as often as found necessary as outlined in Chap. 9562. Special precautions and instructions when using asbestos and diatomaceous-earth filter aid should be observed.

5. Drains from fuel oil heaters and from heating coils in lubricating oil tanks and fuel oil tanks always shall be passed through an inspection tank before discharging into the feed system. Frequent inspections of these tanks are necessary so that the presence of oil will be discovered soon after its first appearance, so that drains may be diverted to the bilge until the source of contamination is removed.

9560.54 AVOIDING EXCESSIVE MAKEUP FEED

It is necessary to add makeup feedwater to the system to replace water lost by leakage. All boilers, piping, glands, and valves should be kept tight and in efficient condition. The amount of makeup feed used per hour in port and per mile under way should be checked daily and every effort made to keep these amounts at low and consistent level.

9560.55 FILLING BOILERS

A boiler which has been opened for cleaning, overhaul, and inspection should be filled with hot deaerated feedwater, treated immediately and subsequently lighted off within 48 hours after filling whenever conditions permit (see chapter 9510). The short time of a steam test is sufficient to initiate the changes in the treatment chemicals discussed in the following article, as well as mixing the boiler water thoroughly so that the maximum protection against corrosion will be insured. The hottest deaerated water available should be used for filling a boiler, the method for obtaining such water depending upon the feed system as discussed in Chap. 9562. An idle boiler should always be secured in accordance with chapter 9510.17, unless it is to be lighted off immediately. Partial filling or securing boilers at steaming level introduces the possibility of steam drum general corrosion discussed in chapter 9560.31. Steam testing a boiler soon after its overhaul is good engineering practice.

Part 5. Water Treatment-600 psi Boilers and Below

9560.71 NATURE OF BOILER COMPOUND

The system of water treatment used for naval vessels with auxiliary and propulsion boilers operating at pressures at or below 600 psi is based on the use of Navy boiler compound. This formula has been designed to meet the most severe conditions which are likely to be encountered in a well-managed ship. However, the factor of safety thus provided in the compound is not sufficient to warrant any laxity on the part of ship's personnel in keeping the purity of the boiler feedwater at the highest attainable point. The ingredients of Navy boiler compound are disodium phosphate, Na_2HPO_4 , sodium carbonate (soda ash), Na_2CO_3 , and cornstarch. The first two chemicals work together in converting scale-forming salts into relatively harmless sludges. The two in conjunction are not only more thorough than either by itself but, in addition, form a mixed sludge, which, being made up of both phosphate and carbonate, has

less tendency than either alone to agglomerate and form an adherent, cohesive mass. The sodium carbonate serves the additional purpose of providing the necessary alkalinity control. Actually, under boiler steaming conditions, most of the soda ash is converted to sodium hydroxide, while the remainder goes into the conditioning reaction described above. The cornstarch lends fluidity to the sludge resulting from the reaction of the other two ingredients so that it does not pack in the mud drums, but may be sluiced out easily. The cornstarch also effects a very desirable reduction in the tendency of boiler water to foam and thereby reduces carryover and moisture in the steam.

9560.72 DETERMINATION OF DOSAGE

The amount of Navy boiler compound required by a boiler may be determined from the nomographs of figures 9560-9 and 9560-10 if the volume of water in the boiler at steaming level and the alkalinity and hardness of the boiler water are known. Illustrative lines are given in figure 9560-9 to demonstrate the use of the charts. The upper line illustrates the calculation of the dosage necessary to bring the alkalinity to 3.5 eph when filling a boiler which holds 3,400 gallons at steaming level. Reserve feedwater or condensate may be assumed to have zero alkalinity so that a straight edge is held from the point of zero alkalinity on the right scale to the point of 3,400 gallons on the left scale. This line cuts the middle

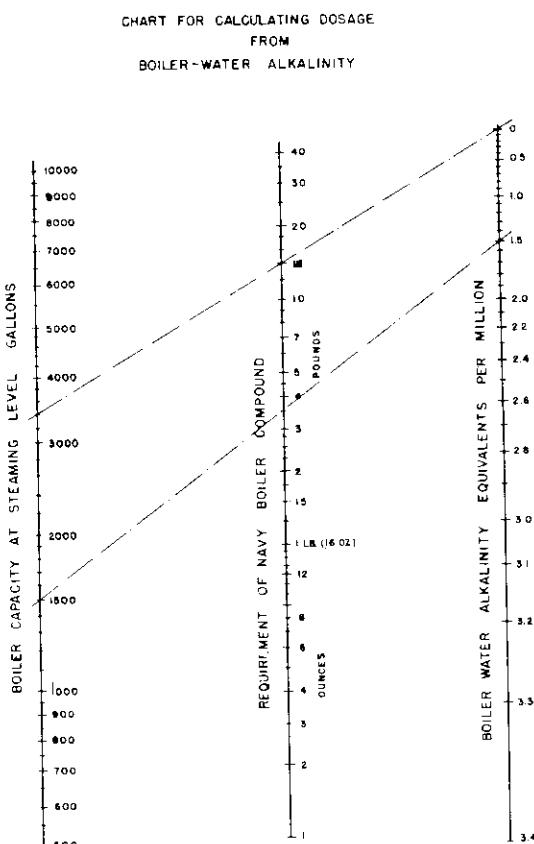


Figure 9560-9.

CHART FOR CALCULATING DOSAGE
FROM
BOILER-WATER HARDNESS

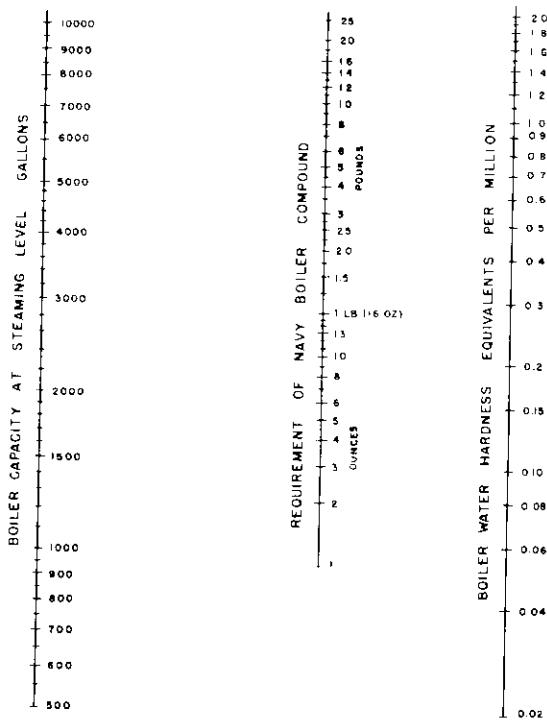


Figure 9560-10.

3,400 gallons on the left scale. This line cuts the middle scale at 15 pounds, indicating that 15 pounds of Navy boiler compound are required for the initial dose. The lower line illustrates the calculation of the dosage for a steaming boiler which holds 1,500 gallons at steaming level, the boiler water of which has been found to have an alkalinity of 1.5 ephm. A line from 1.5 on the right scale to 1,500 on the left scale cuts the middle scale at 3.5. This indicates that a dose of 3.5 pounds of Navy boiler compound is required to bring the alkalinity to 3.5 ephm. In case hardness occurs in boiler water, the required amount of Navy boiler compound for the elimination of the hardness is calculated from figure 9560-10 in a similar manner. A straight edge is laid across the chart from the point of the determined hardness on the right scale to the point on the left scale corresponding to the water content of the boiler at steaming level. The point at which this line intersects the middle scale indicates the amount of compound required to reduce the hardness to zero. Generally when hardness is found in the boiler water, the alkalinity is low. For example, assume a boiler holds 1500 gallons at steaming level and the water has an alkalinity of 2.4 ephm and a hardness of 0.04 ephm. The alkalinity dosage chart should be employed in determining the necessary addition of Navy boiler compound. For this example, the two pounds of dosage required would result in a boiler water alkalinity of 3.5 ephm and eliminate the hardness. The addition of one ounce of dosage would eliminate

the hardness but would have little, if any, effect on the alkalinity.

9560.73 USE OF CHARTS

The amount of boiler compound calculated from figure 9560-9 as outlined above, in each case will be sufficient to raise the boiler-water alkalinity to 3.5 ephm. If the boiler-water alkalinity is within the range of 2.5 to 3.5 ephm, no dose need be given. However, prior to securing a boiler for bottom blowdown, the required dosage should be added to bring the boiler water alkalinity to 3.5 ephm. In rare cases in which hardness occurs in boiler water, the full dose indicated by figure 9560-10 shall be added, even though this amount of compound increases the boiler water alkalinity above the higher allowable limit. The excess alkalinity then must be removed by blowdown.

9560.74 BOILER WATER HARDNESS

The occurrence of boiler-water hardness usually is evidence that the makeup feedwater contains excessive hardness, although false soap hardness may result from the presence of zinc supplied either by condenser corrosion or from galvanized storage tanks. The amount of compound which is added to maintain the proper alkalinity should simultaneously ensure zero hardness of the boiler water if proper feedwater is used.

The source of any unusual hardness in the boiler or feedwater should be searched for, found, and corrected. If the boiler water consistently shows hardness, and the measures taken fail to remedy this condition, the Ship Systems Command shall be advised. Navy boiler compound shall be added immediately to a boiler water containing hardness.

9560.75 METHOD OF ADDING COMPOUND

Navy boiler compound should be mixed by stirring vigorously for about 5 minutes in hot, preferably boiling water. The mixture should be made up using about 1 pound of compound to 5 quarts of water. The compound may be added to the boilers in several ways. Each dose must be added to the individual boiler for which it is intended. The method applicable to most types of naval feed systems consists of adding the compound to the feed compound injection tank and discharging to the desired boiler through the main feed line. The feedwater should be run through the injection tank for at least several minutes to insure complete injection into the boiler and flushing of the tank. The method applicable to ships not equipped with feed compound injection tanks consists of using the emergency feed pump and discharging through the auxiliary feed line to the desired boiler, the compound being added to the feed pump suction. After the compound has been added, the emergency pump should be run a sufficient length of time to wash out the entire feedline. When only one boiler is steaming, as in port, the dose may be added directly to the port-use feed-pump or auxiliary-feed booster-pump suction. Boiler compound should be added in single or intermittent doses, but never in a continuous, dilute steam. Boiler compound should never be added to the fresh-water-drain collecting tanks.

9560.76 FREQUENCY OF TESTS OF BOILER WATER
(where 3-M cards are installed, preventive maintenance shall be conducted in accordance with the 3-M cards. See also other paragraphs listed in index under "Frequency of tests.")

Boiler water must be tested for alkalinity, chloride, conductivity and hardness under various conditions as follows:

1. Steaming boiler-daily and after any water treatment (chemical addition or blowdown)
2. Idle boilers-weekly, after any treatment and prior to light off.
3. When boilers are filled with feedwater.
4. One hour after the addition of boiler compound and one-half hour after blowdown.
5. Whenever unusual conditions make it desirable.

9560.77 FREQUENCY OF FEEDWATER TESTS

1. **Alkalinity.** Alkalinity of feedwater is determined only when it constitutes the charge of a freshly filled boiler or when it consists of shore water as an emergency feed.

2. **Chloride.** Feedwater is tested for chloride in accordance with the following schedule:

- a. **Distiller discharge to reserve feed tanks** at each filling of the measuring tank.
- b. **Condensate: main condensers**—every 15 minutes while underway and every 30 minutes while standing by.
- c. **Condensate: auxiliary condensers**—every 30 minutes.
- d. **Feed tanks**—such feed tanks on the main line as deaerating feed tanks and surge tanks one each watch.
- e. **Reserve feed tanks**—Daily and prior to use.

Chloride can be determined either with the electrical salinity indicator or by the chemical method described in article 9560.102. It is recommended that the chemical method be used whenever checking feedwater from the feed tanks and reserve feed tanks. The electrical salinity indicator readings should be checked frequently by the chemical methods.

3. **Hardness.** Feedwater is tested for hardness in accordance with the following schedule:

- a. Feed tanks-daily
- b. Reserve feed tanks-daily and prior to use

4. **Dissolved Oxygen.** Vessels equipped with deaerators (deaerating feed tanks) shall make daily determinations of the dissolved oxygen content of the water discharged from each deaerator in operation (idle deaerators should not be tested).

Dissolved oxygen determinations should also be made on samples of water from other points in the feedwater system to locate sources of air leaking into the system or sources of oxygen contamination of the feedwater. The prescribed methods for drawing a sample, and fixing and titrating the dissolved oxygen samples must be followed in detail if reliable results are to be obtained.

9560.78 PREPARATION REAGENTS

Reagents for use in the various tests on water are supplied as standard stock solutions either 10 or 20 times reagent strength, in powder form, or ready for use. These stock solutions or powders must be diluted or dissolved accurately to reagent strength with the equipment provided in the boiler water testing cabinet. Distilled water shall be used for all dilutions of stock solution in which water is

used. Standard stock solutions of reagents should be used. Requisitions should state that reagents are for use with the boiler water testing outfit. For information regarding stock catalog numbers see article 9560.116.

9560.79 REAGENT NITRIC ACID

A twentieth normal (0.05 N) solution of nitric acid is used for alkalinity determinations. The method for the preparation of the twentieth normal solution from standard stock solution is given below.

Preparation from stock solution. The reagent solution for use in the cabinet is made up from the stock, normal (1.0 N) nitric acid. Rinse the bottle from the cabinet marked ACID at least twice with distilled water. Rinse the 100-ml. graduated cylinder with distilled water and then a small amount of the stock acid solution. With the graduated cylinder, measure exactly 50-ml. of the stock solution of stand acid into the rinsed bottle. Fill the bottle exactly to the 1,000-ml. mark with distilled water, stopper, and shake until contents are well mixed. Remove the stopper, replace the burette assembly, and return to cabinet. Fill the burette.

9560.80 REAGENT MERCURIC NITRATE

A fortieth normal (0.025 N) solution of mercuric nitrate is used for the chloride determination. It should be prepared from the standard stock solution in accordance with the instructions given below.

Preparation from stock solution. The stock solution of mercuric nitrate is one-half normal (0.5 N) and thus is 20 times as strong as the reagent solution. Rinse liter bottle marked MERCURIC NITRATE and the 100-ml. graduated cylinder at least twice with distilled water. Then, rinse the 100-ml. graduated cylinder with a small amount of stock solution of mercuric nitrate. Fill the cylinder to the 50-ml. mark with stock solution and transfer to the liter bottle. Fill the bottle to the mark on the neck with distilled water, stopper and shake until the contents are well mixed. Remove the stopper, replace the burette assembly, and return the bottle to the cabinet. Fill the burette.

9560.81 REAGENT SOAP SOLUTION

A hundredth normal (0.01 N) soap solution is used for determination of hardness. It should be prepared from the standard stock solution in accordance with the following instructions. The stock soap solution is 10 times as strong as the reagent solution.

1. **Preparation from stock solution.** Rinse the bottle marked SOAP with distilled water and then with ethyl alcohol. Rinse the graduated cylinder from the cabinet with ethyl alcohol and then with a small amount of the stock soap solution. Fill the cylinder to the 100 ml. mark with stock soap solution and transfer to the liter bottle. Add sufficient pure ethyl alcohol to bring the level in the bottle exactly to the 1,000 ml. mark, stopper, and shake until thoroughly mixed. Replace the burette assembly and return to the cabinet. Fill the burette. Denatured alcohol should not be used for the preparation of soap solution.

2. The lather factor of a solution of soap is the amount of the solution required to form a lather which persists for at least five minutes on a sample of pure water. This lather factor is fairly constant, hence, it is assumed to be 0.4 ml.

9560.82 PHENOLPHTHALEIN INDICATOR

To prepare phenolphthalein indicator solution, dissolve 1/2 gram of phenolphthalein powder in 25 ml. of pure ethyl alcohol, add 25 ml. of distilled water, and mix well.

9560.83 METHYL PURPLE INDICATOR

Methyl purple indicator is furnished in solution ready to use.

9560.84 CHLORIDE INDICATOR

To prepare the chloride indicator solution, empty the contents of a single capsule of dry chloride indicator into the chloride indicator dropping bottle. Next add 50 ml. of 95 percent ethyl alcohol or isopropyl alcohol. Then place the stopper in the bottle and shake to dissolve the contents.

9560.85 DISSOLVED OXYGEN TEST REAGENTS

There are two shipboard methods for dissolved oxygen in the feedwater from the deaerating feed tank. They are Method A, the titration method, and Method B, the colorimetric method.

1. Method A Reagents:

a. Reagent sodium thiosulfate—A stock solution of sodium thiosulfate 20 times reagent strength, is supplied. To make up the reagent solution for titration, remove the burette and stopper assembly from the thiosulfate reagent bottle and rinse the bottle several times with distilled water. Rinse the 100 ml. graduated cylinder from the boiler water testing cabinet with a small portion of distilled water and then with stock sodium thiosulfate solution. Measure exactly 50 ml. of stock solution into the thiosulfate reagent bottle. Fill the thiosulfate bottle to the 1,000 ml. mark on the neck with distilled water; stopper with the solid rubber stopper provided, and mix the solution thoroughly by shaking the bottle. Replace the burette and stopper assembly in the neck of thiosulfate bottle, return the reagent bottle to the cabinet, and fill the burette. Mark the date in pencil on the roughened area above the label of the bottle. At the end of the week, discard whatever remains of the solution and make up fresh reagent thiosulfate solution.

b. Starch indicator—Prepare starch indicator in accordance with the following instructions. Rinse and then fill the 150 ml. beaker three-fourths full with distilled water. Place the beaker on the hot plate in the cabinet, heat the water to boiling, and sprinkle into it from the tip of the spatula a mound of soluble starch about one-half inch long. Stir the boiling solution for about one-half minute with the blade of the spatula, turn off the hot plate, remove the beaker, and allow its contents to cool. Rinse the starch dropping bottle with distilled water and fill it with the cooled starch solution. Starch solution must be prepared fresh on day of test.

c. Dissolved oxygen fixing solutions—The dissolved oxygen fixing solutions (I, manganese sulfate; II, alkaline iodide; III, sulfuric acid) are supplied in the proper strength and are to be used in the reagent bottles. These reagent bottles should not be more than 1/3 filled with reagent.

2. Method B. Reagents:

The three reagents for this method are supplied in plastic tubes for ready use without dilution in an amount premeasured for one determination.

- a. Class A—Manganous sulfate reagent.
- b. Class B—Sodium hydroxide reagent.
- c. Class C—Sulfamic acid and ortho-tolidine dihydrochloride reagent.

9560.86 BOILER WATER CONDITIONS TO BE MAINTAINED

Constituent Requirements

Alkalinity, Phenolphthalein	2.5–3.5 epm
Hardness	Zero
Chloride	(See 9560.92)
Conductivity (For propulsion boilers only)	1300 micromhos/cm max.

9560.87 ALKALINITY AND HARDNESS LIMITS

Navy boiler compound shall be used as necessary to maintain zero hardness and alkalinity between 2.5 and 3.5 epm in the water of all boilers at all times. A ship unable to adhere to these instructions, or obtaining unsatisfactory conditions despite adherence to these instructions, shall advise the Ship Systems Command.

9560.88 ALKALINITY VARIATIONS IN STEAMING AND IDLE BOILERS

When a freshly filled boiler is treated with Navy boiler compound, the sodium carbonate (soda ash) remains as soda ash until the boiler is put on the line. When the boiler starts producing steam almost all the soda ash is converted to sodium hydroxide (caustic soda). When a boiler has been steamed and is secured, the previously formed caustic soda gradually reverts to soda ash. The alkalinity of the boiler water having soda ash in solution is different from that having caustic soda in solution. Therefore, the alkalinity of a steaming boiler is different from that of an idle boiler. In addition, the alkalinity of the idle boiler which has previously been steamed varies with time.

No one test method is suitable for the determination of alkalinity of the water in both steaming and idle boilers because of the conversion in either direction between soda ash and caustic soda (and the interaction of disodium phosphate with water). Therefore, two methods for determining alkalinity are used. The method selected depends on the status of the boiler when the sample is taken.

The phenolphthalein method is used to determine the alkalinity of water sampled from a boiler that:

- a. is steaming, or
- b. has been steamed, then secured and remained idle for six days or less, and has not been treated with Navy boiler compound during the idle period.

The details of the phenolphthalein alkalinity method are given in Article 9560.100.

The average of the phenolphthalein and the methyl purple alkalinites is used to determine the alkalinity of water sampled from a boiler that:

- a. is idle, but has been treated with Navy boiler compound after being secured, or
- b. has been idle seven days or more.

The details of the methyl purple alkalinity method are given in Article 9560.101. An example of the calculation for determining the average of the phenolphthalein and methyl purple alkalinites follows:

Assume a phenolphthalein alkalinity of 1.8 epm and a methyl purple alkalinity of 3.2 epm. The average of the phenolphthalein alkalinity and the methyl purple alkalinity is:

$$\frac{1.8 \text{ epm} + 3.2 \text{ epm}}{2} = \frac{5.0 \text{ epm}}{2} = 2.5 \text{ epm}$$

9560.89 CONDUCTIVITY LIMITS

A direct relationship exists between the amount of ionized dissolved solids in the boiler water and the conductivity of the boiler water. Therefore, conductivity values can be used to determine when the boiler water contains an excessive amount of dissolved solids and, hence establish when the boiler should be blown down. The maximum boiler water conductivity permitted in main propulsion boilers operating at 600 psi and below is 1300 micromhos/cm. When the conductivity exceeds this limit, the boiler must be given surface blows until the conductivity is less than 1300 micromhos/cm.

9560.90 CHLORIDE LIMITS

The chloride concentration is another indication of the amount of dissolved solids in the boiler water. To avoid the troubles caused by high concentrations of dissolved solids, the chloride concentration of the boiler water should be maintained as low as possible, preferably below 1 epm. The maximum chloride concentration permitted for boilers of various types is given below:

1. Main propulsion boilers (600 psi and lower) – 2 epm max.
2. Auxiliary boilers – 15 epm max.

Whenever the chloride content of a boiler water exceeds the maximum limit, the excess chloride must be removed by blowdown or the boiler secured, drained and refilled. It is better feedwater economy to secure, drain, and refill, rather than attempting to blowdown a propulsion boiler which has reached a chloride content of 5.0 epm, provided, of course, that the contaminating source has been corrected.

9560.91 FEEDWATER REQUIREMENTS

Feedwater and feedwater components normally are tested for chloride, hardness, and dissolved oxygen. Dissolved oxygen is determined only by ships having deaerating feed tanks.

The following requirements must be observe in the case of feedwater, being deviated from only in emergencies.

Feedwater Component	Requirements
Evaporator Distillate	Chloride – 0.065 epm max.
Reserve feed tanks	Chloride – 0.25 epm max. Hardness – 0.20 epm max.
Makeup feedwater	Chloride – 0.25 epm max. Hardness – 0.20 epm
Condensate Feedwater (Degaerating feed tanks and surge tanks)	Chloride – 0.05 epm max. Chloride – 0.15 epm max. Hardness – 0.20 epm max. Dissolved oxygen – 0.02 ppm max. (DFT's only)

9560.92 SHORE SOURCE FEEDWATER AND STEAM REQUIREMENTS

Each shipment of shore source feedwater ("rainmaker," shore steam condensate or commercial), shall be accompanied by a certificate of analysis showing that the water meets the requirements listed below. Shore steam employed as a steam blanket on an idle boiler or as superheater protection steam during boiler light-off shall meet these requirements.

Constituent or Property	Requirements
pH	5.0–9.0
Dissolved Solids	10 ppm max.
Conductivity	25 micromhos/cm max.
Dissolved Silica	0.2 ppm max.
Hardness	0.1 epm max.

Each shipment of shore source feedwater shall be sampled and tested prior to acceptance for agreement with the following requirements:

Constituent or Property	Requirements
Hardness	0.1 epm max.
Alkalinity	Colorless to phenolphthalein, green to methyl purple

The hardness test shall be performed in accordance with article 9560.103. The alkalinity shall be determined as follows:

1. Measure approximately 50 ml. of feedwater sample with a clean graduated cylinder.
2. Pour the 50 ml. sample into a clean casserole and add 4 drops of phenolphthalein indicator.
3. Stir and observe any color development. The sample should remain colorless.
4. Rinse the casserole with distilled water.
5. Measure a second 50 ml. sample of the feedwater and pour into the clean casserole.
6. Add 4 drops of methyl purple indicator, stir and observe the color of the sample.
7. The color of the sample should be green.

The collection of drains for use as feedwater, when using shore steam, is prohibited.

9560.93 ADDITIONAL FEEDWATER REQUIREMENTS

Shore water should not be used except in case of emergency. Before use, it must be distilled in the ships evaporators. Shore water should be low in hardness and chloride. In addition it should be neutral, green to methyl purple and colorless to phenolphthalein (Consult article 9560.43).

Evaporator coil drains are to be tested when starting the evaporator plant.

9560.94 SAMPLING BOILER WATER

The boiler water sample should be representative of the boiler water in the boiler. To accomplish this, the sample flow should pass through a sample cooler so that the sample collected is cooled to less than 100° F., preferably to 80° F. (a thermometer should be used). The first step is to initiate coolant flow through cooler. This is an important safety step. Sample valves before the cooler are then opened full. The

sample valve after the cooler is opened until, on a steaming boiler, the sample flow flashes to steam. The cooler outlet sample valve is throttled until the sample flow is at the proper temperature. The sample container, ideally a quart plastic container with a screw cap (see article 9560.116), is rinsed three times with small portions of the sample flow. The sample container is then completely filled with boiler water sample and capped. The sample should be subjected to testing within one-half after collecting. The sample should be protected against contamination through undue exposure to air or particles dropping into the sample by tightly stoppering the bottle.

9560.95 SAMPLING FEEDWATER

All feedwater samples except feedwater dissolved oxygen samples shall be collected in clean plastic bottles with caps. The sampling connection or apparatus shall be flushed with the sample flow so as to aid in obtaining a representative sample. Hot samples must be cooled to less than 100° F. prior to testing (a thermometer should be used).

9560.96 COLLECTING DISSOLVED OXYGEN SAMPLES FROM DEAERATING FEED TANK

The dissolved oxygen sampling connection should be located on the side of the vertical section of the DFT outlet to the main feed booster pump upstream of any branches to other pumps in the feedwater system. The sampling lines, valves and coolers shall be installed in accordance with BUSHIPS (NAVSHIPS) Mechanical Standard Dwg. #810-1385735-B. Attach a short length of black neoprene rubber tubing, provided in the testing cabinet, to the outlet nipple of the sample line. Insert into the rubber tubing a length of glass tubing. With the cooling water secured in such a manner that shell pressure developed on the coolant side by hot sample flow is relieved, start a flow of sample water at maximum rate through the cooler or coolers to flush the sample system. Measure the approximate rate of flow. When the sample flow reaches a temperature of 140° F., as measured by a thermometer, continue the sample flow for the length of time corresponding to the flow rate in the following table:

Flow, ml. per min.	Time, minutes
600	5
500	8
400	13
300	20

Upon completion of the hot flush, start a flow of cooling water and adjust cooling water and sample flow rate for the correct conditions depending on which analytical method is employed.

Method A—Titration

The sample flow rate should be adjusted to 300 ml. per minute with a sample temperature less than 70° F. as measured by a thermometer. Insert the glass tubing to the bottom of a clean sample bottle. Allow the sample to flow continuously for seven minutes and keep the pointed glass stopper wet in water which overflows the sample bottle. Slowly withdraw the glass tubing without interrupting the sample flow and drop the glass stopper into the neck of the bottle immediately, twisting it securely in place. Hold the stopper securely in place, invert and tap the bottle gently.

If a bubble is present, no matter how small, discard the sample and collect a new one. Do not confuse an imperfection in the glass with an air bubble in the sample. The sample is then treated as is given in article 9560.111.

Method B—Colorimetric

The sample flow rate should be adjusted to 500 ml. per minute having a temperature at least 70° F. but no more than 100° F. as measured with a thermometer. Insert the glass tubing to the bottom of a clean sample bottle. If the sample flow rate has been adjusted properly, the bottle should fill in two minutes. Allow the sample bottle to overflow for 12 minutes, keeping the sample bottle stopper wet in the overflow. Slowly withdraw the glass tubing without interrupting the flow. Drop the stopper immediately into the neck of the bottle. Twist the stopper with slight pressure to secure it. If a bubble is present, no matter how small, discard the sample and collect a new one. Do not confuse an imperfection in the glass with an air bubble in the sample. The sample is then immediately fixed at the sampling location as given in article 9560.111.

9560.97 EQUIPMENT FOR BOILER WATER TESTS

The equipment required for conducting all but the conductivity test is assembled in the boiler water testing cabinet which is illustrated in figure 9560-11. A 1-liter bottle is provided for each of the following three reagents: nitric acid, mercuric nitrate, and soap solution. Each bottle has a raised or ground mark on the neck which indicates 1 liter (1,000 ml.) so that testing solutions can be made up directly in the reagent bottles without the necessity for separate measurement and mixing. A 10 ml. automatic zero burette and an aspirator bulb for filling the burette are fitted into the stopper of each reagent bottle. In filling burettes, however, care should be taken to ensure that the delivery tip is filled to the outlet with the reagent liquid. All titrations must be started at the zero mark. The burette is designed to drain to the zero mark automatically after filling. The reading of the liquid level in a burette, pipette, or graduated cylinder should always be made at the bottom of the curved surface, called the meniscus. Do not attempt to remove the burette or bulb from the stopper. If it is necessary to replace a broken burette, the stem of the new burette and the stopper should be thoroughly wet before the new burette is inserted.

CAUTION: If the stem and stopper are not wet, the stem will bind in the stopper and may break under the force applied. Such a break produces broken glass with dangerously sharp edges that could cause serious injury to the hands.

Occasionally lubricate the stopcock of each burette with the grease provided. Excessive grease should be avoided since it will plug the burette tip and stopcock bore. Care should be exercised to avoid any pressure on the burette tip, especially when turning the stopcock. The stopcock can be manipulated best with the left hand. The thumb and forefinger should encircle the burette nozzle, with the finger ends on the stopcock handle, the right hand then is available for stirring. The following equipment also is included in the cabinet:

1. Bottle for phenolphthalein indicator.
2. Bottle for methyl purple indicator.



Figure 9560-11. Boiler water testing cabinet.

3. Bottle for chloride indicator.
4. Six stirring rods.
5. Two porcelain casseroles.
6. 100 ml. and 10 ml. graduated cylinders.
7. One 8-ounce, square bottle for soap hardness test.
8. One collapsible tube of stopcock grease.
9. Solid stoppers for reagent bottles for use in mixing testing solutions.

Replacement of any of these items may be obtained from usual naval sources. For information regarding stock catalog numbers, see article 9560.116.

The equipment used in the conductivity test consists of two elements: (1) A meter containing a compact and accurate Wheatstone Bridge with a cathode-ray tube as a balance indicator, and (2) a conductivity cell with two platinized electrodes. The meter is calibrated in terms of micromhos/cm and for accurate results must be used with a conductivity cell of definite cell constant. Information regarding stock numbers is given in article 9560.116.

9560.98 CARE OF CHEMICAL EQUIPMENT

All chemical equipment must be kept scrupulously clean if reliable results are to be obtained. All burettes should be full at all times to prevent solutions from drying on the upper walls and thus altering the strength of the reagent in the burette. The soap-solution burette can be cleaned with either distilled water or ethyl alcohol. Dishes, pipettes, and graduated cylinders should be kept clean by rinsing in distilled water and wiping immediately after each use. Rubbing with the fingers may be required to remove the purple ring left by the chloride indicator on the side of the casserole. No chemical glassware or porcelain ware should be cleaned with strong lye or scouring powders. If soap and water will not clean these properly, a weak acid solution can be used. The acid solution must be rinsed out thoroughly with distilled water.

9560.99 DETERIORATION OF CHEMICALS

Test chemicals are subject to deterioration due to storage at high temperatures and/or old age. Deteriorated chemicals are not to be used as they will lead to incorrect test results. To ensure accurate results, all test chemicals must be stored in areas where temperatures are preferably below 80° F. but not exceeding 100° F. Unless otherwise specified (see Paragraph 9560.141) test chemicals should be discarded either two years from date of manufacture or one year from time of receipt on board ship, whichever is earlier, in accordance with NAVSUP Manual 35041.

To assist in the detection of deteriorated chemicals, standard solutions have been developed and are available in the stock system. A list of the standards and the respective stock number is given below:

Standards	Federal Stock Number
Class a.—Standard alkalinity solution, 6.0 epm methyl purple alkalinity	1H6810-985-7129
Class b.—Standard chloride solution, 5.0 epm chloride	1H6810-985-7130
Class c.—Standard chloride solution, 0.1 epm chloride	1H6810-985-7131
Class d.—Standard hardness solution, zero hardness	1H6810-985-7132
Class e.—Standard hardness solution, 1.0 epm hardness	1H6810-985-7133

Using the applicable standard, check the quality of the boiler water testing chemicals at least once every 3 months. The standards should be analyzed in accordance with the methods set forth in this chapter. The analytical results obtained should be within the following limits:

Standard	Limits
Alkalinity (6.0 epm)	5.4--6.6 epm
Chloride (5.5 epm)	4.5--5.5 epm
Chloride (0.1 epm)	0.075--0.125 epm
Hardness (zero)	0.4 ml titration or less
Hardness (1.0 epm)	0.9--1.1 epm

If the results obtained are not within the specified limits, fresh test chemicals should be prepared and checked against the appropriate standard. If the results still are not within specified limits, a shipyard chemist should be contacted at the earliest opportunity for assistance in locating the source of the error.

9560.100 PHENOLPHTHALEIN ALKALINITY

The phenolphthalein alkalinity is determined in the following manner:

1. Rinse the clean, 100 ml. graduated cylinder with some of the water to be tested.
2. Transfer exactly 50 ml. of sample into the clean porcelain casserole which has been rinsed with distilled water.
3. Add two or three drops of phenolphthalein indicator, which will give the sample a deep pink color if the sample is alkaline.
4. Fill the nitric acid burette and allow it to drain down to zero.
5. Add the reagent acid solution (0.05N) from the burette while stirring the sample continuously. Add only a drop at a time as the color begins to fade until the pink color entirely disappears.

6. Read the burette.

7. The burette reading (in milliliters) equals the alkalinity of the sample in equivalents per million. For example, a burette reading of 2.6 milliliters represents an alkalinity of 2.6 epm.

9560.101 METHYL PURPLE ALKALINITY

The methyl purple alkalinity is determined in the following manner: Measure 50 ml. of water into the porcelain casserole, taking the precautions outlined above, and add two drops of methyl-purple indicator, which will give the solution a green color if the sample is alkaline. Stir the sample and simultaneously add reagent acid solution (0.05N) until the color changes to purple. A gray tint precedes the purple end point color and serves as a warning of its approach. As soon as the color of the titrated sample changes from green to purple, read the burette and record the result. This color change is quite sharp in clear water, but if the water is red with suspended iron compounds, as may be the case with boiler water, a greenish grey color frequently persists between the green and the purple rendering the end point indefinite. However, as pointed out in article 9560.94, all water samples should be free from suspended matter. If turbid water is encountered, it should be discarded for a clear sample.

9560.102 DETERMINATION OF CHLORIDE

Determine the chloride content of the boiler water as follows:

1. Rinse the clean, 100 ml. graduated cylinder with some of the water to be tested.

2. Measure 25 ml. of sample and pour into the clean porcelain casserole that has been rinsed with distilled water.

3. Add five drops of chloride indicator to the sample. This will turn the sample red or violet depending on the alkalinity.

4. Place the casserole under the nitric acid burette, add reagent nitric acid one drop at a time until the violet color changes to a pale yellow and then add exactly 1 ml. excess of reagent nitric acid.

5. Place the casserole under the mercuric nitrate burette and fill the burette to the zero point.

6. Add reagent mercuric nitrate solution (0.025N) from the burette while stirring continuously until the pale yellow of a sample disappears and a pale blue-violet color persists throughout the solution. The rate of mercuric nitrate should be reasonably constant during the early part of the titration then reduced to drops of the solution as the end point is approached (blue-violet color).

7. Read the burette.

8. The burette reading in milliliters equals the chloride content of the sample in equivalents per million. For example, a burette reading of 5.5 ml. indicates a chloride concentration of 5.5 epm in the sample. In case the chloride concentration exceeds 20 epm, it will be more convenient to use a correspondingly smaller sample of boiler water rather than to refill the burette repeatedly. In such a case, dilute the smaller sample to 25 ml. in the graduated cylinder with distilled water and mix well. The chloride concentration of the original sample can then be calculated as follows:

$$\frac{\text{Burette reading (ml.)} \times 25}{\text{Volume of solution diluted (ml.)}} = \text{epm of chloride}$$

For example, if a 5 ml. sample is diluted to 25 ml., and the reading is 10 ml., then the chloride content is calculated as follows:

$$\frac{10 \text{ ml.} \times 25}{5 \text{ ml.}} = 50 \text{ epm}$$

9560.103 DETERMINATION OF HARDNESS

Determine the hardness content of the boiler water as follows:

1. Rinse the clean, 100 ml. graduated cylinder with some of the water to be tested.
2. Measure 50 ml. of sample and pour into the 8-ounce bottle which has been rinsed with distilled water.
3. Fill the soap burette and allow it to drain down to zero.
4. From the burette, add 0.4 ml. of soap solution; stopper the bottle, and shake it vigorously. Lay the bottle on its side on the bottom of the cabinet and start a stop watch.
5. If the lather persists and completely covers the surface of the water for 5 minutes, report "zero hardness."
6. If the lather does not persist, add more soap solution, in 0.1 ml increments; stopper and shake. Lay the bottle on its side and start a stop watch.
7. Repeat (6) until a lather is obtained which completely covers the surface of the water for 5 minutes.
8. Read the burette.
9. Subtract 0.4 from the burette reading.

10. The burette reading minus 0.4 times 0.2 equals the hardness of the sample in equivalent parts per million. For example, if the titration is 0.6, the hardness of the sample is 0.04 epm:

$$(0.6 - 0.4) \times 0.2 = 0.04 \text{ epm}$$

The amount of soap solution to be added under paragraph six will vary between 0.1 ml and 0.5 ml. A few titrations on waters of different hardness values will aid in gaging a proper addition. Too much soap solution should never be added.

9560.104 DETERMINATION OF CONDUCTIVITY

1. Connect the conductivity meter and the conductivity cell and warm up the instrument in accordance with the manufacturer's instructions.

2. Add a sufficient quantity of sample solution to a 250 ml beaker so that the air holes of the conductivity cell are at least 1/2" below the surface of the water.

3. Rinse the conductivity cell with distilled water.

4. Place the cell in the boiler water sample. Move the cell up and down under the solution several times to insure removal of air bubbles inside the cell. Immerse the cell to a point above the air vents.

5. Measure the temperature of the solution with a thermometer; then set the temperature compensation dial to the corresponding value.

6. Adjust the conductivity dial until the tuning eye deflects to the widest angle.

7. Record the conductivity reading on the Boiler Record Sheet (NAVSHIPS 114).

8. When the conductivity determination is completed, rinse and store the conductivity cell in distilled water. Distillate from shipboard distilling plants is adequate for this purpose.

9. If it is necessary to store the cell out of water at any time, rinse the cell well before it dries. If this is not done, an insoluble coating may form on the electrodes which will result in lack of sharpness of the "eye." Sharpness can frequently be restored by dipping the cell for about two minutes in 10-15 percent by weight hydrochloric acid and then rinsing well with distilled water. The cells should be replaced if no improvement is noted after this treatment. Every three months, check the accuracy of the meter and cell using the standard solution described below for this purpose.

Class i—Standard conductivity solution, FSN 1H 6810-945-7682, 1400 micromhos/cm.

The analytical results obtained should be in the range of 1300 to 1500 micromhos/cm. If the results are not within these limits, a shipyard chemist should be contacted at the earliest opportunity for assistance in locating and correcting the source of error. (See 9560.139, 1c)

9560.105 FEEDWATER TESTS

Alkalinity is not determined on feedwater except when the feedwater constitutes the charge of a freshly filled boiler or when it consists of shore water used as emergency feed. Methyl purple indicator is used for determining alkalinity of a freshly filled boiler. This test is made only to determine the proper initial boiler compound dosage.

9560.106 CHLORIDE DETERMINATION

To obtain the chloride content of feedwater in terms of epm, the chloride test is the same as that outlined in article 9560.102 for boiler water, except that the sample size is 100 ml. and the burette reading is divided by four. For example, if 100 ml. of feedwater requires 2.0 ml. of mercuric nitrate, the chloride concentration is $(2.0 \div 4)$ or 0.5 epm.

9560.107 HARDNESS DETERMINATION

The methods for determining and calculating soap hardness in normal feedwater are identical with those outlined for boiler water in article 9560.103. This method should be supplemented as indicated below when the hardness of shore water is being determined since such waters frequently yield false end points.

9560.108 ASSURANCE AGAINST FALSE END POINT

When determining the hardness of samples in which a false end point is suspected, follow the procedure below. Determine the hardness as described in article 9560.103 and record the amount of soap solution required for the 5-minute lather. Add 0.5 ml. more soap solution and shake the bottle vigorously. If the lather persists for 5 minutes, use the original titration value (milliliters required to form the first 5-minute lather) in calculating soap hardness. If the lather is destroyed or fails to persist 5 minutes, continue adding soap solution in 0.1 ml. increments until a stable lather is established. Calculate the true hardness from the total volume of soap consumed by the method given in article 9560.103. A second false end point will not occur.

9560.109 DISSOLVED OXYGEN TESTING EQUIPMENT

Method A—Titration

The cabinet is illustrated in figure 9560-12. The principle items in the cabinet are three 400 ml. reagent bottles, each with a side arm aspirator and a 2 ml. automatic zero pipette, for manganous sulfate, alkaline iodide, and sulfuric acid solutions; one-liter reagent bottle with an aspirator and a 10 ml. automatic zero burette for sodium thiosulfate solution; two sample bottles with conical pointed glass stoppers; a hot plate and beaker for preparing starch solution; and a large casserole for making titrations. The cabinet also contains glass and rubber sampling tubing, a bottle of soluble starch, a starch dropping bottle, a thermometer, a spatula, and a tube of lubricant.

Method B—Colorimetric

The principle items in this cabinet are the following:

1. Two one-liter sample bottles with ground glass stoppers
2. One bottle rack
3. One colorimetric comparator
4. Four comparison tubes
5. Three color standards representing 0.02, 0.04, and 0.06 parts per million (ppm) dissolved oxygen
6. A plain glass disc representing 0.00 ppm dissolved oxygen

7. One pair of scissors
8. One holder for three reagent tubes
9. One two-foot length of 3/8 inch i.d. rubber tubing
10. Six 10 in. lengths of glass tubing

For information regarding stock catalog numbers, see article 9560.116.

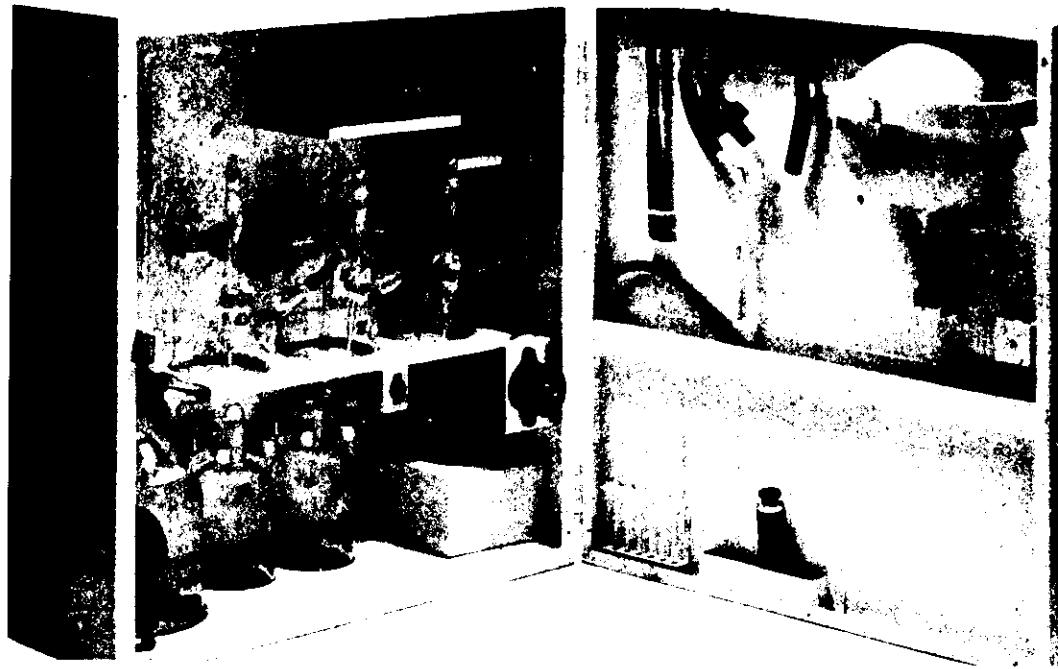


Figure 9560-12. Dissolved oxygen testing cabinet, Method A

9560.110 CARE OF OXYGEN-TESTING EQUIPMENT

General rules for the care of equipment are given in article 9560.98. Additional precautions are required for maintaining oxygen testing equipment in satisfactory working order.

Method A—Titration

The manganous sulfate (I) and alkaline iodide (II) solutions are very concentrated so that a slight evaporation clogs the discharge tubes of their pipettes. The alkaline iodide solution, in addition, will attack the glass of its pipette and cause freezing of the stopcock if it is allowed to remain in the pipette for more than 8 hours. These difficulties can be avoided if both pipettes are cleaned promptly after each use. To clean the manganous sulfate (I) pipette, fill the beaker with distilled water and raise it slowly onto the tip of the pipette with the stopcock opened, then lower the beaker and permit the stopcock tip to drain. Repeat this operation several times with at least two changes of water. Perform the same rinsing operation of the alkaline iodide (II) pipette and allowing it to remain covered with distilled water in the beaker until the next use of the cabinet.

CAUTION: The alkaline iodide (II) and sulfuric acid (III) solutions are very strong, corrosive reagents. Care should be taken to avoid spilling either of these solutions on the person or the clothing of the operator or in the cabinet. A further danger is that mixing these concentrated solutions causes a violent reaction which results in spattering. Accidental mixing can be avoided by clearly marking the 400 ml. reagent bottles from left to right with I (manganous sulfate), II (alkaline iodide), III (sulfuric acid). An etched circle is provided on each bottle for such pencilled markings.

Method B—Colorimetric

The sample bottles must be kept scrupulously clean at all times. The bottles should not be used for anything else but collecting dissolved oxygen feedwater samples. If the ground glass of the stopper or the neck of the bottle becomes scored, the bottle should be replaced. Dust must not be allowed to accumulate on the surfaces of the color comparator; therefore, the comparator should only be exposed when inserting vials for the actual dissolved oxygen determination. The scissors should be rinsed with water and dried immediately after use. The vials employed in the colorimetric comparison should be rinsed with water after every use. The bottoms of the vials should not be scratched or marred in any way. The class B and class C reagents are strong, corrosive reagents. Care should be taken to avoid spilling either of these reagents on the person.

9560.111 FIXING DISSOLVED OXYGEN SAMPLES

The methods for fixing dissolved oxygen samples collected as prescribed in article 9560.96 are given below:

Method A—Titration

1. Replace the plug, which has been stored in water in the beaker, in the stopcock of the oxygen II pipette, and close the stopcocks on all three pipettes. Fill each pipette using the aspirator bulb.

CAUTION: The capacities of the pipettes are small so that care must be exercised in filling, or excess reagent will be forced out of the vent hole. Upon release of pressure, excess reagent will siphon back into the bottle. Drain a small amount from each

pipette into the 150 ml. beaker so that each pipette tip is full of reagent without any air bubbles. Discard the drained reagent and rinse the beaker. Refill the three pipettes.

2. Remove the stopper from the sampling bottle and raise it onto the tip of the oxygen I pipette; open the stopcock on the pipette and allow the contents to drain into the sample.

3. As the level of the solution in the pipette drops into the tip, lower the sample bottle from the tip of the oxygen I pipette, and immediately raise the sample bottle onto the tip of the oxygen II pipette, opening that stopcock.

4. Allow the contents of oxygen II pipette to drain completely into the sample bottle, lowering the sample bottle as the liquid level drops in the pipette tip. Replace the stopper in the sample bottle and close the stopcocks on the oxygen I and oxygen II pipettes.

5. Pour to waste the excess solution around the neck of the stopper and then, holding the neck of the sample bottle between two fingers with the thumb on top of the stopper, swing the sample bottle in a horizontal circle to mix the contents thoroughly.

6. Allow the sample to stand until the precipitate settles and the sample is clear above the shoulder of the bottle.

7. Remove the stopper and raise the bottle onto the tip of the oxygen III pipette, opening the stopcock on the pipette.

8. When the contents of the pipette have drained into the sample, close the stopcock; replace the stopper; and again swirl the sample to mix it thoroughly.

9. When all the precipitate has dissolved and the sample is clear, it is fixed, and may be exposed to the air.

Method B—Colorimetric

1. Prior to collecting sample, cut off the tops of the tubes, Class A reagent and Class B reagent, and place them in their respective holes in the reagent holder. Invert the Class C reagent tube and cut off the bottom. Place this tube in the reagent holder.

2. Carry the reagent holder containing the reagents to the sampling location.

3. Immediately upon collection of the sample, proceed quickly, after removing the stopper from the sample, to invert the Class A reagent over the bottle opening and have the tube opening about 1/2 inch above the surface of the water. Squeeze the tube thereby injecting the reagent into the sample. Quickly add the Class B reagent in the manner.

4. Immediately drop the glass stopper into the neck of the bottle. Twist the stopper to secure and mix the contents of bottle by swirling in an almost horizontal circle.

5. Let the bottle stand until the precipitate settles below the shoulder of the bottle.

6. Remove the stopper and quickly add the reagent Class C.

7. Immediately drop the stopper into the neck of the bottle. Twist to secure. Mix the contents as before.

8. If at any time, an air bubble is entrapped in the bottle up to this point, the sample should be discarded and a new one collected. Most air bubbles are introduced by too careful insertion of the stopper into the neck of the bottle when required to do so, giving a slight twist with gentle pressure.

9. When all the precipitate has dissolved and the sample is clear, it is fixed, and may be exposed to the air.

9560.112 DISSOLVED OXYGEN DETERMINATION

The fixed samples of article 9560.111 are determined as follows:

Method A—Titration

Titration must be completed within 15 minutes after fixing and within 30 minutes after the sample has been collected. The temperature of the fixed sample must be below 70° F. during the titration with sodium thiosulfate.

1. Fill the burette in the thiosulfate bottle using the aspirator.

2. Place the iron ring in the holder between the thiosulfate bottle and the rack for sampling bottles.

3. Place the clean casserole which has been rinsed with distilled water in the ring beneath the tip of the thiosulfate burette.

4. Pour to waste any liquid from the neck around the stopper of the sampling bottle; remove the stopper; and pour the entire contents of the sampling bottle into the casserole.

5. Add about 10 drops of starch from the dropping bottle to the sample in the casserole. (Note in article 9560.85 that starch solution must be made up fresh daily.)

6. If no blue color appears in the sample at step 5, record the oxygen value as less than 0.02 ppm.

7. If the solution turns blue, add thiosulfate solution from the burette, drop by drop, stirring continuously with a glass rod or length of glass tubing until the blue color just disappears.

8. Read the burette and multiply the reading by 0.2. The resulting figure is the dissolved oxygen content of the sample in parts per million. For example:

$$\begin{aligned} \text{Burette reading} &= 0.4 \\ 0.4 \times 0.2 + 0.02 &= 0.10 \text{ ppm. dissolved oxygen.} \end{aligned}$$

Method B—Colorimetric

The determination must be completed within 10 minutes of fixing the sample.

1. Rinse a clean comparison tube with a small amount of the fixed sample. Discard the rinse. Fill the tube to mark with the fixed sample.

2. Turn on light switch to the right of the tube holder.

3. Move comparator forward and insert the comparison tube in the hole to the left of 0.02 ppm standard.

4. Compare the color of the sample to the color of 0.02 ppm standard color.

5. If the sample is less yellow than the 0.02 ppm standard, report less than 0.02 ppm.

6. If the color of the sample matches the 0.02 ppm standard, report 0.02 ppm.

7. If the color of the sample is more yellow than the 0.02 ppm standard, move the sample tube to obtain a color match or a position between two standard colors.

8. If the color of the sample matches one of the standards, report the value of the matching standard.

9. If the color of the sample is between two standard colors, report the average value.

10. If the color of the sample is more yellow than 0.06 ppm standard, transfer the sample to a graduated cylinder, add an equal amount of distilled water to the graduated cylinder, mix and pour back into the comparison tube to the mark. Proceed as above and multiply result by 2.

11. When test is completed, record result in working log, switch off light, rinse all glassware with distilled water, store the equipment and close comparator.

9560.113 INTERPRETATION OF RESULT

A result greater than 0.02 ppm of dissolved oxygen is evidence of malfunctioning of the deaerator, the source of which should be sought and corrected. Despite the fact that normal results on a well run ship will be 0.02 ppm or less on successive days, there should be no relaxation of the several precautions enumerated in foregoing articles and daily dissolved oxygen determination should not be omitted.

(For information, it may be noted that the deaerating feed heaters are designed to reduce the dissolved oxygen level in the feedwater to less than 0.014 ppm. As neither of the Navy methods of determination is designed to read dissolved oxygen amounts in the range below 0.02 ppm, for an "acceptance" test of the equipment or system it is necessary to employ a method having the necessary precision in the lower range. For the special purpose of an

acceptance test, either Referee Method A (Indigo Carmine) or Referee Method C (Potentiometric) of ASTM Procedure D888 should be employed.)

9560.114 BLOWDOWN

Blowdown is one of the most neglected treatments in shipboard service. Since it represents an apparent waste of water, personnel are prone to minimize blowdown and to permit solid concentration. This lack of blowdown is primarily responsible for failures from baked sludge. Blowdown points are shown in figure 9560-13.

Inasmuch as the conductivity test is the guide to blowdown, it only measures the amount of ionized dissolved solids in the boiler water. It does not indicate the presence of such corrosion sludges as iron oxide. Consequently, some blowdown must be given even if the conductivity is low. At the present time, it is required that the boiler be given a 10 percent surface blow daily. This daily surface blow should keep the chloride and other dissolved solids in check. If it does not, apply extra surface blows to keep the conductivity and chloride below the limit.

BOILER BLOWDOWN POINTS

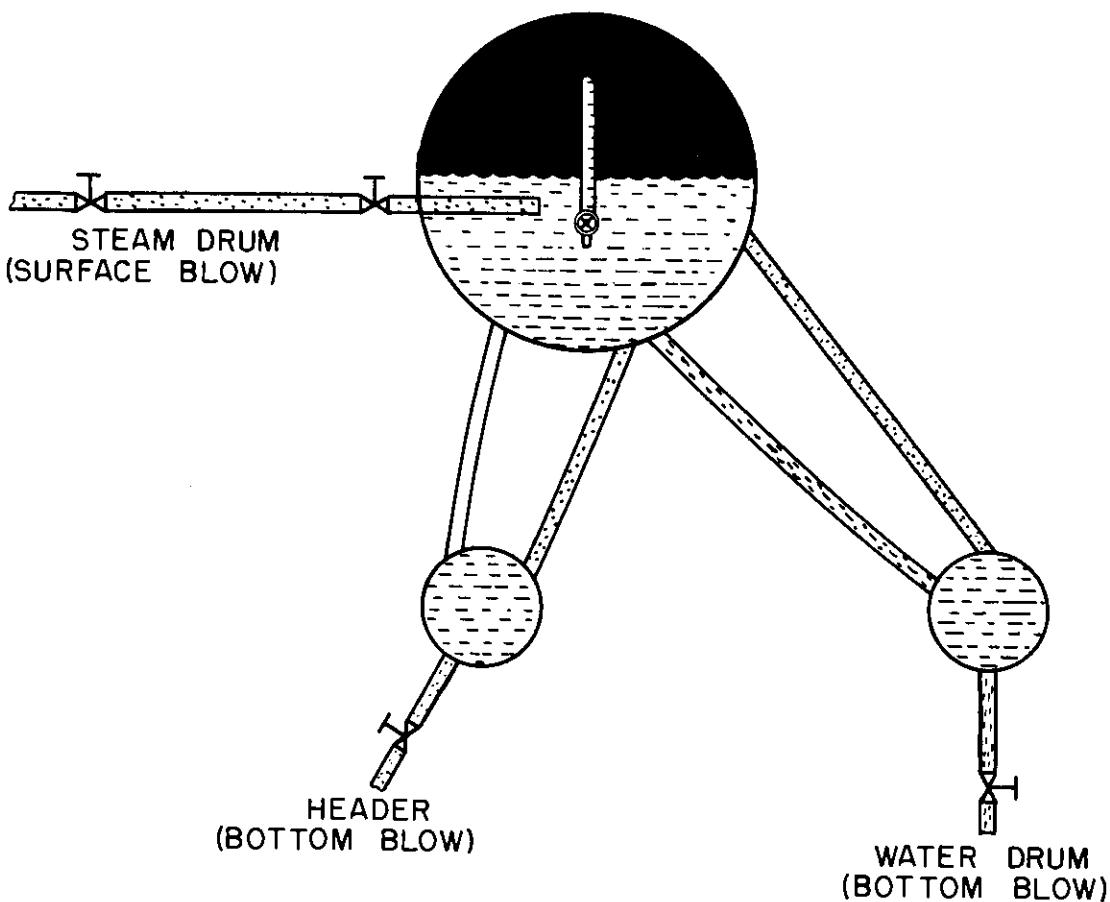


Figure 9560-13. Boiler blowdown points.

The procedure for calculating the amount of water employed in performing blowdown is as follows:

1. Just prior to the blowdown with the boiler steaming at normal water level, obtain a boiler water sample.
2. Determine and record the conductivity result of this first boiler water sample.
3. Perform the blowdown procedure.
4. Collect a second boiler water sample after the boiler has been steaming for 30 minutes at normal water level.
5. Determine and record the conductivity result of the second boiler water sample.
6. Calculate the percent (%) blowdown by substitution of the respective conductivities in the following:

$$\frac{(\text{Before blowdown conductivity} - \text{After blowdown conductivity})}{\text{Before blowdown conductivity}} \times 100 = \% \text{ Blowdown}$$

For example:

Assume that the conductivity before blowdown = 900 micromhos/cm

Assume that the conductivity after blowdown = 810 micromhos/cm

Then the percent blowdown is found by substituting in the formula given in step #6 above

$$\frac{900 - 810}{900} \times 100 = \frac{90 \times 100}{900} = 10\% \text{ blowdown}$$

In addition to the daily surface blows, the boilers must be given periodic bottom blows to remove solids which have settled out of the water. Blowdown should be applied before adding treating chemicals rather than after adding treating chemicals. Bottom blows also should be applied each time the boiler is secured and whenever the boiler water is turbid.

The methods for applying blowdown and the recommended used are given in article 9510.361-365.

9560.115 TEST RECORDS-WATER TREATMENT LOGS FOR FEEDWATER AND FOR BOILER WATER OF 600 PSI BOILERS AND BELOW

1. For Feedwater: Feedwater logs (NAVSHIPS 9560/4) are provided for feedwater.
2. For boiler water of 600 psi boilers and below: Boiler water treatment logs-NAVY BOILER COMPOUND (NAVSHIPS 9560/1) are provided for boiler water tests of 600 psi boilers and below.

Ships should prepare such additional test sheets as are necessary for entering the results of other tests. See article 9560.4 for availability of forms.

9560.116 STOCK INFORMATION FOR WATER TREATMENT CHEMICALS, TEST CHEMICALS AND EQUIPMENT

1. Navy Boiler Compound, Specification MIL-B-3242, 50 lb. drum, FSN 6850-255-0429.
2. Boiler water testing outfit Specification No. MIL-W-16642 distributed from Naval Supply Centers, Norfolk and Oakland.

6640-372-0839—Complete outfit includes the following standard stock items (individual items may be requisitioned separately):

1 Tube, collapsible, stopcock lubricant	9150-273-2406
3 Aspirator-bulb assemblies for filling burettes	6640-291-1162
1 Dropper bottle "TK" 60 ml. for methyl-purple indicator	6640-264-8307
1 Dropper bottle "TK" 60 ml. for phenolphthalein indicator	6640-264-8308
1 Dropper bottle "TK" 60 ml. for chloride indicator	6640-264-8306
1 Bottle, 8 oz. square for hardness test	8125-179-0136
1 Reagent bottle, 1-1. for nitric acid solution	8125-253-2495
1 Reagent bottle, 1-1. for mercuric nitrate	8125-253-2498
1 Reagent bottle, 1-1. for soap solution	8125-253-2497
3 Burettes, automatic-zero, 10 ml. capacity	6640-264-6951
1 Cabinet	6640-292-3679
1 Casserole, porcelain, white	6640-271-1398
1 Cylinder, 10 ml. capacity, graduated	6640-264-8302
1 Cylinder, 100 ml. capacity, graduated	6640-264-8303
6 Rods, stirring, glass, 7 in long, 3/16 in. diameter	6640-190-0154
3. Reagents-Boiler water testing, Specification No. MIL-C-15000:	
Nitric acid solution, 1.0 normal, 1-qt. bottle	6810-270-9978
Mercuric nitrate solution, 0.5 normal, 1-qt. bottle	6810-281-4163
Stock soap solution, 0.1 normal, 1-qt. bottle	6810-252-1345
Methyl-purple indicator, 4-ounce bottle	6810-616-9185
Phenolphthalein (indicator), 1-oz. bottle	6810-134-0000
Chloride indicator, 12 capsules	HA6810-753-4907
Ethyl alcohol, ACS, 1-gal. can (For preparing soap, phenolphthalein and chloride indicator solutions)	6810-264-6507
Isopropyl alcohol, ACS, 1-gal. (For preparing chloride indicator)	6810-227-0410

4.A.—Method A. Dissolved oxygen testing outfit Specification No. MIL-T-20641 distributed from Naval Supply Centers, Norfolk and Oakland.

6640-372-0840—Complete outfit includes the following standard stock items (individual items may be requisitioned separately):

1 Tube, collapsible, stopcock lubricant	9150-273-2406
1 Electric heater unit, ring-type (hot plate)	6640-290-4404

41/2 ft. rubber tubing	4720-189-9718
1 Aspirator-bulb-assembly for filling burettes	6640-291-1162
3 Aspirator-bulb-assemblies for filling pipettes	6640-291-8076
1 Beaker, Griffin, 150 ml.	6640-264-8313
1 Dropper bottle for starch indicator	8125-179-0142
2 Sampling bottles, 300 ml.	8125-179-0143
3 Reagent bottles, 400 ml.	8125-285-8489
1 Reagent bottle, 1000 ml.	8125-248-9010
1 Burette, 10 ml. capacity	6640-264-6951
1 Metal cabinet	6640-292-3676
1 Casserole, porcelain, 500 ml.	6640-271-1397
3 Pipettes, 2 ml. capacity	6640-290-4407
1 Spatula, laboratory, steel, nickel-plated	6640-174-1967
6 Lengths tubing, glass	6640-245-7130

4.B.—Method B. Dissolved oxygen testing outfit specification MIL-T-2409 (SHIPS) distributed from Naval Supply Centers, Norfolk, Oakland, and Long Beach. 6850-985-2988—Complete outfit

5.A.—Method A. Reagents for Method A dissolved oxygen testing specification No. MIL-C-20640.

Manganese sulfate solution 1-qt. bottle, (solution I)	6810-290-3842
Alkaline potassium iodide solution, 1-qt. bottle (solution II)	6810-290-3843
Sulfuric acid solution, 1-qt. bottle (solution III)	6810-290-3836
Sodium thiosulfate solution, 0.15 normal, 1-qt. bottle	6810-279-5553
Soluble starch, 1-oz. bottle	6810-818-1813

5.B.—Method B. Reagents for Method B dissolved oxygen testing specification No. MIL-C-24208 (SHIPS).

Class A—Manganous sulfate reagent, box of 12 tubes	6810-926-9136
Class B—Sodium Hydroxide reagent, box of 12 tubes	6810-926-9137
Class C—Sulfamic Acid—Orthotolidine reagent, box of 12 tubes	6810-926-9138

6. Conductivity Testing Equipment.

Solubridge, specif conductance, 50-8000 micromhos/cm	IP6625-620-4539
Dip-type conductivity cell, cell constant of 2.0	IP6630-620-4540
Beaker, plastic (Griffin style), 250 ml.	9L6640-720-2755
Thermometer, metal, dial type (0-220°F)	6685-290-5533
Class i standard conductivity solution (1400 micromhos per cm)	6810-945-7682

7. Sample Bottles.

Polyethylene bottle, 1-qt., screw cap	8125-326-5479
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Part 6. Water Treatment—1200 psi Boilers

9560.131 NATURE OF TREATMENT

It is necessary to control the quality of the boiler water in 1,200 psi boilers within narrower limits than can be maintained with Navy Boiler Compound. For such closer control, two chemicals, disodium phosphate, and caustic soda (sodium hydroxide), have been substituted for boiler compound to provide independent control of pH (instead of alkalinity) and phosphate (instead of hardness). Treatment consists simply in adding either chemical in small increments as necessary to keep the proper balance of pH and phosphate. For closer control of the dissolved solids in the boiler water, an electrical conductivity method is used to determine the need for blowdown. The method of mixing and adding chemicals, testing for chloride and blowing down are essentially the same as on other naval vessels. The tests for alkalinity and hardness are no longer required for boiler water, but hardness still is required for feedwater.

NOTE: The following articles of this chapter do not apply to boilers treated in this manner:

9560.71	Nature of Navy Boiler Compound.
9560.87	Alkalinity and Hardness limits.
9560.72	Determination of Dosage.
9560.73	Use of Charts.
9560.74	Boiler Water Hardness.
9560.88	Alkalinity Variations in Steaming and Idle Boilers.
9560.100	Phenolphthalein Alkalinity.
9560.101	Methyl Purple Alkalinity.
9560.103	

9560.132 CHEMICAL TREATMENT OF BOILER WATER

1. **Determination of dosage to a freshly filled boiler.** The amounts of disodium phosphate and caustic soda needed to raise the phosphate content and pH value of the boiler water approximately to the specified upper limits are shown in table IV.

Table IV Low Phosphate Treatment

Gallons Untreated Water Added	Ounces Disodium Phosphate To Be Added	Ounces Caustic Soda To Be Added
100	0.5	1
500	2.5	5
1000	5.0	10
1500	7.5	15
2000	10.0	20

2. **Determination of dosage to a steaming boiler.** Add disodium phosphate or caustic soda as required to maintain the phosphate content and pH value of the boiler water within the specified ranges. The amount of disodium phosphate needed to raise the phosphate content to 25 ppm may be estimated by use of figure 9560-14. For example, to raise the phosphate content from 8 ppm to 25 ppm draw a horizontal line from 8 ppm on the vertical scale. Draw a vertical line down from where it intersects the disodium phosphate line. Read the amount of phosphate to be added at the point where the vertical line intersects the horizontal

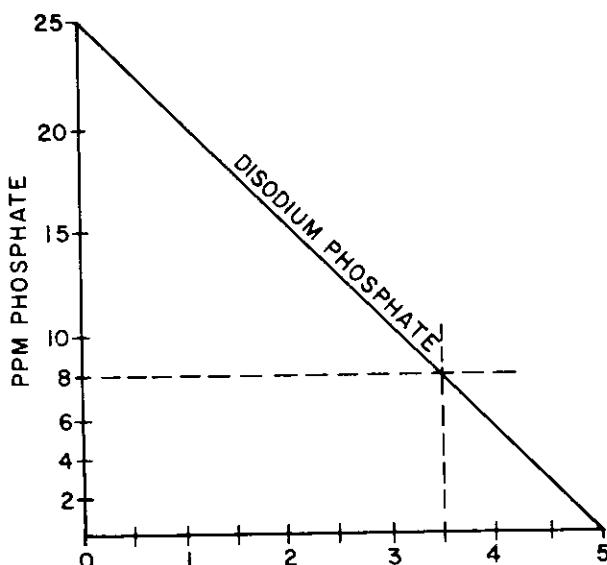


Figure 9560-14. Ounces of treatment per 1,000 gallons to raise the phosphate content to 25 ppm

scale. In this example, approximately three and one-half ounces of disodium phosphate are needed for each 1,000 gallons of water in the boiler.

To determine the amount of caustic soda needed to maintained the pH of the boiler water within limits, figure 9560-15 should be used. For example, to raise the pH of the boiler water from 10.2 to 11.0, draw a horizontal line from 10.2 on the vertical scale. Draw a vertical line down from where it intersects the caustic soda line. Read the amount of caustic soda to be added at the point where the vertical line intersects the horizontal scale. In this example, approximately six and one-quarter ounces of caustic soda are needed for each 1000 gallons of water in the boiler.

3. **Addition of chemicals to the boiler.** Completely dis- solve the disodium phosphate in several gallons of hot water and feed the solution to the boiler. Completely dis- solve the caustic soda in several gallons of cold water be- fore adding to the boiler. Care shall be taken to ensure the following:

- The chemical treatment is not lost in the bilge
- The chemical treatment is fed to the boiler requiring the treatment
- The treatment tank and lines are well flushed

CAUTION: Avoid contact of caustic solution with skin or eyes. In case of contact, rinse quickly and thoroughly with cold water and report to sick bay.

9560.133 FREQUENCY OF BOILER WATER TESTING

The boiler water will be sample and tested for pH value, phosphate content, chloride content and conductivity as listed below. Sample the boiler water from the water drum through a cooler capable of reducing the temperature to 100° F. or less. The boiler water will be retested for pH value, phosphate content, chloride content and conductivity one-half hour after blowdown and one hour after addition of chemicals.

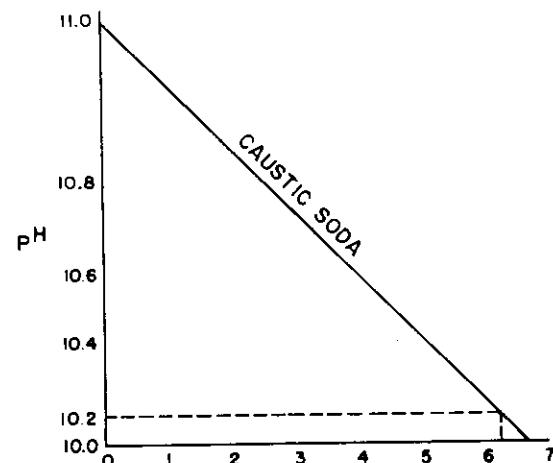


Figure 9560-15. Ounces of treatment per 1,000 gallons to raise pH value to 11.0

1. Sample and test freshly filled boilers hourly until proper water conditions have been established.
2. Sample and test normal steaming boilers daily and after any water treatment (chemical addition or blowdown).
3. Sample and test idle boilers weekly, after any water treatment and prior to light-off.
4. In case of sea-water contamination or other instances of improper water conditions in steaming boilers, sample and test hourly, while adjusting conditions until they are within the specified limits.

9560.134 FREQUENCY OF BOILER FEEDWATER TESTS

The testing of boiler feedwater is the same as described in article 9560.77.

9560.135 BOILER WATER CONDITIONS TO BE MAINTAINED

Constituent or property	Requirements
pH	10.4 to 11.0
Phosphate	10 to 25 ppm
Chloride	2 ppm. max.
Conductivity	700 micromhos/cm. max.

NOTE: Soap hardness will be zero if the phosphate is in range specified.

It should be pointed out that the chloride and conductivity values given above are maximum and not required values. In practice, it is possible to keep the pH and phosphate content of the boiler water within limits while main- taining the conductivity and chloride content of the boiler water well below maximum values. The best way to ensure that low dissolved solids are being carried in the boiler water is to maintain the chloride content as low as possible, pref- erably below 1 ppm.

To ensure that an adequate phosphate reserve always is present in the boiler water, the phosphate content should

be kept near the upper limit at all times. Wherever it is necessary to add treating chemicals to the boiler water, a sufficient quantity should be added to bring the constituents (pH or phosphate) to the upper limits. If the phosphate content of the boiler water drops below 10 ppm on two consecutive days, the boiler water should be sampled and tested at least once per watch until the source of contamination is located and corrected. Prior to securing a boiler for bottom blowdown, the boiler water should be chemically treated to bring conditions to a pH of 11.0 and a phosphate concentration of 25 ppm.

9560.136 FEEDWATER CONDITIONS TO BE MAINTAINED

The feedwater conditions to be maintained are the same as those described in articles 9560.91 and 9560.92.

9560.137 PREPARATIONS OF REAGENTS FROM STOCK SOLUTIONS

1. Instructions for preparation of reagents required are given in articles 9560.78 through 9560.85.

9560.138 SAMPLING

The sampling instructions are the same as those described in articles 9560.94 through 9560.96.

9560.139 METHODS OF ANALYSIS-BOILER WATER TESTS

1. General Test Procedures.

a. Boiler water is tested for pH value and phosphate content using the Taylor comparator kit. (The kit contains plastic components which are reasonably durable; however, they may warp or deteriorate if not properly cared for. Water or other liquids should not be allowed to stand on them nor should they be exposed to heat for prolonged periods. When liquids are spilled on the plastic components, they should be dried promptly.)

b. The chloride determination is made using the boiler water testing cabinet and test procedures described in article 9560.102.

c. Conductivity is determined with a Solu-Bridge, a commercial device manufacturer by Industrial Instruments, Inc. Each Solu-Bridge is calibrated in such a way that it must be used with a conductivity cell of a definite cell constant. It is important to always remember that for accurate results, a Solu-Bridge can be used only with a cell of the correct constant. The cell contains two electrodes plated with platinum black, the surfaces of which should not be scraped or handled at any time. When the cell is not in use, it should be stored in distilled water. (See 9560.104).

2. **pH Determination.** This test is made using the Taylor pH slide comparator, pH range of 10.0 to 11.6 and acyl red indicator provided with the Taylor kit. The commercial Taylor pH slide comparator must be modified to make it suitable for use with Navy boiler water. Revise the pH scale on the comparator by adding 0.2 pH unit to each reading. (For example, the pH reading 10.0 should be revised to read 10.2. This should be done by completely obliterating the present value and durably inscribing the correct value directly on the comparator.) Also, the acyl

red indicator deteriorates after being exposed to air for 6 months, therefore, it should be discarded 6 months after it is opened. The expiration date should be recorded directly on the bottle. The test procedure is as follows:

a. Carefully filter the water to be tested, using the folded filter paper and plastic funnel to remove all sludge, scale and other suspended solids which will interfere with the test. Sufficient water should be filtered to conduct both the pH and phosphate tests. Collect the filtered water in the graduated cylinder or a clean sample bottle.

b. Rinse three test tubes with a small portion of the filtered boiler water sample.

c. Then, fill three test tubes to the 5 ml. mark with the filtered water to be tested and place them in the holes back of the three slots in the base.

d. To the middle tube add 0.5 ml. of acyl red pH indicator solution by means of the 0.5 ml. pipette and nipple and mix thoroughly. The 0.5 ml. pipette (dropper) contains 0.5 ml. of solution when filled to the mark.

e. Place the acyl red pH slide on the base and the base on the shelf of the lamp. With the lamp switch on, move the slide in front of the test samples until a match is obtained. Read the pH directly from values on the slide. If, however, the color of the sample does not match either of two standards but lies between the colors of two consecutive standards, the pH is taken as the average of the two.

3. **Phosphate Determination.** This test is made using the Taylor low phosphate slide comparator, range from 0 to 25 ppm phosphate, according to the following instructions:

a. Wash one of the mixing tubes with the filtered sample to be tested (see pH Determination) and fill to the lower mark (10 ml.) of the tube. Carefully add molybdate reagent to the second mark (14 ml.), stopper, and mix well. Add 1 dipper-full (about 0.1 gram or about 0.004 ounce) of dry stannous chloride, stopper, and again mix well. A blue color will form. Wait a full minute before comparing with the standard but complete the phosphate determination within the five minutes or the color will fade, making a color match difficult.

b. Rinse a 5 ml. test tube with a small amount of the blue solution.

c. Then fill the 5 ml. test tube with the blue solution and place it in the middle hold of the comparator base. Fill two other 5 ml. test tubes with the filtered, but untreated, boiler water and place them in the remaining holes back of the slots of the comparator base.

d. Place the phosphate slide on the base and place the base on the shelf of the lamp. With the lamp on, move the slide in front of the test samples until a color match is obtained. Be sure the arrow on the slide is directly in line with the arrow on the base. The phosphate value is then read off directly from the values on the slide. If the color does not match either of two standards but lies between them, the phosphate is taken as the average of the two.

e. If the color of the sample is darker than the darkest standard on the slide, repeat the test using a diluted solution consisting of one half filtered boiler water and one half distilled water. Multiply the comparator value by two to obtain the phosphate content of the original boiler water.

CAUTION: Molybdate reagent is a strong acid and should be handled to prevent spilling on clothing or

skin. Spilled reagent should be neutralized with sodium bicarbonate and flushed with water. Bottles of molybdate reagent should be kept stoppered when not in use.

4. **Conductivity Determination.** Same as described in article 9560.104.

5. **Chloride Determination.** Same as described in article 9560.102.

9560.140 FEEDWATER TESTS

Same as described in articles 9560.105 through 9560.112.

9560.141 DETERIORATION OF CHEMICALS

The acyl red pH indicator used in the preceding test is subject to deterioration when repeatedly exposed to air and high temperature. For accurate test results, the container of this chemical should be closed immediately after use and stored in areas where temperatures are preferably below 80° F. but not above 100° F. Six months after date of manufacture, the acyl red should be discarded in accordance with BUSANDA Manual 35041. To assist in determining when these two test chemicals have deteriorated, standards are available in the stock system. These standards and the respective stock numbers are given below:

Standards	Federal Stock Number
Class g—Standard low phosphate solution, 15 ppm phosphate	1H6810-985-7135
Class h—pH standard, buffer tablets or powders, pH-10.8	1H6810-985-7128

Using the applicable standard, check the quality of the boiler water testing chemicals at least once every 3 months. The standards should be analyzed in accordance with the methods set forth in this chapter. The analytical results should be within the following limits:

Standard	Limits
Low phosphate (15 ppm)	10-20 ppm
pH 10.8*	10.8-11.2

*The standard pH solution should correspond to a value of 11.0 on the ships' corrected pH slides.

If the results obtained are not within the specified limits, fresh test chemicals should be used and checked against the appropriate standard. If the results still are not within specified limits, a shipyard chemist should be contacted at the earliest opportunity for assistance in locating the source of the error.

Other test chemicals should be checked for deterioration as stated in article 9560.99.

9560.142 BOILER WATER BLOWDOWN

Same as described in article 9560.118.

9560.143 TEST RECORDS-WATER TREATMENT LOGS FOR FEEDWATER AND FOR BOILER WATER OF 1200 PSI BOILERS

1. For Feedwater: Feedwater logs (NAVSHIPS 9560/4) are provided for feedwater.

2. For boiler water of 1200 psi boilers: Boiler water treatment Logs—Low phosphate treatment (NAVSHIPS 9560/3) are provided for boiler water tests of 1200 psi boilers.

Ships should prepare such additional test sheets as are necessary for entering the results of other tests. See article 9560.4 for availability of forms.

9560.144 STOCK INFORMATION

The disodium phosphate required, purchased under Federal Specification O-S-639, is available in the standard Navy stock system under FSN 6810-584-4298 in 25-pound drums. (This chemical is also known as dibasic sodium-phosphate, anhydrous, technical grade; or disodium monohydrogen phosphate, anhydrous, technical grade.) The caustic soda, also known as lye or sodium hydroxide, is purchased under Federal Specification O-S-598 and is available under FSN 6810-243-4435 in 13-ounce cans. Stock information on equipment required to conduct the pH and phosphate tests is given below.

Information on other chemicals and equipment required is given in article 9560.116.

W. A. Taylor Co. Boiler Water Slide Comparator Outfit for 1200 psi Ships	Taylor Catalog No.
1—Complete Kit (Model P) (Contains all equipment for low phosphate determination, except Dalite Lamp)	1106
1—pH color standard slide, Acyl Red, pH (10.0-11.6) (Contains pH slide comparator, vial of indicator solution and 0.5 ml. pipette)	1000-P
1—Midget Dalite Lamp	1070
Replacement Parts for above Kits:	
1—Bulb, electric, special, 40W, 110V	506
1—Bottle, 16 oz., plastic, dispensing assembly	486A
1—Test tube, 5 ml.	500
1—Filter paper, No. 5, 9.0 cm.	518
1—Cleaner, sponge, 7" for mixing tube #516	529A
1—Mixing tube, low phosphate	516
1—Color standard, single (give actual slide value, name of slide or set)	503
1—Dalite lamp glass filter	505
1—Funnel, 50 mm, plastic	517
1—Low phosphate slide only	1105B
Low Phosphate and pH Test Chemicals	Federal Stock Number
1—Molybdate Reagent, 1 qt. Taylor Code No. 601	1HA-6810-903-0507

W. A. Taylor Co. Boiler Water Slide Comparator Outfit for 1200 psi Ships	Taylor Catalog No.
1-Stannous Chloride Powder, vial, 1/2 oz. Taylor Code 602-P15	1H-6810-832-6551
1-Acyl red indicator solution, vial 1/2 oz. Taylor Code No. 1003P	1H-6810-965-2321

NOTE: The stannous chloride powder is supplied in a box of 12 one-half ounce vials.

The Acyl Red Indicator solution is forwarded quarterly to each ship requiring it for testing. This is done on an automatic basis by the supplier.

Part 7. Water Treatment-Ships with Diatomite Feedwater Filters

9560.151 REASON FOR SPECIAL INSTRUCTIONS

1. Ships equipped with diatomite feedwater filters (Republic, Skinner, Hercules or Davis) have different water conditions from other naval ships. In other ships, sea water is the only feedwater contaminant. Consequently, the feedwater is neutral or slightly acid and the chloride concentration is a good indication of the total dissolved solids being fed to the boilers. The uniform composition of the sea water contaminant makes it possible simultaneously to control hardness and alkalinity with Navy Boiler Compound. This is normally a uniform mixture of disodium phosphate, soda ash, and starch in proper proportions to counteract the effects of sea salts.

2. The filter aids used in the Diatomite filters on certain ships add hardness to the feedwater over and above that introduced as sea salts. If extra boiler compound is added to control this hardness, high boiler water alkalinity results.

9560.152 THEORY OF SPECIAL TREATMENT

The revised treatment overcomes this problem of extraordinary hardness by supplying separate treating chemicals rather than a mixture. They include caustic soda (lye) which increases alkalinity, disodium phosphate which reduces hardness without increasing alkalinity significantly, and corn starch which aids in conditioning of sludges. The caustic soda is added on the basis of the present alkalinity tests to keep the boiler water between 2.5-3.5 epm of alkalinity. The phosphate is added on the basis of a new colorimetric phosphate test as necessary to keep 20 to 100 ppm of phosphate in the boiler water at all times. Starch is added in proportion to the phosphate.

NOTE: The following articles of this chapter do not apply to boilers treated in this manner.

- 9560.71 Nature of Boiler Compound
- 9560.72 Determination of Dosage
- 9560.73 Use of Charts
- 9560.74 Boiler Water Hardness
- 9560.87 Alkalinity and Hardness Limits

9560.153 CHEMICAL TREATMENT OF BOILER WATER

1. **Determination of dosage to a freshly filled boiler.** The amounts of disodium phosphate, cornstarch, and caustic soda needed to raise the phosphate content and alkalinity approximate to the upper specified limits are shown in table V.

TABLE V. Treatment for Ships With Diatomite Feedwater Filters

Phosphate-Starch Addition			
Gallons Untreated Water Added	Ounces Disodium Phosphate to be Added	Ounces Cornstarch to be Added	Ounces Caustic Soda to be Added
100	2	0.5	2
500	10	2.5	10
1000	20	5.05	20
1500	30	7.5	30
2000	40	10.0	40

2. **Determination of dosage to a steaming boiler.** Add disodium phosphate or caustic soda in increments as required to maintain the phosphate content and alkalinity within the specified ranges. A weight of starch equal to 1/4 the weight of phosphate is to be added with the phosphate. The amount of disodium phosphate needed to raise the phosphate content to 100 ppm may be estimated by use of figure 9560-16. The amount of starch needed can also be estimated from figure 9560-16. For example, to raise the phosphate content from 15 ppm to 100 ppm, draw a horizontal line from 15 ppm on the vertical scale. Draw vertical lines from the points where it intersects the starch and disodium phosphate lines. Read the amounts of starch and phosphate needed at the points where the vertical lines intersect the horizontal scale. In this example, about four and one quarter ounces of starch and 17 ounces of phosphate are needed for each 1,000 gallons of water in the boiler.

To determine the amount of caustic soda needed to maintain the alkalinity of the boiler water within limits, figure 9560-17 should be used. For example, to raise the alkalinity of the boiler water from 2.0 to 3.5, draw a horizontal line from 2.0 on the vertical scale. Draw a vertical line down from where it intersects the caustic soda line. Read the amount of caustic soda to be added at the point where the vertical line intersects the horizontal scale. In

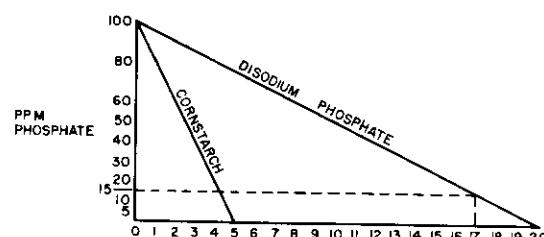


Figure 9560-16. Ounces of treatment per 1,000 gallons to raise phosphate to 100 ppm.

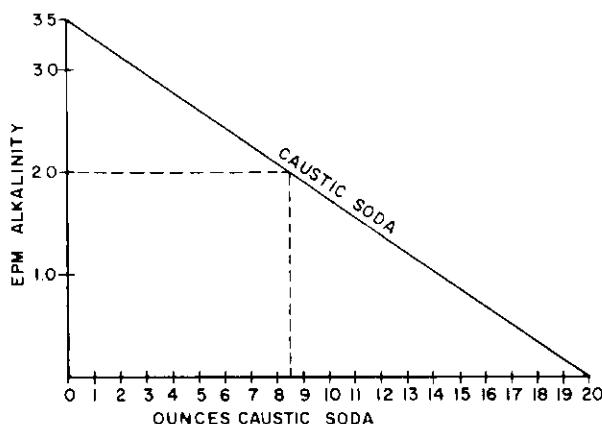


Figure 9560-17. Ounces of treatment per 1000 gallons to raise the alkalinity content to 3.5 epm.

this example, approximately eight and one-half ounces of caustic soda are needed for each 1000 gallons of water in the boiler.

3. **Addition of chemicals to the boiler.** Completely dissolve the phosphate in several gallons of hot water and then stir into a cold-water paste of the starch. The paste is prepared by adding a small amount of water to the starch and mixing well until all the starch is wet. Feed the phosphate starch mixture to the boiler. Completely dissolve the caustic soda in several gallons of cold water.

CAUTION: Avoid contact of the caustic solution with skin or eyes. In case of contact, rinse quickly and thoroughly with cold water and report to sick bay

9560.154 FREQUENCY OF TESTS ON BOILER WATER

The boiler water will be sampled and tested for conductivity, phosphate, chloride, and alkalinity content in accordance with the procedures and schedule outlined in article 9560.133.

9560.155 FREQUENCY OF TESTS OF BOILER FEED WATER

Same as described in article 9560.77

9560.156 PREPARATION OF REAGENTS

Instructions for the preparation of the reagents required are given in articles 9560.78 through 9560.85.

9560.157 BOILER WATER CONDITIONS TO BE MAINTAINED

Constituent or property	Requirement
Phosphate	20 to 100 ppm.
Alkalinity, phenolphthalein	2.5 to 3.5 epm.
Chloride	2 epm.
Conductivity	1300 micromhos/cm. max.

NOTE: Soap hardness will be zero if the phosphate is in the range specified.

Prior to securing a boiler for bottom blowdown, chemically treat the boiler water to bring the alkalinity to 3.5 epm and the phosphate concentration to 100 ppm. Prior to placing a replacement feedwater filter on the line, the phosphate concentration of the boiler water shall be at 100 ppm.

9560.158 FEEDWATER REQUIREMENTS

Same as described in articles 9560.91 and 9560.92.

9560.159 METHODS OF ANALYSIS FOR BOILER WATER TESTS

1. **General test procedures.** The boiler water will be tested for conductivity, chloride and alkalinity in accordance with the procedures in articles 9560.100, 9560.102 and 9560.104. The boiler water is tested for phosphate content using either the Taylor high phosphate comparator or LaMotte phosphate comparator.

2. **Phosphate determination (Taylor High Phosphate Comparator 5-100 ppm Phosphate).**

a. Wash one of the mixing tubes with the clear boiler water to be tested (filter the water through filter paper if dirty) and fill to the lower mark (5 ml.) of the tube. Carefully add molybdate reagent to the second mark (15 ml.), stopper and mix well. Add two dippers-full (about 0.2 gram or about 0.008 ounce) of dry stannous chloride, stopper and agam mix well. A blue color will form. Complete the following steps of the phosphate determination within the next 5 minutes or the color will fade, making a color match difficult

b. Fill a 5 ml. test tube with the blue solution and place it in the middle hole of the comparator base. Fill two other 5 ml. test tubes with the clear filtered boiler water and place them in the remaining holes of the comparator base.

c. Place the phosphate slide on the base and place the base on the shelf of the lamp. With the lamp on, move the slide in front of the test samples until a color match is obtained. Be sure the arrow on the slide is directly in line with an arrow on the base. The phosphate value is then read off directly from the values on the slide. If the color does not match either of two standards, but lies between them, the phosphate is taken as the average of the two.

d. If the color of the sample is darker than the darkest standard on the slide, repeat the test using a diluted solution consisting of one half filtered boiler water and one-half distilled water. Multiply the comparator value by two to obtain the phosphate content of the original boiler water.

CAUTION: Molybdate reagent is a strong acid and should be handled as noted in 9560.139, 3.

3. **Phosphate determination (LaMotte Kit).**

a. Rinse one of the marked test tubes with clear, filtered boiler water to be tested.

b. With the 1 ml. graduated dropper, add 1 ml. of the clear, filtered boiler water to the tube.

c. Add distilled water to the mark on the tube (10 ml.).

d. With the 0.5 ml. graduated dropper, add 0.5 ml. of reagent A (sulfuric acid).

CAUTION: Reagent A is a strong acid. If spilled on skin or clothing, flush with plenty of water, neutralize with baking soda, and flush. Contact with eyes causes serious damage. Flush immediately with water and seek medical aid.

- e. Add one tablet BC (molybdate and reducing agent).
- f. Stopper tube and shake it until the tablet dissolves.
- g. Place tube in middle hole of comparator next to the ground glass.
- h. Place consecutive standard tubes (for example, 30 and 40 ppm) on either side.
- i. View against a daylight lamp and change standards until phosphate value is found.
- j. For phosphate concentrations above 100 ppm, test a mixture of half boiler water and half distilled water; multiply the readings by two.

9560.160 FEEDWATER TESTS

Same as described in articles 9560.105 through 9560.107.

9560.161 DETERIORATION OF CHEMICALS

For accurate test results, the stannous chloride container should be closed immediately after use and stored in areas where temperatures are preferably below 80° F. but not above 100° F. To determine whether this chemical is fit for use, the following standard solution should be used.

Standard	Federal Stock Number
Class f—Standard high phosphate solution, 50 ppm phosphate	1H6810-985-7134

Using the above standard, check the quality of the stannous chloride solution at least once every 3 months. The analytical results obtained should be within the following limits.

Standard	Limits
High Phosphate (50 ppm)	40–60 ppm

If the results are not within the specified limits, discard that vial of stannous chloride and repeat the test using a different vial of stannous chloride powder. If the results still are not within specified limits, a shipyard chemist should be contacted at the earliest opportunity for assistance in locating the source of the error. Other chemicals should be checked for deterioration as stated in article 9560.99.

9560.162 BOILER WATER BLOWDOWN

This is the same as described in article 9560.114.

9560.163 SAMPLING

This is the same as described in articles 9560.94 through 9560.95 or 9560.96.

9560.164 STOCK INFORMATION

a. Test Records—Water Treatment Logs for Feedwater and for Boiler Water of Ships with Diatomite Feedwater Filters.

1. For Feedwater: Feedwater logs (NAVSHIPS 9560/4) are provided for feedwater.
2. For Boiler Water of ships with diatomite feedwater filters: Boiler water treatment logs—High phosphate treatment (NAVSHIPS 9560/2) are provided for boiler water tests for ships with diatomite feedwater filters.

Ships should prepare such additional test sheets as are necessary for entering the results of other tests. (See article 9560.4 for availability of forms.)

b. Stock information. The disodium phosphate required, is purchased under Federal Specification O-S-639 and is available in the standard Navy stock system under FSN 6810-584-4298 in 25-pound drums. This chemical is also known as dibasic sodium-phosphate, anhydrous, technical grade; or disodium monohydrogen phosphate, anhydrous, technical grade. The required caustic soda, also known as lye or sodium hydroxide, is purchased under Federal Specification P-S-631, and is available under FSN 6810-243-4435 in 13-ounce cans. The cornstarch is available under FSN 6810-656-1041 in 5-pound boxes. Stock information on chemicals and equipment required to conduct the phosphate analysis is given below.

W. A. Taylor Co. Boiler Water Slide Comparator Outfit for Ships with Diatomite Filters

1—Complete Kit (Model P)	1101
(Contains all equipment for high phosphate determination except Dalite lamp)	
1—Midget Dalite lamp	1070
Replacement parts for foregoing kit are the same as under article 9560.144 except as follows:	
1—Mixing tube, high phosphate	515
1—High phosphate slide only	1100B

High Phosphate Test Chemicals

1—Stannous Chloride Powder, vial, 1/2 oz, Taylor Code 602-P15, one supplied with the Outfit.	
Box of 12 vials has	FSN 1H-6810-832-6551
1—Molybdate Reagent, 1 qt. Taylor Code 601	FSN 1HA-6810-903-0507

Information on other chemicals and equipment required is given in article 9560.116.

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