



Vecom Marine
clean ships - clean seas

BOILER WATER TREATMENT

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WATER TREATMENT

THE NEED FOR CONTROL

Whether distilled or raw (city) water is used for boiler make-up, chemical treatment is necessary to counteract harmful substances which are present. Particularly, the contaminants present in raw water are inorganic sodium compounds of chloride, sulfate and carbonate and the hardness (calcium and magnesium) compounds of these same materials. Gases such as oxygen and carbon dioxide are present in feed water, distilled or row water. Marine evaporators do not remove all of the salts and minerals from seawater. Minute particles are carried over from the evaporator in the water vapor and are present in the distillate. Any leaks in the distiller, condensers or any part of the feed system which is sea water cooled will add solids and further magnify the existing problems.

COMMON IMPURITIES FOUND IN WATER

CALCIUM CARBONATE (CaCO₃)

Calcium carbonate precipitates from calcium bicarbonate, a much more soluble form, at the boiling point of water. But as calcium carbonate it has a measurable solubility in water of approximately 19 PPM. This solubility is sufficient to cause it to form scale; the insoluble precipitate is in equilibrium with that which is in solution, some therefore dissolving, while some comes out of solution. In so crystallizing, it cements other free particles of matter not otherwise scale forming, including precipitated calcium carbonate.

CALCIUM SULFATE (CaSO₄)

Calcium sulfate precipitates forming a hard scale if the solubility at a given temperature is exceeded. For example, at 104°F the solubility is 1551 PPM; at 212°F the solubility is 1246 PPM; and 40 PPM at 428°F. Calcium sulfate has inverse solubility (becomes less soluble as the temperature increases) causing deposition problems. This negative solubility characteristic makes it more prone to crystallize where the heat is greatest; principally in the fire box where the highest heat concentration occurs. Normal acids have no effect in dissolving this scale.

MAGNESIUM SULFATE (MgSO₄)

Magnesium Sulfate is one of the most soluble of salts, having a solubility of 20% in cold water and 42% in boiling water. It exists only in water of low pH.

COPPER

Copper is introduced into the system by corrosion of copper piping and copper alloys. In cooling systems this may be caused by excessive use of water treatment, causing highly alkaline conditions.

In boilers, the source of this corrosion is excessive use of hydrazine, or leaking internal de-super-heater elements in boiler drums, which allow alkaline boiler water to enter the de-super-heater steam system and corrode copper and copper alloys, bringing the copper to the boiler. Copper in the boiler displaces tube steel or "plates out". This condition frequently takes place under scale or sludge deposits and is often described as "under deposit corrosion". Copper deposits are a serious problem on new high-pressure boilers.

SILICA (SiO₂)

Silica is not generally found in Marine Boilers except in minute quantities. Silica will produce a very hard scale and may be admitted to systems only if severe carry-over has occurred from evaporators distilling water from rivers



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where the silica content is high, or if feed water is taken from cement washed tanks. In certain cases, when raw water is evaporated and is high in silica, carry-over may admit silica into the distilled water system. On some new vessels where silicate coatings have been used in distilled water storage tanks, initial silica readings may be high and should be tested often and controlled by blowdown. Silica may cause difficulty in cooling water systems by forming calcium and magnesium silicate scale.

IRON OXIDES (FeO-Fe₂O₃-Fe₃O₄)

Iron may enter the boiler as a result of corrosion in the pre-boiler sections or ports of the feed system, or may redeposit as a result of corrosion in the boiler itself. Often, iron oxide will deposit and retard heat transfer within a boiler tube, sometimes resulting in tube failure. When iron is not present in the raw water feed, its presence in the boiler or cooling system indicates active corrosion, a more serious problem than its presence in scale in which it appears by occlusion. Rust, the reddish form, is fully oxidized. More often, in a boiler with limited oxygen, it is in the reduced or black form (Fe₃O₄). Fe₃O₄ is magnetic and can be readily detected with a magnet.

OIL

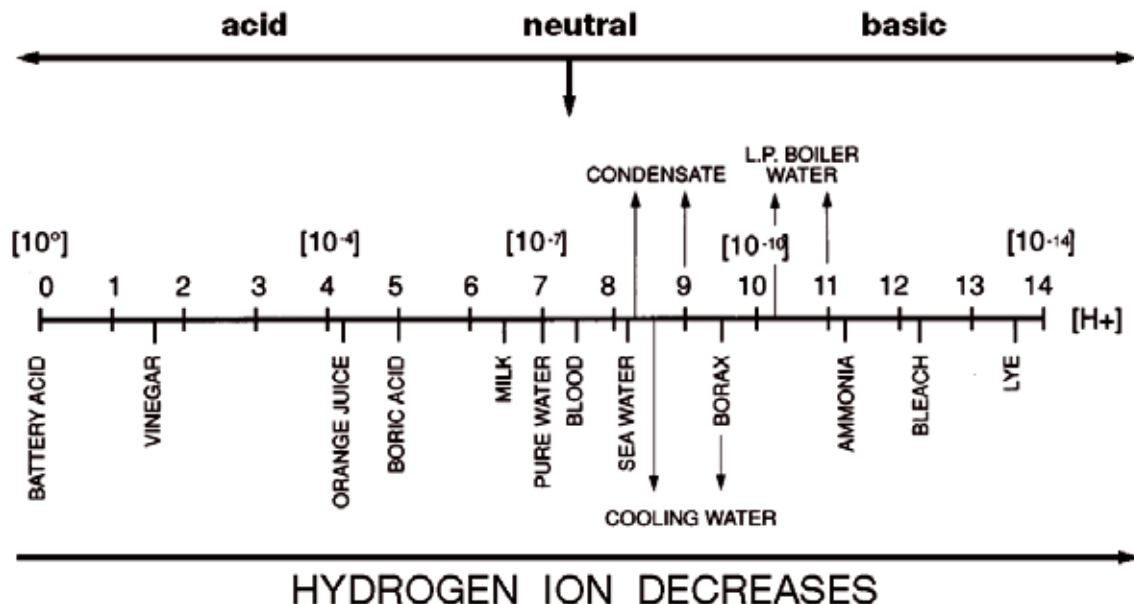
To prevent oil from entering condensate and feedwater systems, certain safety equipment is generally incorporated to remove or arrest such contamination if this should arise. There are certain occasions due to mechanical failure (for example, faulty oil deflectors at turbine glands passing lube oil to gland seal condensers and main condensers, etc., or leaks at tank heating coils) causing oil to enter a boiler.

Any oil film on internal heating surfaces is dangerous, impairing heat transfer drastically to the extent that comparable heat retarding effects can be likened to considerable dense scale build-up. Oil films therefore cause overheating of tube metal, resulting in tube blistering and failure, or cracking of engine parts. If oil contamination is suspected, immediate action must be undertaken for its removal. A simple test explained in this book indicates how emulsified oil in water can be detected. Depending upon the degree of contamination, corrective measures can be adopted using LIQUID COAGULANT or other VECOM products as ALKALINE CLEANER (ALKACLEAN) or an emulsifier.

DISSOLVED GASES

Dissolved Gases are present in distilled water in the form of oxygen and carbon dioxide. Each enters the condensate system from leaks in the vacuum side or open exposure to the atmosphere, the atmospheric drain tank, surge tank, or feed filter tank. Due to chemical reactions in water, carbon dioxide can form carbonic acid (H₂CO₃), lowering the pH of the condensate, making it corrosive.

Oxygen is highly corrosive causing localized pitting and attack of boiler metal. Mechanical deaerating equipment, if installed, is designed to remove the majority of these dissolved gases. However, the most efficient deaerating equipment still passes about 5 parts per billion of dissolved Gases. Chemical treatment is required to render these gases harmless.



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ACIDITY, NEUTRALITY AND ALKALINITY:

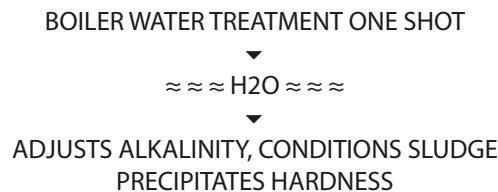
All water can be classified into one of these categories. Acidity, Neutrality and Alkalinity are, however, only very general terms, and to know the degree of each condition we require accurate methods of monitoring. The accepted terminology denoting the exact characteristics we desire is pH. pH is a numerical designation between 0 and 14 with 7 (the midway point) being neutral. Any value down from 7 to 0 is the acid range, and values from 7 up to 14 are in the alkaline range.

The terminology pH is the negative logarithm of the hydrogen ion concentration to the base 10. Therefore, a hydrogen ion concentration of 10 is expressed as pH 7 (neutral), 10-1 pH 1 (acid), and 10-14 pH 14 (alkaline). It is therefore obvious that the difference between each number is 10 times and the difference between pH 7 and pH 10 is actually 1000 times.

VECOM BOILER WATER TREATMENT CHEMICALS

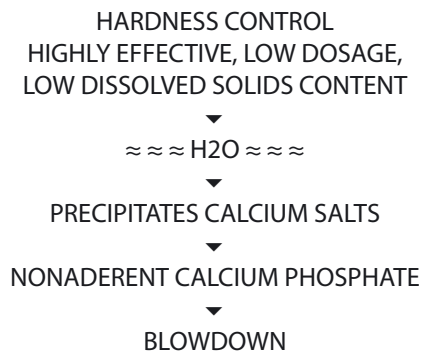
BOILER WATER TREATMENT - ONE SHOT

BOILER WATER TREATMENT - ONE SHOT is a convenience product used when one chemical only is required as a boiler water treatment BWT - ONE SHOT is used principally in small, low-pressure boilers. It precipitates hardness and provides necessary alkalinity and coagulants in one, easy-to-use, liquid product.



HARDNESS CONTROL

HARDNESS CONTROL is used in boiler water treatment to precipitate dissolved calcium hardness salts and to convert these salts to non-adherent calcium phosphate sludge, which can be easily removed by blowdown. HARDNESS CONTROL used in the VECOM system is highly effective in performing the function required using minimum dosages.

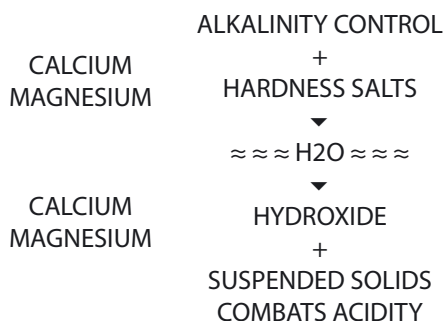


ALKALINITY CONTROL

ALKALINITY CONTROL is used to combine with the hardness salts converting them to hydroxide suspended solids. In addition, ALKALINITY CONTROL is used to maintain the required alkalinity in the boiler water to prevent acid corrosion. By adopting simple testing procedures, to determine the phenolphthalein alkalinity and the total alkalinity (M-alkalinity) we can determine the amount of free caustic present in the boiler water by using the formula 2 (P)-M-OH. If a positive number is obtained, free caustic (OH alkalinity) is present in the boiler water. The term "excess chemicals" or "reserve of chemicals" is the insurance that chemicals are always readily available to perform their necessary functions.

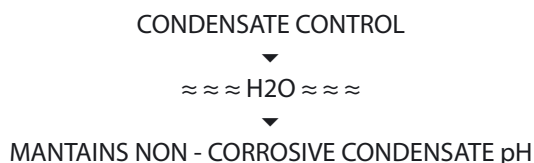
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CONDENSATE CONTROL

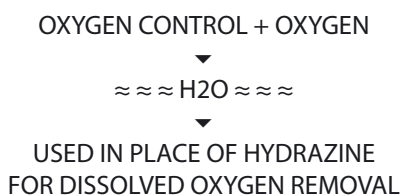
CONDENSATE CONTROL is a neutralizing volatile amine used for raising pH of condensate and steam to a non-corrosive level. (pH 8.3-9.0). The dosage is determined by the results of a daily condensate pH test. For optimum control of the condensate pH, CONDENSATE CONTROL should be dosed using a continuous feed system. It can be introduced by using a flowmeter, or metering pump, to the storage area of D.C. heater, atmospheric drain tank condensate of feed systems. Optimum control of condensate pH is achieved by dosing separately from the hydrazine dosage system; however, CONDENSATE CONTROL is compatible with hydrazine, and can be dosed with the hydrazine dosing system.



OXYGEN CONTROL

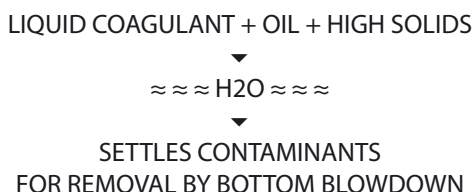
OXYGEN CONTROL is an oxygen scavenger used in stead of hydrazine where economy is of importance, or used in low-pressure boilers having open feed systems where feed inlet temperatures are low. OXIGEN CONTROL, when combined with oxygen, forms additional boiler water solids. It is also used as a substitute for hydrazine when oxides may be a problem, as in laid up ships being returned to service.

An amine (CONDENSATE CONTROL) should be used in conjunction with OXIGEN CONTROL to maintain the condensate pH within the desirable ranges.



LIQUID COAGULANT

LIQUID COAGULANT is used in boilers when suspect oil is present or as a sludge conditioner when high solids are experienced. LIQUID COAGULANT should be dosed at 250cc. (1/2 pint) per day. No testing is necessary if used regularly, daily flash blowdown is advisable. LIQUID COAGULANT should not be used in high-pressure boilers (above 28 kg/cm).



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HYDRAZINE (N₂H₄)

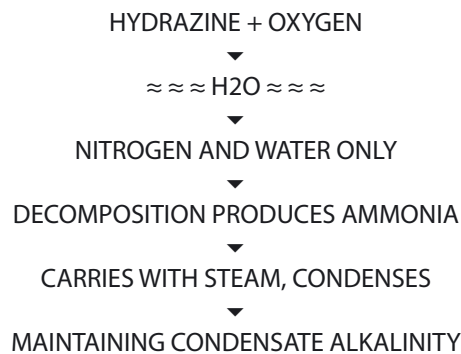
HYDRAZINE is a colorless liquid at ordinary temperatures, being completely miscible with water. Its solution has an odor resembling ammonia, but less pungent. It is used to efficiently remove oxygen from the boiler water. HYDRAZINE reacts with oxygen, acting as a scavenger. The reaction results in nitrogen and water, no solids being added to the boiler water. The decomposition reactions also result in the formation of minute quantities of ammonia, which carry over with steam, aiding in maintaining the condensate pH in an alkaline range and, thereby, combating acidic formation. HYDRAZINE should be added to the system using a separate dosing tank. The tank should be filled daily and HYDRAZINE diluted with condensate and fed continuously to the storage section of the deaerator, feed pump suction or atmospheric drain tank over a 24 hour period. The preferred method of feeding HYDRAZINE is to the storage section of the deaerator, if fitted. It is important that HYDRAZINE should not be overdosed.

Excessive free ammonia and oxygen, when combined, form a corrosive condition on non-ferrous metals. This corrosive action can cause copper to deposit in the watersides of boilers, causing additional boiler problems. The reaction of HYDRAZINE in boilers is therefore threefold:

It scavenges any free or dissolved oxygen.

It removes and reduces red iron oxide to a metal protective black coating (black magnetite).

It raises the pH of the condensate to safe levels, eliminating acid corrosion of the condensate and pre-boiler sections of the system.



BLOWDOWN CONTROL

Blowdown is necessary to lower the boiler water concentration by removing dissolved and suspended solids. Without controlled blowdown, oil solids in the boiler water would build up. Excessive build-up can cause priming and carry-over and could choke boiler tubes and headers with sludge, resulting in poor circulation, over-heating and possible tube failures.

When chemicals are added to boiler water to protect the internals, it is obvious that an increase in dissolved solids will occur. As the treatment reacts with the contaminants in the water, sludge is formed. Additionally, solids, dissolved and suspended, are carried into the boiler by the make-up water, and concentration of these continues. Eventually there is a need for blowdown and it is necessary to monitor this rate of concentration. A positive method of determining total dissolved solids of boiler water is the measurement of specific conductance using a dissolved solids meter. (TDS Meter DIST 1 or HI 8734).

Blowdown is conducted depending upon the degree of solids by the following methods:

Continuous Blowdown: Used when dissolved solids are high. This method is usually adopted through the sampling line, if a continuous blowdown line is not installed, and can safely be used when a boiler is steaming.

Bottom Flash Blow: When giving a boiler a bottom flash blow, all fires must be extinguished to prevent blistering of tubes, due to upset circulation. Bottom flash blows are given when quick dilution of boiler water is required and to remove sludge. Boilers should be allowed to cool and pressure lowered to no more than 75% of working pressure. This allows suspended solids to drop to the mud drum so they can be removed when the blowdown valve is opened. The blowdown valve should be opened quickly and immediately closed to prevent boiler tube damage.

Allow boiler to stand for 5 minutes, which allows more solids to gravitate to mud drum and repeat by quickly opening and closing bottom blowdown valve. This procedure should be repeated allowing about 5 minutes between each

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blow until desired quantity of sludge has been removed or replaced.

It should be stressed that too little blowdown is dangerous for reasons already stated and excessive blowdown is costly in the form of wasted water, heat, fuel and chemicals.

DUMPING THE BOILER

Never dump (drain) all the water from the boiler while the metal is still hot. After the boiler is off line it retains heat for a considerable length of time. Draining all the water from the boiler at this time may permit suspended solids to bake on the tube surfaces. It is recommended that the boiler be dumped when the danger of baking on sludge is removed. This usually means twenty-four (24) hours all pressure has been removed.

CHEMICAL CLEANING OF BOILERS

Boiling Out Procedures

Boiling out procedures should be followed only when light oils or minor contamination occurs. When massive quantities of heavy oil or asphalt are found in boilers, DEGREASER GP should be used to chemically clean and neutralize the boiler. Simple boiling out procedures are usually not effective against heavy contamination. We suggest you contact your nearest VECOM SERVICE ENGINEER for the quickest and most economical procedures to employ.

In case DEGREASER GP is not available ALKACLEAN is a special alkaline cleaner suitable for removing oils, sludge and dirt from boilers.

In the event of minor oil contamination, VECOM LIQUID COAGULANT can be used to prevent the oily traces from adhering to the tube surfaces and to allow these traces to be blown out during regular blowdown procedures.

Boilers should be boiled out when:

They are new, before being placed into service. Boiling out removes oily preservatives and other undesirable foreign matter.

When major boiler tube renewals are completed.

When traces of oil are present in watersides.

An alkaline cleaner (ALKACLEAN) should be employed using 3% of boiler water capacity. Circulation by pump, and heat should be supplied during the boiling out period.

SPECIAL CONSIDERATION FOR NEWBUILDINGS

Pre-operational Cleaning: VECOM MARINE recommends pre-operational chemical cleaning of boilers because of the inevitable introduction of mill scale and foreign substances into watersides during construction. Recommended products for this operation are DESCALING LIQUID or SAFE DESCALER. Consult your VECOM MARINE representative for cleaning procedures.

SCALE AND RUST REMOVAL

Many different types of scale and sludge deposits are possible, as explained in the section of this manual concerned with impurities found in water. The best approach to chemical cleaning is to arrange for an inspection of watersides by a VECOM SERVICE ENGINEER. If this is not possible, a scale of sludge sample with an accompanying description should be forwarded to VECOM for laboratory examination. Some descaling procedures may be performed by the ship's crew, using DESCALING LIQUID or SAFE DESCALER. Other situations call for special chemical cleaning equipment and chemicals. It is of importance to remove oil contamination before chemical scale removal so that chemicals will work properly.

SCALE SEQUESTRANT FOR DESCALING WHILE STEAMING

SCALE SEQUESTRANT is a new organic sequestering agent in a liquid form, which can be used to descale boilers while operating. Its chelating action is effective against either heavy scale or light baked-on sludge. Normally a boiler containing light scale or phosphate sludge will require only 30 day's treatment. SCALE SEQUESTRANT is added to the boiler at the rate of 4 liters per two tons of boiler capacity daily. Also add 500 ml of LIQUID COAGULANT to aid in dispersing the solids. Bottom blow boiler daily.

OXIGEN CONTROL or HYDRAZINE should be added to boilers to eliminate dissolved oxygen since this may retard the action of SCALE SEQUESTRANT. Boiler pH should be adjusted in the range of 10.0 to 11.0.

BOILER LAY UP PROCEDURE

Boilers are more susceptible to corrosion during lay up or idle periods than during operating conditions, therefore, adequate precautions must be undertaken during lay up. Several methods may be adopted to combat the harmful effects of low pH and oxygen attack on metal surfaces and to protect the fireside against acidic attack from deposits containing moisture, particularly when sulfur type compounds are present. At least one day before a boiler is removed from service prior to lay up, an organic sludge conditioner (LIQUID COAGULANT) should be dosed to the boiler. The rate of blowdown should be increased in order to keep the amount of sludge to a minimum and as non-adherent as possible. Never drain a boiler while under pressure. Heat from the refractory etc., will cause remaining sludge to bake on internal surfaces. Prior adopting one of the following methods, the boiler should be drained and thoroughly washed down internally. Use a high-pressure hose and preferably hot water.

PROTECTING THE WATERSIDES USING ONE OF THE FOLLOWING WET METHODS:

It is important to maintain high concentrations of corrosion inhibitors in the boiler water; the boiler should be kept completely filled to exclude any air.

Wet Method # 1: Use NCLT maintaining concentrations between 2300-3500 PPM of sodium nitrite (corresponding to 1500-2300 PPM nitrite), plus ALKALINITY CONTROL if necessary to obtain a pH level above 9,5.

Wet Method # 2: Use VECOM HYDRAZINE maintaining concentrations of 250 PPM. This concentration is sufficient to raise the boiler water pH to a safe and satisfactory level of 9,5, without further additional chemicals. (1.7 lt. of HYDRAZINE dosed per ton will give 250 PPM HYDRAZINE). It is also advisable to connect an inert gas cylinder on the upper part of the economizer and maintain a 2 Kg/cm² pressure to avoid possible HYDRAZINE leaking. Drain boiler of excess HYDRAZINE and refill before returning to service. Test concentration of various chemicals (nitrite, pH etc.) at different water levels (bottom-half, surface etc.) if necessary circulate boiler water with ships pump or with an additional external pump. In each case after chemicals have been added and the boiler filled to normal working level (preferably with hot, deaerated, feed water) the boiler should be fired and run only long enough to provide sufficient circulation to obtain uniform concentrations of chemical treatment throughout the boiler, and to eliminate its oxygen. Steam should be vented during this operation.

Where boilers are equipped with superheaters, the instructions supplied by the boiler manufacturer for laying up superheaters should be followed.

HANDLING OF FIRESIDE:

The Fireside of all laid-up boilers should be thoroughly cleaned to remove all soot and carbon deposits. It is good practice to keep a small heater in the fireside during the lay up period to prevent corrosion due to moisture or humidity which joins with sulfur laden soot and starts a sulfuric acid attack on boiler metal.

STORAGE OF REAGENTS

The shelf life of test reagents varies with storage conditions. Always store reagent chemicals in a cool, dry, dark storage area. Light, heat, and humidity affect many reagents. Minimize inaccurate readings and troublesome restocking by proper storage of spare reagents. Always rotate reagent bottles using the oldest reagent first. Many engineers find it helpful to mark the delivery date on each reagent bottle immediately on delivery.

RECOMMENDED CHEMICAL LIMITS FOR BOILERS

Boilers	7-28 kg/cm² and low-pressure steam generation	28-57 kg/cm²	57-102 kg/cm² coordinated phosphate - pH	Adjustment
Boilerwater				
Hardness, PPM	0	0	0	Hardness Control or Boiler Treat - blowdown to reduce
Phosphate, PPM	20 - 40	20 - 40	10 - 25	
P-Alkalinity, PPM	100 - 150	100 - 130	0 - 50	Alkalinity Control or Boiler Treat - blowdown to reduce
M-Alkalinity, PPM	less than twice "P"	less than twice "P"	max. 100	
Chlorides, PPM	max. 100 never exceed 300	max. 36 distilled feed	max. 20 distilled feed	Blowdown
Hydrazine, PPM or Sulfite, PPM	0.10 - 0.20 20 - 30	0.10 - 0.15 10 - 15	0.03 - 0.10 -	Hydrazine to increase, Oxygen Control to increase
Conductivity TDS - PPM	600	300	90	Blowdown to reduce
pH	10.5 - 11	10 - 11	9.6 - 10.3	Alkalinity Control to increase
*Silica	-	-	max. 6	Blowdown to reduce
*Copper, PPM	0.5	0.5	0.5	Control condensate corrosion
*Iron, PPM	1.0	1.0	1.0	
Condensate				
pH	8.3 - 9.0	8.3 - 9.0	8.3 - 9.0	Condensate Control to increase
P-Alkalinity	-	-	max. 10	
Ammonia, PPM	-	-	0.3	Reduce Hydrazine dose
Chlorides, PPM	max. 10	max. 5	max. 2	Stop contamination
*Iron, PPM	0.05	0.05	0.05	Locate source of corrosion
*Copper, PPM	0.02	0.02	0.02	
Feedwater				
Hardness, PPM	0	0	0	Stop contamination
Chlorides, PPM	max. 10	max. 5	max. 2	
Oxygen, PPM	<500 PPB	<500 PPB	max. <5 PPB	Verify proper working Derehator Increase Hydrazine dosage

INITIAL DOSE PER TON OF DISTILLED WATER

Chemical	up to 25 kg/cm²	from 28 to 57 kg/cm²	over 57 kg/cm²
Hardness Control	100 ml	50 ml	10 ml
Alkalinity Control	250 ml	200 ml	20 ml
Condensate Control	250 ml	daily test and adjust dosage	
Liquid Coagulant	250 ml	-	-
Hydrazine	100 ml	100 ml	100 ml

* Those tests marked by an asterisk are optional and not normally performed aboard ship.

Sealed samples identifying the source should be given to a *VECOM MARINE* engineer, or mailed directly to a convenient *VECOM MARINE* office.

Conductivity Measure: The units μ Mhos are a measure of inverse resistance. Example: 1000 μ Mhos corresponds with approximately 700 PPM of TDS.