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1. Introduction

It has been recognized by engine operators that the boiler plays the very important role in operating the ship. In it the boiler water treatment is the important factor that have influences upon the safety control and economical operation for the boiler. Therefore, its appropriate water treatment is required.

However, there have been many cases where this water treatment, though very important, are neglected up to now because of such reasons as "technical difficulty", "difficulty to understand its control method", etc.

We, Miura Co., Ltd., have a number of rich experiences and achievements different from those of general water treatment manufacturers in this important water treatment field, from the standpoint of being the manufacturer of the marine auxiliary boilers and land-use small once-through boilers.

The explanations and handling procedures for the chemicals and water quality tester manufactured on the basis of the above are summarized in this manual.

We hope for the boiler operators to read this manual carefully and operate Z BOILERS with more energy-saving and safety.
2. Terminology

The following guide words are used for your safe, effective operation.

⚠️ WARNING

- Indicates any condition or practice which if not observed, could result in personal injury and/or death.

⚠️ CAUTION

- Indicates any condition or practice which if not observed or remedied, could result in damage or destruction of the property and/or minor personal injury.

NOTE

- When a caution is used to prevent a component proper from failing, a point essential to effective operation, an item to be remembered for trouble-free operation, or so on, is to be explained, it is shown with the guide word "Note".

- A numeral in this symbol indicates the page of related item.
3. Basic Safety Precautions

⚠️ Warning

- When operating a Z Boiler or dealing with chemicals, the following safety precautions must be strictly observed. Neglecting these items may result in serious bodily injury to the operator.
- For detailed information about hazards, toxicity and measures for emergency or fire, please refer to the safety data sheet (MSDS) of the product.

<table>
<thead>
<tr>
<th>Hazard (Irritation)</th>
<th>Hazardous or irritating substance to human body, or materials containing them</th>
<th>Put on gloves</th>
<th>Especially hazardous substance for contact with the hand (e.g., burns by chemicals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear a mask</td>
<td>Especially hazardous substance for inhalation</td>
<td>Do not mix</td>
<td>Hazardous substance which may produce heats or toxic gases when mixed</td>
</tr>
<tr>
<td>Wear goggles</td>
<td>Especially hazardous substance for coming into contact with the eye</td>
<td>Do not dispose into the environment</td>
<td>Harmful to the environment and fishes when disposed into the environment</td>
</tr>
</tbody>
</table>

Verify the system before operation

Never operate the system improperly.
- Operate and maintain the system only after the contents of the manual are completely understood.
- Understand symbols and their chemical meanings.

Wear appropriate attire and safety equipment

Always put on protective clothing.
- Always wear a helmet, goggles, safety shoes, leather gloves, etc. Particularly when dealing with chemicals, always put on gloves and goggles to prevent severe accidents by spattering of chemicals.

Remarks during operation

Do not touch the system unnecessarily.
- During operation, do not touch other parts of the system except for the operating part. Touching may cause severe accidents such as electric shocks or burns.
4. Damages Resulted from Water and Their Measures

4-1. Damages due to Scales

The largest damage factor that obstructs the economical operation of the boiler is scale adhesion to inside walls of water tubes.

Except distilled water, any other feed water (natural, industrial, or city water supplied from the land) contains hardness components and silica components, and they are concentrated on the water tube surfaces to become insoluble solids and adhere on the surfaces. These solids are called scales (boiler stones). Though depending on their compositions, physical properties, adhering conditions, the thermal conductivities of the scales are extremely lower than that of steel (i.e., approximately 1/20 to 1/100), as shown in Table 1. Therefore, they decreases the boiler efficiency. In addition, when such scale adhesion is too severe, the adhered area is superheated locally, and mechanical properties of the material there decrease remarkably to cause such damages as swelling and bursting.

In consideration of the above the operator must always carry out water treatment fully. Scale-forming materials in feed water are as follows:

Table 1 Thermal conductivities of scales and steel

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal conductivity (kcal/m h °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scales composed mainly of silicate</td>
<td>0.2~0.4</td>
</tr>
<tr>
<td>Scales composed mainly of carbonate</td>
<td>0.4~0.6</td>
</tr>
<tr>
<td>Scales composed mainly of sulfate</td>
<td>0.6~2.0</td>
</tr>
<tr>
<td>Scales composed mainly of mild steel</td>
<td>4.0~6.0</td>
</tr>
<tr>
<td>Soot</td>
<td>0.06~0.1</td>
</tr>
<tr>
<td>Scales composed mainly of fats</td>
<td>0.1</td>
</tr>
</tbody>
</table>

⚠️ CAUTION

Scale adhesion is too severe, the adhered area is overheated locally, and strength of the materials decreases remarkably to cause such damage as swelling and bursting. Therefore, the operator must always pay attention to the quality of the water.

Scale-forming compounds in feed water are as follows:

1. Carbonate hardness components \( \text{Ca} \rightarrow (\text{HCO}_3)^- \& \text{Mg} \rightarrow (\text{HCO}_3)^- \)
   - Calcium bicarbonate \([\text{Ca} (\text{HCO}_3)]_2\) is decomposed thermally in the boiler.
   - \( \text{Ca} (\text{HCO}_3)_2 \rightarrow \text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \)
   - Then it changes to calcium carbonate \([\text{CaCO}_3]\) and deposits or adheres near the feed-water inlet to become scales.

2. Non-carbonate hardness components \( \rightarrow \text{CaSO}_4 \& \text{MgSO}_4 \)
   - Event at the concentration soluble in circulating boiler water, calcium sulfate \([\text{CaSO}_4]\) will be concentrated to its solubility limit at the concentration layer of the heating surface by boiling down to become hard scales difficult to remove mechanically.

3. Silica \( \rightarrow \text{SiO}_2 \)
   - Silica \([\text{SiO}_2]\) binds with aluminium ions and so on to form very-hard scales.
   - This can hardly be removed with the mechanical method (tube cleaner or so on).

4. Iron oxide
   - This is a corrosion product in feed water and deposits to the boiler bottom to become sludge or is included by other scales to become scales.
4-2. Preventive Measures against Scale Adhesion

In order to prevent scales it is natural to remove hardness components, silica, etc. of scale-forming materials. The detailed methods are as follows:

(1) Removal of hardness
   a) Hardness components are removed from raw water with a water-softener. — (External treatment)
      *Z boilers are fitted with water-softeners as the standard.
   b) By adding boiler compound to the feed-water tank (to feed water with a chemical injection device, if fitted), scales are changed to sludge in the boiler and discharged outside the boiler by blow-down. — (Internal treatment)
      This has two methods.
      However, it is the most desirable treatment method fundamentally to carry out (a) external treatment and then (b) internal treatment.
      For a) it is necessary to carry out periodical check of the water-softener and, if degraded, regenerate it with sea water.
      For b) it is necessary to use boiler compound for the purpose of removing hardness and to carry out periodical blow-down.
      *We supply the boiler compounds, Z-LIFE (S-105 & P-12) and BOILER MATE (SX-M & W1-M) for the purpose of removing hardness. These react chemically to boiler water directly and change its hardness components to sludge. In addition these phosphate films that have an excellent effect of corrosion prevention. When pH is 10.5 or higher and phosphate ions are included, the hardness in boiler water can be considered to be zero. When chlorine ions are maintained at 400 ppm or lower under the above conditions, the above phosphate film is formed on the boiler surfaces.

(2) Removal of silica component
   In order to remove silica, mechanical methods are available, but they require high costs for equipment. Therefore, for low-pressure boilers the following methods are adopted to lighten damages.
   a) By keeping boiler water at high alkalinity, its silica solubility is kept high to prevent silica scales from adhering.
   b) By blow-down, the silica concentration is kept low.
      *We supply the alkalinity control boiler compounds, Z-LIFE (S-205 & P-12) and BOILER MATE (SX-M & W1-M).
4-3. Damages due to Corrosion

Corrosion depends in general on water qualities, such as pH, kinds and concentrations of dissolved gases and salts, etc., and environments, such as temperature, flow speed, etc. For the boilers dissolved oxygen and pH are the most affecting factors to corrosion. Kinds of corrosion are as follows:

(1) Corrosion due to Dissolved Oxygen in Feed Water
When dissolved oxygen exists in boiler water, the protective films are destroyed and iron begins to elute.
In addition, under these conditions, if the corrosion products become deposits and are keepep up on steel surfaces, oxygen concentration cells are composed and iron elutes there concentivaly. This causes pitting in which corrosion proceeds deeply into the steel surface.
Besides, if corrosion products in the condensate/ feed water system are conveyed into the boiler and deposited there, oxygen concentration cells are composed with oxygen, if exists there. This also causes corrosion similarly.

(2) Corrosion due to improper pH value
If boiler water is low in pH (acidic), corrosion is accelerated due to its high hydrogen ion concentration.
Fe (OH)₃ + 2H⁺ → Fe²⁺ + 2H₂O

(3) Corrosion due to Dissolved Salts
At the temperature and pressure in the boiler some salts are decomposed in water or react with other dissolved salts to form free acids or corrosion products, which may corrode boiler inside surfaces.
Especially, chlorides in boiler water form hydrochloric acid through decomposition and accelerate corrosion remarkably.
(Major Causes of Corrosion)

| Causes of corrosion on water qualities | pH is low. In high temperature water corrosion proceeds even in high pH. | Concentration of dissolved oxygen is high. | Concentrations of harmful ions, especially Cl⁻, is high. |

4-4. Preventive measures against Corrosion

In order to prevent corrosion it is necessary to remove dissolved oxygen, to control pH to its proper value, and to restrain chlorine concentration.

(1) Removal of Dissolved Oxygen

Dissolved oxygen is the most harmful cause of corrosion (pitting), and any water in contact with air dissolves oxygen.

There are two kinds of methods to remove dissolved oxygen, i.e. mechanically and chemically.

Marine auxiliary boilers in general adopt the latter. The chemical method uses hydrazine (or sodium sulfite in some cases) as an oxygen scavenger. When hydrazine remains in boiler water, this shows that dissolved oxygen has removed completely. Therefore, boiler water should so controlled that hydrazine (or sulfite ion when sodium sulfite is used) remains in it.

*The oxygen scavengers, RD-M, manufactured by us react rapidly with dissolved oxygen in feed water, which affects corrosion reaction most, and remove dissolved oxygen effectively.

(2) Control of pH

Corrosion of steel in hot water, such as boiler water, is minimum near about 12 in pH. When pH is higher or lower than this value, the corrosion rate increases (see Fig. 2).

However, in the actual boiler local boiler water concentration at inside walls of steam tubes, and so, with mean boiler water pH controlled at 12, pH of concentrated boiler water is higher than 12, and there is a possibility of alkali corrosion.

Thus, to prevent this pH of local concentrated boiler water from becoming excessively high, the upper limit of mean boiler water pH should be restricted a little lower than 12.

*The boiler compounds Z-LIFE (S-105, S-205 & P-12) and BOILER MATE (SX-M & W1-M), manufactured by us have excellent pH control and alkalinity regulation.

(3) Restraint of Chlorine Ions

Boiler water includes chlorine ions invariably, and these destroy corrosion-preventive films formed on metal surfaces and accelerate corrosion. Therefore, the lower the concentration is, the better it is.

Besides, since there exists at the same time in boiler water no material that deposits chlorine ions, the chlorine ion concentration in boiler water can be considered as the scale of the concentration level of boiler water. In addition this is effective in checking the condenser for sea water leaks.

Carry out the water quality inspection of know the chlorine ion concentration and, if excessively high, restrain it by blow-down.
4-5. Corrosion Preventive Measures for Condensate System

Condensate is pure water that scarcely includes soluble solids and scarcely has the cushioning ability against pH. Therefore, if CO₂ or SO₂ carried in with steam is contained in condensate even in low concentration, its pH becomes easily low and general corrosion occurs on steel surfaces of the condensate system.

In order to prevent the above pH decrease of condensate, such a chemical as hydrazine or volatile amine is used. This chemical is decomposed in high temperature water, evaporates together with steam, resolves again when steam condenses, and increases pH.

*The condensation controller, Neutral M, manufactured by us is the excellent condensate controller which contains volatile amine as the principal component.

4-6. Damages due to Carry-over

Carry-over is the phenomenon in which solids solving or being turbid in boiler water transfer to the outside of the boiler, being mixed with steam.

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**CAUTION**

When solids in boiler water transfer to the steam system, the steam purity decreases, and such troubles as decrease of product quality, swelling or bursting of the heater, etc. may be caused.

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4-7. Preventive Measures against Carry-over

It is necessary to control alkali components, to restrain the total solid concentration, and to prevent fats from mixing in.  

(1) Control of Alkalinity

Alkalinity should be controlled to prevent carry-over and alkaline corrosion by curbing alkaline components in boiler water to some degree. It is also controlled in order to reduce the concentrations of total solids, silica, etc.

Alkalinity can be divided into two kinds; P-alkalinity and M-alkalinity. P-alkalinity shows the concentration of more than 8.3pH, while M-alkalinity is total alkalinity and starts from 4.8pH upward.

The same chemicals as those prescribed for pH value control are used to modify alkalinity. Notice, however, that water which has been treated through the water softener heightens alkalinity, when used as feed water. So, it is preferable to use acid ortho-phosphate or polyphosphate, which is effective in reducing excessive alkalinity.

Since correlation between pH and alkalinity (especially P-alkalinity) is nearly constant, pH control can be substituted for alkalinity control.

*The boiler compounds, Z-LIFE (S-105, S-205 & P-12), manufactured by us are most suitable to pH and alkalinity control and have excellent effects.

(2) Total Solid

Excessive solids tend to cause carry-over of boiler water, and so low concentration of total solid is preferable. The problem of high concentration can be solved by increasing the blow-down amount.

(3) Fats

Take care not to carry fats into the boiler, since they tend to cause foaming and carry-over of boiler water. Also, they may carbonize on heating surfaces, and thus accelerate scaling.

*In addition to the simplex boiler compounds (S-105, S-205 and P-12) and the simplex oxygen scavengers RD-M introduced above, we offer the BOILER MATE series (SX-M & W1-M), the complex boiler compounds which are very easy to handle (boiler compounds such that each has all functions). We also recommend using these.
5. **Standard Values of Boiler and Feed Water**

<table>
<thead>
<tr>
<th></th>
<th>Feed water</th>
<th>Boiler water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7~9</td>
<td>11.0~11.8</td>
</tr>
<tr>
<td>Total residual substances after evaporation</td>
<td>p.p.m.</td>
<td>Below 3000</td>
</tr>
<tr>
<td>Electric conductivity</td>
<td>μ s/cm</td>
<td>Below 2000</td>
</tr>
<tr>
<td>P-alkalinity</td>
<td>CaCO₂</td>
<td>80~600</td>
</tr>
<tr>
<td>M-alkalinity</td>
<td>CaCO₂</td>
<td>Below 60</td>
</tr>
<tr>
<td>Hardness</td>
<td>CaCO₂</td>
<td>0</td>
</tr>
<tr>
<td>Chlorine ion</td>
<td>Cl⁻</td>
<td>Below 200</td>
</tr>
<tr>
<td>Total iron</td>
<td>Fe</td>
<td>Below 0.3</td>
</tr>
<tr>
<td>Silica</td>
<td>SiO₂</td>
<td>Below 250</td>
</tr>
<tr>
<td>Fats</td>
<td>p.p.m.</td>
<td>Preferably 0</td>
</tr>
</tbody>
</table>

---

When changing the water, do not make any drastic changes to pH. The boiler is very sensitive to pH. Keep the water at the recommended values.
<table>
<thead>
<tr>
<th>Item</th>
<th>Content of item</th>
<th>Adjustment</th>
<th>Damage caused</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Scale of acidity and alkalinity. Rough estimate of effect of boiler compound.</td>
<td>Dosage of Z-LIFE or BOILER MATE. Blow-down in case of high concentration.</td>
<td>Acceleration of corrosion on boiler steel. Incomplete softening.</td>
<td>With respect to boiler water alkali-treated with Z-LIFE, BOILER-MATE, etc., any one of two treatments (pH and P-alkalinity) will suffice. (Any one of two measurement will suffice.)</td>
</tr>
<tr>
<td>Total solid</td>
<td>Sum of solute and suspended solid in water.</td>
<td>Blow-down.</td>
<td>Carry-over. Factor of all damages that originate in water.</td>
<td></td>
</tr>
<tr>
<td>Electric conductivity</td>
<td>Concentration of impurities given by conductivity of water.</td>
<td>Blow-down.</td>
<td>Carry-over. Factor of all damages that originate in water.</td>
<td></td>
</tr>
<tr>
<td>P-alkalinity</td>
<td>Concentration of alkaline matters of higher than 9.0pH. Rough estimate of dosage for boiler compounds.</td>
<td>Dosage of Z-LIFE or BOILER-MATE. Blow-down in case of high concentration.</td>
<td>Corrosion on boiler steel. Adhesion of silica scale.</td>
<td></td>
</tr>
<tr>
<td>M-alkalinity</td>
<td>Concentration of alkaline matters of higher than 4.8pH.</td>
<td>Dosage of Z-LIFE or BOILER-MATE. Blow-down in case of high concentration.</td>
<td>High value in supplementary feed water generates much CO₂ and lowers pH value of condensate.</td>
<td></td>
</tr>
<tr>
<td>Total ion</td>
<td>Rough estimate of iron elution in boiler and its systems.</td>
<td>Dosage of Z-LIFE and Z-KISSY or BOILER-MATE.</td>
<td>Iron elution from boiler steel and boiler systems.</td>
<td></td>
</tr>
<tr>
<td>Silica</td>
<td>Component of hard scale.</td>
<td>Increase of P-alkalinity by dosage of Z-LIFE (S-205 or P-12) or BOILER-MATE with blow-down.</td>
<td>Adhesion of silica scale. Carry-over of silica.</td>
<td></td>
</tr>
<tr>
<td>Sulfite ion</td>
<td>Rough estimate of the dosage of oxygen scavengers, Z. KISSY RD-M. Measure the concentration only for using Z-KISSY RD-M.</td>
<td>Dosage of Z- KISSY RD-M.</td>
<td>Pitting or increase of corrosion on boiler steel</td>
<td></td>
</tr>
<tr>
<td>PAA concentration</td>
<td>Rough estimate of the dosage of boiler compound (BOILER MATE W1-M. Measure the concentration only for using W1-M.</td>
<td>Dosage of boiler compounds W1-M.</td>
<td>Adhesion of scales Corrosion and pitting</td>
<td></td>
</tr>
</tbody>
</table>
6. Marine Boiler Compounds for Z Boiler

To prevent the boiler from damages due to water, proper chemicals should be selected and used. We, Miura Co., Ltd. have prepared the following chemicals for boilers to meet demands of the customers.

⚠️ Warning
- When dealing with chemicals, always put on gloves and goggles to prevent severe accidents such as burns or sight loss by spattering of chemicals.
- Wash the skin with water if it has been in contact with chemicals.
- If the chemical has come into contact with the eye, wash it with water and consult a doctor.

6-1. Boiler Compound, Z-LIFE, S-105
   a) Major component: Sodium polyphosphate
   b) Pack & form: 10kg polyethylene package, fluid
   c) Effects:
      - Maintenance of phosphatic ions.
      - Prevention of scaling of hardness.
      - Prevention of priming.
   d) Notes: Control the dosage by measuring phosphate ions in the boiler water.
   e) Directions for use: See Chap. 9.

9. Dosage of Chemical

6-2. Boiler Compound, Z-LIFE, S-205
   a) Major component: High alkaline material
   b) Pack & form: 10 kg polyethylene package, fluid
   c) Effects:
      - Regulation of pH and alkalinity values.
   d) Notes: Control the dosage by measuring pH in the boiler water.
   e) Directions for use: See Chap. 9.

9. Dosage of Chemical
6-3 Composite Boiler Compound, BOILER MATE SX-M (Citrate composite compound)

a) Major component: Alkaline agent
Sodium citrate (composed of only food additives)

b) Pack & form: 11 kg fluid in a polyethylene bag in a cardboard box.

c) Effects:
Regulation of pH and alkalinity and prevention of corrosion by forming a deoxygenation film on a liquid surface. Prevention of scaling due to water hardness by keeping citrate ions. Chemically removing dissolved oxygen to prevent corrosion.

d) Notes:
On-site measurement cannot be applied to the concentration of citric acid in the ship. But if you send a sample of your boiler water to us, we will advise you of the dosage after analyzing it.

e) Directions for use: See Chap. 9.

For reference, see 9. Dosage of Boiler Compound for Z Boiler

6-4 Composite Boiler Compound, BOILER MATE W1-M (Tannin composite compound)

a) Major component: Alkaline agent
Tannic acid
Gluconic acid
Potassium PAA
Special dispersing agent

b) Pack & form: 10 kg fluid in a polyethylene bag in a cardboard box.

c) Effects:
Regulation of pH and alkalinity and prevention of corrosion by forming a deoxygenation film on a liquid surface. Prevention of scaling due to water hardness by a special dispersing agent

d) Notes:
It is possible to determine dosage by on-site measurement of PAA, if you purchase a kit for the PAA experiment.

e) Directions for use: see Chap. 9.

For reference, see 9. Dosage of Boiler Compound for Z Boiler
6-5. Powdery Boiler Compound, Z-LIFE, P-12
   a) Major component: Alkaline agent
      Phosphate
   b) Pack & form: 10 kg white powder in polyethylene
      package and carton.
   c) Effects: Preventing corrosion by regulation of pH
      and alkalinity values.
   d) Notes: Control the dosage by measuring
      phosphate ions and pH in the boiler
      water.
   e) Directions for use: See Chap. 9.

7. Marine Boiler Oxygen Scavenger for Z Boiler

Dissolved oxygen in boiler water can be the most harmful cause of corrosion, and thus can greatly
affect boiler steel. It is very important to remove this dissolved oxygen.

⚠️ Warning

- When dealing with chemicals, always put on gloves and goggles to prevent severe accidents such as
  burns or sight loss by spattering of chemicals.
- Wash the skin with water if it has been in contact with chemicals.
- If the chemical has come into contact with the eye, wash it with water and consult a doctor.
- Concerning emergency treatment, refer to the safety data sheet of each compound.

7-1. Powdery Oxygen Scavenger, Z- KISSY RD-M
   a) Major component: Sodium sulfite
      Stabilized catalyst
      Deoxygenation catalyst
   b) Pack & form: 10 kg powder in a polyethylene bag in a
      cardboard box
   c) Effects: Prevention of corrosion by chemically
      removing dissolved oxygen in water.
   d) Notes: It is possible to control the dosage by
      measurement of sulfite ions in a boiler
      water.
   e) Directions for use: See Chap. 9.

For reference, see 9. Dosage of Boiler Compound for Z Boiler
8. Other Chemicals for Z Boiler

<table>
<thead>
<tr>
<th>Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>• When dealing with chemicals, always put on gloves and goggles to prevent severe accidents such as burns or sight loss by spattering of chemicals.</td>
</tr>
<tr>
<td>• Wash the skin with water, if it has been in contact with chemicals.</td>
</tr>
<tr>
<td>• If chemical has come into contact with the eye, wash it with water and consult a doctor.</td>
</tr>
<tr>
<td>• Concerning emergency treatment, refer to the safety data sheet of each compound.</td>
</tr>
</tbody>
</table>

### 8-1. Condensate Controller, NEUTRAL M

Condensate is in itself pure water and barely has the cushioning ability against pH. Therefore, if condensate includes even a small amount of CO₂ or SO₂ carried in together with steam, the pH value will easily decrease and corrosion will grow on the steel surfaces in the condensate system. To prevent such corrosion, the condensate controller is used.

<table>
<thead>
<tr>
<th>a) Major component:</th>
<th>Volatile neutralizing amine</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Pack &amp; form:</td>
<td>20 kg polyethylene package, fluid</td>
</tr>
<tr>
<td>c) Effects:</td>
<td>By neutralizing carbonic acid and</td>
</tr>
<tr>
<td></td>
<td>sulfurous acid in condensate, this</td>
</tr>
<tr>
<td></td>
<td>increases the pH value, and thus</td>
</tr>
<tr>
<td></td>
<td>prevents corrosion of iron caused by</td>
</tr>
<tr>
<td></td>
<td>CO₂ and SO₂. This gasifies in</td>
</tr>
<tr>
<td></td>
<td>evaporation of water, goes back to the</td>
</tr>
<tr>
<td></td>
<td>feed water line, and thus circulates in</td>
</tr>
<tr>
<td></td>
<td>the system during boiler operation.</td>
</tr>
<tr>
<td>d) Directions for use:</td>
<td>Add this into the chemical feed tank</td>
</tr>
<tr>
<td></td>
<td>which contain boiler compound and</td>
</tr>
<tr>
<td></td>
<td>oxygen scavenger.</td>
</tr>
<tr>
<td></td>
<td>(1.5 to 3) × M × (100-a)/100 ppm.</td>
</tr>
<tr>
<td></td>
<td>where</td>
</tr>
<tr>
<td></td>
<td>M : M-alkalinity of supplementary water</td>
</tr>
<tr>
<td></td>
<td>a : Drain recovery ratio</td>
</tr>
</tbody>
</table>

### 8-2. Boiler Cleaning Agent, HICALESS M

<table>
<thead>
<tr>
<th>a) Major component:</th>
<th>Hydrochloric acid ammonia fluoride</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Pack &amp; form:</td>
<td>20 kg polyethylene package, fluid</td>
</tr>
<tr>
<td>c) Effects:</td>
<td>Cleaning agent to be used in removing</td>
</tr>
<tr>
<td></td>
<td>scales adhering to boiler, exhaust gas</td>
</tr>
<tr>
<td></td>
<td>exonomizer, and distilling plant.</td>
</tr>
<tr>
<td>d) Directions for use:</td>
<td>Clean boiler with 10~25% HICALESS</td>
</tr>
<tr>
<td></td>
<td>M solution with or without circulation.</td>
</tr>
<tr>
<td></td>
<td>Since forming occurs during pickling,</td>
</tr>
<tr>
<td></td>
<td>mix deforming agent(50cc) with</td>
</tr>
<tr>
<td></td>
<td>HICALESS M in advance.</td>
</tr>
</tbody>
</table>
8-3. Descaling Agent, SCALE DESTROYER F2
   a) Major component: Ethylenediamine tetraacetic acid
c   b) Pack & form: 10 kg polyethylene package, fluid.
c   c) Effects: This has features to remove scale
        having adhered because of non-installation, malfunction or so on of the
        water-softener, with boiler operating. However, in such cases, it takes a long
        period (2 weeks~1 month) to remove scale fully.
c   d) Directions for use: Add this into chemical feed tank which
        contains boiler compound and oxygen scavenger, to obtain 100 to 200 ppm. It
        is unnecessary to change dosages of boiler compound and oxygen scavenger.

8-4. Hot-Water Boiler Rust Preventive, MINESTAR F
   a) Major component: Sodium polyphosphate
   b) Pack & form: 5 kg, solid, netted
   c) Effects: Prevention of red water of hot-water
        supply boiler. Available for foods.
   d) Directions for use: Put netted MINESTAR F (1 kg) together
        with its container into cistern tank. If no
        cistern tank is provided, fit feeder in feed
        water line and put MINISTER F in it.
        This is effective for 1 to 2 months with 1
        kg of dosage and 1 t/h of flow rate.

---

**Warning**

- As some chemicals contain powerful drugs, please consult our maintenance staff when disposing of the chemical.
- Chemicals cannot be preserved in contact with air for a long time. Never add a distilled solution to the original compound, it may cause degradation, crystallization, etc. of the compound.
9. Dosage of Boiler Compound for Z Boiler

⚠️ Warning

Never do operations except as they are described in the manual. Neglecting the directions may result in serious bodily injury to the operator.

9-1. Boiler compound, Z-LIFE, S-105, S-205

<table>
<thead>
<tr>
<th>Kind of feed water</th>
<th>Compound</th>
<th>Amount of boiler compound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At first use and full blow-down</td>
</tr>
<tr>
<td>Hard water</td>
<td>S105</td>
<td>1000 cc per 1-ton boiler water</td>
</tr>
<tr>
<td></td>
<td>S205</td>
<td>1000 cc per 1-ton boiler water</td>
</tr>
<tr>
<td>Soft water</td>
<td>S105</td>
<td>400 cc per 1-ton boiler water</td>
</tr>
<tr>
<td></td>
<td>S205</td>
<td>800 cc per 1-ton boiler water</td>
</tr>
</tbody>
</table>

Notes:
1) Because these are the theoretical values, in practice, modify these dosages to keep the standard values of boiler water, measuring it with a tester.
2) Dilute them 10 to 30 times for use.

9-2 Composite Compound, BOILER MATE, SX-M

<table>
<thead>
<tr>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>At first use &amp; full blow-down</td>
</tr>
<tr>
<td>2000 cc per 1-ton boiler water</td>
</tr>
<tr>
<td>After first use (normal operation)</td>
</tr>
<tr>
<td>2000 cc per 1-ton make up water</td>
</tr>
</tbody>
</table>

1) Control the dosage based on periodical water analyses by measurement of citrate concentration in the boiler water using the analyzer in Miura Head office.
2) Dilute it for use.

⚠️ Warning

As some compounds contain powerful drugs, please consult our maintenance staff when disposing of the compound.
9-3 Composite Compound, BOILER MATE, W1-M

<table>
<thead>
<tr>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>At first use and full blow down</td>
</tr>
<tr>
<td>1,600 cc/1 ton boiler water</td>
</tr>
</tbody>
</table>

(1) Determine the dosage by measuring PAA concentration in the boiler water.
(2) Adjust the concentration of W1-M to 1,000-2,000 ppm.

Method:
Either dosage of original solution or distilled solution is available.
Mixing with any other Miura brand boiler compound will not produce sediment.
* After cleaning the inside of the chemical tank, throw it into the tank.

9-4 Powdery Boiler Compound, Z-LIFE, P-12

<table>
<thead>
<tr>
<th>Kind of feed water</th>
<th>Amount of dosage (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At first use &amp; full blow-down</td>
</tr>
<tr>
<td>Soft water</td>
<td>100g/1-ton boiler water</td>
</tr>
<tr>
<td>Hard water</td>
<td>130g/1-ton boiler water</td>
</tr>
</tbody>
</table>

(1) Adjust the phosphoric ion concentration and the pH value to standard values.
(2) Dilute it about 20 times for use.
(3) Seal airtight after dosage because of its hygroscopicity.

9-5 Powdery Oxygen scavenger, Z- KISSY RD-M

<table>
<thead>
<tr>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial and full blow down</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Usual operation</td>
</tr>
</tbody>
</table>

(1) Dilute them more than 10 times with 40°C soft water for use. Do not froth up in dilution. Determine the dosage by measuring the sulfite ion concentration in the boiler water.
(2) Adjust the sulfite ion concentration to 10-40 ppm.
(3) Initial dosage depends on the temperature. Refer to "Temperature of feed water and the basic dosage of Oxygen scavenger Z- KISSY RD-M" in Table 12.

(4) Estimate the blow down amount from changes of the water level gauge based on the table in page 36.

Note:
Because these are the theoretical values, in practice, modify these dosages to keep the standard values of boiler water, measuring it with a tester.
9-6. Attached Figures

Attached Fig. 1
Hardness removal ability of boiler compound Z-LIFE, S-105

Attached Fig. 2
Residual phosphate ion versus dosage of boiler compound Z-LIFE, S-105

Attached Fig. 3
Residual phosphate ion versus dosage of boiler compound Z-LIFE, S-105

Attached Fig. 4
Water-softerning ability (in silica concentration) of boiler compound Z-LIFE, S-205

Attached Fig. 5
pH versus dosage of boiler compound Z-LIFE, S-205

Attached Fig. 6
Residual phosphate ion in boiler water versus dosage of Z-LIFE, P-12
Note

For the standard dosages and addition procedures/water treatment, their theoretical values and essential points are described. For the details, follow guidance of our maintenance members and/or technicians.
10. Procedural Specifications for Addition of Chemicals

Boiler compound and oxygen scavenger must be added bit by bit, not at a time, to avoid a sudden change of the pH value, alkalinity, and solids in the boiler. See the figure below.

![Diagram of boiler system]

**Note**

1) Always put covers on the chemical feed tank and the cascade tank to inhibit their contact with air to as low level as possible.

2) The higher the temperature of the cascade tank is, the less the concentration of dissolved oxygen in it becomes. Control the temperature of the cascade tank after reading the specification of the feed pump.

3) Locate the chemical feed tank above the water level of the cascade tank without fail.

4) To modify the dosage of chemical, adjust the needle valve.

5) Oxygen scavenger should always be added bit by bit from the chemical feed tank, while boiler compounds can be added directly into the cascade tank.

**CAUTION**

- As acid or alkali compounds may cause troubles such as eruption depending on the operator's condition, the following directions must be strictly observed.
- When dealing with chemicals, always put on gloves and goggles to prevent severe accidents such as burns or sight loss by spattering of chemicals.
- Wash the skin with water if it has been in contact with chemical.
- If chemical has touched the eyes, eash it with water and consult a doctor.
- Concerning emergency treatments, refer to the safety data sheet of each compound.
11. Norms of Maintenance of Boiler Water

11-1. Norms of Maintenance
For maintenance of boiler water, measure the following items at the prescribed frequency. Increase or decrease the dosage of chemical, the amount of blow-down, etc., referring to the standard values for boiler water.

<table>
<thead>
<tr>
<th>Item</th>
<th>Samples</th>
<th>Supplementary feed (raw water)</th>
<th>Condensate (drain water)</th>
<th>Feed water</th>
<th>Boiler water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling position</td>
<td>Outlet of water softener</td>
<td>Intake of cascade tank</td>
<td>Outlet of cascade tank</td>
<td>Salt valve</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>Every day</td>
<td>Once a week</td>
<td>Once a day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td>Every day</td>
<td>(Water-softener) Once a day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-alkalinity</td>
<td>Every day</td>
<td>Once a week</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorine ion</td>
<td>Everytime water in loaded to raw water tank</td>
<td>Once a week</td>
<td>Twice a week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate ion</td>
<td>Twice a week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAA</td>
<td>Twice a week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfite ion</td>
<td>Twice a week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrate concentration</td>
<td>Timely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11-2. Explanations of Standard and Measured Values

a) Check of soft water at the outlet
   Every day, check water at the outlet of the water softener to confirm that soft water is being fed.

b) Chlorine ions in supplementary feed water
   Measure chlorine ions in supplementary feed water every time water is loaded to the raw water tank, and see the quality of water roughly and immediately.

c) pH in condensate
   To avoid corrosion in the condensate system, keep the pH value of the condensate within 7 to 9. If the pH value is below 7, increase the dosage of BOILER MATE NEUTRAL M, and if the value is above 9, decrease the dosage of BOILER MATE NEUTRAL M.

d) Chlorine ions in condensate
   Since condensate is in itself pure, it includes no chlorine ions. However, when sea water leaks into the condenser, chlorine ions are found in the condensate. Thus, if the chlorine ions are found in the condensate, sea water leaks without fail. Then, check the condensate system for leaks and also increase blow-down.

e) M-alkalinity in feed water
   In addition, high M-alkalinity may cause the pH value of condensate to decrease, and so keep the former below 60 ppm.

f) Chlorine ions in feed water
   Measure it once a week, and with the measured values and feed water flow, determine the amount of blow-down.

g) pH value and alkalinity of boiler water
   If the pH value and alkalinity of boiler water are not within their standard ranges, proceed as follows:
If the measured value is lower than the standard, increase the dosage of Z-LIFE S-205, P-12 or BOILER MATE (SX-M, W1-M), and if the measured value is higher, blow down boiler water immediately.

h) Chlorine ions in boiler water
   If the chlorine ion concentration of boiler water is higher than its standard value, blow down water immediately.

i) Phosphate ions in boiler water
   Measure the phosphate ion concentration of boiler water when Z-LIFE S-105 or P-12 is used.
   If the phosphate ion concentration of boiler water is not within its standard range, proceed as follows:
   If the measured value is lower than the standard, increase the dosage of Z-LIFE S-105, P-12, or BOILER MATE, and if the measured value is higher, blow down boiler water immediately.
   However, if the concentration is unusually high, decrease the dosage of Z-LIFE S-105, P-12 or BOILER MATE.

j) PAA concentration
   Measure the PAA concentration of boiler water when boiler compound BOILER MATE W1-M is used. Its standard range is 1000-2000 ppm for tank water. If the measured value is lower than the standard, increase the dosage of W1-M, and if the measured value is higher, blow down boiler water to reduce the dosage.

k) Sulfite ion concentration
   Measure the sulfite ion concentration of boiler water when powdery oxygen scavenger Z-KISSY RD-M is used. If sulfite ions are detected in feed water, the amount of residual oxygen must be nearly zero, and therefore the dissolved oxygen in boiler water must also be zero. The dosage is reduced to small amounts to the extent that sulfite ions are barely detected.

l) Citric acid concentration
   Measure the citric acid concentration of boiler water when the boiler compound BOILER MATE SX-M is used. As it is impossible to measure the citric acid concentration on ship, please consult our water analysis services, and we will give you advice based on the measurement results.

11-3. Norms of Sampling of Boiler Water

If general, it is most preferable to take out samples of boiler water from the position of the boiler where water is most highly concentrated. This is one of the reasons why the sampling valve is fitted to the position where water is thought to be most highly concentrated, considering the construction of Z Boiler and boiler water circulation in them.

In sampling boiler water note the following:

![CAUTION](image.png)

1) Open and close the sampling valve slowly. Don't open the valve suddenly.
2) Flash the piping with sampling valve enough before carry out sampling.
3) Take sufficient caution in handling the sampling valve, since hot water including steam might come out of its outlet violently.

![Note](image.png)

1) Carry out sampling and test of boiler water at least once a week.
2) Carry out sampling and test before blow-down as far as possible, and determine the amount of blow down and the dosage of boiler compounds with the test results.
12. Blow-down of Boiler Water

**Warning**

Never do operations except as they are described in the manual. Neglecting the directions may result in serious bodily injury to the operator.

12-1. Outline

Impurities in feed water and chemicals put into the boiler as boiler compounds will gradually accumulate inside the boiler. Concentration of solute salts and suspensoids will increase in boiler water gradually, and this often causes foaming and carry-over. In addition, increase of corrosive components will invite corrosion of tubes, and also accumulation of sludge will cause various troubles such as forming of scales, overheating resulting from it, and clogging of insufficiently-circulating positions.

Blow-down of boiler water is carried out to prevent these troubles. This is the operation to discharge concentrated boiler water out of the boiler and to regulate the concentrations in boiler water within the standards.

12-2. Surface Blow-down

a) Amount of blow-down

\[
\text{Amount of blow-down (ton)} = \frac{\text{Feed water flow (ton)} \times \text{Concentration of component in feed water (\%)}}{\text{Concentration of component in boiler water (\%)}}
\]

Note: Chlorine ions, alkalinity, electric conductivity, etc. are used as the concentration of the component in the above formula.

b) Procedures

- Blow down when the concentration of the component has come close to its standard value.
- Blow down when the boiler is under a low load.
- Repeat blow-down (till the low water level alarm buzzer sounds) and water supply 2 or 3 times alternately, with the feed water pump in service.
- Carry out blow-down 1 to 4 times a day.

Surface blow:

This is to remove concentrated boiler water from the evaporating surface. Carry out this before bottom blow-down.

12-3. Bottom Blow-down

In order to eliminate sludge accumulation, blow down boiler water through the bottom blow-down valve every day when the boiler is under a low load (at the beginning of the operation, for example) or at shut-down.

**Note**

The number of times for blow-down depends on the feed water quality, the condensation ratio and the boiler operation rate.

Concerning the interval of blow-down, please consult our maintenance staff.

**Warning**

As the blowing valve becomes very hot, be careful that it does not cause serious burns. Please consult our maintenance staff about the blowing valve.

bottom blow-down valve
13. Norms of Periodical Maintenance and checking for Boiler Inside

Boiler maintenance and inside checking are very important in maintaining the water quality and judging water treatment results, and also are effective means to keep the highly-efficient boiler operation and to estimate inspection works before docking.

For the ship where the quality of loaded water varies these are the essential periodical works. Follow the procedures shown below.

13-1. Periodical Maintenance and Checking Procedures

<table>
<thead>
<tr>
<th>Item</th>
<th>Procedure</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness check of water-softener</td>
<td>Sample water at outlet of water-softener and check its coloration change with hardness indicator.</td>
<td></td>
</tr>
<tr>
<td>Surface blow-down</td>
<td>Open surface blow-down valve to blow down a portion of boiler water.</td>
<td>Every day</td>
</tr>
<tr>
<td>Bottom blow-down</td>
<td>Open bottom blow-down valve to blow down a portion of boiler water.</td>
<td></td>
</tr>
<tr>
<td>Surface detecting cylinder blow-down</td>
<td>Open surface detecting cylinder blow-down valve to blow down water in this cylinder.</td>
<td></td>
</tr>
<tr>
<td>Total blow-down</td>
<td>Open bottom blow-down valve to blow down boiler water totally.</td>
<td>Timely</td>
</tr>
<tr>
<td>Boiler inside checking</td>
<td>Open inspection holes on upper and lower drums and check scale adhering conditions on drum inside walls and water tube insides visually or with inspection mirror. When scale adhesion of more than 1 mm thick is recognized, consult us immediately.</td>
<td>Every 3 months</td>
</tr>
</tbody>
</table>

*For the other matters, follow the boiler operation manual.

13-2. Points to be Checked

Quality control of boiler water and around the boiler can roughly evaluated by checking the following points.

1) Scale Adhesion

Scales are most likely to adhere in the interior of the steam drum and the water tubes, and so check these positions especially. Sometimes scales adhere more in the lower rather than the upper part of the water tubes, and especially places around the feed water intake are most severely affected. In some cases the tube is completely clogged as shown in the photograph and this causes damages to the tube.

sample photo of scale adhesion
2) Sludge Accumulation
   There are many types of sludge adhesion and accumulation. In the boiler, accumulation in the lower
   water drum is most noticeable.
   Discharge such sludges by blow-down to avoid possible corrosion induced by them, although sludges
   themselves are not directly harmful in any means.

3) Corrosion in Various Positions
   The forms of corrosion found at interior inspection can be divided into two types: total corrosion which
   occurs overall and local corrosion (or erosion) which is caused by pitting, a mass of pitting, or adherent
   corrosive matters.
   Corrosion of boilers occurs most likely on the interior of the water tubes, especially near the water
   surface of the steam drum, (local corrosion caused by pitting and adherent corrosive matters). Caution
   should also be taken to the mounting parts of the water tubes to the drum, and sometimes expanded
   parts of the tubes.

[Sample photo of corrosion]

14. Chemical Cleaning of Boiler

   Contamination in the running boiler depends on the corrosion history in the boiler, control conditions of feed
   and boiler water, operation time length, number of starting/stopping operations, and major materials of the
   feed water system. In addition, as the adhesion thicknesses of scale and sludge vary from place to place in
   the boiler, so do the characteristics of the adhering scale and sludge, such as their components and
   hardnesses. Therefore, though it is impossible to state in any general term when the boiler interior should be
   cleansed, it is considered necessary int the following cases.
   a) When adhesion of thick scale (more than 1 mm) on the heating surface or accumulation of sludge
      (more than 20 mm) in the boiler bottom is observed.
   b) When the steam evaporation has decreased, while fuel consumption has increased and it takes
      more time to raise the boiler pressure at the start of the operation.
   c) When organic matters or fats have gotten into boiler water.
   d) When total iron concentration in boiler water is high (several dozen mg Fe/L or more) water
      continues to be colored red."

   The above-cited phenomena can be a help in determining whether chemical cleaning is needed or not,
   but any judgement should finally be based on the conditions of scale adhesion, sludge accumulation
   and corrosion inside the boiler.

Note

When a too-difficult judgement is called for, inform us, Miura Co., Ltd.

"Various chemical cleaning methods (chemicals used, cleaning procedures, etc.) are available, depending on
the damage conditions and also on the boiler types. Do not fail to consult us.
15. Water Analysis Service

We, Miura Co., Ltd., are offering the free water analysis service to encourage the users to practice correct quality control of water for the efficient and safe use of our boilers.

Send us the samples of feed water, boiler water, etc. at the time of port call. Then we will be able to give the user a proper advice, if needed, after analyzing the samples in detail and comprehending the practical conditions of boiler water. We are waiting the requests of the users.

Regarding PAA and sulfite ion concentrations, please send the result of the analysis just after they are obtained from the on-site measurement to the following address:

<table>
<thead>
<tr>
<th>REPORT FORM OF WATER ANALYSIS</th>
<th>USER: M/V MIURA MARU</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOILER MFD NO. 890-88-151</td>
<td>MEASURED VALUE</td>
</tr>
<tr>
<td>Date of sampling Analysis request NO.</td>
<td>Apr. 8, 92 33171</td>
</tr>
<tr>
<td>Sample division Concentration time</td>
<td>BOILER WATER DRAIN WATER SOFT WATER</td>
</tr>
<tr>
<td>Chemical</td>
<td>Standard value for BOILER WATER</td>
</tr>
<tr>
<td>pH (25℃)</td>
<td>11.3</td>
</tr>
<tr>
<td>Electric conductivity (US/cm)</td>
<td>3620</td>
</tr>
<tr>
<td>M-alkalinity (mgCaCO₃/l)</td>
<td>29</td>
</tr>
<tr>
<td>Chlorine ion (mgCl²/l)</td>
<td>301</td>
</tr>
<tr>
<td>Hardness (mgCaCO₃/l)</td>
<td>103</td>
</tr>
<tr>
<td>Silica (mgSiO₂/l)</td>
<td>17</td>
</tr>
<tr>
<td>Total iron (mgFe/l)</td>
<td>0.08</td>
</tr>
<tr>
<td>Manganese (mgMn/l)</td>
<td>0.0</td>
</tr>
<tr>
<td>Phosphate ion (mgPO₄³⁻/l)</td>
<td>0.0</td>
</tr>
<tr>
<td>Appearance</td>
<td>CLEAR</td>
</tr>
</tbody>
</table>

Send the samples to the following address:
Maintenance Section, Marine Boiler Division, Miura Co., Ltd.
7 Horie-cho, Matsuyama, Ehime 799-2696, Japan
Tel: +81-89-979-7066
16. **Maintenance of Boiler during Shutdown**

Since corrosion occurs during not only operation but also shutdown, anti-corrosion measures should be taken also during shutdown.

16-1. **Maintenance during general Shutdown (i.e. Day-Time Operation and Night-time Shutdown)**

1) Close the main steam valve with the pressure kept high after stopping the boiler and keep it as it is for shutdown.
2) Next morning before start-up, repeat 2 or 3 times blow-down through the bottom valve (until the low water level alarm buzzer sounds) and water supply alternately.

16-2. **Full-Water Maintenance (for Longer Shutdown)**

a) **Preparation**

1) After putting off the fire, with the pressure of less than 2 kg/cm², repeat 4 or 5 time blow-down (until the low water level alarm buzzer sounds) and water supply alternately.
2) One hour or more after putting off the fire, practice full blow-down.
3) Then remove sludge from the interior of the boiler as much as possible.

b) **Maintenance method**

1) Full the boiler with water dosed with boiler compounds and oxygen scavenger. (The dosage of boiler compounds is the same as that during boiler operation. As for oxygen scavenger, add 2 or 3 times as much.) Supply water until it overflows from the air vent valve.
2) Ignite the burner to heat up and boil boiler water properly. Remove dissolved gas out of water through the air vent valve fully.
3) Pressurize the boiler to about 1 kg/cm² with the feed pump. Then seal up the boiler.
4) Check boiler water for quality and pressure at regular interval during shutdown. If these are improper, add chemicals and pressurize it.

c) **Chemicals to be used**

1) Add boiler compounds enough to sustain the pH value of boiler water around 11.5 to 12.
   As for the dosage of oxygen scavenger, a small amount of it should remain in the boiler, after treating residual oxygen in feed water.
2) 1000 cc of boiler compound S-105 per 1 ton feed water.
   1000 cc of boiler compound S-205 per 1 ton feed water.
   86 g of oxygen scavenger RD-M per 1 ton feed water (20°C)
17. Open Manual for Simple Water Quality Teater and test paper

17-1. Operation Manual for Simple Water Quality Tester (Type MT-3)

Water quality analysis is an essential work in comprehending the water treatment condition. To be effective the water quality should be in the proper values. Excessive dosage is not effective. From this viewpoint our water quality tester, type MT-3, is the tester very easy to handle, which has been developed with the motto of "Simpler handling procedures".

[Items to be measured]
1) M-alkalinity
2) pH
3) Chlorine ion
4) Hardness indicator

⚠️ Warning

- When taking a sample of the boiler water, please open the sampling valve slowly so as not to spout steam or spatter the boiler water. Carelessness may result in serious bodily injury, such as burns to the operator.
- When dealing with chemicals, always put on gloves and goggles to prevent severe accidents such as burns or sight loss by splattering of chemicals.
- Wash the skin with water if it has been in contact with chemicals.
- If the chemical has come into contact with the eye, wash it with water and consult a doctor.
- Concerning emergency treatments, refer to the safety data sheet of each compound.
Boiler water is not necessarily colorless and transparent. Since judgement by color is required in measuring the following items, use colorless and transparent boiler water which has been filtered.

**Test 1. M-alkalinity (CaCO₃) for feed water**

M-alkalinity stands for the basic components in the feed water indirectly. M-alkalinity components in the feed water decomposes and raises pH of the boiler water. pH of the boiler water rise slowly if M-alkalinity in the feed water is low.

Reagents: M-1 indicator, M-2 reagent

**Procedure**

1. Make cool the sample water to the atmospheric temperature and then filter it if turbid.
2. Take 50 ml of the sample water into the beaker and add 5 to 6 drops of M-1 indicator (the color changes to red-green)
3. Add M-2 reagent by syringe till the color changes to grayish-purple and count the number of drops.

Twice the number of drops indicates M-alkalinity of the feed. M-alkalinity of feed water (CaCO₃, ppm) = 2 × [number of drops]

**CAUTION**

Use the syringe vertically.

---

**Test 2. pH for boiler water**

The pH value means the measure of whether the solution is acid or alkaline. When the pH value is less than 7, the solution is acid, and when it is more than 7, the solution is alkaline.

The pH value of the boiler water should be kept between 11.0 and 11.8 in order to prevent the corrosion of boiler, to remove the hardness of boiler water and to avoid the silica scale build-up.

Reagent: pH test paper

**Procedure**

1. Make cool the sample water to the atmospheric temperature and then filter it if turbid.
2. Immense the tip of the test paper into the sample water.
3. Pull it up immediately and compare the changed color with the color examples on the box.

**CAUTION**

Please be sure that the temperature of the test water is less than 25°C.
Boiler water is not necessarily colorless and transparent. Since judgement by color is required in measuring the following items, use colorless and transparent boiler water which has been filtered.

**Test 1. M-alkalinity (CaCO₃) for feed water**

M-alkalinity stands for the basic components in the feed water indirectly. M-alkalinity components in the feed water decomposes and raises pH of the boiler water. pH of the boiler water rise slowly if M-alkalinity in the feed water is low.

Reagents: M-1 indicator, M-2 reagent

**Procedure**

1. Make cool the sample water to the atmospheric temperature and then filter it if turbid.
2. Take 50 ml of the sample water into the beaker and add 5 to 6 drops of M-1 indicator (the color changes to red-green)
3. Add M-2 reagent by syringe till the color changes to grayish-purple and count the number of drops.

Twice the number of drops indicates M-alkalinity of the feed water:

\[
\text{M-alkalinity of feed water (CaCO₃ ppm)} = 2 \times \text{[number of drops]}
\]

**CAUTION**

Use the syringe vertically

**Test 2. pH for boiler water**

The pH value means the measure of whether the solution is acid or alkaline. When the pH value is less than 7, the solution is acid, and when it is more than 7, the solution is alkaline.

The pH value of the boiler water should be kept between 11.0 and 11.8 in order to prevent the corrosion of boiler, to remove the hardness of boiler water and to avoid the silica scale build-up.

Reagent: pH test paper

**Procedure**

1. Make cool the sample water to the atmospheric temperature and then filter it if turbid.
2. Immerse the tip of the test paper into the sample water.
3. Pull it up immediately and compare the changed color with the color examples on the box.

**CAUTION**

Please be sure that the temperature of the test water is less than 25°C.
Test 3. CHLORINE ION (Cl⁻ ppm)
Chlorine ion is one of the impurities whose amount should be limited to prevent the boiler from corrosion and to estimate the concentration degree of whole solids in the boiler water by measuring the amount of chlorine ion, the concentration ratio and blow-down ratio can be calculated.
Reagents: CL-0 oxidizing agent, CL-1 indicator, CL-2 regulator, CL-3 reagent

Procedure
1. Make cool the sample water to the atomospheric temperature and then filter it if turbid.
2. If the sample contains such reducing agent as sulfite ion or hydrazine, add 10 drops of CL-0 Reagent and wait one minute.
3. And add 5 to 6 drops of CL-1 indicator (the color changes to blue) Further add CL-2 regulator till the sample water changes completely to green-blue color.
4. Add CL-3 reagent by syringe till the color changes to purple and then count the number of drops.
Ten times number of drops shows chlorine ions.
Chlorine ion (Cl⁻ ppm) 10× (number [number of drops]

<table>
<thead>
<tr>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the syringe vertically</td>
</tr>
</tbody>
</table>

Concentrated ratio = \( \frac{\text{CL}^- \text{ion in boiler water (ppm)}}{\text{CL}^- \text{ion in feed water (ppm)}} \)
Blow-down rate of boiler = \( \frac{100}{\text{Concentrated ratio}} \) (%)

Test 4. Hardness for soft water
Hardness is the cause of the scaling in the boiler. To prevent scale, it is necessary to keep the hardness in the boiler feed water below 1 ppm.
Reagent: Hardness indicator

Procedure
1. Before measurements, about 2 liters of soft water is discharged from the outlet of the water softener.
2. Wash the measuring beaker with soft water.
3. Add 4 drops of the indicator to the beaker.*1
4. Add a small amount (about 20 ml) of test water to the beaker, and stir it thoroughly.
5. After stirring, add test water to the beaker so that the total volume becomes 50 ml.
6. Observe the color change. *2

*1 For accurate analyses, be sure that there are 4 drops of the indicator and 50 ml of total volume. Use the indicator container vertically, and drop the indicator solution slowly.
*2 Observe the color change soon after stirring. It may be impossible to conduct accurate analyses after 10 minutes, as the color may change again.
Color change

<table>
<thead>
<tr>
<th>Color</th>
<th>Judgement</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light blue - Blue</td>
<td>OK</td>
<td>Soft water</td>
</tr>
<tr>
<td>Blue purple - Red</td>
<td>No good</td>
<td>Hard water</td>
</tr>
</tbody>
</table>

Reagents and Apparatus MT-3

<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>Qty</th>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Treatment Manual</td>
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<td>0000-000-1239-0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PH Test Paper</td>
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<tr>
<td>3</td>
<td>M-2 Reagent</td>
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<td>5</td>
<td>CL-3 Reagent</td>
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<td>0000-000-HL46-0</td>
<td>30ml</td>
</tr>
<tr>
<td>6</td>
<td>CL-2 Regulator</td>
<td>1</td>
<td>0000-000-HL45-0</td>
<td>35ml</td>
</tr>
<tr>
<td>7</td>
<td>CL-1 Indicator</td>
<td>1</td>
<td>0000-000-HL44-0</td>
<td>35ml</td>
</tr>
<tr>
<td>8</td>
<td>CL-O Oxidizer</td>
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<td>0000-000-HL49-0</td>
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<td>9</td>
<td>Filter Paper</td>
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<td>10</td>
<td>Beaker</td>
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<td>Mess-Cylinder</td>
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<td>0000-000-1204-0</td>
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<td>Funnel</td>
<td>1</td>
<td>0000-000-1205-0</td>
<td>60 ø</td>
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<td>Conical Beaker</td>
<td>1</td>
<td>0000-000-1203-0</td>
<td>100ml</td>
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<tr>
<td>14</td>
<td>Syringe</td>
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<td>S119-017-9010-0</td>
<td>5ml</td>
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<td>15</td>
<td>Hardness Indicator</td>
<td>1</td>
<td>0000-000-9140-0</td>
<td>30ml</td>
</tr>
</tbody>
</table>

17-2. How to use the phosphate ion testing paper (POR)

Phosphate ion acts preventing the corrosion of boiler also in the boiler precipitating the residual hardness in feed water.

If the boiler water indicates over 10.5 PH with the presence of phosphate ion, the hardness is determined to be 0.

So, a proper amount of phosphate ion must be always present in the boiler water.

Reagent: Phosphate ion test strip

Procedure

1. Make cool the sample water to the atmospheric temperature and then filter it if turbid.
2. Immerse the test zone below the black line of the test strip into the sample water and keep it till the water is absorbed up to the yellow test zone.
   Note: test strip should not touch the water of the beaker.
3. Soon after the sample water is absorbed, removed the test strip from the sample water. Wait 20 seconds: then compare the color change with the tint chart.
17-3. How to use the sulfite ion testing paper

Introduction
The sulfite ion test paper is used for easy measurement of the sulfite ion concentration in boiler and feed waters. Assessment of concentration is based on color comparison, and no special equipment or reagent is necessary. A package containing 100 pieces can be used for 100 tests.

Sensitivity
The result is judged by colorimetry using six levels of color scales: 0, 10, 40, 80, 180, and 400 ppm, respectively.

Procedure
1. If the sample water is turbid, remove the turbidity by filtration before measurement.
2. Immerse the test zone of the testing paper into the sample water for one second.
3. Compare the color change.
   If the pH value is within the range 6-12, the measurement is not affected, but if the pH value is out of this range, please consult us.
   Please keep the sulfite ion testing papers in a cool and dry place. After taking a testing paper out of the container, close the container immediately.
   Measure the concentration immediately after taking the samples out of the boiler water. If the sample water is left for a long time, sulfite ion reacts with oxygen in the atmosphere, and this makes the color comparison inaccurate.

⚠️ Warning
- When taking the boiler water as a sample, please open the sample valve slowly so as not to spout steam or spatter the boiler water. Carelessness may result in serious bodily injury, such as burns to the operator.
- When dealing with chemicals, always put on gloves and goggles to prevent severe accidents such as burns or sight loss by spattering of chemicals.
- Wash the skin with water if it has been in contact with chemicals.
- If the chemical has come into contact with the eye, wash it with water and consult a doctor.
- Concerning emergency treatments, refer to the safety data sheet of each compound.
Control standard of an oxygen scavenger, Z-KISSY RD-M

| Sulfite ion concentration | 10-40 ppm |

If sulfite ion is detected in the boiler water, the amount of dissolved oxygen is assumed to be approximately zero.

⚠️ Warning

The reaction of sulfite ion with residual oxygen produces sulfate ion, which causes corrosion. It is dangerous to introduce an excess dosage of oxygen scavenger "Z-KISSY RD-M." Introduce small amounts to only the extent that sulfite ion is detected.

17-4 How to use the PAA testing kit

Introduction

The PAA testing kit allows easy and economical measurement of the concentration of BOILER MATE W1-M. This method is based on the turbidity from a chemical reaction and uses a specially designed measuring test-cylinder. The turbidity is directly proportional to the concentration of BOILER MATE W1-M.

PAA testing kit Apparatus and reagents

<table>
<thead>
<tr>
<th>NO.</th>
<th>Testing kit</th>
<th>Capacity</th>
<th>Product number</th>
<th>Number of articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cylinder</td>
<td></td>
<td>S800-001-6600-0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Judge bar</td>
<td></td>
<td>S700-002-0700-0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Glass pipette</td>
<td>5ml</td>
<td>S199-017-9020-0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Syringe</td>
<td></td>
<td>S199-017-9030-0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Polyethylene syringe</td>
<td>5ml</td>
<td>S199-017-9010-0</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>AC-1 regular solution</td>
<td>250ml</td>
<td>0000-000-9514-0</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>AC-2 indicator reagent</td>
<td>250ml</td>
<td>0000-000-9515-0</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Operation manual MSDS</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Preventive measures for safety

Please refer to the product safety data-sheet (MSDS) for more detailed information.
Sampling of water.
If the sample is turbid or particulate matter is present, filter the sample through filter paper before testing.

ANALYZING PROCEDURE
1. Cool the sample water to the ambient temperature.
   Filter the sample, if the sample is turbid.
   Determine the appropriate sample volume from the Table.
   Measure the sample water into the Testing cylinder and dilute to the 75mL mark with soft water or destilled water.
   NOTE
   The scale on the Testing cylinder can be used to measure sample water volume larger than 10mL. In order to improve the accuracy of the analyzing, use a pipette to measure sample water volume of 10mL or less.
   Recommended sample size: 75mL for Feed water
   5-10mL for Boiler water
2. Add 5mL of AC-1 and 5mL of AC-2 to Testing cylinder.
   Stir the solution slowly, with the Dipstick.
   Wait 10 minutes.
   NOTE
   10 minutes waiting period is required for complete reaction.
   Do not shake! It may cause bubble.
3. Viewing from the top of Testing cylinder, determine the turbidity units by lowering the Dipstick into the Testing cylinder until the black circles target disappears.
4. Record the scale at the intersection of the Dipstick and the test liquid level on the Testing cylinder.
   Use the Table to determine the concentration (mg/l) of W1-M corresponding to the sample water volume and measurement record.

W1-M CONCENTRATION (mg/l) TABLE

<table>
<thead>
<tr>
<th>SCALE</th>
<th>75</th>
<th>40</th>
<th>30</th>
<th>20</th>
<th>15</th>
<th>10</th>
<th>5</th>
<th>4</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0</td>
<td>90</td>
<td>169</td>
<td>225</td>
<td>338</td>
<td>450</td>
<td>675</td>
<td>1350</td>
<td>1688</td>
<td>2250</td>
</tr>
<tr>
<td>15.0</td>
<td>100</td>
<td>188</td>
<td>250</td>
<td>375</td>
<td>500</td>
<td>750</td>
<td>1500</td>
<td>1875</td>
<td>2500</td>
</tr>
<tr>
<td>14.0</td>
<td>110</td>
<td>206</td>
<td>275</td>
<td>413</td>
<td>550</td>
<td>825</td>
<td>1650</td>
<td>2063</td>
<td>2750</td>
</tr>
<tr>
<td>13.0</td>
<td>120</td>
<td>225</td>
<td>300</td>
<td>450</td>
<td>600</td>
<td>900</td>
<td>1800</td>
<td>2250</td>
<td>3000</td>
</tr>
<tr>
<td>12.0</td>
<td>130</td>
<td>244</td>
<td>325</td>
<td>488</td>
<td>650</td>
<td>975</td>
<td>1950</td>
<td>2438</td>
<td>3250</td>
</tr>
<tr>
<td>11.0</td>
<td>140</td>
<td>263</td>
<td>350</td>
<td>525</td>
<td>700</td>
<td>1050</td>
<td>2100</td>
<td>2625</td>
<td>3500</td>
</tr>
<tr>
<td>10.0</td>
<td>150</td>
<td>281</td>
<td>375</td>
<td>563</td>
<td>750</td>
<td>1125</td>
<td>2250</td>
<td>2813</td>
<td>3750</td>
</tr>
</tbody>
</table>
Standard dosage of BOILER MATE W1-M

| W1-M concentration in boiler water | 1,000-2,000 ppm |

Example of measurement and countermeasure

Boiler water
1) Collect 10 ml of boiler water using the glass pipette, pour into the test cylinder and dilute with soft or distilled water up to 75 ml.
2) As explained in section 2, add AC-1 and AC-2 and wait for 10 minutes.

Example 1
The scale reaches 10.0 when the dipstick is lowered. The intersection cell of the column corresponding to 10 ml of collected water and the scale 10.0 gives a value of 1,125 as W1-M (mg/l) concentration. This example indicates that this boiler water concentration is 1,125 mg/l, which is considered to be appropriate range.

Example 2
The scale reaches 16.0 when the dipstick is lowered. According to the above concentration table this value is 675 mg/l. It is lower than the standard value. It is necessary to increase the dosage.

Example 3
If because of low turbidity, the scale on the dipstick is higher than 16.0, meaning that the value is out of scale, or if the concentric circles are visible even after the evaluation bar has reached the bottom of the cylinder, it is necessary to conduct the test again. Increase the amount of sampling water volume from 10 ml to 15 or 20 ml and repeat the test.

Example 4
If because of high turbidity, the marks disappear before reaching the 10.0 value on the dipstick. Decrease the amount of sampling water volume from 10 ml to 5 or 4 ml and repeat the test.

⚠️ Warning
- When dealing with chemicals, always put on gloves and goggles to prevent severe accidents such as burns or sight loss by spattering of chemicals.
- Wash the skin with water if it has been in contact with chemicals.
- If the chemical has come into contact with the eye, wash it with water and consult a doctor.
- Concerning emergency treatments, refer to the safety data sheet of each compound.
### Specification Table

<table>
<thead>
<tr>
<th>Specification</th>
<th>Equivalent Evaporation kg/H</th>
<th>Water Capacity (l)</th>
<th>Valve of Water Level Gauge at 1cm (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W=60°C, P=7kgf/cm</td>
<td>Full</td>
<td>Normal</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>VWS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>180</td>
<td>181</td>
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<td>359</td>
<td>384</td>
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<td>718</td>
<td>565</td>
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<td>400/350</td>
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<td>3,280</td>
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<tr>
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<td>430</td>
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<td>717</td>
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## Specification Table

<table>
<thead>
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<th>Specification</th>
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<td>Normal</td>
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<tr>
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MIURA

Z BOILER

Head Office:
Miura Co., Ltd.
Marine Boiler Division
7, HORIE-CHO, MATSUYAMA-SHI,
EHIME, 799-2696 JAPAN
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1-4-26, Takanawa Minato-ku, Tokyo
TEL: (+81) 3 3449 3821
FAX: (+81) 3 3440 0944

Koyo Co., Ltd.
2-27, Minaminakamachi Hyogo-ku, Kobe
TEL: (+81) 78 681 5411
FAX: (+81) 78 681 6567

Chuo machinery Co., Ltd
22, yata Honmachi, Nakagawa-ku,
Nagoya
TEL: (+81) 52 363 4645
FAX: (+81) 52 383 3607

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- KOREA
  DONG YANG ENGINEERING Co., LTD.
  #10-11, 2 Ka MYEONG-RYUN-DONG
  DONGRAE-KU PUSAN, KOREA
  TEL: (+82) 51 552 6503
  FAX: (+82) 51 557 4830

- TAIWAN
  NAIKAI ENGINEERING CONSULTANT Co., LTD.
  3F, NO. 34, LANE 55 TUNG HSIN RD.
  KEELUNG, TAIWAN, R.O.C.
  TEL: (+886) 22 4657554
  FAX: (+886) 22 4652182

  MING YUNG MACHINERY, LTD.
  27, SHIN SHING STREET.
  YAN CHERNG DISTRICT
  KAOSIUNG, TAIWAN, R.O.C.
  TEL: (+886) 7 521 6266
  FAX: (+886) 7 521 9368

- SINGAPORE
  TAKANAS ENGINEERING PTE. LTD.
  BLK 6 PANDAN LOOP #01-102 JURONG,
  SINGAPORE 0512
  TEL: (+65) 777 5856
  FAX: (+65) 779 6711

  FUJI TRADING (SINGAPORE) PTE. LTD.
  #24 CHIA PING ROAD, SINGAPORE 619976
  TEL: (+65) 264 1755
  FAX: (+65) 265 0443

- UAE
  IN CONJUNCTION WITH FUJI TRADING CO., LTD.
  P.O. BOX 64 88 DUBAI
  UAE
  TEL: (+971) 4 342 211
  FAX: (+971) 4 342 662

- THE NETHERLANDS
  NICOVERKEN HOLLAND B.V.
  REGOUTSTRAAT 3125 BH SCHIEDAM,
  THE NETHERLANDS
  TEL: (+31) 10 437 0877
  FAX: (+31) 10 415 7150

  FUJI TRADING (MARINE) B.V.
  POST BOX 2498
  3000 CL ROTTERDAM
  SLUISJESDUIK 109
  THE NETHERLANDS
  TEL: (+31) 10 429 8833
  FAX: (+31) 10 429 5227

- GERMANY
  TAKANAS MARINE ENGINEERING GMBH
  "FRUCHT Hof" OBERHAFENSTR. 1
  20097 HAMBURG
  GERMANY
  TEL: (+49) 40 32 1305
  FAX: (+49) 40 33 0606

- USA
  CISCO BOILER SERVICE CO., INC.
  5709 OLD SPANISH TRAIL HOUSTON,
  TX 77023
  USA
  TEL: (+1) 713 928 5700
  FAX: (+1) 713 928 5795

  INDUSTRIAL BOILER SERVICE, INC.
  23132 EAST ECHO LAKE ROAD SNOHOMISH,
  WA 98296
  USA
  TEL: (+1) 206 624 1171
  FAX: (+1) 206 483 9112