CYCLOTHERM® of WATERTOWN, INC.
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Technical Manual

Operation & Maintenance

Boiler Model – MC4000W-2-43

Serial Number: 26154

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The Cyclotherm Package Boiler, referred to below by Cyclotherm Sales Order, Serial Number, and National Board Number was engineered and built in our plant with the highest standards of workmanship, and to the latest A.S.M.E. Quality Control Procedures

All Cyclotherm Boilers are constructed in accordance with the A.S.M.E. Boiler and Pressure Vessel Code, Section 1, and are stamped and filed with the National Board of Boiler and Pressure Vessels.

All the information contained in this manual is of importance to the owner, and must be read and referred to carefully with regard to proper installation, start up, maintenance, and operation.

All Inquiries directed to the manufacturer concerning this product must include the identification numbers located on the boiler nameplate, pressure vessel, and listed below.

Customer: Marinette Marine Corporation

Installation: ARRV

Cyclotherm Sales Order No.: C8-10-10

Serial No.: 26154

National Board No.: 18,013

Date: 2012

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Cyclotherm Package Boiler Warrantee

Cyclotherm warrants all equipment manufactured by it and bearing its' nameplate to be free from defects in workmanship or materials under normal use and service for the period of one year from the date of shipment. If any part of the equipment herein described and sold by Cyclotherm, proves to be defective in workmanship or material and if such part is within twelve months from date of purchase from the factory of Cyclotherm returned to such factory, transportation charges prepaid, or material, it will be replaced or repaired free of charge, FOB factory of Cyclotherm. The warrantee shall be limited to equipment sold by Cyclotherm of Watertown, Inc or its authorized agents, dealers, or distributors, in the hands of the original purchaser, and upon which equipment normal and proper maintenance has been rendered by the purchaser.

Note: This warrantee does not apply to: refractory's, gauges, steam outlet valves, blow off valves, and any electronic photo and amplifier tubes, fuses, or filter glasses. Warrantee does not include damages sustained in transit. This warrantee does not include improper functioning of the equipment due to local conditions beyond our control.

The warrantee given herein shall not apply to any damage to the equipment occasioned by firing said equipment under conditions of insufficient water therein, or by lack of boiler water treatment and/or blow down procedures.

Manufacturer assumes no responsibility or liability with respect to the use, misuse, purpose or suitability of its equipment. Manufacturer shall not be liable for any direct or indirect consequential damages of the type or character resulting from such damages involving manufacturer's equipment.

A defect within the meaning of this warrantee is any part, or parts, of the said equipment or in the workmanship thereon shall, when such part of workmanship is capable of being renewed, repaired or replaced, be deemed to be a defect only with respect to such part or parts, or workmanship; and Cyclotherm undertakes to replace, repair or renew the defective part or parts, or workmanship. Cyclotherm assumes no liability for consequential damages of any kind. Purchaser by acceptance of this equipment assumes full responsibility for its' use or misuse by purchaser, his employees, or others

(Warrantee Continued)

This warrantee is expressly in lieu of all other warrantees, guarantees, obligations or liabilities, expressed or implied by Cyclotherm of Watertown, Inc or its' representatives. All statutory or implied warrantees, other than title are hereby expressly negative and excluded.

Orders submitted on purchasers own forms, which forms may contain statements, clauses, or conditions modifying, adding to, repugnant to, or inconsistent with the terms and provisions therein contained, are accepted by Cyclotherm only upon condition and with the express understanding that notwithstanding any such statements, clauses, or conditions contained in any order forms of purchaser, the liabilities of Cyclotherm in accepting and consummating any such order, Cyclotherm shall be deemed not in any way to have changed, enlarged or modified its liability or obligations as fixed by the terms and conditions of sale stated by Cyclotherm above.

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General Description – MC – 4000 Package Boiler

Design – Horizontal modified scotch marine firetube boiler

Designed for automatic, unattended operation onboard marine vessels

Boiler capacity – 4000 lbs/hr steam from and at 212 degrees F. normal operation
- 4800 lbs/hr steam from and at 212 degrees F. overload operation

Design pressure – 150 psi

Operating pressure setting – 35 psi, field adjustable as desired

Hydrostatic test pressure – 225 psi

Safety valve settings – 1 @ 145 psi, 1 @ 148 psi (other pressure settings available upon request)

Overall dimensions – 90.125” high x 57” wide x 107” long

Dry weight – 7550 lbs

Wet weight – 10050 lbs

Fuel consumption – 330 lbs/hr (on maximum firing rate)

Modulating burner – 5:1 turn minimum down ratio

Nominal stack temperature at normal operation – 550 F. max

Efficiency at rated capacity – 80% minimum

Type of fuel burned - #2 diesel, F-76, JP-5, and similar grades

Blower motor – 10 hp, 220/440 volt AC, 60 hz, 3 ph

Feed water pump motor – 3 hp, 220/440 volt AC, 60 hz, 3 ph

Fuel pump motor – 1 hp, 220/440 volt AC, 60 hz, 3 ph

Controls – 120 volt AC, 60 hz,

Included as standard features on the boiler assembly are;

Feed water pump and motor and related piping and valves to boiler are installed on boiler. All piping is complete with valves, feedwater pressure relief valve, check valve, strainer, and a chemical treatment tank with bypass piping.

Fuel oil pump and motor and related equipment is installed on the boiler. The method of fuel atomization is of the high-pressure mechanical design. There are 2 fuel oil solenoid valves and a low pressure-sensing device in the fuel train upstream of the burner. The firing rate of the burner is a modulating design that is controlled by our standard back pressure method and variable capacity nozzle. The fuel system pump assembly has a constant relief system that governs the system fuel pressure.

Combustion air blower and motor assembly and related equipment is installed on the boiler. There is a low air pressure sensing device on the blower to monitor the system air pressure and shut down the burner upon a pressure that is too low to support fuel combustion.

Automatic combustion control monitors and controls the burner and firing rate of the burner. A modutrol motor is used to control the firing rate and fuel/air ratio of the burner during combustion. The automatic combustion control that controls this system is located in the boiler control panel.

The control panel on the boiler contains the automatic combustion control, water level relays, the modutrol motor transformer, a time delay relay for the feedwater system, and relays for operating the status/indicating light panel. Mounted near the panel are the operating pressuretrol, the high limit steam pressure safety shut down pressuretrol, and the operating switches for low water reset, the on/off switches for the boiler, the push button stations for the blower and feedwater pump operation, and the automatic/manual switch for the firing rate operational control.

Mounted on the front of the boiler is the burner assembly and control panel complete with status lights and alarm. The modutrol motor and fuel regulating valve are located on the burner assembly as well as the flame scanning sensor.

The water level control system consists of a probe system internal to the boiler shell that monitors the water level and automatically activates the feedwater pump system as needed. There are also 2 low water level probes to shut the burner off in the event of a low water condition. Mounted on the front of the boiler is a water level gauge glass and tri-cock valves for a visual check on the water level in the boiler.

There are 2 motor controllers supplied with the boiler but mounted separately from the boiler at installation. Where permitted, we install the motor controllers in the main boiler control panel. These controllers are for the operation of the blower and feedwater pump motors. The fuel oil pump is driven by the blower motor.

The steam pressure relief valves, steam stop valve, and bottom blow down valve are assembled on the boiler.

All hand holes, access plates, inspection plates, and gaskets are included with the boiler assembly. The hand hole size is 3 ½ x 4 ½.

The standard approval authority for the construction and assembly of this boiler is A.S.M.E., the American Bureau of Shipping, and the United States Coast Guard as applicable.

The safety features on the boiler are designed for a failsafe operation, and are in complete compliance with the above approval authorities.

The boiler is supplied with a flanged flue outlet for connection of the flue piping, supplied by others.

Each boiler is performance tested prior to shipment.

Principal 0f Cyclonic Combustion

The Cyclotherm principle of combustion and heat transfer has an important part of its designed, relatively high velocity air flow. This high velocity air is introduced at a tangent to the main cylindrical combustion chamber. The centrifugal force holds the air to the outside of the combustion chamber creating high tangential velocity, but relatively low axial velocity through the chamber. The core, or cone, of this cylindrical shape acts as a fuel induction chamber.

The atomized fuel progressively mixes with combustion supporting air as it is carried downstream to the furnace. Fuel that is introduced into the combustion chamber is slowly preheated, breaking down into hydrogen and carbon. The hydrogen is immediately consumed as it mixes with air, and this acts as supporting combustion for the carbon particles. The high velocity air and products of combustion result in a controlled turbulence which keeps the carbon particles scrubbed free of ash, assuring complete combustion.

This action also minimizes the possibility of direct flame impingement on the combustion chamber, which would immediately drop the flame temperature, causing carbon from unburned fuel, low efficiency and excessive smoke at the stack outlet. High velocity air, at a constant pressure, also satisfies the requirements for complete controlled combustion, while overcoming the resistance in the boiler passes.

The design of the Cyclotherm blower, although similar to those commercially manufactured for varying uses, has been developed in order to provide constant pressure and velocity, as well as providing the required CFM for efficient combustion. A typical enclosed impeller with radial blades provides this constant pressure with varying capacity demand. Since the blower can be considered a single purpose unit our design utilizes the most efficient area wherein pressure and horsepower do not radically change with changes in capacity.

In summary, the design of the Cyclotherm blower utilizes the most efficient segments of capacity, pressure, horsepower curves; to maximize pressure variance with capacity change in the furnace section.

The Cyclotherm method of combustion and heat transfer results in complete combustion in the combustion chamber, and utilizes the maximum heat transfer from “Radiation” (the area radiating surface) and “Convection” (the high velocity of the hot gasses).

Water Conditioning and Boiler Cleaning

The amount of cleaning and water conditioning required on the inner surface of your Cyclotherm Generator depends on the water used in your locality.

The type of water conditioning used and the method of application will depend on the water conditioner and treatment desired. We prefer not to recommend any particular company or product to fill your requirements as you will be more satisfied after consulting with one or more such companies, then you will be able to study their requirements and chose the proper treatment best suited for your needs.

The information below is provided as a general description.

Air with no moisture will not readily corrode steel, and neutral water with no air also will not appreciably corrode steel. However, air and moisture together will cause corrosion and eventually failure of any steel structure.

Surface waters such as rivers, lakes, reservoirs, etc. are usually saturated with air, the amount retained depending on the temperature of the water. The colder the water, the more air it will hold in the solution. When water becomes warmer, the retained air is liberated and if this should happen in a boiler under unfavorable conditions, the combustion of air and water will cause the pitting type of corrosion.

A boiler need not be operating to have this pitting start. If raw water containing dissolved air is put in a boiler and let stand, the water starts to warm up, oxygen is liberated and may attach itself to a tube or other exposed steel part. A pit may form under the air bubble, and when the boiler is put into service, the pit may continue to develop until failure of the tube takes place.

Pits can also form in an operating boiler if connections are not tight or if air is getting back into the system, due to vacuum from condensation.

This entire problem can be minimized by keeping air out of the system, keeping the water sufficiently alkaline, or by using a chemical inhibitor.

Air can be kept out by the following methods:

1. Use as little make up water as possible in a closed system. Leaks or improperly operating vents cause a loss of volume thereby increasing the necessity of make up water. Periodic draining of large or small amounts of water should be avoided for the same reason, and in addition, cause less use of chemical treatment.
2. If practical a feed water heater should be used to preheat the incoming water to release the dissolved air present in nearly all water supply.
3. A chemical air scavenger such as sodium sulfite or certain organic materials may be used to react chemically with the oxygen and thereby remove it.

4. A boiler should never be filled with fresh water and allowed to stand for any period of time before being put on the line unless certain precautions are taken. As soon as it is filled, it should be brought up to temperature for 15 to 30 minutes. If steam or hot water is not needed, the boiler should be closed up tight and cooled down. This rids the water of any dissolved air.
5. On installation, or when new tubes are installed in the boiler, the tubes should be cleaned off when installing them whether by boiling out with a cleaning compound, or if only a few tubes are replaced, by wiping them clean at the time of installation. Tubes are coated with various oils to protect them during shipment and storage. Such oils, left on the tubes have been known to aggravate oxygen, resulting in some abnormally short service lives.

It is our belief that satisfactory service life can be attained by following the preceding suggestions, which involve keeping the tubes clean, keeping air out of the boiler and controlling water conditioning with proper treatment. You should contact a water conditioning company for proper treatment of water in your area.

Installation Instructions

1. Locate the Cyclotherm in the desired position.
    A. Comply with installation requirements of the National Board of Fire Underwriters, and any local ordinances and Authorities.
    B. Locate the Cyclotherm with reference to fuel storage tank so that fuel supply and return lines will be as short as possible consistent with applicable codes and regulations.
    C. Level up the unit, placing shims under the support skid if required.
2. Make all outlet, blow off drain and connections.
    A. Install outlet valve
    B. Install safety valve (s), connect discharge piping from valve. Do not restrict valve openings. Support piping so that no strain is placed on safety valve.
    C. Install blow off valve. Connect blow off line to drain, or blow down tank.
    D. The stack should be installed in such a way that excessive back pressure will not be built up in the combustion chamber. Do not make stack smaller than the flue outlet on the Cyclotherm. Avoid sharp bends or other restrictions to free flow of flue gases from the Cyclotherm.
    E. After installation of the Cyclotherm is completed, prepare it for operation in accordance with Operating Instructions in this manual.
3. Fuel Connections – oil fired units
    A. Install oil storage tank of sufficient capacity to care for the requirements of the installation. The size, location, construction, safe guarding and piping of the tank should be in accordance with the regulations of the National Board of Underwriters and applicable state, local, and applicable ordinances.
    B. Install oil supply and return lines.
        1. Locate pump suction line several inches from the bottom of the tank to avoid picking up sludge or water.
        2. The return line must be an individual line back to the supply tank. Do not connect it to the suction line since trapped air will cause poor performance. Make sure supply and return lines are separate and air tight.
        3. If oil storage tank is located above the oil pump, install an anti-siphon valve at the highest point in the supply line. This prevents oil from being siphoned out of the tank, if the suction line should break, or leak.
        4. If the tank is located below the fuel pump, provide a check valve in the suction line near the tank, or a foot valve at the tank end of the suction line. This will keep the suction line filled with oil so that the pump will hold its prime.
        5. All piping should be standard full weight wrought iron or steel pipe, or approved brass or copper tubing with approved fittings.

6. Ream ends of pipe after cutting. Measure pipe accurately so that strains will not occur at the joints. Pipe joints and connections must be tight. Use litharge and glycerin or other good pipe joint compound on the male threads only.

4. Electrical connections
    A. Refer to the wiring diagram provided in the control panel or in this manual. Make suitable connections to the applicable equipment components provided on the unit.
    B. Connect power supply to control cabinet fused disconnect.
    C. Install separate safety switches for each motor circuit and check to make certain rotation is correct before making connections permanent.

Fuel System of Light Oil Modulating Burner

The components of the fuel system furnished with your Cyclotherm arranged for modulating operation using light oil are listed below and also on the accompanying Fuel System Diagram.

Fuel Oil Strainer

Fuel Oil Filter

Fuel Oil Pump & Motor

Fuel Pressure Relief Valve

Fuel Supply Pressure Gauge

Fuel Supply Safety Pressure Switch

Fuel Supply Solenoid Valves

Variable Capacity Fuel Nozzle

Fuel Return Check Valve

Fuel Return Pressure Gauge

Fuel Pressure Regulating Valve

Other parts of the fuel system not furnished but required for operation include oil supply storage tank, oil supply line with certain valves and the oil return line.

Fuel Supply Storage Tank

The type, size, and location of the storage tank should be chosen to suit the requirements of the boiler installation and in accordance with applicable Coded and safety requirements.

Oil Supply Line

The supply line should be as short as possible, consistent with location codes and safety regulations. It is essential that the supply line be absolutely air tight. Suction lift should be virtually limited to ten feet; if possible the supply line should contain no restrictions or unnecessary bends. There are some conditions to be considered for the installation of a suction line which may affect the performance of the fuel pump which in turn may affect the performance of the boiler. Four factors to be considered when selecting the suction line size are; maximum volume of fuel, viscosity of the fuel, length of the suction line, and the number of bends used (curved fittings).

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Foot Valve or Check Valve

When the oil supply tank is located lower than the burner, the end of the suction line at the tank should be equipped with a foot valve, or a check valve may be installed in the line near the tank. The check valve or foot valve keeps the suction line filled with oil when the oil pump is not in operation.

Anti-Siphon Valve

An anti-siphon valve should be installed when the tank is higher than the burner. Underwriter regulations require an anti-siphon valve when underground tanks are located above the burner level. The anti-siphon valve prevents oil from siphoning out of the tank if the suction line breaks or develops a leak.

Shut off Valves

It is recommended that a shut off valve be installed in the suction line near the fuel pump. This valve should only be used when repairs are being made.

Fuel Oil Strainer

The Fuel strainer is a duplex strainer that has two working elements – one that is in service straining fuel to the fuel pump, and another chamber element that is in standby. The purpose of this duplex strainer is to facilitate changing from one strainer element chamber to the other while the boiler is operating without the need of shutting down the boiler for this change. The strainer has a clamping mechanism that when loosened, the dirty element can be removed for cleaning.

Fuel Oil Filter

The oil filter is a self cleaning designed element in that to periodically clean the filter element, the handle on the top is rotated for this purpose. This design is used so that the filter element can be cleaned without the need of shutting down the boiler for this operation.

Fuel Pump & Motor

The fuel pump is a rotary gear, positive displacement pump with a capacity considerably greater than the consumption requirements of the burner. The pump is directly connected in a close coupled design to the fuel pump motor as a single unit.

Oil Supply Pressure Gauge

An oil pressure gauge with a stop valve is provided in the fuel oil discharge line. This stop valve should be closed at initial start to prevent damage to the gauge. Extreme fluctuations of the pressure gauge during starting periods are an indication that all air is not purged from the suction

line. If fluctuations do not stop after a reasonable amount of time, the suction line should be thoroughly examined for air leaks.

On the initial start of the Cyclotherm, the fuel oil pump may fail to build up pressure due to air in the supply line. The safety controls that exist will then shut off the unit. The oil filter and strainer should be filled with fuel oil, also make certain the fuel pump has proper rotation and turns freely. If it is desired to fill the oil suction line, it is recommended that the motor starter for the pump be manually operated until suction line is free of air.

Fuel Pressure Relief Valve

The pressure relief valve is adjusted at the factory to maintain approximately 200 to 250 psi of oil pressure. If adjustments are necessary, the cap on the oil pressure valve should be removed. To increase the pressure, turn the adjustment screw clockwise – to decrease the pressure turn the screw counter clockwise. This valve sets the system pressure at 200 psi between the fuel pump and the fuel nozzle during operation for pressure atomization of fuel at the nozzle.

Fuel Supply Pressure Switch and Transducer

The pressure switch is located on the supply line between the pump and the fuel supply solenoid valves. If the system pressure is inadequate to support proper atomization of the fuel, or if there is a drop in the system pressure, this safety device will shut the unit down.

Fuel Supply Solenoid Valves

The oil solenoid valves are installed in the fuel supply line operation of the unit controlling oil to the nozzle. The solenoid valve operation is controlled by the combustion control in the control cabinet. At the proper timing during the light off sequencing, a signal is sent to open the solenoid valves to allow fuel to flow to the nozzle.

Variable Capacity Nozzle Assembly

The Cyclotherm variable capacity nozzle assembly is the only atomizing nozzle of its kind used on oil burning equipment in the field today.

The Cyclotherm oil atomizing nozzle assembly is composed of the nozzle body which contains drilled supply and return ports, the front and rear atomizing discs, and the nozzle retainer nut. A steel pin on the face of the nozzle body provides means of locating the rear nozzle disc in correct position relative to the oil supply and return ports in the nozzle body.

In operation, oil at approximately 200 to 250 psi is delivered through the nozzle body and rear disc to an annular groove surrounding 4 tangential supply slots. From the groove the oil passes through the slots at an extremely high velocity and into a concave whirl chamber where a cyclonic velocity of the fuel is created, and the velocity is further increased. Some of the fuel oil passes from the whirl chamber through the front orifice disc in the form of a conical rotational

fine spray mist and is ignited to create the cyclonic flame pattern in the combustion chamber. The remainder of the fuel oil passes from the whirl chamber through the center orifice in the rear disc and through the return port in the nozzle body continuing through the return line to the fuel pressure regulating valve. The fuel pressure regulating valve position determines a certain amount of back pressure in the return line flow. Back pressure on this return line is determined by the setting of the oil regulating valve which governs the amount of oil that passes through the front disc to be fired. The higher the amount of back pressure, the more fuel oil volume is delivered into the firing chamber. The lower the amount of back pressure, the less amount of fuel is delivered to the firing chamber.

Periodic cleaning of the nozzle is required, and necessary. Before removing the nozzle body from the burner head, mark or measure its position so that it can be replaced correctly. Disassemble the nozzle using a suitable wrench that fits securely on the nut flats. Do not in any case grip the nozzle with pipe wrenches or unprotected vice jaws. For cleaning, use clean light oil or other solvent and/or low air pressure. Do not use wires or other metallic tools to clean nozzle discs.

Pressure Gauge (oil return line)

This gauge indicates the back pressure on the return port of the oil nozzle assembly and it's reading is a direct indication of the amount of fuel oil being fired. The higher the pressure reading, the higher the firing rate and volume of oil is being fired.

Fuel Pressure Regulating Valve

This valve is an adjustable port valve in which the position of this valve is controlled by the modutrol motor. The modutrol motor is controlled by the combustion control and modulating pressure or temperature device on the boiler and sets the position of the regulating valve to create the proper amount of return line back pressure to achieve a higher or lower firing rate of the burner. At high fire, the adjustable port valve is closed to create a higher back pressure and at low fire the valve is in a more opened position to reduce the return line back pressure and achieve a lower firing rate. There is an adjustable port inside the valve that can be adjusted with an adjustment knob for fine tuning the amount of back pressure settings.

Preparing for Initial Firing

1. Open the rear cover of the boiler and visually check rear cover refractory, rear chamber refractory, burner head and throat refractory at the front of the boiler for any shipment damage, cracks, etc. Check to see if tube inserts are in place in the tubes. Loosen but do not remove bolts holding shell to skid assembly to allow for expansion and contraction of the unit during operation.
2. Check voltage to panel box fuses for control system. It should correspond to specified control voltage of 120 VAC.
3. Check voltage to blower starter and make sure it corresponds to specified voltage of 460 VAC.
4. Check blower motor rotation for correct direction of blower fan as indicated on the motor or blower housing. In case of an electric motor, three phase could run in either direction according to the phasing of the incoming lines. Reversing two of the three lines will reverse rotation of the motor. In case of the installation of a turbine drive to run the fan, it would be installed for only one direction.
5. Fill Boiler with water to normal level from outside water supply. We suggest the use of water at room temperature if possible and not preheated water by a preheated water supply to minimize the thermal shock effect on the cold tubes with hot water.
6. Energize the control panel circuit which is operated by a fused disconnect switch near the panel box.
7. All boilers have at least two low water cut off systems. On this unit, there are two probe systems that contact the water inside the boiler and send signal to relays in the control cabinet. By draining the boiler from the rear blow down drain valve slowly, the probe type low water cut off system will drop out the low water relay. Further reducing the water level by approximately ½" the emergency low water relay will drop out. The boiler is provided with a low water probe, and an auxiliary (or emergency) low water probe immersed directly into the water directly through the boiler shell in the top of the boiler vessel. In the case of low water cut off probes, there are relays in the control panel that are operated by each low water probe that will turn the burner off and shut the boiler down in the event of low water.
8. Each boiler has an air damper. The air pressure and volume is adjustable on low and high fire and is operated by a modulating motor which opens and closes an air damper to the blower fan. The position of this air inlet damper determines the blower pressure and volume entering the furnace. At low fire the air damper should be approximately 30% open and at high fire the air damper should be approximately 90% open for rated capacity of the boiler. Installation conditions will change these setting slightly. The air damper arm from the modulating motor is adjustable at the swivel joints, and the low fire setting on the air damper may have to be adjusted manually at the original start up to the required 30% open. At the time of start up on low fire there is an interlock safety air pressure switch on the blower housing which is set for 3 – 4" WC. This switch has to

have enough air pressure for low fire start to make contact between the R and W terminals inside the switch to complete the circuit for ignition trials and the main fuel to come on at the prescribed time according to the combustion control in the control panel. At no time is this air safety switch to be jumped out or bypassed. This is a safety control device so the boiler will not let fuel into the combustion chamber with no air to support combustion.

9. On the oil pump starter there is a switch marked manual/off/automatic. Make sure suction and return lines are both open and gauge valve is closed for initial running. Place selector switch in manual position and let pump run until oil is being pumped (check return line). Open gauge valve and check pressures. The supply pressure at the pump should read 200 psi, and the return pressure gauge should read zero. The pump system pressure is adjusted by the relief valve mounted on the pump. Unscrew the large cap at top of the valve, loosen locking nut, screw clockwise for higher pressure, and counter clockwise for lower pressure. Adjust to proper pressure by reading gauge on the pump set. Slight pressure drop may occur after solenoid valves open, readjustment may be necessary. Tighten lock nut and install cap. Place selector switch into automatic position.
10. Shut off main fuel shut off valve until ignition electrodes, solenoid valves, and photo eye flame detector are checked for proper operation. After all of the above steps are taken, and all resets such as low water, and flame failure contacts have been established as operating, put the boiler on/off switch to the on position.
11. The blower motor will start, and the combustion control will cycle the boiler through a prepurge cycle to clear air inside the combustion chamber. The firing rate on the modutrol motor will move from high fire to the low fire position. If all safety interlocks are made and in the circuit the combustion control will proceed to the ignition trial period. At the time of trial for ignition, the ignition transformer is energized, the electrodes will energize, the solenoid valves will open and then ignition occurs. If the flame scanner recognizes an ignited flame, the combustion control programmer monitors the flame will shut down the burner when the set point for temperature or pressure has been reached, or if there is a safety fault that occurs during the running cycle.
12. The initial sequence should be run through several times with the main fuel valves closed to observe the ignition electrode spark and make minor adjustments to achieve a strong bright spark pattern. Combustion control reset will have to be actuated after each sequence. Place modulation switch on end of panel box on low fire position. Place selector switch on oil pump starter on automatic position. Oil pump should automatically energize when sequence begins. The presence of spark on the electrodes can be observed through the peep sight hole in the electrode holder before the fuel shut off valves are opened. Spark can also be witnessed through the rear cover sight glass.
13. The modulation of the air and fuel mixture is established by adjustment of the air inlet damper and the modulated fuel valve in the main fuel line. Both the air and fuel

modulation controls are operated from the modutrol motor arm and are adjusted accordingly for best CO2 and clean flame.

Adjusting Modulated Burners Before Start up

The fuel air ratio is adjusted by means of the air damper assembly and your fuel regulating valve.

On combination gas / oil burners the oil-air ratio is always adjusted before the gas-air ratio.

To set up units on oil the adjustments are made to the oil regulating valve and the air damper assembly.

1. Oil – Modulating: On the oil regulating valve, there is a slotted linkage arm. This arm controls the movement of the valve. Placing linkage toward top of slot increases travel of the valve; place linkage toward bottom of the slot valve travel is shortened. The slot on end of oil regulating valve should be approximately horizontal, at low fire position. If not, the set screw can be loosened and the shaft turned with a screw driver, retighten set screw. On the back of the oil regulating valve there is a small knob, this is for adjusting your low fire back pressure. High fire is adjusted by adjusting the movement of the oil regulating valve so it stops at the desired back pressure for high fire.
2. Modutrol Motor Adjustment: The modulator motor with linkage generally moves through 160 degrees from low fire to high fire. The modutrol motor arm is slotted for air damper linkage and has three holes for the oil valve linkage. The closer the linkage is to the center hub the shorter the travel is on either the fuel regulating valve or the air damper arm. The farther from the hub the longer the travel of the linkages. On the modutrol motor arm there are two set screws, when loosened this will allow the modutrol motor arm to be turned by hand from the low fire position to the high fire position (160 degrees from low fire – some modutrol motors have a 90 degree travel). On the Marine Series boilers, the modutrol motor controls the travel of the air damper only, and the linkage connection to the fuel regulating valve is connected by linkage to the air damper lever, and is driven by the air damper lever.
3. Loosen set screws on modutrol motor arm. At end of air damper arm toward boiler there are two set screws holding the damper arm to the damper shaft. Loosen these two set screws. Move the damper shaft to the closed position – mark the shaft and damper arm. Move the damper shaft to the full open position and mark. The point between these two marks is the damper travel. With modutrol motor arm in low fire position place damper shaft approximately 1/3 of the distance between open and closed position marked on the damper arm. Lock arm on shaft with set screws. Move modutrol motor arm to high fire position. At this position the damper should be at the full open position. Loosen damper arm and move damper shaft toward full open position. If not close to full open position, readjustment of linkage is required to obtain full open position on high fire and 1/3 open on low fire. These adjustments are approximate and will have to be adjusted during fine tuning after firing burner.
4. General Start Up Procedure for fuel/air ration and Initial Firing: When approximate settings are made, lock damper arm on shaft. Lock modutrol motor arm on hub, in low fire position. Prepare for initial start. Place oil pump starter in automatic position. Check to see that all resets are actuated and made – water level, flame failure, etc. Place modulation switch on end of panel box in low fire position. Place on/off switch to on position, prepurge cycle will begin. After the prepurge cycles back to low fire position, ignition trial begins. The ignition electrodes

are energized and the fuel solenoid valves open. After the flame is lit, read the back pressure setting on the fuel regulating valve gauge. Adjust the low fire back pressure to 38 psi – to adjust back pressure on low fire you turn adjusting knob on back of regulating valve until you reach desired pressure. After boiler is showing 3 to 5 psi of pressure, or 5 to 10 degrees temperature increase, loosen set screws on modutrol motor arm and run up to high fire position. Check pressure gauge and adjust higher or lower by changing travel of valve as needed. The high fire back pressure should be 120 psi. Put back into low fire position and re-check back pressure, adjust as needed. Take CO2 reading, 10 – 12 for low fire. If the CO2 reading is low decrease air volume with damper. If reading high CO2 increase volume of air. Move to high fire. Take CO2 reading, 12 for high fire and no visible emissions. Due to varying conditions of fuels used the best CO2 and least amount of emissions are more efficient than specific back pressure readings.

Maintenance

Section 1 – Preventative Maintenance

List of Section:

A. General
B. Care of Waterside
C. Cleaning Fire Tubes
D. Refractory Maintenance
E. Blower, Fuel Pump & Fuel System
F. Electrical

Section 2 – Corrective Maintenance

List of Section:

A. General
B. Ignition Failure
C. Solenoid Failure
D. Burner Smokes or Pulsates
E. Oil Pump Fails To Deliver
F. Blower Fails To Deliver
G. Safety & Relief Valves

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Subject: **Recommended Maintenance Procedures**

A. Daily

1. Inspect boiler fuel train for leaks, correct as needed
2. Inspect boiler for water leaks, correct as needed
3. Insure that there are no combustible materials near boiler
4. Clean boiler components and immediate boiler area, keep clean
5. Insure that boiler operates properly. Inspect for:
    a. Proper start up sequence, operating and standby operations
    b. Proper water control temperature operation
    c. Smoke free operation of boiler
    d. Listen for unusual noises in boiler operation, pinpoint problem and correct as needed
6. Perform proper blow down procedures – 2 times daily

B. Weekly

1. Clean burner nozzle and disc set
2. Clean electrodes
3. Adjust ignition electrodes if disturbed
4. Clean flame scanner
5. Inspect, clean, or replace as needed fuel strainers and filters
6. Inspect boiler fuel pump pressure, adjust if needed

C. Monthly

1. Analyze sample of boiler water, chemically treat feedwater as needed

C. Every Three Months

1. Grease all pump and motor bearings
2. Perform a flue gas analysis, inspect fuel pressure settings, adjust combustion fuel to air ratio as needed for clean operation
3. Remove and inspect fuel return check valves, clean/replace if needed

D. Every Six Months

1. Inspect refractory in burner, burner throat, and rear cover, repair as needed

E. Annually

1. Inspect fireside of boiler for water leakage, thoroughly clean, correct problems as needed, install new gaskets
2. Inspect water side of boiler, thoroughly clean, correct problems as needed, install new gaskets
3. Inspect all motor bearings, clean, repack bearing chambers with new grease, replace bearings if worn
4. Inspect blower fan, replace if damaged
5. Inspect and adjust fan clearance in blower housing as needed at air intake of fan
6. Inspect fuel solenoid valves for proper operation and leakage, replace if needed
7. Replace or repair any leaking valves, fittings, or piping in fuel, water, and combustion air systems
8. Perform Hydrotest of boiler pressure vessel, inspect for leaks
9. Inspect water pressure relief valves for proper operation
10. Inspect tube inserts in back end of boiler return tubes, clean / replace if worn

Section 1

General:

A. Breakdowns can often be prevented or minimized by following a regular maintenance schedule and by prompt action when operating difficulties or material defects are indicated. Daily cleaning of exposed component surfaces will tend to bring to the operator's attention small oil and/or water leaks which might otherwise go unnoticed until more serious trouble developed.

   Check and correct any oil leaks as soon as possible. Wipe up any oil which may have leaked and thus remove the danger of fire hazard.

   Correct steam and/or water leaks at the earliest opportunity. Do not permit leaky hand holes to go unattended, as corrosion will soon take place in the boiler shell adjacent to the leak

Care of the Waterside:

B. When boiler is placed in service for the first time, it should be cleaned in the following manner.
   1. Fill the boiler until water reaches normal water line.
   2. Dissolve chemicals thoroughly in water before introducing into boiler.
   3. Chemical solution: 1 lb each soda ash and caustic soda per 1 thousand lbs of water.
   4. Open air vent and close main outlet valve. Start boiler and when up to temperature, close air vent valve. Bring boiler up to 1/3 operating temperature or pressure and hold for 48 hours.
   5. Cool and drain boiler, remove hand hole covers, hose and flush out interior of boiler thoroughly.
   6. Aggravated cases of dirty boilers are sometimes better corrected by blowing off under pressure.
   7. At this time, new water should be treated.
   8. The available boiler feed water must be analyzed to determine the proper water treatment necessary and to determine the correct blow down procedure. All water going into the boiler should be free of dissolved oxygen. The PH of the feed water going into the boiler should be maintained between 8.5 and 9. The PH of the boiler water should be kept between 10.8 and 11.5.

Cleaning the Fire Tube

C. Remove the front and/or rear cover and clean boiler tubes periodically, depending on the number of hours operated each day. The first period should be after one month of operation. The operators experience will be a guide for all subsequent cleaning periods.

   To clean the fire tubes, remove the rear cover, wire brush all tubes to loosen carbon. Remove the expansion relief and clean out door from the front end of the boiler. The carbon collected in the space between front head and tube sheet can be hoed out of this opening. Check the interior for any mislaid tools or rags prior to replacing the rear cover and clean out door. If space at the rear of the boiler is not sufficient to permit brushing tubes it will be necessary to remove both front and rear covers. Wire brush the tubes from the front end and remove the loose carbon from the rear.

Refractory Maintenance:

D. Inspect all refractory in the boiler every 3 months and repair or replace if damaged.

Blower, Fuel Pump & Fuel System:

E. Check fuel oil strainers, filters, and entire fuel oil system weekly to make sure everything is clean and all joints are tight. This prevents accumulation of fuel oil thereby reducing fire hazards.

Lubrication:

F. Grease all pump and motor bearings every 3 months. Once a year repack bearing chambers with fresh clean grease. Wash out bearings in kerosene and/or diesel oil and smear grease on bearing balls when assembling. Fill remaining space in bearing chamber ½ full of clean grease. Use high quality lithium grease.
G. Inspect and clean ignition electrodes and burner nozzle after each fifty hours of operation or more often if so dictated by operating experience. Keep flame scanner window lens clean and gaskets tight.
   Refer to manufacturer's bulletin section for maintenance instructions for oil solenoid valves, control relays, and other components.
   Electric motors should be disassembled annually; the bearings and chambers thoroughly cleaned out and repacked with fresh clean grease. Take every precaution to keep dirt and grit out of bearing chambers.

Section 2

General:

A. If the burner shuts down and fails to restart, the trouble can be isolated in the boiler feed water, fuel oil supply, or electrical control systems. Down time will be cut to a minimum by conduction the following series of checks to see that:

1. There is water in the boiler
2. Pressure or temperature control is adjusted to approximate maximum operating range desired.
3. Electrical control circuit has the proper supply voltage, and that there are no open circuits.
4. Oil is in tank
5. There is water supply to boiler
6. Combustion control is in starting position (press reset button)
7. Water level relay is reset (press reset button on control panel)

Ignition Failure:

B. Should ignition failure occur when burner is started, the photo electric flame detector will not close the relay of the combustion control to lock in the oil solenoid valves; therefore, the program will sequence into a flame failure status. On ignition failure, check the following possible causes:
    1. Ignition transformer dead
    2. High tension lead broken or grounded
    3. High tension ignition electrode insulator cracked
    4. Carbon deposit on ignition electrodes or insulators
    5. Ignition electrode setting incorrect
    6. Faulty ignition cable connector
    7. Combustion control not functioning properly
    8. Oil pump not delivering oil
    9. Oil solenoid valve fails to open
    10. Blower not delivering air
    11. Faulty air safety switch

    To start burner after ignition or flame failure, a waiting period of approximately 5 minutes is necessary to allow safety switch heater in combustion control to cool. Trip reset button on combustion control and turn burner switch on.

Flame Failure:

C. In the event of flame failure, the photo electric flame detector will drop out a relay in the combustion control shutting off the oil solenoid valves. Blower motor will continue to run for 70 seconds until the post purge cycle of the combustion control is completed. The status will state flame failure. Check the following possible causes:
   1. Dirty glass in flame detector
   2. Bad tube in flame detector
   3. Faulty flame signal amplifier in combustion control
   4. Faulty combustion control
   5. Loose connection on flame scanner
   6. Lack of fuel
   7. Nozzle clogged
   8. Suction line, filter, or strainer clogged
   9. Fuel pressure relief valve faulty
   10. Solenoid valve faulty
   11. Faulty oil pump, blower, or air safety switch
   12. Faulty fuel pressure switch
   13. Faulty pressuretrol or aquastat

   To start burner after flame failure, trip reset button on combustion control and press burner switch on.

Oil Solenoid Valve Failure:

D. 1. Fails to open or operate when energized:
   a. Faulty control circuit – Use test lamp and check if electric power is connected to solenoid coil. Check voltage with meter, it must conform to nameplate rating.
   b. Coil Failure – Use test lamp and check coil to see if it is open or burned out. Replace if necessary.
   c. Excessive pressure – Check pressure, it must not exceed nameplate rating.
   d. Binding core and valve operating parts – Disassemble solenoid and check core for binding due to lodgment of dirt, scale, etc. Inspect core tube and make sure it is not bent or damaged. Clean and reassemble. All parts have a smooth operating fit.

   2. Fails to close or return to original position:

   a. Foreign matter on valve seat – Disassemble valve and inspect for dirt and other foreign matter lodged under valve seat.

b. Residual magnetism – Disassemble solenoid from valve body. Place core in normal position in solenoid and energize and de-energize coil. The coil should drop free each time it is de-energized.

3. Solenoid chatters and buzzes when energized:

a. Dirt on seating surface of core and plug nut – Remove solenoid assembly from valve body and inspect pole seating surfaces of core and plug nut; they should be clean and smooth. If not, file top surface of core with flat file, and with flat end of screwdriver or chisel, scrape plug nut surface.

b. Valve fails to open – disassemble valve and check for bonding of internal operating parts. Check voltage and pressure to see if it conforms to the nameplate rating.

c. Loose solenoid parts – Tighten all external solenoid parts such as housing, flux washers, etc. so that they cannot vibrate when coil is energized.

4. Valve seat leakage:

a. Dirt under seat – Disassemble valve and inspect for dirt and other matter under valve seat.

b. Worn seat and disc – Disassemble valve and inspect valve seat and disc. If parts are worn replace with new seat and disc obtained from the factory. "O" rings should be replaced if worn or broken.

5. Coil failure and over heating:

a. Excessive voltage – Check voltage with meter, it must conform to nameplate rating.

b. Valve fails to operate when energized – Check pressure; it must not exceed nameplate rating. Disassemble solenoid and check core tube and make sure it is not bent or damaged. Clean and reassemble. Parts have a smooth sliding fit.

c. Water in coil housing – Water in coil housing due to condensation. Leakage in core tube joints will result in coil failure. If leakage develops in core tube joints, replace with new solenoid assembly.

Burner smokes or pulsates:

E. 1. Excessive return line oil pressure
2. Dirty nozzle
3. Nozzle not positioned correctly
4. Insufficient combustion air supply
5. Low oil pressure

6. Incorrect burner linkage setting
7. Incorrect setting of primary air valve
8. Fluctuating voltage to blower motor

Oil pump fails to deliver:

F. 1. Leak in suction line
2. Insufficient fuel
3. Dirty strainers
4. Worn pump member
5. Improper oil relief valve setting or defective relief valve
6. Defective gaskets on pump
7. Leaky pump seal
8. Motor coupling slipping
9. Seized bearings in motor or bearing assembly
10. Insufficient supply voltage to motor
11. Fluctuating voltage

Blower fails to deliver:

G. 1. Fan blades dirty
2. Restriction at blower inlet
3. Seized bearings in motor or bearing assembly
4. Bent shaft (excessive vibration)
5. Air inlet screen dirty
6. Insufficient supply voltage to motor
7. Fluctuating voltage
8. Rotation reversed

Trouble Shooting Data

Note: Before changing adjustments on boiler, it is recommended to check or replace gauges as a check for gauge accuracy.

1. No Ignition Flame:
   A. Air switch not made
   B. Low water cut off not made
   C. Fuel valve (s) failing to open
   D. Bad spark from transformer
   E. Incorrect electrode setting
   F. Dirty electrode
   G. Too much combustion air on low fire
   H. Primary air setting too far open
   I. Flame failure reset may need to be reset
2. Flame ignites – shuts down:
   A. Photo eye or flame scanner not sensing flame
   B. Dirty flame scanner glass
   C. Flame amplifier in combustion control defective
   D. Defective main fuel solenoid valves
   E. Fuel pressure switch not made or defective
   F. Fuel pump not pumping or defective (see fuel system page)
   G. Fuel pressure relief valve defective
3. Main Flame Ignites – smoking occurs
   A. Dirty or plugged nozzle
   B. On modulating units, inlet and outlet of nozzle connections reversed
   C. Nozzle tip not properly installed or positioned
   D. Improper oil and air fuel/air ratio back pressure settings
   E. Incorrect pump pressure
   F. Fan out of adjustment – not close enough to inlet of blower housing
   G. Motor running slow or loose - V belts loose or slipping
4. Boiler Not Modulating Properly:
   A. Potentiometer in operating pressuretrol or aquastat broken or dirty contacts
   B. Modutrol motor contacts dirty or on some models Aux switch not properly set
5. High Stack Temperature:
   A. Tube inserts in rear end of tubes missing or burned out
   B. Boiler being over fired
6. Low Water Cut Off With Water In Boiler:
   A. Over treated water causing foaming and priming
   B. Low water electrode deteriorated enough to prevent contact

7. Oil Dripping Out Of Primary Air Shroud:
   A. Oil nozzle not far enough through burner cone
   B. Loose tubing inside of nozzle barrel body
   C. Nozzle barrel nut not tight enough
   D. Improper mounting of disc set inside nozzle
   E. Bad check valves on return line
8. After Burn When Boiler Shuts Down:
   A. Bad check valves in return line
   B. Dirt under fuel solenoid valve seat
   C. Bad coil on solenoid valve
   D. Defective solenoid valve
9. Boiler Shuts Off On Flame Failure:
   A. Check oil pump for proper operation
   B. Visually check flame scanner assembly for excessive dirt on lens, heat or cracking
   C. Check fuel supply, filters, pressure, etc
   D. See trouble shooting guide for combustion control in bulletin section
   E. Check pressuretrols or aquastats for proper operation. If high limit is set too close to the operating setting the boiler may go off on high limit in which case on most units, a manual reset is needed to continue operation
   F. Press reset button (s) and check sequence of boiler operation
10. Excessive Vibration On Blower Motor Housing:
   A. Loose fan on shaft
   B. Loose shaft in bearing unit
   C. Loose shaft on motor
   D. Bad bearings in motor or bearing unit
   E. Loose motor or bearing supports
   F. Defective fan
11. Tracing Causes Of High Vacuum On Oil Pump:
   A. Strainer plugged with dirt or lint
   B. Restricted orifices through fittings
   C. Screens in strainers of too small area
   D. Restricted areas through check valves, or anti-siphon valves
   E. Small or restricted piping supplying oil to boiler

These causes can be detected by installing a vacuum gauge directly at the pump suction. The maximum vacuum at the pump suction should never exceed 10" mercury. It is necessary to keep below 10" not because of the inability of the pump to handle higher vacuums, but primarily because of the vaporization that is liable to take place at higher vacuum. The point at which any oil will vaporize is influenced greatly by temperature of the oil. Vaporization caused by higher vacuums will generally result in considerable noise in the relief valve, caused by low pressure, fluctuation in pressure, or poor combustion.

Any noise caused by vaporization cannot be distinguished from the noise which is set up by air entering the suction side of the pump.

Finding the cause of high vacuum can be accomplished only by installing a vacuum gauge at different points along the suction line (if possible) until a point beyond the restriction has been reached. The tank must be provided with a proper vent. High vacuum on the suction side may be traced to a plugged tank vent.

When leakage is found at the end of a mechanical seal pump, it is advisable that the pump be returned for repair. Pump performance, as well as boiler performance depends upon good installation of suction lines.

12. Pump operation is noisy:
    A. Suction lift excessive
    B. Misalignment of pump coupling
    C. Air leak in suction line
    D. Mechanical defect in pump
    E. Coupling slipping
    F. Strainer or Filter clogged

Instructions for Installing Refractory in Burner Head

1. Remove all refractory from burner head cover
2. Clean all inside surfaces of burner head cover
3. Check all refractory anchors, replace anchors if broken
4. Remove burner cover and place flat on the floor for refractory placement
5. Before pouring refractory, install burner cone, also use short pieces of properly sized pipe for additional openings.
6. Mix Kast-O-Lite refractory thoroughly before adding water. Segregation of materials may have occurred during shipping. Mix in a clean mortar box. If large quantity of refractory is required, a concrete mixer can be used. For pouring or ramming, add 2 ¾ to 3 gallons of water per 50 lbs of refractory mix. Water should be clean and at a temperature of 60 to 70 degrees. Mix refractory and place into burner cover within 20 minutes – refractory sets rapidly.
7. Remove short pieces of pipe after approximately 15 minutes after refractory is poured.
8. Refractory should be molded flush with burner cone.
9. Allow refractory to dry up for 24 hours before placing into service, then bring up to operating temperature gradually to prevent formation of steam within the refractory.

Instructions for Installing Refractory in Rear Cover

1. Remove all old refractory from rear cover (while on boiler if hinged connection)
2. Clean entire inside surface of rear cover
3. Check all refractory anchors. Replace anchors if broken and add additional anchors if needed.
4. Remove rear cover and place flat on the floor for refractory placement
5. Apply 1" thick layer of insulative castable block mix. This is a moist shapeable material. Lightly pound or tamp into place.
6. Mix Kast-O-Lite refractory thoroughly before adding water. Segregation of materials may have occurred during shipping. Mix with clean water 60 to 70 degrees following instructions on refractory bag keeping mix to a stiff consistency for ramming to desired shape.
7. Place refractory in rear cover and ram to desired shape to remove trapped air from the mixture. Setting time is approximately 20 minutes
8. Allow refractory to dry for 24 hours before placing into service, and then bring temperature up gradually to prevent formation of steam inside refractory.
9. If refractory is molded out beyond refractory retainer ring of rear cover install temporary extension ring and pour refractory.
10. Remove extension ring approximately 1 to 2 hours later and mold refractory with trowel to desired shape.
11. If rear cover has a sight glass viewing hole, use 1 ½" pipe before pouring refractory. Remove pipe in approximately 3 hours during setting of refractory.

Procedure for Laying Up Boiler

There are two methods of laying up boilers, the wet method and the dry method. In each, the boiler is first thoroughly cleaned and checked.

Wet Method:

Fill the boiler to the vent level, preferably with deserted water. During filling, introduce solution of caustic soda and sodium sulfite in the feed line. Analysis should indicate establishment of a PH from7 to 11, preferably 10 to 11, and an excess sulfite reading of 30 to 40 PPM. In some cases, a balanced tank is used to keep the boiler completely full. The make up from the tank comes from the main supply system.

Advocates of the wet method claim for it a distinct saving in time and labor both for laying up the boiler and returning it to service, however external services should be checked periodically to guard against sweating.

On small Cyclotherm units, the rear cover should be removed and on larger units the door opened. The refractory should be kept as dry as possible.

Dry Method:

After draining the boiler, make sure that the stop valve is tight. If no leakage appears, remove the bonnet from the feed line check valve. Remove all hand hole plates to permit mopping and air blasting internal sections of the boiler. In addition, blow out non draining elements.

Some provisions should be made for natural circulation of room air by removing all hand hole plates in the boiler. One operating company takes the precaution of putting in screened dummy plates to keep out foreign matter.

With either method above, it is recommended that the boiler be checked periodically.

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Recommended Spare Parts, FOB Watertown, New York

Reference: MC4000W Water Heater 4/3/2013
Serial Number 26154
Assembly & Foundation Drawing G-22144-E
Material List Drawing F-22142

	Description	Part No.	Quantity	Unit Price	Extended
1.	Fuel oil pump	9	1	$1,520.00	$ 1,520.00
2.	Ignition electrodes	14	6	90.00	540.00
3.	Wiring harness	15	1 set	1,230.00	1,230.00
4.	Oil nozzle assembly	16	2	550.00	1,100.00
5.	Nozzle tip & disc set	16A	6	400.00	2,400.00
6.	Water pressure/temp gauge	18	1	450.00	450.00
7.	Blower wheel	20	1	1,994.00	1,994.00
8.	Combustion control assy	21	1	2,850.00	2,850.00
9.	Burner observation port	26	2	40.00	80.00
10.	V Belts, blower	29	1 set	420.00	420.00
11.	Safety relief valve	33	2	850.00	1,700.00
12.	Low water electrode	40	2	90.00	180.00
13.	Low water relay	40B	1	280.00	280.00
14.	Blower motor controller	42	1	750.00	750.00
15.	Fuel pump motor controller	42A	1	750.00	750.00
16.	Fuel solenoid valve	49	2	645.00	1,290.00
17.	Fuel pump relief valve	51	1	320.00	320.00
18.	Fuel supply pressure gauge	56	1	60.00	60.00
19.	Fuel return pressure gauge	59	1	60.00	60.00
20.	Modutrol motor	62	1	850.00	850.00
21.	Operating aquastat	65-1	1	425.00	425.00
22.	Modulating aquastat	65-2	1	425.00	425.00
23.	Fuel regulating valve	88	1	1,750.00	1,750.00
24.	Fuel return check valve	103	4	189.00	756.00
25.	Flame scanner	183	1	280.00	280.00
26.	Air safety switch	227	1	140.00	140.00
27.	Observation port, rear cover	236	2	75.00	150.00
28.	Fuel pressure switch	500	1	510.00	510.00
29.	High temp limit aquastat	502-1	1	425.00	425.00
30.	Hand hole plate assembly	3” x 4”	6	298.00	1,788.00
31.	Hand hole plate gaskets	3” x 4”	24	7.50	180.00
32.	Fireside gaskets	RK1	4	908.00	3,632.00
33.	Tube brush & handle	2”	2	75.00	150.00