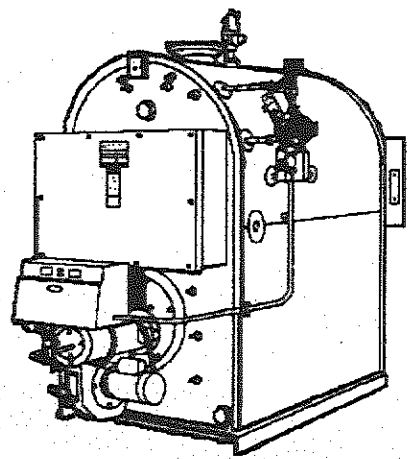
KEWANEE®



Installation, Operation and Maintenance Manual

for

Classic V Firebox Boilers

Thank You for Purchasing Kewanee Boiler Room Equipment

Since 1868, Kewanee has been committed to providing equipment of lasting quality and value to each of its many customers. It is our goal that every piece of Kewanee equipment purchased provides the same reliable operating excellence that was built into it by the skilled craftsmen at our Kewanee factory.

The following **Installation, Operation and Maintenance Manual for Kewanee Classic V Firebox Boilers** is designed to help you properly install, operate and care for your Kewanee equipment. We recommend that you read this manual through to familiarize yourself with its contents before installing and operating your Kewanee equipment.

Due to a wide variety of everchanging state and local codes, this manual contains information designed to show how a basic unit operates. The operation of all equipment must comply with all applicable regulations and codes by any authorities having jurisdiction. These legal requirements take precedence over anything contained herein. At Kewanee, engineering and development toward product improvements are a continuing process, therefore, the specific information in this book may be subject to change without notice.

Kewanee Boiler Room Equipment has been designed and manufactured to produce a long lifetime of dependable efficient service. All components of Kewanee equipment were chosen for their ability to enhance this design goal. Although these components provide a high degree of protection and safety during normal operating conditions, we highly advise that you pay close attention to any notes, cautions and warnings and maintain an awareness of the hazards and dangers inherent in careful handling of fuel firing devices.

In our many years in business, we have found that two things alone greatly impact the dependable operation and long life of our equipment:

- **Operator responsibility and knowledge**
- **Consistent preventive maintenance**

Operator Responsibility

It is the operator's responsibility to provide the daily care and attention required to properly maintain the boiler room equipment. This manual is intended to act as a guide and reference source for those operations, but it cannot replace the keen eye and experienced touch of a trained boiler room operator. It is recommended that a boiler room log be maintained to record daily, weekly, monthly and yearly activities as well as any unusual occurrences.

Consistent Preventive Maintenance

Regular effective maintenance is the best way to obtain the most efficient operation of Kewanee boiler room equipment. We have found that the life and efficiency of this equipment is dependent upon the consistency of care it receives. Often efficient operation is a matter of keeping the boiler clean and the firing equipment properly regulated. With proper installation, regular care and the use of Genuine Kewanee Renewal Parts, your quality Kewanee equipment will last indefinitely.

Safety Precautions and Abbreviations

It is important for all personnel operating this Kewanee product to read and fully understand the following safety precautions and abbreviations and the various sections of this manual before operating the equipment.

Failure to obey these safety precautions may result in damage to your Kewanee equipment, serious personal injury or even death.

Safety Precautions

NOTE: This safety precaution indicates information that is vital to the operation or maintenance of your Kewanee equipment.

CAUTION: This safety precaution indicates a potentially hazardous situation which, if not avoided, could result in damage to the equipment.

WARNING!!! THIS SAFETY PRECAUTION INDICATES A POTENTIALLY HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, COULD RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

DANGER!!! This safety precaution indicates a situation which, if not followed exactly, could result in seriously personal injury or death!

Abbreviations

AI	Authorized Inspector
ASME	American Society of Mechanical Engineers
BHP	Boiler Horsepower
BTU	British Thermal Unit
BTUH	British Thermal Unit per Hour
CFM	Cubic Feet per Minute
° F	Degrees Fahrenheit
EPA	Environmental Protection Agency
FM	Factory Mutual
GPM	Gallons Per Minute
HP	Horsepower
i.e.	For example
in.	Inch
IRI	Industrial Risk Insurance
Lbs.	Pounds
MB	Master Bill
MBH	Thousands of BTUH
No.	Number
ppm	Parts Per Million
PSI	Pounds per Square Inch
UL	Underwriters' Laboratory

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Section 1

GENERAL INFORMATION

1. INTRODUCTION

This manual on Kewanee Boilers has been prepared for the purpose of assisting the installation, operating, maintenance, and service personnel.

The manual information is, of necessity, general in nature since it may be modified by consulting engineers specifications, state or local codes, utility and insurance underwriter's requirements.

NOTE: Read complete manual prior to proceeding with any operations.

For additional information on these modifications, get in touch with your local Kewanee sales representative or contact the factory direct at Kewanee Boiler Manufacturing Company, Inc., 101 Franklin Street, Kewanee, Illinois 61443, Telephone (309) 853-3541 or E-mail us at http://www.kewaneeboiler.com.

2. APPROVALS AND WARRANTY REQUIREMENTS

Kewanee Package Boilers, which are listed by Underwriters' Laboratories, Inc., include a UL "B" label.

Kewanee units meeting the requirement of Factory Mutual Fire Insurance Companies (FM), Industrial Risk Insurers (IRI) and special State, local and utility codes are available on special order.

3. LIMITED WARRANTY

A. Warranty

Kewanee Boiler Manufacturing Company, Inc. (herein referred to as "Seller") warrants that at the time of shipment the products manufactured by it shall be merchantable, free from defects in material and workmanship, and shall possess the characteristics represented in writing by Seller. Seller's warranty is conditioned upon the product being properly installed, maintained, and operated in a manner that does not vary materially from that under which such product is usually tested under industry standards existing at time of sale. This warranty is made to the Original Buyer and...

1. For firetube boilers and packaged firetube boiler, is for a period of 12 (twelve) months from the date the product is first placed in use or 18 (eighteen) months from date of shipment, whichever shall be less. AND/OR

2. For all other products is for a period of 12 (twelve) months from the date of shipment.

B. Warranty Adjustment

1. Seller agrees to replace or repair (at its sole option), but not install, any product of its manufacture or part or portion thereof which, upon test and examination by Seller, proves defective within the terms of the above warranty.

2. Buyer must notify Seller in writing of any claimed breach of this warranty within 30 (thirty) days of the discovery of any defect, or Buyer's warranty rights hereunder will lapse.

3. No product will be accepted for return or replacement without the written authorization of Seller. Upon such authorization, and in accordance with instructions from Seller, the product will be returned to Seller's place of manufacture, shipping charges prepaid by Buyer. Seller shall not be liable for any costs or expenses connected with warranty adjustments, except that Seller shall furnish a replacement or repair of a product or part which is proved to the satisfaction of Seller to be defective in material or workmanship as provided in the above warranty; further, Seller shall furnish to Buyer the replacement or repaired part with freight allowed (but no local cartage) inside the continental United States (excluding Alaska and Hawaii) to the first destination.

C. Exclusions from Warranty

1. The foregoing warranty is limited solely as set forth herein, and applies only for the period designated above. This warranty takes the place of and supersedes all other warranties, whether express or implied in law. There are no express warranties except those contained herein, and to the extent permitted by law, implied warranties or warranties of fitness for a particular purpose are excluded.

2. Except for the remedies provided by this warranty, Seller shall not be liable for any loss, damage, indirect or consequential damages of any kind, whether based upon warranty, contract or negligence, arising in connection with the sale, use, or repair of the product. The maximum liability of Seller in connection with this limited warranty shall not exceed the contract price for the product claimed to be defective.

3. This warranty does not extend to any product manufactured by Seller which has been subjected to misuse, misapplication, neglect, accident, improper installation, or use in violation of instruction furnished by Seller.

4. The warranty does not extend to or apply to any product which has been repaired or altered at any place other than Seller's factory or by persons not expressly approved by Seller; nor to

any product, the serial number, model number, or any identification of which has been removed, defaced, or changed.

5. Components manufactured by any supplier other than Seller shall bear only those warranties made by the manufacturer of that product.

4. DAMAGES AND PENALTIES

The Seller shall have no liability for any liquidated damages, consequential damages, or penalties assessed whatsoever unless specifically agreed to in writing.

5. VARIANCES, RETURNS AND BACK CHARGES

No claims for variances from, or shortages in, orders will be considered by the Seller unless presented to it within 30 (thirty) days after receipt of product. Any shipping weights and/or costs given or estimated herein are approximate, for the Buyer's convenience only, and not guaranteed by the Seller. Products may not be returned for credit unless and until the Seller has agreed in writing to accept them. When returns are accepted, a full credit shall be given, less deductions for missing parts, inbound freight and a restocking charge of 25% (percent). All transportation costs for returned products must be paid by the Buyer. Back charges will not be accepted without written authorization from the company. The Seller must have in writing a description of any work to be done and an estimate of the cost, thereof, before any back charge is authorized.

6. TESTS

If tests are requested by the Buyer to determine the performance of products covered in the Seller's quotation form, the test procedure to be used must be acceptable to the Seller, and the Buyer agrees to pay to the Seller the cost of any such tests.

7. PRODUCT CHANGES

Factors beyond the control of Seller and the need for continuing improvement requires the making of changes in products from time to time. The Seller reserves the right to make reasonable changes in products of any kind without notice, and to deliver revised designs or models of products against any order, unless this right is specifically waived by Seller in writing. The Seller shall have no responsibility whatsoever with respect to changes made by the manufacturer of products sold but not manufactured by the Seller.

8. START-UP AND/OR SERVICE

Whenever an order includes start-up and/or service agreements, The Seller shall not be obligated to provide either start-up, warranty parts or service as long as payment terms are in default.

Section 2

REQUIREMENTS

1. This manual has been prepared to assist the installer, owner and operator of Kewanee boilers to obtain lasting and trouble free service from their pressure vessel for years to come.

2. This manual contains suggestions and rules which should be followed. Efficient operation is a matter of keeping the boiler clean and the firing equipment properly regulated. Since the life of the boiler is dependent upon the care it receives, special emphasis is placed on that subject.

3. Kewanee boilers are built in accordance with The American Society of Mechanical Engineers (ASME) code. All vessels are thoroughly inspected by an Authorized Inspector (AI), holding a commission from The National Board of Boiler and Pressure Vessel Inspectors. The AI is an employee of the insurance company holding Kewanee's policy.

4. Boilers manufactured at Kewanee are built in accordance with the following codes.

   A. Boilers built in accordance with ASME Boiler and Pressure Vessel Code, Section IV, Low Pressure Heating Boilers.

      1. Steam boilers for operation at pressure not exceeding 15 PSI.
      2. Hot water heating and hot water supply boilers for operation at pressures not exceeding 160 PSI and/or temperatures not to exceed 250° F.

   B. Boilers built in accordance with ASME Boiler and Pressure Vessel Code, Section I, High Pressure Power Boilers.

      1. Any boiler built which exceeds the parameters in Paragraph 4. A. (1) and (2).

Section 3

IDENTIFICATION

1. BOILER DATA PLATE

Each boiler has a Data Plate attached to the unit in some conspicuous location. See sample data plate in Figure 1.

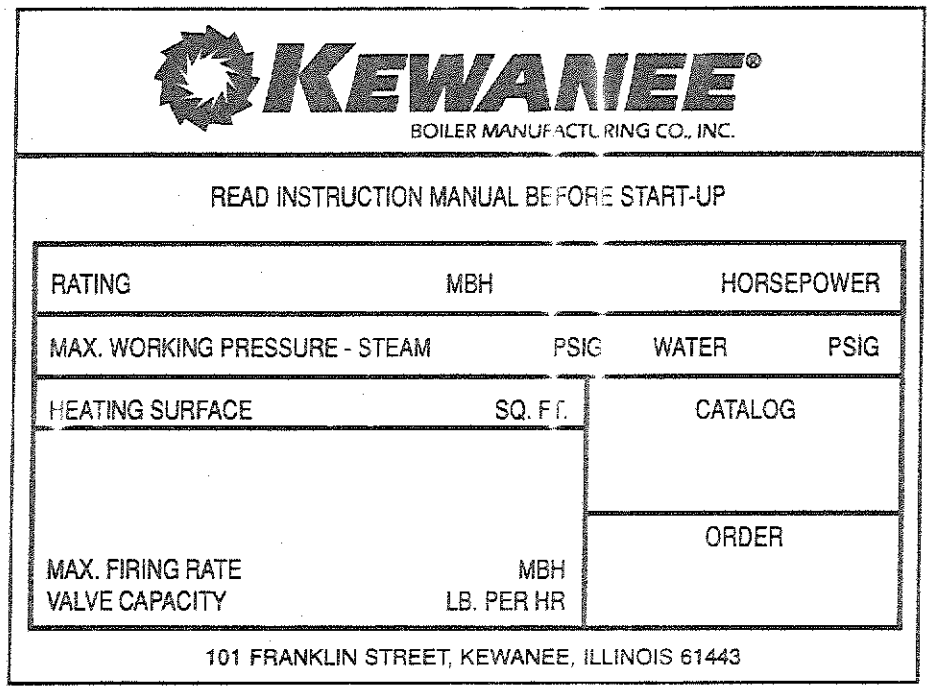
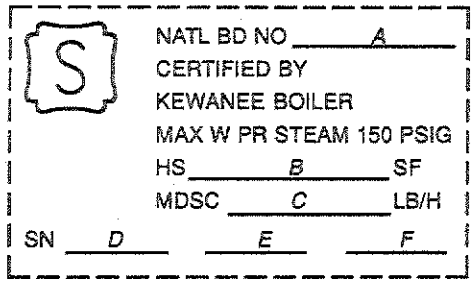


Figure 1 - Data Plate

2. BOILER STAMPING

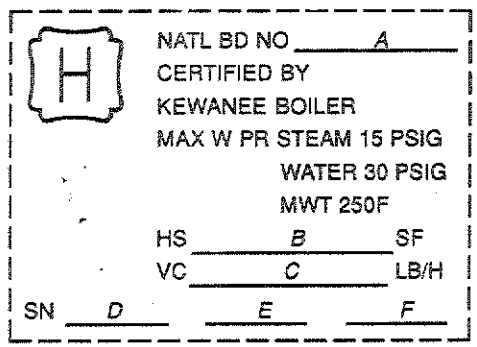
Each boiler has identifying marks stamped on the vessel shell plate. These stampings should be visible and legible and applied in accordance with ASME Section I or IV, whichever is applicable. A facsimile of these stampings is found on Figure 2 (High Pressure Power Boiler) and Figure 3 (Low Pressure Heating Boiler).



All letters of stamping are 5/16" high

A - National Board Number
B - Fireside Heating Surface
C - Maximum Designed Steaming Capacity
D - Boiler Serial Number
E - Year in which the boiler was constructed
F - Boiler Model Number

Figure 2 - High Pressure Stamping



All letters of stamping are 5/16" high

A - National Board Number
B - Fireside Heating Surface
C - Valve Capacity
D - Boiler Serial Number
E - Year in which the boiler was constructed
F - Boiler Model Number

Figure 3 - Low Pressure Stamping

3. MANUFACTURER'S DATA REPORT

Every boiler shipped from Kewanee, which has been assigned a National Board Number, has its construction specifications on file at The National Board of Pressure Vessel Inspectors, 1155 North High Street, Columbus, Ohio 43201. The mechanism by which this is done is the Manufacturer's Data Report. At the time the boiler is shipped, the end user is provided with a copy of this data report, which he should keep in his files for inspection by jurisdictional inspectors. Additional copies of the Manufacturer's Data Report can be obtained from The National Board, if required.

4. BOILER DESIGN SPECIFICS

Boilers manufactured at Kewanee Boiler Manufacturing Co. Inc., fall under two categories: 1) Scotch Design Firetube; 2) Firebox. All are of the "Firetube" design. **Instructions and information in this manual apply to Kewanee Classic III Scotch Design Boiler Models ONLY.** Model numbers more closely follow the basic series of boilers and are illustrated in Figures 4 and 5.

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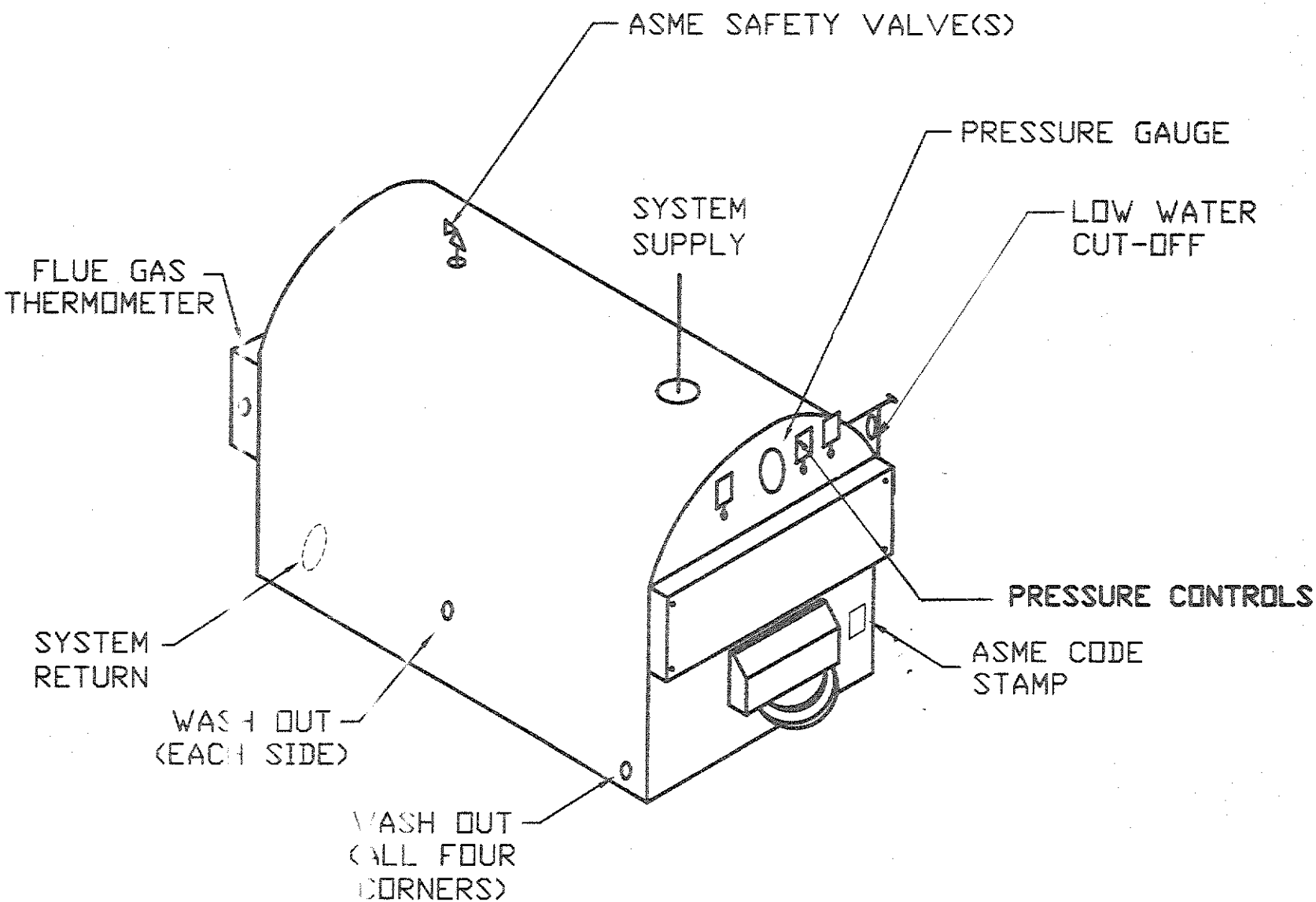

Figure 4 - Identification and Location of Tapping and Trim on Kewanee Classic V Steam Boilers

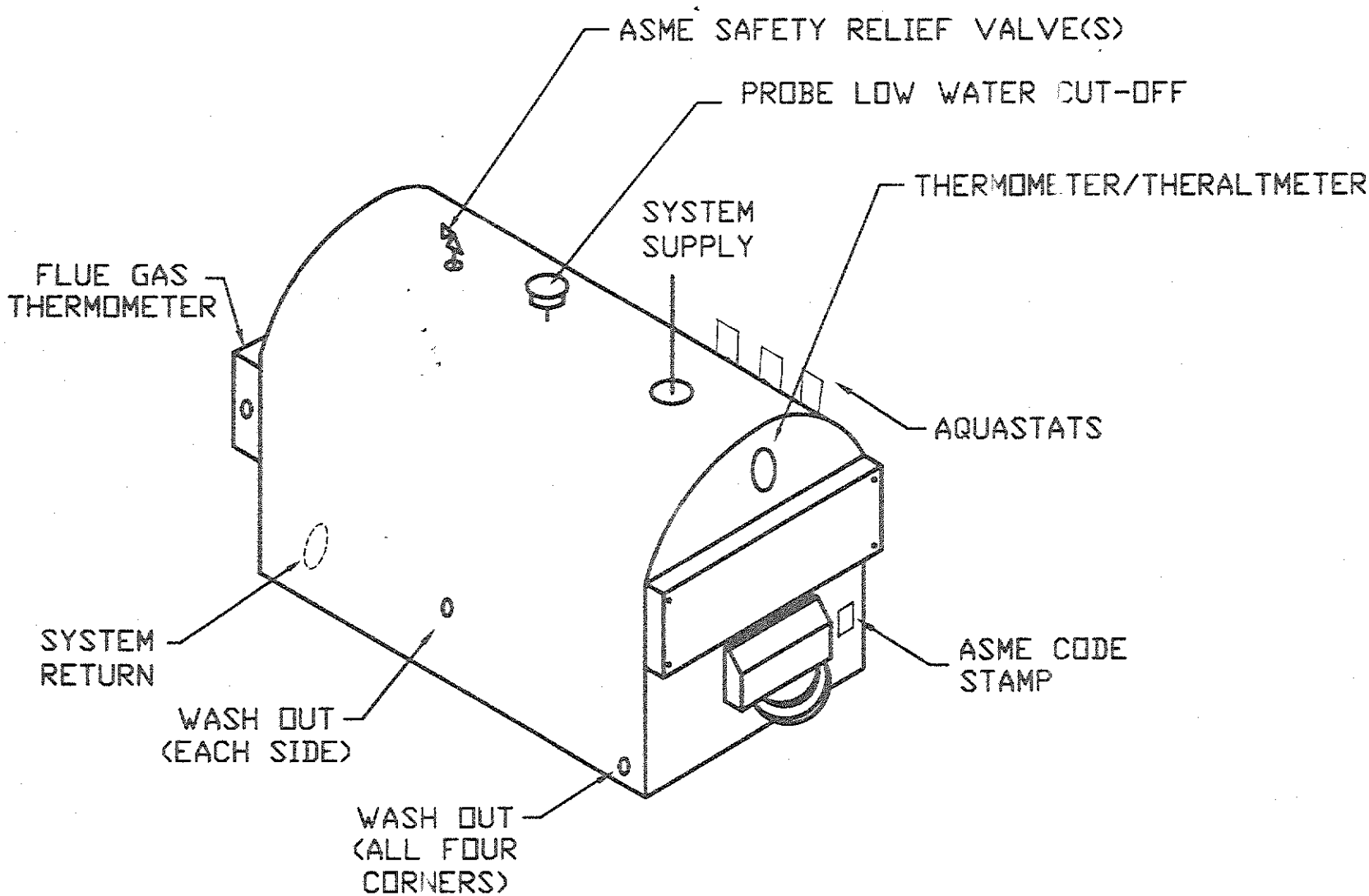

Figure 5 - Identification and Location of Tapping and Trim on Kewanee Classic V Water Boilers

Section 4

PRE-INSTALLATION INSTRUCTIONS

1. INSPECT SHIPMENT

Carefully check shipment for any signs of damage.

A. During the manufacturing process, and in preparation for shipment, Kewanee boilers are thoroughly checked to ensure that they are free of manufacturing defects.

As a final step prior to final cleaning and painting, package boiler units are firetested. Results of this test are found in the appropriate Burner Service Manual.

B. Check for external damage to the jacket, cabinets, pumps, gas trains and internal damage to the boiler and control cabinets. Protection covers around controls, etc. should be removed immediately.

C. Check all "ship loose" boxes to ensure that all boiler trim has arrived intact. Look for shortages and damage. Once again, shortages must be verified and reported immediately. The longer the items lay around, the more difficult it is to substantiate a claim.

D. Any claims for damage or shortage in shipment must be filed against the carrier by the consignee. No claims for variances from, or shortage in orders, will be allowed by the manufacturer unless presented within thirty (30) days after receipt of goods.

2. SETTING THE UNIT

A. Larger boilers are equipped with lifting lugs to be used in maneuvering the boiler into position. The boiler can also be rolled into position on a series of pipes.

B. The unit should be located in the boiler room so as to provide ease of venting and adequate clearance for maintenance, serviceability and installation of piping. The tube pull space should be adhered to as referenced on the Master Bill. This will allow for tube replacement when required.

C. Floor construction should have adequate load bearing characteristics to bear the weight of the boiler filled with water and be level. setting. A boiler foundation or housekeeping pad is recommended if the boiler room floor is weak or uneven or if a water condition exists. Boilers are not to be installed on combustible flooring.

3. CHIMNEY OR VENT

A. The Kewanee Classic V Firebox is designed for forced or natural draft firing as application permits and

may be used with a conventional natural draft stack or a stub vent.

B. Draft controls are not normally required although they may be used on installations where a natural draft stack is used or on multiple boiler installations with a common stack.

4. AIR SUPPLY

A. Adequate combustion air is critical to your boiler and its associated equipment operation. A free and unobstructed air intake to the boiler room must be made available. As a "guideline", 1 square inch of free air is required for every 4000 BTUH input on the firing equipment.

B. EXAMPLE: V110 firing rate = 3,795 MBH

$$\frac{3{,}795{,}000 \text{ BTUH}}{4{,}000 \text{ BTUH/in.}^2} = 949 \text{ in.}^2 \text{ free area}$$

C. In spaces utilizing supply and exhaust fans, the supply fan capacity must exceed the exhaust fan capacity by at least 10%. Be cautious when using barometric dampers in boiler exhaust. They can, in some cases, rob the boiler room of much needed air. Allowing 20% for ventilation, air supply CFM equals boiler horsepower times 10.8. It is always recommended to consult local building codes for compliance.

5. LAY-UP PROCEDURES FOR BOILERS IN STORAGE

A. It is a general practice to install a boiler within 30 days of shipment. If for some reason the job is delayed for over 30 days, precautions must be taken to ensure the boiler is in dry lay up.

B. When steel boilers are out of service for any length of time, such as a lay-up for the summer, they must be protected from corrosion. This may be done either by draining them and keeping the surfaces thoroughly dry or by completely filling the boiler with properly treated water.

1. Dry Method - The boiler is drained, flushed, and inspected. The surfaces are then thoroughly dried by means of hot air. If the boiler room is dry and well ventilated, the boiler may be left open to the atmosphere. An alternate procedure is to use a suitable moisture absorbent, such as quicklime or silica gel, which is placed in the boiler in a suitable location. The boiler is then tightly closed. Every two or three months the boiler should be checked and the lime or gel replaced or regenerated, if necessary.

2. Wet Method - The boiler is drained, flushed, and inspected. It is then filled to the normal water level and steamed for a short time with the boiler vented to the atmosphere to expel dissolved gases. If the boiler is to be used to heat water or

for reheat in connection with an air conditioning system, it may be left in this state ready to operate. If, however, it is to be completely idle for some time, it is preferable to fill the boiler to the top of the drum. In any case, water treatment should be used. This may be the treatment regularly being used, or a caustic soda (400 ppm) and sodium sulphite (100 ppm), or sodium chromate, in which case a minimum of at least 100 ppm should be maintained on steam boilers and 300 ppm on hot water boilers. During the down time, it is good practice to occasionally circulate the water with a pump. This is necessary to prevent stratification and insure that fresh inhibitor is in contact with the metal. It is a well known fact that corrosion is apt to be more serious during the down time than when the boiler is actually in service.

3. With either case, dry or wet, your water treatment specialists should dictate the method and be responsible for the condition of the boiler.

Section 5

INSTALLATION INSTRUCTIONS

1. BOILER PIPING

Attach supply and return piping lines. Insert plugs and bushings in connections as required. Supply and return headers are detailed in Figures 6 and 7.

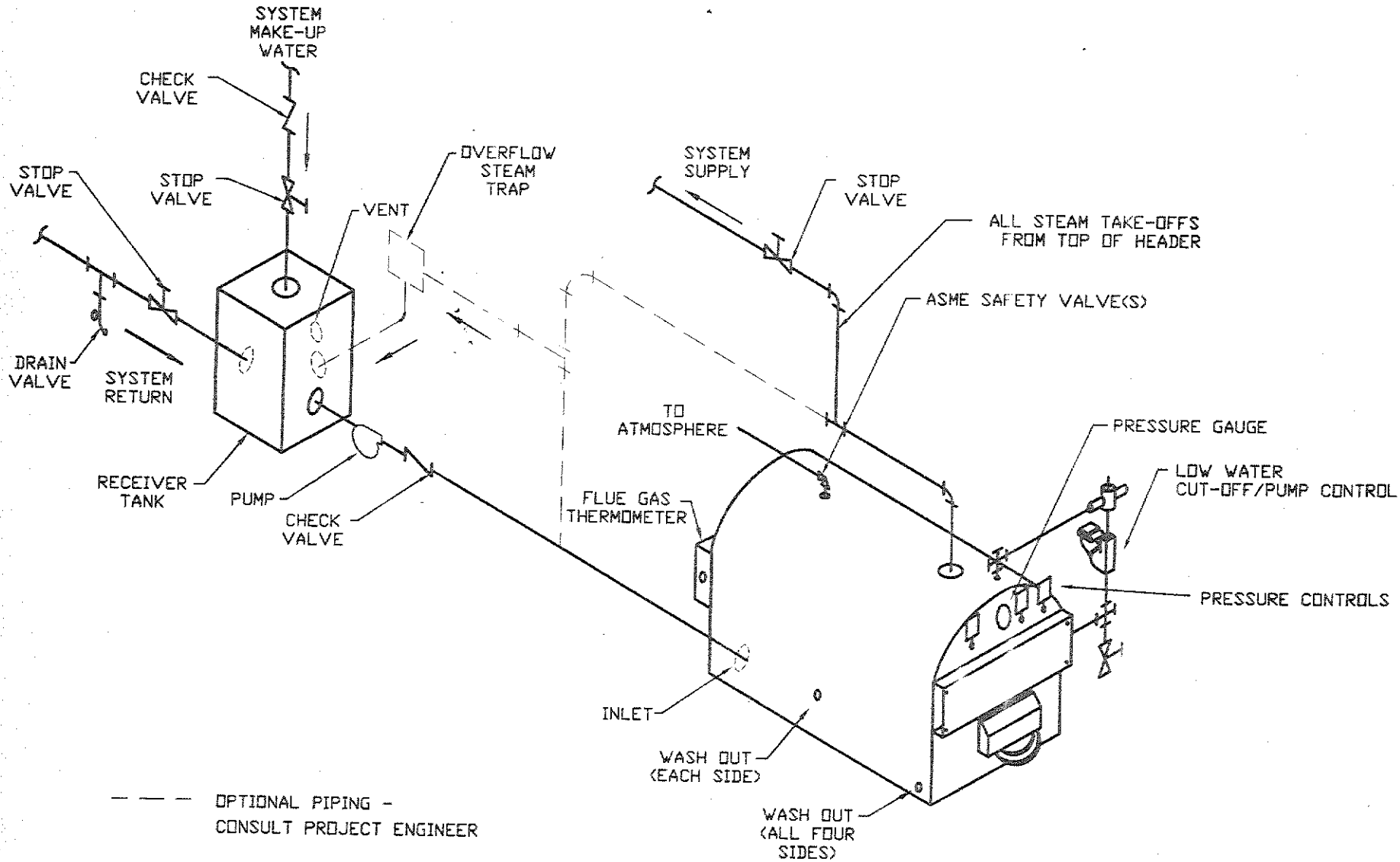

Figure 6 - Typical Installation Piping for Single Low Pressure Steam Boiler
Specific Applications May Require Significant Modifications - Consult Project Engineer

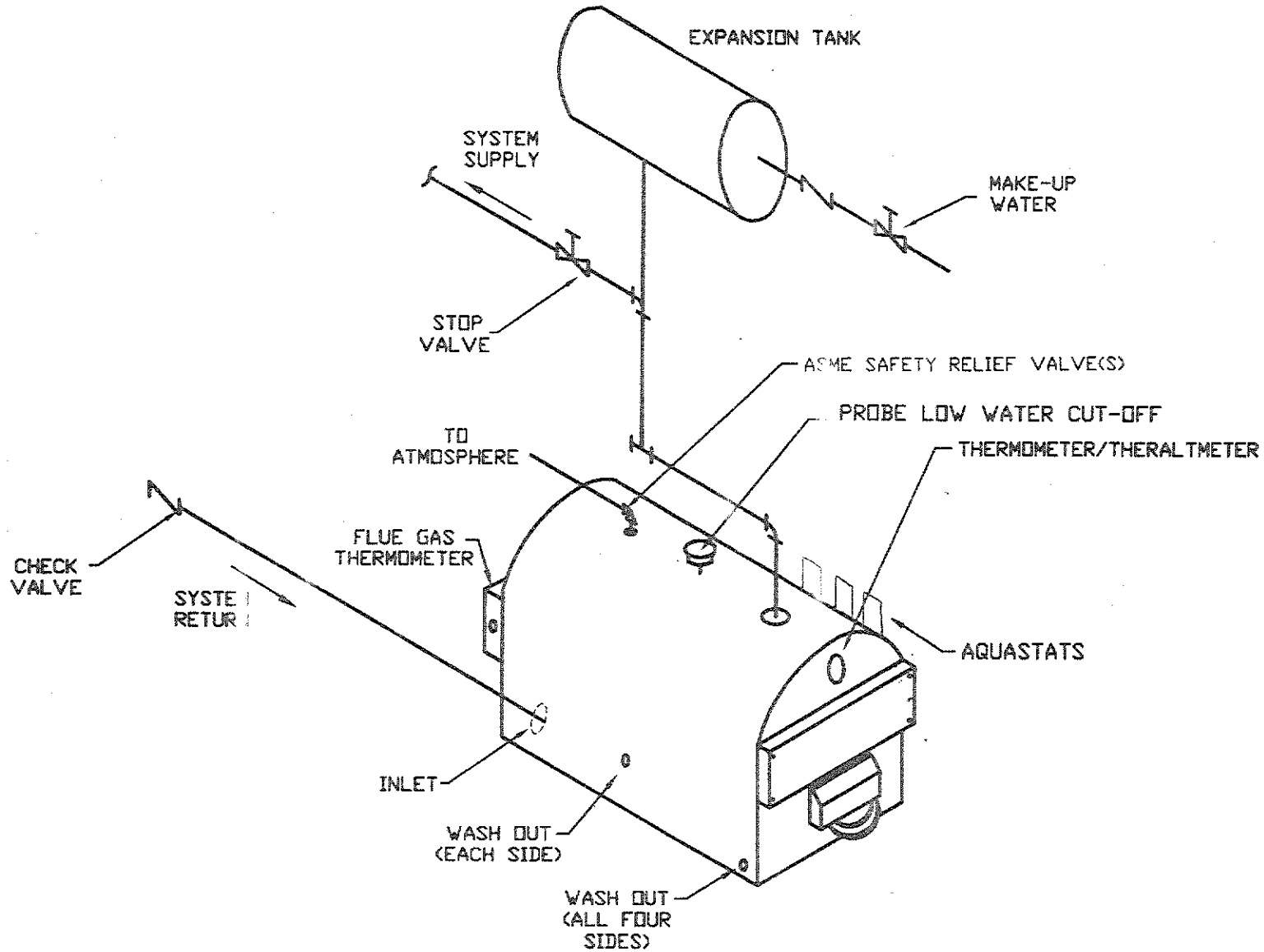

Figure 7 - Typical Installation Piping for Single Low Pressure Water Boiler
Specific Applications May Require Significant Modifications - Consult Project Engineer

CAUTION: Boiler installation must comply with the minimum piping requirements in order to insure maximum performance and reliability. Particular attention should be given to the construction of the steam header on steam boilers.

CAUTION: FOR WATER BOILERS!!! The nominal temperature differential between supply and return recommended for scotch water boilers is 20°F. Return temperature must be above 150° F. Differential between supply and return should never exceed 50°.

CAUTION: The boiler should not be operated for any length of time at a temperature setting that allows the formation of condensate in the tubes or smokebox. On cold start up condensation can be expected until the boiler warms up. If formation of condensate persists, the low limit should be adjusted upward until condensate no longer forms.

2. RECOMMENDED RECIRCULATION LOOP - FOR WATER BOILERS

The following guidelines relating to system water temperature fluctuation and flow through the boiler must be observed.

A. It is important to operate your boiler in such a manner as to prevent temperature fluctuations of more than 40° F at any time. Rapid temperature changes within the boiler can create stresses in the boiler metal. These stresses can cause damage to the boiler by loosening tubes or in more severe instances, can crack tube sheet ligaments, furnaces or waterlegs.

B. To help prevent temperature fluctuation and insure proper circulation through the boiler, a recirculation loop is recommended. The recirculation flow should be at least 1/2 GPM/BHP at all times the boiler is on-line for operation.

3. STANDARD EQUIPMENT

A. STEAM TRIM - pump control/low water cut-off with alarm contacts - piped with quick opening blow-off valve. Gauge glass set with hand-operated cock. Steam pressure gauge. Operating pressuretrol and manual reset high limit pressuretrol. ASME side outlet safety valve(s).

B. WATER TRIM - manual reset probe type low water cut-off, pressure and temperature gauge or pressure/altitude gauge. Operating aquastat and manual reset high limit aquastat. ASME side outlet safety relief valve(s).

C. ACCESSORIES AND OPTIONAL EQUIPMENT - Kewanee Boiler Manufacturing Company, Inc. manufacturers and offers a wide variety of optional and accessory equipment to enhance the performance and longevity of your boiler. For additional information, get in touch with your local Kewanee sales representative or contact the factory direct at Kewanee Boiler Manufacturing Co., Inc., 101 Franklin Street, Kewanee, Illinois 61443, Telephone (309) 853-3541 or E-mail us at http://www.kewaneeboiler.com

4. BOIL OUT INSTRUCTIONS

A. Before operating the new boiler, it should be washed (boiled) out to remove oil, grease, pipe joint compound, etc. that has accumulated during construction and installation. This is usually taken care of by the heating contractor. Washing (boil) out, must not be neglected because impurities may damage the boiler or cause an unsatisfactory operating condition.

B. The following steps are quite general in nature. If a local water treatment company is going to be part of your boiler's maintenance program, they should be contacted for recommendation as to what boil out chemicals they recommend and how they will affect their overall treatment program.

1. Remove any foreign materials which may be left in the boiler.

2. Check out burner equipment up to, but not including, the actual firing. Refer to burner manufacturer's service manual.

3. Remove any controls or accessories that may be damaged by the chemicals used.

4. Remove a plug from a tapping on the highest part of the boiler. (If no other opening is available, remove the safety valve carefully to avoid damaging it.)

5. Determine the water content of the boiler. This information is provided to you on your respective boiler's MB drawing in your submittal package, record print package or burner manufacturer's service manual.

6. Measure out one pound of trisodium phosphate for each 50 gallons of water to be put into the steam boiler or the hot water boiler system. Mix the chemical with sufficient water to make a concentrated solution for pouring into the boiler.

7. Fill the boiler half full of water, and then pour in the concentrated cleaning solution.

8. Replace the plug or safety valves, and close up other openings that may have been opened.

9. Steam boilers may then be filled with additional water up to the proper water level. (Gauge glass)

10. Water boilers and the entire system may be filled with additional water up to the expansion tank. To assure a full system, open all air vents until water is emitted.

11. Start the firing equipment, and check the operating limit and safety controls in accordance with burner manufacturer's service manual.

NOTE: On cold light-off the operator should be aware that a significant amount of condensate can form in the firesides and become evident at the drains provided in the smokeboxes. This is normal and should not be cause for alarm.

12. Operate the boiler as though in conventional service, reaching normal operating temperatures for water or normal pressures for steam. Maintain at low fire until boiler is warmed up to prevent thermal shock.

13. Steam boilers should be operated for a few days to bring oil and dirt from the system back to the boiler. If desired, the condensate return may be discarded to the drain and operation continued until the condensate runs clear.

14. Water boilers should be operated for one day with pumped circulation throughout the entire water system.

15. Stop the firing equipment.

16. Drain the boiler and water system to a location that can safely handle hot water. Be aware of local EPA regulations with regards to discharge of waste water.

17. Use a high pressure water stream to hose down the waterside of the boiler.

18. Refill the boiler system with fresh water; steam boiler to proper water level; water boiler to expansion tank, venting air as it is filled.

19. Bring water temperature up to at least 200° F.

20. Add boiler water treatment chemicals as required.

21. Tighten handhole, manhole covers and plugs while boiler is hot.

22. The boiler is now ready to put into service or on standby.

23. In stubborn cases, another boil out may be necessary.

24. The boiler is drained, flushed, and inspected. The surfaces are then thoroughly dried by means of hot air. If the boiler room is dry and well ventilated, the boiler may be left open to the atmosphere. An alternate procedure is to use a suitable moisture absorbent, such as quicklime or silica gel, which is placed in the boiler in a

suitable location. The boiler is then tightly closed. Every two or three months the boiler should be checked and the lime or gel replaced or regenerated, if necessary.

C. The outside surface of the boiler should be covered with insulation to prevent needless heat loss from the shell. By reducing the heat loss from the boiler, excessive boiler room temperatures are avoided and better economy is obtained. Package boilers are jacketed at Kewanee. If done on the job, this is usually not accomplished until the boiler has been in operation for a week or so to ensure joint tightness.

D. The boiler must be fired at a low rate for at least one day to dry out the refractory linings. Adjust the firing apparatus for a low firing rate and operate intermittently to keep combustion chamber warm. Drying procedure should be carried out together with the boil out.

Section 6

OPERATION OF BOILER

NOTE: All tests MUST BE conducted by qualified personnel under the direct control of a qualified supervisor.

1. ALWAYS INSPECT INSTALLATION THOROUGHLY BEFORE STARTING BURNER.

2. FILL SYSTEM WITH WATER

CAUTION: Any time raw water is introduced into the boiler it must be heated to at least 180° F immediately to dissipate the dissolved gases which can otherwise cause internal corrosion to the boiler.

Water level must be maintained in the boiler with strict compliance to the ASME Code.

A. Section I (High Pressure) Boilers - Top of lower gauge glass nut (lowest visible water level) must be located three inches (3") above the top of the highest firetube projection.

B. Section IV (Low Pressure) Boilers - Top of lower gauge glass nut (lowest visible water level) must be located one inch (1") above the top of the highest fire tube projection.

WARNING!!! ON A HOT WATER SYSTEM THE PRESSURE MUST NOT EXCEED 30 LBS. UNLESS THE BOILER IS ESPECIALLY DESIGNED FOR A HIGHER WORKING PRESSURE. IF BOILER PRESSURE EXCEEDS PRESSURE SETTING OF SAFETY RELIEF VALVE(S), VALVE(S) WILL RELIEVE IMMEDIATELY, BUT CAUSE OF RELIEF MUST BE INVESTIGATED AND CORRECTED. EXCESS PRESSURE IS DANGEROUS AND CAN CAUSE DAMAGE TO HEATING SYSTEM, PERSONAL INJURY OR SERIOUS PROPERTY DAMAGE.

C. The water level in the boiler will be maintained by a water level controller, if the boiler is equipped with this type of control. The valves at the top and bottom of the water gauge glass must be kept open so that true boiler water level will be shown in the glass.

D. Care must be taken to insure that the steam and water equalizer lines to the water column and controller are kept clean and free from fouling. These should be "rodded" out at least on an annual basis and be blown down with a frequency as dictated by water quality (see Figure 8).

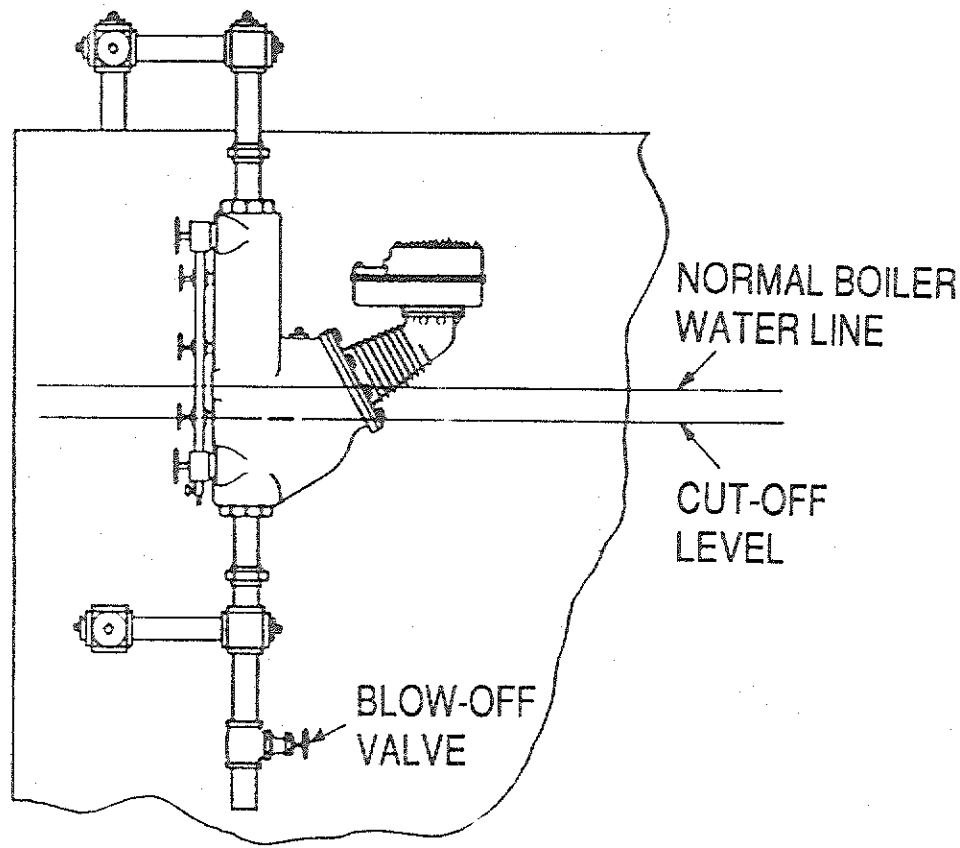

Figure 3

3. FEEDWATER CONNECTION

It is imperative that all feedwater entering the boiler be fed through the return connection at the rear, lower centerline in rear head. This allows for even distribution.

4. FIRING APPARATUS

A. Depending on configuration, Kewanee boilers can be fired with a number of devices. Regardless of the fuel or method employed, all systems should be operated in accordance with manufacturer's instructions. These are obtained either from the contractor or directly from the burner manufacturer.

B. Your Kewanee boiler is a quality product, engineered to extract usable heat from the fuel burned and will continue to do so as long as the burner is adjusted properly and heating surfaces are kept clean. Safety and economy are prime objectives in the operation of every boiler plant. Everyone in daily contact with the boiler room should be familiar with his equipment and give it diligent attention. He should acquaint himself with all rules pertaining to the care and maintenance of his equipment as set forth by state, local and insurance regulations.

C. Adjust burner according to the burner manufacturer's specifications. Refer to burner manufacturer's installation manual furnished with your Kewanee boiler.

5. PRESSURE AND TEMPERATURE CONTROLS

CAUTION: BEFORE INSTALLATION OF THE BOILER IS CONSIDERED COMPLETE THE OPERATION OF THE BOILER CONTROLS MUST BE CHECKED, PARTICULARLY THE LOW WATER CUT-OFF AND THE HIGH LIMIT CONTROL.

A. Careful consideration must be taken when determining what pressure or temperature the boiler should be operated at. On steam boilers, the pressure should be high enough to support the load, but in the case of high pressure boilers, it should never be reduced too low so as to allow high exit steam velocities to aggravate water carry-over through the steam supply nozzle.

B. Hot water boilers must be controlled hot enough to carry the system load, but should never be allowed to go below the point where the boilers can be thermally shocked or where dew point is reached in the breeching and stack. A good "rule of thumb" is to never allow a hot water boiler return water temperature to fall below 150° F. and never allow the differential temperature across the boiler to exceed 50° F.

C. Always warm up your boilers at the "low" firing rate and leave them there until pressure is indicated on the steam boiler pressure gauge or until hot water boilers return water temperature is above 150° F. Never

allow system pressure to exceed designed working pressure of the vessel.

6. WATER LEVEL CONTROLS

Water level controls are essential to the safe operation of a boiler. Depending on the application, they indicate water level (gauge glass), control the starting and stopping of a boiler feed pump and secure the burners if water level gets dangerously low. Though often neglected, they need regular attention to ensure smooth and safe operation. They should be blown down daily to ensure the float chamber remains free of foreign matter. When blowing down, the level in the gauge glass should be observed and the feed pump control function and low water cut-off function tested as well (see Figure 9).

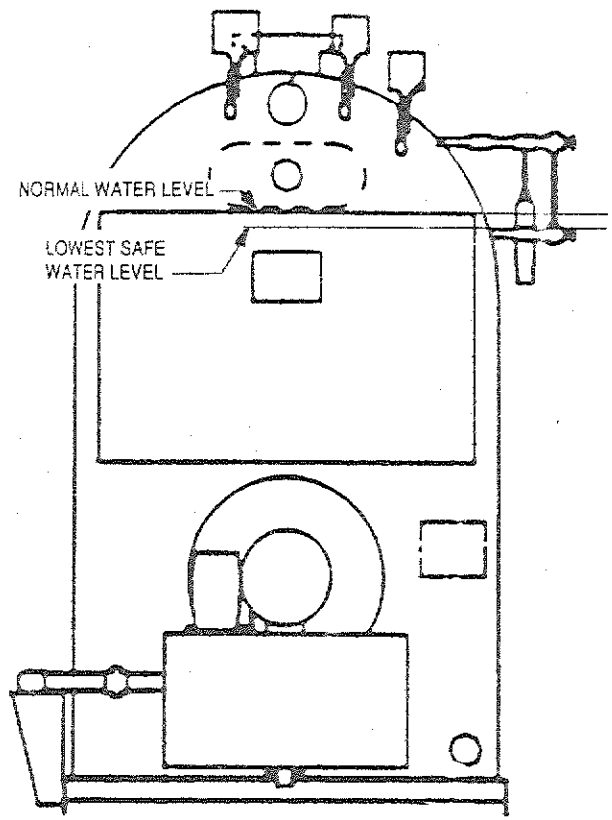

Figure 9

7. SAFETY AND SAFETY RELIEF VALVES

Safety and safety relief valves are used to relieve excessive pressure generated within the boiler. The safety or safety relief valve (or valves) is the final line of protection against over pressurization.

A. Safety Valves - Used for steam service, a safety valve is an automatic pressure relieving device, actuated by the pressure generated within the boiler and characterized by full opening pop action.

B. Safety Relief Valves - A safety relief valve is an automatic pressure relieving device actuated by the pressure generated within the boiler. It is used primarily on water boilers. Valves of this type are spring loaded without full opening pop action.

C. Safety and safety relief valves should be lifted by hand on a monthly basis. They should be lifted under pressure on an annual basis. Any problem whatsoever with the valve should be referred to an ASME Authorized Repair Station.

8. BLOW OFF

Boiler blow off (blowdown) is utilized to remove impurities from the boiler. Impurities may be either dissolved or non-dissolved. Frequency of blowdown is dictated by water treatment program. Blow off on Firebox boilers is typically from a "T" in the return adjacent to the boiler inlet. In severe cases the washouts in the mud legs (bottom four corners) can be utilized also.

A. Low Pressure Boilers - The use of the blow-off or drain valve in a low pressure heating boiler is for discharging rust colored water and sediment which settles to the bottom of the boiler. Quantity and frequency of blowdown is based on water quality and site specific conditions. Excessive discharge is wasteful and should be avoided.

B. High Pressure Boilers - The use of the blow off in high pressure boilers is to remove concentration of dissolved and undissolved solids to prevent foaming and undesirable water carryover in the steam. The amount and blow down frequency depends on the severity of boiler service, amount of makeup water used and type of chemical treatment utilized. Amount and blow down frequency should be determined by chemical analysis. "Guessing at it" should be avoided at all cost.

Blow down only during periods of light load.

On boilers equipped with a quick opening and slow opening valves. The quick opening valve should be opened first and shut last. The actual blow down should be performed with the slow opening valve.

9. SYSTEM DESIGN, APPLICATION AND OPERATING REQUIREMENTS FOR HOT WATER BOILERS

A. Excessive stresses in a boiler can lead to leaks at flue tube joints and to component fatigue due to thermal stress cycling resulting in failure of staybolts and cracked tube sheets. When the burner is at its maximum firing rate, the furnace temperature in a hot water boiler is strongly influenced by the boiler operating pressure, or more accurately, the saturation temperature that corresponds to the operating pressure. The flue tube and shell temperatures are mainly controlled by the operating water temperature regardless of burner firing rate. Thermal expansions of the flue tubes and shell are, therefore, controlled by water temperature, but thermal expansion of the furnace is controlled by water pressure. Because differential thermal expansion between the furnace and the flue tubes or shell can result in excessive stresses in boiler components, it is essential to consider the relationship between boiler operating temperature and boiler operating pressure. Consideration of this relationship leads to the conclusion that a hot water boiler should operate at a temperature not much below the saturation temperature that corresponds to the operating pressure. Kewanee has determined that for medium sized boilers this temperature difference should never exceed 100° F. It is intuitive that for larger boilers the maximum temperature difference should be even smaller. Every effort should be made to keep the boiler operating temperature as high as possible,thereby reducing temperature differentials between the furnace tube and the flue tubes or shell.

B. For 30 psi hot water boilers, the minimum permissible return water temperature is 150° F. For boilers operating at higher pressures, the minimum permissible return water temperature is a function of the operating pressure and the boiler size.

C. The return water temperature should always be within 50° F of the supply temperature.

D. Return water temperature should be continuously monitored. Any time that the return water temperature falls below any of the critical values, the burner firing rate should be returned to low fire. A low fire hold aquastat is provided for this purpose. A low fire hold timer may be used in addition to the aquastat, but never in place of it.

E. A minimum water flow rate of 1/2 gpm per boiler horsepower is required to eliminate thermal stratification. The burner circuit may be interlocked with a flow switch to assure that this minimum flow rate is established prior to starting the burner.

F. The heating system must be designed to eliminate any possibility of a large volume of cool water returning to a hot boiler as may occur when pumps cycle or when zone valves open.

G. Changes in boiler water temperature must occur gradually and should not exceed 2° F per minute.

H. The burner firing rate should be as constant and as low as possible consistent with the load demand in order to reduce the effects of component fatigue due to thermal stress cycling. Any control system that causes a burner to cycle on and off at any rate above low fire must be corrected.

I. The direction of water flow through the boiler should always agree with the instructions contained in the Care and Operations Manual provided with the boiler.

J. In order to satisfy the boiler's operating requirements as listed above, the judicious use of recirculating pumps, slow-opening water valves and temperature controls is encouraged and may be required in many applications of hot water boilers.

Section 7

WATER TREATMENT

NOTE: The information contained in this section is general in nature. The specific treatment program for your boiler should be dictated by local conditions. Kewanee Boiler Manufacturing Co., Inc. will not be held responsible for owner's failure to exercise sound engineering practices with regards to proper water treatment that results in premature failures of boiler components.

1. CONSIDERATIONS

In deciding what type of treatment to use, the following factors should be considered:

A. The type of boiler, i.e., steam or hot water.

B. The nature of the raw water, i.e., hard or soft, corrosive or scale forming.

C. Preliminary treatment of the water, i.e., softeners, preheaters, deaerators.

D. The amount of makeup water and blowdown required.

E. The use of the steam, i.e., for heating only or for other purposes.

F. The amount of supervision and control testing available.

2. SERVICES OF WATER TREATMENT SPECIALISTS

Each boiler installation should be considered on an individual basis. Review the final decision with a reputable water treatment company. These companies furnish a service and/or chemicals for boiler water treatment. They are in a position to make recommendations based on local water conditions and the particular installation involved. They also furnish test kits accompanied by simple analytical procedures for day-to-day analysis by the local maintenance people. Samples are taken at suitable intervals and sent to

their laboratories for confirmatory analysis. When setting up arrangements with such concerns, do not hesitate to ask for the chemical formula of the treatments prescribed.

3. CONFORMITY WITH LOCAL ORDINANCES

Make sure the boiler compound used does not violate any local ordinance with respect to disposal of blowdowns, draining of boilers, etc.

4. BOILER WATER TROUBLES

A. Corrosion - Raw water, as received from the city mains or wells, contains impurities including dissolved gases such as oxygen and carbon dioxide. When the water is soft, this makes the water acidic and corrosive. The boiler metal and condensate return lines will be attacked. This can be general overall corrosion or localized pitting or cracking in stressed metal. High temperatures accelerate these reactions. If left uncorrected, serious pitting can result with possible rupture of boiler tubes. Rusty water in the gauge glass is a sure sign of corrosion in the heating system or in the boiler itself.

B. Scale Deposits - All raw water contains dissolved salts. Where the water is hard, these are mainly calcium and magnesium compounds. Under boiler operating conditions, these salts come out of solution and form scale deposits on the hot boiler metal. This is due to decomposition of the bicarbonates and to the decreased solubility of calcium salts at higher temperatures. As the water is evaporated, the solids are left behind and the scale deposits build up. Scale forms an insulating barrier on the boiler tubes, resulting in heat losses and lower efficiency. Scale deposits can also cause overheating and failure of boiler metal.

C. Metal (Caustic) Embrittlement - Under certain conditions of high caustic alkalinity where the metal is under stress, cracks can develop in the metal below the waterline and in welds and longitudinal seams.

D. Foaming, Priming and Carryover - These difficulties, occurring in steam boilers only, are closely associated and refer to the formation of froth and suds on the surface of the water. Where this is severe, boiler water is carried over with the steam. Excessive dissolved solids carried over can form deposits in the steam piping and valves.

5. CHEMICALS USED

The following chemicals are commonly used for boiler water treatment.

A. Inorganic

1. Caustic Soda (sodium hydroxide) - NaOH
2. Trisodium Phosphate (TSP) - Na_3PO_4
3. Sodium Acid Phosphate - NaH_2PO_4

4. Sodium Tripolyphosphate - $Na_5P_3O_{10}$
5. Sodium Borate - $Na_2B_4O_7$
6. Sodium Sulphite - Na_2SO_3
7. Sodium Nitrate - $NaNO_3$
8. Sodium Nitrite - $NaNO_2$

B. Organic

1. Sodium Alginate and other seaweed derivatives
2. Quebrancho Tannin
3. Lignin Sulfonate
4. Starch

6. FUNCTIONS OF CHEMICALS

A. Caustic Soda - Use of caustic soda is one way to insure proper pH and complete precipitation of the magnesium salts. The optimum pH is 9.5 with a permissible minimum of 9.0. Recommended level is 9.0 - 9.5.

B. Chromates and Sulphites - Sodium chromate and sodium sulphite are used to control corrosion. Sodium sulphite is an oxygen scavenger picking up the oxygen which converts the sulphite to sodium sulphate.

NOTE: Chromate is still recognized as one of the best inhibitors for protection of metal, although it is now prohibited by most states or cities for use as water treatment due to the toxic effect of the chromate when dumped in rivers, streams and sanitary sewage systems.

C. Phosphates - The various sodium phosphates serve to precipitate the hard water salts as insoluble lime and magnesia phosphates. Polyphosphates are a form of phosphate that sequester rather than precipitate.

D. Nitrates and Nitrites - Nitrates serve to prevent metal embrittlement. Nitrites act similarly to sulphites, but under certain conditions where dissimilar metals are immersed in the boiler water, particularly copper or brass and soft solder, nitrites can cause very severe localized corrosion unless suitable inhibiting agents are present. Until recently, nitrites have not been commonly used where the water is boiled. Their use is generally confined to hot water systems.

E. Organic Agents - The organic agents act as protective colloids. When the inorganic treatment chemicals precipitate the hard water salts, these organic agents tend to keep the insoluble matter in suspension as a sludge and prevent the formation of dense adherent scale on the heat transfer boiler surfaces.

F. Boiler Compounds - Commercial boiler compounds are, for the most part, mixtures of the chemicals described in the above part. They may be either solid or liquid. The latter are solutions of the chemicals and

may present easier handling and feeding. While the combinations are many, there are two widely used basic types:

1. Those based on chromates (local authority may limit the use of chromates);

2. Those based on alkaline salt combinations plus sodium sulphite.

7. TREATMENT ALTERNATIVES

A. External or Internal Treatment - Water for boiler use may be treated externally or internally. One practical external treatment is by means of a zeolite softener. Where the water is very hard, it is frequently more economical to install a softener than to pay for the extra treatment required by the hard water. Using softened water, however, can create other problems. Corrosion is aggravated due to increased carbon dioxide, and foaming is apt to occur. The use of deaerators to remove oxygen and carbon dioxide by heating the water before it enters the boiler might be considered external treatment. In general, however, the principal problem is internal treatment.

B. Seasonal or Continuous Treatment - In considering boiler water treatment, installations can be divided into three categories, as follows:

Class 1 - No treatment;

Class 2 - Seasonal or semi-seasonal treatment with limited chemical control;

Class 3 - Complete treatment with continuous chemical control.

8. BLOWDOWN

The purpose of blowdown is to keep the amount of dissolved solids and sludge in the boiler water under control. As the water is turned into steam, the solids remain behind and unless there is 100% condensate return, the solid content tends to build up. As a rule of thumb, about 1500 to 2000 ppm can be considered as a safe maximum. A hard water containing 200 ppm in the feedwater would tolerate five concentrations in the boiler. On the other hand, a soft water with 25 ppm solids could be concentrated 40 times before reaching the critical point. To maintain satisfactory operation conditions, the first water would require 20% blowdown while the second would require only 2%. Blowdowns may be necessary once a day. Blowdown should be held to a minimum, since it involves heat losses and, if excessive, wastes treatment chemicals. Drains receiving blowdown water should be connected to the sanitary sewer.

9. FEEDERS

Simple feeders are preferable, particularly where the treatment is to be added periodically, i.e., more than once or twice a season. Where there is any appreciable amount of

blowdown, or loss of condensate, additional treatment will be necessary from time to time. A number of different types may be employed. These include open-type gravity feeders where the treatment is to be fed manually in one slug or in periodic small shots; closed-type gravity-drip and bypass feeders where the treatment is to be fed in proportion to the amount of makeup water; and pot type proportional feeders where slowly dissolving treatment crystals or briquettes are used.

10. PROCEDURES

A. Determination of Water Containing Capacity - Determine the water containing capacity of the boiler so instructions can be given regarding the required amount of boiler water treatment compound. If this information is not given on the boiler, in the boiler catalog, or other publications, then meter the water at the time of the initial filling and record the information. Kewanee records this information on the System MB drawing found on the submittal and record prints and in Burner Service Manual.

B. Making a pH or Alkalinity Test - The condition of the boiler water can be quickly tested with hydrion paper which is used in the same manner as litmus paper, except it gives specific readings. A color chart on the side of the small hydrion dispenser gives the reading in pH. Hydrion paper is inexpensive and obtainable from any chemical supply house or through your local druggist. If a more precise measurement of pH is desired, a color slide comparator kit is recommended.

C. Mixing and Handling Chemicals - The chemicals, if liquid, should be diluted; or if solid, dissolved in accordance with the supplier's directions before adding them to the system. If the treatment is a solid, make sure it is fully dissolved. A simple hand paddle to stir the solution is frequently all that is necessary. If the chemicals are slow to dissolve, a steam line for heating the water and agitating the mixture may be used to accelerate solution. The use of compressed air for this purpose is undesirable since additional oxygen will be introduced, which will neutralize reducing agents such as sodium sulphite. Since the treatment chemicals may be highly alkaline or skin irritating, it is advisable to wear goggles and gloves when they are being handled and mixed.

CAUTION: Do not permit the dry material or the concentrated solution to come in contact with skin or clothing.

D. Treatment of Laid-Up Boilers - When steel boilers are out of service for any length of time, such as a lay-up for the summer, they must be protected from corrosion. This may be done either by draining them and keeping the surfaces thoroughly dry or by completely filling the boiler with properly treated water.

1. Dry Method - The boiler is drained, flushed, and inspected. The surfaces are then thoroughly dried by means of hot air. If the boiler room is dry and well ventilated, the boiler may be left

open to the atmosphere. An alternate procedure is to use a suitable moisture absorbent, such as quicklime or silica gel, which is placed in the boiler in a suitable location. The boiler is then tightly closed. Every two or three months the boiler should be checked and the lime or gel replaced or regenerated, if necessary.

2. Wet Method - The boiler is drained, flushed, and inspected. It is then filled to the normal water level and steamed for a short time with the boiler vented to the atmosphere to expel dissolved gases. If the boiler is to be used to heat water or for reheat in connection with an air conditioning system, it may be left in this state ready to operate. If, however, it is to be completely idle for some time, it is preferable to fill the boiler to the top of the drum. In any case, treatment should be used. This may be the treatment regularly being used, or a caustic soda (400 ppm) and sodium sulphite (100 ppm), or sodium chromate, in which case a minimum of at least 100 ppm should be maintained on steam boilers and 300 ppm on hot water boilers. During the down time, if feasible, it is good practice to occasionally circulate the water with a pump. This is necessary to prevent stratification and insure that fresh inhibitor is in contact with the metal. This is also true of hot water systems. It is a well known fact that corrosion is apt to be more serious during the down time than when the boiler is actually in service.

Section 8

MAINTENANCE

WARNING!!! THIS PROCEDURE IS GENERALLY REQUIRED IN PREPARATION FOR CORRECTIVE OR PREVENTATIVE MAINTENANCE ON THE UNIT. THIS PROCEDURE MUST BE SUPERVISED BY AN INDIVIDUAL WHO IS THOROUGHLY QUALIFIED IN OPERATION AND MAINTENANCE OF THE EQUIPMENT AT HAND. THIS IS WRITTEN WITH HIGH PRESSURE POWER BOILERS IN MIND, BUT THE PRINCIPLES ARE APPLICABLE TO LOW PRESSURE HEATING BOILERS AND HOT WATER BOILERS AS WELL.

1. BOILER SHUTDOWN/COOL DOWN PROCEDURE

A. Decrease plant load as low as possible.

B. Turn burner switch off. If control power from burner is used to support accessories, leave on until boiler/system has cooled down.

C. Shut and lock manual gas and oil valves as applicable.

D. In single boiler installations, some small steam loads can remain on to assist in a controlled cool down of the boiler (i.e., deaerator). In multiple boiler

installations, shut the non-return valve and back-up valve. Lock them shut.

E. Allow the boiler feed pump to remain active. As the boiler cools down, the water level is reduced by demand or shrink. It is best to be aware of boiler water level at all times.

F. When boiler pressure has decreased to 5 to 10 PSI on the pressure gauge, open the boiler manual vent valve on the top of the boiler. This is to act as a sentinel against an increase in pressure and to prevent the boiler from going into a vacuum. Lock the valve open.

CAUTION: Depending on the size of the boiler, the large mass of heating surfaces that are still hot can cause the boiler water temperature to increase, even if the gauge pressure is "Zero PSI". It is better to allow the entire system to cool gradually. Never force cool on the boiler or system, as damage can also be inflicted due to "thermal shock".

G. When boiler and water temperature drops below 120° F, turn off the power to the unit and lock out the circuit breakers.

H. If required, open front and rear doors for observations of fireside surfaces.

I. Drain boiler down as far as required (usually completely). Make sure the vent valve on the top of the boiler remains open. Open and lock the float control low water cut-off drain valves. These will serve as an additional vent.

J. Shut and lock all boiler feed valves and any blowdown valves that can be affected by other boilers in the same facility (i.e., bottom blowdown valves can tie into a common blowdown separator in a multiple boiler installation).

K. If it is necessary to remove handhole and/or manhole plates for waterside inspection or maintenance, use extreme caution. Loosen the nuts securing the arch enough to allow the plate to drop approximately 1/8" when tapped loose with a mallet. Once again, ensure the pressure in the boiler is "Zero PSI" before loosening the plate. Remove the plate the remainder of the way. Wear gloves and eye protection at all times.

2. FIRESIDE CLEANING

The frequency of fireside cleaning depends largely on the fuel burned and equipment adjustments. If combustion is complete, the firesides should not require frequent cleaning. It is important to realize that for every 1/32 inch of carbon or soot deposits on fireside surfaces you can expect a 10 percent loss in efficiency. A good indicator of efficiency is stack temperature. Under similar firing conditions, an increase in stack temperature of 100° F can indicate a need for fireside cleaning. Fireside cleaning is normally accomplished by mechanical means. The surfaces are scraped or wire brushed and the soot is vacuumed up. After

cleaning, if the boiler is to remain idle for an extended period of time (over 30 days), a thin film of oil can be applied to the fireside surfaces to prevent corrosion.

3. WATERSIDE CLEANING

The best defense against waterside fouling is a carefully and conscientiously applied water treatment program. Sludge and suspended solids that precipitate out of the boiler water and settle into the low point can be removed by washing with high velocity water. Chemicals and salts that become encrusted on waterside surfaces may need removal by mechanical means. In severe cases, acid cleaning may be required. This should be accomplished by a professional boiler repair organization which has the proper equipment to handle and dispose of the acids. After cleaning, if the boiler is to remain idle for an extended period of time (over 30 days), it should be placed in dry lay-up. The boiler is first thoroughly dried and then sealed with a desiccant inside to absorb moisture. Wet lay-up can be used for short inactive periods. The boiler is filled with chemically treated water and boiled off to remove oxygen. The boiler is then sealed until ready for use. When placing the boiler back in service, always use new handhole and manhole gaskets.

4. WATER GAUGE GLASS REPLACEMENT

The water gauge glass should be removed and cleaned when necessary. Routine blowing down of the glass will aid in maintaining cleanliness. The water gauge glass can be removed by isolating the glass with the isolation valves. For safety reasons, it is better to do so with the boiler secured and isolated at zero pressure. When a water gauge glass has been broken, remove the broken pieces. Before inserting the new glass, see that the drain is open and that the glass is of the exact length required. Ensure the connections are in exact plumb with each other. Install the glass with a new gasket, brass ring and wear washer. Clean the stuffing box nut thoroughly and be careful not to tighten too tight. Warm the glass gradually by opening the top valve slightly and let a small amount of steam flow through the glass. Shut the drain valve after the glass has warmed up. Slowly open the bottom valve and observe the water level. Open the top valve fully.

5. MANHOLE, HANDHOLE COVERS AND PLUGS

When installing, always use new gaskets with appropriate pressure and temperature rating. All metal surfaces must be thoroughly cleaned where the covers bear against the shell plate. Fiberglass gaskets can be coated with a thin coat of conventional, linseed oil based pipe dope prior to installation. Buna-N-Rubber gaskets require no lubrication or sealing. Care should be used when centering the cover plate and gasket in the shell opening before drawing up the bolts. A thin coat of Never-Seeze on the bolt threads will make future removal easier. Draw bolts up firmly but do not over tighten. It may be necessary to go around all plugs while increasing system pressure to make them leak proof. As all handhole and manhole plates seat with system pressure, over tightening the bolts can cause future removal problems when the system is cold and de-pressurized. Washout plug threads should be lubricated with a thin coat of pipe dope, and the gaskets should be replaced.

6. MAINTAIN DRIP TIGHT CONNECTIONS

Repair all minor leaks promptly. If serious leaks occur, shut the boiler down immediately and cool gradually. All piping connections must be maintained leak proof as even minor leaks, if neglected, may become serious. This applies especially to water column, water glass, level control piping, manhole and handholes. Pipe nipples should be replaced if there is evidence of leaking. Leaky plugs in boiler shell should be replaced with new plugs or nipples and caps. Tube joints must be inspected periodically to ensure they are leak free. All support systems and auxiliary equipment must be maintained in top condition to ensure long and trouble free operation of the boiler room system.

7. FOAMING AND PRIMING

Foaming and priming in the steam boiler will cause large quantities of water to be carried over into the steam main. It will be detected by violent fluctuations of the water in the glass or by sudden dropping of the water level from the glass. Impurities will show as tiny specks or flakes floating in the boiler water. The following reasons may be the cause of the trouble:

A. Dirt or oil in boiler water.

B. Over-dose of water treatment.

C. Carrying too high a water level in boiler.

D. Load demand exceeds boiler rating.

E. Sudden increases in load (sudden pressure drop).

In case of serious trouble, stop the burner and decrease the load on the boiler until the true water level can be determined. Then alternately blow down and feed fresh water several times. If the trouble continues, it will be necessary to wash out the boiler and refill with fresh water. Test safety valve and connections of pressure gauge, water column and water glass to make sure that they are clear and unobstructed by the impurities which are responsible for priming.

A practical check to determine if impurities are causing foam is to place a sample of boiler water in a beaker and bring it to a boil. If contaminants exist, it will foam. A similar test in a second beaker filled with tap water will determine how bad the boiler water is.

8. CORROSION AND PITTING

Corrosion of the boiler on either the waterside or the fireside can be of very serious consequence and should be guarded against.

Waterside corrosion is generally caused by an unfavorable water condition or oxygen, which attacks the metal and forms pit marks or holes in the tubes. Control of the boiler water alkalinity and deaeration is considered the best means of preventing waterside corrosion. The proper alkalinity for boiler operation is recommended as a minimum pH value of 9.0. The boiler should be examined regularly for corrosion.

Every time the boiler is cleaned, the interior surfaces should be carefully examined for water corrosion. Waterside corrosion in its earliest stages will be detected by small "mounds" of black iron oxide in powdered form along the top and sides of the firetubes. Concentrated pitting will occur under these "mounds".

Corrosion can be controlled by proper water treatment, and the problem should be referred to a water chemist.

Fireside corrosion occurs mostly during standby or when the boiler is not in use. In some cases it develops during normal firing periods. It will be detected either by a concentrated pitting action, particularly along the bottom of the firetubes, or by a general thinning of the metal at the entrance of the direct tubes.

Fireside corrosion is generally caused by the action of moisture on the carbon or soot coated surfaces. Moisture from the flue gases, condensing on the cooler boiler surfaces, combines with sulfur in the soot to form sulfuric acid, which is highly corrosive to the metal. This condition can be very severe with coal fired boilers because of the high sulphur content of the fuel. It is usually more active along the bottom of the firetubes where moisture collects.

Fireside corrosion can be prevented by keeping the fire surfaces clean and dry.

NOTE: Protect the coal fired boiler from fireside corrosion at the end of every heating season.

9. SCALE IN BOILER

Lime or hard scale does not normally occur in the low pressure heating boiler, since practically the same water is used over and over. It is essential, however, to maintain all air and vent valves in good condition, to keep the system leak proof and to use the blow-off sparingly. In addition, water treatment should be applied for corrosion. When so maintained, there will be no scale, mud or sediment in the boiler, and the water will remain clear.

In the operation of a steam boiler, it is desirable to return as much of the condensate as possible to the boiler in order to reduce the amount of raw make-up water to an absolute minimum. Some industrial processes require live steam, which cannot be returned to the boiler, and all steam consumed in this manner must be replaced with make-up water.

Natural waters invariably contain minerals or salts in solution, and when water is concentrated these substances are precipitated or separated from the solution as solids. The precipitate is either carried in suspension or it settles out in the form of soft scale (mud) or hard scale.
In a steam boiler, the water is distilled and discharged through the steam outlet while the solids remain. There is, therefore, a gradual accumulation of solids inside the boiler when raw feedwater is used. Salts, which are carried in suspension, cause foaming and priming. Mud and scale inside the boiler cause overheating and damage. Every

gallon of raw water fed to the boiler increases the mineral concentration, and unless corrective measures are taken, there will be unsatisfactory operation and damage to the boiler.

Soft scale and salts in suspension may be reduced by blowing down and washing out. Where the water supply is hard, the make-up water should be treated to prevent scale. Since the type of treatment or compound will depend upon the mineral content and analysis of the water supply, it must be determined by an experienced boiler water chemist.

10. MAINTENANCE SCHEDULE

Listed below are suggested frequencies for the various routines and tests to be performed in connection with inspection and maintenance of boilers.

A. Daily (Boilers in Service) - Observe operating pressures and temperature and general conditions. Determine cause of any unusual noises or conditions and make necessary corrections.

1. Record parameters on logs at prescribed interval.
2. Check water level.
3. Blow down low water cut-off and gauge glass.
4. Blow down boiler.
5. Check and record chemistry of boiler water.
6. Inspect burner linkages.
7. Inspect pumps (inspect belts, couplings, seals, etc.)
8. Inspect compressors (check oil level, belts, couplings, etc.)
9. Check temperatures and record.
    a. Fuel
    b. Feedwater
    c. Stack
    d. Economizer
    e. Air heater
10. Check pressures and records.
    a. Boiler
    b. Fuel
    c. Feedwater
11. Inspect burner flame. Record any unusual sightings.

B. Weekly (Boilers in Service)

1. Observe condition of flame; correct if flame is smoky or if burner starts with a puff (for oil, observe daily.)

2. Check fuel supply (oil only).

3. Observe operation of circulating pump(s).

4. Check all burner linkages to be sure that there has been no change from its original marked position. Tighten, if necessary. Check to ensure linkage not binding. Lubricate, if necessary.

5. On low pressure steam boilers, open the blowdown valve of the low water cut-off while the burner is running. The burner should shut down when the water level drops in the glass, showing that the low water cut-off is operating properly and that the float bowl is clean.

6. On steam heating boilers, the gauge cocks and blowdown valves on the water column and water glass should be operated to make sure the connections are open. If used, test water feeder.

7. Note condition of belts or flexible couplings on oil pumps and air compressors. Have spare belts available (if used) and replace any cracked belts. Excessive side wear indicates need for realigning sheaves or correcting belt tension.

8. Check compressor oil pressure and maintain at manufacturer's recommended pressure. Check oil level and maintain between high and low level marks. Do not overfill with oil. Use oil approved by compressor manufacturer.

9. Check flame safeguard. Ensure proper shutdown and re-light sequence by simulating a flame failure and supervising a re-light.

10. Measure and record flame signal strength.

C. Monthly (Boilers in Service)

1. Test limit controls.

2. Test operating controls.

3. Check boiler room floor drains for proper functioning.

4. Inspect fuel supply systems in boiler room area.

5. Check condition of heating surfaces (for preheated oil installation, inspect more frequently: twice a month).

6. Check ignition assembly and electrode. Clean, if necessary.

7. Clean oil nozzle (if necessary). Never use a sharp instrument on the nozzle. If nozzle becomes damaged, replace it. On burners firing

No. 5 or No. 6 oil, more frequent nozzle cleaning may be necessary.

8. Clean flame detector lens with a soft, clean, lint-free cloth. Check scanner cell. Test.

9. Check air dampers and blower wheel. Remove any accumulation of lint or dirt.

10. Inspect condition of refractory.

11. Clean intake filter element on the air compressor in nonflammable solvent. The frequency of cleaning will depend on air supply conditions. The standard air filter is of sufficient size and design to meet normal conditions.

12. Inspect the oil strainer and clean, if necessary. The frequency of cleaning will depend upon the frequency of the burner operation and the quality of oil in use. Be sure the cap gasket is in good order and mating surfaces are clean. A light coat of clean oil will help secure a vacuum-tight joint.

NOTE: Close the gate valve ahead of the strainer before removing the cap to prevent loss of oil prime.

13. Lubricate motors in accordance with motor manufacturer's instructions. (May be annual requirement.)

14. Check safety valves by manually lifting with handle provided. Ensure they reset.

15. Check and record flue gas analysis. Compare with previous readings to detect any trends. Make appropriate adjustments if required.

16. Lubricate all damper and drive arm bearing surfaces with a dry lubricant.

D. Annually

1. Have unit inspected and checked by your local Kewanee Service Representative.

NOTE: Annual maintenance should be conducted in the spring to afford ample time to repair serious problems.

2. Check condition of oil tank. Clean and remove sludge, if necessary.

3. Routine maintenance of circulating pump and expansion tank equipment.

4. Routine maintenance of entire combustion control equipment.

5. Inspect gas piping for proper support and tightness.

6. Drain and clean sediment and accumulated carbon from electric oil heater and boiler mounted oil heater.

7. If the burner is to be out of service for the summer, be sure to close all valves and break all power connections to the burner and auxiliaries.

CAUTION: Humidity Effects - To protect against high resistance leakage in the electronic circuit resulting from high humidity, it is recommended that the Flame Safeguard Control be left powered continually even when not in operation. If it is necessary to shut down completely for an extended period, the control should be thoroughly cleaned, and power should be turned on for 48 hours before putting the control back in operation.

8. Completely tear down boiler and thoroughly clean fireside and waterside. Inspect for deterioration which could indicate an inadequate water treatment program.

NOTE: While boiler is torn down, it should be inspected by the authorized boiler inspector.

9. Reassemble boiler using new gaskets with appropriate pressure and temperature rating. Perform hydrostatic test.

10. Clean and inspect low water cut-off. This includes float chamber, if applicable.

11. Clean and inspect all burner components. Perform tune up and record readings as a comparison base. Replace any defective components.

12. Check all operating and safety devices, including a pop on safety/safety relief valves, flame safeguard checks, and leak test of safety shutoff valves.

13. Check and clean all external systems including steam traps, combustion air inlets, etc.

NOTE: Other maintenance as recommended by individual component manufacturers. An effective maintenance program is one that is tailored to the individual installation.

Section 9

TESTS AND INSPECTIONS

1. INITIAL INSPECTION AT PLACE OF INSTALLATION

As opposed to inspection during manufacture which pertains primarily to conforming to Code construction requirements, this inspection will be concerned with whether boiler supports, piping arrangements, safety/safety relief valves, other valves, water columns, gauge cocks, altitude gauges, thermometers, controls and other apparatus on the boiler meet Code and/or other jurisdictional

requirements. The inspector usually represents the same jurisdiction which will be making subsequent periodic inspections.

2. PERIODIC INSPECTING OF EXISTING BOILERS

The main purposes for re-inspection include protection against loss or damage to the pressure vessel because of corrosion, pitting, etc., protection against unsafe operating conditions possibly caused by changes in piping or controls or lack of testing of safety devices. It is important that inspections be thorough and complete, and so that important elements may all be checked. The following recommended directions and instructions for such inspections are given.

A. All boilers should be prepared for inspection, whenever necessary, by the owner or user when notified by the inspector.

The owner or user should prepare the boiler for an internal inspection and should prepare for and apply the hydrostatic test whenever necessary on the date specified in the presence of the authorized inspector.

B. Before inspection, every part of a boiler that is accessible should be open and properly prepared for examination, internally and externally. In cooling down a boiler for inspection or repairs, the water should not be withdrawn until the setting is sufficiently cooled to avoid damage to the boiler, and when possible, it should be allowed to cool down naturally.

C. Preparation - The owner or user should prepare a boiler for internal inspection in the following manner.

1. Water should be drained and boiler washed thoroughly.

2. All manhole and handhole plates, wash-out plugs and water column connections should be removed and the furnace and combustion chambers thoroughly cooled and cleaned.

3. All grates of internally fired boilers should be removed.

4. Brickwork should be removed, as required by the inspector, in order to determine the condition of the furnace, supports or other parts.

5. Any leakage of hot water into the boiler should be cut off by disconnecting the pipe or valve at the most convenient point.

D. It is not necessary to remove insulation material, refractory or fixed parts of the boiler unless defects or deterioration are suspected. Where there is moisture or vapor showing through the covering, the covering should be removed at once and a complete investigation made.

Every effort should be made to discover the true condition, even if it means drilling holes or cutting away parts.

E. The inspector should get as close to the parts of the boiler as is possible in order to obtain the best possible vision of the surface and to use a good artificial light if natural light is not adequate.

F. Whenever the inspector deems it necessary to test boiler apparatus, controls, etc., these tests should be made by a plant operator in the presence of the inspector, unless otherwise ordered.

G. Scale, Oil, Etc. - The inspector should examine all surfaces of the exposed metal inside to observe any action caused by treatment, scale solvents, oil or other substances which may have entered the boiler. Any evidence of oil should be noted carefully, as a small amount is dangerous, and immediate steps should be taken to prevent the entrance of any more oil into the boiler.

H. Corrosion, Grooving - Corrosion along or immediately adjacent to a seam is more serious than a similar amount of corrosion in the solid plate away from the seams. Grooving and cracks along longitudinal seams are especially significant, as they are likely to occur when the material is highly stressed. Severe corrosion is likely to occur at points where the circulation of water is poor; such places should be examined very carefully.

For the purpose of estimating the effect of corrosion or other defects upon the strength of a shell, comparison should be made with the efficiency of the longitudinal joint of the same boiler, the strength of which is usually less than that of the solid sheet.

I. Manholes and Other Openings - The manhole(s) and other reinforcing plates, as well as nozzles and other connections flanged or screwed into the boiler, should be examined internally, as well as externally, to see that they are not cracked or deformed. Wherever possible, observation should be made from the inside of the boiler as to the thoroughness with which its pipe connections are made to the boiler. All openings to external attachments, such as connections to a low water cut-off and openings to safety/safety relief valves, should be examined to see if they are free from obstructions.

J. Fireside Surfaces - Bulging, Blistering, Leaks - Particular attention should be given to the plate or tube surface exposed to fire. The inspector should observe whether any part of the boiler has become deformed during operation by bulging or blistering. If bulges or blisters appear, it could seriously weaken the plate or tube, and especially when water is leaking from such a defect, the boiler should be discontinued from service until the defective part or parts have received proper repairs. Care should be made to detect leakage from any part of the boiler structure, particularly in the vicinity of seams and tube ends. Firetubes sometimes blister but rarely collapse; the inspector should examine the tubes for such defect. If bulges or blisters are found, they should be examined by an authorized inspector.

K. Testing Staybolts - The inspector should test staybolts by tapping one end of each bolt with a hammer and, when practicable, a hammer or other heavy tool should be held at the opposite end to make the test more effective.

L. Tube Defects - Tubes in horizontal firetube boilers deteriorate more rapidly at the ends toward the fire, and they should be carefully tapped with a light hammer on their outer surface to ascertain if there has been a significant reduction in thickness. They should be reached, as far as possible, either through the handholes, if any, or inspected at the ends.

The surface of tubes should be carefully examined to detect bulges or cracks or any evidence of defective welds. Where there is a strong draft, the tubes may become thinned by erosion produced by the impingement of particles of fuel and ash. A leak from a tube frequently causes a corrosive action on a number of tubes in its immediate vicinity.

M. Ligaments Between Tube Holes - The ligaments between tube holes in the heads of all firetube boilers and in shells of watertube boilers should be examined. If leakage is noted, broken ligaments are probably the reason.

N. Pipe Connections and Fittings - All piping should be examined for leaks. If any are found, it should be determined whether they are the result of excess strains, due to expansion or contraction, or other causes. The general arrangement of the piping in regard to the provisions for expansion and drainage, as well as adequate support at the proper points, should be carefully noted.

The arrangement of connections between individual boilers and the supply and return headers should be especially noted to see that any change of position of the boiler due to settling or other causes has not placed an undue strain on the piping.

It should be ascertained whether all pipe connections to the boiler possess the proper strength in their fastenings, whether tapped into or welded to the boiler shell. The inspector should determine whether there is proper provision for the expansion and contraction of such piping and that there is no undue vibration tending to damage the parts subjected to it. This includes all water pipes. Special attention should be given to the blowoff pipes with their connections and fittings because the expansion and contraction, due to rapid changes in temperature and water-hammer action, bring a great strain upon the entire blow-off system. The freedom of the blow-off and drain connection on each boiler should be tested, whenever possible, by opening the valve for a few seconds, at which time it can be determined whether there is excessive vibration.

O. Low Water Cut-off - All automatically fired boilers are required to be equipped with an automatic low water fuel cut-off so located as to automatically cut off the fuel supply when the surface of the water falls

below the lowest safe waterline. Such a fuel control device may be attached directly to the boiler shell or to the tapped openings provided for attaching a water glass direct to a boiler.

Designs embodying a float and float bowl shall have a vertical straightway valve drain pipe at the lowest point in the water equalizing pipe connections, by which the bowl and the equalizing pipe can be flushed and the device tested.

P. Localization of Heat - Localization of heat brought about by improper or defective burner or stoker installation or operation, creating a blowpipe effect upon the boiler, should be cause for shutdown of the boiler until the condition is corrected.

Q. Suspended Boilers - Freedom of Expansion - Where boilers are suspended (i.e., high firebox), the supports and settings should be examined carefully, especially at points where the boiler structure comes near the setting walls or floor to make sure that ash and soot will not bind the boiler structure at such points and produce excessive strains on the structure owing to the expansion of the parts under operating conditions.

R. Safety Valve/Safety Relief Valves - As these devices are the most important safety device on the boiler, it should be inspected with the utmost care. There should be no accumulation of rust, scale or other foreign substances in the body of the valve, which will interfere with its free operation. The valve should not leak under operating conditions. The opening pressure and freedom of operation of the valve should be tested preferably by raising the pressure to the point of opening. If this cannot be done, the valve should be tested by opening with the try lever. Where the valve has a discharge pipe, the inspector should determine, at the time the valve is operating, whether or not the drain opening in the discharge pipe is free , and in accordance with the Code requirement.

If the inspector deems it necessary, in order to determine the freedom of discharge from a safety relief valve, the discharge connection should be removed. Under no circumstances shall a stop valve be permitted between a boiler and its safety relief valve.

S. Combination Temperature and Pressure Gauges - A test gauge connection is provided on the boiler so that the gauge on the boiler can be tested under operating conditions.

T. Incorrect Repairs - When repairs have been made, especially tube replacements, the inspector should observe whether the work has been done safely and properly. Excessive rolling of tubes, where they are accessible, is a common fault of inexperienced workmen. When it is difficult to reach the tube end, they are frequently under rolled. This inevitably results in separation of the parts.

U. Hydrostatic Tests - When there is a question or doubt about the extent of a defect found in a boiler, the inspector, in order to more fully decide upon its seriousness, should cause the application of hydrostatic pressure under the Code provisions.

As dictated by the inspector, a hydrostatic pressure test shall not exceed that specified by applicable code. During the test, the safety/safety relief valve should be removed from the boiler, as should all controls and devices unable to withstand the test pressure without damage. It is suggested that the minimum temperature of the water be 70° F and the maximum 160° F.

V. Suggestions - The inspector, whether he is the employee of a state, province, municipality or insurance company, should be well informed of the natural and neglectful causes of defects and deterioration of boilers. He should be extremely conscientious and careful in his observations, taking sufficient time to make the examinations thorough in every way, taking no one's statement as final as to conditions not observed by him, and, in the event of inability to make a thorough inspection, he should note it in his report and not accept the statement of others.

The inspector should make a general observation of the boiler room and apparatus, as well as of the attendants, as a guide in forming an opinion of the general care of the equipment. He should question responsible employees as to the history of old boilers,

their peculiarities and behavior, ascertain what, if any, repairs have been made and their character, and he should investigate and determine whether they were made properly and safely.

Section 10

REPAIRS

DANGER!!! DO NOT ATTEMPT OR PERMIT REPAIRS ON ANY BOILER WHILE IT IS IN SERVICE OR UNDER PRESSURE!

1. All repairs should be properly supervised by an Authorized Boiler Inspector or responsible engineer.

2. Notification - Before any repair work is attempted, the authorized Inspector carrying a Commission from the National Board of Boiler and Pressure Vessel Inspectors should be notified, and the scope of the work should be reviewed and approved by him.

3. Requirements - All repair work should be conducted by an Authorized Boiler Repair organization carrying a repair stamp ("R") issued by The National Board of Pressure Vessel Inspectors. This will ensure that the Boiler Repair organization is thoroughly acquainted with approved procedures for making pressure vessel repair. All procedures should be conducted in accordance with the

applicable code and approved by the Authorized Inspector. All material specifications can be found on the ASME Data Report, which was prepared for the boiler in question.

4. Safety - Every precaution must be taken to insure against injury to personnel who are working in the boiler room and particularly to those working inside the boiler. The main burner power switch must be pulled and tagged out. All isolation valves to the fuel systems must be shut and locked. All isolation valves to the steam or hot water system must be shut and locked. Wherever possible, two valve protection is desirable. The area to be worked on must be thoroughly ventilated to insure against toxic fumes, and there should always be a safety man outside the boiler anytime a man is working inside.

5. Additional Applicable Publications - All operators and supervisors should be thoroughly familiar with the following sections of the ASME Boiler and Pressure Code or as they relate to the boilers and pressure vessels covered by this manual.

   Section I - Power Boilers

   Section II-A - Material Specifications - Ferrous Materials

   Section IV - Heating Boilers

   Section VI - Recommended Rules for Care and Operation of Heating Boilers

   Section VII - Recommended Guidelines for Care of Power Boilers

   Section IX - Welding and Brazing Qualifications

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