

OPERATOR'S MANUAL INSTALLATION OPERATION MAINTENANCE

DANSTOKER

High Pressure Hot Water Boilers

FUELS :

- **Oil • Gas • Biofuels**
- **Flue gases from engines and turbines**
- **Flue gases from combustion in grates, killns, incinerators and combustion chambers**

December 2005

Introduction

The boiler supplied to this heating plant has been manufactured on basis of the most up-to-date and proven construction principles, in compliance with the design code and approval standards agreed.

Thus, you have ample guarantee of having purchased a product where all conceivable efforts have been made to manufacture and supply a product of high quality and longevity.

However, the life of the boiler and its accessories is closely connected to and dependent on proper service and maintenance of the boiler plant. Therefore, provided constant, knowledgeable and competent control and service routines are applied, the running and functioning of the boiler and the equipment supplied by Danstoker will be safe and economical.

As manufacturer of the boiler we have in the following described some sound and useful guidelines for the operation and maintenance of the boiler and the accessory equipment, supplied by Danstoker.

Many of these guidelines are intended as general advice and assistance, whereas others describe **stipulated factors that unconditionally have to be observed – failure to do so will otherwise cause your right to present a valid complaint to Danstoker to lapse. Consequently, it is of the utmost importance that this manual is studied carefully.**

With a view to prolonging the life of the boiler and in order to avoid costly boiler damage we shall therefore specifically draw your attention to the following paragraphs (however, not limited to these sections) :

- Paragraph 3.5 (Firing/Operation of the combustion equipment)
- Paragraph 4.1 (Daily operation and maintenance)
- Paragraph 5 (Boiler and feed water systems)

In this connection it should be noted that any equipment, included in the boiler plant and which has *not* been supplied or designed by **Danstoker a-s**, may have a major influence on the information provided in this manual. The information given herein does not replace specific instructions, if any, pertaining directly to such equipment or accessories, as those instructions shall have to be minutely observed.

Consequently, the personnel in charge of the operation and supervision of the plant (it is taken for granted that this personnel is properly and sufficiently qualified) is requested to thoroughly study the information given in this manual and to combine this information with that of other instructions, applicable to the entire plant in general.

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Enclosures:

- **Operation Journal – (daily registrations) Boiler parametres**
- **Operation Journal – (daily registrations) Water analyses**

Installation

Boiler Foundation

A foundation cast in concrete or a steel foundation is to be erected at the place of installation. The foundation is to be made with a slight fall, thereby allowing all the water to be drained off through the blowdown valve (drain valve). The foundation is to be dimensioned so as to comply with local rules and regulations applicable and must be sufficiently strong to bear the total load of the boiler (flooded weight!), of accessory equipment and, if any, of service platforms and galleries.

If not otherwise explicitly specified, the weight normally indicated by Danstoker is the weight without water.

For your calculation of the total foundation load, you have to allow for the boiler weight inclusive of its water content as well as specific weights of the oil/gas burner or other combustion equipment, possibly a pre-heating blower placed at the boiler top, galleries, ladders, boiler mountings, piping systems, etc. Such additional weights will vary according to the layout and scope of the specific installation.

The concrete foundation may be provided with steel foundation plates, on which the boiler saddles are to be secured by bolts, respectively should be allowed to move freely. In case sliding foil is used (to allow free movement) the thickness of same should be allowed for when deciding the level of the foundation plates.

As standard, Danstoker boilers provided with saddles/feet will be supplied with a piece of sliding foil (thickness 0,8 mm) in a dimension matching one boiler saddle. Please note that during transportation the sliding foil will be placed on or inside the boiler together with a cleaning brush and a socket wrench intended to tighten the cleaning and inspection doors.

For “box-type” boilers, where the entire bottom plate is calculated to be able to transfer the load from the boiler to a specially designed foundation (which is normally an integrated part of the combustion equipment), the requirement with regard to tightness between the boiler bottom and the foundation will be decisive for the choice of joint/packing material to be used.

After placing the boiler in its foundation, make sure to verify that the packing material is placed correctly.

Such packing material is **not** included in the normal boiler scope of supply, if not specifically stated.

Hoisting procedure for horizontal boilers

All Danstoker boilers are provided with two lifting/suspension eyes. The boiler is to be lifted from the transport vehicle by means of these lifting eyes, as illustrated in the drawing below, where the optimal lifting angle is 60° - this angle should be respected, only a deviation of a few degrees is permissible.

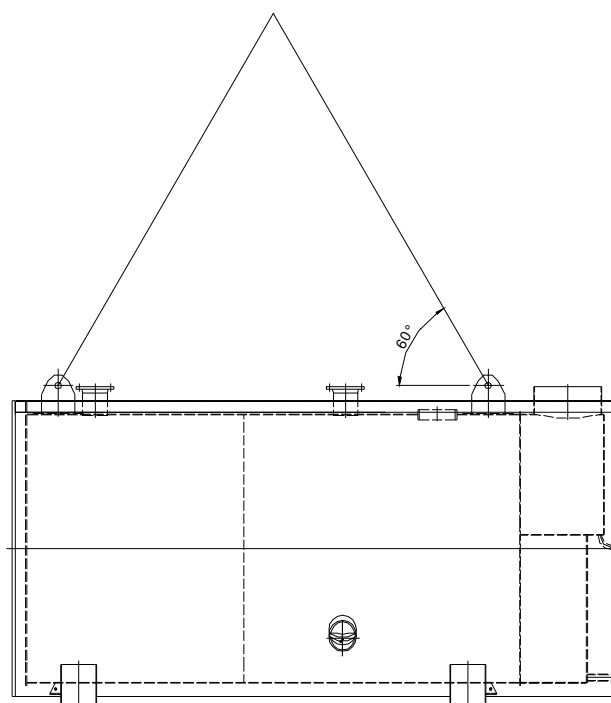
When using a lifting bar the angle will typically exceed 60° , which will be the optimal solution when lifting very heavy boilers.

In this way the boiler may be carefully hoisted into position on its foundation.



Warning! Mortal danger! It is not allowed to pass or stay under the boiler while it is suspended.

The boiler is heavy, and it is very important that all necessary precautions have been taken to make sure that the hoisting may be carried out under safe and reliable conditions. Only professional and duly qualified personnel may be in charge of moving and transporting the boiler.



In case the boiler is to be moved over a plane surface, it may be rolled on roller-skates, to be placed under the saddles. Each saddle is provided with handling brackets. These brackets may be used to lift the boiler, but **ONLY** by means of a lifting jack.

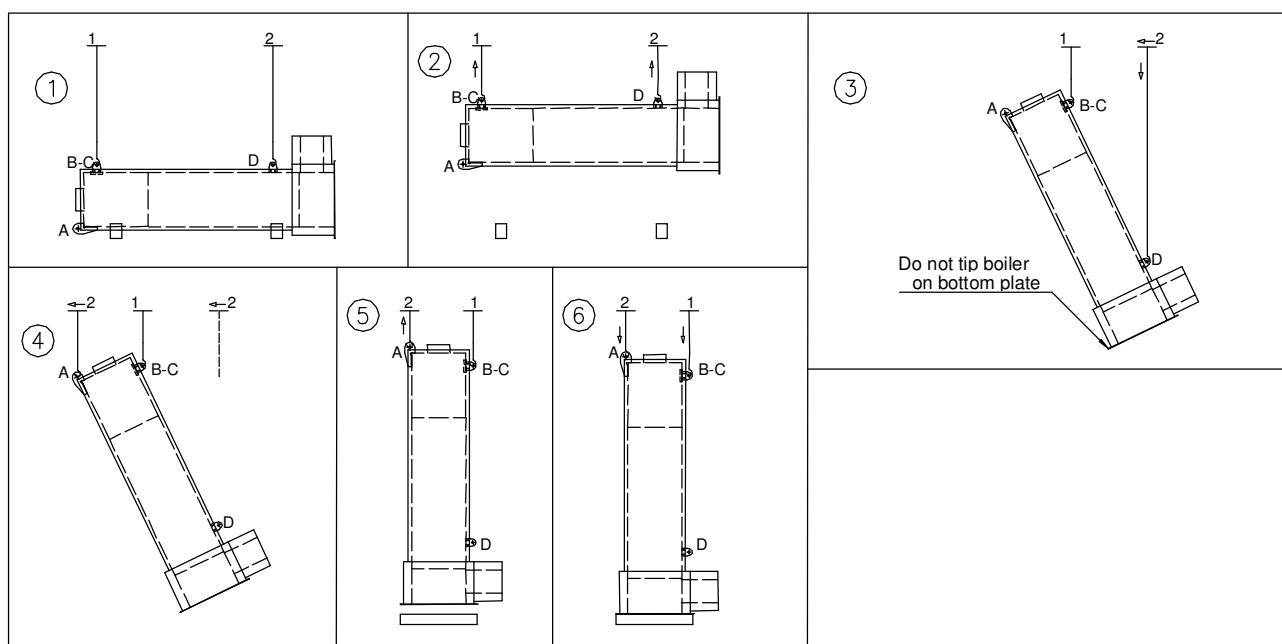


The brackets are NOT to be used for moving or lifting the boiler by means of a fork-lift truck or similar equipment.

Hoisting procedure for vertical boilers

1. The vertical boiler is provided with 4 lifting eyes (**A, B, C og D**). When the boiler arrives on site on its specially designed transport saddles, the eye (**A**) is facing downwards, whereas the three other eyes are facing upwards (**B and C at the top of the boiler and D at the bottom of the boiler**). From this position the boiler is to be hoisted by means of two separate cranes, where crane (**1**) is holding the two lifting eyes at the top (**B-C**) while the other crane (**2**) is holding the lifting eye at the bottom (**D**).
2. Proceed to hoist the boiler off the truck. The special transport saddles are to be cut off or dismantled. Then lift the boiler so that it is free of the ground or the foundation, when the boiler is tipped around.

3. The crane (2) holding the lifting eye at the bottom (D) is then to ease the wire or the chain until the boiler is hanging exclusively (by natural gravity) in the lifting eyes (B-C) at the top. It is important that simultaneously the crane (2) follows this movement horizontally in order not to create a lopsided or unbalanced pull, which might cause one of the cranes to tip over. **The boiler is under no circumstance to rest on the bottom plate in this position**, as it may result in deforming the bottom plate and/or the combustion chamber at the bottom of the boiler.
4. The crane (2) holding the bottom of the boiler is then to let go of the lifting eye (D). Hereafter the crane (2) is to move to the opposite of the other crane (1) holding the boiler by the lifting eyes (B-C). Crane (2) is then to hold the lifting eye (A).
5. From this position the boiler is now ready to be hoisted into the final vertical angle, by having crane (2) pull the lifting eye (A).
6. Once the boiler has been hoisted into its final positioning angle, both cranes are simultaneously and at the same speed to be eased, thereby allowing the boiler to be placed carefully on its concrete foundation.



Installation of the boiler and boiler mountings

Any boiler may be installed only in such places and under such conditions, complying with rules and regulations stipulated by the relevant local and/or national authorities in the country of installation. Here we are referring to for example the position and design of the boiler room, access and exit conditions, accessibility for maintenance and service of the boiler (flue gas and water sides alike) and its accessory equipment.

Placing the boiler on its foundation

At the top the boiler is provided with 2 lifting eyes, allowing the boiler to be easily lifted into position on its foundation by means of a crane. If a crane cannot be used, it is possible to roll the boiler into position by means of transport rollers.

The boiler is furthermore provided with handling brackets, suitable to facilitate the final handling and adjustment, once the boiler has been placed on its foundation.

The boiler is to be placed level on the foundation (on its transverse and longitudinal axes alike) - however, if applicable, possibly with a slight fall towards the bottom blow-down/drain valve.

Securing the boiler on the foundation

With a view to allowing a lengthwise expansion of the boiler, it is **essential that the rear boiler saddle can move freely** on the foundation. This will be ensured by placing the rear boiler saddle on sliding foil and by securing the front boiler saddle to the foundation - by means of welding or bolts.

In case of special conditions at the place of installation, it may prove necessary to secure the rear boiler saddle and instead allow the front boiler saddle to move freely.

The lengthwise expansion between the centres of the boiler saddles may be calculated according to the following formula:

$$\Delta L \cong L \times 1.2 \times (T_2 - T_1) / 1000 \quad [\text{mm}] \quad \text{where}$$

L = center distance between the boiler saddles [m]
 T_2 = the boiler's max. permissible operation temperature [°C]
 T_1 = the boiler's temperature in cold condition [°C]

Fitting of boiler mountings, control and safety equipment

The boiler is to be provided with boiler mountings and control and safety equipment, as required by local and/or national regulations.

The boiler mountings must be of a good quality and reliable and suitable for the actual operation conditions in terms of material and design and furthermore they are to comply with the requirements stipulated by the relevant national boiler authority.

When fitting boiler mountings and other accessory equipment, make sure that all packing surfaces and threaded connections are properly lubricated in graphite, dissolved in oil, or with another heat-resistant lubricant.



IMPORTANT !! We draw your attention to the fact that it may prove necessary to adapt the equipment described, in order to make it comply with specific national regulations in the country of installation.

Safety valves

The safety valves used must be type-approved for use in the specific country of installation, and the blow-off capacity must at the set release pressure be approved according to current regulations, applicable in the country of installation.

The safety valves constituting the last link in the system providing protection against excessive pressure in the boiler plant, it is extremely important to make sure that the mounting onto the boiler and connection to the blow-off pipe is carried out correctly and with care. The safety valves will normally be provided with protection houses on inlets and outlets. Only once the valves have been mounted on the boiler (ready to be connected to the piping), are you to remove these houses together with the protection of the lever arm.

If applicable, you are kindly referred to special instructions.

Service platform and ladder

The design and scope of supply of service platforms and ladders, if any, must comply with local rules and regulations applicable. In case the boiler is exposed to weights and loads from platforms and ladders, it is important to make sure that the areas concerned are sufficiently strong to bear such loads.

Boiler connections

Once the boiler has been correctly erected on its foundation, you may proceed to establish the boiler connections, piping and ducting.

In general it applies to all such connections that they are to be carried out in accordance with national and/or local rules and regulations.



PLEASE NOTE : The branch connections of the boiler are under no circumstances to be exposed to external loads or moments!

Connection to the chimney

The boiler is connected to the chimney via the flue gas duct, which may be connected to the boiler either by means of a welded joint or if necessary by means of a flexible connection with a view to making compensation for the thermal expansion of the flue gas duct and possible movements in relation to the chimney.

Connection to the distribution system

Connection to the distribution/heating system is to be established in such a manner that no movements of the piping will affect the boiler's flow and return branch sockets. If necessary, flexible connections shall be installed in order to compensate for any thermal expansion and movements of the piping system.

Connection to the blowdown system

In connection with inspections and/or repairs of the boiler and in case the boiler is taken out of operation it may be required to drain off the boiler water. The draining-off should always be conducted in a manner not likely to expose the operation personnel or other persons to any inconvenience or danger. Normally the drained-off water cannot be re-used and shall therefore be led to the draining well.



Normally, water with temperatures exceeding 35 °C is not allowed to be discharged into the public sewage system on a continuous basis. Consequently, it is recommended to conduct the draining of water via a blowdown tank or a well. Thereby the temperature of the drained-off water may be reduced by means of external cooling water or stone.

It is very important that the blowdown system is established in such a manner that the boiler's drain branches are not exposed excessively to the effect of surges and/or the thermal lengthwise expansion of the blowdown piping.

In high pressure hot water plants equipped with more boilers, the piping from each boiler's individual blowdown valves should be led and connected separately to the blowdown tank.



IMPORTANT !! We draw your attention to the fact that all regulations, stipulated by the local authorities in the country of installation specifically with regard to disposal of water to the sewage system, are always to be complied with.

Connection to the blow-off pipe from safety valves

The safety valves are to be mounted in such a manner that no vibrations, nor static or dynamic loads from the blow-off piping (and the silencer, if applicable) can be transferred to the safety valves. It must be ensured that blowing-off from the safety valves is allowed to take place in a safe manner, and the blow-off piping is normally to be led into open air (protected against frost).

The blow-off piping from the safety valves is to be established with a fall of minimum 0.5% and to be carried out so as not to cause formation of water pockets. In the immediate vicinity of the safety valves a drain point is to be established in the blow-off piping by means of an unclosable tell-tale pipe, led to a suitable place in the boiler room where any leaks will be detected immediately.

In case the blow-off piping is ended vertically, closable drains may be established as well.



Furthermore, the blow-off piping is to be made so that the counter-pressure during the blowing-off does not exceed the permissible pressure of the valve.

For further information you are referred to special mounting instructions, if any.

Installation of pumps and piping

Boiler shunt pump

An excessive difference between the flow and the return temperatures is likely to cause severe and harmful thermal stress in the boiler materials.

Such thermal stress, resulting from the thermal expansion and contraction of the materials, may cause leakages at for example expanded smoke-tubes or cracking in stay bolts and welded joints - which may again on their part cause leakages.

In order to avoid such stress in the materials the boiler is to be provided with a boiler shunt pump, so as to make sure that the prescribed MINIMUM return temperature to the boiler can be observed and maintained at all times.

For further reference you are kindly referred to **Daily operation and maintenance** (Section 4) – where for example the permissible temperature conditions of the boiler are stated.

The boiler shunt system may be established in a variety of ways, depending on the desired regulation conditions, possibly also related to the actual investment and operation costs of the shunt pump and the accessory regulation equipment.

The shunt circuit's connection point on the boiler return piping should be placed so that the correctly mixed temperature of the return water is achieved before the boiler's return branch socket.

The position of the shunt pump must be selected on basis of the requirements, stipulated by the pump manufacturer, in terms of necessary inlet pressure at the suction side of the pump. Furthermore, there must be sufficient space and access to perform correct connection and normal maintenance of the shunt pump, the closing and non-return valves as well as of other necessary control and regulation equipment.

When mounting the shunt pump and the piping, due consideration is to be given in order not to expose the shunt pump to damaging effects from piping and valves. If of a certain length, the piping system is to be properly supported before and after the shunt pump.

Undesirable noise from the shunt pump may be reduced by mounting compensators close to the pump's inlet and outlet and by placing the shunt pump on vibration absorbing material.

Standstill shunt pump

In case the boiler is taken out of operation for shorter or longer periods of time - particularly applicable to peak-load boilers - you are to proceed to preserve the boiler as described in **Preservation during Standstill (idle periods)**.

When choosing **wet preservation** the boiler can be kept warm and dry - i.e. heating surfaces holding a temperature of minimum 40 to 45 °C - by circulating hot water from another boiler by means of a standstill shunt system. Hereby the energy loss will be considerably reduced and the risk of corrosion will likewise be minimized.

The boiler standstill shunt system may be established in a variety of ways, depending on the desired regulation conditions, possibly also related to the actual investment and operation costs of the standstill shunt pump and its regulation equipment.

However, the system should be so established that the valve to the boiler's return branch socket will close during the standstill periods and that simultaneously the valve at the flow branch socket will remain open. On the suction side, the standstill shunt pump is to be connected to the boiler's branch socket specifically intended for standstill shunting, and the pressure side is to be led to the flow line of the heating system, immediately before the main pump.

In this way the hot flow water from the boiler(s) in operation will circulate backwards through the boiler that has been taken out of operation and heat this boiler to the correct temperature. On account of the water's variation of density throughout the boiler, the coldest water will always leave the boiler first.

The position of the standstill shunt pump must be selected on basis of the requirements, stipulated by the pump manufacturer, with regard to necessary inlet pressure at the suction side of the pump. Furthermore, there must be sufficient space and access to perform correct connection and normal maintenance of the pump, the closing and non-return valves as well as of other necessary control and regulation equipment.

When mounting the standstill shunt pump and the piping, due consideration is to be given in order not to expose the pump to damaging stress effects from piping and valves. If of a certain length, the piping system is to be properly supported before and after the shunt pump.

Undesirable noise from the standstill shunt pump may be reduced by mounting compensators close to the pump's inlet and outlet and by placing the pump on vibration absorbing material.

Feed water pumps

Feed water pumps should be mounted on a concrete foundation, sufficiently high to secure that the pumps will not be ruined in case the floor is flooded. Furthermore, the foundation should be big enough to allow sufficient space for correct connection and normal maintenance of pipings, valves and other necessary equipment.

For the position and mounting of feed water pumps, due consideration should be given to the normal lowest water level in the deaerator tank during operation, thereby making it possible to comply with the minimum inlet pressure at the pumps suction connecting branch, stipulated by the pump manufacturer – normally approx. 0,3 bar. The suction piping from the deaerator tank is to be led (with a fall) towards the feed water pump and with the fewest possible bends.

Feed water piping

When mounting feed water pumps and the feed water piping, it must be ensured that no harmful effects are transferred to the pump(s) from piping and valves. Piping systems of a certain length should be properly supported before and after the feed water pump.

Undesirable noise from the feed water pumps may be damped by mounting compensators close to the pumps' inlet and outlet and/or by placing the pumps on vibration absorbing material.

In plants where the feed water supply is controlled by automatic starts/stops of the feed water pumps, it is important to secure piping bends, on account of the fact that these starts/stops have a tendency to cause chock effects (water hammer effects) in the piping system.



PLEASE NOTE: In case a modulating feed water valve, which can be closed completely during operation, is used in the feed water system, a feedback connection to the deaerator tank should be established, dimensioned for the required minimum flow stipulated by the pump manufacturer with a view to safeguarding the pump against damage.

Piping

In case more boilers are connected to a common distribution system, proper precautions must be taken with a view to prevent hot water, due to incorrect operation or defective closing valves, from penetrating into a boiler that is accessible for inspection through a man hole.

This may be avoided by removing a suitable piece of piping, by the insertion of blind flanges or by mounting 2 closing valves, with an intermediate drain of a suitable size, intended to function as a so-called "tell-tale" facility.



PLEASE NOTE !! All piping is to be dimensioned, manufactured, mounted and controlled in compliance with rules and regulations, stipulated by the relevant national authorities.

When determining the layout and construction of the piping system, the following circumstances should be taken into consideration :

- All piping complete with valves and fittings must be appropriately placed and supported so as to allow thermal expansion and contraction, without exposing the system to excessive loads.
- In case the heating system is likely to be closed down during the winter, it must be possible also to empty and drain the pipes adequately, unless the piping otherwise has been properly protected against frost - e.g. by adding to the water sufficient amounts of a frost-proof mixture.
- The piping should be adequately insulated in order to prevent causing damage (scalding) to the operation personnel, to avoid unnecessary energy loss and in order to comply with the health-and-safety-at-work regulations applicable.

Installation of the blowdown tank

The purpose of the blowdown tank is to dispose of the blowdown water deriving from the boiler in a safe and appropriate manner. As blowdown of the boiler water is conducted with the explicit purpose of removing dirt and impurities from the water, **the blowdown water is not to be re-used and is to be led to a discharge well.**



PLEASE NOTE! We draw your attention to the fact that specific requirements, stipulated by the local authorities with regard to discharge of water to the sewerage system, are to be complied with.

It is very important to establish the blowdown piping in such a manner that the blowdown branch sockets on the boiler are not exposed in any way to stress or loads from surges and/or lengthwise thermal expansion of the blowdown piping.

Mounting of the tank's valves and fittings, regulation and safety equipment, etc. is to be carried out in accordance with relevant instructions.

Installation of thermal deaerator

The deaerator tank is to be placed on a level and solid steel frame, thereby allowing maintenance of the necessary pressure - normally approx. 0.3 bar - at the suction branch of the boiler feed water pump, as prescribed by the pump manufacturer.

When designing the steel support, due consideration must be applied in order to allow for the lengthwise thermal expansion of the deaerator tank caused by temperature fluctuations. Therefore, only one of the tank's feet is to be secured by bolts, whereas the other should be allowed to move freely in relation to the surface of the steel support frame.

Mounting of the necessary valves and fittings, regulation and safety equipment, etc., is to be carried out in accordance with separate instructions.

Installation of feed water tank

The feed water tank is to be placed on a level and solid steel support, thereby allowing maintenance of the necessary pressure at the suction branch of the boiler feed water pump, as prescribed by the pump manufacturer.

When designing the steel support due consideration must be applied in order to allow for the lengthwise thermal expansion of the feed water tank due to temperature fluctuations. Therefore, only one of the tank's feet is to be secured by bolts, whereas the other should be allowed to move freely in relation to the surface of the steel support frame.

Mounting of the necessary valves and fittings, regulation and safety equipment, etc., is to be carried out in accordance with separate instructions.

The Expansion System

All water-based applications must be equipped with one or more expansion tanks, the total capacity of which should be sufficiently big to accommodate the thermal expansion of the water during normal operation conditions.

In practice this implies that the tank(s) must be able to accommodate the cubic expansion of the water when being heated from 10 °C to the temperature in the heating plant, at which the excess temperature safety device will stop the combustion, however, without exceeding the set release pressure of the plant's safety valves.

With a view to determining the actual volume of the expansion system it will often be necessary to apply imperic values and practical experience, due to the fact that it may prove difficult - in spite of extensive and correct theoretical indications of the water capacity in pipes, radiators, heat-consuming components and boilers - to calculate the precise water content in the hot water application.

It may also be a further advantage that the expansion tank is slightly over-dimensioned in order to be able to accommodate a possible future extension of the plant.

The expansion tank may be connected at any place in the plant.



PLEASE NOTE ! The expansion tank itself as well as the connecting piping between the expansion tank and other components of the installation must be dimensioned so as to comply with the requirements, stipulated by the relevant national authorities in the country of installation.

The pressure in the system is provided by addition of a gas from a pressure tank (and/or by addition of steam). Under certain operation conditions the expansion tank may be provided with a membrane to separate the air and the water sections. The pre-set pressure of the tank must comply with current regulations in the country of installation.



PLEASE NOTE ! Under all operation conditions you must make sure that the pressure is sufficient throughout the plant so as to avoid generation of steam.

Pressure-Maintaining System

Another solution to maintain the pressure in the plant is to use a pressure-maintaining pump, which from an (perhaps non-pressurized) expansion tank will pump small amounts of water on a permanent basis into the circulation system of the plant.

A pressure release valve, mounted after the pressure-maintaining pump, is to ensure that the pressure in the plant is held within the prescribed limits. With a view to preventing oxygen from penetrating into the expansion tank, the tank may be provided with a membrane to separate the air and the water sections.

The Flue Gas Duct

It is of vital importance that the entire flue gas ducting is designed optimally with a view to minimizing the flue gas resistance throughout the system, thereby being able to make considerable savings with regard to operation costs (in terms of electricity consumption) of the combustion air fan and/or the suction fan.

The flue gas duct - to be manufactured in materials suitable for the operational conditions available and for the fuel used - must be short and provided with as few bends as possible. All duct elbows should be made with a large radius - minimum 1½ times the diameter of the duct.

It goes without saying that any national or local authorities' stipulations with regard to layout, inspection and cleaning of the flue gas ducts should always be complied with.

Mounting

The duct is to be placed in solid supports, thereby preventing excessive loads to be transferred to neither boiler nor chimney. In order to prevent flue gases from leaking into the boiler room (in case of over-pressure combustion) it is recommendable to assemble and connect the flue gas ducting by way of welding. If necessary the connections are to be provided with flexible connections for compensation of the thermal expansion of the flue gas duct and thereby allowing a certain margin of movement in relation to the chimney.

Connection of measuring and regulation equipment

The ducting system is to be provided with an adequate number of correctly and appropriately placed muffs for measuring and regulating equipment normally used - however, it should also allow for equipment required for periodical control measurements.

Insulation

With due regard to the safety and comfort of the operation personnel and to the general environment in the boiler room, the flue gas duct should be adequately insulated and provided with proper casing in materials suitable for the operation and installation conditions.

The insulation and the casing should be made with due regard to the connections for the measuring and regulating equipment.

Any outdoor parts of the flue gas ducts should likewise be suitably insulated and clad in order to comply with the installation conditions.

Start-up Procedure

Erection Supervision / Inspection

Prior to putting a new high pressure hot water plant into operation it is to be submitted to an erection inspection in order to ensure that the boiler plant complies with the requirements stipulated by the relevant national authorities in the country of installation.

In case the boiler plant is to function in unattended operation (normally surveillance every 24 or 72 hours) the specific authorisation to do so has to be applied for at the relevant national authority.

At this initial erection inspection the inspector verifies that the manufacture approval certificate, provided by the boiler-maker, is in order and that the prescriptions given with regard to boiler room layout, erection, operation, maintenance, all accessory equipment, their piping and all further equipment have been properly observed.

As far as boilers in unattended operation are concerned, it must furthermore be verified that the documentation required is available.

Provided that no significant irregularities are found during this erection inspection, the findings are recorded in the boiler logbook, completed by a statement to the effect that permission to put the boiler into operation has been granted.



A boiler plant may normally be put in operation only after the relevant national authorities in the country of installation have conducted an erection inspection and subsequently have granted the necessary permission.

It is always the full responsibility of the boiler owner that the boiler plant and its control and safety equipment is in perfect working condition and in compliance with the regulations concerned - and that the operation personnel is sufficiently skilled and qualified and holds the necessary permits for operating and maintaining the high pressure hot water plant in question.

Inspections prior to starting-up (filling of water)

Prior to starting up the boiler plant it is of vital importance to proceed to conducting a thorough visual inspection of all the components of the plant in order to secure a subsequent correct operation.

This inspection should comprise the following :

- Verification that all flange assemblies have been made with the correct feed moment.
- Verification that all inside surfaces are clean and that no objects have been left inside - for example cleaning tools or spare parts.
- Verification that all cleaning hatches and doors are closed and appropriately tightened.
- Verification that all pipe connections have been correctly connected and that protective covers, if any, have been removed.

PLEASE NOTE that all branch sockets on DANSTOKER boilers are protected with red plastic lids.

- Verification that all heat-affected areas are sufficiently insulated and that the insulation is intact everywhere.
- Verification that the safety valves are mounted as stipulated and that their drain and blow-off tubes are correctly connected.



WARNING ! Scalding risk from blow-off steam

It is important to ensure that the drain pipes from the safety valves are carefully mounted and connected to a protecting drain. Failure to do so may constitute a severe scalding risk to the operation personnel in case one of the safety valves should blow off steam directly - and unprotected - to the surroundings.

- Verification that the smoke damper, if any, is open.

- Verification that the inspection glass is appropriately tightened in open or closed position. Please note that the observation glass is always to be handled with care in order to avoid hurting the boiler operator – especially in over-pressure boiler plants – in case the glass might break. Whenever not used, the inspection glass should always be closed.
- Verification that draining sockets for condensate likely to develop in the smoke-box, the flue gas duct and in the chimney are in order.
- Verification that all the safety equipment mounted on the boiler has been correctly connected and tested.
- Verification that all electrical connections have been made correctly and that all electrical systems are working as intended.
- Verification that the combustion system and the combustion equipment is correctly mounted and has been tested mechanically.

Adjustment of electrodes for water level control

The number and the position of the various electrodes/probes will depend on the layout of the system as well as on the regulations stipulated by the national authorities in the country of installation.

The water level control system consists of a number of electrodes/probes mounted in flanges, placed on the boiler top - and perhaps also inside a water level flask (typically placed on the side of the boiler), provided with LW (low water) mark and water level indicators.

In high pressure hot water plants the water level control system is normally placed on an intermediary tube (a so-called “Christmas tree”) between the flow branch socket and the hot water system.

The lengths of the individual electrodes are adjusted by the boiler manufacturer to comply with the theoretical lengths, stipulated by current national regulations and general operation experiences – **See Fig. 1: Adjustment of electrodes for water level control.**

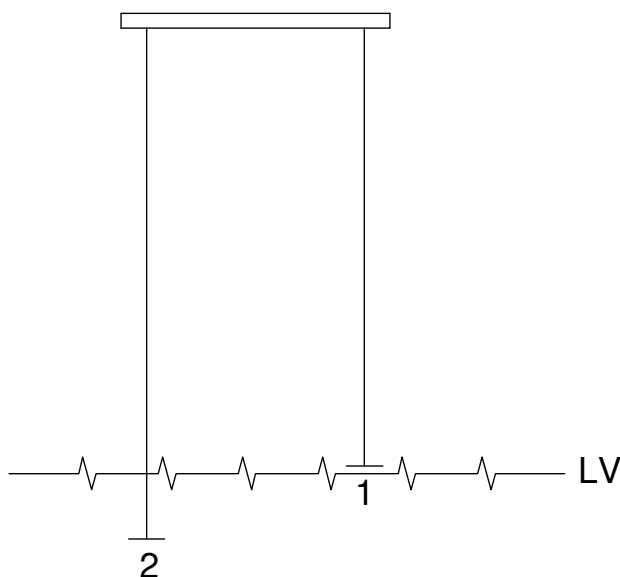


Figure 1: Adjustment of electrodes for water level control.

Once the boiler has been erected on its foundation it may prove necessary to make a correction of the individual lengths of the electrodes – possibly on basis of instructions provided by the national authority in connection with the erection supervision.

Adoption of the following procedure for shortening and/or adjustment of lengths of electrodes is recommended after having filled the boiler with appropriately treated boiler feed water :

Low water electrode (electrode No. 1)

The electrode is to be just free of the water surface, when the water level is flush with the L-W (low water) mark.

Low-low water electrode(s) (electrodes No. 2)

The electrode(s) shall be maximum 30 mm below the L-W mark. However, the water level shall at all times be visible in the water gauge glasses.

Boiling-out / Cleaning of the boiler

The boiler is an all-welded construction and no lubricants have been used for the manufacture. Therefore, it is normally not necessary to conduct an alcalic boiling-out of the boiler, unless there are specific requirements with regard to the purity of the boiler water.

However, it is always recommendable to conduct a cleaning of the water circuit, prior to putting a new boiler into operation.

In case you want to make sure that the boiler surfaces in the water side are completely clean, or in case the boiler has been contaminated during operation with fats or oils of any kind, it is recommendable to adopt the treatment described below.



PLEASE NOTE: Prior to starting the firing equipment in connection with the boiling-out, the proper permits to operate the boiler, issued by the relevant national authorities, must be available.

Inspection

The boiler is to be inspected in the water and flue gas sides and mislaid objects, if any, are to be removed.

Preparations

The boiler - and preferrably also the piping system – is to be flushed with water, if possible by demineralized or softened water. New gaskets for the head and man holes covers shall be available for mounting after completion of the boiling-out.

Filling the boiler with water and chemicals

The boiler is to be filled with demineralized or softened water to slightly above the L-W mark. Simultaneously chemicals are to be added through the upper man hole or though another available branch sockets at the boiler top.

Chemicals to be used :

4 to 5 kg trisodium phosphate - Na_3PO_4 - per m^3 water.

The chemicals are to be dissolved - while stirring - in hot water before being fed into the boiler.

Shutting off the boiler

After the chemicals have been added, the man hole cover(s) and the flow/return and feed water valves are to be closed, whereas the manometer valve and air valve are to be kept open.

Firing

The firing is to be conducted at lowest load, equivalent to approx. 15% to 25% of max. nominal boiler rating and shall be conducted at a moderate phase, while observing the following intervals :

1st hour: 5 minutes operation - 10 minutes stop
2nd hour : 10 minutes operation - 10 minutes stop
3rd hour : 15 minutes operation - 10 minutes stop

The air valve is to be shut at approx. 1 to 1½ bar(o) boiler pressure, when pure steam escapes through the valve.

Hereafter, proceed continuous firing on lowest load until a boiler pressure of 5 bar(o) has been reached. Hold this pressure for a duration of approx. 8 hours - and subsequently stop the burner or the combustion equipment.

In case the firing process involves admission of hot flue gases to be led through the boiler, the firing will have to be conducted and adjusted - depending on the temperature of the flue gases - to the actual conditions, possibly regulated by means of a bypass damper.

In biomass-fired boilers there will normally be no problems in this respect, due to the fact that the firing equipment itself will require a gentle firing process.

Cleaning

Now proceed to empty the boiler through the bottom blowdown or drain valves.

Once the boiler has been cooled down, proceed to open all handholes and/or manholes and to flush the boiler carefully from above, with the bottom blowdown valves in open position. The blowdown valves should not be activated until the boiler is completely clean, in order to avoid damage due to impurities.

If necessary, the bottom blowdown valves should be dismantled in order to remove any foreign matters.

Flushing of the boiler and preferably also the piping system should if possible be conducted by means of demineralized or softened water.

Final preparations

Proceed to mount new gaskets in headholes and manholes and subsequently carefully tighten these covers. Hereafter the boiler is ready to be put into operation, as described in **Start-up of boiler plant (section 3)**.



Please note !

In case the boiler is not put in operation immediately after the boiling-out, the procedures for “Preservation during standstill” (section 8) should be complied with.

Start-up of the boiler plant

In general

The information below describing the start-up of a high pressure hot water boiler from cold condition is to be considered as a guide only, and the accessory equipment described is based on the Danish rules and regulations applicable to high pressure hot water boilers.



CAUTION !

We draw your attention to the fact that it may prove necessary to adapt the equipment described in order to comply with national authorities' requirements in the country of installation.

The following points are to be verified prior to putting the plant in operation :

- Fill the boiler with appropriately treated water, complying with the requirements to the water quality, as stipulated in **Requirements to Water Quality (Section 5.2)**. During filling of water, the air in the boiler is to be scavenged through the air valve, which will have to be kept open until only water flows through the valve on a continuous basis.
- Verify that the water treatment plant is ready for operation - and check that the necessary chemicals are available in the dosing plant.
- Check that all valves are in correct start position, as stated below.
- Check that there are no signs of leakages.
- Verify that regulation and control panels are operational.

Position / Setting of valves

The setting of valves is difficult to describe, as Danstoker did not supply the heating system that the boiler is connected to. Consequently, Danstoker is not familiar with the exact layout details and position of valves.

The variety of layouts of for example the shunt system, the expansion system, the feed water system, the pump group, etc., will imply equal amounts of varieties with regard to setting of valves.

Therefore, we recommend that you consult relevant documentation in this respect, for example written documentation provided by the responsible supplier/contractor of the entire heating system (inclusive of the boiler supply).

However, with the purpose of preventing the boiler from being exposed to inappropriate temperature and pressure conditions, Danstoker stipulates requirements that may be observed by means of a correct setting of valves during start-up procedures of the boiler - i.e. :

- Water circulation in the boiler is to be established (either via a shunt or via the entire network).
- Establish facility for supply of feed water.
- The standstill shunt, if any, must be shut off (the connection as well as the pump itself).
- The valve to the automatic air valve, if any, must be open.
- All bottom drain or blowdown valves must be closed.

- Air valves, if any, must be closed.
- Valves connecting the pressure part to various measuring equipment must be open.

Start-up of water treatment system

Please consult special instructions for start-up of the water treatment unit.

Start-up of the feed water system

The feed water system may be supplied, designed and/or constructed by a supplier other than **Danstoker a.s.** Therefore, the following instructions are indicative only and serve merely as general information.

Prior to putting the boiler plant in operation, the feed water system is to be operational.

When starting the feed water system, the following points are to be checked and/or carried out :

- Check the raw water supply and the quality of the raw water.
- Verify that the water treatment system (softening unit) is operational.
- Check the water level in the feed water tank and/or the deaerator tank.
- Check that the water level regulation of the feed water tank is functioning so that the water supply from the water treatment plant can maintain the water level required. Also check that the feed water pump will stop at too low water level in the feed water tank.
- Start the water treatment system, if not already in operation.
- Check the temperature in the deaerator tank to make sure that feed water holding a correct temperature may be fed into the boiler.
- Verify that the automatic water level regulation (on the boiler and/or on the deaerator/feed water tank) is functioning correctly. The regulation will normally function on/off in the form of starts/stops of the boiler feed water pump.

Firing / Operation of the firing equipment

Definition of firing equipment (burner)

As the Danstoker boilers are often used in applications designed specifically for the client's individual purposes, the expression of **FIRING EQUIPMENT (burner)** used in this manual may apply to a large variety of firing methods and combustion principles.

As examples we could mention oil and gas burners, dual fuel burners, turbines and engines, combustion of various kinds in kilns, incinerators, combustion chambers and combustion on grates.

This variety of combustion equipment may call for special attention in terms of firing and start-up procedures, interruption of the firing, maintenance, etc.

In general

The longevity of the boiler depends among other things on the number of boiler starts. In this connection an average of max. 1,000 cold starts and max. 10,000 warm starts may be expected in the course of a 20-year lifetime, with operation loads ranging between 40% and 100%.

Furthermore, it is a fact that the longer time the boiler is allowed for each single start and the slower the boiler is released from minimum to maximum nominal load, the longer the life of the boiler will be.

With a view to obtaining a gradual and uniform heating of the boiler material and the refractory lining alike, if any, and with a view to avoiding excessive temperature stress in the boiler body (and thereby the risk of causing cracks, fissures and leakages on account of different dilation co-efficients of the boiler material) **it is of the utmost importance to observe and comply with the instructions given in the following.**

Typical damage in case the boiler is fired excessively fast may be the development of cracks and fissures in tube and stay weldings at the first pass (reversing chamber and rear tube plate). Such damage is caused by the longitudinal dilation of the furnace, due to the fact that the furnace material, when firing the boiler excessively fast, will dilate faster than the remaining parts of the boiler.



PLEASE NOTE: Your right to present a valid claim to Danstoker shall lapse, in case the firing of the boiler to the operation temperature is conducted too fast, or if the modulation from 25% load to 100% load is done too quickly.

We distinguish between two start-up situations – i.e. :

The boiler is already in operation

Whenever the boiler is already in operation – i.e. that the firing equipment has been in operation within the last 5 minutes – the firing equipment may be used freely.

However, please note that the firing equipment must always be run slowly up in load from approx. 25% to 100% load – i.e. a minimum duration of 10 minutes (please see Fig. 1).

All other situations

In all other operation situations the firing load must at no time exceed 15% to 25% PRIOR to achieving the operation temperature!

No crystal-clear and unambiguous indication can be given as to the length of the low-load period. Depending on the circumstances this low-load period may vary from several days (initial start-up of a new plant) to approx. 15 minutes (boilers which are stand-still-heated and kept at the operation temperature).

Only once the operation temperature has been achieved, the firing equipment – after running minimum 15 minutes AT the operation temperature – may be released for maximum load (please see Fig. 1).

However, please note that the firing equipment must always be run slowly up in load from approx. 25% to 100% load – i.e. a minimum duration of 10 minutes (please see Fig. 1).

These instructions also apply to boilers running in cascade operation!

Special requirements, however, may be stipulated with regard to the initial start-up of a boiler plant, with a view to allowing sufficient time for the optimal drying process of the boiler's refractory lining.

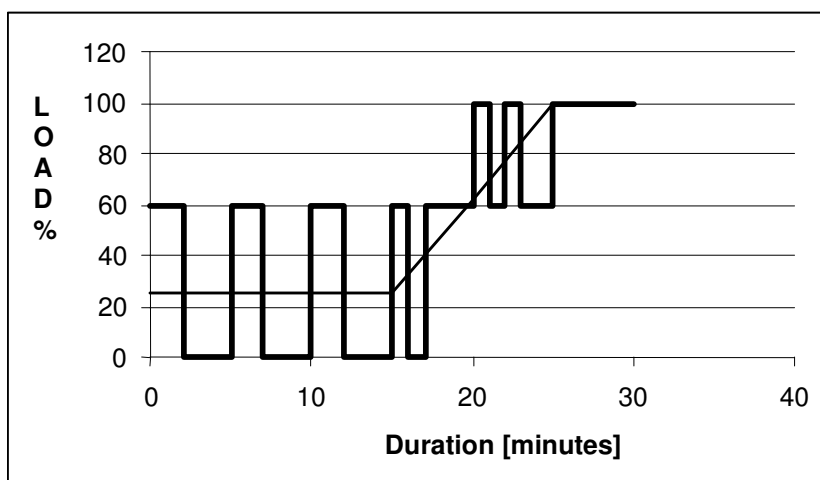


Fig. 1

Figure 1: The thin line illustrated the ideal start-up sequence, and the black line illustrated the start-up procedure of a 2-step burner.

Controls to be made when starting up the boiler

Control of the boiler pressure

During the start-up period the volume of the boiler/plant water will increase. Provided that the expansion system is correctly dimensioned, this volume increase will not cause the pressure to rise.

If, however, the increase of the pressure is so great that it is getting close to the permissible pressure, the bottom drain valve may be activated for a short while in order thereby to reduce the pressure to slightly under the normal level. In this manner it will be avoided to activate the safety valves unnecessarily.

Subsequently, an adjustment of the capacity of the expansion system should be made accordingly.

Scavenging

In case feed water that has not in advance been completely deoxygenated is used - free oxygen will gradually develop during the heating of the boiler water to operation temperature. This oxygen is to be removed **immediately** from the boiler plant via deaerators, fitted on ventilating pots, to be placed on the highest points of the plant.

The correct function of the deaerators should be checked at regular intervals.

Control of condensate water

The vapour generated by the combustion will during the start-up phase and in the initial operation period to a large extent condensate in the boiler's smoke tubes until the flue gas system has been completely heated.

It is therefore of great importance always to verify the correct function of the drain sockets fitted in the smoke-box, in the flue gas duct and in the chimney, in order thereby to minimize the risk of corrosion.

All drains from the flue gas system are to be provided with water traps or other types of separation between the boiler's flue gas side and the atmosphere. These separations must be inspected at regular intervals – however, always in connection with momentary shut-downs of the firing equipment.

After-tightening

Once – during the firing of the boiler – the temperature and the pressure start to rise in the boiler and once the operation pressure has been achieved, you may proceed to look for possible leakages.

Verify that all flange connections, the valves' packing boxes as well as hand, head and man holes, etc. fit tightly. It is particularly important to make this check when the boiler is being put in operation for the first time or when it has been taken out of operation for a prolonged period of time.

If a leakage is found, after-tightening of flange connections and the like should be made immediately, provided it is evaluated that they can be tightened with-out stopping the boiler plant. If need be, the firing load should be reduced, thereby ensuring that the pressure will not rise while the tightening is being carried out.

Unnecessary violence or power should not be applied when making the tightening in order to avoid damaging the packing material or the bolts.

Doors and hatches as well as joints on air and flue gas ducting should likewise be checked with regard to leakages.

During operation

Daily operation and maintenance

It is of vital importance that the boiler capacity is adjusted so as to correspond to the varying heat requirements of the boiler plant, without exposing the boiler unit to extremely low or extremely high loads. Thereby you will achieve a much greater operational safety, a considerably more economical operation as well as a longer lifetime of the boiler.

Once the boiler has been put into operation, it must be kept under pressure until the next inspection. However, it is advisable to reduce the pressure, whenever the boiler is not in operation with a view to minimizing the chimney and the radiation loss.

The heat input (the fuel quantity) is to be adapted according to the instructions for the firing unit in question and is to be adjusted to meet the general heat requirement with a view to achieving an **even and homogenous transfer of energy** from the boiler's heating surfaces to the boiler water.

The boiler is not to be used for burning other types of fuel than those agreed and specified for this particular supply, unless an analysis has been made of the fuel and its possible corrosive effects on the materials that have been used for the manufacture of the boiler and/or the combustion equipment.

Likewise the combustion air used in the heating plant must not contain particles or be contaminated by other agents, likely to have a deteriorating or corrosive effect on the boiler or other parts of the combustion plant.

If necessary, suitable counter-measures must be initiated.



Danstoker cannot be made responsible for any chemical and/or temperature-related deterioration of the materials of the boiler and of the combustion plant, nor for any consequence of burning unsuitable fuels !

Likewise Danstoker cannot be made responsible for metal fatigue, caused by repeated pressure variations/fluctuations.



With a view to minimizing the risk of corrosion, the temperature of the return water - and the smoke temperature as well - should be kept as high as possible and must at any rate never be lower than the temperatures stated below :

	<u>Return water</u>	<u>Flue gas</u>
Combustion of <u>BIO-GAS</u>	80 °C	160 °C
Combustion of <u>NATURAL GAS</u>	60 °C	120 °C
Combustion of <u>LIGHT FUEL OIL</u> (max. sulphur content : 0,5 %)	60 °C	120 °C
Combustion of <u>FUEL OIL</u> (max. sulphur content : 0,5 %)	60 °C	120 °C
Combustion of <u>FUEL OIL</u> (max. sulphur content: 2,5%)	70 °C	160 °C

	<u>Return water</u>	<u>Flue gas</u>
Combustion of <u>STRAW</u> (*)	85 °C	120 °C
Combustion of <u>WOOD</u> – please see below.		

(*) Depending on the fuel quality and the content of chemicals and salts contained in the fuel and the combustion air.

Combustion of WOOD

	Air excess 1,9	Air excess 1,6	Air excess 1,3
Water content / humidity of the wood	Minimum return	water	temperature to the boiler
15%	76 °C	80 °C	84 °C
25%	80 °C	84 °C	88 °C
35%	84 °C	88 °C	93 °C
45%	88 °C	93 °C	98 °C
55%	93 °C	98 °C	104 °C
65%	100 °C	104 °C	108 °C
Minimum flue gas temperature, irrespective of humidity of fuel	120 °C	120 °C	120 °C



In case you find any traces of corrosion in the boiler or register aggressive agents in the fuel, the combustion air, the exhaust gases or the ashes, likely to cause corrosion, the heating plant should be stopped immediately and the unintended and inappropriate conditions set right

If in doubt, you should immediately contact the supplier of the plant.



With a view to avoiding thermal stress and thermo chock the following conditions must be complied with :

- **Maximum permissible temperature difference between the flow and return water of the boiler is 30 °C.**
- **The temperature difference shall be kept as low as possible.**
- **At boiler loads less than 30% of nominal capacity, there must be a water flow through the boiler of minimum 30% of the nominal flow.**

PLEASE NOTE that failure to comply with the above stipulations will cause the Danstoker warranty obligations to lapse !!

The safety equipment of the boiler should be checked on a daily basis according to current regulations.

Water analyses shall be made once a day, and if necessary the chemical dosing and the blow-down quantities are to be adjusted accordingly, in order to ensure that the boiler water complies at all times with the prescribed requirements.

The combustion should be checked on a daily basis by visual inspection and furthermore preferably by analysis measurements of the exhaust gas. In case of irregularities or deviations, the combustion must immediately be adjusted accordingly.

The inspection glass should only be activated during standstill or at low burner load in order to prevent damage on the glass and/or the packing. When not used, the inspection glass must always be tightened in closed position. If the glass should break when in open position (in over-pressure boilers), it may cause severe damage to the plastic-coated cover plates.

In case of leakages from stuffing boxes and flange gaskets, they should be tightened immediately, as the packing surfaces are otherwise worn excessively.

Cleaning and inspection covers should be checked at regular intervals, and if necessary tightened. They must fit completely tight, otherwise the resulting leakages are likely to discolour and damage the cover plates.

Stop of the boiler

Operation situations may occur where it will prove necessary to stop the boiler for shorter or longer periods of time.

Normal boiler stops

In installations where the boiler is intended to generate high pressure hot water only for a part of the day and/or only on normal working days, the boiler is usually stopped after the operation period by modulating the burner/combustion equipment slowly down to minimum load.

Hereafter the following procedure is to be complied with :

- The firing and the energy supply (oil, gas, biofuel, hot flue gases, etc.) is to be stopped by switching the fuel control into "OFF" position.
- In installations equipped with a single boiler, the oil supply aggregate is stopped. In plants fired by heavy fuel, however, the circulation should be continued in case there is a risk of the oil stiffening in the piping system. If the normal heating media (hot water) is not available, the electrical preheater must be coupled in.
- The feed water supply is to be stopped by switching the feed water pump regulator into "OFF" position. Simultaneously the feed water valves at the boiler and at the deaerator/feed water tank alike are to be closed.
- The boiler shunt pump to be stopped.
- The main circulation pump to be stopped.
- In case it is possible to establish a standstill heating system - as described in **Standstill shunt pump (section 1)** - proceed to start this system.

Hereafter, the boiler may be left in this condition until the next normal start-up.

Stop for normal boiler inspection and maintenance

In case the boiler is taken out of operation with a view to performing ordinary periodic inspections and maintenance, it may prove necessary to accelerate the cooling down of the boiler in order to provide access to the flue gas and water circuits within a reasonable period of time.

However, it is of vital importance to conduct the cooling-down in a homogeneous and gradual manner, in order to prevent excessive material stress likely to cause damage to the boiler construction.

The cooling down should be conducted at a maximum rate of approximately 2 °C per minute.

You are recommended to apply the following procedure :

- Run the boiler slowly down to minimum load and proceed to stop the firing and the energy supply (oil, gas, biofuel, hot flue gases, etc.) by switching the combustion control into "OFF" position.
- The fuel supply valve to the oil burner, respectively to the gas burner, is to be closed. In plants with a single boiler the oil supply aggregate is to be stopped. In plants fired by heavy fuel, however, the circulation should be maintained in case there is a risk of the oil getting hard in the piping system. If the normal heating media is not available, the electrical preheater should be coupled in.
- In boiler plants burning solid fuel endeavours must be made to try to minimize the amount of unburnt fuel in the boiler whenever the fuel supply is stopped - subsequently, the burning-out should be accomplished by means of a combustion air fan, running at reduced rate. When the burning-out is sufficiently advanced, you may proceed to stop the combustion air fan altogether, and the final combustion continues by means of the air that the smoke exhauster alone will supply to the fuel. In case the draft conditions are sufficient to remove the remaining smoke, you may proceed to stop the smoke exhauster completely.
- The temperature is to be slowly lowered by continuously circulating return water from the network through the boiler (in case this is possible) until there is no longer a temperature difference between the flow and the return branch sockets of the boiler. Subsequently, the flow and return closing valves are to be closed.

- Proceed to decrease the pressure in the boiler gradually by repeatedly and briefly activating the bottom drain valve.
- For boilers, fitted with an oil or a gas burner, the burner is to be swung out of the burner front plate, if possible. Likewise the inspection door in the boiler rear end is to be opened. In this manner there will be a further cooling from the flue gas side of the boiler water and/or the boiler construction due to the draft of air thereby achieved. An important condition for doing so, however, is the fact that the boiler flue gas outlet is led separately from the boiler to the chimney.
- For boilers, fitted with a combustion aggregate for solid fuel or oil/gas burners with separate combustion air fans, this fan may furthermore be utilized for ventilating the smoke circuit of the boiler and thereby contribute to a uniform and gradual cooling.
- The feed water supply is to be stopped by switching the feed water pump control into "OFF" position. Simultaneously the closing valve at the deaerator/feed water tank is to be closed.
- Once the permissible temperature for discharging the boiler water into for example the municipal sewerage system has been achieved, you may proceed to open the bottom drain valve and drain off all the water.
- Once the pressure in the boiler is approx. 0.5 barg, the air valve may be opened, thereby facilitating the emptying process of the boiler and preventing a vacuum from building up inside the boiler.
- Once the boiler has been emptied of water, the bottom drain valve(s) is/are to be closed again. Prior to closing the drain valve(s), you may flush the boiler in the water circuit with cold water through the hand, head or man holes, in order to remove possible remains of impurities and deposits.

Emergency stops

In the course of operation, certain dangerous situations may occur, which will call for an immediate stop of the boiler - a so-called emergency stop. In case such situations occur, the boiler plant is to be stopped by activating the emergency stop, that must be available in the control panel and/or on other suitable places in the boiler room, in compliance with the current regulations applicable in the country of installation.

After activating the emergency stop the boiler's closing valves are to be closed, in case this can be done without causing any risk to the operation personnel. Further actions and measures to be adopted will depend on the actual reason for the emergency stop.

The following situations may necessitate an emergency stop of the boiler plant :

- Development of sudden circumstances of unknown origin - such as abnormal sounds (rumbling, knocking) or movements from the boiler plant.
- In case signs of overheating or deformation in parts of the boiler construction are registered.
- Explosion of the fire-tubes or the furnace.
- Failures in the safety equipment, which cannot be exchanged/repaired during normal operation.
- Failures in the feed water system, which will cause a stop of the feed water supply to the boiler.
- In case of breaks or leakages that cannot not immediately be eliminated and in case of failures or leakages in the make-up water system, which will cause a stop of the necessary make-up water supply to the boiler.
- In case of imminent fire danger or actual fire in the fuel supply.
- In case of power failure, causing the combustion not to start automatically again.
- In case of the pressure rising above or falling below the normal level in the boiler and the piping system.



The national authorities in the country of installation shall be summoned immediately after discovery of any conditions likely to have an effect on the safety of the plant. Prior to the arrival on site of a representative from the authority in question you may not proceed to conduct any modification or clearing/removal operations of the damaged part or its immediate environment, unless it is imperative to do so with a view to saving lives or to prevent additional accidents or extensive loss and damage.

Logbook (Recording of operation data)

Once the system has achieved normal operating conditions, you may proceed to check and record all process parameters, such as pressure and temperatures in the system.

Such data will provide the operators with valuable information that may be used as a reference when comparing process data with actual values obtained when the installation was new - with a clean system and clean tubes.

Furthermore, all unnormal situations that may occur are to be recorded, a fact that may prove of great importance with a view to establishing on a later occasion the reason(s) for - for example - boiler damage or other irregularities.

Enclosed with this manual (at the back) you will find suggested layouts of such LOG-BOOKS (Operation Journals) for :

- **Daily registrations (boiler parametres)**
- **Daily registrations (water analyses)**

Boiler and feed water system

In general

Boiler water

Impurities in the boiler feed water affect not only the efficiency of the boiler plant, but also its safety - consequently this issue is of major concern to the operating personnel, and it deserves special focus and attention.

The problems, which will inevitably arise in case untreated (or insufficiently treated) water is used in a hot water plant, may appear already within a very short time of operation !!

The typical problems will be :

- Formation of scale and deposits on the heating surfaces in the boiler.



In case any trace of scale is found in the boiler, your right to present a valid claim to Danstoker shall lapse.

- Deposits of sludge and rust, which - in connection with the oxygen content of the water - will result in pitting under these deposits. Furthermore, other plant components outside the boiler are likely to be damaged if similar impurities are deposited there.
- Oxygen corrosion on boiler parts as well as in the piping, radiators and other parts outside the boiler.
- Corrosion in the boiler and in other parts of the installation on account of an excessively high salt content in the circulation water.
- Excessive use of sodium hydroxide (NaOH) for adjustment of the pH-value may cause stress corrosion cracking (or caustic embrittlement) in the form of typical micro cracks/fissures.

The main objective of proper treatment of the water, fed into a hot water plant, is therefore :

- **To prevent impurities from entering the system altogether.**
- **To eliminate the harmful effects of these impurities, if any.**

The undesirable impurities usually find their way into the circulation system via the feed water system. Without a correct treatment of the water (mechanical and/or chemical), the risk of provoking scale formation and corrosion in the hot water system and its accessory equipment will be unacceptably high.

In the following are stipulated requirements to the quality of the water in high pressure hot water plants. These requirements are based on the TRD 612 recommendations as well as extensive general experiences from such plants.

Thus, compliance with these instructions provides the optimal operation form.

**PLEASE NOTE :**

Failure to comply with the requirements stipulated below with regard to water quality will cause the Danstoker warranty obligations to lapse !!

Requirements to water quality

Requirements to FEED WATER and CIRCULATION WATER in fire-tube boilers generating *HIGH PRESSURE HOT WATER*

FEED AND CIRCULATION WATER				
General condition :				
The water is to be clear and free from odour and undissolved solids !				
Quality classification		Saline water	Non-saline water	
Conductivity at 25 °C	µS/cm	> 100 to 1500	≤ 30	> 30 to 100
pH-value at 25 °C (*)		9,0 to 10,5	9,0 to 10,0	9,0 to 10,5
Oxygen O ₂ FEED WATER	mg/l	< 0,02	< 0,1	< 0,05
Oxygen O ₂ CIRCUL.WATER	mg/l	0	0	0
Total hardness (ca + Mg)	mmol/l	< 0,02	< 0,02	< 0,02
<p>Subject to all values being measured at the inlet to the boiler.</p> <p>(*) It is recommended to adjust the pH-value by means of tri-sodium phosphate (Na₃PO₄) and only use sodium hydrate (NaOH) whenever the pH-value stipulated cannot be achieved by means of Na₃PO₄ alone.</p> <p>The above requirements are identical to the recommendations stated in TRD 612, and many years of operation experiences have established that an operation based on non-saline water offers many advantages, for example by reducing the risk of corrosion.</p>				



Danstoker cannot in any way be held responsible for the chemical and/or temperature-related deterioration of the boiler materials - nor for the consequences of the use of feed and circulation water that does not comply with the requirements stated above !!

Treatment of feed water

The treatment of the feed water is a form of preventive treatment. The purer the feed water is, the less problems will arise in connection with the feed and circulation water treatment - and thereby allowing you to avoid possible operation problems in the future.

- With a view to determining the form of preventive treatment required, it is essential to have the raw water source properly examined and the raw water thoroughly analysed.
- The required water treatment depends not only on the desired quality of the water, but also on the composition of the raw water itself.



CAUTION !

It is important to have the raw water analysed at regular intervals and not only rely on the initial/original water analysis. The conditions may change and the composition of impurities may change accordingly.

Formation of scale

The formation of scale on the heating surfaces of the boiler will result in a reduction of the boiler efficiency on account of the decreased heat transfer, resulting in a deterioration of the operation economy.

Depending on the composition of the raw water the scale may - in addition to calcium carbonate - also contain silicate compounds, iron and cobber oxides. These salts may cause development of scale on the fire-tube walls and on other steel surfaces - unless appropriate counter-measures are initiated in the form of treatment of the make-up water.

However, the main concern in connection with scale is the risk of excessive heating of the water-cooled surfaces of the boiler.

The circulating boiler water functions as a cooling media for the heating surfaces (the tubes), and as the scale deposits have a low heat transfer coefficient, the scale deposits will result in a lower cooling efficiency and cause the temperature of the steel material to increase.



PLEASE NOTE: Your right to present a valid claim to Danstoker a-s shall lapse, whenever scale is found in the boiler.

Consequently, it is essential that the scale-generating agents are removed from the make-up water by means of a softening unit - or alternatively by means of a de-salting unit.

The water treatment system chosen must be dimensioned so as to have sufficient capacity to treat the amount of make-up water required to compensate for the loss of circulation water that disappears through leakages throughout the entire water system.

Furthermore, the system must have additional extra capacity to allow for smaller pipe bursts and re-filling of a certain length of piping in connection with pipe exchanges.

When determining the capacity it should also be considered whether the unit - within a reasonable time - shall be capable of filling the entire circulation system.

Sludge and rust deposits

The suspended particles may be found in a variety of forms and must be removed from the raw water, provided the raw water is to be used as make-up water.

Larger particles - such as sludge and rust shells - are removed by filtering (partial flow) 3 to 5% of the circulating water. The water (for filtering) shall be taken out from the bottom of a pipe on the return piping of the network - and preferably at the lowest point.

Organic matters and micro-organisms must likewise be removed from the raw water, provided the raw water is to be used as make-up water.

The matters that we wish to remove often consist of very small particles, and consequently they must be collected into larger particles by adding special chemicals to the water - i.e. by means of so-called **flocking**. Subsequently, it will be possible to remove these particles - either by flotation or sedimentation. Any small particles, if any, still remaining in the water can be removed by leading the water through an open sand filter.

Dissolved gases (oxygen, carbon dioxide, nitrogen)

The raw water (tap water) contains oxygen, free carbon dioxide and nitrogen, all in the form of dissolved gases.

The oxygen - which constitutes approx. 20% of the dissolved gases - is undesirable in district heating water, as it **may cause severe corrosion** on metal and alloys, used in high pressure hot water heating plants. Tap water with a temperature of 8 °C may contain up to approx. 11 mg of oxygen per litre water - however, the normal content is approx. 9 mg/litre.

Under sludge deposits on for example the furnace, reversing chambers and smoke tubes, where only a part of the steel surface is covered, the oxygenous water may cause pitting. Pitting develops very fast and constitutes the most serious type of corrosion inside a boiler.

Therefore, the oxygen must be removed from the water by thermal or chemical deaeration.

The thermal deaeration may take place in a deaerator tank, in which the feed water will be heated to approx. 105 °C, while being under a pressure of approx. 0.2 baro. In this process the content of oxygen in the water may normally be reduced to 0.02 mg/l.

Any still remaining oxygen is to be removed by adding chemicals to the feed water, before it is subsequently pumped into the hot water system.

Carbon dioxides normally do not constitute a severe problem in connection with feed water for hot water heating systems, as a conditioning of the water to hold a pH-value between 9 and 10 will convert free carbon dioxide to sodium carbonate.

Nitrogen - which constitutes approx. 80% of the dissolved gases - is not in itself corrosive, however, as it is not possible to remove the oxygen selectively, the deaerator is to be so dimensioned that also the nitrogen is removed in the process.

Dissolved salts

Dissolved salts, chlorides (NaCl, MgCl₂), sulphates (MgSO₄, CaSO₄) and carbonates (CaCO₃) - which may enter the boiler with untreated make-up water, must also be removed in order to prevent the formation of scale and corrosion in the system.

This removal may be conducted by adopting one of the following methods - i.e. by **ion exchange** or by **reverse osmosis**.

A typical **ion exchange unit** consists of a very sour cation and a very basic anion exchanger, a regeneration equipment with hydrochloric acid and sodium hydrate tank as well as a neutralization unit, which will neutralize any excess of acid and base from the regeneration liquids, before the water is led to the sewage system.

A **reverse osmosis unit** (RO-unit) is primarily used whenever reduction of the salt content in the water is of vital importance. The pureness of the permeate depends on the quality of the raw water which is to be treated.

Reverse osmosis is a membrane separation process which, by means of a high water pressure, is capable of separating (rejecting) the dissolved salts (ions) contained in the raw water and letting the clean water molecules pass through the membrane.

In reality it is the water molecules that are removed from the dissolved salts and not, as is known from ion exchange, the ions that are removed from the water.

The dissolved salts are removed almost 100% and the pores of the membranes are so small that even micro-organisms like bacteria and pyrogenics cannot penetrate.

The treated, purified water (the permeate) is collected in the reservoir tank, and from here it will be pumped to the user installation. The "fouled" water (the concentrate) will be led to sewer.

The decision as to which type of unit to be used depends on 3 conditions :

- The quality of the raw water
- Environmental conditions - i.e. handling of acids and lye as well as discharge to the sewage system
- Economical optimization

All in all - the advantages achieved by using saltfree make-up water (as compared to using only softened make-up water) will normally by far outweigh the slightly higher expenses incurred.

Treatment of feed and circulation water

In order to counteract the problems and effects of a possible contamination, the boiler water - i.e. the circulating water in the entire hot water plant - is to be treated chemically - and mechanically - in order to eliminate the following :

- Scale formation in the water side of the boiler
- Corrosion

The purpose of the chemical treatment is :

- To neutralize acidifying salts in the boiler water, i.e. to maintain a slightly alkaline condition.
- To add chemicals in order to remove and/or counteract the formation of scale on account of the residual hardness of the feed water and from any untreated hard water originating from leakages in the domestic hot water heating systems and/or process plants.
- To catch impurities by provoking sedimentation (formation of sludge), which may be removed by blowing down the boiler or by filtration.
- To prevent corrosion by oxidation caused by the introduction of oxygenous water through leakages in the domestic hot water heating system and/or process plants, by the introduction of atmospheric air through the expansion plants, emptied plant components, leaking gaskets and pumps.

The feed and circulation (boiler) water must be conditioned in order to comply with the requirements to the water quality by conducting current controls and, if necessary, an adjustment of the feed and circulation water by adding the necessary chemicals and by proceeding to remove the subsequent sludge deposits by means of partial-flow filtration.

Bottom blow-down of the boiler

Whenever heat is being generated in a boiler, the concentration of heavy impurities and suspended salts will increase at the bottom of the boiler, due to the fact that this place offers the best conditions for a sedimentation of these particles on account of the relatively low velocity of the boiler water.

With a view to preventing this concentration from causing corrosion or excessive heating of the boiler material, it is necessary at regular intervals to drain off a certain amount of water from the boiler – i.e. to blowdown the boiler. Therefore, this “boiler blowdown” constitutes an essential part of the general control of the overall boiler water treatment.

Addition / Dosing of chemicals

The importance of applying a correct water treatment method and the addition of chemicals cannot be over-stressed !!

The chemicals are best dosed into the system by means of a suitable – reliable! - and infinitely variable dosing unit.

The use of unreliable poor-quality equipment may have the implication that insufficient quantities of chemicals will be added to the system for prolonged periods of time - during which period the treatment will be entirely inappropriate. This may lead to the onset of corrosion and formation of scale in the boiler and subsequently considerable repair costs that by far outweigh the cost of a reliable chemical dosing equipment.

Taking of water samples

In order to ensure proper operating conditions it is imperative that the exact quality of the water - and the water composition as well - is known from day to day, in order that the necessary measures and treatment may be applied immediately for correcting and setting right any unsatisfactory and undesirable conditions. It is therefore extremely important - **at regular intervals** - to take out samples of the water used in the plant.

1. Take out samples of the raw water used - **every week**.
2. On a **daily basis**, proceed to take samples of :

- The feed and circulation water

The necessary information about the quality of the water is obtained by means of a few simple tests, which are conducted on the samples taken.

The following tests shall be made :

- **pH value** of the feed and circulation water
- **Hardness** of the feed and circulation water
- **Conductivity** of the feed and circulation water
- **O₂ content** in the feed and circulation water – or alternative excess of oxygen-binding agents.

You are kindly referred to the suggested layouts of a water quality logbook (annexed to this manual).

Water Sampling procedure

When taking water samples for analysis, the following procedure is recommended :

1. Clean the water sample bottle to be used.
For repeated samples from the same water source, it is recommendable to use the same bottle for the samples.
2. Open the cooling water to the sample cooler.
3. Gradually open the sample test valve. Flush the cooler and piping with a high flow rate until sample flow is hot.
4. Reduce the flow rate to about 200 to 500 ml/minute.
5. Take the water sample when the temperature of the water is below 25 °C.
6. Rinse the sample bottle three times with sample water before filling it.
The bottle shall always be filled to the top and sealed immediately.
The bottle shall remain sealed until the analysis can be performed.
7. Once the sample has been taken, close the sample test inlet valve first, and then proceed to close the cooling water inlet valve.

Boiler inspection and service

In general

Only very little maintenance is to be performed on the boiler itself. The necessary and appropriate inspections are mentioned in the following sections.

If desirable, you may sign a Service Agreement with Danstoker's service department in order to have Danstoker conduct the more extensive periodic inspections (see the Introduction).



Please note that NO alterations and/or repairs of the boiler unit during the warranty period may be undertaken without the prior written permission of Danstoker a-s.

Failure to observe this stipulation will cause Danstoker's warranty obligations to lapse.

Alterations and repairs undertaken **after** the warranty period has expired, may be performed only by companies and personnel, duly skilled and licensed to manufacture pressure vessels or to carry out work on pressure vessels.

It is recommended that the operator/owner takes contact to Danstoker a-s prior to commencing the repair work anywhere on the pressurised part of the high pressure boiler.



In case the boiler is damaged considerably during operation, the local inspection authority must be advised accordingly, prior to making any attempts to repair the boiler.

Daily inspections

The following inspections should - **as a minimum** (however, depending of the local authority) - be performed on a **daily basis**, and preferably once every work shift:

- The combustion system shall be controlled - and in case of an unbalanced or unsteady combustion the system must be adjusted accordingly.
- The safety equipment of the boiler should be tested and checked according to current regulations applicable. See separate instructions, if any.
- Water analyses should be made on a daily basis, and if necessary the chemical dosing and the blow-down quantities are to be adjusted accordingly to ensure that the feed and the circulation water complies at all times with the prescribed requirements.
- Check and record the flow and the return temperatures. In plants equipped with a boiler shunt arrangement and/or an economiser, the temperatures after this equipment should likewise be noted.
- Check and record the smoke outlet temperature after the boiler. In plants equipped with an economiser, the flue gas temperature between the economiser and the boiler should likewise be noted.
- Check all connections and piping for leakages.
- Check the chemical dosing equipment.
- Take out the necessary water samples and perform an analysis. Record the results of these tests.
- Verify the correct function of the boiler shunt arrangement and the shunt pump. For further information in this connection you are kindly referred to any specific instructions, if any, from the supplier of this equipment.
- The water-gauge sight glasses must be blown out on a daily basis. See special instructions, if any.
- The inspection glass (the viewer) should always be operated with care in order to prevent damages on the glass and/or the gasket. When not used, the inspection glass must always be tightened in closed position.
- The inspection glass is always to be tightened when in closed position. If the glass breaks in open position it will cause severe damage on the cover plates.

- Check and record the make-up water temperature as well as the pressure and temperature of the feed water.
- Verify that the feed water pump unit is functioning correctly. In this connection you are kindly referred to specific instructions provided by the pump manufacturer.

Soot Control

When the boiler has been in operation for a certain period of time, soot deposits will inevitably build up in the boiler tubes. An excess of unburnt fuel may also cause soot deposits to stick to the tube surfaces. This is most likely to happen during operation on low loads and with low smoke temperatures.

The quantity of soot and deposits largely depends on factors such as the type of fuel used, the purity of the flue gases, the flue gas temperature, time in operation, etc.

The required soot cleaning frequency varies from plant to plant, and therefore exact specifications cannot be provided – however, you are kindly referred to the general guidelines below.

The cleaning may be conducted manually, and Danstoker also provides with the boiler a cleaning brush, suitable for the dimension of the tubes.

However, it may prove a great advantage to conduct the cleaning by means of **automatic cleaning equipment**, on account of the fact that the cleaning may be conducted while the boiler is in operation – without inconvenient operation stops.

Danstoker can supply such equipment, i.e. **the DANBLAST chock blast system** – please contact Danstoker for documentation and a price quote.

Soot cleaning intervals

It is recommendable to adopt the following method of checking whether the boiler needs to be cleaned:

1. Check the exhaust gas temperature

If the flue gas temperature after the boiler has increased by 20 °C above the normal value for a clean boiler, the boiler needs cleaning.

2. Check the flue gas resistance

If the flue gas resistance has increased above the normal value for a clean boiler, the intervals between cleanings of the flue gas side must be shortened. The flue gas resistance may be measured by means of a simple U-tube gauge, which is connected to the furnace / combustion chamber of the boiler and the flue gas duct after the boiler.

<p>Please note! An increase of the flue gas resistance is normally insufficient to provide precise indication of the amount of soot deposits on the fire tubes' internal surfaces.</p>

3. Visual control

At regular intervals you must proceed to inspect the smoke tubes visually with regard to soot deposits. If excessive amounts of soot have accumulated, the tubes must be cleaned. Such inspections are particularly important to conduct whenever the quality of the fuel used has been modified.

Tending and maintenance

The boiler's flue gas circuit

By making daily inspections and records of the combustion it will be noted that the flue gas temperature will rise concurrently with the fouling of the fire tubes. With an increase of the flue gas temperature of approx. 20 °C the tubes should be cleaned, as the increased flue gas temperature will result in a deteriorated firing economy.

Whenever the boiler is taken out of operation it should be slowly run down in load, prior to being stopped completely and cooled down. It is recommended to cover up the firing aggregate in order to protect it against soot and other impurities.

The actual cleaning may be conducted with a rotating brush or with a hand brush and vacuum cleaner. With a view to obtaining optimal cleaning, it is essential that the brush fits closely in the tubes.

The most efficient result is achieved when the cleaning is carried out immediately after the boiler has been taken out of operation and while it is still hot and dry.

Under certain conditions it will be possible to establish an automatic soot-cleaning device (air, ultrasound or the like) (you are kindly referred to the description of the Danstoker automatic soot cleaning equipment *DANBLAST* – see section 6.3 Soot Control). Thereby, it will be possible to run continuously without having to take the boiler out of operation in order to clean the flue gas circuit.

After the cleaning of the flue gas circuit has been completed, the soot must immediately be removed from the furnace/combustion chamber, reversing chambers and the smoke-box.



IMPORTANT !!

Water and steam cleaning of the flue gas circuit should not be conducted as part of the ordinary dialy routine, unless the boiler is specifically designed for cleaning with water or steam and unless a prior agreement with Danstoker a-s or a relevant institute has been made. Special instructions will apply in case of cleaning with water and/or steam.

In connection with the cleaning, the heating surfaces of the boiler should be inspected for corrosion damage and/or leakages. Likewise the refractory lining, if any, should be checked.

At least once a year the boiler should be inspected everywhere in the flue gas circuit with regard to possible corrosion damage and leakages. Likewise it should be verified that the refractory lining, if any, is still intact.

This inspection could be conducted by the Danstoker Service Department (see the Introduction) – in case of interest, please contact us for further particulars.

In case corrosion damage is found on the heating surfaces, you are recommended to proceed to conduct an ultrasound examination of the material for evaluation of the boiler's reliability of operation.

The Water Circuit

At least once a year the boiler should be inspected thoroughly in the water circuit.

This inspection could be conducted by the Danstoker Service Department (see the Introduction) – please contact us for further particulars.

The inspection should include the following :

- The boiler is to be emptied of water.

- Man, head and hand hole covers are to be removed and cleaning plugs, if any, are to be dismounted.
- The boiler is then to be thoroughly flushed everywhere in the water circuit.
- Proceed to inspect the boiler in the water circuit to the extent possible.
- Particles found at the bottom of the boiler may be removed by means of a wet vacuum cleaner.
- In case hard deposits of scale on the heating surfaces are found the boiler should immediately be submitted to an acid de-scaling treatment. This treatment must always be conducted by a recognized company, duly skilled and authorized to perform this type of treatment – possibly via the Danstoker Service Department.

It is a fact that as little as 0.5 mm scale will reduce the efficiency of the boiler - and at the same time the existence of scale is likely to cause costly boiler damage.



PLEASE NOTE that in case any trace of scale is found in the boiler, your right to present a valid claim to Danstoker a-s shall lapse.

- The water treatment plant should be checked.
- Feeding of make-up water after the cleaning should be done cautiously and slowly - and of course with appropriately treated water.
- The outside of the boiler should be checked for leakages from man hole covers, valves, flanges, drain pipes and the like. Any damage or irregularities should be set right immediately.

Start-up of the boiler after the inspection shall be conducted as described in **Start-up of the Boiler Plant (section 3)**.

Preservation during Standstill (idle periods)

In general

Whenever a boiler is taken out of operation for a shorter or longer period of time, severe corrosion damage may develop during the idle period in the water and the flue gas circuits alike.

Consequently, appropriate measures and preparations are to be made whenever a boiler is taken out of operation, and the boiler must be inspected at regular intervals with a view to reducing the risk of developing corrosion on the internal surfaces.

The boiler must be kept clean and as dry as possible. All external areas must be protected against corrosion caused by leaking valves and flanges.

Whenever the boiler is taken out of operation for a short period only (i.e. approx. 2 to 4 days) or if it is desirable to keep the boiler ready for starting up with short notice, you are recommended **to keep it warm with a water temperature of 45 to 50 °C** by means of a standstill shunt.

This would have the further advantage of keeping the boiler flue gas areas completely dry during the standstill period (under normal installation conditions).

An appropriate preservation of the boiler provides the best protection against corrosion damage, otherwise likely to develop during a longer standstill period.

We distinguish between 3 types of preservation - i.e. :

- **WET preservation (wet lay-ups) (including Nitrogen Preservation)**
- **DRY preservation (dry lay-ups)**
- **VCI preservation (Vaporized Corrosion Inhibitors)**

A boiler, which is removed from service for a prolonged period of time, must be properly protected against corrosion. First proceed to clean the boiler thoroughly in the flue gas and the water circuits – then subsequently the boiler is to be filled with water (wet lay-up) or the boiler is to be drained altogether (dry lay-up).

A dry lay-up – or alternatively the VCI conservation (please see following pages) - is preferred in case the boiler is idle for more than 1 to 2 months.

For short-term idle periods, the wet lay-up - or alternatively the nitrogen preservation (please see following pages) - will be suitable or even preferable, due to the fact that it will be possible to start up the boiler somewhat faster than is the case with dry lay-ups.

It is recommended to apply one of the lay-up methods described in the following.

Wet preservation (lay-ups) of boilers

A wet lay-up of the boiler requires fewer preparations, the boiler may rapidly be put back into operation, and the protection of the boiler's water side is sufficient. This method can safely be used during shorter idle periods – provided the boiler is stored in a frost-free place.

It is recommended to adopt the following procedure :

- Run the boiler slowly down to minimum load, whereafter the burner or the combustion equipment is to be stopped.
- The boiler's connections to the circulation system are to be shut off. The operation of the shunt pump arrangement, if any, is to be continued until the heat accumulated in the refractory lining and in the still remaining fuel inside the combustion chamber has been transferred to the boiler water - i.e. until the temperatures measured in the flow and return pipings are identical. Subsequently, proceed to stop the shunt pump arrangement.
- Subsequently cool down the boiler until the boiler water has reached the permissible temperature for being discharged into the municipal sewerage system.
- Open the drain valve(s) cautiously, once the pressure in the boiler has decreased to approx. 1 barg. All the water contained in the boiler is to be drained off.
- Empty the boiler and inspect it carefully everywhere. In case any sludge, scale or other deposits are found, proceed to clean the boiler as described in The Water Circuit (Section 7.2).
- Close the drain valves when the boiler is no longer under pressure.
- The air valve should remain open.
- Fill the boiler completely with softened water and add 0.5 litres of a 30% solution of soda lye and 200 g of sodium sulphite per m³ of water.
- Scavenge the boiler continuously while filling water into the system in order to ensure that all the air is removed from the boiler's internal areas.
- Subsequently close the air valve.
- Maintain a hydrostatic pressure of approx. 0.2 barg in the boiler during the idle period. To achieve this pressure, the boiler removed from service can be fitted with an expansion tank, installed and connected as high as possible (for example on an air vent valve).

Maintaining the water level in the boiler

The water level in the expansion tank should be checked regularly, and if the water level decreases, more softened and treated water should be added to the boiler. Adding water to the system should be conducted in such a manner that the risk of developing air pockets is eliminated.

Water Circulation in the boiler

With a view to ensuring that the chemicals are not used up locally it is recommended to establish a circulation system, by using a small pump to circulate the boiler water. The

pump is intended to ensure that the treated water from the bottom of the boiler is pumped back into the system at a connection point placed between the boiler and the expansion tank.

The pump should be activated a couple of hours per week.

Water samples

If the circulation piping is provided with a test cock, water samples may be taken and, after analysis, used to verify whether the water treatment is still sufficient or whether more chemicals have to be added to the system.

The boiler water must be kept alkaline in order to provide the necessary protection against corrosion.

If the pH-value is too low (below 10) sodium hydroxide should be added, and if the surplus of sulphite falls below 100 mg/litre another 100 g of sodium sulphite per m³ of water should be added.

Starting up the boiler after wet lay-ups

If no other work has been performed on the boiler that would require the boiler to be started according to the instructions for the initial firing of the boiler (for example renewal of the refractory lining), the boiler should be started according to the normal start-up procedures – see **Start-up of the boiler plant (Section 3)**.

Flue Gas Circuit

The flue gas circuit must be clean and dry in a boiler that is removed from service.

Soot deposits - in the smoke tubes and in other areas exposed to the flue gases - are likely to cause corrosion when absorbing humidity from the air, especially when burning sulphurous fuels.

Therefore it is of the utmost importance that all surfaces in the flue gas circuit are as clean and dry as possible under the given conditions.

The flue gas outlet should be covered up when the boiler is idle.

Nitrogen preservation

This method is actually a variant of the ordinary “wet lay-up”, described under **Wet Preservation**, as the method implies keeping the boiler filled with boiler water, to which an oxygen-binding agent (100 to 200 g sulphite per m³ of boiler water) has been added. Instead of filling the boiler completely with boiler water, some of the normal water drum is to be filled with nitrogen from a nitrogen bottle through a pressure regulating valve. The pressure regulating valve will ensure (1) correct dosing of nitrogen during cooling down and (2) maintaining an over-pressure in the boiler of approx. 0.2 barg.

When starting up the boiler again the supply of nitrogen is shut off and the boiler may immediately after be fired/started up in compliance with the normal start-up procedures.

The nitrogen trapped inside the boiler will subsequently evaporate into the circulation system, where it will cause no problems whatsoever.

Dry preservation (lay-ups) of boilers

The water side

The boiler is to be emptied of water and subsequently inspected thoroughly. If any sludge, scale or other types of deposits are found, proceed to clean the boiler as described in **The water circuit (Section 7)**.

The Flue Gas side

The preservation of the flue gas side is carried out by cleaning the flue gas circuit thoroughly while the boiler is still warm, and by keeping the boiler's flue gas side completely dry during the idle period.

The following procedure is recommended :

- Remove all loose deposits in the flue gas circuit (use for example a rotating brush and a vacuum cleaner).
- Soak/soften areas with hard deposits.
 - The softening and the subsequent washing out should be conducted by using alkaline/basic water.
 - Hard deposits that cannot be removed after softening and washing out are to be removed by means of mechanical cleaning equipment. When firing fuel oil such deposits are normally vanadium coatings that tend to build up at the entrance to the first smoke tube pass of the boiler.



CAUTION !!

If the furnace/combustion chamber is provided with refractory lining it may become wet, and consequently there is a latent risk of corrosion on the underlying surfaces. However, this risk will be minimized if the refractory lining is sufficiently dried, e.g. by keeping the boiler heated for an appropriate period of time. The heating may be achieved by circulating hot water from another boiler or by blowing heated air through the boiler.

- In order to neutralize any remains of acid, the cleaned heating surfaces in the flue gas side should be given a light coating of powdery calcium or magnesite.
- It is essential that the chemical used is applied as a very fine powder to secure a good adherence and an even distribution on the surfaces. This will provide the most efficient neutralization of the acid deposits. Insert the chemical through the burner opening and let the chimney draft distribute it inside the boiler, if possible.
- If - for some reason - it is difficult or undesirable to use chemicals as a powder, ordinary lime water may alternatively be used instead.
- Minimize the chimney draft as much as possible. Close the flue gas outlet tightly, thereby preventing flue gases deriving from boilers in operation connected to a common chimney from being drawn back into the boiler.
- In case the boiler is placed in a non-heated room or in a place with a high humidity, it will be necessary to take special precautions to keep the air in the boiler dry.

This can be achieved by placing bags of blue silica-gel inside the boiler.

Blue silica-gel will turn red, once it has absorbed humidity. Silica-gel that has absorbed humidity may be re-used after having been dried at 100 to 120 °C for approx. 3 hours. After drying it will regain its original blue colour.

Silica-gel is used to prevent condensate to develop in boilers which are sealed tightly.

- The flue gas circuit should be inspected at regular intervals, for example once a month. Special measures should be taken to detect traces of corrosion, and simultaneously the silica-gel (if applied) should be examined.
- An alternative method to keep the boiler dry is to use an air drying device, which blows dried air into the boiler at a low overpressure of 0.5 to 1 mm WC.

The solution to use a blower to blow heated air through the boiler is suitable in boilers that cannot be properly sealed - especially in older furnace and fire-tube boilers, intended for under-pressure operation.

Use of VCI (Volatile or Vaporized Corrosion Inhibitors)

An alternative method to the ordinary long-term lay-up preservation would be to apply so-called 3-phase inhibitors - VCI – which are chemical compounds with corrosion-inhibiting properties. The VCI will provide a **3-phase protection** of the metal surfaces – i.e. :

- vapour phase
- water phase
- boundary water \leftrightarrow vapour phase

by forming a protective film on the metal surfaces and simultaneously providing a repulsive shield against the water and oxygen molecules.

Therefore, the method may with great advantage be applied for wet and dry lay-ups alike.

With a view to making the right choice of inhibitors and lay-up methods, specialized companies should be consulted in matters relating to shut-downs of the boiler.

