



**Steam boiler – SG model
n.1 x 10 ton/h @10 bar(g)**

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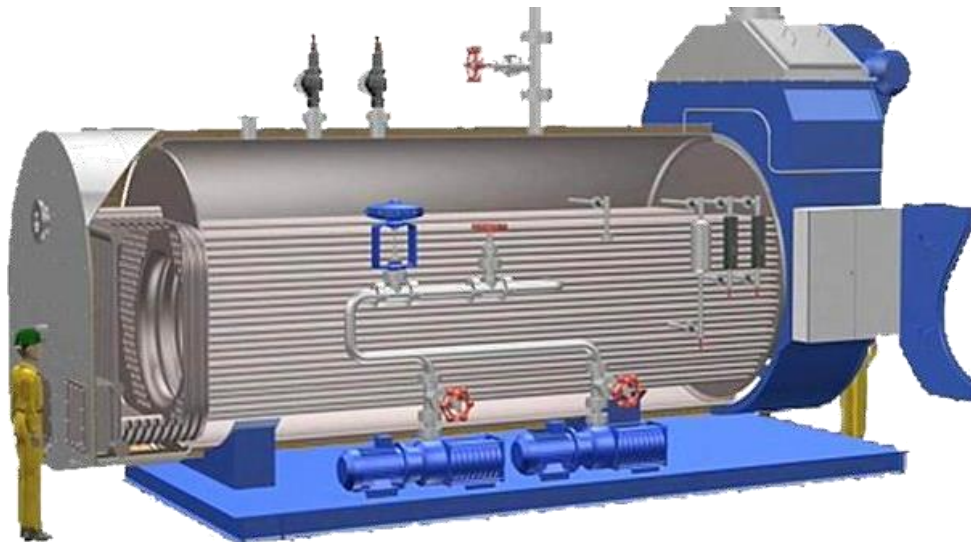
1 TECHICAL HIGHLIGHTS AND SPECIFICATION

1.1 INTRODUCTION TO SG FIRE TUBE STEAM BOILERS

The unique structure of SG boilers is the product of more than 50 years of experience in fire tube and water tube generators, extensively tested with thousands of references around the world.



The SG structure is composed of a strong body with a water tube inversion chamber at the back (membrane type), as shown in the image below.



While ensuring equal, or higher efficiency than traditional three pass boilers, this design provides the following advantages.

A. Easy accessibility to all internal parts of the boiler

In our design, all the internal parts of the boiler are easily accessed from the front doors and the back inspection door, without burner dis-assembly, to allow inspection, cleaning, and repairs. In three pass designs, it is very difficult for the operator to enter the rear gases box, because of the very limited available space. With this design, SG boilers significantly reduce down-time for inspection, cleaning, and maintenance.



SG DESIGN

B. Absence of refractory material on the back

The fumes inversion chamber at the back has no refractory material thanks to the water tube membrane. This solution avoids all problems related to refractory material such as cracking, heat inertias, heat losses etc. The only refractory material used in the SG is the burner tile.

C. Large furnace diameter

In design the furnace diameter is larger compared to three pass boilers, where space is occupied by the third pass tubes bank. This increases the internal flue gas re-circulation (IFGR), decreasing NOx emissions.

D. Robust structure for heavy duty operation

The structure of the boiler does not require the anchoring rods found in three pass boilers. These components may be subject to mechanical thermal stress during working conditions.

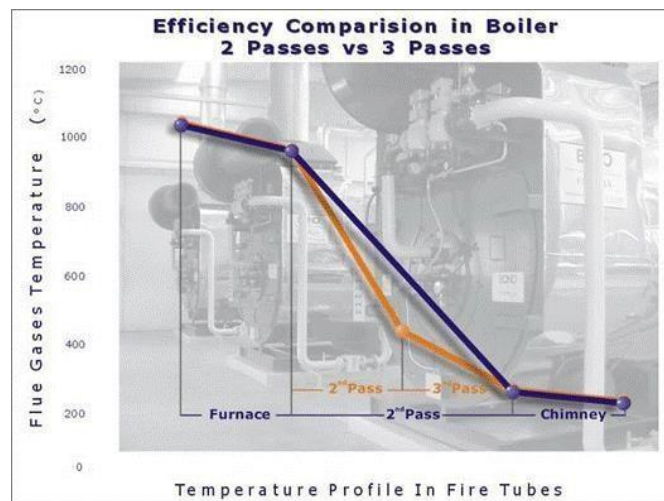


SG DESIGN

E. Optimized heat exchange

In the three-pass design, most of the exchange occurs in the furnace and the second pass, while the third pass has a very limited heat transfer.

The SG design ensures the same or higher efficiency levels optimizing the heat exchange in the boiler and in the water tube membrane.



F. Integrated heat recovery systems

In the SG design, the flue gas exit is placed on the same side of the burner and the air fan. This means that heat recovery systems of different kinds can be easily integrated on the front side of the boiler in a compact design (economizers and air pre-heaters in series). This increases the combined effectiveness of the systems while reducing overall dimensions.



1.2 HE-SMART[®] HEAT RECOVERY SYSTEM (OPTIONAL)

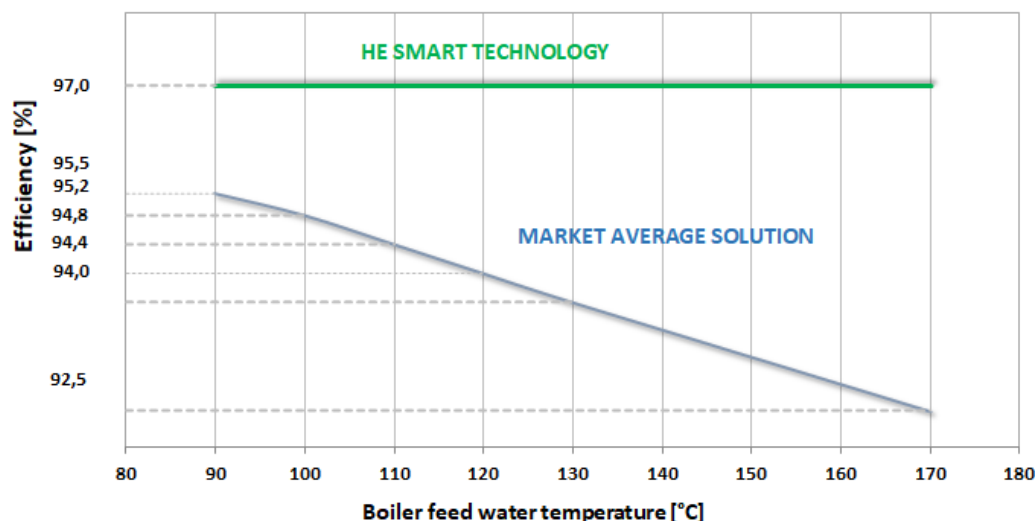
The structure of the SG boiler allows the integration of both air and water pre-heating system on the burner side.



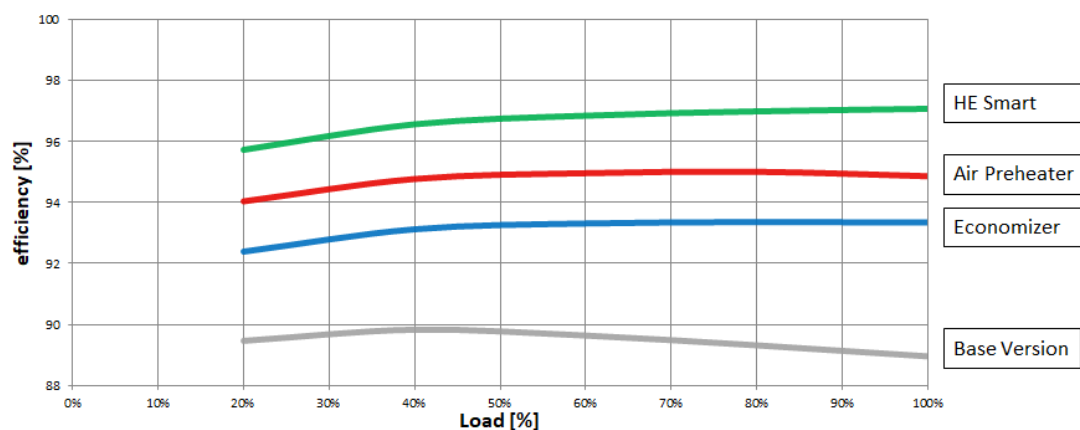
An economizer can be installed inside the flue gas box of the on front of the boiler. The economizer is the most common recovery system for natural gas working boiler and increase the efficiency using the power still available in the flue gas after the tubes thermal exchanges to heat up the water inlet temperature. BONO uses finned type tubes Economizer, with high heating surface to achieve the best efficiency with this technology. Optispark system manage the burner and the water pump always taking in account the efficiency real value to keep it at the best operation value.

The heat recovery system is pushed up with the HE Smart concept, composed of 2 economizers and 1 air pre-heater. The system is equipped with 3-way valves to balance the system at every load and keeping the efficiency at the best value (**up to 97.5%**) without flue gas acid condensation even with high-temperature feedwater.

Efficiency linked to feed water temperature



Thermal efficiency VS load with @ 150°C feed water temperature
4 different fire tube boiler configurations HE-SMART vs Air-Preheater vs ECO vs basic



Ecodesign Preparatory Study on Steam Boilers (ENTR Lot 7)

Presented by

PricewaterhouseCoopers EEIG's consortium
in cooperation with Fraunhofer ISI and I CCS-NTUA

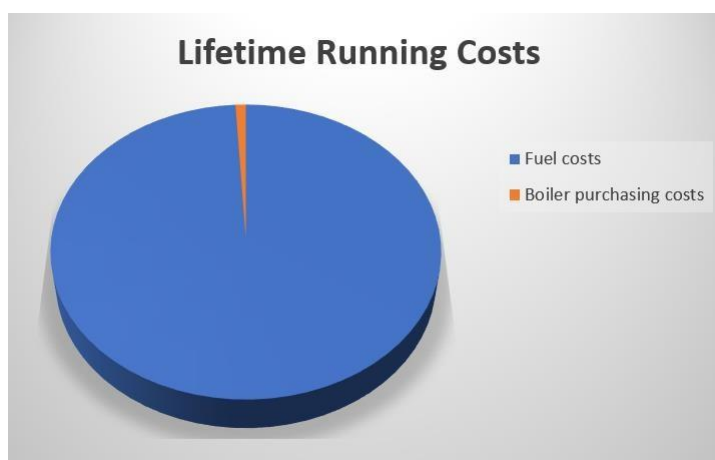
to
European Commission
Directorate General for Enterprise and Industry
Unit B.1 – Sustainable Industrial Policy

www.eco-steamboilers.eu



The study “Ecodesign Preparatory Study on Steam Boilers (ENTR Lot 7)” states that:

The investment cost of a steam generator for industrial application is equivalent to about 1% of the cost of natural gas necessary to run it through its useful life, estimated equal to 15 years.



1.3 OUR SOLUTIONS FOR EFFICIENCY



Load sharing System: between boilers with common manifold for steam (up to 4)

Inverter on motors: to reduce electrical consumption and noise level. (Electrical consumption reduced up to 40%)

Heat recovery systems: to increase boiler thermal efficiency up to 97,5 % with HE-Smart system

Combustion Control: to reduce fuel consumption and emissions (CO, NOx)

Tele-service: analysis of boiler functioning with optimization of parameters directly from Bono factory.

1.4 OPTISUPPORT (OPTIONAL)

OPTISupport is a service offered by Cannon Bono, to guarantee the **best technical assistance** to the customer.

The **technical expertise** of a specialized Cannon Bono technician, **always by your side to advise and support you**



Your expert authorized personnel on site

REMOTE technical support service

- ✓ **Immediate analysis** of problems
- ✓ **Reduction of machine downtime**
- ✓ Possibility to solve the problem **by saving an inspection on site**
- ✓ **Real-time sharing** of audio, video, photos, documents and annotations in **augmented reality**
- ✓ **Increase of reliability and availability** of the machine



If necessary:

Technical support ON SITE



- **Programmed Periodical Maintenance (PPM)**
- **Required Maintenance Activities (RMA)**

And:

- **Training** for technical staff
- **Spare Parts** management consultancy

1.5 OPTICLOUD (OPTIONAL)

OPTICloud is a service offered by Cannon Bono for remote access to machine information, AWS cloud platform based.



Our service allows the access to live parameter in order to have a direct monitoring of boiler, in order to keep the machine's operating status always under control.

By taking advantage of artificial intelligence the running parameters are continuously analysed. The algorithms elaborate the information suggesting preventive and corrective maintenance actions.

Proactive monitoring allows you to maximize performance and business continuity, reducing the risk of machine downtime and reducing its effects.



Strength Points:

- ✓ Automatic **Report System**
- ✓ **Alarm logging** and **mail service for real-time reporting**
- ✓ **Best schedule** of maintenance activity
- ✓ **Reduction of machine downtime** for maintenance activity
- ✓ **Reduction of random failure events**
- ✓ Running always in **best condition**
- ✓ Documents available and always updated

This tool is based on parameters collected with PLC F3 installed on generator board and an hard wired or 3G gateway send all data to cloud platform.

1.6 OPTIMAL PREDICTIVE CONTROL ®

Predictive boiler control is now a reality.

And it has incredible advantages.

Thanks to the research and innovation of the project developed by Cannon Bono in collaboration with the

Polytechnic University of Milan, today we can have an intelligent boiler, increasingly integrated into the digital infrastructures related to Industry 4.0 and the Industrial Internet of Things (IIoT).

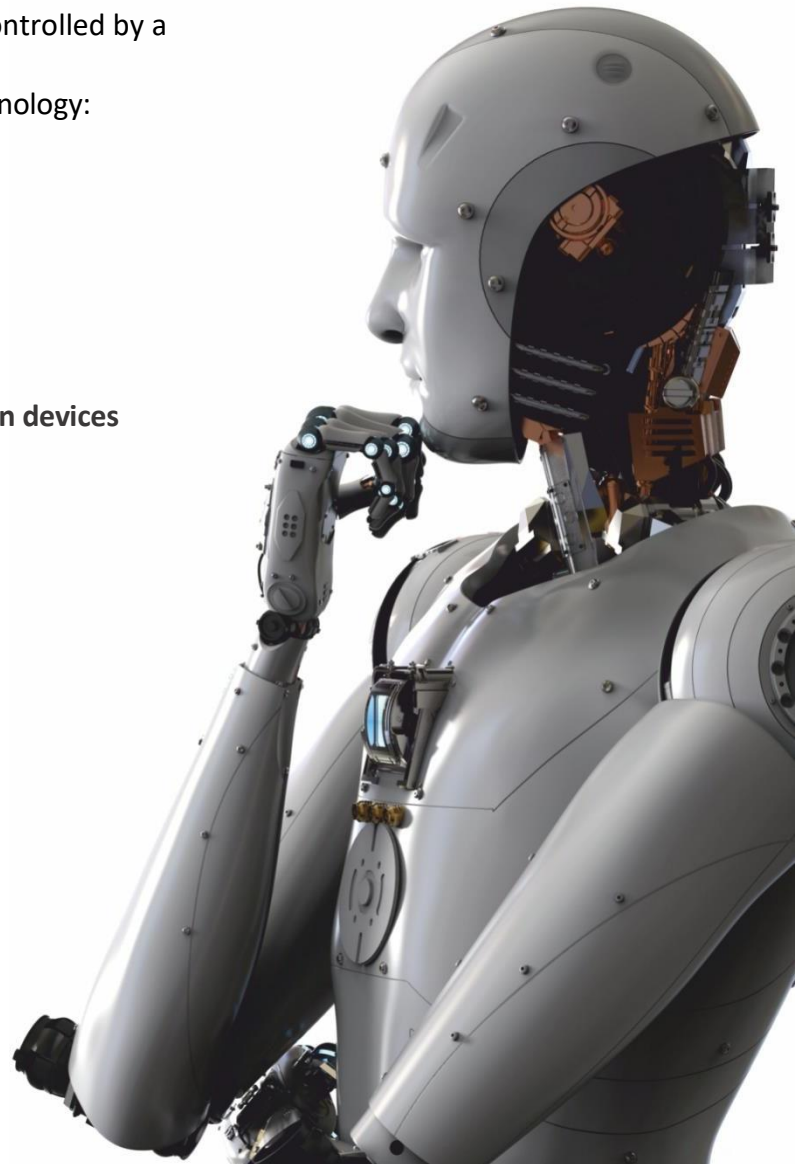
Optimal Predictive Control is the next-generation boiler control system based on a **predictive control model** (MPC). This model is used to simulate the future conditions of the boiler in different production scenarios, in order to set it according to the parameter to be optimized.

Advantages

The advantages were evident after an extensive testing campaign with a manufacturing company in the **Pulp & Paper industry** was completed. The results after nearly six months confirm the robustness of the control scheme and long-term benefits.

A comparison of the performance of the boiler controlled by a traditional PID and by Optimal Predictive Control shows the advantages of this second technology:

- ✓ Increased control accuracy
- ✓ Decreased variability of tracking errors
- ✓ Reduction of the movement of the regulation devices
- ✓ Increased efficiency up to an additional 1%
- ✓ Reduction of human error



2 INTRODUCTION

2.1 DESIGN DATA

This quotation is based on the following data:

Country of destination	Greece
Electrical data	230/400V – 50 Hz – 3 phase
Area of installation	Indoors, boiler room, free of frost, dust, and sand.
Area classification	Safe area
Elevation	< 600 m.a.s.l.
Type of fluid	Saturated steam
Max capacity required	10.000 kg/h
Design pressure	12,0 bar _g
Max Operating pressure	10,0 bar _g
Fuel 1	LPG <i>300mbar_stabilized</i>
NOx emissions @3%O ₂ _dry	< 200 mg/Nm ³
Feed water quality	According to EN 12953:10
Boiler Feed water temperature	90 °C <i>*tbc</i> (condensate + make-up)

3 STANDARD AND CODES

Pressure parts design, calculation and construction	European Directive 2014/68/EU
Pressure parts certification	PED (2014/68/EU)
Electrical equipment	CEI – IEC
Ladders, walkways, supporting structure	EN 14122
Electrical protection degree	IP 54 – IP 55
Alarms sequence	ISA
Electrical protection	Standard, Non-hazardous area
Gas train and BMS	EN 13577-2 / EN 676

4 TECHNICAL SPECIFICATION

4.1 STEAM BOILER DATASHEET

DIMENSIONAL DATA

		SG 1000
Length (with burner)	mm	8.665
Width (with accessories)	mm	3.490
Height (ECO version) Height (HE SMART version)	mm	4.060 4.705
Stack diameter	mm	600
Empty weight	tonn	26,0

FUNCTIONAL DATA

Design pressure	bar _g	12,0
Maximum operating pressure	bar _g	10,5
Steam quality	%	> 99,5
Feed water temperature at deaerator outlet ($\pm 5^{\circ}\text{C}$)	$^{\circ}\text{C}$	90
Steam production capacity	kg/h	10.000
Heat transferred to steam	MW	6,7
Thermal Efficiency (ECO version) @100%	%	95,0 $\pm$ 0,5
Thermal Efficiency (HE SMART version) @100%	%	97,0 $\pm$ 0,5
Pump flow rate (each)	m ³ /h	12,0
Pump static pressure (each)	mcl	150
Pump installed power	kW	11,0

Thermal efficiency and steam production capacity are calculated according to EN 12953-11 "indirect method".

4.2 FEED WATER QUALITY SPECIFICATION

A proper feed water treatment system is mandatory for the issuing and validity of the manufacturer's guarantee. Therefore, it is necessary to carry out a complete analysis of the raw feed water, to select the correct water treatment system. Equally important is the periodic analysis of feed water and boiler water.

If the water treatment is not carried out properly, elements dissolved in the water such as calcium, magnesium or silica can deposit on the iron surfaces of the coil at higher temperatures, causing incrustations and blocking the pipes. In addition, if the feed water is rich in oxygen, the iron in contact with the water will suffer corrosion, leading to holes in the coil. The table below shows the limits values for boiler feed water according to EN 12952-12 and EN 12953-10. In order to maintain the values shown, it is necessary to use water conditioners in addition to water treatment units.

Table 4-1

Parameter	Unit	Feedwater for steam boilers		Make-up water for hot water boilers
Operating pressure	bar (= 0,1 MPa)	> 0,5 to 20	> 20	total range
Appearance	—	clear, free from suspended solids		
Direct conductivity at 25 °C	µS/cm	not specified, only guide values relevant for boiler water see table 5-2		
pH value at 25 °C ^a	—	> 9,2 ^b	> 9,2 ^b	> 7,0
Total hardness (Ca + Mg)	mmol/l	< 0,01 ^c	< 0,01	< 0,05
Iron (Fe) concentration	mg/l	< 0,3	< 0,1	< 0,2
Copper (Cu) concentration	mg/l	< 0,05	< 0,03	< 0,1
Silica (SiO ₂) concentration	mg/l	not specified, only guide values for boiler water relevant, see table 5-2		—
Oxygen (O ₂) concentration	mg/l	< 0,05 ^d	< 0,02	—
Oil/grease concentration (see EN 12953-6)	mg/l	< 1	< 1	< 1
Organic substances (as TOC) concentration	—	see footnote ^e		

^a With copper alloys in the system the pH value shall be maintained in the range 8,7 to 9,2.

^b With softened water pH value > 7,0 the pH value of boiler water according to table 5-2 should be considered.

^c At operating pressure < 1 bar total hardness max. 0,05 mmol/l shall be acceptable.

^d Instead of observing this value at intermittent operation or operation without deaerator if film forming agents and/or excess of oxygen scavenger shall be used.

^e Organic substances are generally a mixture of several different compounds. The composition of such mixtures and the behaviour of their individual components under the conditions of boiler operation are difficult to predict. Organic substances may be decomposed to form carbonic acid or other acidic decomposition products which increase the acid conductivity and cause corrosion or deposits. They also may lead to foaming and/or priming which shall be kept as low as possible.

Table 4-2

Parameter	Unit	Boiler water for steam boilers using			Boiler water for hot water boilers
		Feedwater direct conductivity > 30 $\mu\text{S/cm}$	Feedwater direct conductivity $\leq 30 \mu\text{S/cm}$		
Operating pressure	bar (= 0,1MPa)	> 0,5 to 20	> 20	> 0,5	total range
Appearance	—	clear, no stable foam			
Direct conductivity at 25 °C	$\mu\text{S/cm}$	< 6 000 ^a	see Figure 5-1 ^a	< 1 500	< 1 500
pH value at 25 °C	—	10,5 to 12,0	10,5 to 11,8	10,0 to 11,0 ^{b, c}	9,0 to 11,5 ^d
Composite alkalinity	mmol/l	1 to 15 ^a	1 to 10 ^a	0,1 to 1,0 ^c	< 5
Silica (SiO ₂) concentration	mg/l	pressure dependent, according to figure 5-2			—
Phosphate (PO ₄) ^e	mg/l	10 to 30	10 to 30	6 to 15	—
Organic substances	—	see footnote ^f			—

^a With superheater consider 50 % of the indicated upper value as maximum value,
^b Basic pH adjustment by injecting Na₃PO₄, additional NaOH injection only if the pH value is < 10.
^c If the acid conductivity of the boiler feedwater is < 0,2 $\mu\text{S/cm}$, and its Na + K concentration is < 0,010 mg/l, phosphate injection is not necessary. Under the conditions AVT (all volatile treatment, feedwater pH $\geq$ 9,2 and boiler water pH $\geq$ 8,0) can be applied, in this case the acid conductivity of the boiler water is < 5 $\mu\text{S/cm}$.
^d If non-ferrous materials are present in the system, e. g. aluminium, they may require lower pH value and direct conductivity, however, the protection of the boiler has priority.
^e If coordinated phosphate treatment is used; considering all other values higher PO₄-concentrations are acceptable (see also clause 4).
^f See ^e in table 5-1.

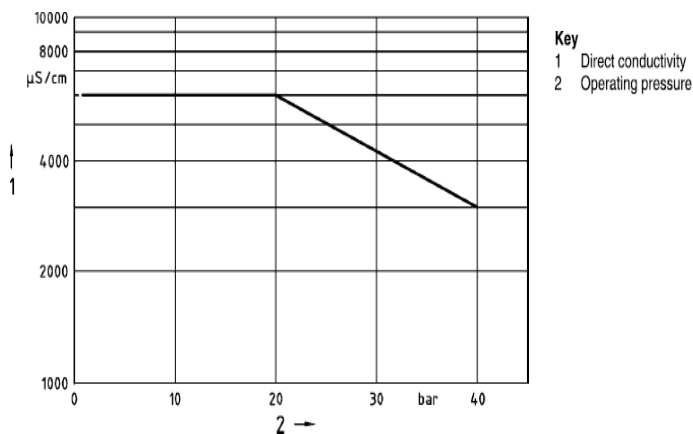


Figure 4-1: Maximum acceptable direct conductivity of the boiler water depending on pressure; feed water direct conductivity >

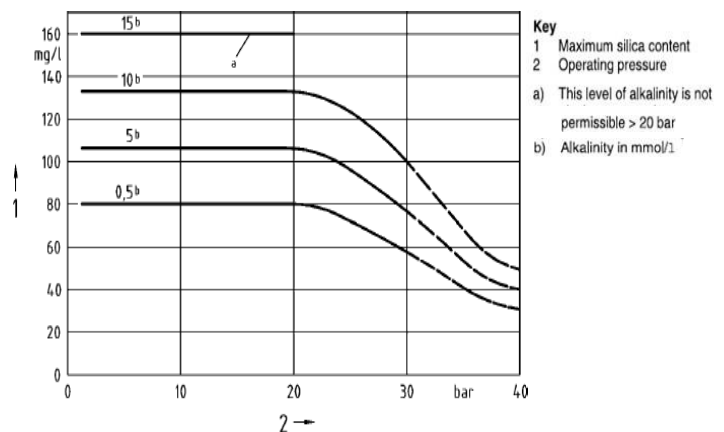


Figure 4-2: Maximum acceptable silica content (SiO₂) of the boiler water depending on pressure.

4.3 STEAM BOILERS TECHNICAL DESCRIPTION

1) BOILER BODY

1.1) BOILER BODY

Boiler structure with 2 passes and WET back; water tube reversing chamber connected to the tube sheet, complete with external insulation and access door.

Plating (laminated steel P355 EN10028 or equivalent) equipped with manhole for cleaning and internal inspection, n° 2 hand holes, service sockets (drawn steel ASTM A 106 Gr. B) flanged (forged steel ASTM A105): steam outlet, safety valves, drain, power supply with internal distributor, instrument and probes sockets, surface blowdown. Flanged connections according to PN16/40 EN 1092-1 (the water supply ramp is always PN40).

Nr. 4 lifting eyebolts.

Moisture separator for steam.

Furnace with large diameter for reduced NOx emissions (Laminated steel P355 EN 10028 or equivalent), FOX type from model SG1000/18 to higher sizes.

Tube plates (P355 EN 10028 or equivalent) DISHED and BUTT WELDED to shell and furnace.

Fire tubes (seamless type, drawn steel ASTM A 210 Gr. A1 or equivalent), expanded and welded to the tube sheets, complete with extractable turbulators for the intensification of heat exchange.

Front flue gas box consisting of a carbon steel sheet body with reinforcement rib profiles; bolted and thermally insulated doors, with hinged opening for full access to the tube sheet and for cleaning and inspection operations. Circular flue gas outlet flange, suitable for direct connection to the chimney.

Flue gas outlet box suitable for economizer included if boiler in ECO or HE-SMART version. Nr. 2 connections 1/2" NPT-F for flue gas temperature measurement. Connection for burner installation and refractory concrete throat.

Rear sight glass for the observation of the flame with high temperature crystal. Pressure measurement connection in combustion chamber.

Base frame of the generator in metal section bar consisting of: fixed front saddle, mobile rear saddle with sliding devices; metal section bar supporting the ground and nr. 4 lifting points by means of hydraulic jacks; complete with fixing points for pump support; nr. 2 stainless steel plates for grounding connection.

Painting for non-insulated carpentry: RAL 7016.

CE PED certification; Risk class IV, verification module B+F (EC type-examination and product verification) or G. Hydraulic test attended by a notified body. Pressure parts calculation according to VSG or EN 12953 standards.

Metal plate riveted to the boiler body reporting factory number, CE mark and technical data.

1.2) INSULATION

Insulation of mineral wool plating: thickness 100 mm, density 100 kg/m³; finish in Aluzinc sheet metal (base) or stainless steel (*on request*).

Galvanized steel screws.

2) ELECTRICAL PANEL / AUTOMATION

Electrical panel compliant with EN 60204 and EN 61439 installed on the machine, IP54 metal carpentry powder coated RAL 7035 (gray) with front door, complete with forced ventilation. CE plate with identification data.

Start, stop, reset, and lock buttons. Limiter safety chains with SIL relays.

Acoustic and visual lockout signal. 230V auxiliary section for the management of safety and regulation logics. Signal wiring carried out with 1.5 mm² cables complete with lugs and tagged with numbering shown in the diagram. Grounding clamp or ground bar for equipotential connection of field electrical utilities. Power section with devices for the control and protection of the burner and field utilities (if supplied). Numbered terminal block for connection between the panel and the field.

Multiple pages single-line wiring diagram for immediate reference. TN-S power supply system with ground cable.

Power section with electric motors protections: supply voltage 400V 3 phases + N; frequency 50Hz.

Environmental conditions: for installation sheltered from bad weather and direct sunlight, Tmin 10°C, Tmax 40°C.

Safety testing and CE electrical conformity certificate.

Electrical board machine system compliant with EN 60204 standards with wiring in closed plastic cable ducts or open metallic cable ladders. Degree of protection of electrical system and field instrumentation IP54.

Electric panel installed on the generator, fully wired and complete with metal support, detachable for field positioning on the boiler front or on accessories side (about 1,5m cables length available).

2.1) CONTROL SYSTEM (PLC)

Generator adjustment by means of Optispark F3 PLC, complete with 10.4" HMI graphic interface.

Predisposition of remote interlock contacts, minimum deaerator level, chemicals pump control.

2.2) BURNER MANAGEMENT SYSTEM (BMS)

Management system of the burner, model BONO BCU, installed in the control panel.

Other BMS available for optional burner different from BONO Burner.

3) INSTRUMENTATION AND ACCESSORIES

3.1) STANDARD INSTRUMENTATION AND ACCESSORIES (Valid for 24h exemption)

Manual valves with started flow type with packing seal, flanged according to PN16/40 - EN1092-1 (always PN40 for valves on the boiler feed water supply line).

Valves and instruments:

- N°1 steam intake PN16 (PN25/40 for stamp pressure > 12 bar-g)
- N°2 Valves for boiler body drain
- N°2 wet back drain valves
- N°1 manual water inlet valve in the boiler
- N°1 flanged valve for feedwater inlet
- N°1 electropneumatic level control valve for boiler feed water
- N°1 manual valve for continuous surface blowdown
- N°1 manual boiler water sampling system, including cooling barrel with stainless steel coil.
- N°2 direct acting safety valves, spring closure, with flanged inlet and discharge connections.
- N°1 pressure gauge with stainless steel case for local boiler pressure indication, dial diameter 200 mm.
- N°1 Safety pressure switch SIL2, as a limiter with blocking intervention for high pressure with manual reset (from boiler panel).
- N°1 temperature steam pressure transmitter with 4-20 mA signal connected to the boiler control PLC, for modulating burner load and standby threshold control.
- N°2 level indicators with reflection crystal and metal armor. Flanged connections with purge and shut-off taps
- N°1 capacitive probe 4-20 mA connected to Optispark F3 for electro-pneumatic valve regulation and pump run-stop control.
- N.2 SELF-CHECKED safety conductive probes for boiler very low water level. Control panel safety relay switching at boiler very low water level, with boiler lock, manual reset. The safety chain is Class IV PED certified, SIL3 safety level according to IEC61508-2.
- N°1 chimney base thermometer (replaced by thermocouple with signal transmission 4-20 mA of flue gas temperature to the chimney if boiler with ECO or HE-SMART recovery system).
- N°1 pressure gauge with stainless steel case for boiler feed water pressure indication, dial diameter 100 mm.

Accessories assembly and functional test, including the assembly certification and verification of the compliances by No.Bo where prescribed by international standards.

3.2) AUTOMATIC BOTTOM BLOWDOWN - OPTION

Automatic Bottom Blow Down system consisting of:

- automatic bottom discharge valve DN40 with electro-pneumatic control (replaces one of the two manual boiler body discharge valves indicated in paragraph 3.1).3.1)
- discharge timing function managed by PLC

3.3) TDS CONDUCTIVITY CONTROL - OPTION

Boiler total dissolved salts (TDS) concentration control system consisting of:

- conductivity probe mounted on the surface purge pipe, for measuring the conductivity of boiler water
- conductivity regulator/limiter mounted on board of control panel, with indication of process variables
- motorized surface purge valve DN15, complete with connection and manual valve for boiler water sampling

3.4) CONTINUOUS SELF-CHECKING FLAME PROBE - OPTION

Flame probe with continuous self-verification, suitable for 72h unmanned operation, UV type.

3.5) INSTRUMENT PACKAGE 72h unmanned operation - OPTION

Instrumentation necessary for boiler management with exemption from the presence of the licensed conductor up to 72h.

The instrumentation includes:

- Automatic Sludge Removal as specified in paragraph 3.2);
- TDS conductivity control as specified in paragraph 3.3);
- Continuous self-verification photocell as specified in paragraph 3.4);

In addition to the safety chains already described, the following are also provided:

- Safety control for shutdown in case of very high conductivity feed water / condensate return (signal charged installer)
- safety chain for stop in case of feed water system fault (signal charged to installer)

***N.B.** For the operation under partial exemption regime up to 72 hours, the analysis of the risks related to the system associated with the generator, with regards to feed water, are charged to the User, as well as the equipment necessary for the related periodic checks.*

Failure to comply with the periodic checks, precludes the operation of the generator in the absence of the Conductor.

Contacts for the management of signals related to:

- Quality of make-up water;
- Condensates quality.

4) BURNER

The refractory throat and burner mounting flange (to be defined according to the selected burner model) are always included.

4.1) MONOBLOCK BURNER

Monoblock burner compliant with EN676 with built-in fan and electronic controls. The burner is equipped with a metal case for containing and conveying combustion air, safety and flame adjustment devices, sight glass, refractory steel flame tube and diffuser disc, gas distributor with multiple nozzles. (The electrical protection power supply of the burner is provided by the boiler's panel).

The burner is supplied assembled on the boiler and functionally tested.

Fuel train complete with safety pressure switches, EN161 class A compliant shut-off valves, gas control valve and gas valves leak testing pressure switch. Train architecture compliant with EN676 (for gas) with the exclusion of filter, reducer, anti-vibration joint and manual shut-off valve.

Burner control is modulating type, with electronic cam.

Standard photocell of non-self-checking type; self-checking photocell included only if options 3.4) or 3.5) are selected.3.4)3.5)

4.2) DUOBLOCK BURNER "LN" - OPTION

Dual-block Cannon BONO model *LN* complete with air box, safety systems and modulating electronic cam control, sight glass, flame tube, diffuser disc and multiple nozzles.

The burner is supplied assembled on the boiler and functionally tested.

Fuel train complete with safety pressure switches, EN161 class A compliant shut-off valves, gas control valve and gas valves leak testing pressure switch. Train architecture compliant with EN676 (for gas) with the exclusion of filter, reducer, anti-vibration coupling and manual shut-off valve.

Standard photocell of non-self-checking type; self-checking photocell included only if options 3.4) or 3.5) are selected.3.4)3.5)

Centrifugal combustion air fan installed above the burner with electric motor, IP54, 2 poles. Air duct is complete with inlet silencer for a sound level < 85 dBA at 1 m distance. Motor pre-wired to boiler electric panel.

4.3) O₂ probe for GAS FUEL

Zirconium oxide probe for fine combustion control. The system consists of a flue gas oxygen measurement probe installed on the generator, transmitter on the panel front for connection to PLC and BMS.

The probe is suitable for use on flue gas from clean fuels combustion: a dust concentration in the flue gas < 100 mg/m³ is allowed.

4.4) FAN VFD - OPTION

Variable Frequency Drive for modulation of the fan rotation speed. For fine control of combustion air and electricity saving with the generator is running at reduced loads.

Standard degree of protection IP54 (out of control panel installation).

Fan VFD may be necessary for the proper functioning of some burner models/sizes.

5) HEAT RECOVERY SYSTEM

5.1) ECONOMIZER

Heat recovery system from flue gases to increase the overall efficiency of the boiler. Includes:

- Nr. 1 finned pack heat exchanger (flue gas - feedwater exchanger), installed on the structure of the front flue gas box consisting of:
 - o air containment frame with rectangular section in carbon steel sheet with reinforcement ribs;
 - o bolted flange for mounting on the flue gas box;
 - o finned pack with horizontal carbon steel tubes welded to end manifolds, aluminum fins;
 - o EN 1092 flanged nozzles for water inlet/outlet;
 - o threaded sockets for drain and vent.
- Shut-off and bypass valves, certified safety valve and drain and vent valves.
- Pre-assembled piping for connection to the feed water line.
- Nr. 1 Thermocouple for measuring the temperature of chimney flue gases.

The economizer is PED certified as pressure equipment.

The option includes the adjustment of the front flue gas box for connection to economizer.

Flue gas outlet box with circular flanged connection, complete with counter-flange.

Insulation with rock wool with a thickness of 70 mm, density 100 kg / m³ and finish in Aluzinc or stainless steel (same finish as the generator).

5.2) **HE-SMART SYSTEM - OPTION**

Patented heat recovery system from combustion flue gases to increase the overall efficiency of the boiler.

Include:

- Nr. 2 finned pack heat exchangers (feedwater – flue gases exchangers) installed on the structure of the front flue gas box, consisting of:
 - o air containment frame with rectangular section in carbon steel sheet with reinforcement ribs;
 - o bolted flange for mounting on the flue gas box;
 - o finned pack with horizontal carbon steel tubes (stainless steel for the upper exchanger) welded to end manifolds, aluminum fins;
 - o EN 1092 flanged stubs for water inlet/outlet;
 - o threaded sockets for drain and vent.
- Nr. 1 Finned pack air heater integrated in the fan/burner air duct, consisting of:
 - o air containment frame with rectangular section in carbon steel sheet with reinforcement ribs;
 - o bolted flange for mounting on the fan/burner duct;
 - o finned pack with horizontal carbon steel tubes welded to end manifolds, aluminum fins;
 - o EN 1092 flanged stubs for water inlet/outlet;
 - o threaded sockets for drain and vent.
- Nr. 2 thermocouples for measuring the temperature of the water upstream the heat exchangers group and downstream the air heater.
- Nr. 1 thermocouple for measuring the temperature of chimney flue gases.
- Shut-off and bypass valves, certified safety valve and drain and vent valves.
- Pre-assembled piping for connection to the feed water line.
- 3-way control electropneumatic valve for HE system, controlled by PLC F3 Optispark.
- signal transmission of measured temperatures to the boiler control system with visualization at HMI.
- Dynamic control of the amount of heat recovered and the temperature of the flue gases at the chimney, integrated into the boiler management system.

All heat exchangers are PED certified as pressure equipment.

The option includes the adjustment of the front flue gas box for connection to economizer.

Flue gas outlet box with circular flanged connection, complete with counter flange.

Insulation with 70 mm thick rock wool, density 100 kg/m³ and finish in stainless steel or Aluzinc (same cladding as the generator), only for water/flue gas heat exchangers. With feed water at temperatures $\geq 150^{\circ}\text{C}$, the insulation of the duct between the air heater and the burner, including the exchanger, is also provided, together with burner insulation with a cushion in textile fiber.

In the HE version, inverter-controlled pumps are provided.

6) **FEEDWATER PUMPS**

6.1) **DOUBLE PUMP (ONE AS BACKUP)**

Two centrifugal pumps, horizontal, directly coupled to IE3 electric motor; supplied mounted on a base directly connected to the boiler (can be disassembled for transportation).

Each pump processes the entire flow rate required by the boiler, so that a pump is always available as a backup to be able to use the boiler at full load in case of failure of the other.

The pumps are complete with pre-assembled pipe up to the boiler inlet with threaded connection for possible connection of the chemical dosing unit (1/2" NPT-F). Pump control and automatic switch-over are managed by PLC.

The pipe is manufactured with welded elbows, not with bent piping. The pipe is supplied painted, not insulated.

Power supply circuit with magneto-thermic switch installed inside the electric panel.

6.2) DOUBLE PUMP (ONE AS BACKUP) WITH VFD - OPTION

In addition to what is included in option 6.1) two VFDs are included for modulation of the rotation speed of the pumps, for fine control of the feed water flow and electricity saving with the generator running at reduced loads.

Standard degree of protection IP54.

A pressure transmitter on feed water line is included.

7) LADDER AND PLATFORM

Ladder and platform for access to the upper part of the generator, complete with supports, in aluminum, EN 14122 certified. The ladder is of the ship's type with a protective cage.

8) TRANSIENT MANAGEMENT (CHIMNEY DAMPER) - OPTION

Transient management system controlled by HMI operator panel; the function can be enabled locally or remotely via ModBus connection. Transient management reduces energy losses due to natural draft to the chimney during downtime, while also ensuring better readiness for generator commissioning when required.

A single-blade butterfly damper for high temperatures (max 350°C) is included, complete with a pneumatic actuator N.A. controlled by a 230 Vac solenoid valve. The actuator is complete with SIL limit box for "damper open/closed status" and with local position indicator.

A flue gas high pressure switch is also included, installed on board the generator for generator shut-off.

9) TEST

The steam generator is always functionally tested at the factory (electrical and software tests, functional tests of safety chains) before shipment.

Fire testing (with burner ignition) at the factory is available **on request**.

10) TECHNICAL DOCUMENTATIONS

- Equipment drawing with foundation loads (ENGLISH – digital)
- Transport drawing with dimensions, weights and indications on handling (ENGLISH – digital)
- P&ID for water/steam and combustion (ENGLISH – digital)
- Electrical diagrams (ENGLISH – digital and paper)
- Boiler Instruction and maintenance manual (ENGLISH and GREEK – digital and paper)
Note: instruction manual of instruments and accessories in English only.
- Boiler management system "Optispark" manual (ENGLISH – digital)
- Boiler control panel HMI language: ENGLISH
- Boiler and Control Panel CE Certification (ENGLISH – digital)
- Boiler main components documentation and CE Certification (ENGLISH – digital)
- Signals serial list (ENGLISH – digital)

Standard of documentation: BONO STANDARD