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1 Subject of specification

This specification and other documents referenced herein establish the minimum requirements for the design, fabrication, erection, inspection and tests for the Waste Heat Recovery Boiler (WHRB).

Waste Heat Recovery Boiler mean tubular arrangements (or, in exceptional cases smoke tube arrangements) in the convection section of reformers or other all-radiant heaters, suitable for preheating of the process feedstock and boiler feed water, generation and superheating of the steam and preheating of the combustion air.

This specification shall be applied in conjunction with basic process requirements attached to the inquiry/purchase order, mainly consisting of:

- Type and arrangement of the WHRB
- Plot plan for WHRB area.
- Design duty
- Allowable pressure drops
- Heat source - process or flue gas, temperature, composition and pressure
- Corrosive elements in heat source (eg. sulphur, vanadium)
- Draft available if the WHRB has to be connected to an existing or common stack.
- Recommended materials
- Properties of process fluid (if applicable)
- Process inlet and outlet temperatures
- Details of any long-term turndown conditions to be taken into account in design
- Environment conditions
- Minimum allowable stack height (if applicable)

2 Scope of validity

This specification applies to the preparation of tender documents, inquiries and contracts for newly planned investment or modernization projects of Grupa LOTOS S.A.

It shall also be a basis for preparing both detailed specifications and inquiries for individual or package unit supplies.

2.1 Deviations

Any deviation from this specification and the relevant specifications, standards and related documents including proposals, which the bidder claims to be economically and / or technically superior solutions must be submitted in writing for review and approval by Grupa LOTOS S.A. Non-approved exceptions are not acceptable by Grupa LOTOS S.A.

The supplier must report in writing any ambiguity in this or any other specifications of Grupa LOTOS S.A. or non-compliance with the referred documents / standards and obtain a written explanation from Grupa LOTOS S.A.

2.2 Order of Precedence

In case of conflicts existing between this specification and other documents, the following order of precedence shall govern:

- The current Polish legislation
- Terms of purchase order / contract and other requirements agreed in writing Grupa LOTOS S.A.
- Data Sheets approved by Grupa LOTOS S.A.
- This specification
- Other Specifications
- Drawings and other documents
- Standards

2.3 Exclusions

Directly fired boilers are excluded from scope of this specification.

3 Design Criteria

The boiler design and construction shall be suitable for the process gas conditions specified representing minimum, nominal and maximum heating values of the gas.

The boiler will receive hot gases from the process described in the applicable data sheets. Typical sources are gas turbine exhaust, furnaces heaters, kilns, incinerators and chemical processes. The type of boiler shall be recommended by the manufacturer based on API RP 534 recommendations.

The applicable data sheets indicate whether the hot gas is clean or dirty. Fire tube and extended surface designs may only be used for clean or moderately clean gases. If the hot gas is dirty, the boiler shall be furnished with soot blower(s) and dust hopper(s).

Additional components such as an economizer, superheater, attemperator and desuperheater shall be furnished complete with all necessary parts to attach and integrate these items with the boiler.

A water-walled radiant section shall be provided when the temperature of the gases approaches to the ash fusion temperature before the gases enter the convection passes.

The boiler shall be designed for continuous operation, 24 hours per day, 7 days per week.

The design of the boiler shall guarantee the performance within the limits of the process and environmental condition specified on the applicable data sheets.

The equipment shall be designed to produce the most economical overall installation, consideration being given to installed cost and the day-to-day operating costs and maintenance cost.

All equipment shall be suitable for use in the industrial environment specified in the data sheets. The equipment shall be furnished with all necessary weather and anti-corrosion protection to prevent damage due to weather, fumes or dust from the plant.

3.1 System arrangement

The Waste Heat Recovery Boiler shall be preferably arranged as a horizontal duct of rectangular cross-section.

For special application vertical duct arrangement with flue gas up- and/or down-flow may be design.

The flue gas duct shall be arranged elevated on concrete piles with a floor elevation equal to the floor elevation of the furnace/heat source.

All tube banks shall be put in place and be removable either from the top or from the same side together with their inlet and outlet manifolds.

Sections of steel structure and ductwork that must be dismantled for removal of the bank or individual coils shall be of bolted design.

If dismantling of supporting structure for tube bundle removal is unavoidable, the necessary prefabricated material for temporary supports and bracings shall be supplied with main equipment.

Generally tube banks shall be suspended from the top with thermal expansion downwards. For horizontally arranged tube banks support on heat resistant bars embedded in the floor refractory is acceptable likewise.

When the manufacturer arranges equipment, the equipment shall be laid out in a compact manner, but with adequate accessibility for field connections, operation, observation, maintenance and removal purposes. Particular attention shall be given to the layout of pipework, valves and instrumentation to ensure convenient access.

4 Basic process design requirements

4.1 Flow Distribution

A flow distribution calculation shall be performed for all manifold-tubes-manifold arrangements for specified minimum and design flow. The flow maldistribution shall not exceed ± 3 % of the average for the full load range.

If necessary for assurance of the required equipartition, special measures shall be taken as restriction of tube diameter tolerances, flow area restrictions at tube inlets etc.

4.2 Heat Transfer Calculation

The tube inside heat transfer coefficient and the maximum fluid temperature shall be calculated under consideration of the calculated flow maldistribution. If this calculated maximum fluid temperature plus a margin of 5 °C exceeds the fluid design temperature specified by Grupa LOTOS S.A., the calculated maximum fluid temperature plus 5 °C shall be taken as basis for determining the metal design temperature.

The outside heat transfer coefficient shall be calculated as combination of convective and radiant heat transfer.

For flue gas temperatures exceeding 700 °C the radiation from the gas volumes in the free area between the tubes of one bank shall be calculated separately for local flue gas and tube wall temperatures.

For flue gas temperatures below 700 °C a correction factor for the convective heat transfer coefficient may be used in accordance with the experience of the manufacturer.

The radiant heat transfer coefficient from the gas layers enclosed between two adjacent tube banks to the first two and last two tube rows of the upstream and downstream banks shall be calculated including the effect of the solid body radiation of the lateral walls, floor and arch.

The radiation from the flue gas inlet to the first tube bank shall be considered to be a black body radiation of flue gas temperature.

5 Basic mechanical design requirements

5.1 Steel structure

The steel structure shall meet the requirements of the Polish building regulations standards and Grupa LOTOS S.A. specification 5120. It is mandatory that fired heater steel structure calculations shall be reviewed, verified and approved by licensed structural engineer in accordance with Polish Building Law prior to installation and putting into operation.

Materials used for fired heater construction shall comply with the relevant PN-EN codes.. The minimum quality of material used for casing plates, structural shapes and main supports shall be S235JRG2 according to PN-EN 10025 or equivalent and S235JR for secondary elements.

The WHRB structure design shall allow for easy disassembly and replacement of the pressure parts.

5.1.1 Tolerances

Required Tolerances shall be as a minimum according PN-EN-ISO13920.

Agglomerations of tolerances are not allowed. For this reason the individual panels, as an integral part of the duct shall not reach in any case the maximum tolerances.

The vertical deviation of the overall steel construction may not exceed 5 mm per 5 m height.

Dishing in flat casing sections and rectangular duct areas shall not exceed a value of 2 mm/m^2.

5.1.2 Platforms, Walkways, stairs and ladders

The WHRB shall be furnished with suitable platforms, stairs and ladders, allowing for access to the inspection/access doors, valves, instruments and auxiliary equipment, according to requirements of Specification No. 5120.

Platforms shall be provided for safe operation and service of the WHRB and its accessories such as:

- Soot blowers (servicing, lubrication, maintenance)
- Dampers
- Guillotine dampers
- Sampling connections,
- All instruments
- Vents, drains, valves etc.

Access by stairways shall be provided to platforms for normal servicing.

Access by ladders shall be provided to the service platforms at the opposite side to stairway and to platforms without stairways and to any location where checking or service may be required.

Alternative escape routs shall be provided.

5.2 Flue gas ducts and stack

For details refer to Grupa LOTOS S.A. specification No 2120 - Flue gas stack, ducts measurement and monitoring nozzles.

Blinds and guillotine dampers should be provided to isolate WHRB connected to the common flue gas channel or stack.

If possible flue gas by-pass shall be provided to allow boiler service during installation operation.

The flue gas duct shall be designed as inside refractory lined steel casing.

If the gas temperature is below 180 ^{o}C external insulation will be preferred.

The fixed-point support of the duct shall be located approximately in the centre of the duct longitudinal and lateral extension with thermal expansion to both ends.

The connections to the furnace outlet flue gas collector on one end and to the induced draft fan on the other shall be by means of multiple layer fabric or corrugated steel expansion joints with internal insulation.

For stabilization of the flue gas flow the minimum distance between the hot end expansion joint and the first tube bank shall be at least equal to 50% of the width or height whatever is the larger dimension.

In case of significant changes of the flow direction the internal guide vanes for flue gas flow stabilization shall be provided.

The minimum distance between the last tube row of each tube bank and first row of the subsequent tube bank shall be 1m for free access.

Access doors min. 600 mm wide and 900 mm high shall be provided to each of these areas in the sidewalls of the duct.

For access to these doors a platform with stairs and escape ladders shall be provided. For horizontal arrangement platform shall be on entire length of the duct.

If an auxiliary firing (eg. during start-up) and this additional flue gas is tied-in to the main duct at a suitable point, the inlet port shall extend over the full width (for floor or roof tie-in) or height (for side wall tie-in point) of the main duct.

The flue gas velocity from auxiliary firing to the main duct shall be at least twice the velocity in the main duct at normal operation conditions of the system.

Special attention shall be paid to the tightness of the duct at maximum precipitation. Appropriate drains and rainwater channels shall be provided to drain all areas of the duct top cover.

The duct shall consist of prefabricated panels either self-supporting or supported by an external steel structure, or combination of both. The prefabricated sections of casing and steel structure shall be prepared for bolted or bolted and seal-welded water- and airtight connection at site.

The minimum plate thickness shall be:

- for the lateral walls 5 mm
- for floor and arch 6 mm.

To prevent bulging and distortion of the panels by uniformed temperature, outside forces and the weight of the refractory, the panels shall be reinforced by welded steel sections or braces. Maximum

brace-to-brace spacing shall be 900 mm. All reinforcement shall be continuous welded from both sides.

The casing of the flue gas ducts shall withstand an overpressure and a vacuum of 2 kPa.

The deflection of the lateral walls by the sum of vacuum and wind load must not lead to damages of the duct refractory lining.

The reinforcement of the casing by the refractory shall not be considered for design.

Bolts, nuts and washers for bolting of panels and steel structures shall be galvanized. At least one washer shall be provided under each nut.

Stack if included in scope of supply shall be designed strictly according to requirements of Grupa LOTOS S.A. specification No 2120.

5.3 Duct refractory

Refractory lining of side walls, floors and roofs shall either be single or double layer insulation castable, applied by pouring in flat position or by gunniting in place, or it shall consist of prefabricated, ceramic fibre modules, compressed to a density of not less than 160 kg/m³.

Castable refractory lining is obligatory for areas of turbulence or high gas velocity and for areas where gas temperatures are near or at the dew point or when the fuel gas contains over 100 ppm of combined metals.

The WHRB manufacturer shall submit information's about lining type selection and thickness calculation for Grupa LOTOS S.A. approval.

All refractory linings shall be arranged, in the way to ensure free expand at the operating temperature, tightness of the expansion joints and replace ability for any part of the refractory setting.

Materials for refractory shall be according ASTM standards.

Anchors material shall be selected based on hot face temperature according to below table:

Hot face temperature [^{o}C]	Anchor Material
< 400	Carbon Steel
400 - 700	TP304 Stainless Steel
>700	TP310 Stainless Steel

Anchor type and spacing shall be determined based on refractory manufacturer standard.

Stored castable mixes cannot be older, than 6 months when mixed and applied.

Design of the refractory insulation shall be based on maximum local flue gas temperature, casing temperature and ambient conditions as specified in the job specific requirements. The refractory application temperature shall exceed the maximum local flue gas temperature by min. 150 °C.

Fabric expansion joints shall be inside insulated by ceramic fibre, bulk density 128 kg/m^3. The fibre shall be erosion protected by temperature resistant wire mesh, material Alloy 800, or woven ceramic fibre fabric.

6 Pressure bearing components

The pressure parts of WHRB shall meet requirements of Directive of the European Parliament and of the Council on the approximation of the law of the Member States concerning pressure equipment 97/23/EC. The Manufacturer / Supplier shall obtain at his own expense all required by the regulations and codes approvals, acceptance, certificate, including these involving Notified Body.

WHRB can be designed based on the ASME BPVC code section I and VIII or PN-EN 12952 (for water tube boilers) and PN-EN 12953 (shell boilers)

The ASME BPVC code is preferred by Grupa LOTOS S.A..

Pressure parts shall be hydrostatically tested in accordance with PED requirements and under Notified Body supervision.

Pressure equipment hall have nameplate in Polish or Polish and English language in accordance with PED 97/23/EC. Nameplates shall be of corrosion resistant material installed on a nameplate bracket by solid stainless steel rivets. Inscriptions on the nameplate shall be engraved. Pressure equipment name plates shall be accessible, located next to fired heater name plate.

6.1 Design pressure

Design pressures specified for the system components are the maximum allowable operating pressures.

For boiler feed water preheater and steam generator the water column resulting from the elevation of the steam disengagement drum above the lowest point of the respective tube arrangement shall be added to the specified in the data sheet pressure.

6.2 Design temperature

The metal design temperature for the heat exchanger tubes shall be the maximum calculated mid wall temperature calculated from the heat transfer calculation plus a margin of 10 °C, or it shall be the specified local fluid design temperature plus:

- 75 °C for gas or gas / steam mixtures at elevated pressure for areas where the flue gas side radiant heat transfer cannot be neglected, and for extended surfaces
- 50 °C for gas or gas steam mixtures at elevated pressure, bare surface and convective heat transfer only.
- 50 °C for high pressure steam superheaters and steam generators for areas with flue gas side radiant heat transfer and for HP-steam generators / superheaters with extended surfaces
- 35 °C for HP-steam superheaters, steam generators and feedwater preheaters, bare surfaces and connective heat transfer only
- It shall be the maximum local flue gas temperature plus a margin of 50 °C, if "no flow" conditions are specified for the design.

For counter flow arrangements staging of the design temperature from feed inlet to outlet is acceptable. The calculation of the local design temperature shall be approved by Grupa LOTOS S.A.

For inlet and outlet manifolds the metal design temperature is

- for steam generators and feedwater preheater outlet the boiling temperature at design pressure

- for gas and steam service including air preheaters and for feedwater inlet the relevant fluid design temperature plus a margin of 15 °C.

6.3 Tube bank design general

For all tube banks of the WHRB, for gas-/steam mixtures, feed water preheating, steam superheating the multipass coil design with common inlet and outlet manifold is recommended.

Tube banks with tube wall temperatures exceeding 500°C under operating or upset conditions shall be of the vertical, top suspended hairpin or multiple hairpin coil type with the manifold arranged horizontally on top of the flue gas duct with exception of the steam generators in natural or forced circulation service, where the inlet of the feed water manifold shall be located at or below the duct bottom.

In the area of lower temperatures and gas or steam service coil arrangement may be vertical or horizontal.

The feed water preheater shall be horizontal, fully drainable arrangement.

If tube metal temperature exceed 500 °C at normal operating conditions the distance of the intermediate supports shall assure sagging of the tubes at least one tube outside diameter within 100 000 hrs, but the maximum allowable distance is 35 tube diameters.

If tube metal temperature exceed 500 °C at normal operating conditions the distance of the intermediate supports shall assure sagging of the tubes of more than one tube outside diameter within 100 000 hrs, but the maximum allowable distance is 35 tube diameters.

The intermediate tube support shall be designed for temperature equal to the maximum flue gas temperature at the inlet to the respective bank plus 30 °C.

Orientation of the inlet and outlet connecting nozzles of the all tube banks manifolds of the Waste Heat Recovery Boiler shall be the same.

Irrespective of the service the first tube bank in flue gas flow direction shall be designed for concurrent flow.

In the case of an auxiliary firing the same applies to the first bank downstream of the auxiliary flue gas inlet or if the temperature of the flue gas which is entering the main duct exceeds the design temperature of this bank by more than 75 °C.

Single coils shall be replaceable without the bank removal.

Only seamless tubes and bends shall be used for fabrication of tube banks for elevated pressures.

Manifolds may be seamless or forged or rolled and longitudinal welded in accordance with the applicable code.

Tube coils may either be manufactured by endless tube bending or by tube / bend assemblies. Unavoidable intermediate tube-to-tube welds that are inaccessible after tube bank assembly shall be 100 % radiographed with min. 2 elliptical exposures and UT examined.

Tube to manifold connections shall only be done by reinforced stub ends, the stub ends welded to the manifolds with full penetration.

Only butt welds with full penetration are acceptable for tube to stub end connections, no socket or fillet welds allowed.

All horizontal manifolds shall be fitted on top with a vent nozzle with blind flange. All vertical manifolds with closed top shall be fitted with a vent nozzle of same design likewise. All vertical manifolds and the horizontal inlet manifold of steam generating coils shall be fitted with a drain

nozzle 1" with double shut-off valves. Rating of flanges and valves shall be in accordance with the Grupa LOTOS S.A. piping specification.

6.4 Steam generation tube banks

Steam generating tube banks for natural and forced circulation shall be of vertical, up flow harp design, inlet and outlet manifold arranged outside the flue gas duct.

Maximum four rows of tubes with in-line or staggered tube pitch shall be connected to one set of manifolds, which inside diameters are less than 600 mm.

Downcomers and risers shall be connected to inlet and outlet manifolds symmetrically for uniform circulation. One downcomer or riser respectively shall serve not more than 2 m length of manifold.

The design of the lateral walls of the flue gas duct as “membrane walls” may be considered

Tube diameter shall not exceed 57 mm (76 mm for vertical arrangement).

6.5 Boiler feed water preheater tube bank

The boiler feed water preheater tube bank may be of bare tube or extended surface type.

Complete drain of the feed water preheater must be assured. Only seamless tubes and return bands shall be used.

6.6 Superheater tube bank

The superheater tube bank is to design for the same design pressure as the steam drum.

No valves are to be provided between saturated steam outlet from the drum and superheater inlet.

Superheater tubes shall have minimum O.D. of 38 mm . Only seamless tubes shall be used.

6.7 Extended surface of the tubes

The extended surface may be used for tube when flue gas temperature is below 700 ^{o}C or calculated fin tip temperature below 650 ^{o}C.

Fins shall be continuously welded to the tube with full penetration.

The minimum thickness of fins shall be 1.5 mm and the maximum height 25 mm. Not more than 165 fins per m of the tube length are permissible.

For tip of the fin temperature below 520 ^{o}C carbon steel is permissible, for temperatures 520 ÷ 655 ^{o}C at least 5 % Cr-0.5 Mo steel is recommended. The use of cast iron is not acceptable.

For the two first finned rows even though the design conditions call for carbon steel 11-13% chromium fins shall be provided.

6.8 Steam disengagement drum

The steam drum shall be fusion welded and not less than 900 mm in diameter and is to be furnished with the manufacturer's standard steam separating devices.

The steam drum must meet the following requirements:

- the normal water level shall not be higher than 50 mm over the drum centreline

- an efficient steam separation and purification system is to be provided.

All steam / water headers and overflow pipes must be connected to the stream drum above maximum water level or appropriate baffles shall be provided inside the drum.

The drum internals include internal distribution pipes for feed water and a collector for continuous blow-down and shall be extent below minimum water level over the full length of the drum.

All internals must be properly supported and easily removable through the manholes for maintenance and inspection. Connection bolts and nuts must be secured from loosening by vibrations.

The steam drum shall be equipped with two manholes of self-sealing type.

The continuous blowdown will be released to a continuous blowdown drum.

Intermittent blowdown and all drains from the boiler will be release to an atmospheric blowdown drum.

6.9 Materials

The materials for all pressure bearing components of the WHRB shall be in full conformity with the applicable code.

No austenitic stainless steel shall be used for parts that are in contact with steam and /or water without written approval by Grupa LOTOS S.A.

Materials for air preheater tubing and tube sheets shall be selected in accordance with the metal temperatures.

The carbon content of unalloyed and alloyed material shall be limited to max. 0.22 %. No combination of ferritic and austenitic tubes and no combination of bare and finned tubes shall be used for one tube bank.

6.10 Vibration Analysis

A vibration analysis shall be performed for all tube banks and the flue gas duct, checking the natural frequencies of all components against the natural frequencies of the flue gas column that are depending on gas properties / temperature and duct dimensions.

In case of resonance to be expected, suitable measures shall be taken for prevention of occurrence of standing waves at any point of the operation range. These measures may be longitudinal partition plates for the tube banks and / or removable partition walls for the free duct areas.

6.11 External Piping

External piping shall be designed and made according to ASME B31.1 and B31.3 (for process piping if any) and Grupa LOTOS S.A. piping standard No 2600.

The piping system shall be designed to allow for complete draining and venting. Piping terminals at battery limit shall be designed to accept forces and moments coming from outside piping. During job execution the loads and moments given by Grupa LOTOS S.A. have to be checked and confirmed.

Piping handling hazardous fluids (eg. hydrocarbons) above 1" is subject of Notified Body approval according Directive 97/23/EC.This piping shall be in accordance with Grupa LOTOS S.A. specification No 8800 "Piping subject to UDT/ZDT approval".

The equipment shall meet the requirements of Polish regulations.

The Manufacturer / Supplier shall obtain, for his account, the entire necessary code, stamps, certificates (acc. to Directive 97/23/EC).

7 Soot blowers

If required, the Manufacturer/Supplier shall furnish soot blowers using steam as the blowing medium, integral with boiler, with all appurtenances required for a complete installation and ash hopers. The blowers shall be properly located and installed to effectively clean the boiler tube surfaces with direct impingement steam on the tubes.

Dense castable refractory or stainless steel shroud plates shall be provided for to protect sidewalls against erosion.

Soot blower shall be spaced to cover a radius of maximum 1.2 m to either side to obtain adequate cleaning.

The soot blower shall adequately clean a maximum 4 rows, bare or extended surface, immediately above and below the lance position.

Adequate soot blowers lance depth must be provided in order the blowers to be effective. A clear depth of 0.5 m is a reasonable minimum.

The lance depth and frequency should be specified after consultation with a soot blower vendor.

Saturated steam of pressure of 1.9 MPa g is recommended for proper operation of the soot blowers.

For to protect tubes against unacceptable corrosion limited to 2.4 MPa g for rotary types and 2.1 MPa g for retractable soot blowers.

The soot blowers shall be controlled by PLC from local panel located at ground. Steam silencer shall be provided for steam line heating up.

8 Instrumentation

Waste heat recovery system shall be provided with complete local instrumentation (in accordance with the applicable standards and Grupa LOTOS S.A. specifications 3010 to 3880) for the control and command system including measurement, control, interlocking, alarm and safety equipment.

General requirements for WHRB control are described in Grupa LOTOS S.A. specification No 3220 “Fired heaters and boilers control and safety interlock system”.

In case of auxiliary firing, complete interlock Burner Management System (BMS) necessary for proper operation of the unit and required by relevant codes shall be included. The complete Burner Management and Safety Interlock System design shall be according to EN Standards (PN-EN-746 – 1,2,3, PN-EN-676; PN-EN-61508 and PN-EN-61511 –1,2) and is a subject of Notified Body approval (for approval requirements and procedure see Grupa LOTOS S.A. specification no 8500).

Vendor is responsible for SIL level calculation according to IEC standards. WHRB instrumentation shall be selected based on calculated SIL level.

It is in vendor responsibility to provide all necessary documents for WHRB control system implementation in to the refinery DCS or PLC. The vendor shall provide necessary data which shall be taken into account in the control system of the heater connected with boiler.

All instruments and devices shall be made and installed in accordance with requirements of Grupa LOTOS S.A. standards group 3000. For instruments located in explosive hazard areas requirements of Grupa LOTOS S.A. specification no 1020 chapter 4.2.3 shall apply.

Instrument connections shall be sized according to instrument specification.

8.1 Temperature Control

If not specified otherwise the local devices for temperature control of the superheated steam and process feed gas will be a part of the design and scope of supply for the Waste Heat Recovery System.

The temperature control may either be done:

- by means of attemperators and feedwater injection
- by means of attemperators and injection of condensate generated by condensation of saturated steam taken from the steam disengagement drum in a surface condenser cooled by the incoming boiler feedwater
- by indirect cooling of a part of the superheated steam and process feed gas in surface coolers arranged in the lower part of the steam disengagement drum.

In any case the entire hardware as surface coolers and condensers, three-way or injection valves, bypass and block-valves, attemperator tubes with inside shroud, interconnecting piping, instrument nozzles, strainer in the injection line, support etc., will be a part of engineering and supply of the Waste Heat Recovery System.

If not specified by Grupa LOTOS S.A. the type of feedwater injector, whether movable piston type (YARVIK or equivalent) directly flanged to the attemperator body or separate injection water control valve, shall be mutually agreed between the manufacturer and Grupa LOTOS S.A..

Water injection valve or three-way valve shall be fitted with pneumatic actuators.

8.2 Steam Quality Control

The boiler shall produce steam of the specified quality.

The steam quality measurements shall be arranged at boiler outlet downstream of the steam temperature controller.

Provisions shall be made to keep the steam quality below the acceptable impurities even in case of decrease of feed water quality, e.g. by chemical injection directly to the steam drum or by increase of continuous blow-down rate.

9 Electrical Requirements

All electrical work, electrical parts, devices, panels and equipment furnished as a part of the WHRB system shall be in accordance with applicable Grupa LOTOS S.A. specifications and including the scope of supply.

Electric motors to be supplied as a part of the packaged system shall be delivered in accordance with the applicable Grupa LOTOS S.A. specifications.

All electric parts, devices, boards and equipment which is a part of the boiler delivery shall be according Grupa LOTOS S.A. appropriate specifications, scope of delivery and standard PN-EN 50156-1.

10 Prefabrication and Erection

10.1 Degree of Prefabrication

All components of the flue gas WHRS system shall be prefabricated to the maximum possible extent.

The limits of a prefabricated modules are determined by shipping dimensions, weight and site handling.

Site welding shall be avoided or limited to a minimum.

10.2 Tube System Prefabrication

Tube banks shall be completely shop assembled including inlet and outlet manifolds or - in case of the air preheaters - including inlet, reversing and outlet chambers.

If longitudinal split of a tube bank is unavoidable due to dimensions or weight, the manifolds shall be split likewise and be bevelled for circumferential site welding.

If a tube bank must be split in cross direction, two intermediate outlet and inlet manifolds with interconnecting transfer line shall be provided.

Piping components, downcomer and riser tubes for steam generators etc. inside the specified scope of supply shall be supplied in prefabricated sections with weld preparation for site welding and the necessary matching length.

Sections of the duct cover or lateral walls that are shop-fitted to a tube bank shall be refractory lined prior to tube bank assembly, the refractory be water protected for shipment and intermediate storage by plastic foil.

10.3 Flue Gas Duct Prefabrication

Walls, floor and cover plate shall be prefabricated in flat sections of transportable size and be prepared for air tight, bolted and seal welded site connections. Duct sections that do not exceed the dimensions for unrestricted land transport shall be shop assembled with refractory lining.

Necessity of pre dray out shall be agreed with Grupa LOTOS S.A.

All refractory anchors shall be shop welded to the duct casing inside if not otherwise noted.

Beams, bracing's etc. of supporting structure, platforms, stairs and ladders shall be prefabricated and prepared for bolted site assembly. Site welding of these components is not acceptable.

11 Inspection

The Inspection and Test Plan (ITP) shall be completed and submitted to Grupa LOTOS S.A. for fixing the notification, review, witness and hold points.

The Manufacturer/Supplier will grant for Grupa LOTOS S.A. representatives unrestricted access to all steps of fabrication and testing in own or his sub-suppliers shops and laboratories.

The Manufacturer/Supplier and his sub-suppliers will provide free of charge the necessary assistance for Grupa LOTOS S.A. inspection as manpower, tools, instruments, cranage etc.

All parts of the heater presented for the inspection shall be subject of a previous dimensional check by the manufacturer. The Manufacturer/Supplier shall prepare a dimensional record indicating the actual dimensions of each and submit it to Grupa LOTOS S.A. before inspection. Any deviations from the specified tolerances shall be clearly marked in this record for clarification.

The parts made available for the inspection shall be free from slag, dirt, oil, welding spatter and other foreign matter.

No protection paint or other filling shall be applied before the equipment has been inspected tested and approved

All loose components included in the scope of supply shall be kept ready for the inspection before dispatch.

Inspection by Grupa LOTOS S.A. shall in no way relieve the Manufacturer/Supplier from the responsibility to meet the requirements of the purchase documents.

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The records listed below shall be available for review by Grupa LOTOS S.A. representative at the time of inspection:

- Mill test reports pressure parts. The test reports shall state the specification to which the material complies, the heat, lot or heat number, and the heat treatment (if any) and the results of chemical analysis and mechanical tests.
- Certificates for non-pressure part
- Certificates for bolting material
- Welding procedure specifications, procedure qualification records and welder qualification tests.
- Radiographic films of required radiographic test incl. the expert's assessment and records of the results of any required magnetic particle, fluid penetrant, or other method of examination.
- Charts or other records of required hydrostatic, pneumatic, and other tests.
- Detailed records of heat treatment (post-weld, normalizing, heating for forming, etc.).
- Certificates for valves and instrumentation
- Certificates for electrical parts

11.1 Welding Inspection

The extent and acceptance standard of welding inspection shall be in accordance with the applicable code, with the following additional requirements:

- 5 % of circumferential welds of manifolds, tubes and pipes that are exempted from radiographic examination in the code requirements shall be radiographed on full circumference to the standards required in the code
- all circumferential welds of manifolds, tubes and pipes that are inaccessible after assembly shall be 100 % radiographed, even if the number of these welds exceeds the required 5 %
- for each of these 5 % circumferential welds or the 100 % inaccessible welds that are found defective during examinations, two additional welds shall be radiographic examined

- all welds of 1 Cr-0.5Mo or higher alloyed material used for pipes and manifolds with a wall thickness exceeding 15 mm, shall be 100 % radiographic examined after post-weld heat treatment.

11.2 Design Check

The design / technical documentation, including strength calculation, of pressure parts / equipment of WRHB shall be verified and approved by authorized inspection party (Notified Body) to certify conformity to mandatory regulations.

It is the Manufacturer / Supplier responsibility that WHRB steel structure design, including calculations, shall be reviewed, verified and approved by licensed structural engineer in accordance with Polish Building Law..

The compliance of WRHB design with requirements of this specification and purchase order will be verified by Grupa LOTOSS.A.

11.3 Rejection

Equipment or parts thereof and materials entering therein, indicating irremediable or injurious defect, improper fabrication, excessive repairs, or they are not in accordance with the requirements of the relevant codes or Grupa LOTOS S.A. specifications shall be subject to rejection. They shall be subject to rejection at any time or place by Grupa LOTOS S.A. or Grupa LOTOS S.A. representative if such conditions are discovered after acceptance of the items at the supplier's shop.

12 Painting and Temporary Corrosion protection

All surfaces of structural steelwork including the exterior surface of air ducts and flue gas ducts shall be shop painted at Manufacturer/Supplier's shop in accordance with Grupa LOTOS S.A. specification no 1190. In duly justified cases structural steelwork may be painted at site. This shall be subject to prior Grupa LOTOS S.A. written approval.

The outside surface of WHRB and inside lined ducts shall be painted with paints having a application temperature of at least 180 °C.

After hydrostatic pressure test all tube / banks manifold shall be properly dried out by means of preheated air.

Plastic caps shall close all nozzles. Wooden plates shall protect flanges.

Cabinets, electrical motors shall be final coated according to manufacturer standards if not otherwise noted.

For the internal metal surface of the flue gas duct that will be site refractory lined one layer of wax-based temporary corrosion protection shall be applied, if not acid resistant coating is specified in the job specific requirements.

Other parts such as piping components, rotating equipment etc. shall be corrosion-protected or shop painted in accordance with the relevant specifications.

For sea transport the systems shall be filled with nitrogen to a pressure of 0.25 bar (g).

A filling and a vent nozzle with one pressure gauge shall be provided on the temporary caps of opposite manifolds.

The temporary welded caps shall remain in place, but the final weld preparations shall be machined and shaped down to the root for easy cutting at site. The flanged blinds shall stay with the temporary gaskets (3 sets of final gaskets and 10 % bolts and nuts to be supplied with the equipment).

The Manufacturer/Supplier shall submit for Grupa LOTOS S.A. approval details of temporary protection against corrosion during transport and storage with information about type of transport package. The tube banks, panels of the duct casing, combustion air duct sections etc. shall be packed in wooden or steel crates. Structural parts shall be bundled, prefabricated piping and fittings shall be packed in water protected cases.

13 Documentation

The documentation shall be delivered in the quantity fixed in the specifications No 6400, 6500 and purchase order documents.

Manufacturer/Supplier shall deliver technical documentation that will cover all drawings, data sheets, operating manuals, manuals and description of components, electrical and instrument documents and brochures necessary for the operating, maintenance, repair and spare parts ordering.

14 Basic Design Information Required from Bidder

The Bidder shall submit completed data sheets, description, diagrams and drawings showing the dimensions, materials, lay-out and main characteristics of:

- Tubes, tube supports and guides, manifolds and connections to inlet and outlet lines
- Calculated tube wall thickness
- Steam drum details, thickness and calculated hold-up time
- Flue gas duct (arrangement, dimensions, position of inspection doors, etc.)
- Cleaning facilities
- Operating conditions
- Heat transfer rates both maximum and average
- Flue gas temperature at the inlet and outlet of each WHRB section
- Guaranteed efficiency
- Battery Limit definition
- WHRB P&ID

15 Relevant documents

Any “Technical Specification” issued by Grupa LOTOS S.A. listed in Contract Files.

16 Norms and standards

Codes and standards listed below form part of this specification. Each publication shall be the latest revision and addendum in effect at the Contract award, unless otherwise specified:

- 97/23/WE (PED) Directive of the European Parliament and of the Council on the approximation of the law of the Member States concerning pressure equipment
- ASME BPVC Sections I – Power Boilers
- ASME BPVC Sections VII – Pressure Vessels
- ASME B31.1 Power Piping
- ASME B31.3 Process Piping
- PN-EN 12952 Water tube boilers
- PN-EN 12953 Shell boilers
- PN-EN 50156-1 Electrical equipment for furnaces and ancillary equipment Requirements for application design and installation
- PN-EN-ISO 13920 Welding - General tolerances for welded constructions - Dimensions for lengths and angles; shape and position
- API RP 534 Heat recovery steam generators
- API RP 556 Instrumentation, Control, and Protective Systems for Gas Fired Heaters
- PN-EN 61508 Functional safety of electrical/electronic/ programmable electronic safety related system (all parts)
- PN-EN 61511-1,2 Safety instrumented systems for the process industry sector; Part 1: Framework, definitions, system, hardware and software requirements; Part 2: Guidelines in the application of IEC 61511-1

17 Record of changes

No.	Date	Description	Introduced by
1	30-11-2013 (rev.1)	Review, update, standardize and changes to the Standard within scope of order No. OK/990/2012	Editorial board coordinated by T.Wróbel
-	31-08-2015	Page layout corrections, no contents changes.	T. Wróbel