Employer
SAKO BRNO A.S.

Project
High-efficient combined heat and power facility utilizing renewable sources (OHB II - line K1)

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PART III, APPENDIX A2
TECHNICAL SPECIFICATIONS FOR INCINERATOR/BOILER

SAKO

RAMBØLL

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1. TECHNICAL SPECIFICATIONS FOR INCINERATOR/BOILER

1.1 General

The incoming waste must be unloaded in the bunker and transported to the waste hopper of the incinerator. The incinerator shall be based on advanced moveable grate mass burn technology. The incinerator shall be able to treat the delivered waste without sorting, and the daily operation shall be so that the operating staff has as little contact as possible with waste, dust, grate riddlings, grate IBA, odour, moisture, hazardous materials and fluids etc.

The incinerator/boiler shall be designed without flue gas recirculation.

Generally, the systems shall be designed in order to let items with a length of up to 1.1 m pass unhindered through hopper, chute, furnace and the IBA extraction system.

2. FEEDING SYSTEM

2.1 Feed hopper

The feed hopper shall be designed in such a way that, when the waste is fed into the hopper by the crane grab, no waste is dropped over the edges. The hopper shall be of proven shape ensuring that clogging and bridging are avoided, e.g. by applying an asymmetric design and different slope angles of the hopper walls.

The feed hopper walls shall be constructed of steel plates reinforced with structural sections in order to withstand the impact of the crane grab and a possible bridge braking equipment.

The hopper top shall be provided with steel plates bended towards the hopper center in order to reduce dust dissipation.

The feed hopper walls shall be designed 1.2 m wider on each side, in respect to the width of the chute.

The hopper walls shall be lined with easily replaceable wear- and corrosion resistant steel plates. Effective noise attenuation shall be included.

The feed hopper shall be suspended in the concrete hopper deck, and the top of the feed hopper walls shall as a minimum be 110 cm above the concrete hopper deck, and it shall be equipped with rounded inside-corners

Space for access behind/between the hopper and the concrete wall to the boiler hall shall preferably be a minimum of 1 m, but shall be agreed with the Employer.

The Contractor shall ensure that the connection between the concrete and the hopper is waterproof.

The back wall of the hopper shall be extended and bended towards the boiler hall wall in order to facilitate safe passing behind the hopper even during crane operation. The construction shall be designed in such a way that a minimum of dust is accumulated on the top.

In order to avoid dust accumulation, no open horizontal cable racks shall be used inside the bunker area.

Design and sizing of the hopper shall be based on a crane grab size in accordance with stipulations in appendix A13 *Process and Design Data*.

2.2 Waste Chute

The design of the waste chute shall facilitate that the subsequent movement/transportation of the waste to the waste feeder is not impeded by clogging/bridging in the chute. This requirement shall be met by increasing the cross-sectional area of the chute in the downwards direction (towards the waste feeder). In addition, the chute shall form an effective air seal to the furnace chamber.

The waste chute shall be equipped with a robust, sturdy hydraulic cut-off gate to prevent backfire and to serve as an air seal when the incinerator is not in operation. The cut-off gate may not obstruct the movement/transportation of the waste towards the incinerator during operation. It shall be possible to operate the gate from the control and monitoring system (CMS) in the control room. Furthermore, it shall be possible manually to operate the cut-off gate. The cut-off gate shall be designed for bridge-breaker purposes. In case of power failure, the system shall be able to operate i.e. by a pressurised hydraulic oil buffer tank.

It shall be possible for items with a length of up to 1.1 m to pass through the waste chute to the furnace chamber in any physical way the item is orientated.

The height of the chute should be 5 m as a minimum in order to secure sufficient buffer capacity and to provide an air-tight seal and to prevent backfire towards the bunker.

The lower part of the waste chute shall be water cooled, in an open cooling water system with forced circulation to avoid local overheating of the water.

The waste chute cooling water shall treated to be fit for purpose and to avoid corrosion. E.g. by using make-up water.

The chute shall be equipped with inspection hatches immediately above the feeding arrangement. The inspection hatches shall correspond to the number of grate lines and as a minimum one (1) inspection hatch per grate line shall be provided.

2.3 Level Measurements in Hopper and Chute

Both hopper and chute shall be equipped with measuring equipment for registration of the waste in the hopper and in the chute.

The level measurement system shall generate a feed signal and waste blockage signal for the hopper. The feed signals shall be distributed to the crane control system.

The chute shall be equipped with level measuring equipment of microwave type, which shall be accessible from the outside.

Above the hopper a minimum of 2 radars shall be installed. The radars shall scan the surface of waste down and across the hopper.

A feed signal shall be generated when both the level measurement in the upper part of the chute and radar state an empty hopper and chute. Only when both signals show empty, waste may be fed to the hopper.

When the level measurement in the upper part of the chute states empty and the radar states full a blockage alarm shall be generated. The bridge-breaker function shall be initiated automatically.

The final concept shall be developed by the Contractor and presented to the Employer for his approval.

2.4 Waste Feeder

The waste feeder shall be designed as a hydraulically operated ram feeder (pusher type). It shall be possible to control the feeding process step less and to ensure an even and controlled supply of the waste across the total width of the grate.

The feeder control shall be of the auto-manual type and manual operation shall be possible from the CMS and locally. Local operation shall be released from the CMS.

The feeding device shall as a minimum be divided into the same number of independently operated sections as the number of grate tracks to allow levelling the waste on the grate.

The position of each feeder section must be monitored by linear position transmitters. The signals must be transferred to the CMS. In addition, the feeder position shall be apparent locally.

The ram feeder including the feeder table shall be designed in such a way that the amount of through-fall of waste and waste retained by the ram feeder is minimized. Access for service via suspended hatches above the ram feeder shall be provided. This access shall be possible without the need for scaffolding. Furthermore, easy exchange (without need of boiler outage) of critical parts of the ram feeder must be possible such as roller wheels etc.

Temperature measurement at the waste pusher shall be established.

Furthermore, if the pusher device is fully or partly cooled, equipment for monitoring such cooling is included in the scope. In case that flue gasses can accumulate inside the waste feeder casing, these gases shall be ventilated towards either the primary or the secondary air intake.

The final concept shall be developed by the Contractor and presented to the Employer for his approval.

A central grease lubrication system for the waste feeder shall be included in the Contract Object as described in Section 18.3 *Automatic and Central grease lubrication.*

3. GRATE

The grate shall be able to transport the waste fully automatically from the feeder to the IBA chute with good mixing of the waste and without obstacles/clogging of any kind or manual intervention at any time. The grate shall be designed and sized with a view to smooth operation in accordance with the quantity, characteristics and varying calorific value and composition of the waste, and in such a way that requirements for waste capacity, operational availability, burn-out rate, quality of the IBA etc. can be fulfilled.

Depending on the grate type offered, the grate shall be divided into individually adjustable grate zones. The grate geometry and the pattern of the grate movement shall be so that optimum features regarding e.g. transportation, agitation and distribution/leveling of the waste bed on the grate surface are ensured.

The grate position of each grate section must be monitored by linear position transmitters. The signals must be transferred to the CMS.

The grate shall be designed with an appropriate width with suitable moderate thermal loads as well as a grate length, which allows a satisfactory thermal treatment of the IBA to ensure the required IBA quality.

The grate shall be designed as an air-cooled grate.

The Contractor shall in his tender proposal clarify if the grate can be retrofitted to become a water-cooled grate, in the case the waste characteristics change within the lifetime of the Line. If yes, the Contractor shall describe how this can be done and the implications it has on the grate, furnace and operation.

Grate bars and other components that are exposed to high temperatures shall be manufactured of chrome-nickel steel alloy according to the Contractor’s experience.

Grate bars shall be suitable for incineration of dry, light, low-ash and high calorific waste without exceeding their temperature limit.

The geometry of the motional pattern of the grate should enable an effective self-cleaning of the grate bars so that the grate bars, for instance by means of relative movement of the bars, keep the air supply slits and the wearing surfaces clear of any impurity, metal melt etc.

The design shall take into account that maintenance of the grate shall be possible in an easy and ergonomic correct way. It shall be possible to locally operate the grate during e.g. maintenance Contract Object.

The primary combustion air – underfire air - should be supplied to the waste layer through small slits in the front side of the grate bars and/or through 1-2 mm slits between the grate bars

The grate shall be designed with a relatively high-pressure loss compared to the pressure loss through the waste layer.

A central grease lubrication system for the grate system shall be included in the Contract Object as described in Section 18.3 *Automatic and Central grease lubrication*.

3.1 Grate Riddlings

The grate riddlings shall be transferred to the IBA system. The grate riddlings transport system shall be well-proven and sealed against the furnace. It shall be possible to make inspections and to remove obstacles from the whole system, also above possible dampers. The design shall ensure that quantity of grate riddlings and the necessity for removing obstacles shall be limited as much as possible.

The riddlings transport system control shall be of the auto-manual type and manual operation shall be possible from the CMS and locally. Motors on the conveyors shall be equipped with torque watch. Local operation shall be released from the CMS.

The Employer prefers a wet grate riddling conveyor system. The grate riddlings shall be transported to the IBA chute.

4. COMBUSTION AIR SYSTEM

4.1 General

The combustion air system including ducts, fans, heat exchangers etc. must be designed to operate at all load points in accordance with the capacity diagram in appendix A13 *Process and Design Data*. The system must be designed for an air excess ratio (λ) of 1.8 at the nominal load point. Operation shall be possible at an excess air ratio optimal to any load point.

The system shall be equipped with an advanced combustion control system.

In general, the duct system shall be designed with circular ducts. For accurate air flow measurements reference is made to appendix A14.5a *Measurements Connections – Flue Gas / Air System.* Permanent, reliable and maintenance-free measuring points shall be established in all individual air zones for continuous measurements of the amount of combustion air and cooling air. Air flow measurements shall be of the venturi type.

The duct system shall be airtight and equipped with airtight inspection and cleaning hatches wherever necessary. The design shall allow for heat expansion. Duct connections shall to the extent possible be welded. The ducts shall be supported to avoid deformation and vibration.

The outside surface of the ducts shall be designed in such a way that dust accumulation is avoided.

At bushings in walls and decks of the structures it shall be ensured that sleeve, collar and covering are dustproof, waterproof, gas tight etc.

Dampers shall be installed where necessary and shall be equipped with drives/actuators with remote actuation except for dampers used only during maintenance and repair. Dampers shall be of the multi blade type, suitable to withstand the maximum pressure difference which may be encountered. The position of the actuators shall provide easy access for display monitoring, service and maintenance.

Primary air shall be drawn from the waste bunker.

Secondary air shall be drawn from the outlet of the IBA extractor and above IBA conveyers in the IBA cellar to capture evaporation of water and hazardous compounds from the IBA. The remaining secondary air may be drawn from the top of the furnace/boiler hall or the waste bunker.

The intake for the secondary air shall be selectable, allowing for the intake to draw air from either the IBA extractor or the furnace/boiler hall or the waste bunker as selected by the operator.

The air intake in the waste bunker shall be located at a level which minimizes the risk of intake of air with a concentration of explosive gases and dust and which does not obstruct possible work on the hopper deck or at the waste cranes i.e. the air intake shall be positioned as with good distance to the waste hopper. Screens at air inlets as well as equipment for cleaning of the air intake and fire-sealing in the duct between waste bunker and boiler hall shall be included. The fire sealing shall be in form of a damper with a minimum fire resistance of 120 minutes. In case of fire in the bunker, the damper shall automatically shut off and a damper towards the boiler hall shall open. The dampers shall be actuated by the same actuator enabling continuous operation of the Contract Object even at a fire in the bunker.

4.2 Primary Air

The primary air shall be injected below the grate via the pressure side of the primary air fan in a number of individually adjustable air zones, which are controlled automatically by means of automatic operated dampers. Dampers must be designed for a tightness of minimum 99.5 %.

All equipment which is part of the primary air system shall be designed for operation in heavy dust loaded air.

Air flow measurements in the individual air zones shall be of the venturi type.

4.3 Secondary Air

Secondary air shall be injected into the post-combustion chamber at the inlet to the first pass of the boiler through a number of individually adjustable rows of nozzles.

The nozzles shall be designed and installed with a view to self-cleaning. In addition, it shall be possible to carry out manual cleaning of the nozzles during normal operation of the incinerator.

Air flow measurements in the injection air zones shall be of the venturi type.

All equipment which is part of the secondary air system shall be designed for operation in heavy dust loaded air.

The CFD simulation shall demonstrate that good penetration of the secondary air is being achieved and that good mixing of the gases is being achieved.

4.4 Fans for Primary and Secondary Air

Separate fans for primary and secondary air shall be installed.

The primary and secondary air fans shall be direct-driven centrifugal fans for heavy duty operation and shall be equipped with frequency regulated motor and equipment for vibration measurements. The vibration measurements shall be transferred to the CMS.

The fans shall be equipped with hatches for inspection and maintenance and designed for heavy duty operation with a view to reliable and long operating periods. It shall be possible to take out the impellers without having to completely dismantle the fans or the duct system.

The fans shall be of a low-noise type and, if necessary, muffled by means of insulation, flexible connections or similar. The fans shall be equipped with flexible connections to the ducts on the inlet and pressure sides.

Necessary vibration absorbers etc., including installation on the concrete base, shall be included in the Contract Object.

Drainage of the fan wheel in case of boiler leakage is part of the Contract Object.

4.5 Air Preheater

An air preheater shall be installed for preheating of the primary air at low calorific values and moist waste.

The Contractor shall indicate on his capacity diagram when it is necessary to utilize air preheating.

The primary air preheater shall be supplied with medium-pressure steam from a turbine bleed and by saturated steam from the steam drum.

Any air preheater needed for heating combustion air drawn from the bunker shall be equipped with online cleaning equipment, e.g. water injection and drainage of the air preheater.

The Contractor shall consider energy optimization in the form of continuous primary and/or secondary air preheating by utilizing turbine bleed steam.

All air preheaters shall be designed in a bare tube structure and shall be designed in such a way that fouling of the preheater is minimized which e.g. includes adequate tube pitching. All air preheaters shall be designed on basis that cleaning of the air preheaters are not required. All air preheaters shall be equipped with an air side by-pass.

All air preheaters shall be equipped with inspection hatches and it must be possible to inspect all pipes in the heat exchanger. All air preheater(s) shall be equipped with a water collecting system for collecting water from cleaning or leakages. The collected water shall be diverted to the gutter and reused in the wastewater pit.

5. CFD-CALCULATIONS

The design of the furnace chamber and afterburning chamber shall secure the necessary mixing, retention time and temperatures required for complete burnout of the flue gases. The Contractor shall carry out a full CFD simulation, covering all load points, including at air excess ratio (λ) of 1.8. The simulations shall be demonstrated in full to the Employer prior to his final decision of the total combustion system, including final selection of the incinerator/boiler geometry, placement of secondary air nozzles etc.

The CFD calculations shall be documented in a report to be delivered as part of the MD1 in the Reviewable Project Data (see appendix C1 *Reviewable Project and Design Data*).

The Contractor shall by the use of CFD modelling verify the temperature and velocity conditions as well as the flow-, particles-, temperature-, CO, NO_x and O_2 profiles of the furnace chamber, the afterburning chamber and the 1st and 2nd pass of the boiler ending with the profile at the inlet of the convection pass. The load cases 70%, 100% and 110% thermal loads shall as a minimum be investigated both at clean boiler condition and fouled boiler condition.

The Contractor shall deliver all necessary input parameters (furnace/boiler geometry, secondary air velocities at the injection nozzles etc) enabling the Employer to do possible further CFD modelling at a later stage by other companies than the Contractor.

6. FURNACE CHAMBER

The size, shape and geometry of the furnace chamber shall minimize the risk of IBA deposits and ash fouling on the walls of the furnace chamber.

The furnace chamber shall be a fully boiler cooled chamber consisting of protected gas-tight welded membrane tube walls.

Minimum 2 access doors must be equipped with inspection windows allowing full inspection (grate and secondary air nozzles). The inspection windows must be equipped with cleaning equipment (air pulse) and must be operational from the door. One supplementary inspection window shall as minimum also be installed.

At the furnace rear wall, a minimum of 2 high temperature retractable furnace cameras shall be installed, covering the entire grate area. Images shall be high-definition colour quality suitable for future digitalizing and usable as IO for combustion control system.

A number of plates suitable for covering the IBA chute opening must be a part of the Contract Object providing safe access to the grate. The plates must have a size that corresponds with the opening size of the access doors. The plates must be fixed in their correct position in order to provide an easy, stable and secure support when entering the furnace chamber through the access doors assuring that it is not possible to fall down into the chute during personnel presence in the furnace/boiler. Alternatively, railings shall be included, to be put up across the end of the grate, to ensure that persons do not accidentally fall into the IBA chute, but still provides access for inspection.

7. AFTERBURNING CHAMBER

The afterburning chamber, consisting of the first part of the first radiation pass of the boiler, is defined as starting after the last injection of secondary air.

Even under the most adverse conditions at operation within the capacity diagram in appendix A13 *Process and Design Data* the flue gas temperature in the actual afterburning chamber shall be increased to not less than 850 °C for a minimum of 2 seconds without any use of the auxiliary burners.

The Contractor shall provide the necessary algorithms in order to calculate the temperature in the afterburning chamber according e.g. to load.

All necessary nozzles for temperature sensors, sampling etc. must be included. This includes nozzles for verification of the retention time criterion (2 sec at 850 °C). Online temperature measurements for verification of the retention time criterion shall be established as 2oo3.

The furnace shall be designed for installation of start-up/auxiliary burners, which are included in the Contract Object (see Section 10.8 *Auxiliary and start-up Burners*).

The Contractor is to suggest a method for establishing a protection ceiling during shut down of the incinerator unit to protect personnel against down falling IBA deposits when being inside the furnace.

The Contractor is to suggest a method for easy erection of scaffolding in the 1st pass of the boiler which shall ensure possibility to carry out simultaneous maintenance work on the grate and up in the 1st pass.

It shall be possible to safely clean deposits in the 1st boiler pass during maintenance stops without risk for personnel on the grate itself.

8. REFRACTORY / CERAMIC LINING / CORROSION PROOF ALLOY CLADDING

Where the membrane tube walls are exposed to corrosion and erosion, the membrane tube wall cooled combustion chambers/boiler membrane walls shall be protected by corrosion proof alloy cladding (Inconel or similar).

The minimum extent of the corrosion proof alloy cladding (Inconel or similar) shall be the entire furnace and 1st pass, screen tubes between 1st and 2nd pass, roof of 1st/2nd pass and upper part of the 2nd pass. Corrosion proof alloy cladding (Inconel or similar) shall as a minimum be applied 2 m below the turning level of the 2nd pass and until the point where the flue gas temperature does not exceed 850°C if this exceeds 2 m below the turning level.

In case it is needed, refractory may be applied on the tube walls instead of corrosion proof alloy cladding in order to warrant that the furnace/boiler is able to meet the 850 °C, 2 seconds requirement at clean and fouled boiler in any operation point within the capacity diagram in appendix A13 *Process and Design Data* and to optimize stable operation of the boiler system. All other protection of the tube walls shall, wherever feasible, be corrosion proof alloy cladding.

The refractory/cladding shall in principle be designed in accordance with the Contractors experience, assuming, however, that the final determination, including selection of materials and design, shall be approved with the Employer.

8.1 Refractory

The refractory shall be carefully adapted to the various furnace and boiler sections in terms of heat transfer, wear and tear, risk of IBA deposits, temperature fluctuations, oxidation, temperature resistance, strength, density and heat balances.

The quality of the materials shall be selected on the basis of recent experience with waste furnace refractory. The materials shall be first class and deemed the most suitable for the task. In case the Contractor proposes use of refractory, references for the actual systems must be provided. Vibrated self-flowing monolithic materials are preferred towards gunned materials and must be applied wherever feasible. In case a gunning system is used, it must be able to show results of low porosity refractory.

The membrane tube wall structure and the refractory shall be carefully matched with the stated maximum calorific values, furnace temperatures etc. in order to minimize the risk of IBA deposits as well as oxidation, erosion and corrosion of the material.

If the refractory solution consists of tiles the tiles must be geometric fitted to the corresponding tube wall geometry.

The tiles shall be handled with care as described below for the bricks. Anchoring must be designed in such a way that skidding is prevented and the necessary provisions must be taken concerning the thermal expansion of the tiles system. Preference is given to systems which are easy to mount and dismount.

In areas of the furnace where lining with bricks is necessary, the brick material shall demonstrate satisfactory mechanical, thermal and chemical resistance. The bricks shall be fully squared and exact in form, but may have to be cut to match with each other. The bricks shall be handled with care during transportation etc., and only intact bricks may be used.

The anchoring of the brick lining shall be designed in such a way that any possibility of skidding of the brickwork is prevented, just as necessary provisions for the thermal expansion between the sections shall be taken by means of expansion joints.

The bricks shall be bricked up with the thinnest possible joints, and the mortar shall correspond to the brick quality.

The procedure to be applied for drying out and heating up the refractory shall be described by the Contractor, which shall include all necessary provisional arrangements and fuel description required for the execution of the drying out and heating up of the refractory.

The Contract Object shall include rent of an auxiliary steam boiler for start-up purpose, if found required for drying out the refractory.

8.2 Corrosion proof alloy cladding

Corrosion proof alloy (like Inconel or similar) shall as far as possible be applied in the workshop under controlled conditions and to the extent possible with automatic welding equipment. Only at transitions or at particular sections the corrosion proof alloy shall be applied by hand at site.

All corrosion proof alloy work must be checked thoroughly before installation and any defects rectified. Cladding work on site must undergo the same extent of examination. The Contractor shall describe how the welding is being performed and how QA of the welding work is handled.

Before corrosion proof alloy cladding the surfaces must be cleaned, degreased and sandblasted to a surface roughness of minimum Sa 2.5.

Corrosion proof alloy cladding shall be carried out with the standards stated in appendix A13 *Process and Design Data*. The minimum thickness of the corrosion proof alloy cladding shall be 2.5 mm.

It is anticipated that corrosion proof alloy is applied in minimum two layers. The average layer thickness must also be stated and how this is evaluated.

Any deviation from the above corrosion proof alloy cladding specification as e.g. single layer welding method based on high pulsation welding, requires the Employers' prior approval.

9. INSULATION, CASING AND ACCESS DOORS

The external cladding of the boiler shall form smooth surfaces without any projecting wall bars, which may build up dust.

The plates for the cladding shall be in accordance with the specifications in appendix A14.4 *Insulation and Cladding for Process*.

The incinerator/boiler shall be insulated according to the requirements in appendix A14.4 *Insulation and Cladding for Process.*

Wherever operation, maintenance and repair works so require, access doors with suitable heat and acid-proof sealing and an effective closure device shall be installed. Location and number of doors shall be agreed upon with the Employer as part of the layout and must for the boiler as a minimum include (in addition to the access doors required in Section 6 *Furnace Chamber*):

- Two levels in the 1st pass.
- At the top of the 2nd pass.
- Near the hopper in 2nd pass.
- Just before the convection pass.
- In the convection pass, access doors must be located before each tube bundle and in two levels.
- Just downstream last economizer bundle and in two levels

These access doors shall be provided on both sides of the boiler at all the above specified locations.

In case access to a door is provided via a gallery, checker plates shall be installed on the gallery in front of the doors. Removable trays made of stainless steel below the door must be installed. Above the door a handle must be placed in order to secure easy access through the door. Possible temperature measurements located near the doors must not obstruct the accessibility.

Reinforcements and structures shall be applied to prevent the inspection doors from becoming out-of-shape or not shutting tight.

10. BOILER

10.1 General

The boiler shall be of the water tube type, designed for natural circulation and with an integrated boiler drum.

The boiler shall comply with the Pressure Equipment Directive (PED).

The boiler shall be constructed and manufactured according to standard for water tube boilers EN 12952 or any other approved regulation in accordance with EN 12952. The Contractor shall state the standard or code of practice, which is to be used for the design.

The boiler shall be designed with 2 empty vertical radiation passes, followed by a horizontal convection pass comprising evaporator-, superheater- and economizer tube sections/tube bundles.

The height of the 1st pass shall be minimum 30 m measured from the grate.

The boiler drum shall be sized for safe and secure continuous operation of the boiler at any point within the capacity diagram in appendix A13 *Process and Design Data*, when one feed water pump is out of operation due to service or breakdown.

Tube pitching shall be adapted to the boiler type, tube dimensions, cleaning method, temperature and dust load of the flue gas as well as the required continuous operation period without manual cleaning. Please refer to appendix A13 *Process and Design Data* for requirements. Tubes in the convection part of the boiler shall be aligned.

The boiler shall be designed for as simple operation, control and maintenance as possible. In the entire boiler area there shall be good access for inspection, repair and maintenance, using stairs.

A fully-automatic water based spray cleaning system shall be installed in the 1st and 2nd pass. The system is not intended for use in a clean boiler. However, the boiler cleaning system may be used in a fully fouled boiler up to once a week.

Continuous measurement of inlet and outlet steam temperatures of each superheater section shall be installed.

It shall be possible to drain the complete boiler system via the drain tank / blow-down tank.

The Contract Object shall include establishment of equipment for boiler blow-down, including drain tank / blow-down tank, tank drainage pump and pipe connections to the technical water tank. From the technical water tank there shall be pipe connections to the wastewater pit and to the Employer’s existing IBA wastewater pit (see appendix A15.4 *Concept Diagram for Water Flows*).

The boiler water from blow down/drainage shall be cooled to a maximum temperature stated in appendix A13 *Process and Design Data*, prior to being led to the wastewater pit or the Employer’s existing IBA wastewater pit. The Contractor shall suggest and include a system for utilizing the energy from cooling the blow down/drainage water e.g. for air preheating.

Under normal operating conditions, no water shall be discharged to the Employer’s existing IBA wastewater pit. In not normal operation situations water may be discharged to the Employer’s existing IBA wastewater pit upon the Employer’s acceptance. Discharge of accumulated water volumes larger than 300 m^3 to the IBA wastewater pit during the commissioning of the Line will not be accepted without the Employer’s written approval.

The blow-down valves shall be pneumatic driven and flow measurement of blow-down shall be possible.

The boiler system shall be equipped with the necessary number of vent points. Each vent and drain point shall be equipped with two valves, and the vent valves shall be arranged in one common rack. The drain valves shall be positioned in common racks which are to be approved by the Employer.

The boiler drum shall be equipped with a gauge glass for local monitoring of boiler drum level. Live feed of the gauge glass shall be transferred to the control room via the CCTV system.

A redundant boiler drum level measurement shall be transferred to the CMS and used for level regulation. The boiler drum level measuring principle shall be differential pressure measurement, compensated for the process conditions.

Limiters (e.g. high-water level, low-water level) shall be of the direct type and based on "2 out of 3" principle.

Continuous measurement of the flue gas temperature and pressure shall be installed before all evaporator sections, superheater sections and economizers. Continuous measurement of the flue gas temperature shall be installed in the ceiling of the 1st and 2nd vertical radiation passes and at the inlet of the horizontal convection pass.

When starting up the boiler (cold start) it shall be possible to utilize the turbine bypass valve to build up pressure, and thus recover all steam during startup through the bypass condenser. If the turbine bypass valve is un-operational, starting up of the boiler shall be possible through the regular boiler start-up valve.

The boiler start-up valve shall be dimensioned for handling live steam flow dropping from maximum flow to zero flow in less than 0.5 seconds without release of steam through the boiler safety valve.

10.2 Radiation passes

The boiler shall be integrated with the furnace. It is a precondition that the first pass of the boiler/the afterburning chamber, the secondary air injection and the furnace chamber are carefully adjusted to each other so that the flue gas will be homogeneous and its flow controlled and stable without dead zones, and so that the fly ash will have as little contact with the boiler walls of the radiation passes as possible.

Turning/transition and ash hopper shall be designed in such a way that they will not give rise to undesirable flow conditions, erosion, corrosion, fouling and ash accumulation.

The boiler shall be equipped with an arrangement for easy inspection and repair of each of the vertical passes of the boiler, i.e. a sky climber.

10.3 Convection pass

The economizer, evaporator and superheater sections in the horizontal convection pass shall be designed as fully demountable tube bundles. This shall inter alia be respected when designing cable routings, access routings, cladding, etc. on top of the boiler. Method for replacement of each of the bundles, taking into account the geometry of installation and surrounding building, must be described by the Contractor.

Each tube bundle shall have a separate inlet and outlet header.

The top of the boiler convection pass must be covered with checker plates with appropriate railing.

The access to the convection boiler surfaces/tube bundles shall be particularly easy for inspection and cleaning purposes. Consequently, the distance between the separate evaporator-, super-heater- and economizer sections in the horizontal pass shall not be less than 800 mm.

The tube bundle cleaning shall be done with individual pneumatic rappers. Each rapper shall as a maximum affect three rows of tubes. The particular tube bundles must be equipped with a special stub on which the rappers are hitting.

Special consideration shall be given to easy replacement of the thermally most exposed super-heater sections. 10 % excess space shall be reserved for possible later modifications of the super-heater section and 10 % excess space shall be reserved for possible later modifications of the economizer section. The location of these is to be agreed upon with the Employer.

The superheaters shall be arranged in such a way, that the steam (and water for the evaporator bundle) is in counter flow with the flue gas (SH1 and SH2), except for the final super heater (SH3) which shall be in co-current flow with the flue gas. The final superheater is the superheater with the highest temperature.

The superheater shall be divided into minimum five sections.

At least two de-superheaters for control of the steam temperature shall be included to ensure an optimal control of the steam temperature, including the outlet temperature of the live steam.

Injection valves for control of the steam temperatures should be dimensioned in such a way that throttling is not required in the rest of the system.

10.4 SNCR system

A complete SNCR system (Selective Non Catalytic Reduction) for NO_X reduction shall be part of the Contract Object.

The system shall be based on injection of urea in the 1st pass of the boiler. The system shall be constructed with minimum 3 levels of injection nozzles. The injection shall be adjusted automatically, corresponding to the temperature window of the SNCR process, achieving the emission limit values stated in Part II.h *Guarantees.*

Accurate temperature measurements shall be able to detect the temperature profile over the cross section of the combustion chamber. Spare levels shall be advised and prepared in order to accommodate future changes in emission levels or change of waste composition.

The injection lances shall be of high alloy steel suitable for the environment in which they operate and with a minimum of exchange/maintenance.

Equipment for manual regulation of the urea water injection shall be included for the purpose of avoiding need for Line shut down in case of problems with the automatic regulation of the urea water injection.

The transport and injection system for urea water shall comply with the general provisions of the Authorities.

The consumption for each set of injection nozzles shall be measured continuously with good accuracy.

The Contract Object shall include pumps (the pumps shall be redundant), pipelines, armatures, nozzles and control system.

The Contract Object shall include an urea leakage detection system and CMS alarm.

A measurement of ammonia slip in the flue gas after the boiler shall be included.

The Employer has an existing storage tanks for urea. The capacity is estimated to be sufficient for use for the new Line in addition to the Existing facility.

Consequently, the urea used shall be from the existing urea storage tank.

The Contract Object shall include all necessary Contract Object for connection to the existing tank including but not limited to establishment of necessary connection flanges at the existing tank, all necessary distribution, dosing equipment (piping, valves etc.), preparation devices and piping.

10.5 Steam Data

The boiler shall be designed to meet the steam data stated in appendix A13 *Process and Design Data*.

The live steam temperature shall be safeguarded by a temperature limiter arrangement (2-out-of 3 voting), even though this is not stipulated by EN 12952. The particular temperature limiters shall be in accordance with DIN 3440. When triggered, the failsafe system shall trip the boiler.

10.6 Flue Gas Temperature Conditions

It is considered important to ensure an even flow and temperature distribution in all boiler passes. In order to limit the risk of corrosion, the temperature of the flue gas in contact with unprotected (without refractory/corrosion proof alloy) boiler walls shall be maximum 850 °C or lower in case the Contractor finds this necessary according to his experience. The temperature requirements shall apply at any load point within the capacity diagram in appendix A13 *Process and Design* at any fouling extent of the boiler. However, this temperature requirement shall not limit the minimum extent of the corrosion proof alloy cladding as stated in Section 8 above.

The boiler shall be designed in such a way that the flue gas in the radiation passes is cooled to a level deemed appropriate in relation to e.g. cleaning and the risk for corrosion of tube sections in the horizontal convection pass (see appendix A13 *Process and Design Data*). In addition, the flue gas temperature shall be even over the cross section at the inlet to the horizontal pass.

10.7 Flue Gas Velocity Conditions

Each section of the boiler shall be designed with suitably low volume and heat loads and reasonably long travel times.

The cross sections shall be sized for moderate flue gas velocities, see appendix A13 *Process and Design Data*.

10.8 Auxiliary and start-up Burners

The incinerator/boiler shall be equipped with auxiliary and start up gas burners to ensure the fulfilment of the temperature requirement of at least 850 °C for 2 seconds in the afterburning chamber during start-up (before waste fire) as well as during continuous operation.

The burners shall automatically start operating in case the temperature in the afterburning chamber during operation tends to drop below 850 °C.

The burners shall be designed for operation on natural gas (see specification of limits of supply in appendix A18 *Limits of Supply*).

Inspection nozzle for visual control of the flame shall be included as well as complete ignition system etc.

The gas burner installations shall be designed so that IBA build-up on the combustion heads is avoided.

Shut off valve on the gas supply shall be connected to the CMS system and be positioned close to each burner to allow easy maintenance of the burners without special requirements on evacuation of gas from the gas pipe.

All installations for auxiliary and start up burners shall follow requirements from the Authorities.

10.9 Make-up Water System

The water treatment plant (producing the make-up water) described in the following is included in the Contract Object.

The quality of the make-up water entering the boiler shall as a minimum comply with the stipulations for pressure level according to specification for steam turbines of "Technische Vereinigung der Großkraftwerksbetreiber" (VGB).

The make-up water plant shall be supplied with fresh water (see fresh water analysis in appendix E2 *Quality of Water flows*) and with pre-treated water from the flue gas condensation, if option 1 is chosen, refer to appendix A21 *Options*.

The make-up water system shall be dimensioned in such a way that it is capable of supplying the quantity and quality needed in all parts of the plant and in every situation. The system shall be able to supply a full boiler filling within 24 hours.

The make-up water system shall be designed in such a way that the make-up water is produced in "batches".

The make-up water tank shall be dimensioned in such a way that it can contain the amount of water corresponding to 120% of the normal water content of the boiler, and it shall be designed with due consideration to the amount of water consumed by the make-up water system for backwashing.

The level in the make-up water tank shall be monitored via the CMS as well as the starts of the make-up water plant.

The total boiler installation shall be designed so that the amount of make-up water consumed during normal operation, start-up and shut-down shall be minimised.

Any pumps required for transportation of the water through the make-up water system shall be included in the Contract Object.

The system shall be designed as a two-step system, where the water is demineralised in the first step and totally demineralised in the second step:

- The 1st step may be based on reverse osmosis (RO)
- The 2nd step may be based on an electrode ionification filter (EDI) followed by a mixed bed acting as safety filter.

Requirements for conductivity for demineralised and totally demineralised water appear from appendix A13 *Process and Design Data*. In case the first step is a RO, a complete CIP-system (Cleaning-In-Place) shall be included for cleaning of the RO-membrane. If the raw water quality requires a pre-treatment like softening or particle filtration due to high SDI (Silt Density Index) content prior to a RO treatment, the Line must include suitable equipment as well.

Storage tanks and/or mixing tanks necessary for the processes are included in the Contract Object and shall be equipped with CO_2 filters.

Two pump sizes must be delivered, one for normal operation and one for quick filling of empty boiler or emergency filling of the system. The pumps for normal operation shall be redundant.

Containers and tanks shall be made of glass fibre, stainless steel or PP.

Pipes for water shall be made of stainless steel, PP or PVC. Pipes for NaOH shall be made of stainless steel or PP and pipes for HCl shall be made of PP only. All pipes made of PP shall be supported by stainless steel plates.

It shall be possible to transport reject water from RO (concentrate) to the technical water tank. Pumps and pipe connections for pumping make up reject water to the technical water tank are included in the Contract Object.

10.10 Conditioning of boiler water

The Contract Object includes a 5 µm condensate filter in the condensate line downstream the condensate pumps. The filter shall be a mechanical filter of the cartridge type designed for filtering 100 % of the circulated quantity.

A complete automatic system for mixing (dilution with water) and addition of the required chemicals to the water/steam circuit shall be included in the Contract Object.

The Contract Object shall also include any local storage tanks and/or mixing tanks for the chemicals required. The boiler water shall be conditioned with NaOH. Alternative chemicals can only be used if accepted by the Employer. Tanks shall be furnished with CO_2-traps on suction air inlets.

If alternative chemicals are accepted, they shall preferably be supplied as solid product to be dissolved on site. The lay-out and arrangement for dissolution shall be discussed with the Employer, particularly with respect to health and safety of handling. Systems for the following purposes shall as a minimum be included in the Contract Object:

- Addition of ammonia water to the feed water (added in the suction line before feed water pumps). A pH value of 9.4 ± 0.2 of the feed water.
- Addition of NaOH to the boiler water. The remaining alkalinity shall be obtained by adding NaOH to the boiler water in one of the downcomers of the boiler. A pH value of 9.5-10 corresponding to a NaOH content of 2-4 mg/kg shall be aimed.
- Conductivity measurement for NaOH dosing control.

Storage tank and piping and pumps for transporting NaOH are included in the Contract Object.

Storage tank and piping and pumps for transporting ammonia water are included in the Contract Object.

The tanks for the chemical dosing systems shall be made of stainless steel or PP. All pipes shall be made in stainless steel. Tanks shall be closed and supplied with CO_2 traps.

The Contract Object shall include displacement pumps offering the possibility of stepless control of the flow, also during operation.

The pumps must be controlled with a timer function, so that the pumps will stop after a certain time in order to prevent an overdosing in the system.

10.11 Sampling System for Water/Steam

The Contractor shall propose a strategy and program for monitoring the steam and water quality. The strategy shall be based on continuous measurements as well as spot sampling, and the purpose is to ensure the operation of the incinerator/boiler/turbine and related systems in the long term.

It must be possible to conduct manual sampling for measurement of:

- Make up water
- Feed water
- Live steam
- Saturated steam
- Boiler water
- Condensate

In addition, outlets for continuous test sampling of direct and acid conductivity for the following shall be included:

- Feed water
- Live steam
- Boiler water

If possible, the manual sampling shall be integrated with the continuous measuring device. Alternatively, the sampling valve shall be place in the room for water sampling.

Direct conductivity shall also be measured for make-up water. Acid conductivity is measured after a cation filter.

The equipment shall be placed in an easily accessible place and the above-mentioned measuring probes shall be connected to the water measuring station.

The sampling probes shall be equipped with coolers supplied with cooling water from the central component cooling system. The coolers shall be dimensioned in such a way that the temperature range of the measuring equipment offered can be observed. The sampling probes shall be cooled to a maximum of 20°C above the ambient temperature at a flow of 1 l/min.

The Contract Object shall include equipment for conductivity measurements of a recognized make.

Alarm signals for limit values and measurements shall be automatically transferred to the CMS.

The design of the sampling system shall be submitted to the Employer for approval in the design phase.

11. DEAERATOR/FEED WATER TANK

The deaerator shall be designed for the specified operating temperature and flow according to the specified operating interval. The specified temperature shall be kept within the stated tolerances under all conditions. In situations where the deaeration steam bleed supply falls below the necessary pressure level (low load or turbine off-line), auxiliary steam from throttled live steam shall be used for deaeration.

Deaeration shall be in accordance with the specifications set up in EN 12952-12.

At cold start, the deaerator must reach the temperature and saturation pressure within 6 hours.

Based on 2oo3 failsafe level measurement in the feed water tank the boiler shall trip at a level in the feed water tank adequate for safe shut-down of the boiler. The reserved volume in the feed water tank for safe shut down corresponds to the difference in volume between boiler trip level and feed water pump trip level. This reserved volume is to be documented by the contractor (however regardless of this documentation not less than volume corresponding to 30 minutes of full boiler load without condensate/make-up water supply to the feed water tank). Reserved operational volume in the feed water tank for operation (difference between normal water level and boiler trip level) shall also correspond to 30 minutes of full boiler load. The contractor shall through HAZOP/risk assessments document safe design of the entire feed water system in relation to dry boiling. The deaerator shall also be designed for deaeration of the supply of makeup water to the water/steam cycle.

The steam exhaust from the deaerator shall be equipped with a degassing condenser unit. Refer to appendix A15.3 *Concept Diagram, Water/Steam Cycle*.

The deaerator is foreseen to be placed at an adequate level in order to assure ample inlet pressure to the feed pumps.

Design and construction of the feed water tank/deaerator shall be in compliance with EN13445 Unfired Pressure Vessels with the additional requirement that the feed water tank/deaerator shall be designed to avoid unacceptable vacuum (by installing vacuum breaker if necessary) and the corrosion allowance shall be minimum 1 mm.

12. FEED PUMP SYSTEM

12.1 Design

The boiler shall be equipped with two identical electrically driven pumps (one redundant), each with frequency converters for step less speed control.

The electrically driven pumps shall be connected to the supply of emergency power. It must be possible to switch randomly between the pumps.

The boiler shall, furthermore, be equipped with one direct diesel engine driven feed water pump. This pump shall be identical with the two electrically driven pumps.

Each of the three feed water pumps shall be designed and dimensioned according to EN 12952-7 regulations and according to the maximum steam production generated in any point of the capacity diagram in appendix A13 *Process and Design Data*, also taking into account simultaneous operation with high rates of process steam production, where additional feed water is necessary for injection-cooling (live steam reduction, turbine bypass operation, etc.).

If water injections (spray coolers) are deemed necessary in the extraction lines, these are included in the Contract Object.

12.2 Construction

The feed pumps shall be executed as multi-stage centrifugal pumps with mechanical gland seals. The impellers shall be made of a corrosion-proof material.

12.3 Minimum Quantity Valve Arrangement

In order to secure the feed pumps against overheating at low load or idle running, the pumps shall be provided with a minimum quantity valve each.

12.4 Standstill Heating

As one pump is capable of supplying the boiler with feed water at full load, the other pumps will be on stand-by.

The Contractor is requested to assess whether standstill heating of the pumps is necessary.

12.5 Filter units

A feed water filter shall be installed upstream each pump. The pressure drop over each filter shall be monitored and send to the CMS, and proper alarms shall be implemented. It shall be possible to clean this filter online without interrupting the feed water system.

12.6 Feed Pump Location

The height between the feed water pumps and the feed water tank shall be sufficient in relation to NPSH of the feed water pumps.

12.7 Design Pressure of the Feed Water Pipe Line

The feed water pipe line shall be designed for max supply pressure from the feed water pumps (at zero flow) i.e. safe guarding of the design pressure of the feed water pipe lines by failsafe tripping of the feed water pumps based on pressure measurements will not be accepted as design solution.

13. COMPONENT COOLING SYSTEM

The component cooling system shall supply the necessary amount of cooling water (water/propylene glycol mixture) at the specified pressure- and temperature level to the cooling water consumers connected to the system.

The system as an entity is a common system. It shall be designed with sufficient redundancy to ensure that sufficient cooling capacity is always available.

The cooling system and its components shall be dimensioned for the maximum cooling demand in the entire system at the most critical meteorological conditions as specified in appendix A13 *Process and Design Data*.

The cooling system shall be based on dry air coolers.

It shall be possible to entirely drain the water/glycol circuit of the component cooler system.

The component air cooler system shall be prepared for later installation of water spray nozzles which can generate a mist, that increases the cooling capacity of the air cooler system.

Vents shall be of the automatic type.

At safety valves and vents spillage shall be collected and diverted to a collection tank for re-injection into the system. Manual contact with glycol must be avoided.

The system shall consist of a circuit with a mixture of water/propylene glycol. The Contract Object includes air coolers, circulation pumps, expansion system, filters, necessary control and shut off valves, piping etc.

The component cooling system shall be connected to the Employer's existing component cooling system. During normal operation cooling for the component cooling system shall be supplied by the Employer's existing cooling supply system based on a chiller which recovers the heat for district heating.

The component cooling system included in the scope of Contract Object must not depend on cooling supply from the existing cooling system and shall have full cooling capacity for Line.

Automatic safe switchover between the cooling suppliers shall be included in the Contract Object, e.g. in case of insufficient supply from the existing cooling supply system.

Specifications for the existing component cooling system can be found in appendix A13 *Process and Design Data*.

14. ASH HANDLING SYSTEMS

The boiler ashes shall be collected underneath the 2nd pass and in hoppers underneath the horizontal pass and transported to the two existing boiler ash/FGT residue silos (supplied by the Employer). All necessary Contract Object related to connection to the existing silos shall be including in the Contract Object.

A manual closing valve shall be installed upstream each silo allowing manual switch between which of the two end product silos the boiler ash shall be transported to.

The ash hoppers shall be designed to avoid blockages. However, as an additional precaution "rodding points" shall be installed in the hoppers in order to be able manually to clear a blockage without having to shut down the Line. The "rodding points" shall be installed in a direction enabling the person to stand at an elevated position doing the "rodding" downwards in the hopper.

The boiler ash transport system can either be pneumatic or mechanical, or a combination. All pneumatic transport systems shall be established as fully redundant i.e. in case of malfunction or service need of the active pneumatic transport system, easy switch over to the stand-by pneumatic transport system from the overall CMS as well as locally, shall be possible in order to continue the ash transport to the silos. Pneumatic transport system shall further comprise efficient and reliable crushers which make the boiler ash suitable for pneumatic transport.

The redundancy for the pneumatic ash transport system shall also comprise the crushers i.e. for each pneumatic sending vessel a separate ash crusher shall be installed upstream.

The design shall be prepared for transport of 2nd pass boiler ash to the IBA chute under compliance with related Authorities requirements on IBA quality.

Mechanical conveyors shall be of heavy-duty design, and the system proposed shall show references of successful operation at similar operating conditions. Torque monitors on the conveyors operating at the most severe conditions shall be installed as well as speed switch on each non-driven end. Alarms from this system shall be transferred to the CMS.

All motors for mechanical conveyors shall be equipped with frequency converters.

The design capacity of all ash conveying systems shall be 250% of nominal load.

Inspection hatches must be placed at the end of every conveyor and where experience shows it necessary for service and maintenance.

A container system shall be installed as an emergency system for discharging boiler ash. The container system shall be positioned upstream the conveying system.

15. IBA HANDLING SYSTEM

The Contract Object shall include a complete IBA handling system including conveyer systems, control equipment, camera monitoring system, etc.

Further the IBA system shall include an arrangement for obtaining bottom ash samples.

15.1 IBA Chute / IBA Extractor(s)

The IBA extractor(s) shall be of the water-filled pusher type, which shall be supplied with water from the wastewater pit.

The IBA chute and IBA extractor(s) shall be designed geometrically so that any items passing the feed arrangement will also pass the IBA extractor(s) without causing problems. Due to the possibility of large metal parts and other lumps the IBA discharger must have a minimum free outlet area of 800 x 2000 mm.

The IBA discharger must be equipped with wear plates everywhere where high mechanical wear is foreseen.

A water overflow system must be included. The overflow water must be diverted to the wastewater pit. The overflow design shall allow easy access for cleaning.

The IBA extractor(s) shall be designed to ensure that the IBA will not dry out and become "concrete" in case of a Line shut down or blockage in the IBA extractor(s). If needed this system shall comprise a back-flushing system.

Above the conveyor on which the IBA from the pusher(s) is pushed, a vapor extractor as part of the secondary air intake shall be installed.

15.2 IBA transport system

From the IBA extractor(s) the IBA shall be discharged on a vibrating conveyor and then transported by belt conveyor(s) to be discharged into the existing IBA bunker. The diverter system guiding the IBA shall be designed according to the Contractor's experience and shall be accepted by the Employer.

The vibrating conveyors shall be in heavy duty design and quality and be able to withstand impacts from IBA and larger incombustible parts falling onto the vibrating conveyor from the IBA expeller. In case of breakdown of the vibrating conveyors they shall be prepared for easy exchange. Special attentions shall be made to appendix A14.3 *Acoustic Noise and Vibrations*.

The vibrating conveyor belt(s) shall have a width of minimum 800 mm.

An IBA scalper shall be included in order to remove large particles from the IBA and collect them in a replaceable container. The collection of coarse parts from the scalper into the replaceable container may not give rise to accumulation of dust and dirt on the floor.

The size of the replaceable container shall be minimum 1 m^3 to facilitate that emptying of the container is required maximum once per day. The scalper shall be demountable and the overall IBA transport solution shall be able to operate without the scalper.

The IBA transport system shall be located indoor or be roofed to shield it from precipitation.

Turns and bends of the IBA transport solution shall be designed with overcapacity in order to avoid spills and blockages.

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A simple emergency IBA handling system shall be supplied in case of malfunction/repair to the main IBA conveying system. The emergency system shall consist of a system with unloading to at least two containers/skips on the floor.

The emergency IBA handling system shall have a capacity for at least 4 hours nominal operation before emptying of containers/skips are needed).

16. WATER AND PROCESS LIQUID SYSTEMS

16.1 Technical water tank

The system shall contain complete equipment for a technical water tank designed for collection of blow down water and boiler drain water.

The Contract Object shall include level measurement in the technical water tank, tank drainage pump and pipe connections to the wastewater pit and to the Employer's existing IBA wastewater pit.

Water discharged from the technical water tank to the wastewater pit or the existing IBA wastewater pit shall be cooled with fresh water to the maximum temperature stated in appendix A13 *Process and Design Data* before entering the pits.

The technical water tank shall be protected against the physical and chemical impacts of the possible liquids transferred to the tank.

The capacity shall be designed for a complete emptying of the boiler, ref.: appendix A13 *Process and Design Data*.

16.2 Wastewater pit

The system shall contain complete equipment for a wastewater pit designed for collection of technical water including blow down water, boiler drain water and for spillages from the area, overflows, flushing water/liquid from inside the building. The wastewater from the flue gas treatment area may also enter the pit.

The Contract Object shall include level measurement in the wastewater pit, pit drainage pump and pipe connections to the IBA extractors and grate shifting conveyor for reuse purposes and overflow pipe connection to the Employer's existing IBA wastewater pit for emergency cases.

The liquid level in the concrete pit shall be minimised and controlled according to the process requirements. It shall be possible to easily empty and clean the pit.

In case of fire, used firefighting water from the boiler hall and flue gas treatment hall area will be collected in the wastewater pit through floor drains. In case of overflow this shall be guided to the Employer's existing IBA wastewater pit.

The pit shall be protected against the physical and chemical impacts of the possible liquids transferred to the pit.

17. DISTRICT HEATING SYSTEM

The district heating system is further described in appendix A19 *District Heating*.

18. MISCELLANEOUS EQUIPMENT

18.1 Flue Gas Ducts

The flue gas ducts shall be adequately supported and shall be provided with guide vanes and approved expansion joints. All expansion joints shall be made of heat and corrosion resistant steel. Necessary nozzles (norm size) shall be provided for permanent instrumentation, checking and testing, pressure reading and sampling of raw flue gas parameters. All necessary galleries for reaching the nozzles shall be included in the Contract Object.

The flue gas ducts shall be designed to prevent built up of deposits during operation.

All welds conducting flue gas shall be seal welded on the inside.

The flue gas ducts shall be insulated in compliance with appendix A14.4 *Insulation and Cladding for Process*.

18.2 Measurement of Flue Gas Concentrations

The Contractor shall include complete supply and establishment of instrumentation for continuous measurement at the boiler outlet comprising as a minimum:

- CO concentrations in the flue gas
- Concentration of NH_3 for control and verification of SNCR performance.
- NO_x for control and monitoring of SNCR-performance.
- O_2 and H_2O (and temperature and pressure, if needed) for furnace control and for calculating pollutant concentrations to reference conditions. The O_2 measurement shall be supplied with redundancy.
- Concentration of HCl
- Concentration of SO_2

Continuous flue gas analysers of a high quality and availability, which have proved their practical applicability, shall be offered. Precision and detection limits shall be in accordance with the low emission limit values required as well as applicable standards. The shift between relevant measuring ranges shall be automatic.

All inlets and outlets shall be galvanic separated. For control and troubleshooting purposes both direct and calculated measuring values (adjusted to normal conditions, 11% O_2, dry flue gas) shall be transferred to the CMS.

Measuring values for both the direct measurements, correction parameters and corrected measurements shall be included in the CMS.

Provisions shall be made to connect external signal logging equipment to collect the raw instrument signals and other signals transferred to the CMS. The intention is to ensure data logging options for use by measurement institute and others. Any such signals shall be 4-20 mA, galvanic separated.

The procurement basis of equipment, layout and position of sampling probes shall be presented to and discussed with the Employer.

18.3 Automatic and Central grease lubrication

Automatic grease lubrication systems shall be installed for the following equipment:

- The cut-off gate for the waste hopper
- The grate
- The IBA extractor
- Mechanical ash conveyors
- IBA belt conveyor/vibrating conveyors
- Rapping system on horizontal convection pass
- Any other operational system requiring continuous lubrication

Central grease lubrication systems shall be installed for technical systems with the following lubrication requirements (except for the above listed systems which shall be automatic greased):

- Where components have to be greased on regularly basis with a small time interval.
- Where components are positioned relatively close to each other.
- Where components have to be greased with the same grease.

A central grease system shall be installed for the waste feeder. Furthermore, the Contractor shall consider whether it is reasonable to install the central grease lubrication system on larger prime movers (fans and feed water pumps etc.).

18.4 Hydraulic System

The incinerator/boiler shall be equipped with a complete, redundant hydraulic pump system with a capacity stated in appendix A13 *Process and Design Data*, for e.g. feeding pushers, grate drives, IBA extractor(s) etc. The hydraulic system shall be located in a separate room.