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Technical Code for Designing Flue Gas Desulfurization Plants of Fossil Fuel Power Plants

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Contents

Foreword

This standard is prepared in accordance with the *Notice on Confirmation of Amending Electric Power Industry Standard of Year 2000* (Electric Power [2000] No. 20) issued by the former State Economic and Trade Commission of the People's Republic of China.

As the country controls the emissions of SO_x from fossil-fueled power plants more and more strictly, an increasingly growing number of flue gas desulfurization plant (FGD plant) have been installed. In order to unify and regulate the design and building standards of flue gas desulfurization plant installed in fossil-fueled power plants, implement the basic policy of "safe and reliable, cost effective and applicable, and comply with the specific situations of the country", and to have rules available to follow, this standard is prepared in combination with actual engineering problems encountered and experiences gained during design and construction of flue gas desulfurization plant for fossil-fueled power plants over recent years.

This standard is proposed and managed by China Electric Power Planning and Engineering Association Standardization Technic Committee.

This standard is prepared by Southwest Electric Power Design Institute.

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1 Scope

This standard specifies the design requirements for flue gas desulfurization plants.

This standard is applicable to the flue gas desulfurization plants built in parallel with construction of a newly-built, extended power plant and that added for an existing power plant, which are installed with boilers of 400 t/h or above. It can also be used as a reference standard for design of flue gas desulfurization plants for power plants with boilers below 400 t/h.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this code. For dated references, subsequent amendments to (excluding the contents of errata), or revisions of, any of these publications do not apply. However parties to agreements based on this code are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

GBJ 87 *Specifications for the Design of Noise Control System in Industrial Enterprises*

GB 8978 *Integrated Wastewater Discharge Standard*

GB 50033 *Standard for Daylighting Design of Buildings*

GB 50160 *Fire Prevention Code for Petrochemical Enterprises Design*

GB 50229 *Code for Fire-Protection Design for Fossil Fuel Power Plants and Substations*

DL 5000 *Technical Code for Design of Fossil Fuel Power Plants*

DL/T 5029 *Standard for Design of Architectural Finishing of Fossil Fuel Power Plant*

DL/T 5035 *Technical Code for Heating Ventilation and Air Conditioning Design of Fossil Fuel Power Plant*

DL/T 5046 *Technical Code for the Design of Wastewater Treatment of Fossil Fuel Power Plants*

DL/T 5120 *DC System Design Code for Small Electric Power*

Project

DL/T 5136 *Technical Code for Designing of Electrical Secondary Wiring in Fossil Fuel Power Plants and Substations*

DL/T 5153 *Technical Rules for Designing Auxiliary Power System of Fossil Fuel Power Plants*

3 General

3.0.1 Selection of desulfurization processes shall be decided through comprehensive technical and economical comparisons in terms of boiler capacity and peak load regulation requirements, quality of coal (especially the reduced sulfur content), desulfurization efficiency stipulated in the sulfur dioxide control planning and environmental impact assessment, the maturity level of the desulfurization process, the supply conditions of the desulfurization agent, the conditions of the water source, the comprehensive utilization conditions of desulfurization by-products and ash, the discharge conditions of wastewater and waste residues resulting from desulfurization, the site layout conditions of power plant.

3.0.2 Selection of the desulfurization process may follow the rules below:

1 In case of construction of a desulfurization plant for boilers of power plants that operate on coal with a sulfur content of no less than 2% or that are installed with large-capacity units (200 MW or above), a limestone-gypsum wet desulfurization process should be preferred and the desulfurization efficiency shall be higher than 90%.

2 In case of construction of a desulfurization plant for boilers of middle and small-sized power plants (below 200 MW) that operate on coal with a sulfur content of less than 2%, or in case of construction of a desulfurization plant for existing units with a residual life of less than 10 years, a semi-dry process, dry process or other less costly mature techniques should be preferred, and the desulfurization efficiency shall be higher than 75% on the premise

that the emissions comply with relevant standards and total emissions of sulfur dioxide (SO_2) is controlled within the specified limits, and the source of absorbent and treatment conditions of by-products are readily available.

3 For coastal power plants that operate on coal with a sulfur content less than 1％, a seawater desulfurization process may be adopted if a coastal area environmental impact assessment report is approved by relevant government authorities and it is warranted through comprehensive technical and economical comparison. The desulfurization efficiency shall be higher than 90％.

4 An electronic beam desulfurization process and ammonia scrubbing desulfurization process may be adopted if a liquid ammonia source and the marketing channel of the by-product of ammonium sulphate are readily available and it is warranted through comprehensive technical and economical comparison and subjected to technical authentication conducted by relevant government authorities. The desulfurization efficiency shall be higher than 90％.

5 Availability of the desulfurization plant shall be higher than 95％.

3.0.3 The design conditions of a flue gas desulfurization plant shall be such that the boiler operates on design coal under BMCR (Boiler Maximum Continuous Rating) condition, while the check condition shall be such that the boiler operates on check coal under BMCR condition. In case of adding a flue gas desulfurization plant for an existing power plant, the design and check conditions of the desulfurization plant shall be determined based on the flue gas parameters measured practically, fully considering the tendency of change in coal supply sources. The design parameters for flue gas at the inlet of the desulfurization plant shall be selected to be those data taken from the location where the desulfurization plant adjoins with the flue gas duct of the main equipment.

3.0.4 The capacity of the flue gas desulfurization plant shall be designed based on flue gas flow under the above stated conditions without reserving any capacity margin.

3.0.5 Since the sulfur content contained in design coal as received to be employed for main works is generally at the average level, SO_2 concentration (both design value and check value) at the inlet of the flue gas desulfurization plant shall be fully investigated. Considering the actual conditions of coal procurement and the change tendency of coal quality, the higher value within the change limits shall be selected.

3.0.6 The necessary analysis made on pollutants of the flue gas, such as Cl (HCl) and F (HF), shall be included in the information regarding the quality of design coal for the flue gas desulfurization plant.

3.0.7 The SO_2 content in the flue gas before desulfurization shall be calculated by using the following equation:

$$M_{SO_2} = 2 \times K \times B_g \times \left(1 - \frac{\eta_{SO_2}}{100}\right) \times \left(1 - \frac{q_4}{100}\right) \frac{S_{ar}}{100} \qquad (3.0.7)$$

Where:

M_{SO_2} —SO_2 content in the flue gas before desulfurization, t/h;

K —Percentage of fuel coal-containing sulfur that is oxidized into SO_2;

B_g —Coal consumption under the boiler BMCR condition;

η_{SO_2} —Desulfurization efficiency of the dust collector, see Table 3.0.7;

q_4 —Heat loss of the boiler resulting from incomplete burning, %;

S_{ar} —Sulfur content of coal as received, %.

Note: For pulverized coal-fired boilers, K=0.85-0.9, which indicates the extent to which sulfur is oxidized into SO_2 during burning. It is recommended that the maximum limit of 0.9 be adopted in design of desulfurization plant.

Table 3.0.7 Desulfurization Efficiency of the Dust Collector

Type of ESP	Dry Type	Washing Water Film Type	Venturi Water Film Type
η_{SO_2} %	0	5	15

3.0.8 The flue gas desulfurization plant shall be able to operate safely and continuously under any load ranging from the boiler minimum load rating (BMLR) to the boiler maximum continuous rating (BMCR). The change rate of load of the flue gas desulfurization plant shall be compatible with that of the boiler.

3.0.9 The electric power supply, water supply, gas supply and steam supply needed by the desulfurization plant shall be supplied from the main works as practically as possible.

3.0.10 After erection of the desulfurization plant, the type, inner lining material, outlet diameter and height etc. of the chimney shall be determined based on the factors such as desulfurization process, outlet temperature, humidity, environmental protection requirements, operation requirements. In case of adding a desulfurization plant for an existing power plant, the existing chimney shall be analyzed and evaluated for the necessity for modification thereof or enhancing its operation monitoring.

4 General Layout

4.1 General Provisions

4.1.1 Desulfurization plant layout shall meet the following requirements:

1 Reasonable process flow, short flue gas duct;

2 Convenient transportation;

3 Full utilization of utilities of main works;

4 Reasonable utilization of terrain and geological features;

5 Land saving, small work quantity and low operating costs;

6 Convenient for construction and ease of maintenance and repair;

7 Compliance with the requirements of environmental protection, labor safety and industrial sanitation.

4.1.2 For a technological modification project, removal of the production buildings and structures as well as the underground pipelines of the operating units shall be avoided. If this is unavoidable, reasonable transitional measures must be taken.

4.1.3 Desulfurization absorbent unloading and storage yards should be located in the upwind direction with the minimum frequency all the year round in a facility area that is relatively densely populated.

4.2 General Layout

4.2.1 The flue gas desulfurization plant shall be arranged according to overall planning and shall not prevent potential expansion of the power plant.

4.2.2 The desulfurization absorber should be located near the chimney. The slurry circulation pump shall be arranged in close proximity to the absorber. Absorbent preparation and the desulfurization by-products treatment yard should be centrally arranged in the vicinity of the absorber or arranged appropriately, taking into consideration the process flow and site conditions.

4.2.3 In case of seawater desulfurization, the aeration tank shall be located close to the drainage facilities, and should be arranged with reference to the location of the circulation water discharging ditch. Water drained from both the aeration tank and the circulation water discharging ditch shall be collected and then discharged centrally.

4.2.4 If the desulfurization plant is not constructed in parallel with the main works, the desulfurization site should be reserved in close proximity to the rear flue gas duct of the boiler induced fan and the chimney. The area of the site shall be determined based on the desulfurization processes that may be employed in the future. The facility that can not be dismantled conveniently shall not be arranged in the reserved site.

4.2.5 The emergency slurry tank or emergency slurry box used in the limestone-gypsum wet desulfurization method should be located such that multiple desulfurization units can share them conveniently.

4.2.6 Whether or not the booster fan, circulation pump, oxidation air fan and other similar devices can be installed outdoors depends upon local meteorological conditions and equipment conditions. In case of outdoor installation, acoustic baffles shall be installed or a space shall be reserved to install the same.

4.2.7 The desulfurization wastewater treatment workshop should be located in close proximity to the gypsum dewatering workshop and designed such that the waste water can be recovered together with that discharged from the main works after being treated up to the standard or discharged. The area for unloading acid and alkali, which is close to the wastewater treatment workshop, shall be located in a remote area where population is less.

4.2.8 The gypsum silo or storehouse should be arranged close to the gypsum dewatering workshop, for which a free driveway shall be provided. The clearance height below the gypsum silo shall be no less than 4.5 m.

4.2.9 The ammonia tank area shall be located at a well-ventilated and safe zone at the boundary of the power plant. The fireproof design of the ammonia tank shall meet the requirements specified in GB 50160.

4.2.10 For electron beam flue-gas desulfurization and ammonia scrubbing desulfurization processes, proper packaging and storage yards for ammonium sulphate shall be arranged based on the marketing conditions and site conditions.

4.3 Vertical Layout

4.3.1 The desulfurization site shall be located at an elevation not being endangered by flood. If the desulfurization equipment is located within the ring road of the main power building, flood protection standards shall be the same with that of the main power building. If it is located beyond the ring road, the flood protection standards shall be the same with that of other sites.

4.3.2 Elevation ±0 m of the main facilities of the desulfurization unit shall be the same with that of the flue gas duct and the chimney at the end of the boiler, and shall be coordinated with site elevation of other areas in the vicinity. In addition, the elevation shall be convenient for transportation and communications, field drainage and reduction of the excavated earth quantity.

4.3.3 For a newly-built power plant, ground leveling and balancing of excavated earth in the desulfurization site shall be considered together with that of the main works. For a technological modification project, excavated earth shall be balanced in the desulfurization site itself. The ground slope of the site after being leveled shall be determined based on the terrain and geological conditions. It is usually 0.5% to 2.0%, and no less than 0.3% for difficult sections, and 3.0% at the most.

4.3.4 Elevation differences between indoor floor and outdoor ground of the buildings and elevation of special sites shall be in accordance with the following requirements:

1 The elevation difference between indoor floor and outdoor ground of buildings with vehicle access is usually 0.15 m-0.30 m;

2 The elevation difference between indoor floor and outdoor ground of buildings without vehicle access may be more than 0.30 m;

3 The elevation of storage areas for flammables, explosives and corrosive liquids should be lower than that of the surrounding roads.

4.3.5 If the excavation volume is considerably large, a stepped layout may be adopted, in this case the elevation difference between two adjacent terraces shall not exceed 5 m with linking steps in between provided. If the earth retaining wall is 3 m high or above, guardrails shall be provided at the top of the wall. The entire desulfurization unit should be arranged on the same elevation level. The unloading site for corrosive liquids should be located at a lower elevation where the ground shall be subject to anti-corrosive treatment.

4.3.6 The drainage mode of the desulfurization site should be the same as that of the main works.

4.4 Transportation

4.4.1 The transportation mode of the desulfurization absorbent and by-products shall be determined through technical and economical comparisons based on the existing situation of local transportation, logistic direction and traffic conditions of the power plant.

4.4.2 A self-dumping sealed tank vehicle shall be used for the transportation of limestone powder, while a self-dumping vehicle with preventive measures against re-entrainment of dust should be used for transportation of limestone lumps and gypsum. Vehicles required shall be subject to assistance and cooperation from local resources.

4.4.3 An FGD island should be provided with convenient access which forms a network together with those of the power plant. The type of such access routes shall be the same as those of the main works. The access routes for transporting absorbent and desulfurization by-products should be 6.0 m-7.0 m wide with a turning radius no less than 9.0 m, and those for ordinary fire fighting, operation, maintenance and repair should be 3.5 m or 4.0 m wide, with a turning radius no less than 7.0 m.

4.4.4 The longitudinal slope of the parking lot of vehicles for loading and unloading of absorbent and desulfurization by-products should be level. In cases where this is not feasible, the maximum slope shall not exceed 1.5％.

4.4.5 In case of transportation of limestone lumps by railway, a grab bucket bridge crane or a slot-type unloading trench should be used for unloading. The railway lines shall be arranged based on factors including number of vehicles arriving at the plant at a time, existing railway conditions, site conditions, line layout and the unloading mode.

4.4.6 In case of transportation of limestone lumps and gypsum by waterway, the coal unloading jetty, ash handling jetty and heavy & large-sized goods jetty or special jetty shall be used in light of the engineering conditions. The shipping tonnage, selection of loading and unloading equipment and in-plant transportation mode shall be determined through comprehensive comparison.

4.4.7 Devices for weighing, sampling and testing shall be available for absorbent received. Also, those devices equipped for the main works may be shared.

4.5 Piping Layout

4.5.1 The overall piping layout shall be determined based on factors including general layout, media carried in the piping, construction, maintenance and repair and shall be coordinated with the main works layout in terms of plan view and spatial locations.

4.5.2 Piping layout shall be short, straight and central appropriately. The pipelines shall be in parallel with the buildings and roads. The main pipeline should be near the main consumer or at the side where most of the branches are located.

4.5.3 Except for pipelines for rainwater and domestic sewage, other pipelines within the desulfurization area should be laid overhead in a suitable manner. The pipelines crossing roads shall have a clearance height of no less than 5.0 m. When being placed on low supports at walkways, the pipelines shall have a clearance height of no less than 2.5 m. If the pipelines are placed on low buttresses, the buttresses should be 0.15 m-0.30 m higher than the ground.

4.5.4 Anticorrosive treatment shall be applied to the slurry channels in the desulfurization area if corrosive liquid will flow through them. Corrosive protection treatment should be applied to the wastewater channels as well. The outdoor cable trenches shall be designed to prevent entry of corrosive slurry.

4.5.5 Rainwater pipelines, domestic sewage pipelines, fire control water pipelines and all types of trenches should not be arranged under the driveways in parallel therewith.

5 Absorbent Preparation Systems

5.0.1 Selection of Absorbent Preparation Systems.

1 Available schemes for absorbent preparation system include:

1) Purchase finished powder product with proper grain size from the market directly, and then mix it with water into limestone slurry.

2) Purchase limestone gravel with certain grain size from the market, and then grind it into limestone slurry with wet ball mill.

3) Purchase limestone gravel from the market, grind it into limestone powder with dry mill, and then add water to mix the powder into limestone slurry.

2 An absorbent preparation system shall be selected through comprehensive technical and economical comparison by considering absorbent sources, investment, operating costs and transportation conditions. If the source of supply is fixed and the price is reasonable, direct purchase of limestone powder is preferred. If the conditions permit and the design plan is reasonable, a wet ball mill absorbent preparation system may be set up by the power plant itself. When it is necessary to build a new plant for limestone powder preparation, cooperation with the local resources, i.e., concentrated construction of the plant, shall be preferred, and comprehensive technical and economical demonstration shall be performed by considering the investment and management mode, process techniques, plant location and transportation conditions.

5.0.2 Two units of 300 MW or above should share one absorbent slurry preparation system. One absorbent slurry preparation system may be shared by several boilers when the planned capacity is clearly defined. For the absorbent slurry preparation system equipped for one unit, one mill should be provided, and the capacity of the limestone slurry tank shall be increased accordingly. For a power plant being installed with units of 200 MW or below, the absorbent slurry preparation system shall be shared by all the units.

5.0.3 In the case that limestone gravels are transported to the plant, a limestone crusher may be required, depending upon factors such as raw material supply and plant layout.

5.0.4 In case two units share one absorbent slurry preparation system, such system should be provided with two wet limestone ball mills and associated limestone slurry cyclone separators. The capacity of each mill shall be selected to be 75% of the limestone consumption under the design conditions, and shall be no less than 50% of the limestone consumption under the check condition. In case several boilers share one absorbent slurry preparation system, *n*+1 wet ball mills and associated limestone slurry cyclone separators shall be provided, *n* for operation, and 1 for standby.

5.0.5 The capacity of each dry mill absorbent preparation system shall be no less than 150% of the limestone consumption under the design condition and no less than the limestone consumption under check condition. The quantity and capacity of the mills shall be determined through comprehensive technical and economical comparison.

5.0.6 The capacity of the limestone slurry tank of the wet limestone ball mill slurry preparation system should be sufficient for storage of the limestone slurry consumption under design conditions for at least 6 h-10 h, while the capacity of the limestone slurry tank of the dry limestone ball mill slurry preparation system shall be sufficient for storage of the limestone slurry consumption under design conditions for at least four hours.

5.0.7 Each absorber shall be provided with two limestone slurry pumps, one for operation, the other for standby.

5.0.8 The capacity of the limestone gravel silo or limestone powder silo shall be determined based on the market and transportation conditions, usually it is determined for storage of the limestone consumption under design conditions for at least three days.

5.0.9 Measures against re-entrainment of dust shall be taken for the absorbent preparation, storage and handling systems.

5.0.10 The corrosive and abrasive effects of the working medium on slurry pipelines shall be allowed for during design. Usually they shall be selected as rubber and plastic lined pipelines or fiberglass reinforced plastic pipelines. The flow rate of the medium in the pipeline shall be designed to avoid slurry sedimentation and minimize the corrosion and pressure loss of the pipeline.

5.0.11 Butterfly valves should be selected for the slurry pipeline, control valves should be avoided as practically as possible. Flow-through diameter of the valves should be the same as that of the pipelines.

5.0.12 Provisions shall be made for the slurry pipelines to facilitate discharging and automatic flushing when the units are stopped.

6 Flue Gas and Sulfur Dioxide Absorbing System

6.1 Sulfur Dioxide Absorbing System

6.1.1 The quantity of absorbers shall be determined based on the capacity of the boiler, the reliability and capacity of the absorber. For units of 300 MW or above, one boiler should be provided with one absorber. For units of 200 MW or below, two boilers should share one absorber.

6.1.2 The design temperature of flue gas at the inlet of the FGD plant shall adopt the temperature of flue gas flowing from the flue gas duct of the main equipment to the connection of the FGD plant when the boiler operates on design coal under BMCR conditions. Usually, the short-term operating temperature of the FGD plant built in parallel with a newly-built unit shall be the temperature of flue gas at the inlet of the FGD plant under rated operating conditions of the boiler plus 50 ℃.

6.1.3 Absorbers shall be provided with mist eliminators. The mist concentration of flue gas at the outlet of the mist eliminator shall not be more than 75 mg/m^3 (standard state) under normal operating conditions. The mist eliminator shall be provided with water flushing devices.

6.1.4 If spray absorber is adopted, absorber slurry circulation pumps should be arranged in the unit system, with each circulation pump corresponding to one layer of nozzles. In the case of circulation pumps arranged in the unit system, one set of spare pump impellers shall be provided in the warehouse, while in the case of those arranged in a header system (slurry originating from outlets of several circulation pumps is collected together and then distributed to respective layers of nozzles), one spare pump should be installed on site.

6.1.5 The absorber slurry circulation pumps shall be in such a number as to well suit the partial-load operating conditions of the boiler and to contribute to high economical efficiency when the absorber is operating under low load conditions.

6.1.6 Each absorber shall be provided with 2×100％ or 3×50％ oxidation air fans, one of which is for standby; or every two absorbers shall be provided with 3×100％ oxidation air fans, two in operation and one for standby.

6.1.7 The FGD plant shall be provided with emergency slurry tanks or ponds, the number of which shall be determined by taking into consideration all the factors such as FGD process, distance and the layout of each absorber. The absorbers within the whole plant may share one emergency slurry tank if the layout conditions permit and the absorbers employ the same wet process system. The emergency slurry tank should have a minimum capacity that corresponds to the lowest operating level of one absorber. If a gypsum slurry drainage system is provided, the emergency slurry tank may be sized to be not less than 500 m^3.

6.1.8 All tanks used to contain suspended slurry shall be subject to corrosion resistance treatment and equipped with mixing devices.

6.1.9 Platforms and ladders shall be provided outside the absorber for inspection and maintenance. No stationary platform shall be provided inside the absorber.

6.1.10 The slurry pipelines shall comply with the requirements set forth in Section 5.0.10-5.0.12.

6.1.11 In light of layout requirements of FGD processes, elevators may be provided for the absorber when necessary. If the layout condition permits, then two absorbers and the FGD control room may share one elevator.

6.2 Flue Gas System

6.2.1 FGD booster fans should be installed at the inlet of the FGD plant, and may also be installed at the outlet thereof if being justified by comprehensive technical and economical comparison. If the conditions permit, then the FGD booster fans may be integrated with the ID fan.

6.2.2 The type, quantity, flow rate and pressure head of the FGD booster fans shall be selected in accordance with the following requirements:

1 Stationary blade adjustable axial flow fans or high efficiency centrifugal fans should be used as the FGD booster fan for large-capacity absorber. Moving blade adjustable axial fans may be used if the dust content of flue gas at inlet of the fan can meet the requirements and it is justified by technical and economical comparison.

2 For units not more than 300 MW, each absorber should be provided with one FGD booster fan and no spare FGD booster is required. For units ranging from 600 MW to 900 MW, each absorber may be provided with two FGD booster fans if being justified by technical and economical comparison.

3 The flow rate and pressure head of the FGD booster fan shall be selected in accordance with the following requirements:

1) The basic air flow rate of the FGD booster fan shall be determined based on the flue gas flow under the design

conditions of the absorber. No less than 10% of air flow margin and a temperature margin of no less than 10 ℃ shall be considered for the FGD booster fan.

2) The basic pressure head of the FGD booster fan shall be the sum of the resistance resulting from the FGD plant itself and the differential pressure between the inlet and outlet of the FGD plant. The pressure at the inlet and outlet shall be provided by the design entity of the main works. The pressure head margin of the FGD booster fan shall be not less than 20%.

6.2.3 A flue gas heat exchanger should be provided for the flue gas system. Under design conditions, the flue gas at the chimney inlet that has undergone desulfurization treatment shall be 80 ℃ or above before being discharged. The flue gas heat exchanger may be eliminated if the environmental protection requirements are satisfied and provisions for corrosion resistance and drainage have been made for the chimney and flue gas ducts, and it is demonstrated reasonable through technical and economical comparison.

6.2.4 A tube heat exchanger with heat medium water acting as the heat transfer medium or a regenerative heat exchanger may be used as the flue gas heat exchanger. In the case that it is difficult to install a cooling heat exchanger on the raw flue gas side, the installation of a steam heat exchanger on the clean flue gas side is allowed. Generally, the air leakage rate of the regenerative heat exchanger for the FGD plant shall be no more than 1% in order to achieve designed desulfurization efficiency.

6.2.5 Measures against corrosion, abrasion, clogging and pollution shall be taken for the heating area of the flue gas heat exchanger and anti-corrosion measures shall also be taken for housings in contact