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**Technical Code for the Design of Ash Handling System of**

**Fossil-fired Power Plant**

**火力发电厂除灰设计技术规程**

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## 2 Terms

### 2.0.1 Particle density

The ratio of the material mass to its true volume.

### 2.0.2 Loose-poured bulk density

The mass per unit volume of particle materials under natural stacking state.

### 2.0.3 Slurry weight density

The percentage of solid weight, flowing in unit time, in the slurry weight.

### 2.0.4 Material gas ratio

The ratio of the material mass, being conveyed in unit time in the pneumatic conveying pipeline, to the gas mass

### 2.0.5 Percentage of mill rejects

The percentage of mill reject amount, being discharged by the medium speed coal mill in unit time, in the coal amount entering into coal mill.

### 3 Pneumatic Ash Handling System

#### 3.1 Basic Requirement

**3.1.1** The on-site ash conveying system should adopt positive pressure pneumatic conveying system. Where the material characteristics and conveying conditions are suitable, positive pressure dense phase pneumatic conveying system should be adopted.

**3.1.2** According to different conveying distances, pneumatic ash conveying system may adopt air slide, negative pressure and other conveying modes and should meet the following requirements:

**1** Where the conveying distance is shorter than 60m, air slide conveying mode may be adopted.

**2** Where the length of conveying pipeline does not exceed 150m, negative pressure pneumatic conveying system may be adopted.

**3** In combination with specific engineering conditions, system combined by various pneumatic conveying modes may be adopted.

**3.1.3** Where the slag warehouse is relatively far and it is difficult to arrange mechanical conveying equipment, pneumatic slag conveying system may be adopted.

**3.1.4** The flow velocity of pneumatic ash handling pipeline shall be determined reasonably according to such factors as ash particle diameter, density, conveying pipe diameter and ash handling and conveying system.

**3.1.5** The pneumatic conveying system design shall consider the effects from local air pressure, air temperature, humidity and other natural conditions.

**3.1.6** Where the boiler adopts electric precipitator, the ash conveying system output of the following stage electric fields shall not be less than the ash amount of the earlier stage electric field under normal working conditions when the preceding stage electric field loses of power.

**3.1.7** Where the boiler slag handling adopts the combined system of air-cooled type slag conveyor and pneumatic slag conveying, high-temperature resistant slag crusher shall be arranged at the outlet of air-cooled type slag conveyor, and the particle size of slag discharged by the slag crusher shall meet the conveying requirements. Buffer slag hopper should be arranged between the slag crusher outlet and the pneumatic conveying equipment.

#### 3.2 Positive Pressure Pneumatic Conveying

**3.2.1** The design output of positive pressure pneumatic ash conveying system should not be less than 150% of the ash discharge amount of boiler when it fires the design coal at the working condition of maximum continuous evaporation and should not be less than 120% of the ash discharge amount of boiler when it fires the check coal.

**3.2.2** Two sets of positive pressure pneumatic slag conveying systems should be set for each boiler that one for operation and the other for standby. The design output of each set of system should not be less than 150% slag discharge amount of design coal and should not be less than 120% slag discharge amount of check coal.

**3.2.3** The bin type pneumatic conveying pump (hereinafter referred to as bin pump) under

the precipitator ash hopper should be arranged in groups. As for the bin pump under the first electric field of electric precipitator and the ash hopper of baghouse precipitator, the quantity of bin pumps being operated simultaneously in each group should not exceed 6.

**3.2.4** The quantity of pneumatic ash conveying pipelines shall be selected reasonably according to the system output, group number of ash conveying equipment, pipeline utilization rate and comprehensive utilization. The conveying output of bin pump being operated simultaneously in each group and the auxiliary ash pipes should not exceed 80t/h. The conveying frequency should be controlled at 6~10 times/h.

**3.2.5** Manual isolating valve shall be installed between the ash hopper and bin pump. Pneumatic switching valve shall be arranged at the branch pipe close to the main conveying pipe.

**3.2.6** The exhaust produced during the feeding process of bin pump should be discharged to the nearby precipitator ash hopper and other silos. The exhaust pipe outlet shall be connected to the upper area of the high level gage of ash hopper and other silos. On the exhaust pipe, pneumatic exhaust valve shall be arranged and the included angle between the exhaust pipe and horizontal plane should not be less than 55°.

**3.2.7** The pneumatic ash conveying pipeline should be provided with automatic anti-blocking measure and blockage-eliminating measure. The outlet of blockage-eliminating pipeline should be arranged at the upper area of the high level gage. The outlet section of blockage-eliminating pipeline shall be arranged obliquely.

**3.2.8** Where the ash from coal economizer and denitration device ash hopper is conveyed to the slag bin, the slag bin exhaust filter shall be set with exhaust fan and the filter bag shall be of high-temperature resistant material.

**3.2.9** Exhaust filter should adopt pulse-jet baghouse precipitator; the dust concentration of the filter exhaust shall meet the requirements of national and local environmental standards; the filtering air velocity of exhaust filter should not be greater than 0.8m/min. The blowback air shall meet the quality requirement of air for instrument and the blowback air pressure and air consumption shall be selected according to the materials provided by the manufacturer.

**3.2.10** The bin pump layout shall meet the following requirements:

1 The included angle between the ash fall pipe and the horizontal plane should not be less than 60°.

2 The bin pump should be arranged on the ground. The clear distance between the bin pump bottom and the ground shall meet the overhaul requirements.

3 Overhaul and maintenance platform should be arranged at the feed valve of bin pump.

**3.2.11** The pressure loss of the positive pressure conveying pipeline shall be the total pressure loss of horizontal, vertical and inclined pipelines as well as various pipeline accessories. To simplify the calculation, each part may be converted to a horizontal pipeline with equivalent length. As for suspension flow conveying, the pressure loss may be calculated according to the following formulae:

$$\Delta P = \left[ \sqrt{P_g^2 + 19.6 P_g \lambda_a \frac{V_g^2 L_{eg}}{2gD}} - P_g \right] (1 + K_\mu) \quad (3.2.11-1)$$

$$L_{eg} = L \pm H + \sum n L_r \quad (3.2.11-2)$$

Where,

$Q$  - the air flow at the initial end of negative pressure equipment,  $\text{m}^3/\text{s}$ ;  
 $v_b$  - the specific volume of air at initial end,  $\text{m}^3/\text{kg}$ ;  
 $v_e$  - the specific volume of air at tail end,  $\text{m}^3/\text{kg}$ ;  
 $P_b$  - the absolute pressure of air at initial end, Pa;  
 $P_e$  - the absolute pressure of air at tail end, Pa;  
 $m$  - the adiabatic coefficient, which may be taken as 1.2;  
 $w$  - the average flow velocity, m/s;  
 $w_b$  - the flow velocity at initial end, m/s;  
 $w_e$  - the flow velocity at tail end, m/s;  
 $g$  - the gravity acceleration, taking  $9.81 \text{ m/s}^2$ ;  
 $L$  - the geometrical length of conveying pipeline, m;  
 $f$  - the friction coefficient; where  $D \leq 200\text{mm}$ ,  $f=0.7$ ; where  $D \geq 200\text{mm}$ ,  $f=1.1-0.002D$ ;  
 $H$  - the vertical rise, m;  
 $N$  - the quantity of  $90^\circ$  elbow, pcs; where the elbow is smaller than  $90^\circ$ , it is converted to  $90^\circ$  elbow.

### 3.4 Pneumatic Ash Conveying Pipeline

**3.4.1** Carbon steel pipe should be adopted for straight pipe section of pneumatic ash conveying pipeline and wear-proof material shall be adopted for elbow and other pipeline accessories. For straight pipe section with higher flow velocity of conveyance medium and serious wear, wear resistant pipeline may also be adopted through technical and economical comparison.

**3.4.2** The straight pipe section, elbow and pipeline accessories of pneumatic slag conveying pipeline shall adopt wear resistant material.

**3.4.3** The wall thickness of pneumatic ash conveying pipeline should not be less than 7mm.

**3.4.4** As for the layout of pneumatic conveying pipeline, the elbow quantity shall be reduced and the curvature radius of wear resistant elbow should be 3~6 times of the pipe diameter of the straight pipe section.

**3.4.5** In the pneumatic ash handling system with relatively long conveying distance, the diameter of ash conveying pipeline shall be changed by sections, and the section quantity and the length of each section shall be determined through calculation.

**3.4.6** At the outlet of ash hopper or when the ash pipe needs to change direction, a straight pipe section not less than 10 times of the pipe diameter should exist before turning.

**3.4.7** The distance from the diameter changing point of the ash conveying pipeline to the elbow should not be less than 6m.

**3.4.8** The pneumatic ash conveying pipeline should be elevated. Where it is arranged on the ground, walkway shall be arranged at the channel; where it is elevated, the distance to railway, highway, building and high voltage line shall meet the requirements of the current professional standards "Technical Code of General Plan Transportation Design for Fossil Fuel Power Plants" (DL/T 5032) and "Operating Code for Overhead Transmission Line" (DL/T 741).

**3.4.9** Where the straight pipe section of the pneumatic ash conveying pipeline is too long and cannot meet the self-compensation requirements of expansion and contraction,

- 1 The inclination of air slide shall not be less than 6%.
  - 2 Air slide should consider damp proof and insulation measures.
  - 3 Isolating service valve and electric flap valve shall be installed between the ash hopper and air slide.
  - 4 Flexible connection should be provided between ash fall pipe and air slide and between blower and tuyere nozzle.
- 3.5.4** The air consumption per unit or the total air pressure of air slide shall be determined respectively through test. Where test data is unavailable, the air consumption per unit may be selected according to  $1.5 \text{ m}^3/(\text{min} \cdot \text{m}^2) \sim 2.5 \text{ m}^3/(\text{min} \cdot \text{m}^2)$  (at standard condition) (air-permeable layer); the total air pressure may be selected according to 3kPa~5kPa.
- 3.5.5** The clean hot air shall be adopted as the conveying air source of the air slide and the hot air temperature should be selected according to  $40^\circ\text{C} \sim 80^\circ\text{C}$ . The air source should be supplied by the dedicated fan, and spare one is not required on this occasion; where conditions permit, the air source may be supplied by boiler blower.
- 3.5.6** One air intake point shall be arranged at the starting point of air slide, one air intake point and one air chamber baffle plate should be arranged respectively at each turning point and every other 30m.
- 3.5.7** The exhaust of air slide should be connected to the flue at the precipitator entrance of the boiler flue gas, and shut-off valve shall be installed between the air slide and flue. The exhaust pipe shall have certain slope to prevent ash deposition.

### 3.6 Dry Ash Classifying System

- 3.6.1** Where market demand for the comprehensive utilization of pulverized fuel ash is good and there is demand for classified ash, dry ash classifying system should be arranged synchronously.
- 3.6.2** Dry ash classifying system should be closed cycle system, and its set number and output shall be determined according to the comprehensive utilization demand.
- 3.6.3** The classifier of dry ash classifying system may be volute or turbine air classifier. The classifier efficiency should not be less than 80% and the dust collection efficiency should not be less than 90%.
- 3.6.4** Where centralized dry ash classifying is adopted, the supporting ash silo should be designed uniformly with the conveying system ash storage silo, and the quantity shall be arranged according to the classification requirements of comprehensively utilized ash, which should not be less than 3 seats; the storage capacity of ash silo shall be appropriate to the comprehensive utilization requirements.
- 3.6.5** The dry ash classifying system shall adopt dedicated wear-proof centrifugal fan, and the through-flow components of classifier, cyclone precipitator and high-voltage centrifugal fan shall be wear-proof material.
- 3.6.6** The conveying speed in the dry ash classifying system pipeline should be 15m/s~20m/s. The straight pipe section of conveying pipeline may adopt carbon steel pipe and the elbow shall be of wear resistant material. The wall thickness of ash conveying pipeline should not be less than 8mm and that of the return air pipeline should not be less than 6mm.



## 4 Hydraulic Ash Handling System

### 4.1 Basic Requirement

**4.1.1** The hydraulic ash handling system may adopt the following forms:

**1** For boiler slag handling, a water sealed slag discharge hopper shall be adopted for cooling; after passing through the hydraulic jet pump and conveying pipeline, ash slurry will be conveyed into a dewatering bin or an ash slurry pond periodically.

**2** For boiler slag handling, a submerged scraper conveyor is used for cooling; after passing through the slag slurry pump and conveying pipeline, slag slurry will be conveyed into a dewatering bin or an ash slurry pond or the ash yard.

**3** For boiler slag handling, a submerged scraper conveyor is adopted for cooling; after passing through a slag trench, slag flows to the slag settling pond itself.

**4.1.2** The hydraulic ash handling system may adopt the following forms:

**1** After dry ash in the ash silo passing through the ash slurry facility for slurring, a centrifugal or plunger ash slurry pump and the conveying pipeline shall be adopted for conveying the ash slurry to the ash yard in a hydraulic manner.

**2** After dry ash in ash hopper of the deduster is slurried, the ash trench, centrifugal ash slurry pump and conveying pipeline shall be adopted for conveying the ash slurry into the ash yard in a hydraulic manner.

**4.1.3** The effective volume of water sealed slag discharge hopper shall not be less than the 8h slag discharge amount of boiler when it fires the design coal at the working condition of maximum continuous evaporation, and shall not be less than the 4h slag discharge amount when it fires the check coal.

**4.1.4** Where periodic operation mode is adopted for ash discharging of ash hopper of flue gas deduster and ash hopper of economizer, and the quench time of each ash discharging period should not be less than 2h.

**4.1.5** Water for ash handling should be qualified industrial waste water through treatment; unqualified drainage of other process systems, waste water and rainwater within the plant area shall not be directly provided to the ash handling system.

**4.1.6** Hydraulic ash handling system shall be equipped with ash slurry valves on outlet of ash pump according to the pipe layout and switching requirements; where the ash yard is higher than the outlet of ash pump and the elevation difference is relatively large, slow-closure check valves shall be installed on outlet pipes of ash pump.

**4.1.7** The flow velocity in the pipeline of hydraulic ash handling system shall meet the requirements of Table 4.1.7:

**4.3.1** Selection of hydraulic jet pump system shall be determined according to such factors as characteristics of ash, conveying conditions and conveying volume.

**4.3.2** Number of boiler slag discharge opening and the configuration of slag crusher, hydraulic jet pump, valve and conveying pipeline shall meet the requirement of discharging the 8h boiler slag discharge volume within 1.5h~2h.

**4.3.3** Each slag discharge opening should be arranged with one set of slag crusher and one set of hydraulic jet pump, without standby ones.

**4.3.4** The slurry weight density in ash slurry pipe should be 15%~18%.

**4.3.5** The ash slurry pipe behind outlet of hydraulic jet pump shall be possessed of the straight pipe section greater than 5 times of pipe diameter.

**4.3.6** Hydraulic jet pump should be arranged on ground; where the hydraulic jet pump is arranged in the trench, on the facility valve a portable cover plate shall be available for the maintenance and overhaul.

## 4.4 Ash Trench

**4.4.1** Ash trench of ash handling system should not be equipped with a standby one. Ash trench shall be arranged in short and straight distance as much as possible and shall be convenient for connection during extension, trench bottom shall be lined with wear-proof cast stone panel, etc..

**4.4.2** The gradient of ash trench should be selected according to the following requirements:

- 1 The gradient of ash trench should not be less than 1%.
- 2 The gradient of solid-state slag trench should not be less than 1.5%.
- 3 The gradient of liquid slag trench should not be less than 2%.
- 4 The gradient of ash trench conveying high-concentration ash slurry should be increased properly.

**4.4.3** The initial depth of slag trench should not be less than 500mm, and the initial depth of ash trench should not be less than 400mm. The distance between the initial point of ash trench and the ash entrance should be 2m~3m. Where water sealed slag discharge hopper is adopted, the initial depth of ash trench may be deepened properly or measures such as arranging a cofferdam may be taken.

**4.4.4** The curvature radius of ash trench should not be less than 2m.

**4.4.5** Design of ash trench shall be convenient for the installation, overhaul and replacement of panels; at the place of walls at both sides about 500mm away from the bottom of ash trench, steps shall be set, of which the width should not be less than 100mm. Where the radius of panel,  $R_0$  is 125mm~350mm, the dimension of trench width shall be determined according to Table 4.4.5 and Figure 4.4.5.

## 4.6 Centrifugal Ash Slurry Pump

**4.6.1** The ash slurry pump should be arranged in the boiler room; the ash slurry pump house should be arranged near the slurring facility.

**4.6.2** Selection of ash pump shall be determined according to such factors as the resistance of ash pipeline, the amount of ash slurry and the ash characteristic curve of pump provided by the manufacturer. The flow of ash pump in operating shall not be less than 110% of the designed and calculated ash slurry amount; the lift shall not be less than 110%~120% of the calculated resistance of ash pipeline at the condition of 100% of the designed and calculated ash slurry amount.

**4.6.3** The number (group) of standby ash slurry pump shall meet the following requirements:

- 1 Where one set (group) is in operating, one set (group) of standby one (s) shall be set.
- 2 Where 2~3 sets (groups) are in operating, 2 sets (groups) of standby ones shall be set.

**4.6.4** Ash pump shall be arranged at a low height or a high height according to the facility requirements and the specific arrangement places and conditions. When designing, it shall be guaranteed that the available net positive suction head shall be greater than the necessary net positive suction head of pump.

**4.6.5** Where in the same pump house there are several sets of ash pumps, the channel between two adjacent sets of pumps shall not be less than 1.2m.

**4.6.6** In front of the ash pump house, an ash buffer pool shall be equipped, of which the effective volume should be selected according to the 3min~5min design flow. The buffer pool shall be equipped with devices or taken with measures to prevent from settlement of ash.

**4.6.7** Where the ash pump is arranged in a low height, the design of pump house shall meet the following requirements:

- 1 Frame of motor of ash pump shall be higher than the ground of pump house by 200mm~300mm.

- 2 In the pump pit of pump room, 2 sets of sewage pumps shall be arranged, of which one is for operation and the other is for standby; the flow of sewage pump may be  $30 \text{ m}^3/\text{h} \sim 50 \text{ m}^3/\text{h}$ .

- 3 Where shaft seal water is used for sealing, the shaft seal water pump shall be arranged at the 0-meter floor of the pump house.

- 4 On inlet pipe of ash pump, valves and compensating devices shall be installed.

- 5 Below the 0-meter floor, the through-wall position of ash pipe and cable shall be sealed; cable trench shall not be arranged in the pump pit of pump house.

- 6 The guard control room and overhaul site shall be arranged at the  $\pm 0\text{m}$  floor.

**4.6.8** Where the ash pump is arranged at a high height, the design of pump house shall meet the following requirements:

- 1 In the same pool, the entrance of suction pipe of each ash pump shall be arranged near.

- 2 Starting measures shall be taken at the place with ash pump.

- 3 Drainage from pump house should be discharged outside the ash pool.

**4.6.9** Where the ash pump requires shaft seal water, specialized seal water pump shall be

installed, of which the outlet pressure and flow shall be selected according to the information of the manufacturer; where the information of the manufacturer is unavailable, its outlet pressure may be determined according to the shaft seal form of ash pump while its flow may be 1% ~ 3% of the sum of flow of ash pumps simultaneously in operation.

**4.6.10** Where ash pumps are in direct series connection, they shall meet the following requirements:

**1** The selection of pump flow and lift shall be determined according to the ash slurry amount and the total resistance of ash pump, and the flow of pumps at all levels shall be same.

**2** Pumps in series should be installed with speed regulating devices which should be installed on the last level pump.

**3** For pumps in series, the two adjacent ones shall be connected with a shortest pipe, on which suitable compensation measures shall be taken.

**4** Where the series level of pump exceeds 3, different seal water pump groups may be arranged according to the series level.

**4.6.11** For the form, basic parameters, technical requirements, test methods and inspection rules of the centrifugal ash slurry pump, the current professional standard "Centrifugal Slurry Pumps"(JB/T 8096) shall be referred to.

## **4.7 Plunger Ash Slurry Pump**

**4.7.1** The plunger ash slurry pump shall be selected according to the conveyed ash slurry amount and the resistance of ash slurry conveying pipeline; the pump flow should be 100% of the sum of ash slurry amount and flushing water amount, and the pressure should be 140% of the resistance of ash slurry conveying pipeline.

**4.7.2** In the same pump house, where the number of plunger ash slurry pump in operation is one, one set of standby pump shall be arranged, and if necessary, the pump foundation may be reserved additionally; where the number in operation is 2~3, 2 sets of standby pumps should be arranged.

**4.7.3** Where the capacity of plunger ash slurry pump fails to meet the conveying requirements, two sets of plunger ash slurry pumps may operate in parallel, and their models and parameters shall be the same.

**4.7.4** The plunger ash slurry pump shall be arranged with an air tank or other buffer facilities on its inlet and outlet pipelines; where the outlet buffer tanks are arranged in parts, they shall be arranged outdoor.

**4.7.5** In the plunger ash slurry pump house, clean and reliable water source for continuously washing and sealing plungers shall be available, and the water amount and water pressure shall be provided by the manufacturer.

**4.7.6** The inlet pressure of plunger ash slurry pump shall be provided by the manufacturer. Where the slurry feeding pump shall be installed for increasing the slurry feeding pressure, the slurry feeding pump shall be connected with the plunger ash slurry pump in the unit system; both the flow and outlet lift of slurry feeding pump shall meet the technical requirements of plunger ash slurry pump.

**4.7.7** Design of plunger ash slurry pump should meet the following requirements:

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