Part 3

ASH AND SLAG HANDLING

3.2. Ash and slag handling systems at TPPs

3.2.2. Ash removal

3.2.2.3. Some issues of optimizing the schemes of pneumatic ash removal systems of thermal power plants

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ABSTRACT

Schemes of pneumatic ash removal installations of some thermal power plants in Russia are presented. Estimation of influencing the schemes of pneumatic ash removal installations on integrated economic parameters of ash removal systems of thermal power plants as a whole is executed. Technical requirements for pneumatic ash removal schemes which should meet optimum pneumatic ash removal systems of thermal power plants are developed. Researches are carried out by employees of Informational and Analytical Center «Ecology of Power Engineering» and Boiler Plants and Ecology of Power Engineering Department of Moscow Power Engineering Institute (Technical University).

KEYWORDS

Thermal power plants, pneumotransport, ash and slag removal

1. SCHEMES OF PNEUMATIC ASH REMOVAL INSTALLATIONS OF SOME THERMAL POWER PLANTS IN RUSSIA

Nowadays about 15 % of ashes, produced at burning coals at the Russian Thermal Power Plants (TPPs) are transported by pneumatic ash removal (PAR) systems, in other cases hydraulic ash removal (HAR) systems are applied. In those systems ashes are transported in the form of a pulp of low concentration for their landfilling at the hydraulic ash disposals (HAD).

For successful solution of the problem on beneficial use of ashes and minimal ecological impact on environment at electric and thermal energy generation it's necessary to apply systems of collecting, transporting, discharge and disposal of ashes with no use of water as the carrying medium.

At TPPs of Russia for collecting, discharge and internal pneumatic transport of dry ash pressure, vacuum, vacuum-pressure and gravity installations and their combinations are applied. Maximum transporting length of pressure installations of internal pneumatic transport is less than 1000 m. Bottom ash/boiler slag at separate fly ash and bottom ash/ boiler slag removal is conveyed using bottom ash/boiler slag installations to the separate bottom ash/boiler slag maps, where it is dewatered and discharged to the consumer.

One of the main disadvantages of pneumatic ash removal system is the increased erosion wear of pipelines and equipment of pneumotransport installations.

A block diagram of the traditional ash removal system transporting fly ash and bottom ash/boiler slag ash pulp to the hydraulic ash disposal with no discharge of fly ash to the consumers is presented in fig. 1. Such systems have extremely unsatisfactory ecological indices. All the mass of fly ash and bottom ash/boiler slag is transported together and disposed in the form of low concentration pulp. Water to ash ratio on mass in the HAR systems is between 10:1 and 50:1.

A block diagram of the existing hydraulic ash removal system of Reftinskaya power plant is shown in fig. 2. This configuration provides discharge of dry ash part to the consumers. Such configurations are introduced at some power plants of Russia where the installations for dry ash discharge (IDAD) have been constructed. However, the main part of fly ash and bottom ash/boiler slag at these TPPs is landfilled at the ash and slag disposals in the form of low concentration pulp. Similar ash removal systems also have unsatisfactory ecological indices, but they are a little better, than those in the previous scheme. One of the disadvantages of such ash removal systems is that the installation for dry ash discharge and pneumatic ash pipelines (PAP) make a dead-end branch. It means that the IDAD is not a transit technological unit and additional operational personnel is needed.

At Reftinskaya power plant of the total capacity 3800 MW 4 power units of 500 MW and 6 units of 300 MW are installed. Ekibastuzskiy coal of the design ash content about 42 % is burned in the boilers. An existing capacity of hydraulic ash disposal provides the power plant operation till 2010. At the expected annual ash production in the amount of 5 million t. the aim of reconstructing the ash removal system of Reftinskaya power plant in accordance with requirements can be hardly satisfactory solved at preservation of the existing technology of transportation and storage of the main ash part in a form of ash pulp of low concentration.

There have been developed several scripts of ash removal organization. A preliminary ecological and economic estimation of two basic of them has been carried on: the existing hydraulic ash removal system is remained and expanded, and a system with dry removal and disposal of the unrequired by consumers ash part is created.

A block diagram of the perspective ash disposal system by the example of Reftinskaya power plant is presented in fig. 3.

This scheme is the most economically profitable as, firstly, fly and bottom ashes are removed separately, that results in no worsening of the consumer properties of ash, secondly, there is an opportunity of discharging dry ash and bottom ash to the consumers, thirdly, IDAD is a transit technological unit of the completed circuit and it doesn't require additional personnel. The main advantage of this configuration in comparison with the others is minimal impact of the ash removal system on environment.

In a basis of developing an alternative ash removal system the basic principle - application of the best available technologies for evacuation of bottom ash from boiler throats, transportation, discharge to users and disposing fly ash and bottom ash with no use of water as the carrying medium has been put.

Dry crushed bottom ash is discharged to the consumers and used as the drainage material at disposing the unrequired dry ash at the dry disposal.

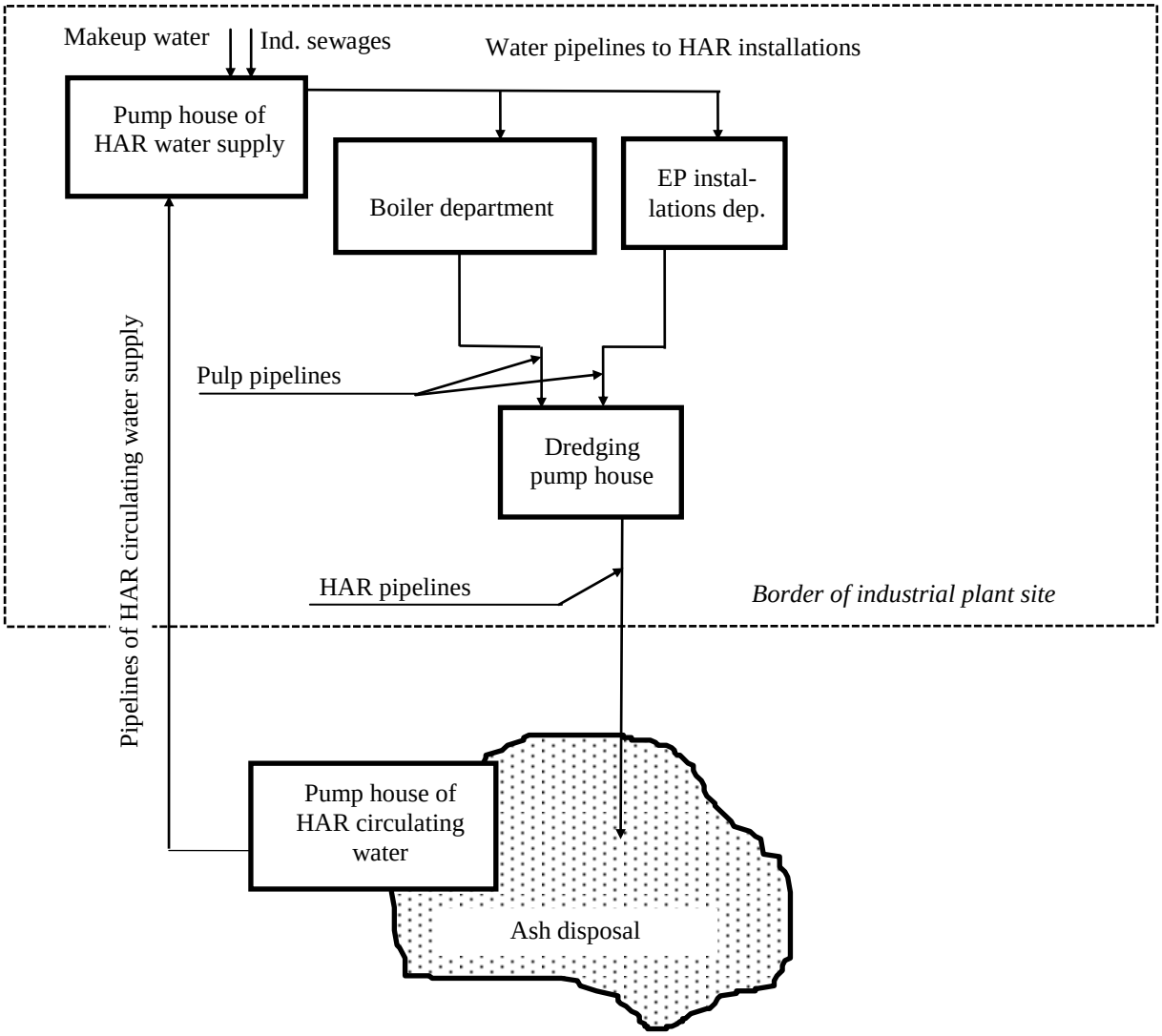

Fig.1. A block diagram of the traditional ash removal system transporting ash pulp to the hydraulic ash disposal with no discharge of fly ash to the consumers.

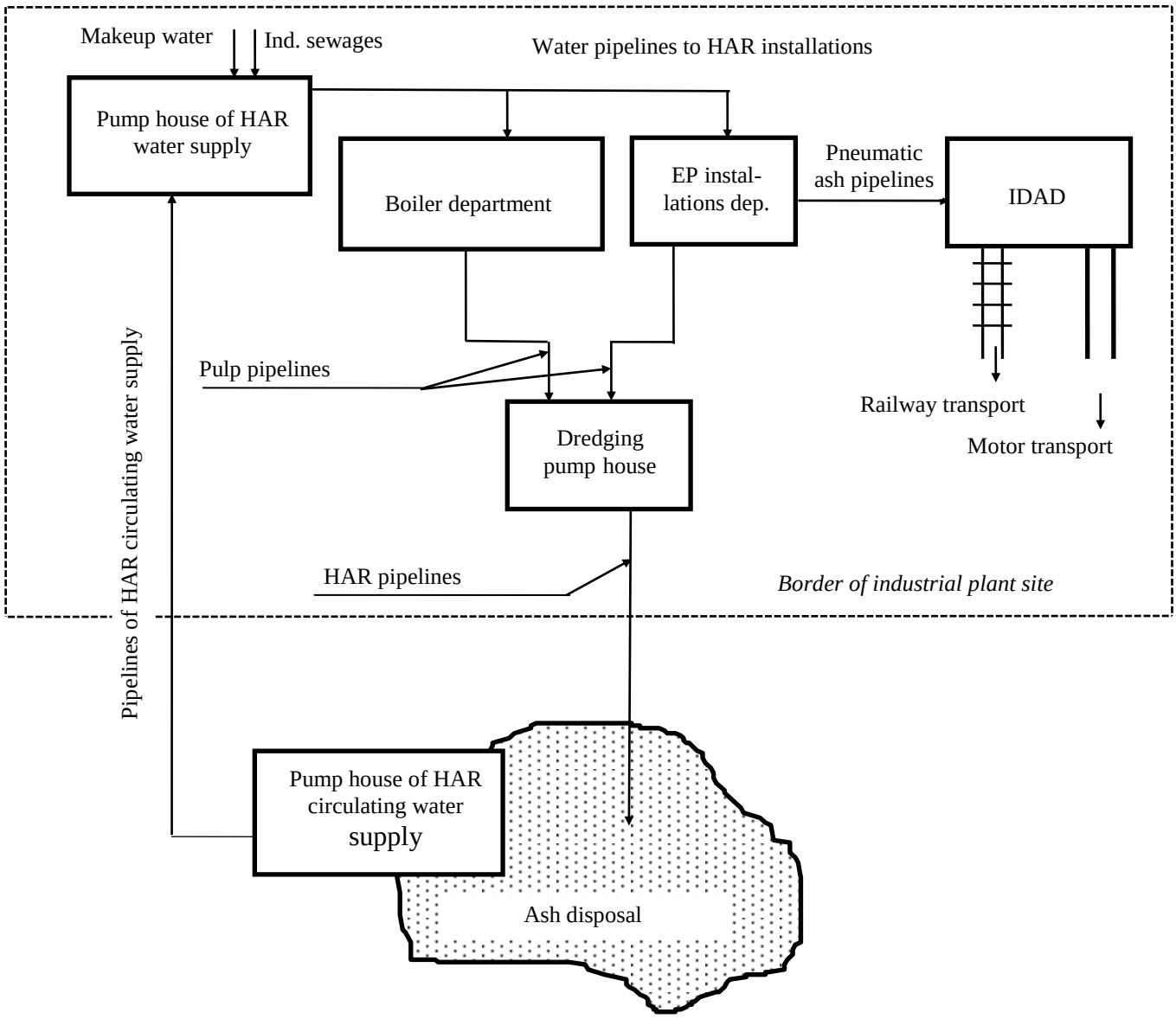

Fig. 2. A block diagram of the existing hydraulic ash removal system of Reftinskaya power plant with the discharge of dry ash part to the consumers.

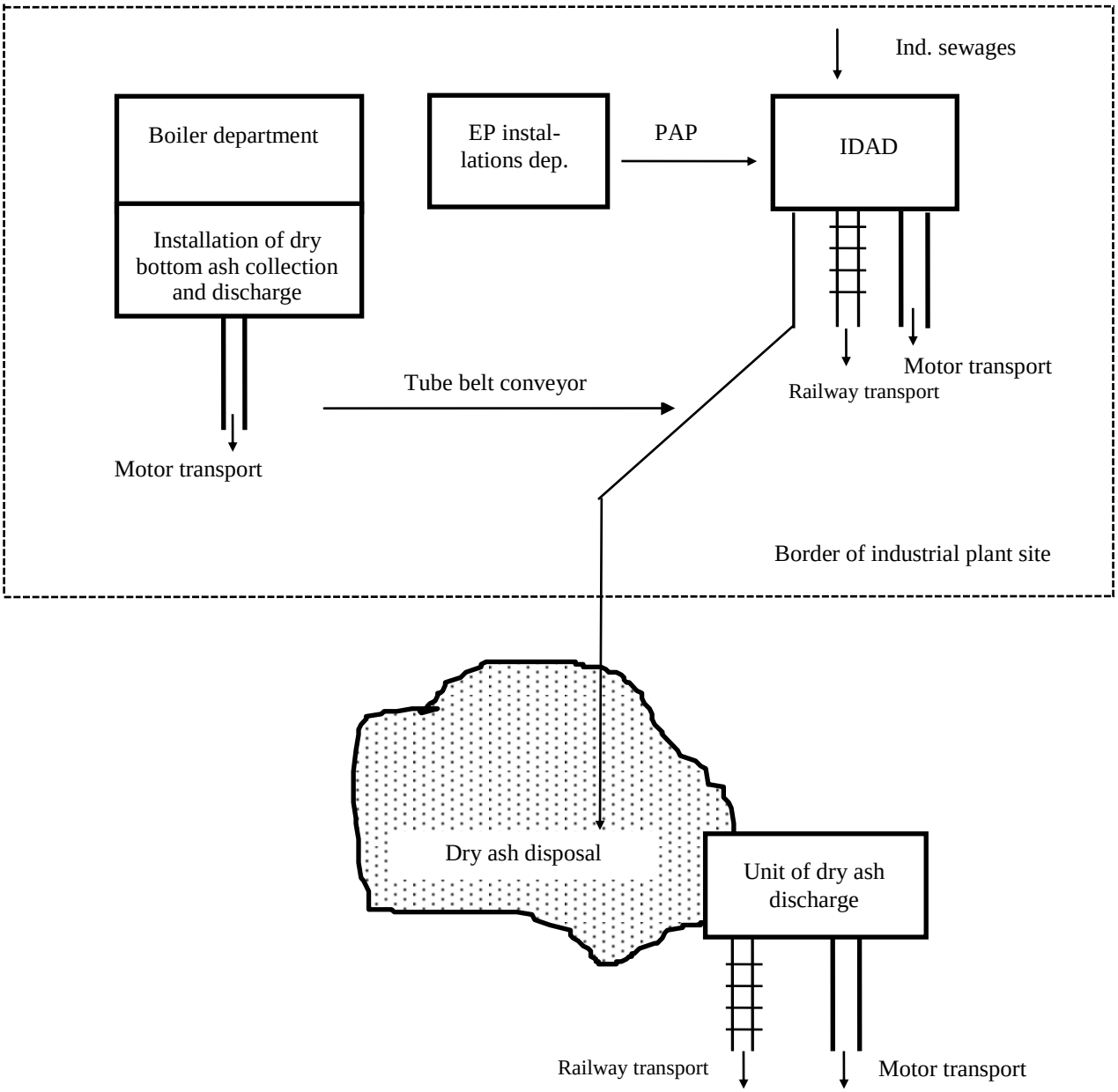

Fig. 3. A block diagram of the perspective ash removal system by the example of Reftinskaya power plant.

2. TECHNICAL REQUIREMENTS FOR PNEUMATIC REMOVAL SYSTEMS OF ASH FROM BOILERS OF TPPS

Technical requirements which should meet optimum pneumatic ash removal systems of thermal power plants are developed according to [1].

2.1. General provisions

A choice of schemes and equipment for pneumatic removal systems of ash should be made by results of the comparative analysis of technical, economic and ecological indices of the possible alternatives of facilities of internal and external ash removal systems in view of the following major factors:

- volumes of ash discharge to existing and potential consumers according to specifications on ash delivery;
- volumes and technology of landfilling the unrequired part of ash at the ash disposals;
- maximal hour and average annual production of ash from the ash collecting installations and their distribution on ash collector bunkers;
- chemical and mineralogical composition, radioactive, physical and mechanical properties of separate fractions and mixture of ash;
- quantities and layout of ash collector bunkers;
- distance and conditions of transportation.

It is necessary to make individual estimation of each installation for achievement of optimum work parameters of pneumotransport systems.

2.2. Operating conditions

2.2.1. Fly ash and bottom ash/boiler slag pneumatic removal systems.

The operation mode of equipment for evacuation of fly ash from bunkers of ash collectors is continuous, round-the-

clock during annual number of hours in operation of all the TPP boilers. Using ash collector bunkers for accumulation of the collected ash is forbidden. The temperature of ash evacuated from bunkers is 110-170^{o}C (it is specified according to the data of the TPP).

The operation mode of equipment for pneumotransport of fly ash and bottom ash/boiler slag from the intermediate bunkers to the ash silo (IDAD) is continuous, round-the-clock during annual number of hours in operation of all the TPP boilers.

Temperature of the transported fly ash is 80-140oC (it is specified by the heat calculation).

2.2.2. Properties of fly ash and bottom ash/boiler slag.

Physical, mechanical and radioactive properties, particle size distribution, chemical and mineralogical composition of bottom ash/boiler slag, mixture of the collected fly ash and its fractions, and also possible limitations on use of ashes and slags for manufacturing commodity output should be certain by the specialized organizations having corresponding licenses. Besides, the commodity market of fly and bottom ash (the mixture and on fractions) and boiler slag for definition of the expected volumes of their discharge with desirable consumer properties of ash and slag to consumers should be investigated. The results of researches specified above are an obligatory part of initial data on designing pneumatic removal systems, units and installations discharging dry fly ash and bottom ash/boiler slag to consumers and their discharge to the dry ash disposals. At designing the data on the mentioned above characteristics of ash and slag which are available at the TPP are considered.

2.3. Productivity requirements

Productivity of equipment for pneumatic removal installations of ash from the electrostatic precipitator bunkers or intermediate bunkers should be defined proceeding from the maximum hour exit of ash from the electrostatic precipitator bunkers in view of its irregularity delivery to the bunkers at the rated load work of the boiler combusting fuel of the worsened quality with the maximum ash content. A productivity reserve factor of installations of internal pneumatic fly ash removal is not less than 1,25.

Productivity of equipment for systems of pneumatic removal of bottom ash/boiler slag from coolers of FBC and CFBC boilers is accepted according to the maximum bottom ash/boiler slag output at the rated load work of the boiler combusting fuel of the worsened quality with the maximum ash content in view of emergency of the boiler furnace unload (on manufacturer data). A productivity reserve factor of installations of internal pneumatic bottom ash removal is not less than 1,25.

Productivity of reception equipment of the IDAD silo should not be less than productivity of installations of internal pneumatic transport of ash and slag.

Productivity of equipment of the unit for dry ash and bottom ash/boiler slag discharge to users is accepted according to the volumes of the maximum hour discharge of ash according to the consumer properties of the customers in view of a schedule on ash delivery agreed with the users and a forecast of ash discharge to the potential users, made on the basis of research of the possible commodity market. Amount of devices charging ash and slag in the automobile or railway transport of the users should not be less than amount of reception devices of the bunkers of this transport, and their productivity should provide transport loading in normative terms.

Productivity of units for preparation and discharge of the unrequired part of ash and slag to the dry ash disposal is accepted in accordance with the maximum-hour output of ash and slag at work of all the TPP boilers and no discharge of dry ash and slag to users. A productivity reserve factor of equipment is not less than 1,15.

Productivity of installations of external pipeline or conveyor transport of ash and slag to the dry ash disposals is accepted in accordance with the maximum-hour ash and slag output at work of all the TPP boilers and no discharge of dry ash and slag to users. A productivity reserve factor of equipment is not less than 1,15.

At dry fly ash (bottom ash/boiler slag) disposals dust exhausting plant should have productivity sufficient for clearing all the volume of pneumatic conveying air in view of switching-off a part of sections for conducting preventive or repair works.

Clearing of the return air from intermediate bunkers of ash and slag internal pneumatic removal systems should be carried out by special air-cleaning installations. An opportunity of dumping the return air in feeding gas ducts of ash collectors of boilers can be stipulated.

Operation of internal and external ash and slag pneumatic removal systems with completely disconnected the return air clearing systems is not allowed.

2.4. Requirements for reliability, durability and redundancy of equipment

The service life of the capital equipment (airslides, pumps, aspiration, charging equipment, mixers) is not less than 10 years. The service life of pneumatic pipelines is not less than 15 years.

The redundancy of internal pneumatic removal equipment by installing water wash devices directly under each bunker of ash collectors and under coolers of FBC and CFBC boilers, and also by installing the reserve pneumotransport equipment is not required.

The capacity of the intermediate bunkers of ash and slag pneumatic removal systems should be not less six-hour production of ash and slag from TPP boilers (at the maximum ash content of fuel and rated load of boilers).

The capacity of the dry fly ash (bottom ash/boiler slag) silo of IDAD without a reserve system of external hydraulic ash removal should not be less than three-day maximum volume of ash (slag) production.

The capacity of the dry fly ash (bottom ash/boiler slag) silo of IDAD with a reserve system of external hydraulic ash removal should not be less than two-day maximum volume of ash (slag) production from TPP boilers.

The pump equipment of the second stage of combined pneumatic removal systems (chamber and pneumatic screw pumps, vacuum pumps, high-pressure jet pumps), charging equipment of ash and slag silos, mixers of units of ash and slag preparation and discharge to the landfills should have 100 % redundancy. For the systems conveying high erosive ashes and slags (from ekibastuzskiy, azeyskiy, kuznetskiy lean, podmoskovnyj coals, anthracites, culm, enrichment middlings, etc.) it is necessary to have additional repair pumps at the stores (at absence of assurances of pump suppliers on term of their maintenance less than 5 years).

2.5. Maintainability requirements

Equipment disposing should provide an opportunity of the unobstructed maintenance service, operating repair and replacement of it as a whole or its separate units applying means of mechanization. The applied equipment of pneumatic removal systems should meet the requirement for recovery of its operational serviceability in time no more than 4 hours at accomplishment of operating repairs or replacement of worn-out parts and units.

2.6. Air supply system requirements

Characteristics of the compressed air used in systems of pressure pneumatic transport of ash and slag, should match to the ratings of the applied equipment and design parameters of pneumatic removal systems. The content of the condensed moisture and oil in the compressed air before pneumotransport systems is categorically forbidden.

The operating mode of air supply compressor plants of ash and slag pneumatic removal systems should match to an operating mode of pneumatic removal systems.

2.7. Requirements for equipping with devices of technological processes control, means of autoregulation, protection, interlocks, signalling systems and distance control

Systems of pneumatic removal, installation of delivery of dry ash to users and its discharge at dry ash disposals should be equipped with devices of technological processes control, means of autoregulation, protection, interlocks, signalling systems and distance control in sufficient volume for reception by the operational personnel of continuous and trustworthy information about work of equipment and technological processes, exclusion of an opportunity of emergencies and maintenance of reliable and economic work of systems evacuating, discharging and storing the ash and slag produced at TPP work.

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