Research on the technical requirements standards of high efficiency precipitator in power industries for assessment

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Abstract. Facing the increasingly severe situation of air pollution, China are now positively promoting the evaluation of high efficiency air pollution control equipments and the research of the relative national standards. This paper showed the significance and the effect of formulating the technical requirements of high efficiency precipitator equipments for assessment national standards in power industries as well as the research thoughts and principle of these standards. It introduce the qualitative and quantitative evaluation requirements of high efficiency precipitators using in power industries and the core technical content such as testing, calculating, evaluation methods and so on. The implementation of a series of national standards is in order to lead and promote the production and application of high efficiency precipitator equipments in the field of the prevention of air pollution in national power industries.

1. Significance and purpose for the preparation of the technical requirements for the evaluation of high-efficiency precipitators

1.1. Supporting the implementation of Chinese government's energy conservation and environmental protection policies

During the Twelfth Five-Year Plan, China's environmental protection technologies, equipment, engineering and standards to control air pollutants have enjoyed vigorous development. Within the period from 2013 to 2015, China has introduced a series of environmental protection policies, including the Opinions on Accelerating the Development of Energy Conservation and Environmental Protection Industry, the Action Plan of Energy Conservation, Emission Reduction and Low-Carbon Development 2014-2015, the Action Plan of Water Pollution Prevention and Control, and other important documents to pose a higher requirement for the standardization of energy conservation and emission reduction and to indicate the development direction of China's energy conservation and environmental protection during the Thirteenth Five-Year Plan[1]. To earnestly carry out the essence of these official documents, National Development and Reform Commission issued the Implementation Plan of Energy Efficiency "Pacesetter" System on January 18, 2015 to develop the long-effect mechanism capable of boosting a constant increase in the energy efficiency level of terminal energy-consuming products, high energy-consuming industries and public organizations through model setting, policy incentives and standard improvement, and to promote energy conservation and emission reduction. The Ministry of Finance, together with other ministries and

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commissions of China concerned, issued the Implementation Plan of Environmental Protection "Pacesetter" System on June 25, 2015 in an effort to facilitate the transformation of environmental management model from "minimum requirement" to the balance between "minimum requirement" and "exemplary role", boost the market players' intrinsic motivation of energy conservation and emission reduction, propel the continuous improvement in environmental performance, advocate green production and consumption and speed up the construction of eco-civilization system. According to the Implementation Plan of Energy Efficiency "Pacesetter" System, the terminal energy-consuming products shall include not merely household electric products, but gradually office equipment, commercial equipment, lighting products, industrial equipment and means of transportation. According to the Implementation Plan of Environmental Protection "Pacesetter" System, the atmosphere, water, solid wastes and noise pollution sources are treated as the leading "reduction" fields, and the system is applied to those environment-friendly products which involve considerable consumption, substantial potentials of emission reduction, relevant well-established product and environment standards, and mature alternative technologies. Therefore, the air pollutant control equipment, as the auxiliary equipment designed to treat environmental pollutants in the production and operation process of industrial equipment, the necessity of increasing its energy efficiency and environmental performance has also been put on agenda.

1.2. Achieving the joint development of energy conservation and environmental protection

As China's industrialization and urbanization process moves further ahead now, the consumption of energy resources has been increasing constantly and the air pollution is confronted by a harsher situation. As a result, there's a more outstanding problem of regional atmospheric environment with such typical pollutants as inhalable particles (PM10) and fine particles. China will focus its efforts on thermal power, iron and steel, cement, petroleum and chemical industry to manage air pollution. As far as power industry is concerned, China will double its efforts to promote the construction of desulfurization, denitrification, dust separation and transformation projects and to upgrade and transform the existing dust separation facilities on a full scale.

As the important equipment for preventing and controlling air pollution, precipitator has been widely used in the smoke purification in power, iron and steel, building materials, metallurgy and chemical industry. According to the standard HJ/T11-1996 Classification and Nomenclature of Environmental Protection Equipment, dust collects can be divided into gravity and inertia dust-separation equipment, whirlwind dust-separation equipment, wet dust-separation equipment, filer-layer precipitator, bag-type precipitator, electrostatic dust-separation equipment and combined-type precipitator[2]. Specifically, the electrostatic precipitator and bag-type precipitator are two traditional devices in the treatment of industrial dusts. The former has such advantages as high smoke-handling capacity and low resistance to operation, but the dust-separation efficiency tends to be affected by the properties of smoke and dust. The latter enjoys low outlet concentration and remains immune to the property of dust, but has considerable system resistance and high energy consumption. In recent years, the combined-type precipitators have achieved the organic combination of electrostatic precipitator and bag-type precipitator. It's a major breakthrough in the dust-separation technology. The dust pre-charger is used to collect most dusts for one thing, and to change the dust filtering characteristics for another to achieve the steady and low-concentration emission. As the precipitators are put into the large-scale utilization, the precipitator market is troubled by such problems as uneven quality, difficult identification of strong and weak points, disorderly competition and separate monopoly, so the industry has suffered huge losses and potential risks. It's true that the national or industry standards on the related products impose some restrictions on their production, but the uniform criteria are unavailable for the comprehensive evaluation of precipitators' quality, safety, environmental protection and energy conservation. Energy conservation and environmental protection are two inseparable factors of equal importance. Only those energy-saving environmental protection devices can play a leading role in the environmental protection. Precipitators can have some environment protection functions as the emission reduction of smoke and dust, PM2.5, demercuration and dioxins,

but as the big energy consumers, they consume more and more energies during their production, operation and maintenance. In this sense, the evaluation of their energy efficiency shall never be neglected. The development and implementation of the technical requirement series for evaluating the high-efficiency precipitators in power industry can scientifically define the evaluation value of energy conservation of precipitators, select and evaluate the high-efficiency precipitators capable of energy conservation and environmental protection, guide and encourage the production and consumption of China's advanced equipment (products) that can effectively control air pollutants, standardize market access threshold, significantly increase the market share of those high-quality, energy-saving, safe and efficient environmental protection equipment, products and services, promote more rapid and efficient industrial development, and finally encourage the use of advanced equipment and eliminate the backward equipment.

2. General considerations for the preparation of national standard series of technical requirements for the evaluation of high-efficiency precipitators

For the environmental protection equipment to control air pollutants, China has develop a well-established standard system which mainly include basic standards, test method standards, product standards and management evaluation standards. The technical standard for the evaluation of high-efficiency environmental protection equipment for control of air pollution falls into the category of management standards, and involves the efficient evaluation of those important independent environmental protection equipment designed for dust separation, desulfurization, denitrification, decarbonization, defogging, deodorization and VOC control. According to the top-down design of this sub-system standard during the early phase of the Twelfth Five-Year Plan, the first step is to design the national standard for the technical requirements of evaluation of high-efficiency precipitators. Thus, the Standardization Committee of the People's Republic of China has approved four standards including the Guideline for the Preparation of the Technical Requirements of the Evaluation of High-efficiency Equipment for Air Pollutant Control, the Technical Requirements of the Evaluation of High-efficiency Environmental Protection Equipment --- Combined Precipitators, the Technical Requirements of the Evaluation of High-efficiency Environmental Protection Equipment --- Electrostatic Precipitators, and the Technical Requirements of the Evaluation of High-efficiency Environmental Protection Equipment --- Bag-type Precipitators, and organized the related enterprises, scientific research institutions, colleges and universities, industry associations and institution to develop the new standards.

2.1. Principle for preparation of standard

When the high-efficiency precipitators are evaluated, it is necessary to consider the properties of equipment and the management work of equipment manufacturers. Towards this end, the following standards are developed and determined.

When the technical requirements and index systems for the evaluation of different types of high-efficiency precipitators are prepared, the characteristics of different precipitators shall be taken into account to guarantee scientific, rational and operable results.

When the index systems for the evaluation of different types of high-efficiency precipitators are created and applied, it is imperative to regulate the production of precipitators and guide the use of high-efficiency precipitators.

When the technical requirements for the evaluation of different types of high-efficiency precipitators are prepared, the index systems concerned shall include technical performance, energy conservation, environmental protection, safety and reliability. In the selection of relevant indices, it proves important to consider comprehensiveness and conciseness, stress major concerns, complete the process from simplicity to complexity, and highlight strong operability and ready access to index data.

The qualitative indices and quantitative indices shall be balanced and combined. Specifically, the former shall give much importance to the accessibility to verification, but the latter shall be

measurable. With the scientific and technological progress and the industrial development, the quantitative and qualitative evaluation indices will experience a constant increase.

For the evaluation indices, the testing methods and principles and the data collection and calculation shall be specified accordingly.

2.2. Considerations for the preparation of standard

General Principle for the Preparation of the Technical Requirements of the Evaluation of High-efficiency Air Pollutant Control Equipment, as a general standard, can be used as a guideline for the standard series of the technical requirements for the evaluation of high-efficiency precipitators. Based on the framework and content requirements as specified by this standard, the technical requirements for the evaluation of high-efficiency equipment can be prepared for different types of precipitators respectively. Meanwhile, the consistency among all the standards must be taken into consideration.

When the standard series of technical requirements for the evaluation of high-efficiency precipitators are prepared, it is essential to consider the national environmental protection laws, other related laws and regulation as well as standards within a given period, including the policies concerning the environmental protection industry, the exploitation, utilization and conservation of resources and energy resources, the ecological construction and air pollutant prevention and control, and the demonstration, promotion, restriction and elimination of those technologies and equipment designed to control air pollutants.

3. Evaluation index requirements of high-efficiency precipitators

3.1. Key terms and definitions

The “high-efficiency precipitators” refer to “the precipitators with advanced technical performance, safe and reliable operation, outstanding environmental protection and leading energy efficiency within the comparable scope when the requirements for environmental protection and emission are satisfied.” When the energy consumption of dust collects are evaluated, the national standard proposes the concept of “specific power consumption” for the first time. This new concept means “the power consumption involved in the treatment of dust contents in flue (working condition) by precipitators.”

3.2. Basic requirements for qualitative evaluation

For the national standard series of technical requirements for the evaluation of high-efficiency precipitators, the basic requirements for qualitative evaluation shall involve the management work, law and regulation compliance, clean production and comprehensive utilization of energy resources of precipitator manufacturers. The related requirements are specified as follows:

--The manufacturers of different precipitators shall develop, implement, maintain and ensure continuous improvement of their quality, environment, occupational health and safety as well as energy management systems, and shall comply with the related requirements from the laws, regulations and standards concerning energy conservation and environmental protection.

--The design, manufacturing, installation, operation, maintenance and examination of different precipitators shall comply with the related national, industrial and corporate standards and engineering design regulations.

--The high-efficiency combined precipitators and electrostatic precipitators shall use the high-voltage power supply with high efficiency and power factor, and the energy-saving and optimized control system of electrostatic precipitators.

--All the precipitators shall use non-toxic and hazard-free materials in the design process.

--All the precipitators shall have the operation noise of no more than 85dB(A) 1.5 m outside the cover of precipitator (including vibrator, motor and transformer of combined precipitator and electrostatic precipitator, pulsed valve, cylinder, valve and motor of bag-type precipitator).

--The manufacturers of different precipitators shall use the clean production technique, equipment and manufacturing technology capable of low resources consumption and small emission. Some

measures of comprehensive utilization shall be taken to maximize the use of wastes and by-products as a result of the corporate operation, minimize the consumption of resources and energy resources, and make the utilization of resources and energy resources more efficient.

3.3. Requirements for quantitative evaluation of key evaluation indices

For the national standard series of technical requirements for the evaluation of high-efficiency precipitators, the quantitative indices shall include those key evaluation indices that have important effects on the quality assurance, reliable operation, energy conservation and environmental protection of high-efficiency precipitators when different types of precipitators are considered. These key evaluation indices can composed of Class-1 indices and Class-2 indices. Specifically, the former includes technical performance index, energy consumption index, environmental protection index, and safety and reliability index. Each indicator can be subdivided into several secondary indicators. Since precipitators involve different types and scopes of application, the selection and adjustment may be made accordingly. It's necessary to set the secondary requirements for those secondary indices of electrostatic precipitators, bag-type precipitators and combined precipitators according to the overall level of current precipitators. As indicated in Table 1, all the secondary indices must have the evaluation value that stays at the advanced level of domestic precipitators of the same type.

Table 1. Requirements for the quantitative evaluation of key evaluation indices of high-efficiency precipitators

Primary indices	Secondary indices	Evaluation requirements for electrostatic precipitators	Evaluation requirements for bag-type precipitators	Evaluation requirements for combined precipitators
Environmental protection index	Dust concentration of outlet flue C-outlet（mg/m^3）	≤20 mg/m^3	C-outlet≤15（standard state, dry basis and benchmark oxygen contents: 6%）	≤15mg/m^3（standard state and dry basis）
Technical performance index	Pressure drop（Pa）	≤200Pa	0.9m/min ≤v<1.0m/min，ΔP≤900 1.0m/min ≤v<1.1m/min，ΔP≤1000 1.1m/min ≤v1.2m/min，ΔP≤1100	When filtration velocity is 1.1 m/min ~1.25 m/min, the combined precipitators have an average pressure drop of no more than 700pa within the service life of filter bag.
	Leakage rate（%）	Supported by generator set of 300MW and above, ≤1.5%; Supported by generator set of 300MW and less, ≤2.0%。	≤1.5	≤1.5%
Safety and relian-ce index	Service life of anode plate	≥10 years	No	≥10 years
	Service life of filter bag	No	When the designed operation condition is satisifed, the	The combined precipitators have an annual damage rate of no more than 0.5% with

						bag-type precipitators have an annual damage rate of no more than 1% with their filter bags, and a life service of no less than five years.		their filter bags, and a life service of no less than five years.。	
		Grade of generator set	≥300MW	≥600MW	≥1000MW	10mg/m^3＜C-outlet ≤20 mg/m^3	C-outlet ≤10 mg/m^3	10 mg/m^3< C-outlet ≤15 mg/m^3	C-outlet≤10 mg/m^3
						When Pm≤300, C ≤0.32.	When Pm≤300 MW, C ≤0.35.	When C-inlet≤300 MW, C≤0.29.	When C-inlet≤300 MW, C≤0.32.
		Easy	0.31	0.29	0.28	When 300 MW ＜ Pm≤600 MW, C ≤0.31.	When 300 MW ＜ Pm≤600 MW, C ≤0.34.	When 300 MW <C 入 ≤600 MW, C≤0.30.	When 300MW <C 入 ≤600 MW, C≤0.33.
power cons-umpti-on index	specific power consumption	Ordinary	0.34	0.32	0.31			When C-inlet ＞ 600MW, C≤0.31.	When C-inlet ＞600 MW, C≤0.34.
		Hard	0.37	0.35	0.34				
		Notes: C is the specific power consumption of electrostatic precipitator.				Notes: V is the filtration velocity of bag-type precipitators; Pm is the power scope of main engine; when the power of main engine is expanded, the specific power consumption is assessed according to the former power of		Notes: C-inlet is the dust concentration of outlet flue of combined precipitators, with the unit of g/m^3; C-outlet is the dust concentration of inlet flue of combined precipitators, with the unit of mg/m3 (standard state and dry basis); C is the specific power consumption of	

	main engine. For instance, when the power of main engine is increased to 350MW, the specific power consumption is assessed in accordance with the requirements of Pm≤300 MW as indicated in the table. C is the specific power consumption of bag-type precipitators.	combined precipitators.

4. Testing, calculation and evaluation methods

4.1. Testing methods of main performance indices

The electrostatic precipitators, bag-type precipitators and combined precipitators shall not be tested within three months following the steady and continuous operation of all the equipment at the rated power for 168 hours and when the designed operation conditions are addressed and the load of main engine is more than 90% of rated load. The service life of filtration bags and anode plates shall be included in the annual statistics following their operation for one year.

The noise of electrostatic precipitators shall be tested according the methods as defined in JB/T11267 [3]; the noise of bag-type precipitators shall be tested according to A-frequency weight of sound level meter at the location with horizontal distance of 1.5 m from precipitators and vertical height of 1.2m. The testing process involves three tests with a duration of 10s for each test. The arithmetic average of three tests is used as the operation noise of precipitators. The combined precipitators shall be tested according to the method specified in JB/T 11829[4].

The dust concentration, pressure drop and leakage rate in the outlet flue of electrostatic precipitators shall be tested according to the measures specified in GB/T 13931[5]. For bag-type precipitators, the dust concentration, pressure drop and leakage rate in the outlet flue shall be tested according to the measures specified in HJ/T 397[6], and the equipment resistance, leakage rate and filtration bag performance shall be tested according to the measures specified in GB/T 6719[7]. For the combined precipitators, the dust concentration of outlet flue, pressure drop, and leakage rate shall be tested according to the Testing Measures for the Performance of Combined Precipitators.

4.2 Calculation and evaluation method

The national standard series of technical requirements for the evaluation of high-efficiency precipitators detailed the calculation methods for four evaluation indicators including pressure drop, leakage rate, specific power consumption and annual damage rate of filtration bags. No more descriptions will be given here. For the specific power consumption of energy consumption indicator, the electrostatic precipitators mainly include such power consuming devices as air induction machines, high-voltage power supply units, low-voltage power consuming units (including vibrating motor, furnace hopper heater and dust hopper heater). The power consumption that affects the bag-type precipitators mainly include the power consumption from equipment resistance and dust removal. The main power consumption in the energy-efficiency evaluation of combined precipitators mainly include the power consumption from equipment resistance, air compressors, high-voltage power supply units

and dust hopper heaters. For the related precipitators, the national standards for energy-efficiency threshold and energy-conservation value are being developed. Finally, according to national standard series of technical requirements for the evaluation of high-efficiency precipitators, the high-efficiency precipitators refer to the precipitators that meet the basic requirements of all the qualitative evaluations and the quantitative evaluation requirements of key evaluation indices.

5. Conclusion

(1) Precipitators are the important supportive devices in air pollutant prevention and control process in the production and operation of industrial equipment. As the high energy-consuming equipment, their energy efficiency shall be improved in response to the increasing environmental protection performance. The preparation and implementation of national standard series of technical requirements for the evaluation of high-efficiency precipitators in key sectors can support the comprehensive evaluation work of high-efficiency precipitators in key sectors, offer the standardized technical support for the implementation of "environmental protection pacesetter" system, and guide and encourage the production and consumption of advanced, efficient, high-quality, safe, energy-saving and environment-friendly precipitators.

(2) The "high-efficiency precipitators" refer to "the precipitators with advanced technical performance, safe and reliable operation, outstanding environmental protection and leading energy efficiency within the comparable scope when the requirements for environmental protection and emission are satisfied." In national standard series of technical requirements for the evaluation of high-efficiency precipitators, the evaluation index system considers the basic requirements of qualitative evaluations and the quantitative evaluation requirements of key evaluation indices. With the scientific and technological progress and the industrial development, the evaluation indices will experience a constant increase.

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