Chapter 8
Standardization

8.1 History Review and Status Analysis

The metallurgical industry has always been at the forefront of industrial standardization. In the period from 1950s to 1970s, the standard system was initially established by referring to or adopting the standards of the former Soviet Union. In the period from 1980s to 1990s, the Japanese and American standards were adopted, and the products were based on Japanese standards and the methods were based on American standards. In the period from the 1990s to the beginning of the twenty-first century, the strategy of adopting "International Standards and Foreign Advanced Standards" was implemented, encouraging active adoption of international standards and European standards. Since 2000, new standards have been added and existing standards have been revised with focus on technological innovation, products upgrading, and customers' satisfaction. At present, the iron and steel industry involves a variety of standards. In materials sector of the industry, it includes standards for irons and steels, refractory materials, metallic ores, non-metallic minerals, cokes, carbons, pig irons, ferroalloys, metallurgical electromechanical equipment, and other products. It also includes standards for energy conservation and comprehensive utilization (metallurgical solid wastes, metallurgical energy conservation, metallurgical water saving, and clean production), safety production, and standard samples.

With the development of standardization, the current standard system and management measures cannot fully meet the actual needs. First, the scope of the standard system is too narrow, mainly limited to industrial products, engineering construction, and environmental protection requirements; second, the mandatory standard formulators are multiple, leading to authority overlapping; third, the government plays a dominant role in standards formulation, while the main market player, such as associations and enterprises, has less share in independently formulating standards that quickly reflect the market demand, resulting in insufficient standard supply; fourth, supervision measures for standard formulation, implementation, evaluation, standardization, etc., are insufficient and this is not conducive to strengthening in-process and post-event supervision.

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At present, the *Standardization Law* is under revision. The General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, and the Standardization Administration jointly issued the *Guiding Opinions on Cultivating and Developing Non-Governmental Organization's Standards* and *Non-Governmental Organization Standardization Part I: Good Practices* (GB/T 20004/1-2016). The document pointed out that the unified management of compulsory standards shall be strengthened, and the mandatory national standards shall be subject to unified administration of the standardization administrative departments of the State Council, which will be responsible for project approval, numbering, publication, and external notification; non-governmental organization's standards shall be introduced and it stipulates that social organizations established according to the law can formulate non-governmental standards for voluntary adoption; the relevant provisions on corporate standards are improved, requiring the establishment of an open system for self-declaration of enterprise products or service standards and replacing the filing mechanism of enterprise product standards.

8.1.1 National Standards

1. Standards for Raw Materials and Fuels

   (1) Development Status. At present, there are 102 national standards related to iron ores, and most of the standards are the ones for iron ore elemental analysis and measurement except two, which are the *Iron Ore Grade Division* (GB/T 32545-2016) and *Terminology of Iron Ores and Direct Reduced Irons* (GB/T 20565-2006).

   (2) Main Existing Problems. The existing iron ore standards are currently focused on analytical testing, and the standards of iron ore quality, especially the mandatory standards for harmful impurities such as S and P in iron ores, are yet to develop. As a result, the quality of imported iron ores in China in the past decade has been varying and there were even shoddy iron ores in disguise of good ones.

2. Technological Equipment Standards

   (1) Development Status. At present, the national standards for technological equipment in the iron and steel industry mainly include *Design Standard for Sintering Plants* (GB 50408-2015), *Code for Design of Iron Ore Pelletizing Works* (GB 50491-2009), *Design Code for Blast Furnace Ironmaking Works* (GB 50427-2015), *Design Code for Steelmaking Works* (GB 50439-2015), *Design Code for Section Steel Rolling Works* (GB 50410-2014), *Design Code for Sheet and Plate Rolling Process* (GB 50629-2010), *Design Code for Wire Rod Rolling Process* (GB 50436-2007), *Design Code for Cold Rolled Strip Lines* (GB 50930-2013), *Design Code for Cold Rolled Electrical Steel* (GB 50997-2014), etc. The standards are mainly

published by the Ministry of Housing and Urban-Rural Development of the People's Republic of China and the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China. The drafting enterprises are metallurgical design providers such as Capital Engineering & Research Incorporation Ltd. (CERI), CISDI Group Co., Ltd. (CISDI), WISDRI Engineering & Research Incorporation Limited (WISDRI), BERIS Engineering and Research Corporation (BERIS), Zhongye Changtian International Engineering Co., Ltd. (CIE), and Northern Engineering & Technology Corporation (NETIC).

(2) Main Existing Problems. The main problem existing in the standardization of technological equipment is the lack of talents involved in the formulation of the standards. In the process of standard implementation, an effective problem feedback mechanism has not been established, which is not conducive to further updating and perfecting the standards. In addition, the supervision of the implementation of technological equipment standards is yet to be improved.

3. Product Standards

(1) Development Status. After the adoption of the standards of the former Soviet Union from 1950s to 1970s and the international standards and advanced foreign standards from 1980s to 1990s, the formulation and revision of product-related standards of China's iron and steel industry mainly centered on technological innovation, product upgrades, and satisfaction of customers' needs since 2000. The product standardization has transformed from production orientation to trade orientation and has played a supporting role in the transformation of the iron and steel industry to the market economy. Since the 11th Five-Year Plan, the standardization level of steel products has been continuously improved, the applicability of standards has been continuously enhanced, and the standard age has been gradually shortened. At the same time, China has developed a number of new product standards that are urgently needed in the market, filling in gaps in domestic-related product standards. In recent years, the national relevant metallurgical product standards have not only played a role in eliminating backward products, but also promoted the structural adjustment and upgrading of the iron and steel industry by actively promoting the standardization of high-end metal structural materials and special metal functional materials.

(2) Main Existing Problems. The national standard formulation and revision process for metallurgical products is still carried out according to the traditional model for many years. The formulation and revision of the relevant standards are mainly planned and approved by government departments, and there are restrictions on standardized management systems and mechanisms, resulting in a series of problems such as slow response of product standards to the market, delayed formulation and revision of standards in connection with emerging fields, and the difficulty of cooperating with the steel-consuming industries.

4. Energy Standards

   (1) Development Status. The energy conservation standard is the basis of the national energy conservation system. Since the 12th Five-Year Plan, the National Standards Committee and the National Development and Reform Commission have approved a total of 206 basic national standards for energy efficiency, energy consumption limits, and energy conservation. Up to now, China has issued 73 mandatory energy efficiency standards, 104 mandatory energy consumption limitation standards, and more than 150 recommended national energy conservation standards, which have played an important role in cutting overcapacity, optimizing industrial structure and achieving energy conservation goals. The energy conservation-related standards committee includes the National Primary Energy Management Technical Standards Committee (TC20) and the National Energy System Technical Standards Committee (TC459), and the committee secretariat is set up at the China National Institute of Standardization. The Metallurgical Industry Planning and Research Institute undertook the routine work of the secretariat of the TC20/Metallurgical Energy Foundation and Management Standardization Working Committee.

   (2) Existing Problems. Compared with the current urgent need to cut overcapacity, promote industrial structure adjustment and optimization, and carry forward the ecological civilization construction, the energy conservation standard system is still not complete, the basis for implementation is still weak, the management mechanism is still not perfect, and some important energy conservation standards are missing, and some of the standards are technically backward and not timely updated. This is particularly true for the standards of energy efficiency of energy-using products, the energy consumption limit of energy-intensive industries, and the energy efficiency of buildings, which are in urgent need of updating.

5. Environmental Protection Standards

   (1) Development Status. On October 1, 2012, the new environmental protection standards for the iron and steel industry were officially implemented, covering eight emission standards such as "*Pollutant Discharge Standards for Iron Ore Mining and Beneficiation*" and "*Air Pollutant Emission Standards for Sintering and Pelletizing Industry*", which were significantly tighter than the old standards. See Fig. 8.1 for more. Through the installation of online monitoring facilities in the key waste generation and discharge processes, the enterprise emission data is connected to the system of the environmental protection departments on real-time basis for strict control on illegal emission. At present, the improvement of environmental protection standards promotes the industrial application of a number of innovative governance technologies.

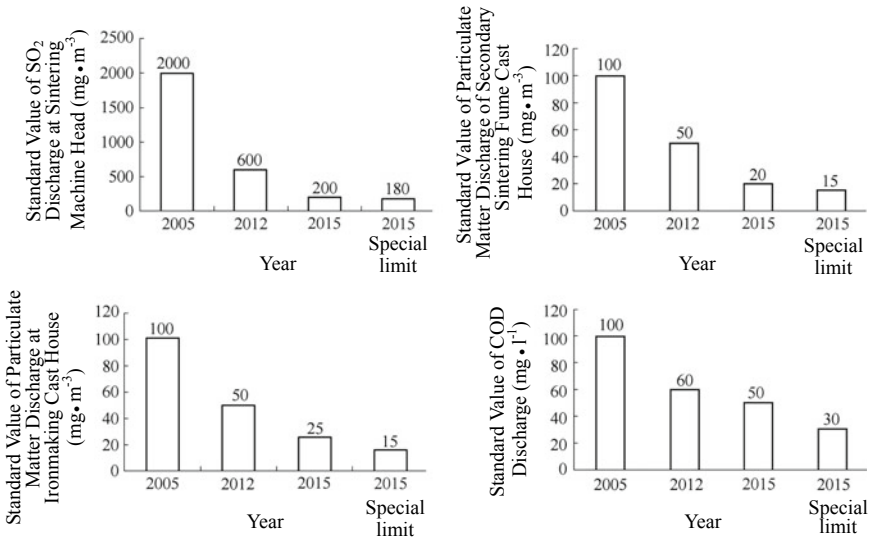

Fig. 8.1 Comparison of new and old environmental protection standards in iron and steel industry

(2) Main Existing Problems. The emission standards of gas pollutants in the sintering process of the iron and steel industry will be upgraded with the successful commissioning of the integrated elimination technology for the pollutants from sintering process, especially for the emission concentration of NO*x* and dioxins. Formulation of the standards shall fully solicit advice from environmental experts in the iron and steel industry. At the supervisory level, it is urgent to promote the dioxin online monitoring system in the iron and steel industry through technological innovation, and to monitor the emission concentration in real time to ensure that the supervision work of the environmental protection department is well grounded.

6. Water Standards

(1) Development Status. The State Council's *Opinion on the Implementation of the Most Stringent Water Resources Management System* ([2012] No. 3 of the State Council) proposes the formulation of mandatory water-saving standards and accelerates the formulation of national standards for water consumption limit in high-water consumption industries and service industries. The government attaches great importance to industrial water-saving standardization work, and the standardization work of high-water consumption industries is entering a stage of rapid standard development and extensive publications. In recent years, in order to meet the demand for industrial water and adapt to the new water-saving situation, the government has accelerated the pace of water-saving standard system establishment. At present, a series of standards have been formulated and issued, including

water-consuming and water-saving basic standards, water-consuming and water-saving assessment standards, water quality standards, water-saving facilities and product standards, water treatment chemicals and materials standards, water-saving design specifications, etc.

Since *General Rules for the Preparation of Water Intake Norm of Industrial Enterprises* was issued, a scientific and reasonable standard system for water intake quotas of industrial enterprises was established. The terms, definitions, and calculation methods for water consumption per unit of product were established. According to the General Rules, the national standards for water intake quotas for high-water consumption industries such as thermal power generation, iron and steel, petroleum refining, cotton printing and dyeing, paper making, beer brewing, alcohol making, monosodium glutamates making, synthetic ammonia making, medicines, electrolytic aluminums, aluminum oxides, and coal beneficiation. have been published. In order to further promote the establishment of water-saving enterprises in the industrial sector, the government has successively formulated the following standards: *Water-saving Enterprise—Thermal Power Generation Industry, Water-saving Enterprise—Iron and Steel Industry, Water-saving Enterprise—Textile Dyeing and Finishing Industry* and *Water-saving Enterprise—Paper Making Industry* and *Water-saving Enterprise—Petroleum Refining Industry*. Among them, *Water Consumption Quota Part II: Steel Complex* (GB/T 18916.2) was released in 2002 and revised in 2012, which has contributed to the reduction of the water consumption per ton of steel in China's iron and steel industry from 40 to 3.5 m^3.

(2) Main Existing Problems. China's water-saving effort is still in a relatively extensive management mode. One of the important reasons is that the water-saving standard system is not complete. At present, there are too many blank areas of water-saving standards, which is difficult to adapt to the needs of the rapid socio-economic development of new technologies in the new phase of the new era. The severe backwardness of water-saving standardization restricts the orderly development of water-saving work and the effective improvement of water-saving precision management.

The publicity and training on water-saving standards are not in place, leading to the inability to accurately understand the scope and statement of the standards in the water-saving management level, causing various disputes in water-saving management, and even slacking the implementation requirements for water-saving standards.

7. Circular Economy Standards

(1) Development Status. The recycling utilization standard system includes green design and manufacturing, clean production, comprehensive utilization, industrial linkage, and circulated revamping. The pilot program for standardization of circular economy was launched in 2007. Up to now, the circular economy standard system has been substantially established and

improved, and a number of circular economy standards have been formulated to fill in the gaps. As of the beginning of 2017, the metallurgical industry's circular economy standardization has seen the formulation of 23 national-level standards. A set of typical models of circular economy standardization that can be replicated and promoted has been created, a number of versatile talents for circular economy standardization have been cultivated, and significant economic, environmental, and social benefits have been achieved. The standardization efficiency has been improved by using "Internet + Standards". The current resource recycling standard system is established on the basis of the theoretical connotation and framework of resource recycling, complies with classification of resource recycling, comprehensively considers life cycle stages of production, circulation and consumption and means of waste recycling, as well as emphasizes industrial symbiosis and linkage. There are currently five national-level standards under preparation.

(2) Main Existing Problems. The main problems existing in the standardization work of cyclic economy are that the standard system is still not complete, the quantity of standards is insufficient, and there are still many vacancies, failing to cover the full production and application fields; there is a deep gap to national policy requirements; the standards committees of each specialty are decentralized and difficult to form synergy, and their substantive participation in international standardization work is insufficient; the current standards are incomplete, outdated, backward, overlapped or in conflict, the standard system is not reasonable enough, and the standard coordination promotion mechanism is imperfect.

8. Logistics Standards

(1) Development Status. At the national level, China has not yet had a complete set of modern logistics standards system that is closely integrated with the supply chain logistics and steel product circulation logistics of the iron and steel industry. In the newly released "*Logistics Standard Catalogue Manual"* by the National Logistics Standardization Technical Committee (Logistics Standards Committee), there is no self-contained logistics standard for iron and steel industry in its specialty category. Five national standards pertaining to the metallurgical category are now in the wait list of Logistics Standards Committee and nothing more in this regard. Therefore, the standardization work in the logistics industry for iron and steel industry is just in its infancy.

(2) Main Existing Problems. There is a lack of relevant research institutions for steel product logistics standards at the national level. The responsible domestic governing authority for standardization is the National Logistics Standardization Technical Committee (TC269). Previously, there was no working group for the research and preparation of steel logistics standardization (TC 269/Steel Logistics Working Group was established on November 15, 2016, and its secretariat is located in the Metallurgical Industry Planning and Research Institute), which has left the formulation and revision

of steel logistics standards stagnate at a relatively backward stage. Under this circumstance, the implementation of interrelated standards in various industries often leads to a situation of "fragmented management", which makes the standard practicability and feasibility difficult.

Top-level design for steel logistics standards is absent. So far, China does not have a complete set of modern logistics standards covering the entire supply chain of iron and steel industry. From the perspective of top-level design, the development of specific work for the formulation and revision of steel logistics standards shall be effectively guided.

9. Informatization Standards

(1) Development Status. Comprehensively promoting the national economy and social informatization is a strategic measure concerning the overall situation of modernization. Informatization is an inevitable choice for China to accelerate industrialization and modernization. The premise of informatization is the sharing of information resources. The basis of information resources sharing is the standardization of informatization.

The standardization of informatization means the formulation, revision, management, and implementation of various information technology standards in various practical activities of developing and utilizing information technology adhering to the principle of staying in line with international standards, publicity of national standards and industry standards, development of local standards and standard system of practicality, and promotion of initiation, implementation, acceptance, the conformity testing, and certification of informatization application projects in order to obtain the best economic and social benefits.

The standardization of informatization, in terms of standardization, includes many links such as the formulation, revision, management, publicity, implementation, and review of various information technology standards. In terms of information technology, it includes the generation, identification, collection, classification, encoding, storage, processing, transmission, and other aspects. At present, informatization standards mainly include informatization standard systems, information technology basic standards, network infrastructure standards, and information security standards.

(2) Main Existing Problems. China's standardization efforts have provided effective support for promoting the sound and rapid development of China's economy and society. However, there are many problems in the standardization of informatization. Compared with the national strategic deployment and the demand of industrial development and market, there is still a big gap to fill, mainly in the following aspects:

The ability to participate in international standardization events is still far from the developed countries;

The adaptability and effectiveness of standards need to be further improved;

The implementation of standardization work needs to be further strengthened;

The scientificity of some standards, especially those related to life and health, needs to be further improved;
Testing methods of some standards need to be further improved.

8.1.2 Industry Standards

1. Standards for Raw Materials and Fuels

   (1) Development Status. At present, there are 102 national standards related to iron ores, and most of the standards are the ones for iron ore elemental analysis and measurement except two that are the *Iron Ore Grade Classification* (GB/T 32545-2016) and *Terminology of Iron Ores and Direct Reduced Irons* (GB/T 20565-2006). Relevant national authorities have issued many industry standards in terms of coal component testing technology, coal mining equipment, and safety technologies.
   (2) Main Existing Problems. The existing iron ore standards are currently focused on analytical testing standards, and the standards of iron ore quality, especially the mandatory standards for harmful impurities such as S and P in iron ores, are yet to be developed. As a result, the quality of imported iron ores in China in the past decade has been varying and there were even shoddy iron ores in disguise of good ones. There are few industry standards available for the coal and coke, and most of the available standards are national standards.

2. Technological Equipment Standards

   (1) Development Status. The industry standards of China's metallurgical technology equipment have formed a relatively complete system, involving more than 100 industry standards and covering the full process from sintering to ironmaking, steelmaking, and steel rolling process. It provides a technical basis for the design, manufacture, and application of large-scale packaged equipment, and the level of manufacture and application of metallurgical equipment in China has been greatly improved as a result. The industry standards have played their role in optimizing the industrial structure, eliminating the backward technology and high energy consumption equipment in the industry, and developing China's ability of manufacturing technology and independent system integration of large-scale equipment in China's iron and steel industry, thus creating conditions for the rapid development of China's industry.
   (2) Main Existing Problems. China's iron and steel industry is characterized of large scale and uneven level of technological equipment. And most of the industry standards are recommended standards. The overall level of equipment for small and medium-sized private enterprises is poor, and they tend to use standardized process equipment optionally. In addition, steel

smelting and steel rolling equipment are mostly large-scale, packaged, and production line equipment. It is difficult to formulate a uniform standard for a minority of products according to the changing conditions of raw and fuel materials. The manufacturing standards for single machines in packaged equipment cannot meet the requirements of wide applicability, high precision, high speed, and customized production, quantitatively or technically.

3. Product Standards

   (1) Development Status. The total number of national standards and industry standards in China's iron and steel industry has reached more than 2370, of which more than 1100 are products and methodology standards, accounting for less than 50%. The rate of key standards adopting international standards and foreign advanced standards has reached more than 75%. A product standardization system that is oriented to market demand, gradually improved in level, and rational in structure has been substantially established.
   (2) Main Existing Problems. There are still many gaps in product standard system of China's iron and steel industry compared to the standards of the developed countries and the international standards. The existing problems are reflected as: less variety coverage, low indicators, incomplete category, and unable to meet the requirements of the international market; moreover, product standards are still dominated by production standards; technical content lacks freedom and adaptability; in addition, national standards and industry standards are not complete enough to cover corporate standards, failing to meet the individualized need of customers.

4. Energy Standards

   (1) Development Status. At present, the main energy-saving standards available in the industry include energy consumption limitation standards such as *Energy-Saving Design Specifications for Iron and Steel Enterprises*, *Specific Energy Consumption Limit for Crude Steel Production*, *Specific Energy Consumption Limit for Electric Arc Furnace Smelting*, and *Specific Energy Consumption Limit for Coke Production,* and they have played a role in promoting and standardizing energy-saving work across the industry.
   (2) Main Existing Problems. However, there are still two problems: First, the number of standards is less. The iron and steel industry is a highly correlative industry, and however, there are only a dozen of standards for energy conservation available in the industry. More standards are demanded to regulate the industry. Second, the formulation and revision periods of standards are long. Taking the energy consumption limitation standard for crude steel production as an example, the revision time interval of the last two editions has been six years, which cannot adapt to the rapid development of the industry.

5. Environmental Protection Standards

(1) Development Status. As a major stationary industrial pollution source, the iron and steel industry has achieved relatively outstanding achievements in the fields of waste gases, wastewater, and solid wastes treatment in recent years. Among them, the iron and steel industry was once the main source of sulfur dioxide emissions second to power plants, and through the full implementation of sintering flue gas desulfurization and recovery of surplus gas technologies, and the transformation of oil to gas, coal to gas, and other transformation projects in a decade, the quantity of sulfur dioxide emissions has been greatly reduced. In the past ten years, the sulfur dioxide emissions per ton of steel have been reduced from nearly 3 kg to about 0.85 kg, and about two-thirds of the emissions have been reduced. Smoke dust is the most "intuitive" air pollutant in the iron and steel industry. Through continuous revamping of dust removal facilities and increasing dust removal capacity and by using advanced technologies such as the bag filter, the emission of smoke dust per ton of steel has been reduced from 2 to 0.81 kg at the end of 2015. The discharge of wastewater per ton of steel has achieved a decline of about 75%. The total amount and intensity of wastewater discharge have been greatly reduced during the development period of this decade. The total discharge of wastewater from the iron and steel industry also fell to about 400 million cubic meters at the end of the 12th Five-Year Plan from the 1200 million cubic meters at the beginning of the 11th Five-Year Plan. The discharge of wastewater per ton of steel dropped from 3.8 to 0.8 m^3, and enterprises in many consumption limitation areas realized "nearly zero emissions" of wastewater. The comprehensive utilization rate of solid wastes also increased from 94.8% in 2005 to 97.5% in 2015. The amount of solid wastes generated per ton of steel decreased from 628 kg/ton in 2005 to 585 kg/ton in 2015. The environmental protection achievements of the iron and steel industry over the past years are attributed to the increasingly strict environmental emission standards and the implementation of the *New Environmental Protection Law*. On the other hand, the other inseparable impetus is the official release of the *Clean Production Standard—Iron and Steel Industry* (HJ/T 189-2006). Thanks to the leading and mandatory role of the standards, the iron and steel industry has changed from a high-consumption, high-emission, and extensive management growth pattern to the clean production featuring intensive, efficient, and low emission.

In recent years, the research work on the standardization of atmospheric pollutant discharge mainly focuses on the following eight emission standards, for example, the *Emission Standards for Pollutants from the Mining and Beneficiation Process of Iron Ores* (GB 28661-2012), *Emission Standards for Air Pollutants from Metallurgical Sintering and Pelletizing Processes* (GB 28662-2012), *Emission Standard for Pollutants from Iron Making Process* (GB 28663-2012), and the *Pollutant Discharge Standard for Steel-Making Process* (GB 28664-2012), which are stricter compared

with the old standards. In particular, the special emission limits implemented since January 1, 2015, are called the "most stringent" emission standards. The emission concentration limits of various pollution factors required therein are significantly tightened compared with the old standards. Some of the limit values stipulated in the new standards are as low as one-tenth of the old ones. Following emission standards, relevant technical and equipment standards of the metallurgical industry were issued, such as *Technical Specifications for Flue Gas Purification and Recycling Facilities for Silicon-Based Ferro-Alloy Electric Furnaces* (YB/T 4166-2007), *Composite Filter Bag* (GB/T 27869-2011), *Performance Test Method of Electrostatic Precipitator* (GB/T 13931-2002), *Evaluation Technical Requirements for High-Efficiency Environmental Protection Equipment—Electrostatic Precipitator,* and other standards in a series. This promoted the application of advanced environmental protection technology and advanced equipment and ensured the stability and performance guarantee of the operation of environmental protection facilities in the production process.

(2) Main Existing Problems. In recent years, as the tough stance on environmental protection in the iron and steel industry keeps heating up, the market of environmental protection expands and the potential is huge. With the successive introduction of "The 10-Chapter Water Pollution Prevention Action Plan" (The Action Plan for Prevention and Treatment of Water Pollution), "The 10-Chapter Air Pollution Prevention Action Plan" (Air Pollution Prevention and Control Action Plan), and "The 10-Chapter Soil Pollution Prevention Action Plan" (the Action Plan for Soil Pollution Prevention and Control), the demand for assessment of technical equipment, products, and facilities performance is more urgent than ever. However, the current environmental protection market in the metallurgical industry still presents obvious discrete characteristics. The upstream and downstream of the industry chain need to be standardized and guided. The technical regulations and energy efficiency evaluation methods of such environmental protection equipment as desulfurization, denitration, dedusting, water treatment, and slag treatment critically required by raw materials systems, coking, sintering, pelletizing, ironmaking, steelmaking, and steel rolling processes in the metallurgical industry are still insufficient. Even if a small number of environmental protection technology equipment own evaluation index system, they are yet to be tested for practicability by production plants.

Therefore, in combination with the development characteristics of the industry's environmental protection field, a series of green product standards and evaluation regulations, standard methods for business to business environmental protection cost accounting, and standards for evaluating performance of existing environmental protection facilities of enterprises that respond to the needs of the industry shall be carried out, against the standardized applications of some advanced and industrial environmental protection technologies. A standard system that is compatible with the environmental protection in the industry shall be established and gradually improved.

6. Water Standards

(1) Development Status. The iron and steel industry is a high-water-consumption and high-pollution industry, with water consumption accounting for more than 10% of industrial water consumption, ranking third in the industrial sector. In recent years, China's iron and steel industry has achieved remarkable results in water-saving work. The water consumption of key steel enterprises in the industry has been declining year by year. By 2015, the water consumption per ton of steel has dropped to 3.53 m^3. The iron and steel industry has seen establishment of a number of standards, mainly for water supply hydrogeology, seawater desalination technology, and metallurgical wastewater desalination process.

The industry standards for water saving in iron and steel enterprises mainly include *Water Supply Hydrogeological Survey and Water Supply Pipeline and Well Works* (YB/T 9033-1998) for inspection, acceptance, and quality assessment of water supply hydrogeological survey and water supply pipeline and well works; *Technical Specification for Seawater Desalination in Iron and Steel Industry Part I: Low-temperature Multi-effect Distillation* (YB/T 4256.1-2012) for iron and steel enterprises that use low-parameter steam to produce freshwater through low-temperature multi-effect seawater desalination system; *Technical Specification for Metallurgical Production Wastewater Desalination Part I: Reverse Osmosis* (YB/T 4257.1-2012) for the membrane desalination system of metallurgical production wastewater.

(2) Main Existing Problems. Since China's iron and steel industry differs in the production structures, availability of regional water resources, and degree of enthusiasm for water saving, a situation mixed with advanced and backward indicators among enterprises is the fact and is reflected in the difference between the north and the south. Due to the abundant water resources, the southern iron and steel enterprises generally have higher water consumption per unit of product. With the deep processing of China's steel products, the continuous extension of the industry chain and the demand for water is increasing, and the contradiction between water shortage in some regions and the development of the iron and steel industry has been highlighted.

The water-saving standard system in the iron and steel industry is still not perfect. On the one hand, the basic standards are lacking, which is not conducive to guiding and standardizing the formulation and revision of water-saving standards. On the other hand, the water consumption in the iron and steel industry is a complicated one, and the standard shall be refined to each production process. There is still a long way to go for standardization work.

7. Circular Economy Standards

(1) Development Status. China's iron and steel industry has not yet seen the establishment of a systematic circular economy standard system. Although

the National Metallurgical Standards Committee (SAC/TC 183) has specifically carried out the metallurgical solid waste standardization, it only covers the comprehensive utilization standards of part of metallurgical slag and ferrous dust, while the comprehensive utilization standards of tailings, waste rocks, ferroalloy slag, and non-ferrous slag are blank. In addition, the secondary resources comprehensive utilization technology and product standards such as wastewater, waste gas, solid waste, residual heat, and residual energy generated in the metallurgical production process are missing. The standardization of circular economies such as metallurgical large-scale equipment, machinery remanufacturing, and metallurgical industrial parks is still in its infancy. As of the beginning of 2017, the metallurgical industry has seen the establishment of 38 industry-level standards regarding circular economy, including three aspects: basic standards (terms, classification, sample preparation, stacking, and packaging signs), product standards (metallurgical slag and dust) and methodology standards (physical and chemical), and there are currently 11 standards under development.

(2) Main Existing Problems. The main problems existing in the standardization work of circular economy are that the standard system is still not complete, the quantity of standards is insufficient, and there are still many vacancies, failing to cover the full production and application fields; there is a deep gap to national policy requirements; the standards committees of each specialty are decentralized and difficult to form synergy, and their substantive participation in international standardization work is insufficient; the current standards are incomplete, outdated, backward, overlapped or in conflict, the standard system is not reasonable enough, and the standard coordination promotion mechanism is imperfect.

8. Logistics Standards

(1) Development Status. At the industry level, in the absence of a logistics standard system for iron and steel industry, the formulation and revision of industry standards are also lagging behind and mainly focus on the relevant content of intermediate links. Till now, there have been only seven steel logistics industry standards published, and there are still a lot of gaps in the relevant logistics standards as far as the overall supply chain system for iron and steel industry is concerned.

(2) Main Existing Problems. The basis of standardization of steel logistics is weak. First, the steel logistics industry started late and the basis is relatively weak. Due to long-term extensive operation of the logistics links in the iron and steel industry, the management system, management level, personnel quality, and equipment and infrastructures are considered non-core business and subject to long-term insufficiency. At the same time, relevant practitioners are ill-informed about modern logistics concepts, logistics informatization, and logistics standardization and even lack a clear understanding of the connotation and extension of the “Logistics”. Second, the market base

of steel logistics standardization is relatively weak, which directly affects the implementation of logistics standardization of metallurgical links.

Service quality and management level are low. Although the government has paid more and more attention to the logistics link in recent years, and has successively issued a number of related policies, the service and management in the steel logistics link have been at a low level. For example, the inventory management of some iron and steel enterprises is relatively extensive, and the backlog of raw materials and fuels is serious; the transportation department delays in transition and poorly controls it, leading to delays in the logistics links and serious losses on the way; the storage management of circulation links is poor, resulting in frequent internal reclaiming and high cost; the connection between loading/unloading and transportation does not match, resulting in long waiting time of transportation vehicles and ships, and low efficiency.

There is no uniform standard for steel logistics standards. At present, the development of China's steel logistics system is still in a low-level stage. There are many problems in the various links of steel logistics, mainly in the following aspects. First of all, production enterprises and circulation enterprises in iron and steel industry mainly follow their own "conventional custom" process and methods that took form in a long run, which are backward in terms of equipment conditions and management and control methods, and could not keep up with the development requirements of the national overall logistics industry. The technical level and structure of various steel logistics facilities and equipment are not reasonable, the control process is relatively extensive, and the degree of standardization is low, which cannot achieve the effect of high-efficiency operation of modern logistics. Secondly, the standard of steel logistics equipment is not matched, and a standard system of logistics equipment covering raw materials and fuels, auxiliary materials, semi-finished products and finished products from supply, production, and sales to circulation is still absent. Finally, there is no effective connection among the steel logistics process flow, the steel logistics equipment standards, and the steel logistics management and control standards, which leads to an increase in ineffective logistics operations and logistics costs, and a backward logistics service quality, thus seriously restricting the improvement of logistics efficiency.

9. Informatization Standards

(1) Development Status. Before 2016, there were few informatization standards for the iron and steel industry. The standards issued then by the electronics industry and the communication industry will contain some informatization standards, but they were also common ones. In 2016, the Ministry of Industry and Information Technology issued industry standard formulation and revision plan to be carried out in three batches, of which there were 108 standards for metallurgy, but only one was the standard for informatization

of the iron and steel industry. There was only one standard for manufacturing execution system (MES) among the standards released in 2016 by the electronics industry, namely "*Specification for the Manufacturing Execution System (MES) Part II: Software Function of Manufacturing Execution System for Metallurgical Industry*", which is an information standard for the iron and steel industry.

(2) Main Existing Problems. The iron and steel industry is relatively lacking in building information technology standards. In order to implement the strategic plan of "*Made in China 2025*" accelerate the development of intelligent manufacture in the iron and steel industry, and give full play to the regulating and guiding role of standards, measures shall be taken to speed up the progress of setting up information technology standards of iron and steel industry according to the guidance of National Intelligent Manufacturing.

8.1.3 Corporate Standards

1. Product Standards

   (1) Development Status. Product quality must comply with national and industry standards. This is the minimum quality standard for iron and steel enterprises to meet the needs of general customers. The corporate standards are the spire of the standard "Pyramid", which are more inclusive and more competitive. Under the current excess market environment, iron and steel enterprises have developed their own corporate standards to improve product competitiveness, while some of them have developed customized products to meet the individual requirements of high-end customers. "The national standard is the threshold, and the corporate standard shall be the guide". This conception is gradually being recognized and accepted by iron and steel enterprises.

   (2) Main Existing Problems. At present, the guiding role of corporate product standards in the industry is not prominent, partly because of the immature construction of the standardization talents in most iron and steel enterprises in China and the lack of institutions, positions, and trainings established for standardization work. Therefore, the iron and steel enterprises shall speed up the efforts in training their own standardization experts and let them play the role of "the Spokesperson of Corporate Interests".

2. Energy Standards

   (1) Development Status. Energy standards are an important basis for enterprises to implement energy-saving management and are also the technical basis for the government to implement energy-saving policies and strengthen energy-saving supervision. Corporate standardization is an important part of the standardization work and is a comprehensive basic task of the enterprise,

which shall run through the whole process of the production technology and management activities of the enterprise.

With the continuous improvement of the market economy system and the standards being the main basis for market regulation and operation, more and more enterprises have established a standardization system within the enterprise, and energy standardization is an important part of the system. In metallurgical enterprises, the reliable energy security is of great significance for the safe operation of the energy system and the safety of employees. Standardization job is a long-term, arduous, and complex system construction project, which requires the long-term and arduous efforts of management personnel of all levels and kinds and demands persistent attention.

(2) Main Existing Problems. The energy department is the key auxiliary unit of metallurgical enterprises. Generally, it is responsible for the production and supply of energy products (media) such as water, electricity, air, and gas (steam) of metallurgical enterprises. The uninterrupted and non-storage nature of energy product (media) production determines that its output is not only a tangible physical product but a utility. Since energy is not the main product of metallurgical enterprises and each energy medium has common standards available in its respective fields, most of the metallurgical enterprises are not aware of the importance of energy standards, and they have not invested much in this area. Quite a number of enterprises have still not yet set up full-time standardization staff and standardization management institutions; this is particularly true with energy standardization professionals.

3. Environmental Protection Standards

(1) Development Status. With the promulgation of the *New Environmental Protection Law* and the government's increasingly strict requirements of environmental standards of the iron and steel industry, iron and steel enterprises continue to strengthen their efforts in the implementation of clean production, legal discharge and emissions, and the stable operation of the entire plant environmental protection facilities. On the one hand, we must resolutely implement relevant national standards, such as post-evaluation of environmental protection facilities for enterprises, and special restrictions on the emission concentration of local enterprises. On the other hand, with its own enterprise as the frame of reference, the implementation of standardization work shall lead the enterprise's green development transformation through formulating the *Environmental Management Regulations and Regulations for Iron and Steel Enterprise*, the certification of the *Environmental Management System*, and the audit of enterprises' promotion of clean production policy. With the gradual enhancement of corporate environmental protection awareness, corporate environmental management has been gradually standardized and institutionalized. By the end of 2015, according to

the list of enterprises in conformity with the *Regulations on the Standardization of the Iron and Steel Industry (2012 Revision)* published by the Ministry of Industry and Information Technology, 305 iron and steel enterprises have obtained the ISO 14001 environmental quality management system certification, accounting for 90% of the national steel production capacity.

(2) Main Existing Problems. The rapid development of China's iron and steel industry has led to the rapid promotion and application of advanced environmental protection technology, laying a solid foundation for improving the environmental protection level of iron and steel enterprises. However, the corresponding technical specifications, the evaluation of environmental protection facilities' energy efficiency and pollutant removal effect, performance evaluation of environmental emission, corporate environmental cost accounting, and many other standardization works are still in blank or relatively lag period. Despite Baosteel, TISCO, Tangshan Steel, and other benchmarking enterprises that have reached the international advanced level have continued practicing the environmental management and green development concepts, insisting in implementation, learning from internationally advanced counterparts, and creating an internal standardization evaluation system of the enterprise. However, as far as the whole industry is concerned, due to regional diversity, differences in technical equipment levels, and differences in environmental protection concepts, there is still disparity in the level of environmental protection among Chinese iron and steel enterprises. According to the "Statistics of Environmental Protection of Iron and Steel Industry", the per capita emission of backward enterprises is ten times higher than that of the advanced enterprises. The cause of this situation is precisely that the above-mentioned environmental protection standards of the iron and steel industry have not been uniformly introduced in the industry. In addition, environmental protection technology providers with low credit standing and poor environmental protection facilities deteriorated the situation, resulting in the current poor environmental protection facilities in the iron and steel industry and significant differences in the standard conformity effect. In future, enterprises in the industry shall be constrained by a unified standard so that it can comply with the standards of resource-saving and environment-friendly enterprises.

4. Water Standards

(1) Development Status. Water demands of iron and steel enterprises are diversified. There are different processes that require water such as coking, sintering, pelletizing, ironmaking, steelmaking, and steel rolling. It is also reflected in the coexistence of long process and short process, ordinary steel enterprises coexisting with special steel enterprises, primary steel products coexisting with secondary and tertiary products, and coexisting of plants with and without captive power plant. Therefore, due to the different production conditions of enterprises, there will be certain differences in the water consumption structure and water utilization efficiency, which will cause

difficulty in the benchmarking work in terms of enterprise's water-saving analysis and compromise the development of water-saving endeavor.

Iron and steel enterprises usually have internal rules and regulations that suit themselves, for example, *Safety Regulations, Technical Operation Procedures, Equipment Operation and Maintenance Regulations,* and *Regulation for Shifting of Duty*. The relevant corporate standards are also formulated, mainly including the inspection standards for raw materials and fuel procurement, the test standards for product quality and the performance index standards of steel products, and they are used to guide production practices. However, the water-saving standards are still a blank area and corporate water-saving standards are yet to be formulated.

(2) Main Existing Problems. The current water consumption status in iron and steel enterprises is yet to perfect. Water circulation systems are inadequate and there is direct cooling water system still in operation. The water quality stabilization measures such as increasing the concentration multiple are not in place. The energy consumption of system equipment such as pumps is high. Therefore, a set of water-saving standards which have feasibility and adapt to the production and operation of the enterprise itself is badly needed to help enterprises in their efforts of carrying out water-saving work and improving water efficiency.

The water supply and drainage facilities are auxiliary to iron and steel enterprises. There are many problems in its management, such as defective water metering system, low coverage of water quality online monitoring system, poor water-saving awareness of iron and steel enterprises, imperfect management institutions of water supply and drainage, unreasonable water management mechanism, and less attention to the technical transformation of water facilities. In the aspect of enterprise's water-saving management, it is necessary to standardize enterprise water management and strengthen standardization work.

5. Circular Economy Standards

(1) Development Status. The establishment of corporate standard system of circular economy provides a means for the sustainable development of enterprises and can comprehensively guide enterprises to carry out standardization work of circular economy. At the same time, it will promote the enterprise to systematically sort out the existing standards and recognize deficiencies. The corporate standard system of circular economy shall be developed from several aspects such as comprehensive utilization of resources, heat energy recovery and utilization, power saving, water-saving, and waste gas recycling. In response to the development needs of circular economy, a series of corporate standards suitable for the circular economy model shall be formulated to improve and perfect the corporate standards system. For example, Baosteel has successfully developed the slag into microgrits with good corrosion resistance, micro-shrinkage resistance, and high strength and converted this scientific research result into the corporate

standards, the "*Baosteel Microgrits of Blast Furnace Slag*". Based on the standard, it opened the market door and promoted the wide application of the microgrits in large-scale projects such as the cross-river tunnels, which not only save energy but also realize comprehensive utilization of wastes, and can also generate a profit of 50 million yuan per year.

(2) Main Existing Problems. Although enterprises have established a sound and numerous management systems pertaining to the standardization management, they have not really been "Implemented into management and embodied in practice" in the daily production and operation. In the process of standardization management, some enterprises have no specific analysis of problems and have not followed the objective laws. The management standards established tend to lack scientificity, practicality, and feasibility, ending up aiming at the moon. Some enterprises bypass the standard management system under the excuses of exceptions handling, which hinders the implementation and promotion of the same.

6. Logistics Standards

(1) Development Status. The logistics at the iron and steel enterprise level has been treated as the supporting service for quite a long time, and the priority is always given to the "Guarantee production". In recent years, with the decline of the iron and steel industry, logistics has just become the focus of the enterprise's "Cost reduction". However, because it has always been in the auxiliary position with less attention, the enterprise has been adopting the "conventional thinking" of the logistics standardization, and there have been no systematic regulation and formulation of the steel enterprise logistics standards.

The enterprises in the field of market and circulation include a variety of enterprises such as warehousing, transportation, comprehensive service, freight forwarding, ship agencies, processing and distribution, and logistics parks. These enterprises have always followed relevant standards in the industries of logistics, transportation, and trade.

(2) Main Existing Problems. In the downturn background of the iron and steel industry, the logistics link that has been in the role of ancillary services in the past has just been valued by steel enterprises. The cost reduction through logistics has become a fashionable term, but the method of reducing costs and starting points has not been figured out. The cost reduction always takes the form of administrative orders on how much cost shall be reduced, passed down to logistics departments arbitrarily. In the absence of logistics history statistics, information technology, modern logistics centralized control concepts and normative standards, cost reduction has ended up being a digital game. Due to the lack of normative guidelines, incomplete cost reduction that one cost item is reduced only to find another rising becomes a common occurrence, going against the original intention of overall cost reduction.

The logistics in circulation link of iron and steel industry. Due to the incompatibility of the standards, in the fields of warehousing, transportation, loading, and unloading, with various links of steel logistics, the relevant standards encounter problems with their usability and popularity in the industry and the situation is even worsened by the small-scale and disorderly situation of logistics service providers in the industry.

7. Informatization Standards

(1) Development Status. Enterprise informatization refers to the process in which enterprises use computer and network technology to continuously improve the management level of production and management, improve the efficiency and quality of enterprise decision-making through deep development and extensive use of information resources, thereby improving the economic efficiency and core competitiveness of enterprises.

Corporate standardization is a comprehensive basic work of an enterprise, which runs through the entire process of production, technology, and management activities. Standardization is the most basic supporting element for enterprises to implement informatization construction and is the basic insurance of realizing the globalization of information systems and data sharing.

In recent years, the informatization of China's iron and steel industry has developed rapidly. More and more iron and steel enterprises regard informatization as an important means to improve their core competitiveness. Enterprises have invested a large amount of funds in information construction. However, under the traditional management mode, the operation of corporate informatization system is less effective in Chinese enterprises than in world leading enterprises. Domestic iron and steel enterprises generally have large organizational structure and complicated business processes, resulting in long development cycle, high cost, and low operational efficiency of information technology projects. In general, the lack of enterprise information standards, the crude management, and the lag of standardization have seriously hindered the effectiveness of enterprise information operation.

(2) Main Existing Problems. The information system does not match the enterprise management model. Many enterprises do not recognize the relationship between informatization and management standardization. For the same enterprise management information system, its effect will be greatly different from enterprises with different management system. At present, many enterprises have problems in their daily management system that does not match with the software standards.

Lack of Basic Data Standardization. Data standardization is the basic guarantee for enterprises to carry out information construction. Enterprise informatization is about digital design, implementation, application, and management of enterprise data acquisition. Ensuring the standardization of data acquisition is a key factor in the construction of enterprise information

projects. At present, many enterprises fail to standardize data management during the implementation of information technology projects.

Standardization of information system development has not been achieved. The standardization of information system development mainly refers to the compliance with unified system design specifications, program development specifications, and project management specifications in the development of system. At present, many enterprises fail to comply with the design specifications of software engineering when constructing information projects, resulting in repeated changes required by customers, unsatisfactory system operation, and difficulty in system update iteration.

8.2 Development Environment and Policy Orientation

As the comprehensive deepening of reform and opening-up has pushed China's economy to the middle and high-end level, the government's attention to standardization has never been higher. The General Secretary Xi Jinping pointed out that China will actively implement the standardization strategy, give play to the basic, strategic and leading role of standardization, and promote the five developments that are innovation-driven development, coordinated development, green development, development for global progress, and development for the benefit of all through standardization. Premier Li Keqiang stressed that it is necessary to promote industrial upgrading by comprehensively improving standards, develop a new competitive advantage, and promote high-speed economic growth and lead the way to the middle and high-end ranks. The ideas of letting standards lead the improvement of China's manufacturing quality, and promoting the integration of international and domestic standards has been mentioned many times in the papers issued by the State Council such as *Made in China 2025* [1], *Opinions on Giving Play to the Leading Role of Brand Building and Promoting Upgrading of Supply and Demand Structure*, *Standardization and Quality Improvement Plan for Equipment Manufacturing Industry* [2], and *Consumer Goods Standardization and Quality Improvement Plan (2016–2020)*.

Standardization plays an indispensable role in promoting the transformation and upgrading of the iron and steel industry. More and more standards are included in the relevant documents of industrial policies. *Opinions on Cutting Overcapacity of Iron and Steel Industry to Achieve Development by Solving Difficulties* issued by the State Council clearly stated that standards shall play a restrictive and guiding role to reduce the structural overcapacity. The following standards of environmental protection, safety protection, and energy consumption must be followed, and any production facilities failing to do so shall be closed down according to legal procedures: Standards of environment protection: *Water Pollutant Emission Standards for Iron and Steel Industry*, *Air Pollutant Emission Standards for Sintering and Pelletizing Industry*, *Air Pollutant Emission Standards for Iron Making Industry*, *Air Pollutant*

Emission Standards for Steel Making Industry, *Air Pollutant Emission Standards for Steel Rolling Industry*, etc.; energy consumption must meet the mandatory standards such as *Limitation on Specific Energy Consumption of Major Crude Steel Production Processes*; in safety aspects, the following standards must be complied with the *Safety Regulations for Iron-Making*, *Safety Regulations for Steel-Making,* and *Gas Safety Regulations Pellet for Industrial Enterprises*.

8.2.1 Policies and Regulations

In 1957, in order to strengthen the standardization work, China formulated a number of national and ministerial standards according to national conditions, and since then, China's standardization work has embarked on a stage of independent development. After 1958, due to the influence of the leftism, the standardization work suffered severe setbacks. Until the national economic adjustment period in 1962, the standardization work was restored and strengthened. The State Council issued the *Management Measures for Technical Standards for Industrial and Agricultural Products and Engineering Construction*, marking the beginning of a new development era. During the Ten Years of Turmoil, the standardization work was once at a standstill, the legislature was destroyed, and the legal system was seriously devastated.

After the Third Plenary Session of the 11th Central Committee of the Party, with the comprehensive restoration of economic development, the standardization work has received the attention of the government. In order to strengthen the efforts in standardization, in 1979, the State Council promulgated the *Regulations on Standardization Management of the People's Republic of China*. Standardization work has entered a new period of development national wide. The operation mechanism of China's standardization management system has been gradually improved, and the standard system has taken its initial shape. In 1989, the government promulgated the *Standardization Law of the People's Republic of China*, which further defined the framework of China's standard system, standardization management system, and operational mechanism. Subsequently, the State Council promulgated the *Regulations on the Implementation of the Standardization Law of the People's Republic of China* in 1990, putting forward the specific regulations for the implementation of the *Standardization Law*. In order to implement the *Standardization Law* and the *Regulations on the Implementation of the Standardization Law*, as the governing body of standardization work, the former State Bureau of Technical Supervision promulgated a series of more detailed regulations covering the formulation and revision, publishing and standard management of various standards in sectors such as industrial engineering, agriculture, energy, and transportation. During this period, China's standardization laws and regulations were initially established.

Since the *18th National Congress of the Communist Party of China*, the Party Central Committee and the State Council have made a series of decision-making arrangements for strengthening standardization work and promoting standardization reform and development. The Second Plenary Session of the 18th CPC Central Committee proposed to strengthen the construction of technical standards system;

the Third Plenary Session requested the government to strengthen the formulation and implementation of development strategies, plans, policies, and standards; the Fourth Plenary Session regarded standards as an important means of governing the country according to law; the Fifth Plenary Session added the five new development concepts of "Innovation, coordination, green, openness and sharing" into the management of standards; the Leading Group for Overall Reform listed the standardization reform as a key task in 2015.

In March 2015, the State Council issued *The Plan for Furthering the Standardization Reforms* [3] to vigorously promote the reform of China's standardization deployment. The target is to transform the current government-dominated standard formulation system to a new standard system consisting of standards provided by the government and the market players. The standards formulated by the government are reduced from six to four categories, which are mandatory national standards, recommended national standards, recommended industry standards, and recommended local standards. The standards independently formulated by market players are divided into non-governmental organization standards and corporate standards. The government-led standards focus on the basics, and the standards originated from the market are focused on improving competitiveness. At the same time, a standardization management system compatible with the new standard system shall be established and improved.

In May 2015, the State Council issued the *Inter-Ministerial Joint Conference System for Promoting Standardization of the State Council*. The General Administration of Quality Supervision, Inspection and Quarantine (National Standards Committee) is the leader to coordinate the work among 39 ministries. The national standardization work is coordinated under the leadership of the State Council. The working contents include the study and formulation of major policies and guidelines to promote the reform and development of standardization, coordination and cope with major problems in the development process of standardization reform, coordination of the formulation and implementation of cross-sectoral cross-disciplinary and major disputed standards, and review and finalization of the standards that need to be submitted to the State Council for approval.

In December 2015, the *National Standardization System Construction and Development Plan (2016–2020)* [4] issued by the State Council stipulated that by 2020, the international influence and contribution of "China Standards" will be greatly enhanced, and China will enter the ranks of the world standard power. The standard system shall be more complete. The standards provided by the government and the standards independently developed by the market shall coexist in a coordinated manner. The mandatory standards are the bottom line, the recommended standards are the basic frame, and the corporate standards shall be quality enhancer. A set of world influential standards shall be fostered and developed in fields where technology is developing rapidly and the market is innovation-driven. The benefits of standardization have taken full effect. The internationalization level of local standards has been greatly improved. And the foundation of the standardization has been continuously consolidated.

In February 2016, the *Guiding Opinions on Cultivating and Developing Non-Governmental Organization Standards* was jointly issued by the General Administration of Quality Supervision, Inspection and Quarantine and the National Standards Committee to motivate social groups to develop and apply standards, standardize the work of developing non-governmental organization standards, and increase the effective supply of standards. It requires that, by 2020, the development of non-governmental standards independently formulated by the market shall be mature, the number of non-governmental organization standards and their competitiveness shall be steadily improved, the organization standardization achievements shall be widely recognized by the society, and a group of world-known and influential organization standards shall come into effect.

In May 2016, the *Outline of National Innovation Driven Development Strategy* jointly issued by the Central Committee of the Communist Party of China and the State Council dedicated one chapter for the statement of "Implementing the strategy of intellectual property rights, standards, quality and brand" from the height of the Party and the Government, demanding the "Improvement of China's standardization". Therefore, standardization has become an important part of implementing an innovation-driven development strategy.

In February 2017, Premier Li Keqiang presided over executive meeting of the State Council. The meeting saw the approval of the *Standardization Law of the People's Republic of China (Revised Draft)* and decided to submit the draft to the Standing Committee of the National People's Congress for deliberation. This is an important milestone in the revision of the Standard Law, which means that the *Standardization Law of the People's Republic of China*, which has been in force since 1989, will be revised for the first time. The current *Standardization Law of the People's Republic of China* [5] only deals with the standards of industrial production and industrial products. The problems such as "Existence of missing, aging and lagging standards", "Overlapping, redundancy and contradiction", and "Delayed publication of important standards" plagued the development of standardization. The new *Standardization Law* will focus on improving the standards of industrial products, strive to make greater efforts in the formulation and revision of service standards, encourage enterprises to promote industry standards through standard innovation, and promote industrial transformation and economic structural adjustment. The draft also emphasized that it is forbidden to use the standards to engage in setting up industrial barriers, imposing regional blockades, and pursuing unfair competition.

With the attention of the Party Central Committee, the State Council, and the whole society to the standards work, a series of laws and regulations have been formulated and revised, and China has stood at a new historical starting point for the development of China's standardization industry.

8.2.2 Industrial Development

China's iron and steel industry has entered a stage of reduced development, but the demand for iron ore is still at a high level. China Metallurgical Industry Planning and Research Institute predicts that China's iron ore dependence will remain above 85% by 2030; global high-grade resources will gradually shrink and the average grade is showing a downward trend. Under the background of China's environmental protection and energy consumption policies, it is one of the important means to regulate the order of importing iron ores through tighter standards.

There are dozens of various design institutes engaging in China's metallurgical equipment research, and a strong engineering design team focusing on metallurgical geology, mining, smelting, processing, and other specialties has been formed. Under the strategic deployment of the Belt and Road Initiative, China's metallurgical engineering design institutes are actively "Going abroad" and contracting a large number of international capacity cooperation projects in iron and steel making. Relevant technological equipment standards must keep up the pace and carry out standardization of metallurgical process equipment with the aim of achieving the strategic goal of improving the quality and efficiency of the iron and steel industry, transforming, and upgrading. Highlights of follow-up efforts: first is to strengthen the top-level design and management work of standardization. From the perspective of government, it shall support and guide the manufacturing standard system with priority given to major metallurgical equipment standard system, based on *Made in China 2025* and in accordance with the *China Standardization System Construction and Development Plan (2016–2020)*. The second is to speed up the pace of formulation and revision of process equipment standards, responding to the development needs of the market and industry. According to the market requirements, a number of urgently needed standards shall be formulated and revised—for example, the standards of equipment for blast furnaces of 4000 m^3 and above. The third is to increase the efforts on the development and standards formulating of components and supporting parts that are key to packaged metallurgical equipment, as well as formulating standards pertaining to the safety, environmental protection, energy saving, and emission reduction in the production process with packaged metallurgical equipment, in order to improve the technical level and supporting level of metallurgical equipment.

To implement the most stringent management and assessment system of water resources by the government, carry out the *National Standard System Construction and Development Plan*, perform major standardization projects for energy conservation and emission reduction, fulfill the *Opinions on Promoting Contracted Water Saving Management to Boost Water Saving Service Industry Development*, and establish technical standard system of the contracted water-saving management, it is necessary to prepare a series of metallurgical water-saving standards to accelerate the implementation. China's water resources are in short supply and the contradictions between industrial water supply and demand are prominent. The iron and steel industry is a high-water-consumption industry, with huge water consumption. Water resources are an important constraint to the sustainable development of the iron and steel industry.

It is necessary to effectively promote the water-saving standardization work in the iron and steel industry as soon as possible, giving play to the leading role of standards. The existing water-saving standards in China's iron and steel industry are less in quantity, low in quality and always poor in operability, water-saving standardization work is still inadequate, and the water-saving standard system is still not perfect. With the gradual deepening of water-saving work in the iron and steel industry, the development of the water-saving standard system lags behind. It is difficult to adapt to the needs of the industry's water-saving management. It is urgent for professional institutions to improve, innovate, develop and update the water-saving standards system of the iron and steel industry, standardize and promote the industry water-saving standardization work. The water-saving management in the iron and steel industry is backward. The awareness of water-saving is not enough, and it cannot meet the requirements of the country's most stringent water resources management system. It is necessary to introduce a series of water-saving standards for the iron and steel industry as soon as possible, comprehensively covering all aspects of the industry's water-saving management, and strengthen efforts in developing and publicizing standards in order to standardize and guide water conservation management in the industry.

Circular economy is a new technical paradigm and a new way of increasing productivity, providing new ideas and new mechanisms for industrial restructuring, corporate incentives, and the social pursuit of new model of sustainable development. At present, the contradiction between economic development and resource shortage and environmental damage is becoming more and fiercer. Therefore, how to deal with the balance between resources and development and environment and development is a major issue in China's pursuit of the coordinated development of the people and the nature. Standardization is the basis for carrying out circular economy activities and has a fundamental position in the entire circular economy system. To construct a standard system that is oriented to circular economy is not only a top-level design but also a foundation work of standardization. Therefore, the establishment of an industrial circular economy standard system has far-reaching significance for promoting economic, social, and environmental sustainable development.

As a professional logistics standard, steel logistics standardization is an important part of the logistics standard system. The steel logistics standard system shall cover all walks of the sector, including logistics safety, logistics credibility, green logistics, logistics information and advanced facilities and equipment in terms of composition, and drop and pull transport, urban joint distribution, and multimodal transportation. Through formulating the standard system for this specialty, we shall aim to link up all parts of steel logistics industry with all kinds of logistics equipment and information, while ensuring the integrity and safe operation of logistics. Finally, through the implementation of the standards, the goal of promoting efficient, safe, smooth, and green operation of the steel logistics service system is realized.

The level of basic automation and informatization differs much among iron and steel enterprises in China, and they are at different development stages of Industry 1.0, Industry 2.0, and Industry 3.0. The standards of setting up information system are less in quantity, low in quality and poor in operability, and they need to be improved.

In order to improve the integration level between informatization and industrialization and achieve transformation and upgrading of the iron and steel industry, it is necessary to improve the construction of the corresponding information standard system. Due to the semi-continuous and semi-discrete production mode of the iron and steel industry, the informatization construction presents certain complexity. Standard system in iron and steel industry covers a wide range, consumes longer time, faces more resistance, and is hard to yield. And categories of information in the industry are various. To address the imperfect corporate information standard system, it is necessary to formulate a series of standards for the informatization of iron and steel enterprises to constrain and standardize the information construction of them and improve the success rate of information system implementation. In May 2015, the State Council officially issued *Made in China 2025*, the second item of which was to promote the in-depth integration of informatization and industrialization. In May 2016, the State Council issued the *Guiding Opinions on Deepening the Integration of Manufacturing and Internet Development* to deploy the integration of manufacturing and Internet. In order to speed up the implementation of national policies and truly improve the level of integration of informatization and industrialization of iron and steel enterprises, it is necessary to compile a series of standards for metallurgical informatization construction, highlight the leading role of standards, and achieve intelligent upgrading.

8.2.3 Econological Environment

1. Environmental constraints continue to increase and the quality of the ecological environment still needs improvement.

In recent years, China has introduced a series of environmental protection laws and regulations, and the control of pollutants in the iron and steel industry has reached an unprecedented historical time. On January 1, 2015, the newly revised *Environmental Protection Law* was officially implemented and its supporting regulations: the *Interim Measures for the Implementation of Continuous Penalty by Environmental Protection Departments* and the *Interim Measures for Environmental Protection Administrations to Restrict and Stop Production*, were put into effect at the same time. Environmental violations such as excessive discharges will be severely punished by means such as “Daily punishment without upper limit” and “Security detention and criminal responsibility”. Subsequently, the *Opinions of the CPC Central Committee and the State Council on Accelerating the Construction of Ecological Civilization* on April 25 clearly stated the specific objectives of comprehensively promoting pollution prevention and control, requested the local governments to hold the bottom line of environmental protection, supervise polluting enterprises to strictly abide by the quality of environmental protection, and encouraged the persistent construction of ecological civilization in an in-depth and sustained manner. In August of the same year, the *Law of the People’s Republic of China on the Prevention and Control of*

Atmospheric Pollution was revised. It was called the "Most stringent" air pollution prevention and control law in the history. It constructively proposed to strengthen the comprehensive prevention and control of air pollution sources from coal burning and industrial plants, conduct coordinated management of gas pollutants such as air-born particles, sulfur dioxide, and nitrogen oxides. In parallel with the full enforcement of the *Action Plan of Water Pollution Prevention* and the *Action Plan of Soil Pollution Prevention*, the environmental constraints become increasingly tighter and the governance pressure is unprecedentedly mounted.

At present, the environmental carrying capacity of SO_2, NO_x, primary PM2.5, and NH_3 in the country is about 13.6 million tons, 12.6 million tons, 6.2 million tons, and 6.3 million tons, respectively. In 2010, the actual emissions of SO_2, NO_x, primary PM2.5, and NH_3 in the country exceeded the environmental carrying capacity respectively by 66%, 81%, 96%, and 52%. The emissions of major air pollutants far exceeded the regional environmental carrying capacity. Among the key emission-controlled areas, the Beijing-Tianjin-Hebei region has become a serious over-limit area. The over-limit ratios of SO_2, NO_x, and primary PM2.5 in Beijing, Tianjin, and Hebei are all greater than 150%, and the NH_3 over-limit rate is over 100%. Among the 31 provinces and municipalities, the emissions of the four pollutants in the highly polluted six provinces and cities, that are, Henan, Hebei, Tianjin, Anhui, Shandong, and Beijing, exceeded the environmental carrying capacity by more than one time. In the Yangtze River Delta region, the average days of fine air quality among the 25 cities in the first quarter reached 71.0%, with an increase of 7.6 percentage points year on year. The PM2.5 concentration was 61 $\mu g/m^3$, down by 10.3% year on year; the PM10 concentration was 86 $\mu g/m^3$, decreased by 15.7% year on year. In February 2017, the proportion of average days of fine air quality in the 25 cities in the Yangtze River Delta region was 67.6%, decreased by 1.7 percentage points year on year. The PM2.5 concentration was 63 $\mu g/m^3$, flat year on year; the PM10 concentration was 87 $\mu g/m^3$, decreased by 11.2% year on year. In the Pearl River Delta region, the average days of fine air quality among the nine cities in the first quarter reached 87.4%, with a decrease of 10.9 percentage points year on year. The PM2.5 concentration was 46 $\mu g/m^3$, increased by 43.8% year on year; the PM10 concentration was 62 $\mu g/m^3$, increased by 31.9% year on year. In February 2017, the proportion of average days of fine air quality in the nine cities in the Pearl River Delta region was 90.9%, decreased by 8.3 percentage points year on year. The PM2.5 concentration was 41 $\mu g/m^3$, increased by 28.1% year on year; the PM10 concentration was 55 $\mu g/m^3$, increased by 17.0% year on year. Although the overall quality of the environment has improved year by year, the situation is still not optimistic. In particular, the time for improving the quality of the atmospheric environment is urgent and the task is arduous. With the objective demand for maintaining a relatively fast economic development rate, the quality of the ecological environment is still a grim issue. It is necessary to adhere to pollution control according to law, lift up the pollutant discharge threshold in overloaded areas, and introduce standardized supervision and priority monitoring methods for key pollution-producing sources, comprehensively strengthen environmental supervision and law enforcement, and strive to continuously improve environmental quality.

2. Green development is the only way to successful transformation and upgrading of iron and steel enterprises.

As the pillar industry of China's national economy, the iron and steel industry has experienced rapid development since the twenty-first century. However, the gradual accumulation of disorderly capacity expansion and long-term extensive development has caused excessive consumption of resources and energy, seriously affected the ecological environment, and China's environmental carrying capacity has reached the upper limit. With the increasing excess capacity and deterioration of industrial-originated polluting sources, the resources and environment have reached its limits and unable to support the sustainable development of the economy. In recent years, the smog pollution incidents have further aggravated the public's concerns about the pollution of the iron and steel industry. Among the major cities with their air quality announced by the Ministry of Environmental Protection, most of the 20 most polluted cities have steel companies. Therefore, the iron and steel industry's transition to green development is an urgent task. The Chinese iron and steel enterprises represented by Baosteel, TISCO, and HBIS Group have begun to actively explore green management, green development and green transformation, and have achieved remarkable results. On March 25, 2015, at the meeting of the Political Bureau of the Central Committee, General Secretary Xi Jinping proposed "Greenization" for the first time on the top of the "New Industrialization, Urbanization, Informatization and Agricultural Modernization". Green development was mentioned at an unprecedented height. Then, the green development concept has become one of the five development concepts of China's 13th Five-Year Plan. Iron and steel enterprises must adapt to the realistic requirements of China's economic development and green transformation in the new era, vigorously implement the green development model, and adhere to the six-in-one development strategy of "Green Mines, Green Procurement, Green Logistics, Green Manufacturing, Green Products and Green Industries" to enhance comprehensive competitiveness, do better job in the mutualism and intergrowth of steel plants and cities, and achieve comprehensive, coordinated and sustainable development.

At present, the operation effect of the terminal environmental protection facilities in the iron and steel industry is not optimistic. Based on the results of government-led spot inspections to 207 sintering machines in 82 iron and steel enterprises located in 18 provinces, autonomous regions, and municipalities, it was found that the wet desulfurization process, already adopted by 70% of the CISA members, maintains a relatively high desulfurization efficiency, of which the lime-gypsum process, Mg-desulfurization method, and ammonia-sulfur method have real efficiency more than 95%, while the desulfurization efficiency of CFB circulating fluidized bed, SDA rotary spray method, and dense phase semi-dry method can be up to 85% or more. The SO_2 emission concentration in the flue gas can be stably maintained below 200 mg/m^3, and most enterprises can meet the special discharge limit below 180 mg/m^3. Synchronous operation rate of the CISA members can reach 90%. However, through interviews and investigations, it was also found that a small number of private iron and steel enterprises lacked the overall judgment on desulfurization

technology at the beginning of the construction of desulfurization facility and handed over the project to some environmental protection companies with poor creditability, resulting in bad quality in equipment and material selection and high failure rate. The actual operation effect of some desulfurization facilities is less than 40% of the design capability. In addition, the operating cost of the desulfurization device of sintering machines is high and at the expenses of the enterprise, and the government supervision cannot cover each one of the sintering machines. With high law-abiding cost on the one hand and low unlawful cost on the other hand, some enterprises also choose to manipulate monitored data and play false. The active coke dry desulfurization process applied by TISCO, Jiangsu Yonggang, and Baosteel has achieved high desulfurization efficiency while achieving an operating rate of over 95%. The SO_2 emission concentration in the flue gas is controlled below 100 mg/m^3.

The root cause of the huge difference in environmental protection between the above enterprises is that the relevant technical norms and post-evaluation standards have not been issued for regulating relevant environmental protection technologies, technological parameters, and equipment levels. Tightened emission standards and the lag of engineering and technical standards have jointly led to a market of chaos in which environment protection technology providers with poor credit ratings "Swarm in seek of profits only". At this stage, authorities at the national and industry levels have been aware of such problems and taken measures to promote the introduction of relevant restrictive standards, tighten the market access and the approval threshold of environmental protection projects, maximally eliminating such abnormal market practices as the lowest price bid law and the Gresham's law. Only through tighter regulation on the end-of-pipe technology and setting overall standards for environmental protection facilities and the unified accounting standards for environmental protection cost calculation can China's environmental protection work in the iron and steel industry be on the right track, the fair competition and healthy development among all enterprises in the industry be promoted, and the road of transformation and upgrading of green development be embarked on. The purpose is to use the standardization of deep governance measures to lead the sustainable development trend of ecological environment where people and nature coexist harmoniously.

8.3 Case Analysis

8.3.1 Baoshan Iron & Steel Co. Ltd. (Baosteel)

1. Overview of Baosteel's Standardization

At the beginning of establishing the plant, Baosteel also introduced packaged advanced management technologies while purchasing packaged foreign advanced equipment and production technology. On the basis of learning, digesting, and mastering foreign advanced management systems and scientific management experience, Baosteel has gradually formed a systematic management system of its own

with social professional collaboration as conditions, centralized management as the core and grassroots management as basis, and system optimization in consideration of national conditions and factory conditions through persistent reform, development and innovation. Management system based on grassroots management and. It strengthened the grassroots management through the "authority decentralization" and letting down the gravity center of management. It developed the basic management model of "setting target values, giving play to operation head leadership, following operation standards, highlighting the check-based repair mechanism and the self-management".

2. Contents of Baosteel's Standardization

Baosteel's standardization includes eight aspects: standardization of criterion and standards, standardization of management methods, standardization of behavioral actions, standardization of time and series, standardization of work procedures, standardization of safety work, standardization of etiquette, and standardization of clothing and logos. Main contents are shown in Fig. 8.2.

(1) Standardization of Criterion and Standards. It includes criterion standards and technical standards, and their standardization is the premise and core content of Baosteel's standardization operations. The criterion standards are classified into two categories: general criterion and special criterion. The technical standards include product standards, raw material standards, process standards, equipment standards, safety and environmental protection standards and standards for product quality acceptance, packaging, and marking.
(2) Standardization of Management Methods. It includes standardized management of management levels, management businesses, management methods and management tools, and the standardized management over the management system itself by means of standardized principles and methods.
(3) Standardization of Behavioral Actions. It includes standardized methods such as methodology research, job measurement, operation actions, and communication languages.

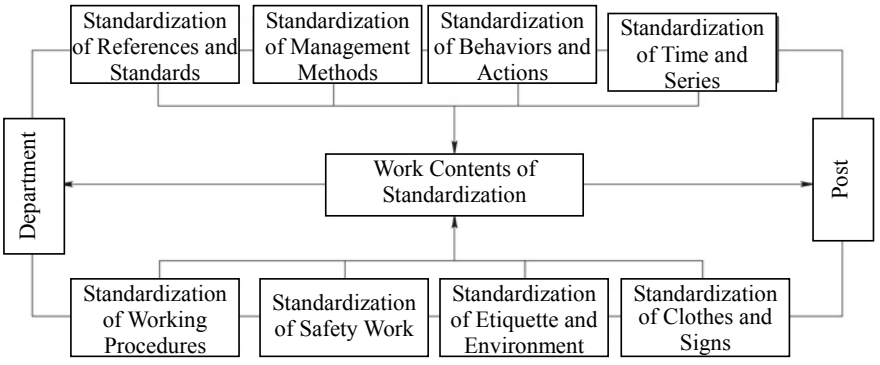

Fig. 8.2 Main contents of Baosteel's standardization operation

(4) Standardization of Time and Series. For example, employees are required to strictly abide by the work schedule; attention is paid to the control accuracy of planned work timing; pursue the standardization of working hours.
(5) Standardization of Working Procedures. It includes process standardization, standardization of work processes, and standardization of procedures in the fields of enterprise technology, businesses and managements, and is the basis and prerequisite for developing job work (job) standards.
(6) Standardization of Safety Work. This includes the development of safety or labor protection standards (or systems) as well as the implementation of safety standards, etc.
(7) Standardization of Etiquette. Including factory environment standardization, work environment standardization, conference management standardization, and social etiquette standardization.
(8) Standardization of Clothing and Logos. Including dress standardization, standardization of logo symbols, and standardization of corporate visual identity systems.

3. Basic Promotion System of Baosteel's Standardization

The company has set up a standardization promotion committee and standardization operation promotion offices under it. Each secondary unit has a departmental standardization operation promotion group and corresponding coordinator.

The company's standardization promotion committee is responsible for defining the objectives of promotion work of standardization and making the summary. According to the company's on-site production situation, it hosts meetings and conferences to promote the company's standardization and holds on-site inspections. It approves the incentives for advanced collectives and individuals who perform well in standardization operations.

The company's standardization promotion office is responsible for the formulation and post-analysis of the company's standardization promotion work plan, as well as preparing meetings and conducting on-site inspections.

The departmental standardization operation promotion team is responsible for formulating the management measures for the standardization operation of the department, defining the milestones and conducting the on-site inspection of the department.

The departmental standardization operation promotion coordinator is responsible for establishing the network system for promoting the standardization operation tasks of this department and is responsible for the daily standardization operation promotion activities.

4. Knowledge and Practices of Baosteel's Standardization

After nearly two decades of promotion, Baosteel's standardized contents have been continuously perfected. The requirements, standards, and practices of promotion have been continuously improved. This has played an important role in improving the on-site management level of the enterprise, enhancing the quality of the workforce and ensuring safe, continuous and smooth on-site production operations, and achieving business goals.

At the same time as standardization operations are carried out within the company, Baosteel continues to explore and has achieved positive results in terms of standard formulation, product certification, scientific research standardization management, and technical regulations. In recent years, Baosteel has compiled and completed a series of internationally advanced national standards such as *Cold-Rolled Steel Sheets and Strips for Deep Drawing*, *Steel Sheets and Steel Strips for Containers*, *Hot-Rolled Wide Strips for Petroleum and Gas Transfer Pipelines*, *Color Coated Steel Sheets and Strips,* and the *Test Methods of Color Coated Steel Sheets and Strips*. At the same time, Baosteel sent its staff relevant to standardization work to participate in meetings of international organizations such as ISO, IEC, API, European Coil Coating Association, and American Coil Coating Association; organized academic exchange activities with American Society for Testing Materials (ASTM); worked together in the GM Steel Products Working Group; and kept itself updated with the latest LCA and environmental reports to prepare for the certification of green signs.

8.3.2 Ansteel Group Corporation (Ansteel)

1. Development Strategy of Ansteel on Standardization

Ansteel Group Corporation (hereinafter referred to as Ansteel) is one of the first 26 standardization demonstration enterprises in Liaoning Province and a member among more than 20 domestic technical committees or technical subcommittees. It has developed standards applicable for productions and managements such as standards for the market research, product development, manufacturing, marketing, and after-sales service. It has undertaken and completed the formulation and revision of over 80 national (industrial) standards and the revision and reorganization of more than 300 corporate standards, contributing to regulating iron and steel enterprises becoming standardized, generalized, and serialized. Ansteel has incorporated the standardization development strategy into the company's overall development strategy. Its guiding lines for standardization work are to thoroughly implement the Outlook of Scientific Development, serve the company's business development, support the company's technological innovation, and ultimately achieve leading position in technology. It formulated its development goals of standardization work in the 12th Five-Year Plan period:

(1) Establishment and Strengthening of Corporate Standards. Optimize the company's standard system and structure and formulate and improve the corporate standards to cover the whole process; 85% of the corporate standards in parallel with international standards shall meet or precede their international counterparts; promote the effective implementation of standards; and significantly enhance the implementation benefits. At present, Ansteel has established a corporate standard system covering the whole process of production and has formed a standard system including procurement standards of raw and fuel materials, intermediate product, finished products, and inspection method standard system, which provides a strong guarantee for the production and operation of the enterprise.

Among the existing corporate standards of Ansteel, more than 50% of them reach and exceed international standard level. Among them, the corporate standards for hot rolling and cold rolling and coated products have accounted for above 90%. The percentage of implementing standards is far higher than the industry level. By promoting the implementation of corporate standards, customers have widely recognized and accepted the Ansteel standards. So far, all of the hot-rolled and cold-rolled products have followed the Ansteel standards.

(2) Multi-Point Coverage to National Standards. Ansteel actively participated in the activities organized by the Standardization Technical Committee, such as Steel Standards Committee, fully involved in the formulation and revision of national standards, and gradually turned the core technology of Ansteel into a national standard in key areas, making Ansteel a leader in national standards work.

By virtue of the opportunities that come with the government's recent advocacy to improve and perfect national standard system and strive to develop the national standards in important sectors, the company has fully engaged in national standardization work and increased its efforts and input in the formulation and revision of national standards. It fully connected to the National Steel Standards Committee and the Standard Committee of Iron Ores and Direct Reduced Iron, Pig Iron and Ferroalloys, became the committee members of the three major committees and its 22 sub-committees, and joined hands with them to apply, submit for approval of and develop national standards. Ansteel has improved the coordinated mechanism of the company's scientific research and standardization work to establish a close cooperation between these two tasks in order to carry out research and formulation of the national standards.

(3) Active Participation in Formulating International Standards. As a leading enterprise in the domestic iron and steel industry, Ansteel has reached a consensus on "Technology must be patented, patents must be embodied in standards and standards must be internationally accepted". Formulating international standards has become part of the company's strategic goals. With leadership support, the company has established a long-term mechanism for international standardization work. The development of international standards has been included in the company's scientific research management. New breakthroughs have been made in participating in international standardization work. Since Anshan Steel became the chair company to the secretariat of the ISO/TCl7/SCl7 subcommittee of "International Committee of Wire Rod and Steel Wire" in 1998, Anshan Steel has formulated five international standards as a domestic convener or participant. Among them, ISO 7989-1:2006 and another international standard, which were complied mainly by Anshan Steel, won the third prize of 2009 China Standard Innovation Contribution. The two international standards (ISO 22034-1:2007 and ISO 22034-2:2007) co-complied by Anshan Steel received the first prize of 2010 China Standard Innovation Contribution. The goal of Ansteel's international standardization has made a great step forward, and the role of Anshan Steel

has gradually transformed from a follower of the international standardization to a substantive participant.

2. Practical Effects of Ansteel Standardization Work

The standardization work of Ansteel has brought good economic benefits and huge social benefits to Ansteel. Through the adoption of European standards, international standards, and foreign advanced standards, Ansteel's heavy rails, shipbuilding steel plates, and container steel plates have won the title of China's famous brand products. The standardization work has promoted the improvement of product quality through the optimization of products, which triggered the brand name effect of enterprises. The national standard for low-power detection method of dendritic structure in continuous casting billets developed by Ansteel can save the company's inspection cost by 500,000 yuan per year. If it is promoted to the whole country, it will produce huge direct benefits. And what's more, it provides relevant parameters that are valuable to continuous casting production, technological parameter setting, and equipment adjustment and have a very significant effect on the improvement of product yield.

The standardization management work has also brought great benefits to Ansteel. The company has studied the application of the "GB/T 2828 sampling inspection procedure in the inspection of steel products". Some steel products were changed from the previous 100% inspection to sampling inspection or exemption from inspection. The inspection cost was saved up to 7 million yuan per year, and the method is still improving through continuous research.

3. Objectives of Standardization Work

(1) Continue to develop the corporate standard system and improve the advancement and applicability of the standards. During the 13th Five-Year Plan period, more than 80% of the corporate standards of Ansteel shall reach or exceed international standard level and the percentage for hot rolling, cold rolling, and coating products shall reach 100%. The structure of the corporate standards shall be improved so that all products be classified according to market demand and corporate standards be developed, in order to achieve green product standards and better meet market demand.
(2) Further improve the competitiveness of Ansteel in the national standardization work and play a leading role in terms of the number of national standards provided by Ansteel in the domestic industry, and, among the standards, 50% were listed in the 12th Five-Year Plan.
(3) Full Participation in International Standardization Work. The international standards formulated or revised by Ansteel shall not be less than one for each year; at the same time, professional international talents who understand both international standardization rules and can independently draft and participate in international standards exchanges shall be cultivated as soon as possible.

8.3.3 Nippon Steel & Sumitomo Metal Corporation (NSSMC)

Nippon Steel & Sumitomo Metal Co., Ltd. (hereinafter referred to as Nippon Steel) is one of the world's largest steel companies and Japan's largest multinational steel company. In addition to the Japanese headquarter, it has manufacturing bases in Asia, Europe, America, the Middle East, and Africa with products covering thick plates, thin sheets, rods and wires, steel pipes, and so on.

Japan has a complete set of industry standards, namely the JIS standard. The JIS standard is the most important and authoritative standard in Japan's national standards and is formulated by the Japanese Industrial Standards Committee (JISC). The JIS standard is divided into 19 items including automobiles, railways, ships, steel products, and fibers. Among them, steel standards include carbon structural steel, alloy structural steel, stainless steel and heat-resistant steel, spring steel, chromium-containing bearing steel, tool steel, and silicon steel for electrical grade.

In addition to the above national standards, the standard used in the Japanese iron and steel industry is the JFS standard made by Japan Iron and Steel Federation. The Japan Iron and Steel Federation is a juridical association among non-profit corporations. One of its main functions is to promote the standardization of the iron and steel industry. In conjunction with the situation of the downstream iron and steel industry, the standardization of steel specifications is carried out. Many Japanese technical regulations and standards are proposed by Japanese companies, reported to the competent government departments through industry associations, and finally issued by the government. The current president of the Japan Iron and Steel Federation is Kosei Shindo, the president of Nippon Steel & Sumitomo.

The Japan Iron and Steel Federation has always attached great importance to the integration of Japanese national standards with international standards to enhance the competitiveness of Japanese companies in the international market. The basic standards or methodology standards shall be directly adopted, while the product standards shall be directly adopted as much as possible. If not, they shall be equivalently adopted as much as possible. If not equivalently adopted, keep the inherent standards. This principle provides a convenient production standard reference for the global businesses of Nippon Steel & Sumitomo Metal.

As early as the twentieth century, when Nippon Steel accepted an order, JIS standards, or international standard +a was written in the technical conditions. In order to meet the customer requirements and win out in the market competition, Nippon Steel developed standard a, namely product standard or supplement technical conditions. This not only reflects the customer's requirements, but also reflects the company's level of technological innovation.

In the steel manufacturing process, Nippon Steel & Sumitomo Metal Co., Ltd., adopts various standards and specifications according to market demand. For example, the steel pipe products such as oil and gas transmission pipes produced by Nippon Steel & Sumitomo Metal Co., Ltd., adopt the standards of the global American Petroleum Institute (API standard), and the bars and wire rods for automotive steel adopt the standards of the Japanese Automobile Standards Organization (JASO

standard) or the standards of the Society of Automotive Engineers (SAE standard); mechanical structural steel, spring steel, bearing steel, and other bar and wire and stainless steel pipes generally follow the JIS standard.

As the Nippon Steel & Sumitomo Metal has continuously developed product research and improved its technical content, it has also formed a corporate standard more superior than the national standards. The "ABREX" series of thick plates produced by Nippon Steel & Sumitomo Metal Co., Ltd. is a wear-resistant component material used for various industrial machines such as construction machinery. It has effectively extended the life of machinery and components, contributing to weight reduction and achieving economy. The "ABREX" series of thick plates are available in four standard types and three high toughness types, which are suitable for a wide range of applications. The environment-friendly steel sheet for electronic parts produced by Nippon Steel & Sumitomo Metal Co., Ltd., which is named the "ECOTRIO" series steel sheet, is used in the electrical and electronic components industry. It is a Ni–Sn–Zn alloy-coated product by alloying the steel sheets with three metal electroplating of Ni, Sn, and Zn.

8.3.4 Pohang Iron & Steel Co. Ltd. (POSCO)

1. Overview of Corporate Standardization

The development of the standardization system of POSCO started from the 1980s, and it established the technical standards and operating standards of the company mainly based on the requirements of the Korean KS standards. Since 1986, the standardization system has been promoted throughout the company. In 1993, the ISO 9002 standard was introduced and the detailed contents of duties, operation procedures, and authority were standardized. In 1995, the standard management system was launched. From 1997 to 1999, QS9000, ISO 9002, ISO 14001, and other system were successively certified. Since 2000, with the official launch of the "Customer-Centered" PI (Process Innovation) project, POSCO has made appropriate adjustments to the original business procedures, simplified the contents of the original standard documents, cleared up the redundancy of standards among departments, set up standard documents conforming to the IT form, and further modified and improved the standard system. In 2012, the POSDMS standard management system was built to set up a networked management system. The functions of standard registration and inquiry were greatly improved.

2. Introduction to Typical Corporate Standards

In addition to actively adjusting the internal standard system, POSCO has also developed a series of standards related to advanced steel products and held a leading position in Korea.

(1) Steel HSA800 for Super High-Rise Architecture. The HSA800 (High Performance Steel for Architecture) developed by POSCO and the Research Institute

of Industrial Science and Technology (RIST) is made through TMCP. Its tensile strength is 800–950 MPa and yield strength is 650–770 MPa. Compared with the existing SM570 for building structure, its minimum tensile strength is increased by more than 40%, which ensures uniform strength and quality. The steel yield ratio is limited to less than 0.85, thus ensuring stability and shock resistance. In addition to the ultra-high strength, if used as a very thick plate material with a thickness of 100 mm, it can also present good deformation properties and is suitable for building structural systems. The cantilever beams assembled with HSA800 steel are not welded. Compared with SM490 steel, the load-bearing structure made of HSA800 steel can reduce the weight by 30% and shorten the construction period by 10%. The steel grade was adopted by the Korea Agency for Technology and Standards (KATS) on October 26, 2011, as a new standard "KSD 5994" (High Performance Steel for Architecture).

(2) High Manganese Steel Technology for LNG Storage Tanks. In March 2014, POSCO and the Korea Advanced Institute of Science and Technology (KAIST) jointly developed a large-capacity LNG storage tank with a storage capacity of 20,000 m^3, which is a 20 times increase compared with the storage capacity of 1000 m^3 of existing storage tanks. The material is high manganese austenitic steel developed by POSCO that is an energy steel that can withstand ultra-low temperature. It is especially suitable for storing LNG at minus 162 °C. Compared with the current stainless steel, it is not only superior in the welding performance but also easier to manufacture the tank body. In January 2015, in cooperation with the Ministry of Trade, Industry and Energy, POSCO formulated a series of new standards such as the *Standard for High Manganese Steel Sheets for Low Temperature Pressure Vessels (KSD 30131)*, *Arc Welding Rods for High Manganese Steel (KSD 7142)*, *Welded Flux Cored Wire for High Manganese Steel (KSD 7143)*, and *Submerged Arc Welding Wire and Flux for High Manganese Steel (KSD 7144)*. The development of these standards can reduce the number of welding, not only increasing production efficiency for customers but also saving manufacturing costs.

3. Remarks

By visiting the plant area, POSCO has mastered the actual situation and incorporated the optimal operation practices in formulating standards. It uses the charts to accurately distinguish the standard content and clean up unnecessary and formal standards. According to the PI project, POSCO revised the system operation manual, deleted duplicative standards existing among departments, unified the business guidelines, improved operation mechanism of the business guidelines, and increased efficiency. Through external cooperation, POSCO developed industry standards, comprehensively improved the practicality of technical standards and operation standards at the same time, vigorously promoted new technologies and new products, and guided the rapid development of the industry.

8.4 Prospect and Path Analysis of Standardization Trend

During the 13th Five-Year Plan period, China's iron and steel industry entered a stage of comprehensively advancing the supply-side structural reform. *The Adjustment and Upgrading Plan of Iron and Steel Industry (2016–2020)* proposes that, given that the iron and steel industry faces problems such as overcapacity, low level of independent innovation, intensifying constraints on resource and environmental protection and poor management of business operations, many of these issues require standards to lead and regulate; cutting excess capacity requires the use of environmental, energy, quality, safety, and technology standards to eliminate backward production capacity; iron and steel industry management and enterprise production and operation activities also require standards to standardize and guide.

8.4.1 Standards of Raw Materials and Fuels

1. Standardization Trend

The standardization work on the raw materials and fuels in China's iron and steel industry started relatively early, and the standardization system is relatively complete. In China, raw materials and fuels such as iron ores, cokes, coal, refractory materials, lime, and ferroalloy carbons have been defined with corresponding quality, classification, testing, and other standards at the national level and industry level. Some product quality standards have been classified very finely; for example, the standards of cokes are classified into metallurgical cokes, foundry cokes, gasification cokes, semi-cokes, and other varieties of quality standards. In addition, some enterprises have also established corporate standards that are suitable for the development needs of enterprises and are used to ensure the implementation of concentrate input strategy of the steel production.

At present, the quality, classification, and testing standards based on single source of raw material and fuel are basically complete. In the future, the standardization of raw materials and fuels will focus on the acceptance, efficient utilization, product grade breakdown and related organizational standards, such as acceptance technical specifications of coking coal, guidelines for cokes graded supply evaluation, and guidelines for evaluation of scrap utilization efficiency.

2. Path Analysis

(1) Continue to improve the standardization system of raw materials and fuels of China's iron and steel industry, learn from previous work experience in national, industry, enterprise and local standardization, and improve the organizational standard system of raw materials and fuels.
(2) Focus on the standardization of raw materials and fuel grade subdivision, evaluation of utilization efficiency, green supply chain and technical guide

of resource security in order to promote the stable supply of raw materials and fuels, and meet the transformation and upgrading needs of the iron and steel industry.

8.4.2 Process Equipment Standards

1. Standardization Trend

China has formed a relatively complete standard system for process equipment in iron and steel industry, and with the continuous improvement of the level of process equipment, the standard system has been continuously improved. It has been embodied in national standards, industry standards, and corporate standards. Before the twenty-first century, the innovation of process equipment in China's iron and steel industry is mainly reflected in upsizing and increase of efficiency in single equipment, such as blast furnace replacing cupola, converter replacing open hearth furnace, continuous casting process replacing die casting, high-speed wire mill replacing double duo mill, mechanized coke ovens replacing primitive ovens, and the like. Since the twenty-first century, the progress of process equipment made by China's iron and steel industry is mainly reflected in the application of synergistic high-efficiency technology between processes, clean steel production platform technology, and intelligent manufacturing technology, such as blast furnace expert system, one hot metal ladle technology, converter one-button steelmaking, thin slab continuous casting and rolling, endless hot rolling, and intelligent manufacturing system supporting mass customization steel. Therefore, in the future, the standardization work of process equipment will focus on new processes and intelligent production, such as technical specifications of ESP endless strip rolling technology and technical specifications of intelligent 7-m and larger large-scale coke oven.

2. Path Analysis

(1) Continue to improve the standardization system of process equipment in China's iron and steel industry, learn from the previous work experience in national, industry, enterprise and local standardization, and improve the organizational standard system of process equipment.
(2) Standardization work in the process equipment of the iron and steel industry shall focus on new technologies and intelligent production aspects. In addition to the standards of the entire equipment, standards for certain specific components can be formulated.

8.4.3 Product Standards

1. Standardization Trend

   (1) Make the selection of standard of metallurgical products more autonomous. In March 1989, China promulgated the *Standardization Law of the People's Republic of China* for the first time, which classified the national standards and industry standards into mandatory standards and recommended standards. It stipulated: The standards and laws that serve to safeguard human health, personal and property safety and enforceable standards stipulated by regulations and laws are mandatory standards while the other standards are recommended standards. Mandatory standards must be observed. The recommended standards are the ones that the government encourages enterprises to adopt voluntarily, and once the company adopts the recommended standards in the contract or agreement, it is subject to the law and becomes mandatory. Measures shall be taken to gradually release the degree of voluntary adoption of recommended standards, giving customers more choices and greater autonomy to reflect the flexibility, timeliness, and economy of standards in the market economy. At present, the national and industrial standards for metallurgical products have all been changed from mandatory ones to the recommended ones.

   (2) Make metallurgical product standards more suitable for market needs. Due to the transformation and upgrading optimization adjustment of China's iron and steel industry, the demand for steels has undergone great changes and the consumption structure becomes more multi-level and diverse. Eliminating backwardness, improving product quality and efficiency, and accelerating the pace of industrial restructuring and product upgrading through scientific and technological progress, it is the fundamental guarantee for China's metallurgical industry to meet market demand and improve competitiveness. It is also the center and focus of metallurgical standardization work.

   (3) Make metallurgical product standards more international. Standards are an important means of competition in the current international market. The differentiated competition between individual products gradually evolves into the competition of industry standards. Controlling and influencing the process of standard formulation and revision become the new focus of market competition. The competitive advantage in terms of standards is an important basis for a country (region) to get more shares of interests in the international market competition. More and more countries and regions recognize the leadership in the formulation of international standards as an important means to promote industrial upgrading, enhance market competitiveness, and resort to advanced technical standards to control the dominant position in international market competition. By adopting international standards and advanced foreign standards, China's iron and steel industry standards can accelerate its pace to meet international standards and narrow the gap to international counterparts. Promoting Chinese standards to "Go global"

can speed up the internationalization of local standards and the output of standards can drive the export of steel products and capacity projects.

2. Path Analysis

(1) Adhere to the combination of advanced and practical standards with priority on the advancement of standards. In today's market competition, standards have become the most powerful means of market competition. Whoever obtains the right to formulate standards and embody its technologies in standards will have the initiative in the market. Technical standards have become the commanding height of competition in an industry, especially high-tech industry. In the mode of conventional large-scale industrial production, products come first before standards. In the era of rapid development of the knowledge economy and science and technology, standards often take the lead. In a certain sense, the competition of the future products is, first of all, the competition of the advanced and practical standards of products. It depends on who can better meet the needs of customers, guide the future development, and create more values for the development of customers.

(2) Actively participate in international standardization activities to promote and accelerate the integration with the international community. Standards are the most important discourse system in current international competition. The winners of standard competition can control the development direction of related technologies and market innovation direction for a long period of time and enjoy extensive control and industry leadership in the international market. Attention shall be paid to actively participating in international standardization activities and actively adopting international standards. In key areas, it is necessary to follow up the whole process of drafting international standards or directly participate in it by sending delegates. We shall involve more in the routine businesses of the secretariat and work groups and control the formulation and revision projects of specific international standards, promote and accelerate the integration of China's product standards with international standards, expand China's influence in the field of international standardization, and safeguard the trade interests of the industry.

8.4.4 Energy Standards

1. Standardization Trend

The iron and steel industry is a key industry for energy conservation and emission reduction, and it is also the industry with the most potential and the most mature conditions to carry out energy conservation standards. At present, the iron and steel

industry has energy consumption limit standards only for the main production processes, and the industry standards for basic energy utilization such as energy conservation and energy utilization are scarce, which is not conducive to standardizing enterprise's basic energy management and developing the industry-based energy conservation work. In view of the current industry development situation, the industry urgently needs enterprises to focus on energy conservation and emission reduction, take initiatives to change its development mode, improve the management level and competitiveness of enterprises through energy-saving standards in order to promote the green transformation of the industry, and take a new industrialized road featuring high technology content, good economic benefits, low resource consumption, and low environmental pollution.

2. Development Path

   (1) Establish a pyramid-shaped model structure, breaking the pattern of small correlation and poor mobility between the previous standards. The national standard is a mandatory standard and the basic standard that all enterprises must strictly abide by in their production activities. It takes position at the bottom of the pyramid. The industry standard is the entry threshold for the industry. It is among the second tier standard system that combines the energy consumption characteristics of the industry with the development trend of the industry on the basis of national standards. The organizational standards shall represent the vanguard of energy-saving technologies in the industry and have three-tier standard systems consisting of national standards, industry standards, and local standards.
   (2) Strengthen the formulation and revision of energy conservation standards in key areas. Accelerate the formulation and revision of energy-saving standards for industries such as steel and non-ferrous metals and establish a standard system covering energy conservation, energy conservation monitoring and management, energy management and auditing of production equipment.
   (3) Implement demonstration projects for energy conservation standardization. Build metallurgical parks or key steel enterprises with demonstration and radiation effects into demonstration projects of energy-saving standardization, promote advanced energy-saving technologies and equipment such as low-temperature waste heat power generation, absorption heat pump heating, ice thermal storage, high-efficiency motors and motor systems, and enhance energy utilization efficiency of enterprises.
   (4) Promote the internationalization of energy conservation standards, keep pace with the development of international standards in the field of metallurgical energy conservation, substantively participate in or lead the formulation of a number of international standards for metallurgical energy conservation, and expand the international market share of metallurgical energy-saving technologies, products, and services. Strengthen bilateral and multilateral international cooperation in formulating metallurgical energy conservation standards and promote the establishment of mutual recognition mechanisms for energy conservation standards with major trading countries.

8.4.5 Environmental Protection Standards

1. Standardization Trend

With the frequent occurrence of air pollution and the increasingly tight water resources, the prevention and control of air pollution in the iron and steel industry and water-saving standardization have drawn more and more attention from environmental protection and related departments. In the future, government-led national-level standards in the field of environmental protection will be formulated and the conflict between regional environmental capacity and production capacity scale in the region will loom large. Under this background, differentiated pollutant discharge standards for different iron and steel enterprises will be put into force and local environmental protection facilities and technical application will be standardized to foster a development mode in which new standards coexist with existing national environmental protection standards and all standards are strictly implemented. The mandatory nature of the standardization work will be in full play to meet the annual reduction of air pollution in the region and continuously upgrade waste gas and wastewater treatment facilities. The aim is to let iron and steel enterprises have laws and standards to follow so as to finally cure the problems such as air pollution across the country, low efficiency of using water resources, difficulty in accounting environmental protection costs, low efficiency of end-of-pipe treatment facilities of steel enterprises, and short equipment service life.

As the competition in the metallurgical market become increasingly fierce, the benefits from standardization will be fully demonstrated. In the competition of steel products, the standardization work for green design products will lay sound basis for controlling the energy consumption of producing steel products and the design of the whole life cycle. Through the evaluation on steel enterprises themselves and its green production involvement, it is intended to encourage a positive market in which enterprises tap their potentials by adhering to standards and enhance utilization efficiency of energy resources in true accordance with national and local environmental protection requirements. Through the leading and restraint role of standards, the undesirable enterprises that sacrifice environment in exchange for its cost advantage of production shall be forced to quit the industry so as to improve the market competitiveness of steel enterprises that comply with environmental protection regulations and follow the green design concept and let them grow bigger and stronger. By doing so, we gradually realize the "high-end quality" transformation requirements of *Made in China 2025* and achieve the comprehensive and sustainable development of iron and steel industry featuring green and orderly growth, higher quality, and efficiency.

It is true that, by looking at the emission standards and water resources utilization indicators in the industry, some indicators have reached or even exceeded the international advanced level. On the surface, the international level of environmental protection standards in China's iron and steel industry has increased significantly, but in fact the operational effects and technical indicators of atmospheric and water pollution control facilities are relatively lagging behind, which greatly restricts the

function of evaluation mechanism for the actual effects of environmental protection facilities in all enterprises. Such problems will be expected to be improved through standardization in future. In addition, China's talent pool in the environmental protection field of the iron and steel industry needs to be expanded. Only through in-depth understanding of all processes and current problems existing in the iron and steel industry can we continuously deepen the understanding of standardization work while improving environmental protection standards in the relevant fields of the iron and steel industry and put forward feasible and forward-looking advice for standardization work. In the future, by cultivating more professionals oriented to metallurgical environmental protection standardization and relying on them to participate in the environmental protection standardization activities of international metallurgical community, China's steel environmental protection standards will rival the world counterparts or even make international standards, leading the environmental standardization work globally.

2. Path Analysis

China has successively issued a number of macro-level laws and regulations such as the *Air Pollution Prevention Action Plan*, *Water Pollution Prevention Action Plan,* and *Soil Pollution Prevention Action Plan* involving many sensitive issues such as air pollution control and total water consumption, water utilization efficiency, and prevention of water pollution. However, it is still necessary to attribute metallurgical nature and features to the general environment protection standards in order to achieve the environmental expectations. *The CPC Central Committee Recommendations for the 13th Five-Year Plan for Economic and Social Development* clearly stated that restrictive targets shall be imposed on the emission of atmospheric pollutants and the most stringent water resources management system in which water resources determine how much and where to produce shall be implemented to build a water-saving society. In addition, the *National Standard System Construction and Development Plan* put the implementation of major projects for energy conservation and emission reduction standard in a prominent position. The revision of the pollutant discharge standards in the iron and steel industry during the 13th Five-Year Plan period will shock the market of the environmental protection transformation at a certain level. The major green renovation projects such as the desulfurization and denitrification of coke oven flue gas and the denitrification of sintering flue gas mentioned in the "*Adjustment and Upgrade Plan for Iron and Steel Industry (2016–2020)*" will also be gradually implemented. *The Opinions on Promoting Contract Water Saving Management to Boost Water Saving Service Industry Development* stated to establish a technical standard system of contract water-saving management. To implement the above-mentioned policies, we must have a "Breakthrough point" and take feasible monitoring and treatment measures to fully play the core role of the standardization work in environment protection and to reduce the standardization work into various steps.

In view that the current environmental protection standards system in China's iron and steel industry is still not perfect, the environmental protection standardization work requires the technical support from a third-party authoritative consulting organization with a strong industry background to comprehensively combine the research and development of environmental protection standards and the enforcement regulations and conduct post-assessment on implemented standards. It shall promptly offer advice to the technical committee of SAC/TC207/metallurgical environmental management standardization and the technical committee of SAC/TC275/metallurgical environmental protection industry standardization on the validity, revision, or abolition of the relevant standards. At the same time, it organizes the presentation, interpretation, training, discussion, and justification of environmental protection standards for the iron and steel industry, and organizes or participates in the formulation, revision, justification, and review of environmental protection standards in the industry.

The Working Group of the Metallurgical Environmental Protection Industry and Environmental Management Standardization will carry out the formulation and revision of standards for the key equipment of environmental protection in the iron and steel industry such as the fully enclosed raw material yard, flue gas desulfurization and denitrification, dust removal, wet electrostatic precipitator, advanced treatment of coking wastewater, and the treatment of cold rolling wastewater; the formulation and revision of products standards; the formulation and revision of standards for flue gas desulfurization equipment from steel slag treatment, equipment for synergistic governance of active coke flue gas; all-in-one equipment for coke oven desulfurization and denitrification, coking wastewater treatment equipment, life cycle evaluation of circulating water pumps, high-efficiency evaluation and energy efficiency evaluation; the formulation and revision of energy efficiency evaluation standards; the standardization and revision of products such as coking and sintering flue gas denitration catalysts, water treatment agents, and high voltage power supply of electrostatic precipitators. It organizes publicity and interpretation of standards of environmental protection equipment and products in metallurgical industry, investigates the implementation of enforced standards for evaluation analysis and information feedback, and writes reports; it submits projects with encouraging achievements in professional fields to the National Standardization Administration Committee and relevant competent authorities for awarding purpose; it organizes the formulation and revision of standards pertaining to environment management and crucial evaluation elements in terms of environmental performance evaluation on China's iron and steel enterprises and on each production unit, the environmental information disclosure of iron and steel enterprises and the environmental cost accounting of iron and steel enterprises; it develops detailed regulations for the technical specifications of the upcoming "Pollutant discharge licensing system" and extends its application in key links and submits assessment specifications for the green products; it aims to comprehensively improve the coverage and precision implementation of environmental protection standards in the iron and steel industry and guide the enterprises in their efforts of standardized the green, standardized, systematic transformation, and upgrading.

8.4.6 Water-Saving Standards

1. Standardization Trend

With the increasingly tight water resources situation, the water-saving standardization work in the iron and steel industry will gradually attract more attention. There will be a situation in which the standards set by the government and the standards independently developed according to the market situation by the iron and steel enterprises develop in parallel and supplement each other in effect. This gives full play to both the mandatory standards and recommended standards and meets the requirements of steel enterprises on saving regional water resources, reclaiming wastewater, reducing the cost of water, and extending the service life of water treatment equipment in steel companies.

With the continuous development of water-saving standardization work, the foundation of water-saving standards in steel industry will continue to be consolidated. Relying on the water-saving work platform, the water-saving work in the iron and steel industry will be more standardized and normalized, promoting the establishment of water-saving standards in the iron and steel industry, developing and cultivating a number of advanced enterprises who lead the way in water-saving standardization in the industry, and creating driving force of water-saving standardization work in the iron and steel industry.

As the competition in the metallurgical market become increasingly fierce, the benefits from standardization will be fully demonstrated. Among the competitors of steel products, standardization work will make the energy consumption of steel products traceable and enable steel enterprises to improve the efficiency of energy resource utilization, meet local environmental protection requirements, enhance product competitiveness, and achieve sustainable development.

China's water consumption indicators in iron and steel industry have been at the international advanced level, and the internationalization of Chinese water-saving standards in the iron and steel industry has increased significantly. In the future, in the process of improving the water-saving standards in the iron and steel industry, China will cultivate more talents with expertise in metallurgical water-saving standardization, participate more in international steel water-saving standardization activities, spread the metallurgical water-saving standards to the world, and lead the global metallurgical water-saving standardization.

2. Path Analysis

China has successively issued the *Measures for the Implementation of the Most Strict Water Resources Management System* and *Water Pollution Prevention Action Plan* and other systems, and put forward requirements from the aspects of total water consumption, water use efficiency, and prevention of water pollution. *The CPC Central Committee Recommendations for the 13th Five-Year Plan for Economic and Social Development* clearly stated that "the most stringent water resources management system in which water resources determine how much and where to produce, shall

be implemented to build a water-saving society". *National Standard System Construction and Development Plan* encouraged to implement major projects for energy conservation and emission reduction standardization; *Opinions on Promoting Contract Water Saving Management to Boost Water Saving Service Industry Development* established a technical standard system of contract water-saving management. To implement these policy documents, we must have a "Breakthrough point" and feasible measures. Standardization work will be the core of water-saving endeavor and one of the important ways to reduce water-saving work into various fields.

It shall be noted that the water-saving standard system in China's iron and steel industry is still not complete. China's steel water-saving standardization work requires a special platform organization who shall investigate and study the implementation of water-saving standards in the iron and steel industry, conduct post-evaluation on the enforced standards, and give advice to the National Standardization Administration Committee and the National Water Conservation Standardization Technical Committee on the validity, revision, and abolish of the relevant standards. At the same time, it shall organize the propaganda, interpretation, training, discussion, and demonstration of water-saving standards in the iron and steel industry, and organize or participate in the revision, formulation, demonstration, and review of water-saving standards in the iron and steel industry.

Through the research on water system in the iron and steel industry, combining with the characteristics of water use in the iron and steel industry, the water-saving standards in the iron and steel industry mainly involve water-saving terminology classification and definition, water-saving management and statistics, water quality and consumption monitoring and measurement, water quotas and water efficiency standards, and calculations and assessments to contract water conservation and management, water balance test methods and assessments, water-saving assessments and appraisal, and other standards.

The Metallurgical Water Saving Standard Working Group will carry out research work on the water-saving standard system of the iron and steel industry, and sort out, establish, and improve the water-saving standard system framework of the iron and steel industry. The focus will be placed on six aspects to develop water-saving standards for the iron and steel industry: basic standards, water quotas, contract water-saving management, wastewater zero-discharge, calculation methods, and assessment and evaluation system.

8.4.7 Circular Economy Standards

1. Standardization Trend

Vigorously promote the comprehensive utilization of metallurgical resources and the standardization of circular economy; accelerate the promotion of standardized management of metallurgical secondary resources recycling and the promotion and application of advanced energy conservation, environmental protection, and comprehensive utilization of resources. Action is taken mainly from the following three aspects.

Technical product standards: standards for comprehensive utilization technologies, products and equipment of metallurgical tailings, waste rocks, smelter wastes, dust and slurry, waste materials, and domestic wastes; standards for comprehensive utilization technologies, products, and equipment of secondary resources such as metallurgical wastewater, waste liquid, waste gas, residual heat, and residual energy.

Iron and steel industry park standards: standards for park spatial layout and industrial structure standards, standards for park industry chain and recycling production, standards for park resource utilization, standards for park pollution prevention and information technology and management.

Key common standards: standards for basic management over statistics, inspection and tests, recovery, storage, and transportation of secondary resources like metallurgical wastewater, waste gas, solid waste, and residual heat and residual energy; standards for comprehensive utilization technologies of existing resources, evaluation standards, and indicator system of cyclic economy of iron and steel enterprises.

2. Path Analysis

Based on the theory of circular economy, the model of circular economy implementation is deeply analyzed. The life cycle analysis method is adopted to build a circular economy system framework based on the feasibility of technology and the development management requirements. Construct a technical standard system, management standard system, and job standard system framework covering all aspects of processes, equipment, inspection, measurement, energy, safety, environmental protection, and quality management. In addition, organize the revision and formulation of relevant standards through standardization means, proceeding from the actual development of circular economy and in combination with the characteristics of the industry. Standardization practitioners shall continue to explore and develop absent standards, and turn the advanced technological achievements and experiences in production management operations into standards. For example, efforts in metallurgical slag treatment shall focus on strengthening the combination of resource utilization technology and standardization, and incorporating new technologies and processes into the standards. In treatment of iron-containing dust sludge, it is urgent to develop corresponding standards to promote clean production in the industry, promote the transformation of scientific research results into productivity, and reduce the dumping of dust pollutants.

8.4.8 Logistics Standards

1. Standardization Trend

Under the current rapid development of "Internet +" drive, the traditional logistics industry, under the influence of Internet technology and new development models, is improving operational efficiency and transforming the industry ecology. Internet technology will integrate logistics resources and bring revolutionary changes to the logistics industry. The main development directions include the logistics system integration and intelligent development, the integration of enterprise logistics system and production system, the diversified development of logistics system by integrating individual technologies, the massive application of IoT technology, and the low-carbon and environment-friendly construction of logistics systems.

With the rapid development of the logistics industry and the active embrace of the Internet technology, the pace of logistics standardization will be further accelerated. Standardization of steel logistics system must base itself on the standardization of hardware facilities while software standardization is distillation. On the basis of the unification of information standards, facilities, and equipment standards, the improvement of operational standards, management standards, and service standards shall be the focus and represent the developing trend of logistics industry in this professional field.

2. Path Analysis

(1) Establish a steel logistics standard system with steel enterprises as the core of the supply chain. The logistics standard system is an organic integration of various standards within the scope of logistics standardization framework. The steel logistics standard system is an institutional framework involving logistics-related standards in the iron and steel industry. The establishment of this standard system is the basis for organizing a scientific and rational structure of standards within the scope of steel logistics standardization work. It is a blueprint that covers the existing practices and future development standards in the field of steel logistics, and is a guiding and fundamental work for the formulation and revision of steel logistics standards.

Due to the core position of the iron and steel enterprises in the metallurgical supply chain system and their significant agglomeration effect on flow of goods, logistics services and logistics information, establishing a steel logistics standard system that treats iron and steel enterprises as core of supply chain and covers the metallurgical circulation field is an effective measure to build logistics standards covering the whole metallurgical supply chain (a complete framework). The scope of the standard system shall help the effective connection between social logistics and enterprise logistics, improve enterprises' dependency on social logistics, indirectly promote the socialization and industrialization of enterprise logistics, and effectively improve the efficiency of enterprise logistics and reduce the logistics of cost.

(2) Guided by the national logistics standard system, a steel logistics standard system framework will be built. The metallurgical supply chain system is segmented into links according to the scope of the entire supply chain covering the supply, production, sales, and circulation of the industry. At the same time, according to the framework of the national logistics standard system, the above-mentioned links are further segmented in accordance with logistics technical standards and logistics services standards, logistics information standards, logistics management standards, etc., establishing a metallurgical supply chain logistics standard framework that covers the whole industry chain. The framework focuses on the content of relevant logistics standards in the micro-logistics sector of the iron and steel industry, including the standards for logistics technology and work-related standards involved in the metallurgical supply chain system. After the main framework, the "Tree trunk" of the steel logistics standard system, is established, the "Branches and leaves" can "Grow" therefrom according to the existing steel logistics standards and the expected ones, and finally, a complete steel logistics standard system can come into being.

(3) Taking the formulation of key standards as a start point, initiate the formulation and revision of steel logistics standards in an orderly manner. The development and revision of steel logistics-related standards are still in its infancy and there are still some gaps in the steel logistics standards. However, as a principle, the formulation and revision of relevant standards shall prioritize the formulation of key standards and unfold orderly the other steel logistics standards. Key standards shall have strong market demand, can immediately solve the problems existing in the current steel logistics operation process, and can improve the logistics operation efficiency and reduce the logistics operation cost for the industry and enterprises. Only through the significance of the key standards can the important role of the formulation and revision of steel logistics standards be highlighted, thus initiating the preparation of other steel logistics standards.

(4) Paying attention to the standardization of production logistics in iron and steel enterprises. Iron and steel enterprises have huge flow of production logistics and complex logistics processes. However, because they belong to the internal logistics of enterprises, they have always been kept in a closed development mode, independent of the social logistics system, with a low degree of socialization. Since the production logistics in steel enterprises are all operated by usage due to its closed model, there are serious shortages of logistics standards, the logistics operation efficiency is low, the connection of logistics links and the logistics operation cost is unsatisfactory. Being confronted with the grim situation of the overall "Cold winter" of the iron and steel industry, the standardization of production logistics in iron and steel enterprises is imminent. At the same time, the production logistics standards of iron and steel enterprises shall be effectively combined with the relevant standards of social logistics and the channels between internal logistics and social logistics must be opened. Internal logistics must

gradually move its development focus to non-steel businesses, expand the degree of enterprise logistics outsourcing, reduce the number of enterprise personnel, and improve the labor productivity of enterprises.

8.4.9 Informatization Standards

1. Standardization Trend

The Adjustment and Upgrade Plan for Iron and Steel Industry (2016–2020) issued by the Ministry of Industry and Information Technology pointed out that the smart manufacturing base must be consolidated. It is necessary to comprehensively carry out the work of standardization and assessment for the integration of information technology and industrialization management system in iron and steel enterprises and promote the standardization of steel intelligent manufacturing.

The Guidelines for the Construction of National Intelligent Manufacturing Standards System (2015 Edition) jointly issued by the Ministry of Industry and Information Technology and the National Standardization Administration Committee pointed out that we will strive to establish a relatively complete system of intelligent manufacturing standards by 2020. More than 500 intelligent manufacturing standards will be formulated and revised so that basic common standards and key technical standards are fully covered. Intelligent manufacturing standards will be widely verified in enterprises and applied in all areas of manufacturing, thus promoting the improvement of China's intelligent manufacturing level and increasing the international competitiveness of Chinese manufacturing standards significantly.

According to the *Construction Guidelines*, the development of informatization standards in the iron and steel industry will also be carried out from three dimensions: life cycle, system level, and intelligent function. The content will contain basic commonality, key technologies, and iron and steel industry standards. There is no affiliation between the intelligent manufacturing standard system and the iron and steel industry standard system, and the contents of the two are intersected. The intersection lies on the part of iron and steel industry application standards in the intelligent manufacturing standard system—for example, the iron and steel industry standards that are used to guide steel-related production, design, management, etc., and the key standards of the iron and steel industry in the intelligent manufacturing standard system that involve the related aspects of intelligent manufacturing such as interconnection and connectivity in the iron and steel manufacturing process.

2. Path Analysis

Intelligent manufacturing is the most effective way to achieve transformation and upgrading of China's iron and steel industry. Intelligent manufacturing has a strong comprehensive nature. It is not only meant to the breakthrough and application of single technology and equipment, but the deep integration and innovative integration

of manufacturing technology and information technology. Therefore, the informatization standards of the iron and steel industry will focus on smart manufacturing in the future and developed from the following aspects:

(1) *The National Intelligent Manufacturing Standard System Construction Guide* will be used as basis for approving projects. *The Construction Guidelines* will be used as the basis for guiding the establishment and revision of national standards and industry standards for intelligent manufacturing in the coming period.
(2) In accordance with the principle of "Prioritizing Common and General Standards and Standards in Urgent Need", the focus will be on establishing standards of cross-domain and cross-industry system integration. By coordinating standard resources and optimizing standard structure, it focuses on solving the bottlenecks in promoting intelligent manufacturing like data integration and interconnection and connectivity.
(3) Being Based on National Conditions and Clearing Obstacles for Cooperation. Based on the characteristics of China's intelligent manufacturing standards such as weak foundation and the imbalance of industry development, we must fully consider the applicability of standards, strengthen the standardization and industrialization of independent intellectual property rights, strengthen communication with advanced manufacturing countries and international standardization organizations, and duly include independent intellectual property rights standards as international standards. At the same time, the international standards that are suitable for the development needs of China's manufacturing industry must be transformed into national standards in a timely manner. Our goal is to set up an intelligent manufacturing standard system with good compatibility and openness.
(4) Advance with the Times and Make Sustained Efforts. Intelligent manufacturing is a huge system of dynamic development. The industry's understanding of intelligent manufacturing will be a gradually deepening process. With the development of intelligent manufacturing technology and industry, new modes and new forms of businesses continue to emerge, and the intelligent manufacturing standard system will be dynamically adjusted and improved.
(5) Establish Application Standards for Intelligent Manufacturing in the iron and steel industry. On the basis of the common standards related to intelligent manufacturing and according to the characteristics of the iron and steel industry, we must accelerate the formulation of application standards for the iron and steel industry such as smart factories, intelligent logistics, network collaborative manufacturing, large-scale personalized customization, and remote operation and maintenance in the iron and steel industry, aiming at a breakthrough in the field of intelligent manufacturing.
(6) Establish a new standard system to develop and coordinate with the standards independently formulated by the market under the leadership of the government.

8.5 Industrial Practices of Standardization

China Metallurgical Industry Planning and Research Institute (hereinafter referred to as MPI) has undertaken secretariat work of six standardization working groups including groups for TC20/metallurgical energy foundation and management, TC207/metallurgical environmental management, TC275/metallurgical environmental protection industry, TC442/water saving in iron and steel industry, TC415/metallurgical resources comprehensive utilization, and TC269/steel logistics. MPI has undertaken the work of the secretariat of five standardization working committees including China Special Steel Enterprise Association, China Steel Structure Association, China Circular Economy Association, Henan Iron and Steel Association, and China Metallurgical Mining Enterprise Association. The China Metallurgical Industry Planning and Research Institute can provide enterprises with comprehensive and systematic standardization consulting services, including formulation and revision of national, industrial, association's, corporate standards, corporate standard system construction and strategic planning, corporate standard-related training, corporate standards public statement, evaluation and improvement, domestic and international standard analytic research and publicity, etc., which are shown in Table 8.1 for detail.

Table 8.1 Practices of MPI in promoting industry standardization

No.	Types	Main content	Typical cases
1	National standards	Be committed to establishing standard systems for metallurgical energy conservation and environmental protection, comprehensive utilization of resources and steel logistics, and strive to promote green, recycling and low-carbon transformation of metallurgical industry, and promote efficient, safe and optimized operation of steel logistics. Relying on six standards working group as platforms, MPI provides services for the establishment, revision, organization and coordination, standard-related training and publicity of relevant national standards for enterprises in need	MPI provides technical services for the formulation and revision of national standards such as the *Methods for Calculating Water Savings in the Iron and Steel Industry* and *Energy Audit Methods for Iron and Steel Enterprises*

(continued)

Table 8.1 (continued)

No.	Types	Main content	Typical cases
2	Industrial standards	We will carry out research and development and conduct pilot work of industry standards in the fields of iron and steel industry products, energy conservation and comprehensive utilization, environmental protection, logistics, green manufacturing, and integration of informatization and industrialization, and promote the transformation and upgrading of China's metallurgical industry and sustainable green development. MPI provides services for the establishment, revision, organization and coordination, standard-related training and publicity of relevant industrial standards for enterprises in need	We have provided technical services for formulation and revision of the following industrial standards: *Guidelines for the Evaluation of Green Manufacturing Plants in Iron and Steel Enterprises*, *Scope and Calculation of Logistics Costs of Steel Enterprises*, *Technical Specifications for Power Demand-Side Management Platforms in the Iron and Steel Industry*, *Technical Requirements for the Charged Raw Materials and Fuels to 4000 m^3 Blast Furnaces and Above*, *Code for the High Level Production Scheduling System (APS) of Iron and Steel Industry*, *Technical Requirements for Waste Heat Recovery of Blast Furnace Slag Granulating Water*, *Technical Specification for Treatment of Chromium-Containing Heavy Metal Wastes by Blast Furnace Method*, *Green Design Product Evaluation Specification for Stainless Steel Kitchenware*, *Technical Specification for Purification Through Sintering/Pellet Wet Desulfurization Flue Gas Cyclone Tube Electrostatic Precipitator*

(continued)

Table 8.1 (continued)

No.	Types	Main content	Typical cases
3	Associational standards	MPI is committed to the formation of a series of standards that adapt to market demand, lead the industry development, and fill gaps. It promotes the supply-side reform of the iron and steel industry through associational standards and meets the customized needs of the upstream and downstream industries of the industry chain for steel products. Relying on five associational standards working group as platforms, MPI provides services for the establishment, revision, organization and coordination, standard-related training and publicity of relevant associational standards	MPI has provided technical services for formulation and revision of the following associational standards: *Sorbite High-Strength Stainless Structural Steel Hot-Rolled Ribbed Steel Bar*, *Sorbite High-Strength Stainless Structural Steel Hot-Rolled Wire Rod*, *Sorbite High-Strength Stainless Structural Steel Hot-Rolled Steel Sheet And Strip*, *Sorbite High-Strength Stainless Cold-Rolled Steel Sheet And Strip*, *Sintered Products Made from Industrial Waste Slag for Stainless Steel Smelting*, *Alloy Square Steel*, *Steel and Alloy Silver Bright Bars for Internal Combustion Engine Valves*, *Stainless Steel Wire Rod for Cold Heading*, *Large Diameter Thick Wall Forging Pipes*, and *High Alloy Hot Die Forging Bars*
4	Corporate standards	The Metallurgical Planning Institute can provide enterprises with comprehensive and systematic standardization consulting services, including formulation and revision of corporate standards, corporate standard system building and strategic planning, corporate standard-related training, corporate standards public statement, evaluation and improvement, domestic and international standard analytic research and publicity, etc.	We have conducted consulting services such as *Product Standard System Construction for Zhengzhou Yongtong Special Steel Co., Ltd.*, *Product Standard System Construction for Jiangsu Shenyuan Group Co., Ltd.*, *Standardization Promotion Strategy for Tianjin Yuantai Derun Steel Pipe Manufacturing Group Co., Ltd.*

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