Study on technical standard of small complete domestic sewage treatment plant

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Abstract: This paper expounds the industry and policy background of small complete domestic sewage treatment plant in China, and discusses the basic principles and basic investigation of the development of technical standard for small complete domestic sewage treatment plant, the key technical contents of standard for small complete domestic sewage treatment plant are expounded. Through the development and implementation of this technical standard, it will provide standardized technical support for standardizing and improving the manufacturing level of small complete domestic sewage treatment plants in China.

1. Introduction

At present, although China's cities and counties at all levels of sewage treatment facilities and drainage pipe network has a considerable scale, the general sewage collection and treatment facilities penetration rate in rural and township areas are still low, with the rapid development of rural economy and society, and rural livestock and poultry breeding industry and rural industry, etc., the residents' life and production water consumption and wastewater emissions also increase with the development. A large number of untreated sewage has seriously polluted the soil, surface water and groundwater, and becomes an important source of pollution in the rural environment, leading to the black and smelly water of the rural river, and also a great threat to people's health that make it an urgent work to treat rural domestic sewage.

In recent years, China has set an ambitious goal of ecological civilization construction. The countryside is an important object of ecological civilization construction, and the construction of beautiful countryside has become the premise and foundation of beautiful China. The state attaches great importance to the construction of beautiful villages, and emphasizes the attention of ecological and environmental protection during the construction of new villages, and the comprehensive improvement of rural living environment should be done in accordance with local conditions. The treatment of rural domestic wastewater was an important part of the remediation of rural living environment and an important measure to implement the rural revitalization strategy.

In 2016, China has successively issued series of important environmental protection industries, planning and guidance documents such as “Outline of the 13th Five-Year Plan for National Economic and Social Development”, “The 13th Five-Year Plan for Ecological and Environmental Protection”, “Notice on the comprehensive work plan for energy conservation and emission reduction in the 13th
Five-Year Plan”, “The 13th Five-Year Plan for the development of energy conservation and environmental protection industry”. In February 2018, the General Office of the CPC Central Committee and the General Office of the State Council issued the “Three-Year Action Plan for Improvement of Rural Human Settlement Environment”. In July 2019, the central agricultural and other nine departments jointly issued “The Guiding Opinions on Promoting the Treatment of Rural Domestic Sewage”. All of these documents raised clear requirements for comprehensive improvement of rural living environment and accelerated treatment of rural domestic wastewater. Agricultural and rural pollution control has become one of the main battlefields of current prevention and control. To this end, based on the reality of China's rural areas, guided by the reduction of sewage, classification of local treatment, recycling and utilization, we should strengthen overall planning, improve the standard system, reasonably choose the technical mode, and actively promote the low cost, low energy consumption, easy maintenance, high efficiency sewage treatment equipment and technology. In October 2020, the "Proposal of the CPC Central Committee on the Formulation of the Fourteenth Five-Year Plan for National Economic and Social Development and the Vision Goals for the Year 2035" further emphasized "comprehensively promoting rural revitalization, implementing rural construction actions, and implementing a new round of improvement of rural living environment. On the basis of the obvious achievements in the past three years, we will continue to carry out the rural toilet revolution, domestic sewage and waste collection and treatment, improve the appearance of the villages, and build a livable and beautiful countryside.”.

The treatment of domestic wastewater in villages and towns in China was developing rapidly with unprecedented strength, and it had become a key work in the field of ecological environmental protection in China. With the increase investment in rural wastewater treatment facilities by national and local governments at all levels, small and medium-sized domestic wastewater treatment facilities serving small towns, rural areas and numerous scattered buildings (groups), communities or residential groups have grown rapidly in recent years. Small wastewater treatment facilities ranging from a few tons to dozens, hundreds or even thousands of tons per day are rapidly popularized in small towns and rural areas in China. While the number of small domestic wastewater treatment facilities increased rapidly, lots of small complete sets of domestic wastewater treatment plants were applied to these facilities. Although the treatment technology, technical parameters and overall dimensions are different for these small sets of domestic sewage treatment plant, mostly of them are products designed in advanced by standardization and seriation, products of the automation degree is high, also can realize the unattended operation, it greatly facilitates the procurement management of construction units, and can be used as a mechanical and electrical equipment directly to purchase, and it is more convenient for site installation, and avoid civil construction and equipment installation mutual influence on timing, the later maintenance operation is also relatively simple.

Therefore, the development and application popularization of small complete sets of domestic sewage treatment plant will undoubtedly promote the equipped, integrated and automated development of small domestic sewage treatment facilities, which is of great significance for the large number of small domestic sewage treatment facilities with scattered owners to improve the degree of standardization. On the other hand, the implementation of relevant environmental protection industry policies and plans of rural domestic sewage treatment cannot be separated from the support of technical standards. From the current progress and actual situation of rural domestic sewage treatment in China, various of technical standards, including discharge standards, product standards, performance testing methods standards, facility operation and maintenance standards, are still not enough. The research of technical standards for small complete sets of domestic sewage treatment plants aims to standardize the development, design and manufacture of small complete sets of domestic sewage treatment plants, and establish a clear basis for product quality control and third-party testing of small complete sets of domestic sewage treatment plants. The establishment and effective implementation of the standard will also make a positive contribution to reducing the cost of engineering construction, shortening the construction period, improving the quality of engineering construction and promoting the quality and efficiency of environmental protection equipment manufacturing industry.
2. Basic principle and research of technical standard of small complete domestic sewage treatment plant

2.1. Basic principle
The development of technical standards for small sets of domestic sewage treatment plants follows the principles of scientific, universality, foresight and expansibility. First of all, in the process of compiling technical standards for small complete sets of domestic sewage treatment plants, we must respect the objective conditions, take into account the particularity of small complete sets of domestic sewage treatment plants, and integrate scientific product development and design and standardization methods. Secondly, the standard should have guidance for all kinds of domestic sewage treatment facilities in application occasions. In addition, in view of the small complete domestic sewage treatment plant is still on development, we should fully consider the enterprise itself and Chinese same industry technical level, production level and management level of the actual situation, and also take into account of the reality of China's environmental protection equipment manufacturing industry rapid development, make the standard can adapt to the development and change of the technical level and production conditions. Finally, with the gradual maturity of domestic sewage treatment technology in the future, as well as the continuous development of related environmental protection equipment technical standards, the content of the technical standard will also be constantly enriched and improved.

2.2. Basic research
Proceed combing, researching and comparing of domestic and foreign existing rural sewage treatment equipment and facilities related technical standards, this can coordinate relations between technical standards of small sets of sewage treatment plant and current foreign, national and industry standards, and can make it more scientific and reasonable to determine the technical index, and easier to operate.

2.2.1. Foreign standards. Mainly include ISO, German, the United States, Britain and other international and foreign standards.
   (1) DIN 4261-2-1984《Small sewage treatment plants; plants with sewage aeration; application, design, construction and testing》
   (2) DIN 4261-4-1984《Small sewage treatment plants; plants with sewage aeration; operation and maintenance》
   (3) DIN 4261 T.1-1991《Small sewage treatment plants; plants without aeration (septic tanks); application, design and construction》
   (4) DIN 4261 T.3-1990《Small sewage treatment plants; operation and maintenance of septic tanks》
   (5) NF P16-800-3-2005《Small wastewater treatment systems up to 50 PT - Part 3 : packaged and/or site assembled domestic wastewater treatment plants》
   (6) DIN EN 12566-3-2005《Small wastewater treatment systems for up to 50 PT - Part 3: Packaged and/or site assembled domestic wastewater treatment plants; German version EN 12566-3:2005》
   (7) ISO 24511-2007《Activities relating to drinking water and wastewater services - Guidelines for the management of wastewater utilities and for the assessment of wastewater services》
   (8) EN 12566-3-2016《Small wastewater treatment systems for up to 50 PT - Part 3: Packaged and/or site assembled domestic wastewater treatment plants; German version EN》
   (9) NSF/ANSI 40-2013《Residential Wastewater Treatment Systems》
   (10) NSF/ANSI 46-2018《Evaluation of components and devices used in wastewater treatment systems》
   (11) NSF/ANSI 240-2017《Drain field Trench Product Sizing for Gravity Dispersal Onsite Wastewater Treatment and Dispersal Systems》
   (12) NSF/ANSI 240-2017《Drain field Trench Product Sizing for Gravity Dispersal Onsite
Wastewater Treatment and Dispersal Systems
(13) ANSI/NSF 46(i18)-2009《Evaluation of components and devices used in wastewater treatment systems》
(14) ANSI/NSF 46(i12)-2006《Evaluation of components and devices used in wastewater treatment systems》
(15) ANSI/NSF 46(i10)-2005《Evaluation of Components and Devices Used in Wastewater Treatment Systems》
(16) ANSI/NSF 46(i11)-2005《Evaluation of Components and Devices Used in Wastewater Treatment Systems》
(17) UL 979-2005《Water treatment appliances》
(18) NSF/ANSI 55-2019《Ultraviolet microbiological water treatment systems》
(19) DIN 4261-1-2010《Small sewage treatment plants - Part 1: Plants for waste water pretreatment》
(20) DIN-Fachbericht CEN/TR 12566-2-2007《Small wastewater treatment systems for up to 50 PT - Part 2: Soil infiltration systems; German version CEN/TR 12566-2:2005》
(21) DIN EN 12566-1-2004《Small wastewater treatment systems for up to 50 PT - Part 1: Prefabricated septic tanks (includes amendment A1:2003); German version EN 12566-1:2000 + A1:2003》
(22) BS EN 12566-6-2016《Small wastewater treatment systems for up to 50 PT. Prefabricated treatment units for septic tank effluent》
(23) BS EN 12566-3-2016《Small wastewater treatment systems for up to 50 PT - Packaged and/or site assembled domestic wastewater treatment plants》
(24) BS EN 14652 2005 + A1:2007《Water conditioning equipment inside buildings - Membrane separation devices - Requirements for performance, safety and testing》
(25) BS EN 12255-7-2002《Wastewater treatment plants. Biological fixed-film reactors》
(26) NF T50-980-2007《Plastics - Evaluation of disposability in waste water treatment plants - Test scheme for final acceptance and specifications》

2.2.2. Domestic standard. At present, the discharge standards related to rural sewage treatment mainly include GB 8978-1996 "Integrated Wastewater Discharge Standard" and GB 18918-2002 "Pollutant Discharge Standard for Urban Wastewater Treatment Plant" for reference. And national standards that is related with rural life sewage disposal equipment include GB/T 28742-2012 "the sewage treatment equipment safety technical specifications" and GB/T 10833-2015 "Technical specification of Marine sewage treatment equipment". The relevant industry standards involve the urban construction, transportation, chemical industry, environmental protection and machinery, its main technical content, scope and core technical specifications are different.

3. Core technical content of small complete domestic sewage treatment plant technical standard

3.1. Standard application scope and key terms definition
Technical standard for small complete domestic sewage treatment plant is applicable to a single set of rated daily treatment volume not exceeding 1000m3/d and domestic sewage as raw water. The complete set of sewage treatment plant with raw water quality similar to domestic sewage can be implemented by reference. “Complete set of small sewage treatment plant” refers to the combination of biochemical method, biochemical method and physicochemical method etc. process, follow the principle of integration, modularity, automation, which is used in the development and design of the sewage purification treatment, achieve water quality standards of complete sets of plants, mainly including bioreactor, process equipment, electrical control equipment, instrumentation and other major parts and pipes, cables, etc.”. Key terms and definitions of the standard also include domestic sewage, bioreactor,
plant room, plant body, integrated unit, split unit, equipment quality (weight), maximum total mass, clean water test, process commissioning.

3.2. Classification and marking of small complete sets of domestic sewage treatment plant
Small complete sets of domestic sewage treatment equipment can be divided into two types according to the overall structure. They’re integrated device and split device. According to the installation occasions, it can be divided into four kinds, including: indoor aboveground device, outdoor buried device, outdoor mobile (container) device, outdoor aboveground device.

Currently in the relevant industry standards that have been issued in China, the naming rules of product types of small sets of domestic sewage treatment plants are relatively chaotic, which is not easy for user to identify the key information of the products. Therefore, a unified naming rules of product types (marks) should be formulated to standardize them. Based on current condition, the technical standard of small complete sets of domestic sewage treatment plant provides the product labeling naming rules of small complete sets of domestic sewage treatment plant. Product mark are consisted of small complete domestic sewage treatment plant code (DWP), raw water quality code, effluent water quality code, treatment capacity code, installation site code and structure material code combination.

3.3. The operating conditions and main processes of small complete sets of domestic sewage treatment plants
In order to ensure the normal operation of the small complete domestic sewage treatment equipment, the technical standard defines the normal and special operating conditions of it. For normal use, applicable raw water conditions, environmental conditions, supporting facilities and installation conditions shall be considered. Among them, the factors of raw water condition include the amount of water, the water temperature, and the quality of influent water. The sewage whose inlet water quality index exceeds the specified in this article may also be treated by a complete set of equipment after proper pretreatment. Environmental factors to be taken into account include ambient air temperature, relative humidity, and altitude. Considerations for supporting facilities include the requirements of regulating tank, clear tank/middle tank, sludge tank, fence and so on. The installation conditions clearly define the requirements of the installation location of the small set of domestic sewage treatment plants in terms of transportation channels and loading and unloading working space, and the requirements of the bearing capacity of the installation base of the equipment, and the requirements of the buried depth and anti-floating of the outdoor buried device. When the small complete domestic sewage treatment plant is in a special application state, the applicable special requirements shall be followed, or follow a special agreement signed between the manufacturer and the user of the small complete domestic sewage treatment plant. If it is used outside normal conditions, the user should raise the demand to the manufacturer of the small domestic sewage treatment plant.

Small complete domestic sewage treatment plant can use biological contact oxidation method, aeration biological filter, moving bed biofilm reactor, anoxic/aerobic activated sludge process, anaerobic/anoxic/aerobic activated sludge method, sequencing batch type activated sludge process, membrane bioreactor and other wastewater treatment process, can also use the combination process of the two or more of above.

3.4. Core technical requirements of small complete domestic sewage treatment plant
The technical requirements of small sets of domestic sewage treatment equipment mainly include appearance requirements, function requirements, manufacturing requirements, strength and tightness requirements, safety requirements, environmental protection requirements, reliability requirements, economic requirements and universal requirements

3.4.1. Appearance requirements. The surface of the body should be smooth, and there should be no scars, convex and concave defects affecting the appearance; All protection and decorative coating should be uniform, there should be no peeling, peeling and other defects; The installation position of each appendant (part) of the complete plant should be accurate, and there should be no defects in each part
that block installation, overhaul and maintenance, etc.; The piping of the complete equipment shall be reasonable in layout and straight in installation.

3.4.2. Function requirement. (1) Treatment effect requirements: the effluent water quality is classified into five categories in this document: excellent, good, medium, ordinary and others. For the limits of pH, chromatics, suspended matter (SS), chemical oxygen demand (COD), five days biochemical oxygen demand (BOD5), ammonia nitrogen, total nitrogen, total phosphorus, anionic surfactants, animal and vegetable oils, petroleum, number of coliform bacteria in feces and other pollutants, the standard sets up limitation for them.

(2) Treatment capacity requirements: the actual treatment capacity of small complete domestic sewage treatment plant should not be less than 95% of its rated treatment capacity. The standard specified the grading requirements of rated treatment capacity of a single set of small complete domestic sewage treatment plant.

(3) Aeration requirements: The aeration equipment of small complete domestic sewage treatment plant should ensure that the air supply in each aeration area meets the design requirements, and the aeration is uniform.

(4) Electrical functional requirements: the electrical control cabinet of a small set of domestic sewage treatment plant should ensure that all electrical components can obtain the required power distribution, and work stably, and the panel of the electrical control cabinet and/or the functions of the man-machine interface can be used normally.

(5) Automatic control requirements: the automatic control system of small complete sets of domestic sewage treatment plant should ensure that it can operate unchecked (excluding the maintenance work of complete sets of plants, such as sewage lifting pump blocking treatment, grid slag cleaning and drug supplement).

3.4.3. Manufacturing requirements. The technical standard specifies the main structure material requirements of the small set of domestic sewage treatment plant for the material carbon steel, stainless steel, FRP or plastic, and also surface treatment requirements, body size for plants made of various materials.

3.4.4. Requirements for strength and tightness. The technical standard stipulates the load capacity, impact strength and compressive strength requirements of the main body of small sets of domestic sewage treatment plants made of different materials (FRP or plastic), as well as the pressure resistance of the bulkhead, and the strength and tightness requirements of the internal piping systems of water, gas and dousing.

3.4.5. Safety requirements. Electrical safety requirements and other safety requirements are included. Technical standards stipulate the requirements for indoor and outdoor electrical control cabinet shell protection level, electrical control cabinet panel emergency stop button, dielectric performance, protection grounding and signal circuit grounding, insulation resistance, leakage protection measures, short circuit protection and overload protection devices, etc.; Other safety requirements include fixed steel ladder, operating platform, protective railing, maintenance cover plate, safety net, anti-slip design, explosion-proof design and other requirements.

3.4.6. Environmental protection requirements. The air pollutants discharged during the normal operation of the small set of domestic sewage treatment plant should meet the following requirements: ammonia ≤1.5g/m3, hydrogen sulfide ≤0.06g/m3, ozone concentration ≤20g/m3, methane ≤1g/m3; The standard stipulates the requirements of different sound pressure levels for noise generated by small sets of domestic sewage treatment plants with daily treatment capacity of 2-1000m3/d during normal operation. In terms of solid pollutant control, the standard stipulates that small sets of domestic sewage treatment plants should be equipped with device that facilitate the collection and removal of sludge, and should be equipped with a sludge pump or other sludge discharge device that can be used to remove sludge.
3.4.7. **Reliability requirement.** The mean time between failure (MTBF) of small complete domestic sewage treatment plant should not be less than 1000 hours.

3.4.8. **Economic requirement.** Include requirements for power consumption, drug consumption and sludge yield, the unit water consumption, water consumption quantity (including phosphorus removal agent, carbon source, disinfectants, functional bacteria agent, membrane cleaning agents, etc. all potions), unit quantity of sewage sludge production (including all excess sludge, chemistry sludge sludge) for standard small sets of sewage treatment plant during normal operation shall be no more than 120% manufacturers specified the upper limit.

3.4.9. **Universal requirement.** The subparts, fasteners and structural parts of small complete domestic sewage treatment plant should select standard parts and conform to the corresponding standards.

3.5. **Test methods and inspection rules for small complete domestic sewage treatment plant**

The technical standard for small complete domestic sewage treatment plant specifies the test methods in eight aspects, including appearance inspection, functional test, manufacturing quality test, strength and tightness test, electrical safety test, pollution monitoring, reliability test, and measurement of energy consumption, drug consumption and mud amount. At the same time, the standard specifies the requirements for inspection classification, delivery inspection, type inspection and others, and also clearly stipulates many inspection items such as the appearance, function, manufacturing, strength and tightness, electrical safety, environmental protection, reliability, economy for small complete domestic sewage treatment plant.

4. **Discussion**

(1) The technical standard for small complete sets of domestic sewage treatment plants stipulate the terms and definitions, classification and types, use conditions, process and composition, technical requirements, test methods, inspection rules, marks, packaging, transportation and storage of the treatment plants; its development fully considers the coordination and consistency with the current Chinese environmental protection industry policy, planning, water pollutant discharge standards, as well as sewage treatment technology, process and standards, reaching the domestic advanced level.

(2) High-quality products need high-quality standards to regulate and lead. The development of the small set of sewage treatment plant technical standards fully embodies the current situation, technical level and characteristics, and industry development present situation of the Chinese small sets of sewage treatment plant. It is of great significance to combine the existing comparison and analysis of relevant technical standards at home and abroad, put forward the scientific and reasonable, advanced applicable product performance index requirements, to promote small sets of sewage treatment device manufacturing technology level, and the healthy development of environmental protection equipment manufacturing industry, effectively protect and improve water environment quality, and realize the sustainable utilization of water resources.

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**Author introduction.**