

Research on the Planning and Construction of National Industrial Metrology Center Park

-- Taking Shandong Province as an Example

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Abstract. Metrology refers to the activity of achieving unified physical and chemical units and ensuring accurate and reliable measurement values. In the field of metrology, we have always adhered to the principle that "Only accurate measurement can make perfect measurement", and have clearly defined the important role of metrology in the manufacturing industry, then take "Only to create a fine, can be accurately measured" as the standard, the dialectical unity between the two. Different from the general sense of industrial architecture, the core task of industrial metrology park is "To build houses for precision equipment, to build laboratories for metrologists", this has put forward many new requirements to the capital construction work from the planning, the design to the construction. With the successful acceptance of the park and put into use, this paper reviews and combs the construction process from the point of view of the pre-planning and design of the park, and puts forward a Shandong model for reference for the construction of similar projects.

Keywords: Industrial Econometrics; Functional Zoning; Special Planning.

1. Overview

Metrology has uniformity, authority, and legality, and is the foundation of national scientific and technological development. Normal and orderly measurement activities can clarify the value of legal units and ensure the normal operation of the national economy, such as how much is 1 ampere (A), and how long is 1 second (s). Shandong Institute of Metrology is a legally established metrological verification institution, which studies and establishes provincial metrological standards and social public metrological standards. At present, Shandong Provincial Institute of Metrology has established 7 national centers, including the National Center for Quality Inspection and Testing of Weighing Instruments, and 14 key management type evaluation laboratories authorized by the State Administration for Market Regulation, including the National Flammable and Explosive Gas Alarm. It serves more than 20000 enterprises annually and more than 600000 measuring instruments for value transmission. There are many key laboratories and a wide range of service targets, which is a typical characteristic of the establishment of Shandong Provincial Institute of Metrology. During the 14th Five Year Plan period, Shandong Province is committed to building a world-class advanced manufacturing base and a growth pole for the digital economy, which has put forward many new requirements for the province's metrology work. In this context, Shandong Institute of Metrology has built the National Industrial Metrology Center Park (hereinafter referred to as the "Park").

2. Planning Concept

2.1. Overall Layout

After approval by the Shandong Provincial Development and Reform Commission, the total investment estimate of the park is about 400 million yuan, covering an area of 70 acres, with a construction area of 65000 square meters, a plot ratio of 1.5, and a building density of 42%. The park has planned four industrial and supporting buildings: 1 # Comprehensive Building (office, conference,



catering, etc.), 2 # Professional Testing Experimental Building and Testing Hall (consisting of 10 individual buildings), 3 # Testing Hall, and reception office. Overall, the park covers a small area, but there are many key laboratories and high-precision equipment.



Figure 1. Planning bird's-eye view

Only with meticulous planning and design can we make good use of every inch of land.

The entire building faces south in the north, with high in the north and low in the south, and symmetrical in the central axis. When planning the overall layout, the park follows the principle of internal and external zoning, clarifies the degree of privacy of different usage spaces, and faces the best display side of the building towards the main urban road. Looking from the main entrance on the west side of the park, the entire park is open and embracing. A circular lane surrounds the park, placing the diverse functions of the experimental building in an open and enclosed space. While ensuring moderate privacy in the use of the internal experimental building, it attracts service objects and passersby in an approachable manner. Following the circular route from north to south, there are 1 # Comprehensive Building, 2 # Experimental Building, and 3 # Testing Hall, followed by sports fields planned to enrich the leisure life of engineers.

Due to the relatively limited greenery in the park, the 4 inner courtyards and 6 rooftops of Building 2 have been greened and beautified during the planning and design process, fully enhancing the visual experience brought by the "fifth facade". We have created a multi platform and multi-level green public space using the technique of "delicate atrium+aerial greening", which not only has large buildings and equipment in the park, but also enables our metrology engineers to embrace nature with big dreams. Overall, the planning of the park is both modern and advanced, integrating the diversity of functions with open spatial intentions, reflecting a strong sense of the times and its own characteristics.



Figure 2. Realistic view of the park

2.2. Planning Techniques

2.2.1. Independent Functions and Unified Business

The park is divided into 5 clusters, including 2 functional clusters. Firstly, the 1 # Comprehensive Building, located at the northern end of the park, has established a strong and stable image with a clear volume and height in appearance. Its functions cover various departments such as office, finance, meetings, catering, and multifunctional halls to ensure the normal operation of the park, making it the most core cluster of the entire park. The business hall is another relatively independent functional group, which serves as the external window of the metrology institute. It is responsible for receiving inspection customers and receiving, sending, operating, charging, and picking up all inspection equipment and instruments. Following the principle of "serving the people," the business hall is independently located in the geometric center of the entire park and adjacent to the main entrance, facilitating customer inspection and providing customers with a "one-stop" service.

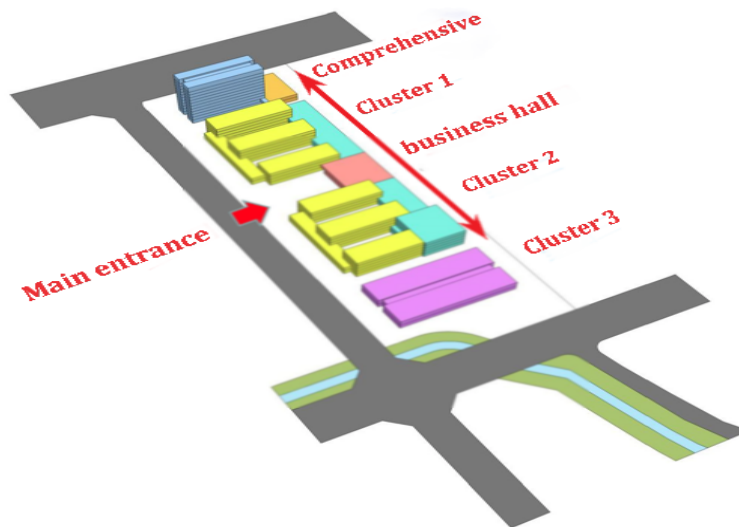


Figure 3. Planning Cluster

The business cluster is divided into three locations, namely Cluster 1 located between Building 1 and the business hall, consisting of a precision, mechanics, and weighing equipment testing building and corresponding testing halls; Cluster 2, located between the business hall and the 3 # testing hall, consists of a thermal, electrical, and electrical testing building and corresponding testing halls; The 3rd Inspection Hall located at the southernmost end of the park is Group 3, which is a land for functional upgrading and belongs to strategic blank space.

Each metrology department extends towards both ends around the business hall, which not only facilitates unified circulation but also creates a sense of spatial sequence. The park is located in the middle and lower reaches of the Yellow River, with a significant temperature difference within a year. In order to reduce the outdoor circulation of equipment and strengthen cooperation among departments, we have specially set up an ultra long corridor (about 280 meters) on the second floor of Building 2 that can connect all individual units. The setting of the corridor breaks the division between traditional standalone buildings, eliminates the class nature of the space, and makes the entire park integrated. We have also set up three intelligent standard box three-dimensional warehouses in the corridor, forming a complete AGV system (Automated Guided Vehicle) with the corridor and elevators. After registration and sorting, the instruments can automatically travel along the designated route. Through linkage with the elevator system and access control system, the inspection instruments can be transported back and forth to various departments through AGV cars.

On the east side of the three business clusters, from north to south are key laboratories such as the Acoustic Testing Hall, Force Measurement Hall, Anechoic Room, High Voltage Hall, and Multi line Enthalpy Difference Room. These laboratories represent the highest level of SDIM. The location of key laboratories should take into account both internal and external factors: the inner side is adjacent

to the department, making it convenient for metrology engineers to conduct experiments; The outer side is adjacent to the sightseeing avenue on the east side of the park, making it convenient for various visiting activities.

2.2.2. Subtraction for Vertical Planning and Addition for Road Planning

Under the premise of fully considering the connection with surrounding municipal roads and pipelines, vertical subtraction is applied in the park planning process. Including two measures: first, make full use of the original soil to reduce the transportation and backfilling of earthwork. We calculate the amount of earthwork transported, backfilled, and compacted during the planning phase based on measurement data, and then balance the earthwork on site. Finally, except for unusable soil such as humus, silt, and frozen soil, the remaining raw soil is basically used to its fullest potential, and the amount of earthwork transported is strictly controlled, greatly reducing the negative impact on the environment. The second is to reduce drainage pressure through the "drainage+water storage+circulating water" mode. The pipeline that most affects earthwork excavation is the drainage pipeline, which has a large diameter and does not avoid other pipelines. In order to scientifically plan underground space, we adhere to the concept of "sponge city+rainwater resource utilization" in the construction process, reduce the pressure of rainwater drainage network, pay attention to the natural accumulation of rainwater, and reasonably arrange the elevation of the municipal comprehensive pipeline network on this basis, avoiding vertical resource waste caused by too deep excavation of drainage pipes.

Adding to the road planning is mainly based on the following two practical reasons: first, in order to meet the fire requirements, circular fire roads are set around the park; Secondly, the urban road construction concept of "narrow road and dense road network" is implemented according to the characteristics of "expensive measuring instruments and slow driving vehicles ". The "narrow" can intensively use land, and the "dense" can prevent congestion. We have built 4 roads to connect with the ring road, forming a compact slow and friendly traffic system.

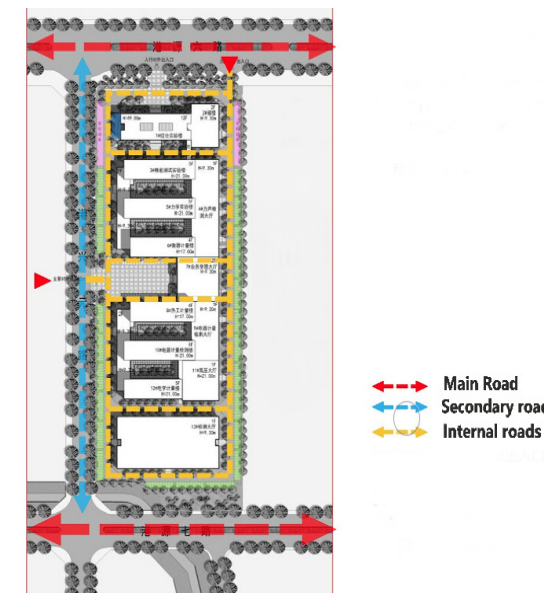


Figure 4. Road network diagram

2.2.3. Facade and Color Planning

The facade is the "clothes" of the building. Whether the clothes and color match well determine the temperament of the whole building. The rich collocation of building facades can often reflect the personality of the building, leave a deep impression and become a unique landmark. In the planning and construction of the park, we have comprehensively considered the cost and actual effect, and selected the building facade combination of "dry-hanging stone+simulated stone paint+other curtain walls" with natural color matching, which has achieved good results.

1 # Comprehensive Building adopts dry hanging stone, which is hung on the facade with bolts and corrosion-resistant flexible connectors. Under the action of external forces (such as wind and earthquake), the cavity between the stone and the structure can produce appropriate deformation to absorb some external forces and avoid wall cracks and falling off. The stone used in the main facade is horizontal, dark gray granite, thick and simple, reflecting the rigorous, pragmatic and stable characteristics of the modern science and Technology Park, giving the building a strong industrial texture.

Most of the building facades outside building 1 are made of imitation stone paint. The colors include gray and dark gray. The color is natural and has the texture of natural stone. It forms a virtual and real contrast with other smooth metal texture materials (steel structure) and glass materials (windows and roof) on the facade. The blocks are interspersed and occluded, greatly enhancing the sense of sculpture and transparency of the building.

In addition, the planning takes full account of the color matching of the fifth facade of the building. When you look down from the park, you can see a lot of green, which is basically the same as the green area you can see when you look down from the commanding height of the complex building to the south, and then to the south is the green water and green mountains outside the park, surrounded by clouds and mists, with a myriad of atmosphere.

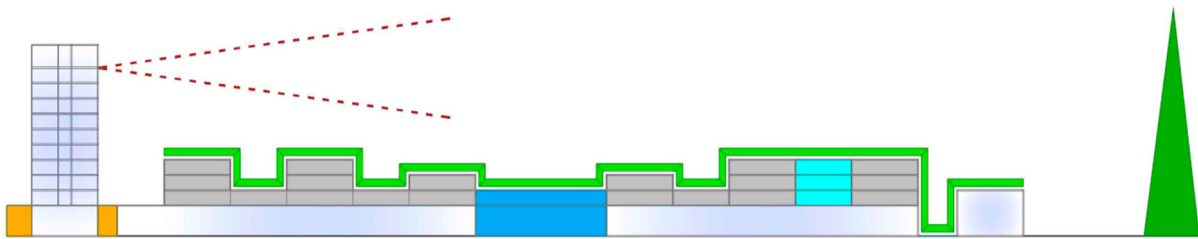


Figure 5. Aerial view of the 1# building

2.2.4. Plan Best, Landscape First

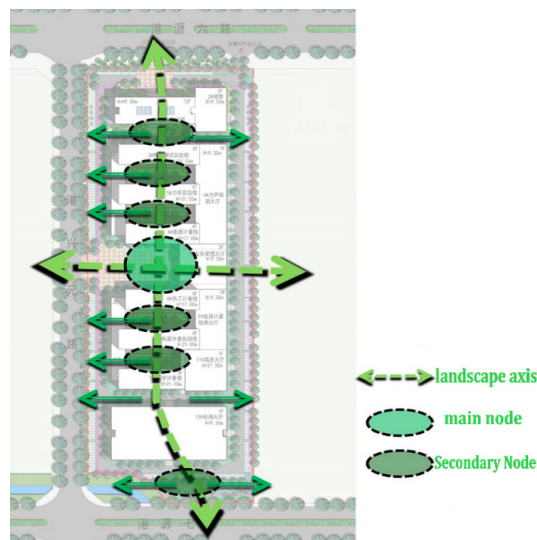


Figure 6. landscape nodes

The traditional design usually follows the sequence of planning, Architecture, structure and then equipment, landscape. The master plan is formulated by the planner first, and then the functions of the scheme are refined and improved by other specialties according to the specifications. Finally, it is the landscape specialty's turn to "fill in the blank" outdoors. The works under this process are often unidirectional, irreversible, or the reversible cost is too high - it is almost impossible to adjust the overall architectural scheme due to the requirements of landscape or equipment specialty. Therefore, when planning, we put forward the requirements of "early intervention and deep intervention" for

landscape designers. At the same time, we require that the planning layout should not be rigidly bound by the tradition, but should combine the local cultural habits and historical and cultural characteristics of Shandong Province, and finally use the landscape to verify the effectiveness of planning and architecture.

Finally, under the guiding ideology of landscape first, the park creatively put forward the construction characteristics of "garden in the park" based on the "one center, two axes and six points", which integrates office space, communication space and rest space, and well realizes the combination of technology and art.

"One center" is the square at the main entrance, which corresponds to the main node of the landscape. For the main node of the landscape, we need to reflect the characteristics of Shandong, and also tell a good story of metrology. Jinan, Shandong Province, is also known as the "Spring City", which is famous for springs. It can be seen from the earliest records in the notes to the *Commentary on the Water ways Classic*. Based on this, we set up a fountain in the central square that can gush all the year round. The fountain is composed of a three-layer platform and three fountain outlets. On the top of the platform stands the sculpture of the Institute standard, which makes the "spring" element closely integrated with the main metrology business represented by the Institute standard. The design prototype of our Institute standard is the Chinese phonetic alphabet letters "J, L" of the word "metrology", which has two meanings: first, the two letters are the first of the phonetic alphabet of the word "metrology", which is easy to remember; Secondly, the two letters are closely combined and embodied in the shape of an Arabic numeral "1". The "1" can be understood as the concept of Shandong Provincial Institute of metrology to strive for the first place. At the same time, it is also like an upward arrow, implying a bold and breakthrough work attitude. The English abbreviation "SDIM" is strongly supported below. The fountain and its logo mean that our college was born in the spring city, based in the spring city, has a long history and serves the whole province. The whole shape of the sculpture and fountain is full and round but not closed, giving a powerful impression of authority, justice and composure.

"Two axes" include: the main axis of symmetry in the east-west direction of the park, which is the real axis; The secondary symmetry axis of the park in the north-south direction, which is the imaginary axis. The combination of the two landscape axes forms the expansion and extension of the landscape in vision and space.

"Six points" refers to six landscape secondary nodes. The core landscape is the four inner courtyards between the above-mentioned detection buildings. From north to south, they are badminton courts, circular winding paths, rest pavilions, and fitness venues.



Figure 7. inner courtyard

2.2.5. Comprehensive Planning of Municipal Pipelines

During the construction of the park, we found that there were many kinds of municipal pipelines, such as the sewage discharged from the chemical laboratory, the wastewater discharged from the medical laboratory, the access of various cables in the electrical laboratory, the access of water supply to the cleaning equipment in each laboratory, the gas system required by the pressure laboratory, and various pipelines required for the operation of the park. In summary, it covers almost all pipelines such as water supply, fire protection, rainwater, sewage, reclaimed water, gas, heat, communication integration, high and low voltage power. There is a sharp contrast between the number of pipelines and the lack of space, so we consider all pipeline construction needs in the planning process and reasonably determine the underground space location and direction of pipeline facilities. At the same time, it is closely linked with underground space, civil air defense construction and long-term planning, and adheres to high starting point planning, high standard design and high-level construction, forming a set of scientific, reasonable and operable pipe network construction concepts.

At the stage of scheme demonstration and planning preparation, the following contents are highlighted:

- (1) Specify the applicable scope of BIM.
- (2) Collect the pipeline use demand of each department, and determine the laying method and avoidance principle of each project pipeline according to the parameters of all pipelines, such as pipe material, pipe diameter, pipe hole, pipeline connection mode, voltage level, etc.
- (3) Coordinate the use needs of each department, and comprehensively determine the location and elevation of various engineering pipelines.
- (4) Determine the arrangement order and position of each pipeline on the road, determine the minimum horizontal and vertical clear distance between pipelines, and put forward the handling principles and requirements in case of contradiction.

In the implementation phase, the following treatment principles were formed:

- (1) Promote the application of Bim in core areas and complex areas.

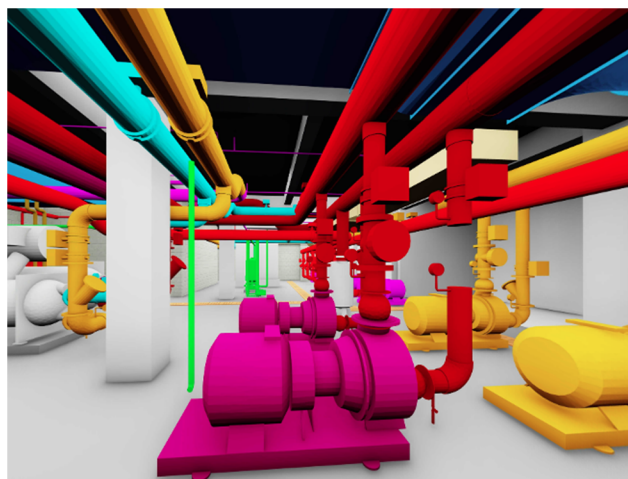


Figure 8. BIM design view of equipment room

- (2) Principle of pipeline avoidance: branch to avoid trunk, the small pipe avoids the large pipe, and the single hole pipe gives way to the multi hole pipe and combined pipe (for example, the thermal power is composed of three layers: working, thermal insulation and external protection).
- (3) Pressure pipe avoids gravity pipe, rainwater avoids sewage, and bendable cable avoids other pipes.
- (4) Decorative pipelines (such as lighting and pouring) avoid functional pipelines.
- (5) Establish the minimum clear distance of pipelines to ensure safe use.

Table 1. distance of pipeline

Pipeline type	water supply	sewage pipeline	Heating	Gas	Power (10kV)	Power (0.38kV)	Communication
water supply	0.15(/)						
sewage pipeline	0.40(1.0)	0.15(/)					
Heating	0.2(1.5)	0.15(1.5)	/				
Gas	0.15(0.5)	0.25(1.5)	/	/			
Power (10kV)	0.30(0.5)	0.30(1.0)	0.30(2.0)	/	/		
Power (0.38kV)	0.25(0.5)	0.25(2.0)	0.25(2.0)	0.30(2.0)	0.30(1.0)	0.25(/)	
Communication	0.15(1.0)	0.15(1.0)	0.25(1.0)	0.30(1.0)	0.25(1.0)	0.25(1.0)	/

Remarks: 1. The data in the table is the minimum vertical clearance, and the data in brackets is the minimum horizontal clearance. The unit in the table is meter.

2. "/" refers to not taking it into account or not allowing pipelines to cross and parallel through technical means.

2.2.6. Underground Space Planning

Different from the planning of above ground facilities, the development and utilization of underground space is a reversible link with high cost. Generally, both cost and function should be considered. There is only one starting point for underground space planning, which is to realize the rational development and utilization of underground space. There are many footholds, which can be reflected in various specialties. We have adopted a series of new technologies in the process of park construction, which effectively ensure the rational development and utilization of underground space.

Process 1: the sewage pipeline crosses the rainwater inspection well.

All drainage pipes are discharged to the main pipeline on the municipal road. Due to the fact that most drainage pipelines rely on gravity drainage, rainwater and sewage pipelines have high requirements for elevation. If encountering pipeline intersections that cannot be coordinated, the only option is to change the pipeline position or change it to inverted siphon. It is very troublesome when both cannot be satisfied. A similar situation was encountered during the construction of our campus. The infrastructure department adopted a new plan for sewage to pass through rainwater inspection wells in response to this working condition. This not only ensures the reasonable planning of the slope of the rainwater and sewage pipeline discharge, but also avoids large-scale excavation, achieving intensive treatment of underground space.

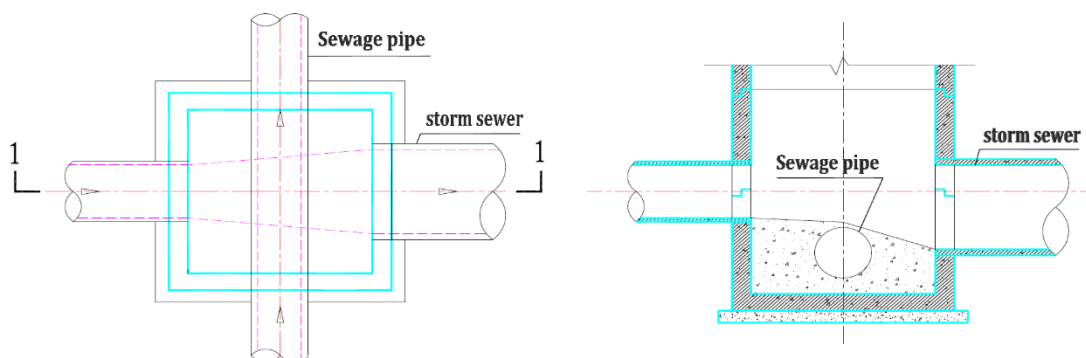


Figure 9. Crossing Well

Process: The base of intelligent street lights.

According to the requirements of the upper level planning, the positioning of the park is a national level smart park, ultimately achieving smart measurement. Therefore, we have always demanded high standards of intelligence and intelligence, and one important aspect is the intelligent street lights. It can achieve multiple functions such as park lighting, video monitoring, intelligent recognition, LED screen information release, 5G base station, etc. High hardware requirements are required, for

example, the windward area of a of intelligent street lights is more than ten times that of a regular light. The rectangular foundation of the conventional design occupies a large area, which affects the laying of other pipelines. In early planning,we chose a circular desktop light pole foundation. While meeting the structural stability requirements, we made reasonable use of the depth of the underground space and compressed the width, Saves valuable underground space.

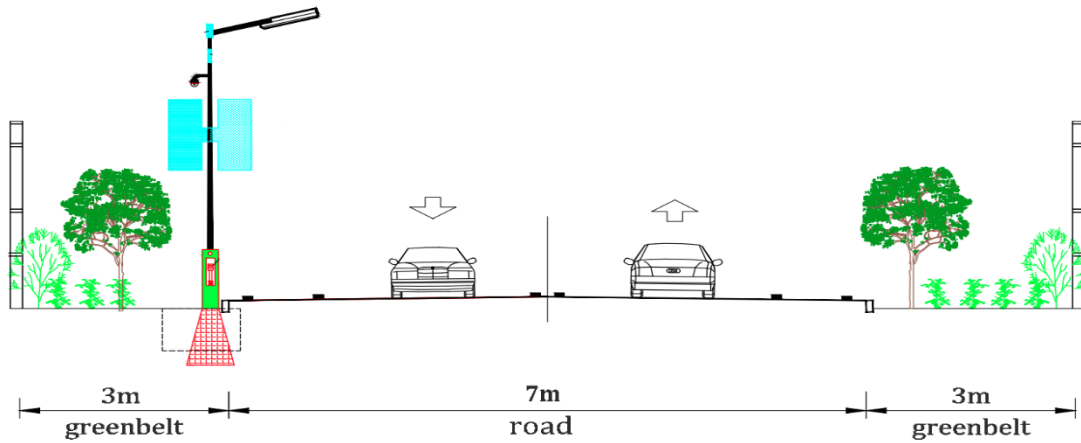


Figure 10. intelligent street lights

2.2.7. Meterage Culture Display

There are three exhibition areas of metrological culture, which are centrally arranged on the first and second floors of the 1 # building, with a total area of about 1100 square meters. Including central control system, large screen system, holographic projection system, immersive experience system, VR interactive system, self-service voice explanation system, etc. The three exhibition areas are planned as follows:

First, the area for the leadership of the Communist Party building. Under the leadership of the Communist Party of China, the exhibition area shows the main line of the development of Metrology in Shandong Province, the development of Metrology in Shandong Province and the fruitful results achieved by SDIM.



Figure 11. exhibition area I

The second is the popular science exhibition area. As a national science popularization education base, we have focused on the construction of this area. It consists of ancient metrology, modern metrology and international metrology. Ancient metrology takes the historical development as the main line, starting from the germination of Metrology in the primitive society and the unification of Metrology by the first emperor of Qin Dynasty. This paper describes the development of Metrology in the past dynasties. In the form of holographic imaging, the ancient metrological exhibits are modeled and displayed interactively. In addition, the exhibition area also introduced the relevant instruments and ancient books of Shandong ancient weights and measures, including graphic display boards and image data. The two sections of modern and international metrology mainly show the

development of China's modern metrology standards and international metrology (International System of units, world metrology day, etc.).

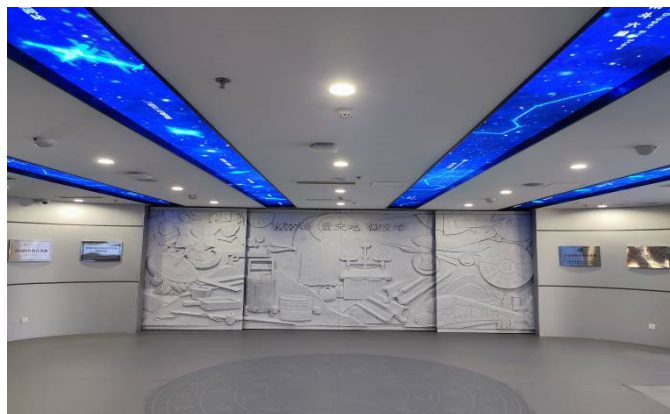


Figure 12. Metrology Exhibition Area II

The third is interactive exhibition area and convenient platform for the public. The interactive exhibition area is mainly equipped with various forms of multimedia interactive experience equipment, so that visitors can feel the charm of Metrology and scientific innovation. Display methods include immersive experience (CAVE), virtual roaming interactive experience (VR), creative game interactive answer, electronic message, etc. A free window has been set up to carry out the inspection activities of glasses, sphygmomanometers, civil meters, gold jewelry, 3C and other projects for the general public, focusing on the public welfare existence of our institutions.

3. Conclusion

The construction of the national industrial measurement center park complements the capacity weakness of SDIM in terms of hardware facilities and development space, and wins the initiative for the development of the next few decades. The project has poured the painstaking efforts of all infrastructure builders of SDIM from the beginning of planning. It is believed that with the successful completion and operation, the park will further consolidate the quality infrastructure of Shandong Province. As the core component of Jinan national inspection, testing and certification public service platform, it can better serve the transformation of the province's new and old driving forces, and provide strong quality assurance for the development and cultivation of "five emerging industries" in Shandong Province.

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Shang Jiankang (1986-), male, from Jining, Shandong, holds a master's degree, and is a senior engineer. He is mainly engaged in municipal engineering and infrastructure projects.

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