

# JTG

Industry Standards of  
the People's Republic of China  
中华人民共和国行业标准

JTG 2182—2020 (EN)

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Standards for Quality Inspection and Verification of Highways  
Part 2: Electrical and Mechanical Works

公路工程质量检验评定标准  
第二册 机电工程

(英文版)

Issued date: December 14, 2020

Effective date: March 1, 2021

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Issued by Ministry of Transport of the People's Republic of China

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Editing organization for English version: Research Institute of Highway Ministry of Transport

Approval authority: Ministry of Transport of the People's Republic of China

Effective date: March 1, 2021

# 中华人民共和国交通运输部

## 公告

第 49 号

### 交通运输部关于发布《公路工程质量检验 评定标准 第二册 机电工程》英、法文版等 4 项 公路工程行业标准外文版的公告

为促进公路工程行业标准的国际交流与共享,现发布《公路工程质量检验评定标准 第二册 机电工程》英文版[JTG 2182—2020(EN)][代替标准号 JTG F80/2—2004(E)]及法文版[JTG 2182—2020(FR)]、《公路钢筋混凝土及预应力混凝土桥涵设计规范》法文版[JTG 3362—2018(FR)]、《公路水泥混凝土路面施工技术细则》法文版[JTG/T F30—2014(FR)]。

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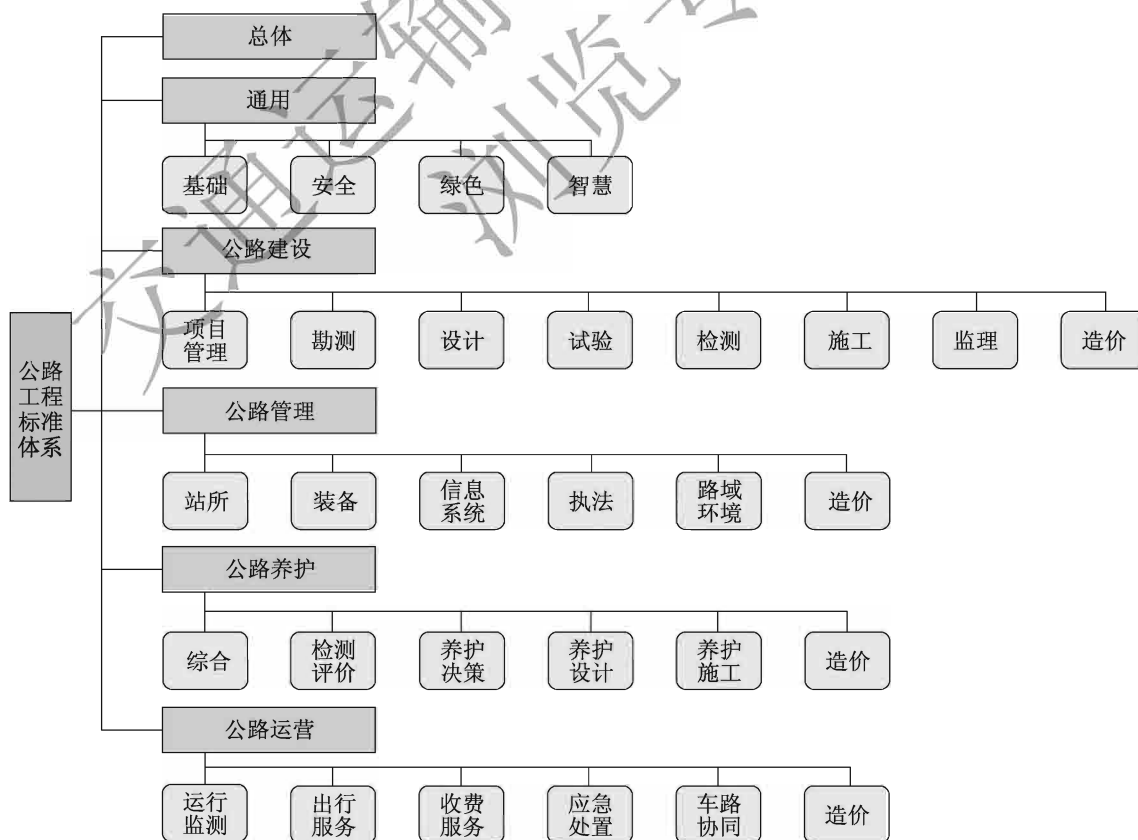
中华人民共和国交通运输部

2023 年 9 月 20 日

# 英文版编译出版说明

标准是人类文明进步的成果,是世界通用的技术语言,促进世界的互联互通。近年来,中国政府大力开展标准化工作,通过标准驱动创新、协调、绿色、开放、共享的共同发展。在丝绸之路经济带与 21 世纪海上丝绸之路,即“一带一路”倡议的指引下,为适应日益增长的全球交通运输发展的需求,增进世界连接,促进知识传播与经验分享,中华人民共和国交通运输部组织编译并发布了一系列中国公路行业标准外文版。

中华人民共和国交通运输部发布的公路工程行业标准代号为 JTG,体系范围涵盖公路工程从规划建设到养护和运营管理全过程所需要的设施、技术、管理与服务标准,也包括相关的安全、环保和经济方面的评价等标准。



中国政府历来高度重视交通基础设施建设,不断完善公路基础设施设计相关的标准规范。二十世纪八十年代,中国在原《公路工程技术标准》(JTJ01-81)基础上,开始制订公路路线、路基、路面、桥梁、涵洞等专业技术规范,并在1985年颁布实施了第一部《公路工程质量检验评定标准》(JTJ 071-85),用于施工过程质量控制以及工程验收。尔后,经历了1994年的第一次修订(JTJ 071-94)和1998年的第二次修订(JTJ 071-98),从2004年的第三次修订开始,分为了“第一册 土建工程(JTG F80/1—2004)”和“第二册 机电工程(JTG F80/2—2004)”,在2017年对土建工程册进行了第四次修订(JTG F80/1—2017),在2020年对机电工程册进行了第一次修订(JTG 2182—2020)。经过四十多年的技术发展,建立了内容较为完整的公路工程质量检验评定体系。

本次编译的《公路工程质量检验评定标准 第二册 机电工程》(JTG 2182—2020)中文版于2020年12月修订发布,并于2021年3月1日实施。

到2022年底,中国公路通车总里程约535万公里,高速公路通车总里程超过17万公里。《公路工程质量检验评定标准》(以下简称《标准》)一直是我国公路工程施工质量验收方面的强制性技术标准,对中国公路工程建设质量提供了重要保障。《标准》以分项工程为基本单元,根据分项工程-分部工程-单位工程的顺序进行逐级评定,参与公路工程的建设项目的施工单位、监理单位、建设项目法人单位、检测单位和质量监督管理部门均应根据《标准》对公路工程质量进行自检、质量评定和验收。

在中国公路建设过程中,随着新材料的投入、设计理念的转变、高污染高成本工艺的淘汰,公路工程质量控制的标准也在不断进步和完善,这些经验与成果在《公路工程质量检验评定标准 第二册 机电工程》(JTG 2182—2020)中得到了充分的体现。本英文版的编译发布便是希望将中国的工程经验和科技成果与各国同行进行交流分享,为其他国家的公路建设提供参考借鉴。

本英文版的编译工作由中华人民共和国交通运输部委托中国路桥工程有限责任公司主持完成,并由中华人民共和国交通运输部公路局组织审定。

本英文版标准的内容与现行中文版一致,如出现异议时,以中文版为准。

感谢中文版主编刘玉新先生在本英文版编译与审定期间给予的指导与支持。

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# The People's Republic of China

## Ministry of Transport

### Public Notice

*No.49*

#### Public Notice on Issuing International Version of Four Specifications of Highway Industry Standards

For promoting international cooperation in standardization of highway transportation industry, the Ministry of Transport hereby issues the international version of the following four Specifications of Highway Industry Standards.

The English version of *Standards for Quality Inspection and Verification of Highways (Part 2: Electrical and Mechanical Works)*, JTG 2182-2020(E), cancels and replaces the original JTG F80/2-2004(E);

The France version of *Standards for Quality Inspection and Verification of Highways (Part 2: Electrical and Mechanical Works)*, JTG 2182-2020(F);

The France version of *Specifications for Design of Highway Reinforced Concrete and Prestressed Concrete Bridges and Culverts*, JTG 3362-2018(F);

The France version of *Technical Guidelines for Construction of Highway Cement Concrete Pavements*, JTG/T F30-2014(F).

The general administration and final interpretation of these Specifications belong to Ministry of Transport, while particular interpretation for application and routine administration of the international version of these Specifications shall be provided by China Road and Bridge Corporation.

In event of any ambiguity or discrepancies between the international version and Chinese version of these Specifications, the Chinese version should be referred and accepted.

Comments, suggestions and inquiries are welcome and should be addressed to China Road and Bridge Corporation by post address, by mail: 88C, Andingmenwai Dajie, Postal Code: 100011; or by E-mail: [kjb@crbc.com](mailto:kjb@crbc.com).

It is hereby announced.

**Ministry of Transport of the People's Republic of China**

September 20, 2023

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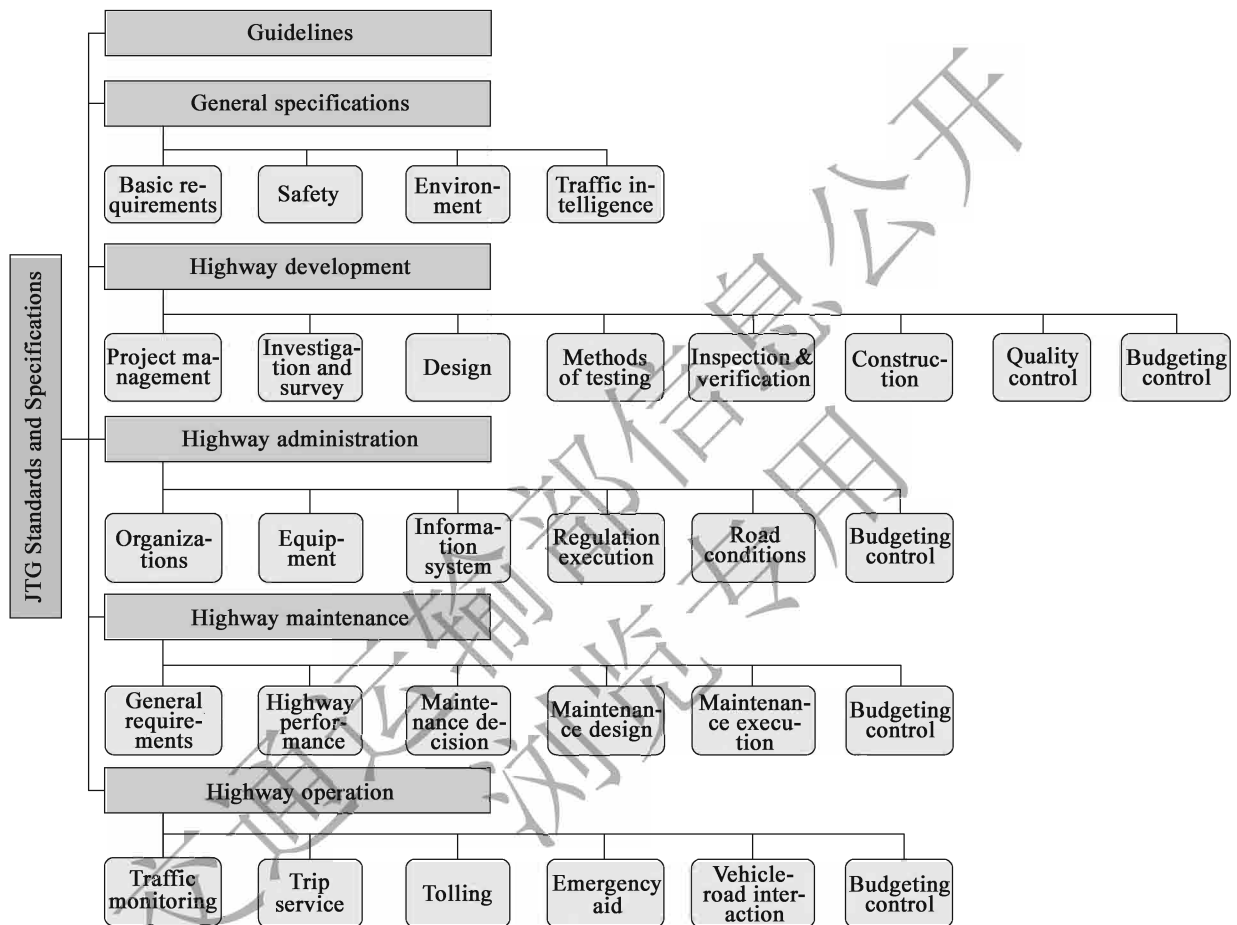
# Introduction to English Version

Standards reflect the achievement of civilization, provide a common language for technical communication, and improve global connectivity. In recent years, the Chinese government has been proactively implementing a strategy for standardization to stimulate innovative, coordinated, greening, open up and inclusive development in China and worldwide. In the light of the Belt and Road Initiative, the Ministry of Transport of the People's Republic of China has organized translation and published international versions of the Chinese transportation industry standards and specifications to cater for the increasing demands for international cooperation in world transportation, achieve interconnected development and to better share knowledge and experience.

JTG is the designation referring to the standards and specifications of the highway transportation industry, issued by the Ministry of Transport of the People's Republic of China. It covers the standards and specifications in terms of technology, administration and service for the whole-lifecycle process from highway planning through to highway maintenance. The criteria for safety, environment and economic assessment are also included.

The Chinese government has always emphasized the development of the transportation infrastructure as a priority, and continuously improved and updated the standards for highway transportation. In the 1980s, following the publication of the principal standard, *JTJ01-81: Technical Standards for Highway Engineering*, a series of professional and vocational specifications were drafted and developed. These specifications involve in highway geometry, subgrade, pavement, bridges and culverts. The first edition of the *Standards for quality inspection and verification of Highways (JTJ 071-85)* was issued and implemented in 1985, followed by a first revision and second revision in 1994 and 1998 respectively, providing guidance for the quality control during construction and the inspection and verification for acceptance. In the third revision in 2004, these Standards were divided into two parts, namely part 1 for civil works (denoted as *F80/1—2004*) and part 2 for electric and

mechanical works ( F80/2—2004 ) under the same title of *Standards for quality inspection and verification of Highways*, as was the fourth revision in 2017 , and the first revision was made to the part 2 of electrical and mechanical works ( denoted as JTG 2182—2020 ) in 2020. For over four decades of technical development and continuous improvement, these Standards have effectively and successively served as guidelines for the inspection and verification of highway construction.



The English version is *JTG 2182—2020: Volume 2: Electrical and Mechanical Works of the Standards for Quality Inspection and Verification of Highways*. The original Chinese version was issued in December 2020 and has been implemented since March 1, 2021.

By the end of 2022, the total length of highways being operated in China about 5.35 million kilometers, of which more than 170 thousand kilometers were motorways. The *Standards for Quality Inspection and Verification of Highways* plays an important role in quality assurance of highway construction, and thus shall be regarded and implemented as mandatory requirements. As required by these Stand-

ards, the inspection and verification shall be executed in an increasing sequence one layer after another from the subdivisions of work, through the divisions of work, to the types of work. The self-inspections, quality assessment and verification for acceptance shall be carried out by various stakeholders of the project, including the contractors, supervisors, client, quality supervisors and relevant government agents.

During the process of highway development in China, many new materials have been introduced and adopted, innovative ideas absorbed into design concepts, some high polluting or low efficient workmanship were eliminated, and consequently the quality control standards have been continuously updated and improved. All these experiences and achievements have been incorporated and summarized in the *JTG 2182—2020: Standards for Quality Inspection and Verification of Highways, Volume 2: Electrical and Mechanical Works*, and also in the English version of these Standards, which may be taken as a reference for engineers, project managers, and other practitioners of highway transportation in other countries.

The English translation of these specifications was conducted by China Road and Bridge Corporation under the authorization of the Ministry of Transport and approved by the Highway Administration of the Ministry of Transport.

The contents and numbering of the chapters, sections, clauses and sub-clauses in the English version are exactly the same as those in the Chinese version. In case of any ambiguity or discrepancies, the Chinese version should prevail.

Acknowledgement is given to Senior Eng. Liu Yuxin, the Editors of the Chinese version, for the valuable assistance and suggestions during editing and reviewing of the English version.

Comments, suggestions and inquiries are welcome and shall be addressed to the organization responsible for the English version: *China Road & Bridge Corporation* (Address: 88C Andingmenwai Dajie, Postal Code: 10011, E-mail: [kjb@crbc.com](mailto:kjb@crbc.com)). The feedback shall be taken into account in future editions.

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# Foreword to Chinese Version

According to the requirements of the *Notice on issuing the project plan for the revision of standards for highways in 2011* (MoT highway [2011] No. 115) issued by the Ministry of Transport of China, the Highway Research Institute of the Ministry of Transport is in charge of updating the former Standards for Quality Inspection and Verification of Highways Volume 2: Electrical and Mechanical Engineering Works (JTG F80/2—2004).

A large number of new products, technologies and workmanship have been widely used in the last decade, which promoted the development of highway electrical and mechanical works. Based on extensive consultation with the Clients, Designers, Contractors, Supervisors and governmental inspection agencies regarding highway mechanical and electrical works, the editing group made a comprehensive revision of the previous edition.

This Standard comprises nine chapters, namely general provisions, terms and definitions, basic requirements, monitoring facilities, communication facilities, toll collection facilities, power supply and distribution facilities, lighting facilities, electrical and mechanical facilities for highway tunnel, and four appendixes, including Appendix A-work classification of electrical and mechanical works, Appendix B-project quality inspection and evaluation form, Appendix C-visual appearance quality defects of electrical and mechanical works, and Appendix D-inspection and evaluation of communication conduit commissioning.

Major updates and revisions made in this edition are as follows.

1. The inspection frequency of subdivisions of electrical and mechanical work has been adjusted, and the requirements for quality assurance data are added.
2. Traffic incident video detecting system and traffic survey facilities are added to

the division of works of monitoring facilities. The road surface condition detector is added to the sub-division of works of the weather detector, and the channel transmission index of HD video signal is added to the sub-division of works of the CCTV monitoring system.

3. IP network system, wavelength division multiplexing (WDM) fiber-optical transmission system and PSTN system are added to the division of work of communication facilities. The sub-division of work of communication conduit and optical/power cable line is divided into two sub-divisions of work, namely communication conduit works, and communication optical cable line and power cable line works. Meanwhile, the wireless mobile communication system and emergency telephone system are deleted.

4. Equipment and software of ETC special lane, ETC gantry system, overweight and/or oversize detection system and Network Toll Management Center (toll center) are added to the division of work of toll collection facilities. The entrance lane equipment and exit lane equipment sub-division of work are adjusted to the sub-divisions of work of the ETC/MTC entrance lane equipment and software and the ETC/MTC exit lane equipment and software.

5. The division of work of low-voltage distribution facilities was changed to the division of work of power supply and distribution facilities; meanwhile, medium-voltage distribution equipment, power cables of medium-voltage equipment, electric vehicle charging system, wind/solar power supply system and power monitoring system are added.

6. The division of works of lighting facilities are divided into four sub-divisions of work: road lighting facilities, toll plaza lighting facilities, service area lighting facilities, and toll canopy lighting facilities. New inspection items of brightness and brightness longitudinal uniformity are added.

7. Traffic incident video detection system and axial flow fan are added to the electrical and mechanical facilities for highway tunnels. The sub-division of work of alarm and guidance facilities is divided into three sub-divisions of work, namely manual fire alarm system, electric signs, and luminous guiding facilities. The automatic fire alarm system is listed separately as a sub-division of work. The sub-division of work of emergency telephone system is adjusted to the sub-division of e-

mergency telephone and cable broadcasting system.

For this edition of the Standards, Liu Yuxin was responsible for drafting Chapters 1 and 2, Zhang Zhiyong for Chapter 3, Zhu Chuangzheng and Wang Lei for Chapter 5, Zhu Liwei and Chu Chengzan for Chapter 6, Chen Jian for Chapter 7, Yang Yong for Chapter 8, Yu Jianghao for Chapter 9 and Tian Liping for Appendix.

Comments, suggestions and inquiries are welcome and should be addressed to the Editing Organization (Contact person: Liu Yuxin, Address: No. 8, Xitucheng Road, Haidian District, Beijing, Research Institute of Highway Ministry of Transport, postal code: 100088, Tel: 010-62071807; fax: 010-62017616; email: yx.liu@rioh.cn).

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# 1 General Provisions

**1.0.1** This standard is formulated to regulate the process of quality inspection and verification of highway electrical and mechanical works, and to unify the criteria of quality inspection and verification so as to ensure the quality of highways.

**1.0.2** This standard is applicable for inspection and verification of construction quality of new construction, upgrading and reconstruction of classified highway mechanical and electrical works.

**1.0.3** The frequency of spot check of each sub-division of highway mechanical and electrical works shall meet the following requirements: 100% of self-inspection by the Contractor; no less than 30% spot check by the Supervisor, no less than 30% in the taking-over quality inspection by measuring and testing agency, and no less than 10% for the completion acceptance inspection. The number of measuring spots shall not be less than three, otherwise all the spots shall be checked.

**1.0.4** If there are no suitable criteria available in this Standard due to special conditions of project area or the application of newly-introduced materials, designs or technologies, the criteria for quality inspection and verification could be developed by referring to relevant technical specifications and design drawings or in accordance with actual conditions and reported to authorities for approval.

**1.0.5** Besides the requirements of this Standard, quality inspection and verification of highway mechanical and electrical works shall conform to the relevant provisions in the current national and industry standards.

# 2 Terms and Definitions

## 2.0.1 Inspection

Activities to evaluate and judge the acceptance of a project by examining, measuring, testing its characteristics and performance, and comparing the results with the request specified in relevant standards.

## 2.0.2 Evaluation

Activities to determine the level of quality by inspecting the sub-divisions of work, divisions of work, types of work and contract packages of a project. ①

## 2.0.3 Dominant item

An inspection item that performs critical and determinant roles in structural safety, durability and major service function, and are denoted by '■' in this Standard.

## 2.0.4 General item

An inspection item rather than a dominant one.

## 2.0.5 Quality of appearance

The external quality and functional status, recognized by direct observation and essential measurement, of highway mechanical and electrical facilities in operation.

① *Translator's note: The sub-division of work, division of work, type of work are activities as WBS Level 2 and WBS Level 1 in the Work Breakdown System (WBS) defined in the construction project.*

# 3 Basic Requirements

## 3.1 General Requirements

3.1.1 Quality inspection and verification of highway works shall be executed hierarchically from sub-division of work, division of work to type of work and shall conform to the provisions as follows.

- 1 In a contract package, the works that are independent in terms of construction conditions and structural functions are defined as type of work.
- 2 A type of work may be divided into divisions of work by system function characteristics.
- 3 A division of work may be further divided into sub-divisions of work in terms of equipment types or functions.

3.1.2 The work classification to identify types of work, division of work and sub-divisions of work shall conform to Appendix A of this Standard.

3.1.3 Quality inspection and verification of highway works shall conform to the provisions as follows:

- 1 After completion, each sub-division of work shall be inspected and verified in accordance with this standard. Concealed work shall be inspected to be qualified before being covered.
- 2 When a division of work or a type of work is completed, the quality verification data of the relevant sub-divisions of work or the relevant divisions of work shall be collected, reviewed, and assessed. The quality of appearance shall also be inspected and the overall work quality shall be verified.

## 3.2 Quality Inspection

**3.2.1** A sub-division of work shall be inspected and evaluated in terms of basic requirements, measurement items, appearance and quality assurance data respectively.

**3.2.2** The quality of a sub-division of work shall be inspected and evaluated only when the basic requirements, in terms of the equipment, accessories and construction control points, are conformed without unacceptable defect existing on appearance, and the quality assurance data are correct and adequate.

**3.2.3** Inspection for basic requirements shall conform to the following provisions:

1 All of the listed basic requirements for sub-divisions of work shall be examined one by one. No quality inspection and verification shall be executed if there is any non-conformity.

2 The model, specification, quantity and quality of the equipment and accessories used in the sub-divisions of work shall satisfy the contract requirements and conform to the corresponding technical standards.

**3.2.4** Inspection and verification of measurement items shall conform to the provisions as follows:

Inspection items shall be inspected by the methods at the frequency as specified for random spot check, and calculate the percentage conformity (qualified rate).

2 Percentage conformity of an inspection item shall be calculated by equation 3.2.4:

$$\begin{aligned} & \text{Percentage conformity of inspection item}(\%) \\ &= \frac{\text{Number of points (sets) qualified}}{\text{Total number of points (sets) inspected}} \times 100\% \quad (3.2.4) \end{aligned}$$

**3.2.5** Qualification criteria of an inspection item shall conform to the provisions as

follows:

- 1 For the quality inspection carried out by the Contractor and Supervisor after completion of the project, the percentage conformity of all items shall be 100%, otherwise they shall be rectified or reworked until meeting the requirements.
- 2 For the taking-over quality inspection and the completion acceptance evaluation carried out by the measuring and testing agency, the percentage conformity of the dominant item shall not be less than 100% and for a general item shall not be less than 90%, otherwise the inspected item is unqualified.

**3.2.6** Appearance shall be fully inspected and conform to specified requirements, otherwise the inspection-verification portfolio shall be verified as unqualified.

**3.2.7** Quality assurance data on works, including site construction logs, test records and quality inspection results, shall be correct, accurate, adequate and complete, and shall include but not be limited to the following:

- 1 Quality assurance data of equipment and materials, including the factory inspection certificate and qualified inspection report issued by qualified inspection organizations.
- 2 The quality inspection results of the spot check of the main raw materials and equipment, including the inspection reports of the authorized samples sent by the contractor and authorized spot-check samples sent by the supervisor;
- 3 Installation and commissioning records of equipment and software.
- 4 Acceptance records and construction image/video data of concealed works.
- 5 Inspection and testing records during construction, including the Contractors' self-inspection records and the Supervisors' spot-check records.
- 6 Inspection and testing records of post-construction.



7 Other necessary documents, including records of abnormal conditions during the construction process, inspection and acceptance documents of relevant industries required according to the actual situation of the project, etc.

### **3.3 Construction Quality Verification**

**3.3.1** Construction quality verification is divided into two categories, qualified and unqualified.

**3.3.2** Data as specified in Appendix B of this Standard shall be provided for quality verification of sub-divisions of work, divisions of work and types of work.

**3.3.3** Quality verification of sub-divisions of work shall conform to the following requirements:

- 1 Basic requirement shall meet the regulation.
- 2 Appearance shall conform to specified requirements.
- 3 Test records shall be complete.
- 4 Measurement items shall be qualified;

**3.3.4** Quality verification on division of works shall conform to the following requirements:

- 1 Data and files for verification shall be complete;
- 2 Sub-division of works shall be verified as qualified;

**3.3.5** Quality verification of a type of work shall conform to the following requirements.

- 1 Data and files for verification shall be complete.

2 Division of works shall be verified as qualified.

**3.3.6** If all of the related types of work are qualified, the contract package is qualified; if all of the related contract packages are qualified, the construction project is qualified.

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# 4 Monitoring Facilities

## 4.1 Vehicle Detector

4.1.1 The vehicle detector shall conform to the following basic requirements:

1 The vehicle detector equipment shall conform to the current *Loop Vehicle Detector* (GB/T 26942), *Magnetic Vehicle Detector* (GB/T 35548), *Traffic Information Collection - Microwave Traffic Flow Detector* (GB/T 20609), *Traffic Information Collection —Video Vehicle Detector* (GB/T 24726) and other relevant standards.

2 The model, specification and quantity of the equipment and accessories of vehicle detectors shall conform to the contract requirements, and the components shall be complete.

3 The installation structure of the vehicle detector shall be stable, and the exterior of the chassis shall be complete.

4 The installation of sensor for vehicle detector shall comply with the design requirements, and the detection area shall be correct.

5 After the installation and commissioning of all the equipment, the vehicle detector shall be maintained in proper working condition.

4.1.2 The measurement items of the vehicle detector shall conform to the provisions in Table 4.1.2.

**Table 4.1.2 Measurement Items of the Vehicle Detector**

Item No.	Inspection items	Technical requirements	Inspection method
1	Foundation size	Meet the design requirements, allowable deviation: (-50,+100) mm	Measure the length and width with tape, and check the acceptance records on concealed works or carry out measurement for the buried depth
2	Thickness of anti-corrosion coating of chassis and column	Meet the design requirements, or the current GB/T 18226 in case of no requirements	By coating thickness gauge
3	Verticality of the column (microwave, video, ultrasonic vehicle detector)	$\leq 5\text{mm/m}$	By total station or verticality measuring instrument
4△	Insulation resistance	Strong-current terminal to chassis enclosure $\geq 50\text{M}\Omega$	By 500V megohmmeter
5△	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester
6△	Lightning protection ground resistance (microwave, video, ultrasonic vehicle detector)	$\leq 10\Omega$	By ground resistance tester
7△	Common ground resistance	If the protective ground electrode and lightning protection ground electrode of field equipment are not in separate arrangement, the common ground resistance is $\leq 1\Omega$	By ground resistance tester
8△	Relative error of traffic flow	Coil, geomagnetism: $\leq 2\%$ ; Microwave, video, ultrasonic: $\leq 5\%$	Compare the manual counting measurement with acquisition results
9	Relative error of vehicle speed	$\leq 5\%$	Compare the speedometer measurement with acquisition results, and take the average of the sum of absolute values of each vehicle speed error.
10△	Transmission performance	Out-of-step phenomenon $\leq 1$ time or $\text{BER} \leq 10^{-8}$ within 24-hour observation; packet loss rate in Ethernet transmission $\leq 0.1\%$	By data transmission tester or network tester
11△	Self-check function	Detect the equipment operation status automatically, and upload the fault information in real time	Function verification
12△	Reset function	Once powered on, the equipment	Function verification

		can automatically return to normal communication mode and be identified by the upper computer or control system; the data stored before power failure or breakdown shall be kept unchanged	
13	Local operation and maintenance function	Be able to connect with portable computer for testing and maintenance	Function verification

**4.1.3** The appearance of the vehicle detector shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **4.2 Weather Detector**

**4.2.1** The weather detector shall conform to the following basic requirements:

- 1 The weather detector equipment shall conform to the current *Specification for Meteorological Observation Facilities of Highway Traffic* (GB/T 33697) and other relevant standards.

- 2 The model, specification and quantity of the equipment and accessories of the weather detector shall conform to the contract requirements, and the components shall be complete.

- 3 The installation structure of the weather detector shall be stable, and the exterior of the main chassis shall be complete.

- 4 The installation height, location and size of the probe shall comply with the design requirements.

- 5 After the installation and commissioning of all the equipment, the weather detector shall be maintained in proper working condition.

4.2.2 The measurement items of the weather detector shall conform to the provisions in Table 4.2.2.

**Table 4.2.2 Measurement Items of the Weather Detector**

Item No.	Inspection items	Technical requirements	Inspection method
1	Foundation size	Meet the design requirements; allowable deviation: (-50,+100) mm	Measure the length and width with tape, and check the acceptance records on concealed work or carry out measurement for the buried depth
2	Thickness of anti-corrosion coating of chassis and column	Meet the design requirements, or conform to the provisions of the current GB/T 18226 in case of no such requirements	By coating thickness gauge
3	Verticality of the column	$\leq 5\text{mm/m}$	By total station or verticality measuring instrument
4△	Insulation resistance	Strong current terminal to casing $\geq 50\text{M}\Omega$	By 500V megohmmeter
5△	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester
6△	Lightning protection ground resistance	$\leq 10\Omega$	By ground resistance tester
7△	Common ground resistance	If the protective ground electrode and lightning protection ground electrode of field equipment are not in separate arrangement, the common ground resistance is $\leq 1\Omega$	By ground resistance tester
8△	Environment detection performance	8.1 Measurement error of temperature detector: $\pm 1.0^\circ\text{C}$	Compare the measurement and acquisition results
		8.2 Measurement error of humidity detector: $\pm 5\%\text{R.H.}$	
		8.3 Measurement error of visibility detector: $\pm 10\%$ or meet the design requirements	
		8.4 Measurement error of wind speed detector: $\pm 5\%$ or meet the design requirements	
9△	Data transmission performance	Out-of-step phenomenon $\leq 1$ time or $\text{BER} \leq 10^{-8}$ within 24-hour observation; packet loss rate in Ethernet transmission	By data transmission tester or network tester

		≤0.1%	
10	Precipitation detection function	Precipitation can be detected	Function verification or historical records viewing
11	Road surface condition detection function	Be able to detect the dry, wet, ponding, snow, ice and other conditions of the pavement	Function verification
12△	Self-check function	Detect the equipment operation state automatically, and upload the fault information in real time in case of fault	Function verification
13△	Reset function	Once powered on, the equipment can automatically return to the normal communication state and be identified by the upper computer or control system; the data stored before power failure or fault remains unchanged	Function verification
14	Local operation and maintenance function	Be able to connect with portable computer for testing and maintenance	Function verification

**4.2.3** The appearance of the weather detector shall comply with the following provisions:

- 1 No unacceptable defects listed in Appendix C of this Standard shall exist.

### **4.3 CCTV Monitoring System**

**4.3.1** The CCTV monitoring system shall conform to the following basic requirements:

- 1 The CCTV monitoring system equipment and accessories shall conform to the current *Video Matrix Switcher* (JT/T 897) and other relevant standards.

- 2 The model, specification and quantity of the equipment and accessories of CCTV monitoring system shall conform to the contract requirements, and the components shall be complete.

- 3 The installation structure of the field camera shall be stable, and the column installation shall be vertical and firm.

- 4 The installation position and height of the Pan-tilt-zoom camera (PTZ) shall

comply with the design requirements.

5 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**4.3.2** The measurement items of the CCTV monitoring system shall conform to the provisions in Table 4.3.2.

**Table 4.3.2 Measurement Items of the CCTV Monitoring System**

Item No.	Inspection items		Technical requirements	Inspection method
1	Foundation size		Meet the design requirements; allowable deviation: (-50,+100) mm	Measure the length and width with tape, and check the acceptance record on concealed work or carry out measurement for the buried depth
2	Thickness of anti-corrosion coating of chassis and column		Meet the design requirements, or conform to the provisions of the current GB/T 18226 in case of no such requirements	By coating thickness gauge
3	Verticality of the column		$\leq 5\text{mm/m}$	By total station or verticality measuring instrument
4△	Insulation resistance		Strong current terminal to chassis enclosure $\geq 50\text{M}\Omega$	By 500V megohmmeter
5△	Protective ground resistance		$\leq 4\Omega$	By ground resistance tester
6△	Lightning protection ground resistance		$\leq 10\Omega$	By ground resistance tester
7△	Common ground resistance		If the protective ground electrode and lightning protection ground electrode of field equipment are not in separate arrangement, the common ground resistance is $\leq 1\Omega$	By ground resistance tester
8 Chan- nel trans- missi- on index	8.1 Standard- definition analog composite video signal	△8.1.1 Video level	$(700\pm 30)\text{ mV}$	The signal generator sends 75% color bar signal or 2T sine square wave and bar pulse signal, which shall be measured by video tester
		△8.1.2 Synchronization pulse amplitude	$(300\pm 20)\text{ mV}$	The signal generator sends 75% color bar signal or 2T sine square wave and bar pulse signal, which shall be measured by video tester



	$\Delta$ 8.1.3 Echo E	$< 7\%$	The signal generator sends 2T sine square wave and bar pulse signal, which shall be measured by video tester
	8.1.4 Luminance nonlinearity	$\leq 5\%$	The signal generator sends the non-modulated five-step signal, which shall be measured by video tester
	8.1.5 chrominance/luminance gain inequality	$\pm 5\%$	The signal generator sends a subcarrier-filled 10T signal or a subcarrier-filled bar pulse signal, which shall be measured by video tester
	8.1.6 Chrominance/Luminance signal latency	$\leq 100\text{ns}$	The signal generator sends a subcarrier-filled 10T signal or a subcarrier-filled bar pulse signal, which shall be measured by video tester
	8.1.7 Differential gain	$\leq 10\%$	The signal generator sends the modulated five-step signal, which shall be measured by video tester
	8.1.8 Differential phase	$\leq 10^\circ$	The signal generator sends the modulated five-step signal, which shall be measured by video tester
	$\Delta$ 8.1.9 Amplitude-frequency characteristics (within 5.8MHz bandwidth)	$\pm 2\text{dB}$	The signal generator sends $\sin x/x$ signal, which shall be measured by video tester
	$\Delta$ 8.1.10 Video signal-to-noise ratio (weighted)	$\geq 56\text{dB}$	The signal generator sends multi-burst signal, which shall be measured by video tester
8.2 High-definition Y, $C_R(P_R)$ , $C_B(P_B)$ video signals	$\Delta$ 8.2.1 Output quantization error of Y signal	$(-10 \sim +10)\%$	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
	$\Delta$ 8.2.2 Output quantization error of $C_R(P_R)$ signal	$(-10 \sim +10)\%$	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
	$\Delta$ 8.2.3 Output quantization error of $C_B(P_B)$ signal	$(-10 \sim +10)\%$	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester

	<p>△8.2.4 Amplitude-frequency characteristics of Y signal</p>	<p>Within 30MHz bandwidth ±3dB</p>	<p>The digital signal generator sends high-definition multi-burst signal or SinX/X signal, which shall be measured by digital video tester</p>
	<p>8.2.5 Nonlinear distortion of Y, C<sub>B</sub>(P<sub>B</sub>) and C<sub>R</sub>(P<sub>R</sub>) signals</p>	<p>≤5%</p>	<p>The digital signal generator sends high-definition five-step wave signal, which shall be measured by digital video tester</p>
	<p>△8.2.6 Linear response of luminance channel (K coefficient of Y signal)</p>	<p>≤3%</p>	<p>The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester</p>
	<p>8.2.7 Signal latency of Y/C<sub>B</sub>(Y/P<sub>B</sub>) and Y/C<sub>R</sub>(Y/P<sub>R</sub>) signals</p>	<p>±10ns</p>	<p>The digital signal generator sends high-definition color bar signal, which shall be measured by digital video tester</p>
	<p>△8.2.8 Signal-to-noise ratio of Y, C<sub>B</sub>(P<sub>B</sub>) and C<sub>R</sub>(P<sub>R</sub>) signals (weighted)</p>	<p>≥56dB</p>	<p>The digital signal generator sends the silent line signal, which shall be measured by digital video tester</p>
8.3 High-definition G, B and R video signals	<p>△8.3.1 Output quantization error of G signal</p>	<p>(-10 ~ +10)%</p>	<p>The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester</p>
	<p>△8.3.2 Output quantization error of B signal</p>	<p>(-10 ~ +10)%</p>	<p>The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester</p>
	<p>△8.3.3 Output quantization error of R signal</p>	<p>(-10 ~ +10)%</p>	<p>The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester</p>
	<p>△8.3.4 Amplitude-frequency characteristics of G/B/R signal</p>	<p>Within 30MHz bandwidth ±3dB</p>	<p>The digital signal generator sends high-definition multi-burst signal or SinX/X signal, which shall be measured by digital video tester</p>
	<p>8.3.5 Nonlinear distortion of G, B and R signals</p>	<p>≤5%</p>	<p>The digital signal generator sends high-definition five-step wave signal, which shall be measured by digital video tester</p>
	<p>△8.3.6 Linear response of luminance channel (K coefficient of G, B and R signals)</p>	<p>≤3%</p>	<p>The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester</p>

		8.3.7 Signal latency of G/B, G/R and B/R signals	$\pm 10\text{ns}$	The digital signal generator sends high-definition color bar signal, which shall be measured by digital video tester
		$\Delta$ 8.3.8 Signal-to-noise ratio of G, B and R signals	$\geq 56\text{dB}$	The digital signal generator sends the silent line signal, which shall be measured by digital video tester
9 Monitor picture index $\Delta$	9.1 Standard-definition analog composite video signal	9.1.1 Snowflakes	$\geq 4$ points	Manual subjective scoring (not less than 3 persons)
		9.1.2 Netlike wrinkle	$\geq 4$ points	
		9.1.3 Black and white rolling blink	$\geq 4$ points	
		9.1.4 Bounce	$\geq 4$ points	
	9.2 HD video signal	9.2.1 Distortion	$\geq 4$ points	
		9.2.2 Trailing	$\geq 4$ points	
		9.2.3 Frame skip	$\geq 4$ points	
		9.2.4 Jitter	$\geq 4$ points	
		9.2.5 Mosaic	$\geq 4$ points	
10 $\Delta$ Data transmission performance	10.1 Throughput of IP network	Meet the requirements on the maximum code stream of the encoder in design documents, or the length of 1518-frame shall be $\geq 99\%$ in case of no such requirements	By the Ethernet performance tester	
	10.2 Transmission delay of IP network	Meet the design requirements, or $\leq 10\text{ms}$ in case of no such requirements	By the Ethernet performance tester	
	10.3 Packet loss rate of IP network	$\leq 0.1\%$ when the traffic load is not greater than 70%	By the Ethernet performance tester	
11 $\Delta$	Horizontal rotation angle of PTZ		Horizontal: $\geq 350^\circ$	Operation inspection
12 $\Delta$	Vertical rotation angle of PTZ		Upward $\geq 15^\circ$ , downward $\geq 90^\circ$	Operation inspection
13 $\Delta$	Monitoring range		Meet the design requirements	Operation inspection
14 $\Delta$	Installation stability of field camera		When affected by strong wind or controlled by zooming, rolling and other operations, the picture moves smoothly without jitter	Operation inspection
15	Automatic aperture adjustment		Regulate automatically	Operation inspection
16	Focusing function		Fast auto-focus	Function verification
17	Zoom function		Be able to adjust the magnification of the camera lens	Function verification

18△	Switching function	The monitoring terminal can switch any camera in the system	Function verification
19	Video recording function	Video can be recorded, and the video playback is clear	Function verification
20△	Reset function	Once powered on, the equipment can automatically reset to the normal communication status, connect with the upper computer or control system, and work reliably	Function verification
<p>Note: The subjective scoring could be assessed by five-level damage system.</p> <p>1) No perceptible damage or interference on the image: 5 points;</p> <p>2) Slightly perceptible damage or interference on the image: 4 points;</p> <p>3) Obvious damage or interference on the image: 3 points;</p> <p>4) Serious damage or interference on the image: 2 points;</p> <p>5) Extremely serious damage or interference on the image: 1 point.</p>			

**4.3.3** The appearance of the CCTV monitoring system shall comply with the following provisions:

There shall be no unacceptable defects listed in Appendix C of this Standard.

## 4.4 Changeable Signs

**4.4.1** The changeable signs shall conform to the following basic requirements:

1 The changeable signs equipment shall conform to the current *Light-emitting Diode Changeable Message Signs of Expressway* (GB/T 23828), *Light-emitting Diode Changeable Speed Limit Signs of Expressway* (GB 23826), *Road Traffic Signal Lamps* (GB 14887), *Specification for LED Lane Control Signs* (JT/T 597) and other relevant standards, depending on their types.

2 The model, specification and quantity of the equipment and accessories of changeable signs shall conform to the contract requirements, and the components shall be complete.

3 The installation structure of the changeable sign shall be stable.

4 The installation position, angle and height of the changeable sign shall comply with the design requirements, and the form and structure of changeable sign frame shall comply with the design requirements.

5 After the installation and commissioning of all the equipment, the changeable sign shall be maintained in proper working condition.

**4.4.2** The measurement items of the changeable sign shall conform to the provisions in Table 4.4.2.

**Table 4.4.2 Measurement Items of the Changeable Sign**

Item No.	Inspection items	Technical requirements	Inspection method
1	Foundation size	Meet the design requirements; allowable deviation: (-50,+100) mm	Measure the length and width with tape, and check the acceptance record on concealed works or carry out measurement for the buried depth
2	Thickness of anti-corrosion coating of chassis and column	Meet the design requirements, or conform to the provisions of the current GB/T 18226 in case of no such requirements	By coating thickness gauge
3	Verticality of the column	$\leq 5\text{mm/m}$	By total station or verticality measuring instrument
4△	Insulation resistance	Strong current terminal to chassis enclosure $\geq 50\text{M}\Omega$	By 500V megohmmeter
5△	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester
6△	Lightning protection ground resistance	$\leq 10\Omega$	By ground resistance tester
7△	Common ground resistance	If the protective ground electrode and lightning protection ground electrode of field equipment are not in separate arrangement, the common ground resistance is $\leq 1\Omega$	By ground resistance tester
8△	Sight distance	When the vehicle travels at the maximum speed limit, it shall not be shorter than the driving sight distance	Operation inspection
9	Chrominance coordinates of light-emitting unit (x, y)	Comply with the provisions of the corresponding product standards	By chrominance/luminance meter

10	Average luminance of display screen	The luminance meets the design requirements. In case of no requirements, the maximum luminance of the changeable message sign and variable speed limit sign in the field shall be $\geq 8000\text{cd/m}^2$ , the maximum luminance of the changeable message sign in tunnel shall be $\geq 5000\text{cd/m}^2$ , and the maximum luminance of the LED lane control sign and traffic signal light shall be $\geq 1500\text{cd/m}^2$	By luminance meter
11△	Data transmission performance	Out-of-step phenomenon $\leq 1$ time or $\text{BER} \leq 10^{-8}$ within 24-hour observation; packet loss rate in Ethernet transmission $\leq 0.1\%$	By data transmission tester or network tester
12△	Display content	Display the contents sent by the computer of the monitoring center on time and in a correct manner	Operation inspection
13△	Luminance control function	The changeable message sign and the variable speed limit sign can automatically adjust the luminance of the display screen in conformance with the ambient brightness	Function verification
14△	Self-check function	Be able to provide confirmation information of the display content and self-check information of the working condition of the machine to the computer of the monitoring center	Function verification
15△	Reset function	Once powered on, the equipment can automatically reset to the normal communication mode and be identified by the upper computer or control system; the data stored before power failure or breakdown remains unchanged	Function verification
16	Local operation and maintenance function	Be able to connect with the portable computer for testing and maintenance	Function verification

4.4.3 The appearance of the changeable sign shall comply with the following provisions:

1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## 4.5 Road Video Traffic Incident Detection System

4.5.1 The road video traffic incident detection system shall conform to the following basic requirements:

1 The equipment of the road video traffic incident detection system shall conform to the current *Video Traffic Incident Detector* (GB/T 28789) and other relevant standards.

2 The model, specification and quantity of the equipment and accessories of the road video traffic incident detection system shall conform to the contract requirements, and the components shall be complete.

3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

4.5.2 The measurement items of the road video traffic incident detection system shall conform to the provisions in Table 4.5.2.

**Table 4.5.2 Measurement Items of the Road Video Traffic Incident Detection System**

Item No.	Inspection items	Technical requirements	Inspection method
1	Ground connection of central equipment	Ground connection wires of protective ground and lightning protection ground are firmly connected to the ground busbar	Visual inspection; measure by ground resistance tester if necessary
2	Incident detection rate	Meet the design requirements, or $\geq 90\%$ within the effective detection range in case of no such requirements	Simulate the incident on site for inspection in the daytime or play a standard incident source video for inspection
3	Relative error of traffic parameter detection	Meet the design requirements, or traffic flow $\leq 10\%$ and vehicle speed $\leq 15\%$ in case of no such requirements	Operation inspection, not less than 50 vehicles
4	Effective detection range	Meet the design requirements, or stop incident $\geq 300\text{m}$ , counterflow driving incident $\geq 200\text{m}$ , pedestrian incident $\geq 100\text{m}$ , abandoned object	Simulate the incident on site for inspection in the daytime or play a standard incident

		incident $\geq 100\text{m}$ , and motor vehicle departure incident $\geq 200\text{m}$ in case of no such requirements	source video for inspection
5△	Typical incident detection function	With the stop, counterflow driving, pedestrian, abandoned object, vehicle departure and other incident detection functions; the system with traffic parameter detection function can detect traffic parameters such as traffic flow and vehicle speed	Function verification
6	Automatic video recording function	The system automatically captures and stores the images of traffic incidents, and can set the recording time as required	Function verification
7	Self-diagnosis and alarm function	In case of video signal loss, system equipment breakdown and network communication fault, the system can process self-diagnosis, recording and alarm.	Function verification
8	Clock synchronization function	Synchronize with master clock of the monitoring system or communication system	Compare with the master clock

**4.5.3** The appearance of the road video traffic incident detection system shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## 4.6 Traffic Survey Facility

**4.6.1** The traffic survey facility shall conform to the following basic requirements:

- 1 The traffic survey facility shall conform to the current *Highway Traffic Survey Equipment* (JT/T 1008) and other relevant standards.
- 2 The model, specification and quantity of the equipment and accessories of traffic survey facility shall conform to the contract requirements, and the components shall be complete.
- 3 The installation structure of the traffic survey facility shall be stable, and the exterior of the chassis shall be complete.



4 The installation of the sensor shall comply with design requirements, and the detection area shall be correct.

5 After the installation and commissioning of all the equipment, the traffic survey facility shall be maintained in proper working condition.

**4.6.2** The measurement items of the traffic survey facility shall conform to the provisions in Table 4.6.2.

**Table 4.6.2 Measurement Items of the Traffic Survey Facility**

Item No.	Inspection items	Technical requirements	Inspection method
1	Foundation size	Meet the design requirements; allowable deviation: (-50,+100) mm	Measure the length and width with tape, and check the acceptance record on concealed work or carry out measurement for the buried depth
2	Thickness of anti-corrosion coating of chassis and column	Meet the design requirements, or conform to the provisions of the current GB/T 18226 in case of no such requirements	By coating thickness gauge
3	Verticality of the column (microwave, video, ultrasound equipment)	$\leq 5\text{mm/m}$	By total station or verticality measuring instrument
4 $\Delta$	Insulation resistance	Strong current terminal to chassis enclosure $\geq 50\text{M}\Omega$	By 500V megohmmeter
5 $\Delta$	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester
6 $\Delta$	Lightning protection ground resistance (microwave, video and ultrasonic traffic survey facilities)	$\leq 10\Omega$	By ground resistance tester
7 $\Delta$	Common ground resistance	If the protective ground electrode and lightning protection ground electrode of field equipment are not in separate arrangement, the common ground resistance $\leq 1\Omega$	By ground resistance tester
8 $\Delta$	Vehicle classification error	Meet the design requirements, or $\leq 10\%$ in case of no such requirements	Compare the measurement and acquisition results

9△	Relative error of traffic flow	Meet the design requirements, or $\leq 5\%$ in case of no such requirements	Compare the manual counting and acquisition results
10△	Relative error of vehicle speed	Meet the design requirements, or $\leq 8\%$ in case of no such requirements	By speedometer and compare with the acquisition results
11△	Transmission performance	Out-of-step phenomenon $\leq 1$ time or $BER \leq 10^{-8}$ within 24-hour observation; packet loss rate in Ethernet transmission $\leq 0.1\%$	By data transmission tester or network tester
12△	Self-check function	Auto-detect the equipment operation status, and upload the fault information in real time in case of breakdown	Function verification
13△	Reset function	Once powered on, the equipment can automatically reset to the normal communication mode and be identified by the upper computer or control system; the data stored before power failure or fault remains unchanged	Function verification
14	Local operation and maintenance function	Be able to connect with portable computer for testing and maintenance	Function verification

**4.6.3** The appearance of the traffic survey facility shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **4.7 Equipment and Software of Monitoring Center (Sub-center)**

**4.7.1** The equipment and software of the monitoring center (sub-center) shall conform to the following basic requirements:

- 1 The software of the monitoring center (sub-center) shall conform to the current *Test Method for Expressway Surveillance and Control System Software (JT/T 965)* and other relevant standards.

2 The machine room of the monitoring center (sub-center) shall be clean and tidy with good ventilation, lighting as well as ambient temperature and humidity conditions.

3 The model, specification and quantity of the equipment and accessories of monitoring centers (sub-center) shall conform to the contract requirements, and the components shall be complete.

4 After the installation and commissioning of all the equipment and software of the monitoring center (sub-center), the system shall be maintained in proper working condition.

5 The monitoring software includes system software and application software. The system software shall be legally authorized and a formal authorization certificate shall be submitted, and the application software shall bear software development and test documents.

**4.7.2** The measurement items of the equipment and software of the monitoring center (sub-center) shall conform to the provisions in Table 4.7.2.

**Table 4.7.2 Measurement Items of the Equipment and Software of Monitoring Center (Sub-center)**

Item No.	Inspection items	Technical requirements	Inspection method
1	Indoor temperature of monitoring room	(18 ~ 28)°C	Measure 10 measuring points with hygrothermograph, and take the average value
2	Indoor humidity of monitoring room	(30 ~ 70)%R.H.	Measure 10 measuring points with hygrothermograph, and take the average value
3	Indoor dust control measures of monitoring room	Class B (No obvious dust shall be visible on the equipment within one week)	Visual inspection
4	Indoor noise of monitoring room	≤70 dB(A)	By sound level meter
5	Illuminance of indoor working environment of monitoring room	(5~200)lx adjustable	By illuminometer

6△	Insulation resistance	Strong current terminal to chassis enclosure $\geq 50M\Omega$	Check the follow-up acceptance record, or spot check 3 sets of equipment by 500V megohmmeter
7△	Common ground resistance of monitoring center	$\leq 1\Omega$	By ground resistance tester
8	Ground connection of central equipment	Ground connection wires of protective ground and lightning protection ground are firmly connected to the ground busbar	Visual inspection; measure by ground resistance tester if necessary
9	Communication polling cycle with field equipment	Meet the design requirements	Operation inspection
10△	Data exchange with downstream equipment	Exchange data with the vehicle detector, weather detector, changeable sign, etc. in real-time and accurate manner according to the setting system polling cycle	For the detector, carry out manual test statistics in the field, and then compare it with the center one by one according to the time period, with the time not less than 30min; for the changeable signs, compare the correctness and real-time performance of information between center and field
11△	Image monitoring function	Be able to monitor the operation status of road	Function verification
12	System operation condition monitoring function	The operation condition of field equipment of the system can be displayed correctly on the computer or large screen	Function verification
13	Information publishing function	Command information is correctly transmitted to the changeable message signs, traffic lights, lane control signs and other equipment through the system	Function verification
14	Statistics, query and report printing functions	Support quick and correct statistics and query of the directives, equipment conditions, system failures, traffic parameters and other data, and print relevant reports	Function verification
15△	Data backup and storage functions	Possess data backup and storage functions, with time records	Function verification

16	Power-on self-diagnosis function	Be able to cyclically detect the operation status of equipment in or out the field of all monitoring centers (sub-centers), and display the fault type and location promptly and correctly.	Function verification
17	Emergency plan of monitoring system	Meet the design requirements	Function verification

**4.7.3** The appearance of the monitoring center (sub-center)equipment shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The layout of equipment on the console shall meet the design requirements, with stable installation, vertical and horizontal alignment and clear identification.
- 3 The layout of CCTV monitors shall meet the design requirements, with complete screen splicing, stable installation, vertical and horizontal alignment and clear identification.

## **4.8 Large-screen Display System**

**4.8.1** The large-screen display system shall conform to the following basic requirements:

- 1 The quantity, model and specification of the screen and accessories shall conform to the contract requirements, and the components shall be complete.
- 2 The installation position, angle and height of the screen shall comply with the design requirements and be firmly installed.
- 3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**4.8.2** The measurement items of the large-screen display system shall conform to the

provisions in Table 4.8.2.

**Table 4.8.2 Measurement Items of the Large-screen Display System**

Item No.	Inspection items	Technical requirements	Inspection method
1	Splicing joint	Meet the design requirements, or $\leq 2\text{mm}$ in case of no such requirements	By measuring tools
2△	Luminance	The luminance when reaching white balance shall meet the design requirements, or ensure the large projection screen $\geq 150\text{ cd/m}^2$ , the LCD and LED display screen $\geq 450\text{ cd/m}^2$ in case of no such requirements	By luminance meter
3	Luminance unevenness	The luminance unevenness with white balance shall meet the design requirements, or $\leq 10\%$ in case of no such requirements	By luminance meter
4	Display function	Correctly display the switched images and other information	Function verification
5△	Window zooming	Be able to zoom and control the selected window at will	Operation inspection
6△	Multi-window display	Display the windows of multiple monitoring screens at the same time	Operation inspection

**4.8.3** The appearance of the large-screen display system shall comply with the following provisions:

- 1 The appearance of the large screen shall be complete without damage, the lens shall be clean, and the screen shall be smooth and neat with uniform color.
- 2 The image shall be clear, stable and jitter-free.
- 3 The image shall be bright, with adjustable vibrant color.

## **4.9 Computer Network of Monitoring System**

**4.9.1** The computer network of the monitoring system shall conform to the following basic requirements:

1 The model, specification and quantity of the network equipment such as network cable, socket, connector, network adapter, hub, switchboard, router, modem and server shall conform to the contract requirements, and the components shall be complete.

2 The crimping type (line-to-line distribution) of socket and double-twisted wire joint shall comply with the provisions of the current EIA/TIA 568A or 586B; only one crimping type can be used in one system, and no mixing is allowed.

3 After the installation and commissioning of all the equipment, the computer network of monitoring system shall be maintained in proper working condition.

**4.9.2** The measurement items of the computer network of monitoring system shall conform to the provisions in Table 4.9.2.

**Table 4.9.2 Measurement Items of the Computer Network of Monitoring System**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Wiring diagram	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
2	Length	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
3△	Return loss	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
4	Insertion loss	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
5△	Near-end crosstalk	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
6	Power sum of near-end crosstalk	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
7	Attenuated far-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
8	Power sum of attenuated far-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
9	Attenuated near-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
10	Power sum of attenuated near-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester

11	Loop resistance		Comply with the provisions of the current GB/T 50312	By validator – network certify tester
12	Time delay		Comply with the provisions of the current GB/T 50312	By validator – network certify tester
13	Time delay inequality		Comply with the provisions of the current GB/T 50312	By validator – network certify tester
14△	Performance requirements of Ethernet system	14.1 Link transmission rate	Meet the design requirements, or meet the requirements of 10Mbps, 100Mbps and 1000Mbps in case of no such requirements	By the ethernet performance tester
		14.2 Throughput rate	Meet the design requirements, or ensure the frame length of 1518 bytes $\geq 99\%$ in case of no such requirements	
		14.3 Transmission delay	Meet the design requirements, or $\leq 10\text{ms}$ in case of no such requirements	
		14.4 Packet loss rate	$\leq 0.1\%$ when the traffic load is not greater than 70%	
15△	Health condition of Ethernet link layer	15.1 Link utilization rate	$\leq 70\%$	By the ethernet performance tester
		15.2 Error rate and errors	$\leq 1\%$	
		15.3 Broadcast frame and multicast frame	$\leq 50\text{fps}$	
		15.4 Conflict (collision) rate	$\leq 1\%$	

**4.9.3** The appearance of the computer network of monitoring system shall comply with the following provisions:

1 The network equipment, cable trough and telecommunications outlet shall be arranged orderly with firm installation and clear identification.

2 Cable routing shall be correct, with firm binding, standard end connection and



correct and clear identification; the bending radius and pre-reserved length of the cable shall comply with the provisions of the current *Code for Engineering Acceptance of Generic Cabling System* (GB/T 50312).

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# 5 Communication Facilities

## 5.1 Communication Conduit Works

5.1.1 The communication conduit works shall conform to the following basic requirements:

- 1 The model and specification of communication conduits and the cross-section combination of conduit group shall meet the design requirements.
- 2 The laying and installation of communication conduits shall meet the requirements of relevant technical specifications.
- 3 The buried depth of communication conduits of various materials from pipe top to the pavement shall meet the design requirements.
- 4 The conduit boxes used when passing through bridges or other structures, and the conduits used in up-lead and down-lead works shall meet the design requirements.
- 5 The manhole (handhole) position shall be accurate, and embedded parts shall be installed firmly with waterproof measures.

5.1.2 The measurement items of the communication conduit works shall conform to the provisions in Table 5.1.2.

**Table 5.1.2 Measurement Items of the Communication Conduit Works**

Item No.	Inspection items	Technical requirements	Inspection method
1	Conduit foundation	Meet the design requirements	Check the acceptance record of concealed work, and carry out splitting for measurement if necessary

2	Conduit laying	Meet the design requirements	Check the acceptance record of concealed work, and carry out splitting for measurement if necessary
3	Backfill tamping	Meet the design requirements	Check the acceptance record of concealed work, and carry out splitting for measurement if necessary
4	Manhole (handhole) and conduit burial	Meet the design requirements	Check the acceptance record of concealed work, and carry out splitting for measurement if necessary
5	Position of manhole (handhole)	Meet the design requirements	By measuring tool
6	Bifurcation type and internal dimensions	Meet the design requirements	Visual inspection; measure the dimension with measuring tool
7	Transverse position of communication conduit	Meet the design requirements	By measuring tool
8△	Hole trial-through test of main conduit	Unblocked	Check the follow-up acceptance record or measure it according to Appendix D of this Standard
9△	Hole trial-through test of plastic pipe for communication conduit works	Unblocked	Check the follow-up acceptance record or measure it by air blowing method
10	Specifications and dimensions of plastic pipes (boxes) for communication conduit works	Meet the design requirements	Check the follow-up acceptance record or measure it with measuring tool
11	Pipe hole plugging	Meet the design requirements	Check the follow-up acceptance record or conduct visual inspection

**5.1.3** The appearance of the communication conduit works shall comply with the following provisions:

1 The pipe plug at the place where the pipe enters the building or manhole (handhole) shall meet the design requirements and be well sealed.

2 The communication conduits used when passing through bridges or other structures shall be installed firmly, arranged orderly, connected smoothly and sealed well.

## **5.2 Communication Optical Cable and Power Cable Line Works**

**5.2.1** The communication optical cable and power cable line works shall conform to the following basic requirements:

1 The model, specification and quantity of communication optical cables and

electrical cables shall conform to the requirements of the contract and relevant technical specifications.

2 The laying, connection, reservation and termination of optical cables and electrical cables shall meet the requirements of relevant technical specifications.

3 The binding of optical cables and electrical cables shall be firm, moderately tight and close, and binding threads shall be uniform, neat and consistent.

4 The optical cables and electrical cables in the trough and bracket shall be straight without obvious twisting and crossing, trough overflow and rollover; the bend shall be moderate; the access troughs and brackets shall be tied neatly.

5 The trough and bracket shall be reliably grounded.

**5.2.2** The measurement items of the communication optical cable and power cable line works shall conform to the provisions in Table 5.2.2.

**Table 5.2.2 Measurement Items of the Communication Optical Cable and Power Cable Line Works**

Item No.	Inspection items	Technical requirements	Inspection method
1	Insulation resistance of optical cable sheath	$\geq 1000\text{M}\Omega\cdot\text{km}$	Check the follow-up acceptance record or measure it with a 1000V megohmmeter (only for buried optical cables)
2△	Average splice loss of single-mode optical fiber	$\leq 0.1\text{dB}$	By optical time-domain reflectometer
3	Maximum splice loss of single-mode optical fiber	$\leq 0.18\text{dB}$	By optical time-domain reflectometer
4△	Average splice loss of multi-mode optical fiber	$\leq 0.08\text{dB}$	By optical time-domain reflectometer
5	Maximum splice loss of multi-mode optical fiber	$\leq 0.14\text{dB}$	By optical time-domain reflectometer
6△	Total attenuation of single-mode optical fiber in repeater section	Meet the design requirements	By optical time-domain reflectometer or illuminant, optical power meter
7△	Total attenuation of multi-mode optical fiber in repeater section	Meet the design requirements	By optical time-domain reflectometer or illuminant, optical power meter

8△	Insulation resistance of audio cable	$\geq 1000\text{M}\Omega \cdot \text{km}$	line-to-line measurement using high-resistance megger
9	Crosstalk attenuation of audio cable	Meet the design requirements	By cable analyzer or crosstalk analyzer
10	DC loop resistance of audio cable	Meet the design requirements	By cable analyzer
11△	Wiring diagram (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
12	Length (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
13△	Return loss (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
14	Insertion loss (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
15△	Near-end crosstalk (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
16	Power sum of near-end crosstalk (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
17	Attenuated far-end crosstalk ratio (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
18	Power sum of attenuated far-end crosstalk ratio (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
19	Attenuated near-end crosstalk ratio (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
20	Power sum of attenuated near-end crosstalk ratio (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
21	Loop resistance (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
22	Time delay (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester

23	Signal latency (network cable)	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
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**5.2.3** The appearance of the optical cable and power cable line works shall comply with the following provisions:

1 The optical cable and electrical cable distribution box (rack) shall be installed stably with vertical and horizontal alignment as well as complete accessories; the optical cable and electrical cable splicing box (case) shall be installed firmly and sealed well.

2 Optical cable and electrical cable lines shall be routed correctly with proper protection measures, orderly arrangement, firm binding, and pre-reserved length in accordance with regulations, and the identification shall be clear and correct.

### **5.3 SDH (Synchronous Digital Hierarchy) Fiber Transmission System**

**5.3.1** The SDH fiber transmission system shall conform to the following basic requirements:

1 The equipment room of the SDH fiber transmission system shall be clean with good ventilation and lighting, and the ambient temperature and humidity shall meet the requirements of Class II communication room in *The Requirement of Environment Conditions for General Equipment Room for Communication* (YD/T 1821-2008).

2 The SDH fiber transmission system equipment shall obtain the telecom equipment network access license; the model, specification and quantity of the SDH fiber transmission system shall conform to the contract requirements, and the components shall be complete.

3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

5.3.2 The measurement items of the SDH fiber transmission system shall conform to the provisions in Table 5.3.2.

**Table 5.3.2 Measurement Items of the SDH Fiber Transmission System**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Reliability of the system equipment installation and connection	The installation and connection of system equipment shall be reliable, and the system has no alarm and no bit error after vibration test	Observe continuously for 15min under the vibration condition (knock properly with rubber hammer)
2	Ground connection	Ground connection wires of protective ground and lightning protection ground are firmly connected to the ground busbar	Visual inspection; measure by ground resistance tester if necessary
3△	Received optical power of system	$P_i \geq P_R + M_c + M_e$ *	By optical power meter
4△	Average transmitted optical power	Meet the design requirements or factory inspection index and parameter	By optical power meter
5△	Sensitivity of received optical	Meet the design requirements or factory inspection index and parameter	By optical power meter and bit-error tester
6△	Bit error index (2M electrical port)	$BER \leq 1 \times 10^{-11}$	By bit-error tester; spot check three 2M branches for each 2M circuit board, and test one branch for 24h and other branches for 15min; multiple branches can be connected in series for testing
		$ESR \leq 1.1 \times 10^{-5}$	
		$SESR \leq 5.5 \times 10^{-7}$	
		$BBER \leq 5.5 \times 10^{-8}$	
7	Allowable bit tolerance of electrical interface	Comply with the provisions of the current YD/T 5095	By PDH/SDH communication performance analyzer
8	Input jitter tolerance	Comply with the provisions of the current YD/T 5095	By PDH/SDH communication performance analyzer
9	Output jitter	Comply with the provisions of the current YD/T 5095	By PDH/SDH communication performance analyzer
10	Drift index of 2M branch intersection	a. $MTIE \leq 18\mu s(24h)$ b. 40h sliding $\leq 1$ time	Test on 2M link with the longest transmission link or timing link passing through the most network elements and asynchronous boundary

11	Authorization management function	No access to the network management system without authorization	Function verification
12△	Automatic protection switching function	Switch to the standby line automatically in case of working loop failure or large bit error	Function verification; measure a loop
13△	Remote access function	Be able to add or delete remote module through network management	Function verification
14△	Configuration function	Be able to add or delete network element components, and display the current configuration graphically	Function verification
15	Network performance monitoring function	Be able to collect and analyze network bit error and other performance parameters in real time	Function verification
16	Laser auto-shutdown function	Be able to shut down automatically when there is no input optical signal	Function verification; test the luminous port of the backup board
17△	Fault location function	Be able to display the fault location in case of fault	Function verification
18	Loss of signal alarm (LOS)	Trigger an alarm	Operation inspection
19△	Power failure alarm	Trigger an alarm	Operation inspection
20△	Loss of frame alignment alarm (LOF)	Trigger an alarm	Operation inspection
21△	AIS alarm	Trigger an alarm	Operation inspection
22△	Reference clock loss alarm	Trigger an alarm	Operation inspection
23	Pointer loss alarm	Trigger an alarm	Operation inspection
24	Far end receive failure (FERF)	Trigger an alarm	Operation inspection
25	Far end receive error (FEBE)	Trigger an alarm	Operation inspection
26	Loss of multiframe of electrical interface (LOM)	Trigger an alarm	Operation inspection
27	Signal degrade ( $BER > 1 \times 10^{-6}$ )	Trigger an alarm	Operation inspection
28	Large bit error of signal ( $BER > 1 \times 10^{-3}$ )	Trigger an alarm	Operation inspection
29	Machine panel failure alarm	Be able to switch automatically and trigger an alarm	Operation inspection
<p>* <b>Note:</b> <math>P_r</math>: measurement of the system received optical power at the receiving end; <math>P_R</math>: receiving sensitivity of receiver; <math>M_c</math>: optical cable redundancy; <math>M_e</math>: equipment redundancy.</p>			



**5.3.3** The appearance of the SDH fiber transmission system shall comply with the following provisions:

1 The layout of the trough, rack (including sub-rack, DDF-Digital Distribution Frame and ODF- Optical Distribution Frame) and equipment shall be arranged reasonable with stable installation; the rack features vertical and horizontal alignment and orderly arrangement; assembling screws shall be fastened and the pre-reserved length shall be consistent.

2 The wiring on the distribution frame shall be orderly and neat, with proper length; the binding shall be firm and the end shall meet the specification requirements; the identification shall be clear and correct.

3 The connecting wires and jumpers (fibers) for equipment connection shall meet the design requirements with proper length, and the identification shall be clear and correct.

## **5.4 IP Network System**

**5.4.1** The IP network system shall conform to the following basic requirements:

1 The equipment room of the IP network system shall be clean with good ventilation and lighting, and the ambient temperature and humidity shall meet the requirements of Class II communication room in *The Requirement of Environment Conditions for General Equipment Room for Communication* (YD/T 1821-2008).

2 The IP network system equipment shall obtain the telecom equipment network access license; the model, specification and quantity of the IP network system shall conform to the contract requirements, and the components shall be complete.

3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

5.4.2 The measurement items of the IP network system shall conform to the provisions in Table 5.4.2.

**Table 5.4.2 Measurement Items of the IP Network System**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Reliability of the system equipment installation and connection	The installation and connection of system equipment shall be reliable, and the system has no alarm and no bit error after vibration test	Observe continuously for 15min under the vibration condition (knock properly with a rubber hammer)
2	Ground connection	Ground connection lines of protective ground and lightning protection ground are firmly connected to the ground busbar	Visual inspection; measure by ground resistance tester if necessary
3△	Average transmitted optical power of IP network interface	Meet the design requirements, or ensure $-11.5\text{dBm} \leq \text{optical power} \leq -3\text{dBm}$ (1000BASE-LX), $-9.5\text{dBm} \leq \text{optical power} \leq -4\text{dBm}$ (1000BASE-SX) in case of no such requirements	By optical power meter
4△	Received optical power of IP network interface	$P_r \geq P_r + M_c + M_e$	By optical power meter
5△	Receiving sensitivity of IP network interface	Meet the design requirements, or meet the following in case of no such requirements: $\leq -19\text{dBm}$ (1000BASE-LX) $\leq -17\text{dBm}$ (1000BASE-SX)	By optical power meter, optical attenuator and traffic generator
6△	Throughput of IP network	Meet the design requirements, or ensure the length of 1518-frame $\geq 99\%$ in case of no such requirements	By the Ethernet performance tester
7△	Transmission delay of IP network	Meet the design requirements, or $\leq 100\text{ms}$ in case of no such requirements	By the Ethernet performance tester
8△	Packet loss rate of IP network	$\leq 0.1\%$ when the traffic load is not greater than 70%	By the Ethernet performance tester
9	Network performance monitoring function	Be able to collect and analyze network bit error and other performance parameters in real time	Function verification

10△	Automatic protection switching function	Switch to the standby line automatically in case of working loop failure or large bit error	Function verification
11	Half-duplex and full-duplex automatic negotiation of IP network interface	Automatic negotiation	By traffic generator or IP network performance analyzer
12△	Traffic control function of IP network	Possess traffic control function when the network traffic exceeds the port traffic	Function verification of traffic generator
13	IP network failure alarm management function	The network management system prompts when a failure occurs	Function verification
14	Authorization management function of IP network	No access to the network management system without authorization	Function verification
15	Enable or disable function of IP port	Be able to enable or disable a port from the network management system	Function verification
16	Network management query and configuration function of IP network	Be able to query and configure related services from the network management system	Function verification
17	Main and standby system processor switching function of IP network	Be able to auto-reset the standby system processor in case of main system processor breakdown	Function verification
18△	Fault diagnosis and location function of IP network	The network management system can display the fault location and information of boards, cards and communication ports	Function verification
19△	VLAN function of IP network	Be able to divide VLAN by port	Function verification
<p>* <b>Note:</b> P<sub>i</sub>: measurement of the system received optical power at the receiving end; P<sub>R</sub>: receiving sensitivity of receiver; M<sub>c</sub>: optical cable redundancy; M<sub>e</sub>: equipment redundancy.</p>			

**5.4.3** The appearance of the IP network system shall comply with the following provisions:

1 The layout of the trough, rack (including sub-rack, DDF and ODF) and equipment shall be reasonable with stable installation; the rack features vertical

and horizontal alignment and orderly arrangement; assembling screws shall be fastened and the pre-reserved length shall be consistent.

2 The wiring on the distribution frame shall be orderly and neat with proper length; the binding shall be firm and the end shall meet the specification requirements; the identification shall be clear and correct.

3 The connecting wires and jumpers (fibers) for equipment connection shall meet the design requirements with proper length, and the identification shall be clear and correct.

## **5.5 WDM (Wavelength-division Multiplexing) Fiber Transmission System**

**5.5.1** The WDM fiber transmission system shall conform to the following basic requirements:

1 The equipment room of the transmission system shall be clean with good ventilation and lighting, and the ambient temperature and humidity shall meet the requirements of Class II communication room in *The Requirement of Environment Conditions for General Equipment Room for Communication* (YD/T 1821-2008).

2 The transmission system equipment shall obtain the telecom equipment network access license; the model, specification and quantity of the transmission system equipment shall conform to the contract requirements, and the components shall be complete.

3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**5.5.2** The measurement items of the WDM fiber transmission system shall conform to the provisions in Table 5.5.2.

**Table 5.5.2 Measurement Items of the WDM Fiber Transmission System**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Reliability of the system equipment installation and connection	The installation and connection of system equipment shall be reliable, and the system has no alarm and no bit error after vibration test	Observe continuously for 15min under the vibration condition (knock properly with a rubber hammer)
2	Ground connection	Ground connection lines of protective ground and lightning protection ground are firmly connected to the ground busbar	Visual inspection; measure by ground resistance tester if necessary
3△	Central wavelength of receiving and transmitting reference point on line side	Comply with the provisions of the current YD/T 1143	By spectrometer
4△	Central frequency deviation of receiving and transmitting reference points on line side	±12.5GHz	By spectrometer
5	Signal power	Meet the design requirements or factory inspection index	By spectrometer
6△	Optical signal-to-noise ratio (OSNR)	> 25dB	By spectrometer
7	Noise	< -21dBm	By spectrometer
8	-20dB bandwidth	< 0.3nm	By spectrometer
9	0Ch central wavelength	Comply with the provisions of the current YD/T 1143	By spectrometer
10△	0Ch minimum side-mode suppression ratio	> 25dB	By spectrometer
11	Central wavelength of demultiplexer	Comply with the provisions of the current YD/T 1143	By spectrometer
12△	Insertion loss of demultiplexer	< 10dB	By spectrometer
13	Maximum difference in insertion loss of demultiplexer	< 2dB	By spectrometer
14△	Isolation degree of adjacent channels of demultiplexer	> 22dB	By broadband light source and spectrometer
15	Center wavelength of multiplexer	Comply with the provisions of the current YD/T 1143	By spectrometer
16△	Insertion loss of multiplexer	< 8dB	By spectrometer
17	Maximum difference in insertion loss of multiplexer	< 2dB	By spectrometer

18△	Isolation degree of adjacent channels of multiplexer	> 22dB	By spectrometer
19△	MPI-SM ~ MPI-RM residual dispersion	Comply with the provisions of the current YD/T 1143	By broadband light source and dispersion analyzer
20△	MPI-SM ~ MPI-RM polarization mode dispersion	Comply with the provisions of the current YD/T 1143	By broadband light source and dispersion analyzer
21	Network performance	Comply with the provisions of the current YD/T 2148	Test in accordance with Article 5.3.2 or Article 5.4.2 of this Standard, depending on the service interface
22△	Automatic protection switching function	Auto-switch to the standby line in case of working loop failure or large bit error	Function verification; measure a loop
23	Network management function	Comply with the provisions of the current YD/T 2148	Function verification
24	Laser auto-shutdown function	Be able to shut down automatically when there is no input optical signal	Function verification; test the luminous port of the backup board
25	Loss of signal alarm (LOS)	Trigger an alarm	Operation inspection
26△	Power failure alarm	Trigger an alarm	Operation inspection
27	Machine panel failure alarm	Be able to switch automatically and trigger an alarm	Operation inspection

**5.5.3** The appearance of the WDM fiber transmission system shall comply with the following provisions:

1 The layout of the trough, rack (including sub-rack, DDF and ODF) and equipment shall be reasonable with stable installation; the rack features vertical and horizontal alignment and orderly arrangement; assembling screws shall be fastened and the remaining length shall be consistent.

2 The wiring on the distribution frame shall be orderly and neat, with proper length; the binding shall be firm and the end shall meet the specification requirements; the identification shall be clear and correct.

3 The connecting wires and jumpers (fibers) for equipment connection shall meet the design requirements with proper length, and the identification shall be clear and correct.

## 5.6 PSTN - Public Service Telephone Network

5.6.1 The PSTN shall conform to the following basic requirements:

1 The equipment room of the PSTN shall be clean with good ventilation and lighting, and the ambient temperature and humidity shall meet the requirements of Class II communication room in *The Requirement of Environment Conditions for General Equipment Room for Communication* (YD/T 1821-2008).

2 The PSTN equipment shall obtain the telecom equipment network access license; the model, specification and quantity of its switching equipment, auxiliary equipment, console and various circuit boards shall conform to the contract requirements, and the components shall be complete.

3 The installation of equipment and its auxiliary equipment shall be firm.

4 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

5.6.2 The measurement items of the PSTN shall conform to the provisions in Table 5.6.2.

**Table 5.6.2 Measurement Items of the PSTN**

Item No.	Inspection items	Technical requirements	Inspection method
1	Ground connection	Ground connection wires of protective ground and lightning protection ground are firmly connected to the ground busbar	Visual inspection; measure by ground resistance tester if necessary
2Δ	Operating voltage	-57V ~ -40V	By multimeter
3	Internal obstacle rate	$\leq 3.4 \times 10^{-4}$	By call simulator
4Δ	Percept of call completed	$\geq 99.96\%$	By call simulator
5Δ	Packet loss rate of Softswitch IP bearer network	$\leq 0.1\%$	By IP network performance analyzer
6	Network jitter of Softswitch IP bearer network	$\leq 10\text{ms}$	By IP network performance analyzer

7	Time delay of Softswitch IP bearer network	≤100ms	By IP network performance analyzer
8	Packet error rate of Softswitch IP bearer network	≤1×10 <sup>-4</sup>	By IP network performance analyzer
9	End-to-end quality of service for voice in Softswitch network	When the network packet loss rate is ≤0.1%, the subjective speech score is ≥4.0, or the average PSQM of objective speech evaluation is ≤1.5 or PESQ is ≥3.3	By subjective scoring or IP voice phone test system
10	Authorization management function	No access to the management system without authorization	Function verification
11	System reset function	The system can reset to normal operation in case of startup after emergency shutdown, or after system switching.	Function verification
12△	User number modification function	After modifying the user number through the network management, the communication function of the original telephone will not be affected	Function verification
13△	Individual user level modification function	After modifying the user level through the network management, the modified user corresponds to the business authority of the new level	Function verification
14	Call barring function	Restrict the user's long-distance calls through network management	Function verification
15	Billing function	Be able to modify the rate, and print and display the fee amount and call records	Function verification
16	Phone call management	Record the phone call information automatically	Function verification
17△	Fault diagnosis and alarm	Trigger an alarm	Operation inspection
18	System switching function	Possess the functions of local office call, inter-office call, new service, etc.	Function verification
19	Multi-party call control function	Be able to establish a point-to-multipoint fast call	Function verification
<p>* Note: Subjective scoring criteria:</p> <p>(1) Very good; the voice is very clear, without distortion and delay; communication is smooth: 5 points;</p> <p>(2) Good; the voice is clear, with little delay and little noise; communication is slightly not smooth: 4 points;</p> <p>(3) Fair; the voice is not clear, with little delay, noise and distortion; communication is available: 3 points;</p> <p>(4) Poor; the voice is not clear, with loud noise, interrupted voice, and serious distortion; communication needs to be repeated for many times: 2 points;</p> <p>(5) Very poor; silent or completely inaudible, with very loud noise; unable to communicate: 1 point.</p>			

### 5.6.3 The appearance of the PSTN shall comply with the following provisions:



1 The layout of the trough, rack and equipment shall be reasonable with stable installation; the rack features vertical and horizontal alignment and orderly arrangement; assembling screws shall be fastened and the remaining length shall be consistent.

2 The wiring on the distribution frame shall be orderly and neat, with proper length; the binding shall be firm and the end shall meet the specification requirements; the identification shall be clear and correct.

3 The connecting wires and jumpers (fibers) for equipment connection shall meet the design requirements, with appropriate length. The identification shall be clear and correct.

## **5.7 Communication Power Supply System**

**5.7.1** The communication power supply system shall conform to the following basic requirements:

1 The model, specification and quantity of the equipment and accessories of communication power supply shall conform to the contract requirements, and the components shall be complete.

2 The connecting strips, bolts and nuts of the battery shall be treated with anti-corrosion and connected firmly.

3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**5.7.2** The measurement items of the communication power supply system shall conform to the provisions in Table 5.7.2.

**Table 5.7.2 Measurement Items of the Communication Power Supply System**

Item No.	Inspection items	Technical requirements	Inspection method
1	Lightning protection of communication power supply system	Meet the design requirements	Operation inspection
2	Ground of communication power supply system	Meet the design requirements	By ground resistance tester
3	Insulation resistance of AC circuit and DC circuit to ground and AC circuit to DC circuit	$\geq 2 \text{ M}\Omega$	By 500V megohmmeter
4△	Main output voltage of switching power supply	(-57.6~-43.2)V or (21.6 ~ 28.8)V	By multimeter
5	System noise voltage	Telephone weighted noise voltage at DC output end shall be $\leq 2\text{mV}$	By psophometer
		Peak-to-peak noise voltage $\leq 200\text{mV}$ at DC output end within 0MHz ~20 MHz frequency band	By psophometer or oscilloscope
6	Battery management function	Be able to switch the operation of discharging, equalizing and floating charging of the battery	By battery performance tester or check the follow-up acceptance record
7△	Alarm function of power system	Visual and audible alarm information can be provided in the machine room when the system is in abnormal state	Function verification
8	Remote maintenance management function	Be able to fulfill the centralized management of telemetry, telecontrol and telesignal	Function verification

**5.7.3** The appearance of the communication power supply system shall comply with the following provisions:

1 The layout of the power supply equipment shall be reasonable, with stable installation, vertical and horizontal alignment and orderly arrangement.

2 The distribution cables for power output shall be laid orderly, with correct routing and position.

3 The connecting wires between the equipment shall be orderly and neat, with proper length and firm binding, and the welding (crimping) connection of the wiring terminal shall be firm and smooth; the identification shall be correct and clear.

# 6 Toll Collection Facilities

## 6.1 Equipment and Software of ETC/MTC Entrance Lane

6.1.1 The equipment and software of ETC/MTC entrance lane shall conform to the following basic requirements:

1 The electrical (manual) barriers, antennas, lane controllers, display terminals, special keyboards, composite reader-writers, patron external display screens, lane information indicator screens, vehicle detectors, license plate recognition devices, lane cameras and other equipment shall comply with the provisions of relevant national and industry standards.

2 The model, specification and quantity of the equipment and accessories of ETC/MTC entrance lane shall conform to the contract requirements, and the components shall be complete.

3 After the installation and commissioning of all the equipment, the equipment and software of the lane shall be maintained in proper working condition.

4 The software of ETC/MTC entrance lane includes system software and application software, of which the system software shall be legally authorized and an official authorization certificate shall be provided, and the application software shall bear software development and test documents.

6.1.2 The measurement items of the equipment and software of ETC/MTC entrance lane shall conform to the provisions in Table 6.1.2.

**Table 6.1.2 Measurement Items of the Equipment and Software of ETC/MTC Entrance**

**Lane**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Insulation resistance of lane equipment	Strong current terminal to casing $\geq 50M\Omega$	By 500V megohmmeter
2△	Common ground resistance of lane equipment	$\leq 1\Omega$	By ground resistance tester
3	Antenna installation height	Meet the design requirements, or $\geq 5.5m$ in case of no such requirements	By measuring tools
4	Thickness of anti-corrosion coating for antenna column	Meet the design requirements, or $\geq 85\mu m$ in case of no such requirements	By coating thickness gauge
5	Chrominance and luminance of lane information indicator screen	The chrominance conforms to the regulations of the current GB/T 23828, the luminance meets the design requirements, or ensure luminance $\geq 5000cd/m^2$ in case of no such requirements	By chrominance/Luminance meter
6△	Control and display of lane information indicator screen	The switching control works normally, and the displayed information is correct	Operation inspection
7	Chrominance and luminance of lane control signs of toll canopy	The chrominance conforms to the current JT/T 597, with nighttime luminance $\geq 1000cd/m^2$	By chrominance/Luminance meter
8△	Control and display of lane control signs for toll canopy	Be able to be controlled according to the design requirements and display correctly	Operation inspection
9△	Control and display of toll lane traffic lights	Be able to be controlled according to the design requirements and display correctly	Operation inspection
10	Chrominance and luminance of patron external display screen	The chrominance conforms to the regulations of the current GB/T 23828, the luminance meets the design requirements, or ensure luminance $\geq 1500cd/m^2$ in case of no such requirements	By chrominance/Luminance meter
11△	Information display of patron external display screen of toll collection	Be able to display the set information in a timely and correct manner when vehicles pass by	Operation inspection; observe the information displayed on the fee display screen
12△	Flash alarm	Be able to trigger according to the set requirements and respond correctly	Operation inspection
13	Lifting/Falling time of electric barrier	Meet the design requirements, or $\leq 1.0s$ in case of no such requirements	By time counter
14	Thickness of anti-	Meet the design requirements, or $\geq 76\mu m$ in	By coating thickness gauge

	corrosion casing coating for electric barrier	case of no such requirements	
15	Electric barrier machine function	Be able to act according to the set operation process, and have the functions of anti-smash and horizontal rotation	Function verification
16	Inductance of loop coil	Meet the design requirements, or meet (50~1000) $\mu$ H in case of no such requirements	By inductance measuring instrument
17	Special keyboard	Flexible operation and accurate response	Operation inspection
18	Composite reader-writer	Read and write the pass card correctly to meet the requirements of state secret	Operation inspection
19 $\Delta$	Lane image capture	Be able to enable the image capture function when the vehicle enters the lane; the captured information meets the design requirements and can be stored and forwarded according to the prescribed format	Operation inspection
20 $\Delta$	Lane camera	Be able to carry out real-time video recording in the set lane area with clear image	Operation inspection
21	Character superimposition	The image information of lane camera and lane capture shall be superimposed clearly and correctly	Operation inspection
22	Automatic license recognition function	The acquired vehicle images are processed and recognized, and the recognition results are saved; the recognition results shall include license plate number, recognition time, license plate color, etc.	Operation inspection
23	Accuracy of license plate recognition	$\geq 95\%$	Test continuously for more than 24h, and check more than 200 pictures
24 $\Delta$	RSU communication area	Width $\leq 3.3$ m	By field intensity meter
25 $\Delta$	Initial state of lane	The lane information indicator screen shows that the lane is closed, and the lane barrier is in a horizontal closed state; the display content in the toll booth meets the design requirements and has the function of malicious login prevention	Operation inspection; malicious login verification function by inputting both correctly and incorrectly once when logging in.
26 $\Delta$	Open state of lane	Be able to open the lane after successful login, and the system enters the working state	Operation inspection
27	Login and logout of lane software system	Be able to log in and out firmly after starting the lane software	Operation inspection
28	Working condition monitoring and fault alarm of lane equipment	Be able to monitor the working state of lane equipment such as antenna, electric barrier and lane control sign, and output alarm	Operation inspection

		prompt information in case of equipment failure	
29	Record log query	Be able to query the transaction process log information of passing vehicles	Operation inspection
30△	Uploading function of lane toll data	Vehicle transaction data is correctly uploaded to the superior toll collection system	Function verification
31	Clock synchronization function	The clock of the lane system is synchronized with the clock of the superior toll collection system	Compare with the master clock
32△	Data transmission	Be able to transmit toll data accurately between the lane and the superior toll collection system	Operation inspection
33	Lane maintenance and reset operation processing	The maintenance menu allows authorized maintainers to perform lane maintenance and reset operation	Operation inspection
34	Support two-piece OBU and one-piece OBU transactions	Support two-piece OBU and one-piece OBU transactions at the same time, and be able to write the entry information in OBU (or ETC card)	Operation inspection
35	Support CPC card transaction	Support CPC card transaction and write the specified entry information	Operation inspection
36	Vehicle information collection	Detect and identify the license plate, vehicle model and other information of passing vehicles automatically, and support manual check and correction of automatically identified vehicle information	Operation inspection
37	Receiving and updating of toll parameters	Possess the functions of receiving and updating toll parameters (such as status list, credit blacklist, list of large transport vehicles, list of toll optimization and reduction in the province, list of special transportation vehicles ("two passenger buses and one dangerous vehicle"- two passenger buses are the tourist coach and the long distance passenger commercial vehicles, one dangerous vehicle is the special truck for transporting dangerous cargo), and write the information of special vehicles denied by ETC system into the transaction record	Operation inspection
38	Receiving of entrance weighing test data	Be able to receive the entrance weighing test data, and judge and dispose it according to relevant regulations	Operation inspection
39	ETC gantry bearing function	Have the ability to receive and update the toll rate of the current station issued by the	Operation inspection

		provincial networking center, write the entry information correctly in OBU (CPU user card) and CPC card and charge it, and form ETC or CPC card traffic record; dispose according to the operation rules when the user balance of stored-value card is insufficient	
40	Automatic information matching	ETC transaction record and CPC card traffic record shall be automatically matched with the captured vehicle pictures and uploaded to the toll station system in real time	Operation inspection
41	Interception of overloaded truck	Make judgment according to the entrance weighing test data, and have the function of automatically intercepting overloaded vehicles	Operation inspection
42	Power judgment of CPC card	The CPC card power judgment function shall be available, and the power shall not be distributed in lanes when it is less than 8%	Operation inspection
43△	Disconnection recovery function	Disconnect the communication link between the lane controller and the toll station, the lane is in normal working condition, and the data is not lost after the restoration of communication link	Function verification
44	Treatment of special vehicle	For special vehicles such as those with tag removal, tag invalidation, status list, credit blacklist, no user card insertion, and inconsistent card signature, display the special information that is consistent with the actual situation on the fee information display screen when the set treatment process is met	Operation inspection
45	Pass with CPC card after successful ETC vehicle transaction	After the successful transaction of normal ETC vehicle, exchange for CPC card for vehicle pass, and meet the specified treatment process	Operation inspection
46△	Normal traffic transaction process of ETC passenger car	Passenger car 1, passenger car 2, passenger car 3 and passenger car 4 pass respectively, the transaction and billing are correct (also with ETC gantry function), and the information display of the fee information display screen is timely and correct	Real vehicle test or history record check
47△	Normal traffic transaction process of ETC truck	Truck 1, truck 2, truck 3, truck 4, truck 5 and truck 6 pass respectively, the transaction and billing are correct (also with ETC gantry function), and the information display of the fee information display screen is timely and	Real vehicle test or history record check

		correct	
48△	Normal traffic transaction process of special ETC vehicle	Special vehicle 1, special vehicle 2, special vehicle 3, special vehicle 4, special vehicle 5 and special vehicle 6 pass respectively, the transaction and billing are correct (also with ETC gantry function), and the information display of the fee information display screen is timely and correct	Real vehicle test or history record check
49△	Traffic transaction process of MTC passenger car	Passenger car 1, passenger car 2, passenger car 3 and passenger car 4 pass respectively, the transaction and billing are correct (also with ETC gantry function), and the information display of the fee information display screen is timely and correct	Real vehicle test or history record check
50△	Traffic transaction process of MTC truck	Truck 1, truck 2, truck 3, truck 4, truck 5 and truck 6 pass respectively, the transaction and billing are correct (also with ETC gantry function), and the information display of the fee information display screen is timely and correct	Real vehicle test or history record check
51△	Traffic transaction process of special MTC vehicle	Special vehicle 1, special vehicle 2, special vehicle 3, special vehicle 4, special vehicle 5 and special vehicle 6 pass respectively, the transaction and billing are correct (also with ETC gantry function), and the information display of the fee information display screen is timely and correct	Real vehicle test or history record check
52	Transaction process for car-following interference	Vehicles with normal electronic tags follow vehicles with abnormal electronic tags or without electronic tags to enter the ETC/MTC entrance lane, and the transaction and release can be completed correctly	Real vehicle test

**6.1.3** The appearance of the equipment of ETC/MTC entrance lane shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The reflective signs on the electric (manual) barrier bars shall be clearly visible and complete.



## 6.2 Equipment and Software of ETC/MTC exit lane

6.2.1 The equipment and software of the ETC/MTC exit lane shall conform to the following basic requirements:

1 The electric (manual) barriers, antennas, lane controllers, display terminals, special keyboards, bill printers, composite reader-writers, patron external display screens, lane information indicator screens, vehicle detectors, license plate recognition equipment, lane cameras and other equipment shall comply with the provisions of relevant national and industry standards.

2 The model, specification and quantity of the equipment and accessories of ETC/MTC exit lane shall conform to the contract requirements, and the components shall be complete.

3 After the installation and commissioning of all the equipment, the equipment and software of the lane shall be maintained in proper working condition.

4 The software of exit mixed-lane includes system software and application software, in which the system software shall be legally authorized and an official authorization certificate shall be provided, and the application software shall bear software development and test documents.

6.2.2 The measurement items of the equipment and software of ETC/MTC exit lane shall conform to the provisions in Table 6.2.2.

**Table 6.2.2 Measurement Items of the Equipment and Software of ETC/MTC exit lane**

Item No.	Inspection items	Technical requirements	Inspection method
1□	Insulation resistance of lane equipment	Strong current terminal to casing $\geq 50M\Omega$	By 500V megohmmeter
2□	Common ground resistance of lane equipment	$\leq 1\Omega$	By ground resistance tester
3	Antenna installation height	Meet the design requirements, or $\geq 5.5m$ in case of no such requirements	By measuring tool

4	Thickness of anti-corrosion coating for antenna column	Meet the design requirements, or $\geq 85\mu\text{m}$ in case of no such requirements	By coating thickness gauge
5	Chrominance and luminance of lane information indicator screen	The chrominance conforms to the regulations of the current GB/T 23828, the luminance meets the design requirements, or ensure luminance $\geq 5000\text{cd}/\text{m}^2$ in case of no such requirements	By chrominance/luminance meter
6□	Control and display of lane information indicator screen	The switching control is normal and the displayed information is correct	Operation inspection
7	Chrominance and luminance of lane control signs of toll canopy	The chrominance conforms to the current JT/T 597, with nighttime luminance $\geq 1000\text{cd}/\text{m}^2$	By chrominance/luminance meter
8□	Control and display of lane control signs for toll canopy	Be able to be controlled according to the design requirements and display correctly	Operation inspection
9□	Control and display of toll lane traffic lights	Be able to be controlled according to the design requirements and display correctly	Operation inspection
10	Chrominance and luminance of patron external display screen of toll collection	The chrominance conforms to the regulations of the current GB/T 23828, the luminance meets the design requirements, or ensure luminance $\geq 1500\text{cd}/\text{m}^2$ in case of no such requirements	By chrominance/luminance meter
11□	Information display of patron external display screen of toll collection	Be able to display the set information timely and correctly when vehicles pass by	Operation inspection; observe the information displayed on the fee display screen
12□	Flash alarm	Be able to trigger according to the set requirements and respond correctly	Operation inspection
13	Lifting/Falling time of electric barrier	Meet the design requirements, or $\leq 1.0\text{s}$ in case of no such requirements	By time counter
14	Thickness of anti-corrosion coating for electric barrier gate casing	Meet the design requirements, or $\geq 76\mu\text{m}$ in case of no such requirements	By coating thickness gauge
15	Electric barrier function	Be able to act according to the set operation flow, and possess the functions of anti-smash and horizontal rotation	Function verification
16	Inductance of loop coil	Meet the design requirements, or meet $(50\sim 1000)\mu\text{H}$ in case of no such requirements	By inductance measuring instrument
17	Special keyboard	Flexible operation and accurate response	Operation inspection
18	Compound reader-writer	Read and write the pass card correctly to meet the requirements of state secret	Operation inspection

19□	Bill printer	Print bills quickly and correctly	Operation inspection
20□	Lane image snapshot	Be able to startup the image snapshot function when the vehicle enters the lane; the snapshot information meets the design requirements and can be stored and forwarded according to the prescribed format	Operation inspection
21□	Lane camera	Be able to carry out real-time video recording in the set lane area with clear image	Operation inspection
22	Character superimposition	The image information of lane camera and lane snapshot shall be superimposed clearly and correctly	Operation inspection
23	Automatic license recognition function	The acquired vehicle images are processed and recognized, and the recognition results are saved; the recognition results shall include license plate number, recognition time, license plate color, etc.	Operation inspection
24	Accuracy of license plate recognition	≥95%	Test continuously for more than 24h, and check more than 200 pictures
25□	RSU communication area	Width ≤ 3.3m	By field intensity meter
26□	Initial state of lane	The lane information indicator screen shows that the lane is closed, and the lane barrier is in a horizontal closed state; the display content in the toll booth meets the design requirements and has the function of malicious login prevention	Operation inspection; malicious login verification function by inputting both correctly and incorrectly once when logging in.
27□	Open state of lane	Be able to open the lane after successful login, and the system enters the working condition	Operation inspection
28	Login and logout of lane software system	Be able to log in and out firmly after starting the lane software	Operation inspection
29	Working condition monitoring and fault alarm of lane equipment	Be able to monitor the working condition of lane equipment such as antenna, electric barrier and lane control sign, and output alarm can prompt information in case of equipment breakdown	Operation inspection
30	Record log query	Be able to query the transaction process log information of passing vehicles	Operation inspection
31□	Uploading function of lane toll data	Vehicle transaction data is correctly uploaded to the superior toll collection system	Function verification
32	Clock synchronization function	The clock of the lane system is synchronized with the clock of the superior toll collection system	Compare with the master clock

33□	Data transmission	Be able to transmit toll data accurately between the lane and the superior toll collection system	Operation inspection
34	Lane maintenance and reset operation processing	The maintenance menu allows authorized maintainers to perform lane maintenance and reset operation	Operation inspection
35	Support two-piece OBU and one-piece OBU transactions	Support two-piece OBU and one-piece OBU transactions at the same time, and be able to clear the entry information in OBU (or ETC card)	Operation inspection
36	Support CPC card transaction	Support CPC card transaction, and clear the station passing information and billing information in the card	Operation inspection
37	Vehicle information collection	Detect and identify the license plate, vehicle model and other information of passing vehicles automatically, and support manual check and modification of automatically identified vehicle information	Operation inspection
38	Receiving and updating of toll parameters	Possess the functions of receiving and updating toll parameters (such as status list, credit blacklist, list of large transport vehicles, list of toll optimization and reduction in the province, list of special transportation vehicles ("two passenger buses and one dangerous vehicle"- two passenger buses are the tourist coach and the long distance passenger commercial vehicles, one dangerous vehicle is the special truck for transporting dangerous cargo), and write the information of special vehicles denied by ETC system into the transaction record	Operation inspection
39	Receiving of exit weighing data	Be able to receive the exit weighing data, judge and deal with it according to relevant regulations	Operation inspection
40	ETC gantry bearing function	Possess the ability to receive and update the toll rate of the current station issued by the provincial networking center, calculate the toll, clear the entry information, station passing information and billing information after the billing and charging, and form the traffic transaction record	Operation inspection
41	Automatic information matching	ETC transaction record and CPC card traffic record shall be automatically matched with the snapshotted vehicle pictures and uploaded	Operation inspection

		to the toll station system in real time	
42□	Disconnection recovery function	Disconnect the communication link between the lane controller and the toll station, the lane is in normal working condition, and the data is not lost after the restoration of communication link	Function verification
43	Handle vehicles using OBU and CPC cards at the same time	Handle it according to CPC card vehicle	Operation inspection
44	Handle vehicles without CPC card or dis-functional card	Calculate the toll according to the license plate number, vehicle model and entry information of the passing vehicle	Operation inspection or history record viewing
45	Handle vehicles with no entrance information in the CPC card or the actual vehicle model and license plate inconsistent with the information in the card	Calculate the toll according to the license plate number and vehicle model information of the passing vehicle	Operation inspection or history record viewing
46	Handle ETC denied vehicle	For ETC denied vehicles such as tag removal, tag invalidation, status list, credit blacklist, no user card insertion, and inconsistent card signature, etc., the handling shall meet the set processing flow, and the special situation prompt information displayed on the patron external display is consistent with the actual situation.	Operation inspection or history record viewing
47	Treatment of oversize and overloaded trucks	Comply with the set process flow and have the function of intercepting oversize and overloaded vehicles	Real vehicle test or history record check
48□	Normal traffic transaction process of ETC passenger car	Passenger car 1, passenger car 2, passenger car 3 and passenger car 4 pass respectively, the transaction processing and billing are correct, and the fee information display screen shows the whole toll amount and related information in a timely and correct manner	Real vehicle test or history record check
49□	Normal traffic transaction process of ETC truck	Truck 1, truck 2, truck 3, truck 4, truck 5 and truck 6 pass respectively, the transaction processing and billing are correct, and the fee information display screen shows the whole toll amount and related information in a timely and correct manner	Real vehicle test or history record check
50□	Normal traffic	Special vehicle 1, special vehicle 2, special	Real vehicle test or history record

	transaction process of special ETC vehicle	vehicle 3, special vehicle 4, special vehicle 5 and special vehicle 6 pass respectively, the transaction processing and billing are correct, and the fee information display screen shows the whole toll amount and related information in a timely and correct manner	check
51□	Traffic transaction process of MTC passenger car	Passenger car 1, passenger car 2, passenger car 3 and passenger car 4 pass respectively, the transaction processing and billing are correct, and the fee information display screen shows the whole toll amount and related information in a timely and correct manner	Real vehicle test or history record check
52□	Traffic transaction process of MTC truck	Truck 1, truck 2, truck 3, truck 4, truck 5 and truck 6 pass respectively, the transaction processing and billing are correct, and the fee information display screen shows the whole toll amount and related information in a timely and correct manner	Real vehicle test or history record check
53□	Traffic transaction process of special MTC vehicle	Special vehicle 1, special vehicle 2, special vehicle 3, special vehicle 4, special vehicle 5 and special vehicle 6 pass respectively, the transaction processing and billing are correct, and the fee information display screen shows the whole toll amount and related information in a timely and correct manner	Real vehicle test or history record check
54	Transaction process for car-following interference	For vehicles with normal electronic tags follow vehicles with abnormal electronic tags or without electronic tags to enter the ETC/MTC exit lane, the transaction and release can be completed correctly.	Real vehicle test

**6.2.3** The appearance of the equipment of ETC/MTC exit lane shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The reflective signs on the electric (manual) barrier bars shall be clearly visible and complete.

## 6.3 Equipment and Software of ETC Lane

**6.3.1** The equipment and software of the ETC lane shall conform to the following basic requirements:

1 The electric (manual) barriers, antennas, lane controllers, display terminals, special keyboards, patron external display screens of toll collection, vehicle detectors, cameras and other equipment shall comply with the provisions of relevant national and industry standards.

2 The model, specification and quantity of the equipment and accessories of ETC lane shall conform to the contract requirements, and the components shall be complete.

3 After the installation and commissioning of all the equipment, the equipment and software of the lane shall be maintained in proper working condition.

4 The software of ETC lane includes system software and application software, in which the system software shall be legally authorized, and an official authorization certificate shall be provided, and the application software shall bear software development and test documents.

**6.3.2** The measurement items of the equipment and software of ETC lane shall conform to the provisions in Table 6.3.2.

**Table 6.3.2 Measurement Items of the Equipment and Software of ETC Lane**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Insulation resistance of lane equipment	Strong current terminal to casing $\geq 50M\Omega$	By 500V megohmmeter
2△	Common ground resistance of lane equipment	$\leq 1\Omega$	By ground resistance tester
3	Antenna installation height	Meet the design requirements, or $\geq 5.5m$ in case of no such requirements	By measuring tool
4	Thickness of anti-corrosion coating for antenna column	Meet the design requirements, or $\geq 85\mu m$ in case of no such requirements	By coating thickness gauge

5	Chrominance and luminance of lane information indicator screen	The chrominance conforms to the regulations of the current GB/T 23828, the luminance meets the design requirements, or ensure luminance $\geq 5000\text{cd/m}^2$ in case of no such requirements	By chrominance/luminance meter
6△	Control and display of lane information indicator screen	The switching control works normally and the displayed information is correct	Operation inspection
7	Chrominance and luminance of lane control signs of toll canopy	The chrominance conforms to the current JT/T 597, with nighttime luminance $\geq 1000\text{cd/m}^2$	By chrominance/luminance meter
8△	Control and display of lane control signs for toll canopy	Be able to be controlled according to the design requirements and display correctly	Operation inspection
9△	Control and display of toll lane traffic lights	Be able to be controlled according to the design requirements and display correctly	Operation inspection
10	Chrominance and luminance of patron external display screen of toll collection	The chrominance conforms to the regulations of the current GB/T 23828, the luminance meets the design requirements, or ensure luminance $\geq 1500\text{cd/m}^2$ in case of no such requirements	By chrominance/luminance meter
11△	Information display of patron external display screen of toll collection	Be able to display the toll fee or other set information correctly when vehicles pass by	Operation inspection; observe the information displayed on the fee display screen
12△	Flash alarm	Be able to trigger the alarm according to the set requirements and respond correctly	Operation inspection
13	Lifting/Falling time of electric barrier	Meet the design requirements, or $\leq 1.0\text{s}$ in case of no such requirements	By time counter
14	Thickness of anti-corrosion coating for electric barrier casing	Meet the design requirements, or $\geq 76\mu\text{m}$ in case of no such requirements	By coating thickness gauge
15△	Electric barrier function	Be able to act according to the specified operation flow, and possess the functions of anti-smash and horizontal rotation	Operation inspection
16	Inductance of loop coil	Meet the design requirements, or meet $(50\sim 1000)\mu\text{H}$ in case of no such requirements	By inductance measuring instrument
17	Special keyboard	Flexible operation and accurate response	Operation inspection
18△	Lane image snapshot	Be able to startup the image snapshot function when the vehicle enters the lane; the snapshotted information meets the design requirements and can be stored and forwarded according to the prescribed format	Operation inspection
19△	Lane camera	Be able to carry out real-time video recording in the set lane area with clear image	Operation inspection



20	Character superimposition	The image information of lane camera and lane snapshot shall be superimposed clearly and correctly	Operation inspection
21	Automatic license recognition function	The acquired vehicle images are processed and recognized, and the recognition results are saved; the recognition results shall include license plate number, recognition time, license plate color, etc.	Operation inspection
22	Correctness of license plate recognition	≥95%	Test continuously for more than 24h, and check more than 200 pictures
23△	RSU communication area	Width ≤ 3.3m	By field intensity meter
24△	Initial state of lane	The lane information indicator screen shows that the lane is closed, and the lane barrier is in a horizontal closed state; the display content in the toll booth meets the design requirements and has the function of malicious login prevention	Operation inspection; malicious login verification function by inputting both correctly and incorrectly once when logging in.
25△	Open state of lane	Be able to open the lane after successful login, and the system enters the working state	Operation inspection
26	Login and logout of lane software system	Be able to log in and out firmly after starting the lane software	Operation inspection
27	Working condition monitoring and fault alarm of lane equipment	Be able to monitor the working state of lane equipment such as antenna, electric barrier and lane control sign, and output alarm prompt information in case of equipment failure	Operation inspection
28	Record log query	Be able to query the transaction process log information of passing vehicles	Operation inspection
29△	Uploading function of lane toll data	Be able to upload vehicle transaction data correctly to the superior toll collection system	Operation inspection
30	Clock synchronization function	The clock of the lane system is synchronized with the clock of the superior toll collection system	Compare with the master clock
31△	Data transmission	Be able to transmit toll data accurately between the lane and the superior toll collection system	Operation inspection
32	Lane maintenance and reset operation processing	The maintenance menu allows authorized maintainers to perform lane maintenance and reset operation	Operation inspection
33	Support two-piece OBU and one-piece OBU transactions	Support two-piece OBU and one-piece OBU transactions at the same time, and be able to write the entry information in OBU (or ETC	Operation inspection

		card)	
34	Receiving and updating of toll parameters	Possess the functions of receiving and updating toll parameters (such as status list, credit blacklist, list of large transport vehicles, list of toll optimization and reduction in the province, list of special transportation vehicles ("two passenger buses and one dangerous vehicle"- two passenger buses are the tourist coach and the long distance passenger commercial vehicles, one dangerous vehicle is the special truck for transporting dangerous cargo), and write the information of special vehicles denied by ETC system into the transaction record	Operation inspection
35	ETC gantry bearing function	Be able to receive and update the toll rate of the current station issued by the provincial networking center, and calculate the toll to form the traffic transaction record	Operation inspection
36△	Disconnection recovery function	Disconnect the communication link between the lane controller and the toll station, the lane is in normal working condition, and the data is not lost after the restoration of communication link	Function verification
37	Handle ETC denied vehicle	For ETC denied vehicles such as tag removal, tag invalidation, status list, credit blacklist, no user card insertion, and inconsistent card signature, etc., the handling shall meet the set processing flow, and the special situation prompt information displayed on the patron external display is consistent with the actual situation.	Operation inspection or log record viewing
38	Treatment of oversize and overloaded vehicles	Comply with the set processing flow and possess the function of intercepting oversize and overloaded vehicles	Real vehicle test or history record check
39△	Normal traffic transaction process of ETC passenger car	Passenger car 1, passenger car 2, passenger car 3 and passenger car 4 pass respectively, the transaction is correct, and the message on patron external display screen of toll collection shall be correct and timely.	Real vehicle test or history record check
40△	Normal traffic transaction process of ETC truck	Truck 1, truck 2, truck 3, truck 4, truck 5 and truck 6 pass respectively, the transaction is correct, and the message on patron external display screen of toll collection shall be	Real vehicle test or history record check

		correct and timely.	
41△	Normal traffic transaction process of special ETC vehicle	Special vehicle 1, special vehicle 2, special vehicle 3, special vehicle 4, special vehicle 5 and special vehicle 6 pass respectively, and the message on patron external display screen of toll collection shall be correct and timely.	Real vehicle test or history record check
42	Transaction process for car-following interference	For vehicles with abnormal electronic tags follow vehicles with normal electronic tags into the ETC lane, the transaction and release can be completed correctly when the following distance is $\geq 2m$	Test the following distance of 3m, 2m and 1m respectively
		For vehicles with normal electronic tags follow vehicles with abnormal electronic tags into the ETC lane, the transaction and release can be completed correctly when the following distance is $\geq 2m$	

**6.3.3** The appearance of the ETC lane equipment shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The reflective signs on the electric (manual) barrier bars shall be clearly visible and complete.

## 6.4 ETC Gantry System

**6.4.1** The ETC gantry system shall conform to the following basic requirements:

- 1 The lane controllers, antennas, license plate recognition equipment, cameras, switches, power supply and distribution equipment, signs, markings, guardrails, etc. shall comply with the provisions of relevant national and industry standards.
- 2 The model, specification and quantity of the equipment and accessories of ETC gantry system shall conform to the contract requirements, and the components shall be complete.
- 3 After the installation and commissioning of all the equipment, the system shall

be maintained in proper working condition.

**6.4.2** The measurement items of the ETC gantry system shall conform to the provisions in Table 6.4.2.

**Table 6.4.2 Measurement Items of the ETC Gantry System**

Item No.	Inspection items	Technical requirements	Inspection method
1	Foundation size	Meet the design requirements; allowable deviation: (-50,+100) mm	Measure the length and width with tape, and check the acceptance record on concealed work or carry out measurement for the buried depth
2	Thickness of anti-corrosion coating of chassis and column	Meet the design requirements, or conform to the provisions of the current GB/T 18226 in case of no such requirements	By coating thickness gauge
3△	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester
4△	Lightning protection ground resistance	$\leq 10\Omega$	By ground resistance tester
5△	Common ground resistance	If the protective ground electrode and lightning protection ground electrode of field equipment are not in separate arrangement, the common ground resistance is $\leq 1\Omega$	By ground resistance tester
6	Equipment status monitoring function	Be able to carry out remote control over the working conditions of lane controller, RSU, license plate recognition equipment, chassis environment, power supply and communication network according to the design requirements	Function verification
7△	ETC segmented billing	Implement ETC segmented billing and form the ETC traffic record	Operation inspection or historical traffic record check
8△	Segmented billing of CPC card	Implement segmented billing of CPC card and form the CPC card traffic record	Operation inspection or historical traffic record check
9	Vehicle image capture and automatic license plate recognition	The front and rear cameras can capture the images of passing vehicles, the captured images are clear and complete, and the automatic license plate recognition result is outputted	Function verification
10	Accuracy of license plate recognition	$\geq 95\%$	Test the traffic up (down) section of the gantry continuously for more than 24h, and check more than 200

			pictures
11△	Record generation, storage and query	Generate and store ETC traffic record, CPC card traffic record, vehicle image record and status monitoring record according to the design requirements, and support the query of relevant record in the toll audit system	Function verification
12	Equipment remote control	Allow remote authorization and login of key equipment (such as antenna, license plate recognition equipment, and lane controller), and to adjust and update key equipment parameters, obtain ETC gantry log, backup vehicle traffic record, images etc., and support online upgrade of the system	Function verification
13△	Switching of main and standby antenna systems	Be able to operate the main and standby antenna systems under the Internet connection state; when the main antenna system runs abnormally, it shall be automatically switched to the standby antenna system in time to ensure the uninterrupted operation of the antenna system	Operation inspection
14	Parameter management	Be able to correctly receive the operation parameters issued by the superior system, and the system can run normally after the update of operation parameters	Function verification
15	Data storage and retransmission	In case of network failure, the system can run offline and store the information of vehicle traffic record. After the network recovery, the stored vehicle traffic record data will be uploaded automatically	Function verification
16	Matching of traffic record	ETC traffic record, CPC card traffic record and vehicle image capture record are automatically matched, and the matching result is correct without duplicate record	Operation inspection or history record check
17△	Clock synchronization	Synchronize with Beidou timing clock	Operation inspection
18	Data transmission	ETC traffic record, CPC card traffic record, captured vehicle image and other data are correctly uploaded to the superior toll collection system	Operation inspection
19	Switching of master-standby communication link	When the existing main communication link for toll collection runs abnormally, it should be automatically switched to the standby communication link in time	Operation inspection

20	Communication area	The area shall meet the needs of correct vehicle traffic transaction	OBU test	
21	Strength of RSU working signal	Not lower than the receiving sensitivity of OBU and CPC card, or meet the data interaction requirements of ETC vehicles and CPC card vehicles during transit	Collect the RSU working signal in the communication area of ETC gantry system automatically, and test the strength of RSU working signal	
22△	RSU operating frequency	Channel 1: 5.830GHz Channel 2: 5.840GHz	Collect the RSU working signal in the communication area of ETC gantry system automatically, and test the RSU operating frequency	
23△	RSU occupied bandwidth	≤5MHz	Collect the RSU working signal in the communication area of ETC gantry system automatically, and test the occupied bandwidth of RSU working signal	
24	RSU preamble	16-bit "1" plus 16-bit "0"	Collect the RSU working signal in the communication area of ETC gantry system automatically, and test the preamble of RSU working signal	
25△	RSU communication process	Meet the latest regulations on DSRC communication process between RSU and OBU as well as between RSU and CPC card	Collect the RSU working signal in the communication area of ETC gantry system automatically, and test the communication process of RSU working signal	
26	Integrated chassis	26.1 Installation conditions	Have installation space for 19-inch rack above 10U	Operation inspection
		26.2 Outdoor air conditioning	Support the automatic adjustment of the temperature in the chassis, as well as the setting of temperature in the chassis based on the difference of ambient temperature in different regions	Operation inspection
		26.3 Dynamic environment monitoring	Be able to monitor smoke, water logging, temperature and humidity, access control and other conditions	Function verification
		26.4 Theft and destruction prevention	Install anti-theft lock, without exposed detachable parts on the chassis	Operation inspection
		26.5 Access control	Access control can be remotely controlled, and the opening and closing status can be monitored	Operation inspection
		26.6 Lighting in	Lighting fixtures work normally	Operation inspection

		chassis		
		26.7 Fire alarm	Support fire detection and alarm	Operation inspection
		26.8 Mobile generator access function	Be able to connect the mobile generator when needed	Operation inspection
27	Power supply & distribution equipment	27.1 Input and output voltage	Meet the requirements of 220V, 380V and other standard voltage classes, with the deviation within $\pm 7\%$	By voltmeter
		27.2 Remote control and monitoring	Be able to remotely control the on-off of power input and output, and monitor the power supply situation in real time	Function verification
		27.3 Automatic alarm and protection	In case of over-/under-voltage, over-current and overload, the power supply system can send an alarm automatically and start protection	Function verification
		27.4 Redundant operation of power supply	The main and standby power supplies run redundantly in parallel; when either the normal power supply or the standby power supply fails, it can be switched to supply power to the equipment in zero time	Function verification
		27.5 Power switching	The main and standby power supplies can be switched in zero time, so as to ensure the uninterrupted operation of the equipment	Function verification

**6.4.3** The appearance of the ETC gantry system shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **6.5 Equipment and Software of Toll Station**

**6.5.1** The toll station equipment and software shall conform to the following basic requirements:

- 1 The model, specification and quantity of the equipment and accessories in the toll station shall conform to the contract requirements, and the components shall be complete.
- 2 After the installation and commissioning of all the equipment, the equipment

and software of the toll station shall be maintained in proper working condition.

3 The software of the toll station includes system software and application software, of which the system software shall be legally authorized and a formal authorization certificate shall be submitted, and the application software shall bear software development and test documents.

**6.5.2** The measurement items of the equipment and software of toll station shall conform to the provisions in Table 6.5.2.

**Table 6.5.2 Measurement Items of the Equipment and Software of Toll Station**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Common ground resistance of toll station	$\leq 1\Omega$	By ground resistance tester
2△	Real-time lane equipment monitoring function	The monitoring computer of toll station can monitor and display the status and operation of lane equipment in real time	Function verification
3	Original data query and statistics function	The query and statistics of original data is supported by dedicated server and toll management computer	Function verification
4△	Image check function	Be able to check the images of passing vehicles at all entrance and exit lanes	Function verification
5	Report generation and printing function	Be able to print various reports through the toll management computer	Function verification
6	View function of rate list	Be able to view the rate list through the toll management computer	Function verification
7	Data communication function with lane controller	The dedicated server can communicate the specified data with the lane controller in different modes	Function verification
8△	Data backup function	According to the specified backup strategy, the toll data and some important files can be backed up, and the toll data or files can be restored as needed in case of system failure	Function verification



9	Character superimposition function	Be able to observe the superimposed information on the monitor	Function verification
10	Data exchange function with toll collection subcenter	Exchange specified data with toll collection subcenter according to the design requirements	Function verification
11	Uploading function of disconnected data	In case of communication failure with the computer of the toll center, the data can be stored locally and uploaded to the computer of the toll center after the communication restoration	Function verification
12△	Image switching function	The monitoring computer can switch and display the camera images in each lane and toll booth	Function verification
13	Special incident viewing function	Be able to view the treatment details of special incident for entrance and exit lanes	Function verification
14	System recovery function	After the recovery or troubleshooting of system crash or power failure, restart the system, and the system can return to the normal working state automatically	Function verification or history record check

**6.5.3** The appearance of the toll station equipment shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The layout of equipment on the console shall meet the design requirements, with stable installation, and proper vertical and horizontal alignment. The identification shall be clear and correct.
- 3 The layout of CCTV monitors shall meet the design requirements, with complete screen splicing, no obvious skew, stable installation, vertical and horizontal alignment. The identification shall be clear and correct.

## **6.6 Equipment and Software of Toll Collection Subcenter**

**6.6.1** The equipment and software of the toll collection subcenter shall conform to the following basic requirements:

1 The model, specification and quantity of the equipment and accessories of toll collection subcenter shall conform to the contract requirements, and the components shall be complete.

2 After the installation and commissioning of all the equipment, the equipment and software of the toll collection subcenter shall be maintained in proper working condition.

3 The software of the toll collection subcenter includes system software and application software, of which the system software shall be legally authorized and a formal authorization certificate shall be submitted, and the application software shall bear software development and test documents.

**6.6.2** The measurement items of the equipment and software of toll collection subcenter shall conform to the provisions in Table 6.6.2.

**Table 6.6.2 Measurement Items of the Equipment and Software of Toll collection subcenter**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Common ground resistance of toll collection subcenter	$\leq 1\Omega$	By ground resistance tester
2△	Data transmission function with toll station	Query and collect the data of each toll station regularly or in real time	Function verification
3△	Image check function	Be able to check all the "problematic" vehicle images for the entrance and exit lanes	Function verification
4	Pass card management function	Be able to manage the issuance and allocation of pass cards	Function verification
5	Report statistics management and printing function	The computer of the toll collection subcenter can print the report	Function verification
6	CCTV image switching and control function for each station and lane	Be able to switch and control CCTV images of various toll stations and lanes	Function verification

7△	Data backup function	According to the specified backup strategy, the toll data and important files can be backed up, and the toll data or files can be restored as needed in case of system failure	Function verification
8	System recovery function	After the recovery or troubleshooting of system crash or power failure, restart the system, and the system can return to the normal working state automatically	Function verification or history record check

**6.6.3** The appearance of the toll collection subcenter equipment shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The layout of equipment on the console shall meet the design requirements, with stable installation, proper vertical and horizontal alignment as well as correct and clear identification.
- 3 The layout of CCTV monitors shall meet the design requirements, with complete screen splicing, no obvious skew, stable installation, vertical and horizontal alignment as well as correct and clear identification.

## **6.7 Equipment and Software of the Networked Toll Collection Management Center (Toll Center)**

**6.7.1** The equipment and software of the networked toll collection management center (toll center) shall conform to the following basic requirements:

- 1 The model, specification and quantity of the equipment and accessories of networked toll collection management center shall conform to the contract requirements, and the components shall be complete.
- 2 After the installation and commissioning of all the equipment, the equipment and software of the networked toll collection management center (toll center) shall

be maintained in proper working condition.

3 The software of the networked toll collection management center (toll center) includes system software and application software, of which the system software shall be legally authorized and a formal authorization certificate shall be submitted, and the application software shall bear software development and test documents.

**6.7.2** The measurement items of the equipment and software of networked toll collection management center (toll center) shall conform to the provisions in Table 6.7.2.

**Table 6.7.2 Measurement Items of the Equipment and Software of Networked Toll Collection Management Center (Toll Center)**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Common ground resistance of networked toll collection management center	$\leq 1\Omega$	By ground resistance tester
2△	Setting and change of rate list and vehicle model classification parameters	Be able to set, change the rate list and vehicle model classification parameters, and download such information to the toll station	Operation inspection
3△	Clock synchronization function	Be able to have uniform calibration over the clock of the toll collection system	Compare with the lower system clock
4	Pass card management function	Make pass cards, official cards and identity cards correctly through authorization, and make recording, statistics and query of the information about the card issued by the center	Function verification
5	Ticket management function	Be able to complete the management functions such as storage, issuance, verification and allocation of tickets	Function verification or record check
6	Toll split	Be able to complete the correct toll split automatically or manually as required	Operation inspection
7△	Data backup function	According to the specified backup strategy, the toll data and important files can be backed up, and the toll data or files can be restored as	Function verification

		needed in case of system failure	
8△	Parameter distribution	The distribution of blacklist, rate and other parameters meets the design requirements	Operation inspection
9△	Report generation and printing	Meet the design requirements	Operation inspection
10△	Toll clearing and bookkeeping	Meet the design requirements	Operation inspection
11△	Toll split and appropriation	Meet the design requirements	Operation inspection
12△	Toll settlement	Meet the design requirements	Operation inspection
13△	Blacklist management	Meet the design requirements	Operation inspection
14	Basic data management	Be able to query, add, delete and modify the operation parameters of the networked toll collection system of the existing tolling highway network, without modifying the software source code	Operation inspection
15	Data transmission	Be able to realize the automatic reception or manual retransmission of the toll data, and exchange data with the lower toll collection system	Operation inspection
16	System recovery function	After the recovery or troubleshooting of system crash or power failure, the system could be rebooted and return to the normal working state automatically	Function verification or history record check
17	Software performance	Be able to meet the design requirements after the normal operation of the system becomes stable	Operation inspection or software evaluation report check

**6.7.3** The appearance of the equipment of the networked toll collection management center (toll center) shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **6.8 IC Card Issuing and Coding System**

**6.8.1** The IC card issuing and coding system shall conform to the following basic

requirements:

1 The model, specification and quantity of the equipment and accessories of IC card issuing and coding system shall conform to the contract requirements, and the components shall be complete.

2 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**6.8.2** The measurement items of the IC card issuing and coding system shall conform to the provisions in Table 6.10.2.

**Table 6.8.2 Measurement Items of the IC Card Issuing and Coding System**

Item No.	Inspection items	Technical requirements	Inspection method
1	Insulation resistance of card issuing equipment	Strong current terminal to casing $\geq 50M\Omega$	By 500V megohmmeter
2	Issuance of identity IC card	Be able to make various types of identity cards	Operation inspection
3	Issuance of official IC card	Be able to make official card	Operation inspection
4	Issuance of prepaid IC card	Be able to make prepaid card	Operation inspection
5	Query, statistics and printing of prepaid card business	The section subcenter can offer a series of query services for cardholders, and print statements, etc.	Operation inspection
6	Issuance of pass IC card	Be able to make pass card	Operation inspection
7	Compatible function	Be able to adapt to different cards made by different manufacturers that meet the standards	Function verification
8△	Anti-conflict function	Be able to identify two cards simultaneously and accurately	Function verification

**6.8.3** The appearance of the IC card issuing and coding system shall comply with the following provisions:

1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## 6.9 Wired Intercom and Emergency Alarm System

**6.9.1** The wired intercom and emergency alarm system shall conform to the following basic requirements:

1 The model, specification and quantity of the equipment and accessories of wired intercom and emergency alarm system shall conform to the contract requirements, and the components shall be complete.

2 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**6.9.2** The measurement items of the wired intercom and emergency alarm system shall conform to the provisions in Table 6.9.2.

**Table 6.9.2 Measurement Items of the Wired Intercom and Emergency Alarm System**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Extension general calling by host	The host can broadcast to all extensions at the same time	Operation inspection
2△	The host calls an extension alone	The host can call any extension in the system	Operation inspection
3△	Host calling by extension	The extension can call the host	Operation inspection
4△	Crosstalk between extensions	No communication between extensions	Operation inspection
5	Volume adjustment of loudspeaker	Adjustable volume	Operation inspection
6	Quality of voice	Clear voice, moderate volume, without noise, hyphenation or other defects	Operation inspection
7	Button status indicator	Visual signal is shown on the host to display the calling extension number	Operation inspection, visual inspection of whether the calling extension number displayed by the host is correct
8	Voice phone system	The host can call and communicate with each extension, with clear voice, moderate volume, but without noise, hyphenation and other defects	Operation inspection
9	Voice interception function	Be able to realize voice recording and interception during charging operation	Function verification

10△	Manual/Pedal alarm function	Be able to drive the alarm by pressing the alarm switch	Function verification
11	Alarm signal output function	When the alarm is triggered, the CCTV monitoring system can switch to the corresponding camera image automatically	Function verification

**6.9.3** The appearance of the wired intercom and emergency alarm system shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **6.10 Transfinite Detection System**

**6.10.1** The transfinite detection system shall conform to the following basic requirements:

- 1 The electric barriers, lane controllers, vehicle separators, tire identifiers, display terminals, automatic license plate recognition equipment, vehicle detectors, cameras and other equipment shall comply with the provisions of relevant national and industry standards.
- 2 The model, specification and quantity of the equipment and accessories of transfinite detection system shall conform to the contract requirements, and the components shall be complete.
- 3 The weighing loader used in the transfinite detection system shall pass the type evaluation of relevant authorities, pass the verification of the metrological service, and obtain the corresponding certificate within the validity period.
- 4 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**6.10.2** The measurement items of the transfinite detection system shall conform to the provisions in Table 6.10.2.



**Table 6.10.2 Measurement Items of the Transfinite Detection System**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Insulation resistance of lane equipment	Strong current terminal to casing $\geq 50M\Omega$	By 500V megohmmeter
2	Ground connection	Ground connection lines of protective ground and lightning protection ground are firmly connected to the ground busbar	Visual inspection; measure by ground resistance tester if necessary
3△	Common ground resistance of equipment	$\leq 1\Omega$	By ground resistance tester
4	Thickness of anti-corrosion casing coating for electric barrier	Meet the design requirements, or $\geq 76\mu\text{m}$ in case of no such requirements	By coating thickness gauge
5△	Electric barrier function	Be able to act according to the set operation process, and have the functions of anti-smash and horizontal rotation	Function verification
6	Control and display of lane traffic lights	Be able to be controlled according to the design requirements and display correctly	Operation inspection
7△	Image capture	Be able to enable the image capture function when the vehicle enters the lane; the captured information meets the design requirements and can be stored and forwarded according to the prescribed format	Function verification
8	Lane camera	Be able to carry out real-time video recording in the set lane area with clear image	Operation inspection
9	Character superimposition	The image information of lane camera and lane capture is superimposed clearly and correctly	Operation inspection
10	Automatic license recognition function	The acquired images are processed and recognized, and the recognition results are saved; the recognition results shall include license plate number, recognition time, license plate color, etc.	Function verification
11△	Flash alarm	Be able to trigger the alarm according to the set requirements and respond correctly	Operation inspection
12	Vehicle separator function	Work stably and output correct results	Function verification
13	Axle type recognizer function	Work stably and output correct results	Function verification
14	Coil inductance	Meet the design requirements, or meet $(50\sim 1000)\mu\text{H}$ in case of no such	By inductance measuring instrument

		requirements	
15△	Weighing control processor function	Be able to classify and identify the vehicle model of weighing vehicles; be able to transmit the measured uniaxial data or complete vehicle data to the transfinite detection system in time	Function verification
16△	Weighing accuracy	Meet the design requirements	Check the metrological verification certificate
17	Weighing calibration function	Be able to set the system as calibration mode, and calibrate the weighing equipment through the buttons on the instrument panel or the setting tools provided by the manufacturer	Function verification
18	Video monitoring function	Be able to monitor and record the full coverage of transfinite detection station area	Function verification
19	System login and logout	Be able to log in and out firmly after starting the transfinite detection system	Operation inspection
20	Information output and display	Output and display the information like vehicle load according to the design requirements	Operation inspection
21	Chrominance and luminance of transfinite information display screen	The chrominance conforms to the regulations of the current GB/T 23828, the luminance meets the design requirements, or ensure luminance $\geq 1500\text{cd/m}^2$ in case of no such requirements	By chrominance/luminance meter
22△	Transfinite alarm and processing function	When the vehicle is detected with transfinite, the system can send an alarm automatically and start the transfinite processing program according to the design requirements	Function verification
23	Data query and statistics	The transfinite detection management computer can make query and statistics over the transfinite detection data, and output statistical report according to the design requirements	Operation inspection
24	Data transmission	After disconnecting the communication link between the transfinite detection system and the superior system, the system can work normally; after the restoration of communication link, the system can transmit the detection data completely	Function verification

6.10.3 The appearance of the transfinite detection system shall comply with the

following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## 6.11 CCTV Monitoring System

**6.11.1** The CCTV monitoring system shall conform to the following basic requirements:

- 1 The CCTV monitoring system equipment shall conform to the current *Video Matrix Switcher* (JT/T 897) and other relevant standards.
- 2 The model, specification and quantity of the equipment and accessories of CCTV monitoring system shall conform to the contract requirements, and the components shall be complete.
- 3 The installation structure of the camera at the toll plaza shall be stable, and the column installation shall be vertical and firm.
- 4 The installation orientation and height of the Pan-tilt-zoom camera, lane camera or camera in toll booth shall comply with the design requirements.
- 5 The connection of video monitoring system of toll center (subcenter), toll station and toll lane should have been opened according to the design requirements.
- 6 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**6.11.2** The measurement items of the CCTV monitoring system shall conform to the provisions in Table 6.11.2.

**Table 6.11.2 Measurement Items of the CCTV monitoring system**

Item No.	Inspection items	Technical requirements	Inspection method
1	Foundation size	Meet the design requirements; allowable deviation: (-50,+100) mm	Measure the length and width with tape, and check the

			acceptance record on concealed work or carry out measurement for the buried depth;	
2	Thickness of anti-corrosion coating of chassis and column	Meet the design requirements, or conform to the provisions of the current GB/T 18226 in case of no such requirements	By coating thickness gauge	
3	Verticality of the column	$\leq 5$ mm/m	By total station or verticality measuring instrument	
4△	Insulation resistance	Strong current terminal to casing $\geq 50M\Omega$	By 500V megohmmeter	
5△	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester	
6△	Lightning protection ground resistance	$\leq 10\Omega$	By ground resistance tester	
7△	Common ground resistance	If the protective ground electrode and lightning protection ground electrode of field equipment are not in separate arrangement, the common ground resistance is $\leq 1\Omega$	By ground resistance tester	
8 Channel transmission index	8.1 Standard-definition analog composite video signal	△8.1.1 Video level	$700\pm 30$ mV	The signal generator sends 75% color bar signal or 2T sine square wave and bar pulse signal, which shall be measured by video tester
		△8.1.2 Synchronization pulse amplitude	$300\pm 20$ mV	The signal generator sends 75% color bar signal or 2T sine square wave and bar pulse signal, which shall be measured by video tester
		△8.1.3 Echo E	$< 7\%$	The signal generator sends 2T sine square wave and bar pulse signal, which shall be measured by video tester
		8.1.4 Luminance nonlinearity	$\leq 5\%$	The signal generator sends the non-modulated five-step signal, which shall be measured by video tester
		8.1.5 Unequal chrominance/luminance gain	$\pm 5\%$	The signal generator sends a subcarrier-filled 10T signal or a subcarrier-filled bar pulse signal, which shall be measured by video tester

		8.1.6 Chrominance/Luminance signal latency	$\leq 100\text{ns}$	The signal generator sends a subcarrier-filled 10T signal or a subcarrier-filled bar pulse signal, which shall be measured by video tester
		8.1.7 Differential gain	$\leq 10\%$	The signal generator sends the modulated five-step signal, which shall be measured by video tester
		8.1.8 Differential phase	$\leq 10^\circ$	The signal generator sends the modulated five-step signal, which shall be measured by video tester
		$\Delta$ 8.1.9 Amplitude-frequency characteristics (within 5.8MHz bandwidth)	$\pm 2\text{dB}$	The signal generator sends $\sin x/x$ signal, which shall be measured by video tester
		$\Delta$ 8.1.10 Video signal-to-noise ratio (weighted)	$\geq 56\text{dB}$	The signal generator sends multi-burst signal, which shall be measured by video tester
	8.2 High-definition $Y, C_R(P_R), C_B(P_B)$ video signals	$\Delta$ 8.2.1 Output quantization error of Y signal	$-10 \sim 10\%$	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
		$\Delta$ 8.2.2 Output quantization error of $C_R(P_R)$ signal	$-10 \sim 10\%$	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
		$\Delta$ 8.2.3 Output quantization error of $C_B(P_B)$ signal	$-10 \sim 10\%$	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
		$\Delta$ 8.2.4 Amplitude-frequency characteristics of Y signal	Within 30MHz bandwidth $\pm 3\text{dB}$	The digital signal generator sends high-definition multi-burst signal or $\sin X/X$ signal, which shall be measured by digital video tester
		8.2.5 Nonlinear distortion of $Y, C_B(P_B)$ and $C_R(P_R)$ signals, %	$\leq 5$	The digital signal generator sends high-definition five-step wave signal, which shall be measured by digital video tester
		$\Delta$ 8.2.6 Linear response of luminance channel (K coefficient of Y signal)	$\leq 3\%$	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester

8.3 High-definition G, B and R video signals	8.2.7 Signal latency of Y/C <sub>B</sub> (Y/P <sub>B</sub> ) and Y/C <sub>R</sub> (Y/P <sub>R</sub> ) signals	±10ns	The digital signal generator sends high-definition color bar signal, which shall be measured by digital video tester
	Δ8.2.8 Signal-to-noise ratio of Y, C <sub>B</sub> (P <sub>B</sub> ) and C <sub>R</sub> (P <sub>R</sub> ) signals (weighted)	≥56dB	The digital signal generator sends the silent line signal, which shall be measured by digital video tester
	Δ8.3.1 Output quantization error of G signal	-10 ~ 10%	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
	Δ8.3.2 Output quantization error of B signal	-10 ~ 10%	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
	Δ8.3.3 Output quantization error of R signal	-10 ~ 10%	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
	Δ8.3.4 Amplitude-frequency characteristics of G/B/R signal	Within 30MHz bandwidth ±3dB	The digital signal generator sends high-definition multi-burst signal or SinX/X signal, which shall be measured by digital video tester
	8.3.5 Nonlinear distortion of G, B and R signals	≤5%	The digital signal generator sends high-definition five-step wave signal, which shall be measured by digital video tester
	Δ8.3.6 Linear response of luminance channel (K coefficient of G, B and R signals)	≤3%	The digital signal generator sends high-definition 2T pulse and banner signal, which shall be measured by digital video tester
	8.3.7 Signal latency of G/B, G/R and B/R signals	±10ns	The digital signal generator sends high-definition color bar signal, which shall be measured by digital video tester
	Δ8.3.8 Signal-to-noise ratio of G, B and R signals	≥56dB	The digital signal generator sends the silent line signal, which shall be measured by digital video tester

9	Monitor picture index $\Delta$	9.1 Standard-definition analog composite video signal	9.1.1 Snowflakes	$\geq 4$ points	Manual (not less than 3 persons) subjective scoring
			9.1.2 Netlike wrinkle	$\geq 4$ points	
			9.1.3 Black and white rolling blink	$\geq 4$ points	
			9.1.4 Bounce	$\geq 4$ points	
	9.2 HD video signal	9.2.1 Distortion	$\geq 4$ points		
		9.2.2 Trailing	$\geq 4$ points		
		9.2.3 Frame skip	$\geq 4$ points		
		9.2.4 Jitter	$\geq 4$ points		
		9.2.5 Mosaic	$\geq 4$ points		
10 $\Delta$	Data transmission performance	10.1 Throughput of IP network	Meet the requirements on the maximum code stream of the encoder in design documents, or the length of 1518-frame shall be $\geq 99\%$ in case of no such requirements	By the Ethernet performance tester	
		10.2 Transmission delay of IP network	Meet the design requirements, or $\leq 10\text{ms}$ in case of no such requirements	By the Ethernet performance tester	
		10.3 Packet loss rate of IP network	$\leq 0.1\%$ when the traffic load is not greater than 70%	By the Ethernet performance tester	
11 $\Delta$	Horizontal rotation angle of PTZ	Horizontal: $\geq 350^\circ$	Operation inspection		
12 $\Delta$	Vertical rotation angle of PTZ	Upward $\geq 15^\circ$ , downward $\geq 90^\circ$	Operation inspection		
13 $\Delta$	Monitoring content	The monitor can clearly identify the vehicle model, license plate and other information	Operation inspection		
14 $\Delta$	Installation stability of field camera	When affected by strong wind or controlled by zooming, rolling and other operations, the picture moves smoothly without jitter	Operation inspection		
15	Automatic aperture adjustment	Regulate automatically	Operation inspection		
16	Focusing function	Fast auto-focus	Function verification		
17	Zoom function	Be able to adjust the magnification of the camera lens	Function verification		
18 $\Delta$	Switching function	The monitoring terminal can switch any camera in the system	Function verification		
19 $\Delta$	Video recording function	Video can be recorded, and the video playback is clear	Function verification		
20	Information superimposition function	Be able to superimpose the information such as time and location (lane number, toll booth	Function verification		

		number) on the image, and display such information clearly	
21△	Recovery function	Once powered on, the equipment can automatically return to the normal communication state, connect with the upper computer or control system, and work reliably	Function verification
<p>Note: The subjective score can be assessed by five-level damage system.</p> <p>1 ) No perceptible damage or interference on the image: 5 points;</p> <p>2 ) Slightly perceptible damage or interference on the image: 4 points;</p> <p>3 ) Obvious damage or interference on the image: 3 points;</p> <p>4 ) Serious damage or interference on the image: 2 points;</p> <p>5 ) Extremely serious damage or interference on the image: 1 point.</p>			

**6.11.3** The appearance of the CCTV monitoring system shall comply with the following provisions:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **6.12 Optical Cable and Electric Cable Line Works in the Toll Station Area**

**6.12.1** The optical cable and electric cable line works in the toll station area shall conform to the following basic requirements:

- 1 The model, specification and quantity of various optical cables and electric cables in the toll station area shall conform to the contract requirements.
- 2 The laying, connection, reservation and termination of optical cables and electric cables shall meet the requirements of relevant technical specifications.
- 3 The binding of optical cables and electric cables shall be firm, moderately tight and close, and binding threads shall be uniform, neat and consistent.



4 The optical cables and electric cables in the trough and bracket shall be straight, without obvious twisting and crossing, trough overflow and rollover; the bend shall be moderate; the access troughs and brackets shall be tied neatly.

5 The trough and bracket shall be reliably grounded.

**6.12.2** The measurement items of the optical cable and electric cable line works in the toll station area shall conform to the provisions in Table 6.12.2.

**Table 6.12.2 Measurement Items of the Optical Cable and Electric Cable Line Works in the Toll Station Area**

Item No.	Inspection items	Technical requirements	Inspection method
1	Total attenuation of single-mode optical fiber	Meet the design requirements	By optical time-domain reflectometer or light source, optical power meter
2	Total attenuation of multi-mode optical fiber	Meet the design requirements	By optical time-domain reflectometer or light source, optical power meter
3△	Insulation resistance of power cable	≥2MΩ	By 500V megohmmeter
4	Buried depth of optical cable and electric cable	Meet the design requirements	Check the record of concealed work, and carry out Operation inspection if necessary

**6.12.3** The appearance of the optical cable and electric cable line works in the toll station area shall comply with the following provisions:

1 The optical cable and electric cable distribution box (frame) shall be installed stably with vertical and horizontal alignment as well as complete accessories; the optical cable and electric cable splicing box (case) shall be installed firmly and sealed well.

2 Optical cable and electric cable lines shall be routed correctly, with proper cable protection measures, orderly arrangement, firm binding, and pre-reserved length in accordance with regulations, and the identification shall be correct and clear.

## **6.13 Computer Network of Toll Collection System**

**6.13.1** The computer network of the toll collection system shall conform to the following basic requirements:

1 The model, specification and quantity of the network equipment such as network cable, socket, connector, network card, hub, switch, router, modem and server shall conform to the contract requirements, and the components shall be complete.

2 The crimping form (line pair distribution) of socket and double-twisted wire joint shall comply with the provisions of the current EIA/TIA 568A or 586B; only one crimping form can be selected in a system, and no mixing is allowed.

3 After the installation and commissioning of all the equipment, the computer system of the toll collection system shall be maintained in proper working condition.

**6.13.2** The measurement items of the computer network of toll collection system shall conform to the provisions in Table 6.13.2.

**Table 6.13.2 Measurement Items of the Computer Network of Toll Collection System**

Item No.	Inspection items	Technical requirements	Inspection method
1△	Wiring diagram	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
2	Length	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
3△	Return loss	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
4	Insertion loss	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
5△	Near-end crosstalk	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
6	Near-end crosstalk power sum	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
7	Attenuated far-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
8	Power sum of attenuated far-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester

9	Attenuated near-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
10	Power sum of attenuated near-end crosstalk ratio	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
11	Loop resistance	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
12	Time delay	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
13	Time delay deviation	Comply with the provisions of the current GB/T 50312	By validator – network certify tester
14△	Performance requirements of Ethernet system	14.1 Link transmission rate	Meet the design requirements, or meet the requirements of 10Mbps, 100Mbps and 1000Mbps in case of no such requirements
		14.2 Throughput	Meet the design requirements, or ensure the length of 1518-frame $\geq 99\%$ in case of no such requirements
		14.3 Transmission delay	Meet the design requirements, or $\leq 10\text{ms}$ in case of no such requirements
		14.4 Packet loss rate	$\leq 0.1\%$ when the traffic load is not greater than 70%
15△	Health condition of Ethernet link layer	15.1 Link utilization	$\leq 70\%$
		15.2 Error rate and errors	$\leq 1\%$
		15.3 Broadcast frame and multicast frame	$\leq 50\text{fps}$
		15.4 Conflict (collision) rate	$\leq 1\%$
16△	Network security performance	Meet the design requirements	Interview, document check, configuration check, case validation test, vulnerability scanning test, permeability test, etc.

**6.13.3** The appearance of the computer network of the toll collection system shall comply with the following provisions:

- 1 The network equipment, cable trough and information socket shall be arranged

orderly with firm installation and clear identification.

2 Cable routing shall be correct with firm binding, standard end connection and correct and clear identification; the bending radius and pre-reserved length of the cable shall comply with the provisions of the current *Code for Engineering Acceptance of Generic Cabling System* (GB/T 50312).

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# 7 Power Supply and Distribution Facilities

## 7.1 Medium-voltage Distribution Equipment

7.1.1 Medium-voltage distribution equipment shall meet the following basic requirements:

1 Power transformers, reactors and extinction coils, instrument transformers, vacuum circuit breakers, Sulphur Hexafluoride (SF6) circuit breakers, Sulphur Hexafluoride (SF6) Gas Insulated Switchgears, isolators, load switches and high voltage fuses, casings, capacitors, arresters, etc. shall comply with 3.6 KV~40.5 KV *AC metal closed switch gear and control equipment* (GB 3906) and relevant standards.

2 The model, specification and quantity of medium-voltage distribution equipment and accessories shall conform to the contract requirements, and the components shall be complete.

3 Exposed conductive parts of electrical equipment shall have reliable electrical connection with ground device. Both ends of the distribution device in rows shall be connected to the ground wires.

4 The phase sequence of each circuit of the distribution unit in substation shall be consistent, and the rigid conductor shall be painted or marked with phase wiring color.

5 The layout of the rack in substation shall be properly arranged with a stable installation, and there shall be no violent vibration or explosion medium.

6 Transformer rooms, power distribution rooms and capacitor rooms shall be provided with facilities to prevent the entering of rain, snow, small animals like snake or mouse from lighting windows, ventilation windows, doors, or cable trenches, etc.

7.1.2 The measurement items of medium-voltage distribution equipment shall conform to the provisions of Table 7.1.2.

**Table 7.1.2 Measurement Items for Medium-voltage Distribution Equipment**

ItemNo.	Inspection Items	Technical requirements	Inspection methods
1	Power transformer	1.1 Insulating oil or SF6 gas	Comply with article 8.0.3 of GB50150-2016 By insulation oil comprehensive tester or SF6 gas comprehensive tester required in article 8.0.3 of GB50150-2016
		1.2 DC resistance of winding with casing	Comply with article 8.0.4 of GB50150-2016 By DC resistance fast tester
		1.3 Tap voltage ratio	Comply with article 8.0.5 of GB50150-2016 By automatic transformer turns ratio and polarity tester
		1.4 Transformer three-phase connection group and single-phase transformer lead wire polarity	Comply with article 8.0.6 of GB50150-2016 By automatic transformer turns ratio and polarity tester
		1.5 Insulation resistance of cores and clamps	Comply with article 8.0.7 of GB50150-2016 By DC megohmmeter
		1.6 Non-pure porcelain casing	Comply with article 8.0.8 of GB50150-2016 By AC withstand voltage tester, DC megohmmeter, insulation oil tester or SF6 gas tester
		1.7 Inspection and testing of on-load voltage regulating switching devices	Comply with article 8.0.9 of GB50150-2016 Operation inspection
		1.8 Insulation resistance of	Comply with article 8.0.10 of GB50150- By DC megohmmeter

		winding with casing, absorption ratio or polarization index	2016		
		1.9 AC withstand voltage of winding with casing	Comply with article 8.0.13 of GB50150-2016	By AC withstand voltage tester	
		1.10 Impulse switch closing at rated voltage	Comply with article 8.0.15 of GB50150-2016	By impulse voltage tester	
		1.11 Phase	Comply with article 8.0.16 of GB50150-2016	By phasing tester	
2	Reactor and extinction coil	Dry reactor	2.1 DC resistance of winding with casing	Comply with article 9.0.3 of GB50150-2016	By DC resistance fast tester
			2.2 Insulation resistance of windings together with casing, absorption ratio or polarization index	Comply with article 9.0.4 of GB50150-2016	By DC megohmmeter
			2.3 AC withstand voltage of winding with casing	Comply with article 9.0.6 of GB50150-2016	By AC voltage tester
			2.4 Impact switch closing at rated voltage	Comply with article 9.0.10 of GB50150-2016	By impulse voltage tester
	extinction coil		2.5 DC resistance of winding with casing	Comply with article 9.0.3 of GB50150-2016	By DC resistance fast tester
			2.6 Insulation resistance of windings together with casing, absorption ratio or polarization index	Comply with article 9.0.4 of GB50150-2016	By DC megohmmeter
			2.7 AC withstand voltage of winding with casing	Comply with article 9.0.6 of GB50150-2016	By AC voltage tester
			2.8 Insulation resistance of fasteners insulated	Comply with article 9.0.7 of GB50150-2016	By DC megohmmeter

			from core		
		Oil-immersed reactor	2.9 DC resistance of winding with casing	Comply with article 9.0.3 of GB50150-2016	By DC resistance fast tester
			2.10 Insulation resistance of winding with the casing, absorption ratio or polarization index	Comply with article 9.0.4 of GB50150-2016	By DC megohmmeter
			2.11 AC withstand voltage of winding with casing	Comply with article 9.0.6 of GB50150-2016	By AC withstand voltage tester
			2.12 Insulation resistance of fasteners insulated from core	Comply with article 9.0.7 of GB50150-2016	By DC megohmmeter
			2.13 Insulating oil	Comply with article 9.0.8 of GB50150-2016	By insulation oil comprehensive test instrument meeting with requirements of article 9.0.8 in GB50150-2016
			2.14 Impact switch closing at rated voltage	Comply with article 9.0.10 of GB50150-2016	By impulse voltage tester
3	Instrument transformers	3.1 Insulation resistance of winding	Comply with article 10.0.3 of the GB50150-2016	By DC megohmmeter	
		3.2 Partial discharge	Comply with article 10.0.5 of the GB50150-2016	By partial discharge detection equipment	
		3.3 AC withstand voltage	Comply with article 10.0.6 of the GB50150-2016	By AC withstand voltage tester	
		3.4 Insulation dielectric properties	Comply with article 10.0.7 of the GB50150-2016	By insulation oil integrated test equipment or SF6 gas integrated test equipment that meets the requirements of 10.0.7 in the GB50150-2016	
		3.5 DC resistance of winding	Comply with article 10.0.8 of the GB50150-2016	By DC resistance fast tester	



		3.6 Wiring groups and polarity	Comply with article 10.0.9 of the GB50150-2016	By automatic transformer turns ratio and polarity tester
		3.7 Error	Comply with article 10.0.10 of the GB50150-2016	By instrument transformer calibrator
		3.8 Excitation characteristic curve of current transformer	Comply with article 10.0.11 of the GB50150-2016	By excitation curve tester of current transformer
		3.9 Excitation characteristics of electromagnetic voltage transformer	Comply with article 10.0.12 of the GB50150-2016	By excitation curve tester of voltage transformer
		3.10 Capacitive Voltage Transformer (CVT)	Comply with article 10.0.13 of the GB50150-2016	By capacitive voltage transformer tester
		3.11 Sealing performance	Comply with article 10.0.14 of the GB50150-2016	By SF6 gas integrated testing equipment meeting the requirements of article 10.0.14 in GB50150-2016
4	Vacuum circuit breaker	4.1 Insulation resistance	Comply with article 11.0.2 of the GB50150-2016	By DC megohmmeter
		4.2 Resistance per phase of conductive circuit	Comply with article 11.0.3 of the GB50150-2016	By DC resistance fast tester
		4.3 AC withstand voltage	Comply with article 11.0.4 of the GB50150-2016	By AC voltage tester
		4.4 Switching on and switching off time of main contact of circuit breaker, synchronism of Switching on and switching off, bouncing time of contact when switching on	Comply with article 11.0.5 of the GB50150-2016	By high voltage switching characteristics tester
		4.5 Insulation resistance and DC	Comply with article 11.0.6 of the	By DC megohmmeter and DC resistance fast tester

		resistance of switching on/off coil and switching on contactor coil	GB50150-2016	
		4.6 Circuit breaker operating mechanic	Comply with article 11.0.7 of the GB50150-2016	Analog test meeting the requirements of article 11.0.7 in GB50150-2016
5	Sulfur hexafluoride circuit breaker	5.1 Insulation resistance	Comply with article 12.0.2 of the GB50150-2016	By DC megohmmeter
		5.2 Phase resistance of conductive circuit	Comply with article 12.0.3 of the GB50150-2016	By DC resistance fast tester
		5.3 AC withstand voltage	Comply with article 12.0.4 of the GB50150-2016	By AC withstand voltage tester
		5.4 Grading capacitor for Circuit Breaker	Comply with article 12.0.5 of the GB50150-2016	Capacitor test in accordance with item 18 of the GB50150-2016
		5.5 Switching on and switching off time of circuit breaker	Comply with article 12.0.6 of the GB50150-2016	By high voltage switching characteristics tester
		5.6 Switching on/off speed of circuit breaker	Comply with article 12.0.7 of the GB50150-2016	By high voltage switching characteristics tester
		5.7 Synchronism and fitting time of switching on/off main and auxiliary contact points of circuit breaker	Comply with article 12.0.8 of the GB50150-2016	By high voltage switching characteristics tester
		5.8 Input time and resistance value of circuit breaker switch closing resistance	Comply with article 12.0.9 of the GB50150-2016	By high voltage switching characteristics tester
		5.9 Switching on/off Circuits Insulation and DC Resistance of Circuit Breaker	Comply with article 12.0.10 of the GB50150-2016	By DC megohmmeter and DC resistance fast tester

		5.10 Circuit breaker operating mechanic	Comply with article 12.0.11 of the GB50150-2016	Analog test meeting the requirements of article 12.0.11 in GB50150-2016
		5.11 Bushing current transformer	Comply with article 12.0.12 of the GB50150-2016	Instrument transformer test in accordance with item 10 of GB50150-2016
		5.12 Water content of SF6 gas in circuit breaker	Comply with article 12.0.13 of the GB50150-2016	By SF6 gas integrated test equipment meeting the requirements of 12.0.13 in GB50150
		5.13 Sealing Test	Comply with article 12.0.14 of the GB50150-2016	By SF6 gas integrated test equipment meeting the requirements of 12.0.14 in GB50150-2016
		5.14 Gas density relay, pressure gauge and pressure action valve	Comply with article 12.0.15 of the GB50150-2016	Operation inspection
6	Sulphur Hexafluoride (SF6) Gas Insulated Switchgear	6.1 Main circuit electrical resistance	Comply with article 13.0.2 of the GB50150-2016	By DC resistance fast tester
		6.2 Components in Gas Insulated Switchgear	Comply with article 13.0.3 of the GB50150-2016	Tests shall be conducted as required under article 13.0.3 of GB50150-2016
		6.3 Sealing	Comply with article 13.0.4 of the GB50150-2016	By SF6 gas integrated test equipment meeting the requirements of 13.0.4 in GB50150-2016
		6.4 Water content of Sulphur hexafluoride gas	Comply with article 13.0.5 of the GB50150-2016	By SF6 gas integrated test equipment meeting the requirements of 13.0.5 in GB50150-2016
		6.5 AC withstand voltage	Comply with article 13.0.6 of the GB50150-2016	By AC withstand voltage tester
		6.6 Operation of Switchgear	Comply with article 13.0.7 of the GB50150-2016	Analog test meeting the condition requirements of article 13.0.7 in GB50150-2016
		6.7 Gas density relay, pressure gauge and pressure action valve	Comply with article 13.0.8 of the GB50150-2016	Operation inspection

7	Isolation switch, load switch and high voltage fuse	7.1 Insulation resistance	Comply with article 14.0.2 of the GB50150-2016	By DC megohmmeter
		7.2 DC resistance of high voltage current limiting fuse tube fuse	符合 GB50150-2016 中 14.0.3 条的规定 Comply with article 14.0.3 of the GB50150-2016	By DC resistance fast tester
		7.3 Resistance of load switch conductive circuit	Comply with article 14.0.4 of the GB50150-2016	By DC resistance fast tester
		7.4 AC withstand voltage	Comply with article 14.0.5 of the GB50150-2016	By AC withstand voltage tester
		7.5 Minimum operating voltage for operating mechanic coils	Comply with article 14.0.6 of the GB50150-2016	Analog test meeting the condition requirements of article 14.0.6 in GB50150-2016
		7.6 Operating mechanic	Comply with article 14.0.7 of the GB50150-2016	Operation inspection
8	Casing	8.1 Insulation resistance	Comply with article 15.0.2 of the GB50150-2016	By DC megohmmeter
		8.2 AC withstand voltage	Comply with article 15.0.4 of the GB50150-2016	By AC withstand voltage tester
		8.3 Insulating oil (other than organic composite insulating sleeving)	Comply with article 15.0.5 of the GB50150-2016	By insulation oil integrated test equipment meeting the requirements of 15.0.5 in GB50150-2016
		8.4 SF6 Casing gases	Comply with article 15.0.6 of the GB50150-2016	By SF6 gas integrated test equipment meeting the requirements of 15.0.6 in GB50150-2016
9	Suspension insulator and post insulator	9.1 Insulation resistance	Comply with article 16.0.2 of the GB50150-2016	By DC megohmmeter
		9.2 AC withstand voltage	Comply with article 16.0.3 of the GB50150-2016	By AC withstand voltage tester
10	Capacitor	10.1 Insulation	Comply with article	By DC insulated resistance

		resistance	18.0.2 of the GB50150-2016	tester
		10.2 Dielectric loss angle tangent value $\tan\delta$ and capacitance value of coupling capacitor and circuit breaker capacitor	Comply with article 18.0.3 of the GB50150-2016	By capacitor tester
		10.3 Capacitance value	Comply with article 18.0.4 of the GB50150-2016	By partial discharge detection equipment
		10.4 AC withstand voltage of shunt capacitor	Comply with article 18.0.5 of the GB50150-2016	By AC withstand voltage tester
		10.5 Impact switch closing	Comply with article 18.0.6 of the GB50150-2016	By impulse voltage tester
11	Lightning arrester	11.1 Metal oxide arrester and base insulation resistance	Comply with article 20.0.3 of the GB50150-2016	By DC megohmmeter
		11.2 Power frequency reference voltage (50hz) and continuous current for metal oxide arresters	Comply with article 20.0.4 of the GB50150-2016	Analog test meeting the condition requirements of article 20.0.4 in GB50150-2016
		11.3 Leakage current at DC reference voltage and 0.75 times DC reference voltage for metal oxide arrester	Comply with article 20.0.5 of the GB50150-2016	Analog test meeting the condition requirements of article 20.0.5 in GB50150-2016
		11.4 Discharge Counter action and monitor ammeter indication	Comply with article 20.0.6 of the GB50150-2016	Operation inspection
		11.5 Power-frequency sparkover voltage	Comply with article 20.0.7 of the GB50150-2016	By AC withstand voltage tester
12	Secondary circuit	12.1 Insulation resistance	Comply with article 22.0.2 of the	By DC megohmmeter

			GB50150-2016	
		12.2 AC withstand voltage	Comply with article 22.0.3 of the GB50150-2016	By AC withstand voltage tester
13	Ground device	13.1 Electrical integrity of ground grid	Comply with article 25.0.2 of the GB50150-2016	DC resistance rapid tester and multimeter measurement
		13.2 Ground resistance	Comply with article 25.0.3 of the GB50150-2016	Measurement of ground resistance tester
14	Setting value of microcomputer integrated protection device		Test the setting value of microcomputer integrated protection device, the whole group items, and the linkage items. Check whether the value is consistent with the design requirements.	By microcomputer relay protection tester

7.1.3 The appearance of medium-voltage distribution equipment shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The high voltage warning signs of medium-voltage distribution equipment is correct and clear.

## 7.2 Medium-voltage Electrical Cables

7.2.1 Medium-voltage equipment power cable shall meet the following basic requirements:

- 1 Medium-voltage equipment power cable shall comply with current *Rated Voltage 1 kV ( $U_m=1.2$  kV) to 35 kV ( $U_m=40.5$  kV) Extruded Insulation Power Cables and Accessories - Part 2: Rated Voltage 6 kV ( $U_m=7.2$  kV) to 30 kV ( $U_m=36$  kV) Cable (GB/T12706.2), Rated Voltage 1 kV ( $U_m=1.2$  kV) to 35 kV ( $U_m=40.5$  kV) Extruded*

*Insulation Power Cables and Accessories - Part 3: Rated Voltage 35 kV ( $U_m=40.5$  kV) Cable (GB/T12706.3) and Rated Voltage 1 kV ( $U_m=1.2$  kV) to 35 kV ( $U_m=40.5$  kV) Extruded Insulation Power Cables and Accessories - Part 4: Rated Voltage 6 kV ( $U_m=7.2$  kV) to 35 kV ( $U_m=40.5$  kV) Power Cable Accessories Test Requirements (GB/T12706.4) and other relevant standards.*

2 Model, specification and quantity of medium-voltage distribution power cables and accessories shall conform to the contract requirements and the components shall be complete.

3 Control cables and fire-resistant cables shall apply copper conductors.

4 The path of the cables shall avoid mechanical external force, overheating, corrosion and other hazards.

5 The ground measures of the armored layer at both ends of the buried cables shall be appropriate, and the cable markings shall meet the design requirements.

7.2.2 The measurement items of power cables for medium-voltage equipment shall conform to Table 7.2.2.

**Table 7.2.2 Measurement Items of Power Cables for Medium-voltage Equipment**

Item No.	Inspection items	Technical requirements	Inspection methods
1	1.1 Insulation resistance	Comply with article 17.0.3 of the GB50150-2016	By DC megohmmeter
	1.2 DC withstand Voltage Test and Leakage Current	Comply with article 17.0.4 of the GB50150-2016	By DC withstand voltage tester
	1.3 AC withstand voltage	Comply with article 17.0.5 of the GB50150-2016	By AC withstand voltage tester
	1.4 Phase at both ends of the cable line	Comply with article 17.0.6 of the GB50150-2016	By phasing tester
	1.5 Cross interconnection	Comply with article 17.0.8 of the GB50150-2016	Test conducted as required by appendix F of GB50150-2016
2	1kV or above overhead 2.1 Insulation resistance of insulators and circuits	Comply with article 24.0.2 of the GB50150-2016	By DC megohmmeter

power cable	2.2 Phase	Comply with article 24.0.4 of the GB50150-2016	By phasing tester
	2.3 Impact switch closing	Comply with article 24.0.5 of the GB50150-2016	By impulse voltage tester
	2.4 Ground Resistance of Tower	Comply with article 24.0.6 of the GB50150-2016	By ground resistance tester

**7.2.3** The appearance of power cables for medium-voltage equipment shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 Cables shall be arranged orderly and bound firmly when their ends are introduced into the cable well.
- 3 Cables enter the wall shall be provided with protective casing, and the pre-reserved length shall meet the requirements of relevant technical specifications.
- 4 The high voltage warning signs of medium-voltage distribution equipment are correct and clear.

### **7.3 Low Voltage Distribution Equipment in the Centre (Station)**

**7.3.1** Low voltage distribution equipment in the center (station) shall meet the following basic requirements:

- 1 The low-voltage distribution equipment in the center (station) shall conform to the provisions of current *Low-voltage Switchgear and Control Equipment* (GB7251) and other relevant standards.
- 2 The model, specification and quantity of low voltage distribution equipment and accessories in the center (station) shall conform to the contract requirements, and the components shall be complete.
- 3 Exposed conductive parts of electrical equipment shall have reliable electrical connection with the ground device. Both ends of the distribution device in rows



shall be connected to the ground wires.

4 The phase sequence of each circuit of the distribution unit in substation shall be consistent, and the rigid conductor shall be painted or marked with phase wiring color.

5 The layout of the rack in substation shall be properly arranged and stably installed, and there shall be no violent vibration or explosion medium.

6 Transformer rooms, power distribution rooms and capacitor rooms shall be provided with facilities to prevent the entering of rain, snow, small animals like snake or mouse from lighting windows, ventilation windows, doors, or cable trenches, etc.

**7.3.2** The measurement items of low-voltage distribution equipment in center (station) shall conform to the requirements of table 7.3.2.

**Table 7.3.2 Measurement Items of Low Voltage Distribution Equipment in the Centre (Station)**

Item No.	Inspection items	Technical requirements	Inspection methods					
1	Levelness of equipment installation	$\leq 3\text{mm/m}$	By measuring tools					
2	Perpendicularity of equipment installation	$\leq 3\text{mm/m}$	By verticality measurement					
3	Insulation resistance of indoor equipment and racks	<table border="1"> <tr> <td>AC Distribution Box (Case)</td> <td rowspan="4">Meet design requirements, and <math>\geq 2\text{M}\Omega</math> if no requirements</td> </tr> <tr> <td>DC distribution box (Case)</td> </tr> <tr> <td>AC regulator</td> </tr> <tr> <td>Uninterruptible power supply</td> </tr> </table>	AC Distribution Box (Case)	Meet design requirements, and $\geq 2\text{M}\Omega$ if no requirements	DC distribution box (Case)	AC regulator	Uninterruptible power supply	Measurement between wiring in the equipment and ground by 500V megohmmeter
AC Distribution Box (Case)	Meet design requirements, and $\geq 2\text{M}\Omega$ if no requirements							
DC distribution box (Case)								
AC regulator								
Uninterruptible power supply								
4	Common ground resistance	$\leq 1\Omega$	By ground resistance measurements					
5	Insulation resistance of generator set control box	$\geq 2\text{M}\Omega$	By 500V megohmmeter					
6	Generator set start-up time	Meet design requirements and $\leq 30\text{s}$ if no requirements	Operation inspection					
7	Phase sequence of generator set	Be consistent with the output mark of	By phase sequence indicator					

			generator set	
8	Output voltage stability of generator set		Meet design requirements	Operation inspection or verification of factory test reports
9	Automatic self-starting conversion function of automatic generator set		After cutting off the power supply, the generator set can start automatically, and send power to the specified line after stabilizing, which can be preferentially switched manually.	Function verification or verification of valid historical records
10	Influence of power supply switching of generator set on Electromechanical System		All equipment of electromechanical system is not abnormal due to power switch of generator set	Site inspection or verification of valid historical records
11	Diesel generator batteries		Battery working normally	Operation inspection
12	Construction quality of ground device in power supply room		The material and size of the earthing conductor, the installation position and the buried depth, the connection between the earthing line and the earthing conductor, and the anticorrosion treatment meet the design requirements	Verification the acceptance records and construction records of concealed works
13	1kV voltage and below level distribution units and feeding wiring (level 1 in a three-level distribution system)	13.1 Insulation resistance	Comply with article 23.0.2 of the GB50150-2016	By DC Megohmmeter
		13.2 AC withstand voltage test for power distribution units	Comply with article 23.0.3 of the GB50150-2016	By equipment that meets the requirements of article 23.0.3 of the GB50150
		13.3 Phase between the feeding lines and the two sides of the feeding line for different power sources in the distribution unit	Comply with article 23.0.4 of the GB50150-2016	By equipment that meets the requirements of article 23.0.4 of the GB50150
14	Low voltage apparatus (Level 1 in a three-level distribution system)	14.1 Insulation resistance of low voltage apparatus with connected cables and secondary circuits	Comply with article 26.0.3 of the GB50150-2016	By DC Megohmmeter
		14.2 Calibration of voltage coil action values	Comply with article 26.0.4 of the GB50150-2016	Operation inspection
		14.3 Setting of tripping devices for low voltage	Comply with article 26.0.6 of the GB50150-2016	Operation inspection

		apparatus		
		14.4 AC withstand voltage of low voltage apparatus with connected cables and secondary circuits	Comply with article 26.0.8 of the GB50150-2016	By AC withstand voltage tester or DC megohmmeter
15	Power factor for low voltage distribution systems		$\geq 0.90$	By power analyzer or power quality analyzer
16	Neutral current		$\leq 25\%$ of minimum phase current in three-phase current	By power quality analyzer
17	Power quality	17.1 Power supply voltage deviation	The voltage deviation of three-phase power supply is $\pm 7\%$ of nominal voltage	Measure 10 min by power quality analyzer
		17.2 Three-phase voltage imbalance	The 95% probability of the 10 min root mean square of the negative sequence imbalance measurement value of the supply voltage $\leq 2\%$	Measure 10 min by power quality analyzer
		17.3 Frequency deviation of power system	The frequency deviation limited value is $\pm 0.2$ Hz	By power quality analyzer
		17.4 Harmonics in Public Grid (Grid nominal voltage 380 V)	Total voltage harmonic distortion rate $\leq 5.0\%$ , odd harmonics voltage content $\leq 4.0\%$ , even harmonics voltage content $\leq 2.0\%$	Measure 10 min by power quality analyzer
			Harmonic current allowable value conforms to the regulation in Table 2- harmonic current allowable value injected into point of common coupling of current <i>Power quality- Harmonics in Public Grid (Quality of electric energy supply-Harmonics in public supply network)</i> (GB 14549) in present	Measure 10 min by power quality analyzer
18	UPS and EPS functions and performance	18.1 Output voltage	UPS output voltage deviation is 5% of nominal voltage; EPS inverter emergency output voltage deviation is 10% of nominal voltage.	Measure 10 min by power quality analyzer
		18.2 Output frequency	The frequency deviation limit is $\pm 0.5$ Hz	The power quality analyzer measures the ratio of integer period to integer period accumulative time in 1 s, 3s or 10 s interval
		18.3 Total harmonic distortion rate	Total harmonic distortion of UPS output and EPS inverter emergency output $\leq 5\%$ respectively	Measure 10 min by power quality analyzer
		18.4 Switching time between electricity and backup power	Meet design requirements	By oscilloscope

		18.5 Display function	Meet design requirements	Function verification
19	Parameter Regulated Power Supply	19.1 Output voltage	Output voltage deviation is $\pm 5\%$ of nominal voltage	Measure 10 min by power quality analyzer
		19.2 Output frequency	The frequency deviation limit is $\pm 0.5$ Hz	Measure 10 min by power quality analyzer
		19.3 Total harmonic distortion rate	Total harmonic distortion $\leq 5\%$	Measure 10 min by power quality analyzer

**7.3.3** The appearance of the low voltage distribution equipment in the center (station) shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **7.4 Power cables for Low Voltage Equipment**

**7.4.1** Power cables for low voltage equipment shall meet the following basic requirements:

- 1 Low voltage equipment power cables shall conform to the *Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1 kV ( $U_m=1.2kV$ ) up to 35kV Rated Voltage kV ( $U_m=40.5 kV$ ) - Part 1: Cables for Rated Voltage 1 kV ( $U_m=1.2 kV$ ) and 3 kV ( $U_m=3.6 kV$ )* (GB/T12706.1) and other relevant standards.

- 2 The model, specification and quantity of low voltage power cables and accessories shall conform to the contract requirements, and the components shall be complete.

- 3 Control cables and fire-resistant cables shall apply copper conductors.

- 4 The path of the cables shall avoid mechanical external force, overheating, corrosion, and other hazards.

- 5 The grounding measures of the armored layer at both ends of the buried cable shall be appropriate, and the installation of cable signs shall meet the design

requirements.

**7.4.2** The measurement items of power cables for low voltage equipment shall conform to Table 7.4.2.

**Table 7.4.2 Measurement Items of Power Cable for Low Voltage Equipment**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Distribution box foundation dimensions and elevations	Meet design requirements	By measuring tape
2	Cable buried depth or cable laying in conduit	Meet design requirements	Verification of concealed works records or operation inspection
3	Coating thickness of distribution box	Meet design requirements, and comply with the current GB / T 18226 when no requirements	By coating thickness gauge
4	Insulation resistance of phase wires to insulating sheath	$\geq 2 \text{ M}\Omega$ (whole process)	By 500V megohmmeter
5	Insulation resistance of distribution box to distribution frame	$\geq 10 \text{ M}\Omega$	By 500V megohmmeter
6	Protective ground resistance of power box and distribution box	$\leq 4 \Omega$	By ground resistance tester
7□	Model and specification for main cable and branch cable for ventilation and lighting Facilities	Meet design requirements	Operation inspection

**7.4.3** The appearance of power cables for low voltage equipment shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 Cables shall be arranged orderly and bound firmly when their ends are introduced into the cable well.
- 3 Cables enter the wall shall be provided with protective casing and shall reserve proper length for further use.

## 7.5 Wind/solar Power Supply System

7.5.1 Wind/solar power supply system shall meet the following basic requirements:

1 The equipment of the wind/solar power supply system shall conform to *General Specifications of Solar Energy Power System for Highway Facilities* (GB/T24716) and relevant standards.

2 Model, specification and quantity of equipment and accessories for wind/solar power supply system shall comply with contract requirements, and the components shall be complete.

3 The shielding sheath ground connection of wire and cable shall be reliable, and be connected to the nearest ground trunk line. All fasteners shall be complete.

4 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

7.5.2 The measurement items of the wind/solar power supply system shall conform to Table 7.5.2.

**Table 7.5.2 Measurement Items of Wind/solar Power Supply System**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Column verticality	$\leq 5$ mm/m	By total station or vertical gauge
2□	Insulation resistance	The insulation resistance of AC 220 V strong current terminal to ground $\geq 50$ M $\Omega$	By 500V megohmmeter
3□	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester
4□	Lightning protection ground resistance	$\leq 10\Omega$	By ground resistance tester
5□	Common ground resistance	The common ground resistance $\leq 1\Omega$ if the protective earthing and lightning protection earthing of the wind/ solar power supply system are not set separately	By ground resistance tester
6	6.1 DC Output Voltage	Meet design requirements	By multimeter

	6.2 AC output voltage	Meet design requirements	By multimeter
	6.3 Output current	Meet design requirements	By multimeter
7	Monitoring function	Monitor the real-time working status, collect and store the operating parameters of the power supply system, and control the power supply system according to the command of the monitoring center.	Function verification
8	Battery management function	The controller can compensate temperature, perform current limiting charging, constant current and voltage charging, and manual/automatic switching function.	Function verification
9	Protection function	The controller possesses the function of self-protection in short circuit, preventing the battery from generating reverse current through solar cell module, and protection of overvoltage and undervoltage.	Function verification
10	State monitoring function	Monitor battery voltage, battery charge and discharge current, wind turbine input voltage/current, photovoltaic square array input voltage/current, load current and other parameters	Function verification

**7.5.3** The appearance of wind/solar power supply system shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **7.6 Electric Vehicle Charging System**

**7.6.1** Electric vehicle charging system shall meet the following basic requirements:

- 1 The equipment of electric vehicle charging system shall comply with the current *Electric Vehicle Conductive Charging System* (GB/T 18487) and other relevant standards.
- 2 The model, specification and quantity of electric vehicle charging system equipment and accessories shall conform to the contract requirements, and the components shall be complete.

3 The shielding sheath ground connection of wire and cable shall be reliable, and be connected to the nearest ground trunk line. All fasteners shall be complete.

4 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

7.6.2 The measurement items of electric vehicle charging system shall conform to Table 7.6.2.

**Table 7.6.2 Measurement Items of Electric Vehicle Charging System**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Verticality	$\leq 5$ mm/m	By vertical gauge
2□	Insulation resistance	$\geq 10M\Omega$	By 500V megohmmeter
3□	Protective ground resistance	$\leq 4\Omega$	By ground resistance tester
4□	Lightning protection ground resistance	$\leq 10\Omega$	By ground resistance tester
5□	Common ground resistance	The common ground resistance $\leq 1\Omega$ if the protective ground and lightning protection ground of electric vehicle charging system are not set separately	By ground resistance tester
6	Input/output voltage	Meet design requirements	Operation inspection
7	Charging mode	Comply with current GB/T 18487 requirements	Operation inspection
8	Connection between electric vehicles and power supply equipment	Comply with current GB/T 18487 requirements	Operation inspection
9	Protection function	The system has lightning, overload and short circuit protection functions	Function verification

7.6.3 Electrical Vehicle charging system appearance shall comply with the following requirements:

1 There shall be no unacceptable defects listed in Appendix C of this Standard.



## 7.7 Power Monitoring System

7.7.1 The power monitoring system shall meet the following basic requirements:

- 1 The power monitoring computer center shall be clean with good ventilation and lighting performance.
- 2 The model, specification and quantity of all equipment and accessories of the power monitoring center shall conform to the contract requirements, and the components shall be complete.
- 3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

7.7.2 The measurement items of the power monitoring system shall conform to Table 7.7.2.

**Table 7.7.2 Measurement Items of Power Monitoring Systems**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Communication management	Monitor the operating condition of each node on the network, trigger alarm and reset automatically when communication fails	Operation inspection
2	2.1 Telemetry function of 10 kV circuit	Telemetering three-phase voltage, current, active power, reactive power, power factor, frequency and other parameters of 10 kV circuit	Function verification
	2.2 Telemetry function of main switch circuit of low voltage	Telemetering three-phase voltage, current, active power, reactive power, power factor, frequency, power consumption and other parameters of low voltage main switch circuit.	
	2.3 Telemetry function of transformer	Telemetering the temperature of transformer and the temperature inside distribution box	
	2.4 Telemetry function of feeder line	Telemetering 0.4 kV feeder line current	
	2.5 UPS and EPS telemetry function	Telemetering UPS and EPS input voltage, output voltage, input current, output current, output frequency, charging current, battery voltage and other parameters	
	2.6 Generator telemetry	Telemetering generator parameters like voltage,	

		function	current, frequency and other parameters	
3	Telesignal function	3.1 Telesignal function of 10kV circuit	Telesignal the position status and fault alarm of 10kV incoming and outgoing switches	Function verification
		3.2 Transformer telesignal function	Telesignal the transformer outgoing main switch status, fuse burn-out signal, ground status, transformer temperature, fan start signal	
		3.3 Telesignal function of switch status, contactor and circuit breaker	Telesignal 0.4 kV output hand/automatic switch status, operating status and fault alarm of contactor and circuit breaker	
		3.4 Reactive power compensation telesignal function	Telesignal the reactive power compensation status signal and the switching on signal of fuse switch disconnector and circuit breaker	
		3.5 Telesignal function of UPS and EPS	Telesignal UPS and EPS AC/ Inverter power supply, overload, low voltage after battery discharge, inverter or converter failure	
4	Telecontrol function	4.1 Telecontrol function of high and low voltage bus	Telecontrol high and low voltage bus switch	Function verification
		4.2 Telecontrol function of reactive power compensator	Telecontrol reactive power compensation device switching	
		4.3 Telecontrol function of lighting box and fan box	Telecontrol lighting box, fan box, etc.	
		4.4 Telecontrol of generators	Telecontrol the conversion between public electric supply and generator power, generator unit start-up and shutdown	
5	Environmental monitoring of distribution room		Possess functions of automatic intrusion alarming, temperature and humidity monitoring, and smoke detecting	Operation inspection
6	Report management function		Be able to query various reports required by design documents	Function verification

7.7.3 The appearance of the power monitoring system shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The equipment on the console shall be arranged reasonable with stable installation, and the identification shall be correct and clear.

# 8 Lighting Facilities

## 8.1 Lighting Facilities for Road

8.1.1 Lighting facilities for road shall meet the following basic requirements:

1 According to their types, road lighting luminaires shall comply with the current *High Mast Lighting System with Raising and Lowering Equipment* (GB/T26943) and *LED Lighting Luminaires for Highway* (JT/T939) and other relevant standards.

2 Model, specification and quantity of lighting equipment and accessories shall be in accordance with the contract requirements, and components shall be complete.

3 The structural dimensions, embedded parts, installation position and installing spacings of the mounting support for lighting luminaires shall conform to the design requirements.

4 After the installation and commissioning of all the equipment, the lighting facilities for road shall be maintained in proper working condition.

8.1.2 The measurement items of lighting facilities for road shall comply with Table 8.1.1.

Table 8.1.1 Measurement Items of Lighting Facilities for Road

Item No.	Inspection items	Technical requirements	Inspection methods
1	Base dimension of lamppost	Meet design requirements, tolerance: (-50,+100) mm	Measure the length and width with measuring tape, inspect the buried depth of concealed works by checking the acceptance record or measure on site

2□	Wall thickness of the lamppost	Meet design requirements	By ultrasonic thickness gauge
3	Anticorrosive coating thickness of metal lamppost	Meet design requirements, and comply with the current GB/T18226 speculations when no requirement.	By coating thickness gauge
4	Perpendicularity of lamppost	≤3mm/m	By total station or vertical gauge
5	Protective ground resistance of lighting control devices	≤4Ω	By ground resistance tester
6	Lightning protection ground resistance of lamppost	≤10Ω	By ground resistance tester
7	Average brightness of pavement	Meet design requirements, ≥2 cd/m <sup>2</sup> when no requirement.	By luminometer
8	Total brightness uniformity of pavement	Meet design requirements, ≥0.4 when no requirement.	By luminometer
9	Longitudinal brightness uniformity of pavement	Meet design requirements, ≥0.7 when no requirement.	By luminometer
10	Lighting Control Mode	With automatic and manual control mode or meet design requirements	Operation inspection
11	Lifting and lowering function of high mast lamp panel	Meet design requirements	Function verification
12	Linkage function between brightness sensor and lighting lamp	Meet design requirements	Function verification
13	Timing control function	Controllable	Function verification

**8.1.3** The appearance of lighting facilities for road shall comply with the following requirements:

1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## 8.2 Toll Plaza Lighting

**8.2.1** Toll plaza lighting shall meet the following basic requirements:

1 Toll plaza lighting luminaires, according to their types, shall comply with the current *High Mast Lighting System with Raising and Lowering Equipment* (GB/T26943) and *LED Lighting Luminaires for Highway* (JT/T939) and other relevant standards.

2 The model, specification and quantity of lighting equipment and accessories in toll plaza shall conform to the contract requirements, and the components shall be complete.

3 The structural dimensions, embedded parts, installation position and installing spacings of the mounting support for lighting fixtures shall conform to the design requirements.

4 After the installation and commissioning of all the equipment, toll plaza lighting facilities shall be maintained in proper working condition.

**8.2.2** Measurement items of lighting facilities in toll plaza shall comply with Table 8.2.1.

**Table 8.2.1 Measurement Items of Lighting Facilities in Toll Plaza**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Base dimensions of lamppost	Meet design requirements, tolerance :(-50,+100) mm	Measure the length and width with measuring tape, inspect the buried depth of concealed works by checking the acceptance record or measure on site
2	Wall thickness of the lamppost	Meet design requirements	By ultrasonic thickness gauge
3	Anticorrosive coating of metal lamppost	Meet design requirements, and comply with the current GB/T 18226 when no requirement.	By coating thickness gauge
4	Perpendicularity of lamppost	$\leq 3\text{mm/m}$	By total station or vertical gauge
5	Ground resistance of lighting control devices	$\leq 4\Omega$	By ground resistance tester
6	Lightning protection ground resistance of lamppost	$\leq 10\Omega$	By ground resistance tester
7	Average illumination of pavement in toll plaza	Meet design requirements, $\geq 20\text{ lx}$ when no requirement	By illuminometer
8	Total illumination uniformity of pavement in toll plaza	Meet design requirements, $\geq 0.4\%$ when no requirement	By illuminometer
9	Lighting Control Mode	With automatic and manual control mode or meet design requirements	Operation inspection
10	Lifting and lowering function of high mast lamp panel	Meet design requirements	Function verification

11	Linkage function between brightness sensor and lighting lamp	Meet design requirements	Function verification
12	Timing control function	Controllable	Function verification

**8.2.3** The appearance of lighting facilities in toll plaza shall comply with the following regulations.

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.

### **8.3 Lighting Facilities in Service Areas**

**8.3.1** Lighting facilities in service area shall meet the following basic requirements:

- 1 Lighting luminaires in service area, according to their types, shall comply with the current *High Mast Lighting System with Raising and Lowering Equipment* (GB/T26943) and *LED Lighting Luminaires for Highway* (JT/T939) and other relevant standards.

- 2 The model, specification and quantity of lighting equipment and accessories in service area shall conform to the contract requirements, and the components shall be complete.

- 3 The structural dimensions, embedded parts, installation position and installing spacings of the mounting support for lighting fixtures shall conform to the design requirements.

- 4 After the installation and commissioning of all the equipment, the lighting facilities in the service area shall be maintained in proper working condition.

**8.3.2** Measurement items of lighting facilities in service area shall comply with Table 8.3.1.

**Table 8.3.1 Measurement Items of Lighting Facilities in Service Areas**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Base dimensions of lamppost	Meet design requirements, tolerance: (-50,+100) mm	Measure the length and width with measuring tape, inspect the buried depth of concealed works by checking the acceptance record or measure on site.
2	Wall thickness of the lamppost	Meet design requirements	By ultrasonic thickness gauge
3	Anticorrosive coating thickness of metal lamppost	Meet design requirements, and comply with the current GB/T 18226 when no requirement.	By coating thickness gauge
4	Perpendicularity of lamppost	≤3mm/m	By total station or vertical gauge
5	Ground resistance of lighting control devices	≤4Ω	By ground resistance tester
6	Lightning protection ground resistance of lamppost	≤10Ω	By ground resistance tester
7	Average illumination of pavement in service area	Meet design requirements, ≥10 lx when no requirement	By illuminometer
8	Total illumination uniformity of pavement in service area	Meet design requirements, ≥0.3 when no requirement	By illuminometer
9	Lighting Control Mode	With automatic and manual control mode or meet design requirements	Operation inspection
10	Lifting and lowering function of high mast lamp panel	Meet design requirements	Function verification
11	Linkage function between brightness sensor and lighting lamp	Meet design requirements	Function verification
12	Timing control function	Controllable	Function verification

**8.3.3** The appearance of lighting facilities in service area shall comply with the following regulations.

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## **8.4 lighting Facilities of Toll Canopy**

**8.4.1** Lighting facilities of toll canopy shall meet the following basic requirements:

- 1 The model, specification and quantity of the toll canopy lighting facilities and accessories shall conform to the contract requirements, and the components shall

be complete.

2 Lighting luminaires shall be installed firmly and reliably.

3 Upon installation and commissioning of all equipment, toll canopy lighting facilities shall be maintained in proper working condition.

**8.4.2** Measurement items of lighting facilities of toll canopy shall comply with Table 8.4.1.

**Table 8.4.1 Measurement Items of Toll Canopy Lighting Facilities**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Ground resistance of lighting control devices	$\leq 4\Omega$	By ground resistance tester
2	Pavement average illumination of charging lanes	Meet design requirements, or $\geq 50$ lx when no requirement	By illuminometer
3	Total illumination uniformity of pavement for charging lanes	Meet design requirements, or $\geq 0.6$ when no requirement.	By illuminometer
4	Pavement average brightness of toll lanes	Meet design requirements, or $\geq 3.5$ cd/m <sup>2</sup> when no requirement.	By Luminometer
5	Total brightness uniformity of pavement for toll lanes	Meet design requirements, or $\geq 0.5$ when no requirement.	By Luminometer
6	Longitudinal brightness uniformity of pavement for toll lanes	Meet design requirements, or $\geq 0.8$ when no requirement.	By Luminometer
7	Chromogenic index	Meet design requirements, or $\geq 70$ when no requirement.	By spectral radiometer
8	Lighting Control Mode	With automatic and manual control mode or meet design requirements.	Operation inspection
9	Timing control function	Controllable	Function verification

**8.4.3** Lighting facilities of toll canopy shall meet the following requirements:

1 There shall be no unacceptable defects listed in Appendix C to this Standard.



# 9 Electrical and Mechanical Facilities for Highway Tunnel

## 9.1 Vehicle Detectors

9.1.1 The inspection and evaluation of the sub-division work of vehicle detector shall be carried out in accordance with section 4.1 of this standard.

## 9.2 Closed Circuit Television (CCTV) Monitoring System

9.2.1 The inspection and evaluation of the sub-division work of closed circuit television(CCTV) monitoring system shall be carried out in accordance with Section 4.3 of this Standard.

## 9.3 Emergency Telephone and Cable Broadcasting Systems

9.3.1 Emergency telephone and cable broadcasting systems shall meet the following basic requirements:

1 Emergency telephone and cable broadcasting system equipment shall comply with the current *Specifications of Wired-emergency Telephone System of Expressway* (GB/T 19516) and other relevant standards.

2 Model, specification and quantity of equipment and accessories for emergency telephone and cable broadcasting system shall comply with the contract requirements, and the components shall be complete.

3 The signs on the emergency telephone extension shall comply with the current *Road Traffic Signs and Markings* (GB5768).

4 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

9.3.2 The measurement items of emergency telephone and cable broadcasting system shall comply with Table 9.3.2.

**Table 9.3.2 Measurement Items of Emergency Telephone and Cable Broadcasting System**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Ground connection	Ground wire of chassis shall be connected firmly to the tunnel ground busbar	Visual inspection
2	Common ground resistance in tunnel	$\leq 1\Omega$	By ground resistance tester
3	Height of microphone from base platform	Meet design requirements	By measuring tape
4	Extension volume	$\geq 90\text{dB (A)}$	Press the "0" button continuously for 10s on the duty extension of console, and measure with sound level meter at 400mm in front of loudspeaker.
5	Extension voice quality	Clear voice, no obvious broken word	Subjective evaluation
6	Call response performance	Sensitive response	Operation inspection
7	Push-button prompt	The information of push-button prompt is simple and easy to understand	Visual measure
8	Noise suppression	There shall be no buzzing, rustling, ringing, whistling, and other noises on phone calling, radio broadcasting and static time.	Subjective evaluation
9	Call function	Press the calling button to call the console host	Function verification
10	Address code display function	Console can display the location information of call.	Function verification
11	Ring response	Console will ring in response when calling.	Function verification
12	Voice Prompt Function	After the calling, the phone has a waiting signal or prompt tone.	Function verification
13	Recording function	The console can record	Function verification

		automatically	
14	Failure reporting function	The center can automatically display the failure information immediately.	Function verification
15	Calling cancel function	Calling can be cancelled by console.	Function verification
16	Report generation and printing functions	The system can automatically generate events, failures, duty reports and possess the function of querying and printing.	Function verification
17	Timing self-check function	The system can automatically detect the working status of the circuit connection, battery and equipment according to the set cycle	Function verification
18	Manual self-check function	The system can manually set up real-time working status detection of circuit connection, battery and equipment.	Function verification
19	Power-up self-reset function	The system can automatically restore the working status after power-up.	Function verification
20	Height of broadcast loudspeaker	Meet design requirements	By measuring tape
21	Broadcast volume	$\geq 110\text{dB (A)}$	Measure the volume with sound level meter 1m in front of the loudspeaker
22	Broadcast sound quality	When the ambient noise $\leq 90\text{ dB}$ , the voice is clear and the broadcast contents can be heard clearly in the tunnel	Subjective evaluation
23	Broadcasting section switching function	With the function of multi-channel switching and broadcast selecting, it can broadcast in single-broadcasting section or multi-broadcasting section.	Function verification
24	Broadcast program source selection function	The monitor can broadcast in real time or play recorded programs	Function verification
25	Volume control function	The volume of the broadcast can be adjusted.	Function verification
26	Circular broadcasting function	The specified program source can be played circularly	Function verification

**9.3.3** The appearance of emergency telephone and cable broadcasting systems shall comply with the following requirements:

1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## 9.4 Environmental Detection Equipment

9.4.1 Environmental detection equipment shall meet the following basic requirements:

- 1 Environmental detection equipment shall comply with the current *Tunnel Environment Detection Equipment* (GB /T 26944) and other relevant standards.
- 2 Model, specification and quantity of environmental detection equipment and accessories shall conform to the contract requirements, and the components shall be complete.
- 3 The environmental detection equipment and its sensors shall be installed in the correct position and meet the design requirements.
- 4 After the installation and commissioning of all the equipment, the environmental detection equipment shall be maintained in proper working condition.

9.4.2 The measurement items of environmental detection equipment shall comply with Table 9.4.2.

**Table 9.4.2 Measurement Items of Environmental Detection Equipment**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Ground connection of control box	Ground wire of box shall be firmly connected to the tunnel ground busbar	Visual inspection
2	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester
3	3.1 Measurement error of CO sensor	$\pm 1$ ppm or meets design requirements	Compare with CO concentration gauge or access to relevant information
	3.2 Measurement error of smoke sensor	$\pm 0.0002$ m <sup>-1</sup> or meet design requirements	Compare with visibility gauge or access to relevant information
	3.3 Measurement error of illuminance sensor	$\pm 2\%$ or meet design requirements	Compare with illuminometer or access to relevant information

	3.4 Measurement error of wind speed sensor	±0.2 m/s or meet design requirements	Compare with anemometer or access to relevant information
	3.5 Measurement error of wind direction sensor	Positive and reverse direction correct or meet design requirements	Compare with standard azimuth dial or access to relevant information
4	Data collection function	With the function of collecting data of CO, smoke, illumination, wind speed and wind direction	Function verification
5	Data uploading cycle	Meet design requirements	Operation inspection
6	Linkage function with fan, lighting and other equipments.	Meet design requirements	Function verification

**9.4.3** Appearance of environmental detection equipment shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## **9.5 Manual Fire Alarm System**

**9.5.1** Manual fire alarm system shall meet the following basic requirements:

- 1 Model, specification and quantity of manual fire alarm system equipment and accessories shall meet the contract requirements, and the components shall be complete.

- 2 Manual fire alarm system equipment shall be installed in the correct position and meet the design requirements.

- 3 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**9.5.2** The measurement items of the manual fire alarm system shall conform to Table 9.5.2.

**Table 9.5.2 Measurement Items of Manual Fire Alarm System**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Ground connection of fire alarm host	Ground wire of host chassis shall be firmly connected to the tunnel ground busbar	Visual inspection
2	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester
3	Alarm volume of tunnel management station	90~120 dB (A) or meet design requirements	By sound level gauge
4	Alarm signal output	Transmit alarm location information to tunnel management station	Operation inspection
5	Linkage function between alarm button and alarm	Trigger the alarm after press the alarm button	Function verification

**9.5.3** The appearance of the manual fire alarm system shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## **9.6 Automatic Fire Alarm System**

**9.6.1** The automatic fire alarm system shall meet the following basic requirements:

- 1 Fire detectors, fire alarms and other equipment shall comply with relevant national or industry standards.
- 2 Model, specification and quantity of automatic fire alarm system equipment and accessories shall meet the contract requirements, and the components shall be complete.
- 3 Equipment of automatic fire alarm system shall be installed in the correct position and meet the design requirements.
- 4 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

9.6.2 The measurement items of the automatic fire alarm system shall comply with Table 9.6.2.

**Table 9.6.2 Measurement Items of Automatic Fire Alarm System**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Ground connection of fire alarm host	Ground wire of host chassis shall be firmly connected to the tunnel ground busbar	Visual inspection
2	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester
3	Automatic alarm response time of fire detector	$\leq 60s$	Operation inspection (fire basin method)
4	Sensitivity of fire detector	Reliable fire detection without missing report. Transmit detection data to the fire controller and upper computer	Operation inspection
5	Malfunction alarm function	The upstream computer can alarm if there is a circuit break on fire detector and communication link, or an outage of the fire alarm main host	Function verification

9.6.3 The appearance of the automatic fire alarm system shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## 9.7 Electro-optic Sign

9.7.1 The electro-optic sign shall meet the following basic requirements:

- 1 Model, specification and quantity of electro-optic sign equipment and accessories shall conform to the contract requirements, and the components shall be complete.
- 2 The electro-optic sign equipment shall be installed in correct position and meet the design requirements.

3 After the installation and commissioning of all the equipment, the electro-optic sign shall be maintained in proper working condition.

9.7.2 The measurement items of the electro-optic sign shall comply with Table 9.7.2.

**Table 9.7.2 Measurement Items of Electro-optic Sign**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Ground connection of control box	Ground wire of box shall be firmly connected to the tunnel ground busbar.	Visual inspection
2	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester
3	Brightness of electro-optic sign	5~300 cd/m <sup>2</sup> for evacuation sign, and 150~300 cd/m <sup>2</sup> for the white part of other electro-optic sign	By luminometer

9.7.3 The appearance of the electro-optic sign shall comply with the following requirements:

1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## 9.8 Luminous Guiding Facility

9.8.1 Luminescence guiding facilities shall meet the following basic requirements:

1 The luminescence guiding facilities shall comply with the current *Highway Tunnel Luminescence Guiding Facilities* (JT/T820) and other relevant standards.

2 Model, specification and quantity of the equipment and accessories for the luminescence guiding facilities shall conform to the contract requirements, and the components shall be complete.

3 The equipment of luminescence guiding facilities shall be installed in correct position and meet the design requirements.



4 After the installation and commissioning of all the equipment, the luminescence guiding facilities shall be maintained in proper working condition.

**9.8.2** The measurement items of the luminescence guiding facility shall comply with Table 9.8.2.

**Table 9.8.2 Measurement Items of Luminescence Guiding Facilities**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Insulation resistance	Strong current terminal to the case $\geq 50 \text{ M}\Omega$	By 500V megohmmeter
2	Ground connection of controller case	Ground wire of case shall be firmly connected to the tunnel ground busbar.	Visual inspection
3	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester
4	Control function	Manually control the start-up and stop of guiding facilities	Function verification

**9.8.3** The appearance of the luminescence guiding facility shall comply with the following requirements:

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## **9.9 Changeable Signs**

**9.9.1** The inspection and evaluation of sub-division work of changeable signs shall be carried out in accordance with article 4.4 of this Standard.

## **9.10 Tunnel Video Traffic Incident Detection System**

**9.10.1** The tunnel video traffic incident detection system shall meet the following basic requirements:

- 1 The equipment of the tunnel video traffic incident detection system shall conform to the current *Video Traffic Incident Detector* (GB /T 28789) and other relevant standards.

2 Model, specification and quantity of the equipment and accessories of tunnel video traffic incident detection system shall conform to the contract requirements, and the components shall be complete.

3 Equipment rack and case rack shall be well grounded.

4 After the installation and commissioning of all the equipment, the system shall be maintained in proper working condition.

**9.10.2** The measurement items of the tunnel video traffic incident detection system shall be in accordance with Table 9.10.2.

**Table 9.10.2 Measurement Items of Video Traffic Incident Detection System of Tunnel**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Ground of center equipment	Ground wire of protective ground and lightning protection ground shall be firmly connected to the ground busbar.	Visual inspection. if necessary, measured by ground resistance tester.
2	Incident detection rate	Meet design requirements; or $\geq 90\%$ under normal opening conditions of tunnel lighting facilities if there is no requirements	Measured by field incident simulation or playback of standard incident source video.
3	Typical incident detecting function	The system can automatically detect the incidents including traffic stop, counterflow driving, pedestrian, objects abandoning and smoke, and output corresponding reports and prompt alarming messages.	Function verification
4	Automatic video recording function	The system automatically captures and stores images of traffic incidents and can set the recording time as required	Function verification
5	Self-diagnosis and alarm function	The system can self-diagnose, record and alarm in case of the video signal loss, equipment failure and the network communication breakdowns.	Function verification
6	Clock synchronization function	Synchronize with main clock of monitoring system or communication system	Compare with the main clock

**9.10.3** The appearance of the tunnel video traffic incident detection system shall comply with the following requirements:

1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## 9.11 Jet Fan

9.11.1 Jet fan shall meet the following basic requirements.

- 1 Model, specification and quantity of the equipment and accessories of the jet fan shall conform to the contract requirements, and the components shall be complete.
- 2 The structural dimensions, embedded parts, installation position and installation spacings of the mounting support of the jet fan shall conform to the design requirements, and the inspection report of the tensile drawing capacity of the embedded parts of the fan shall be attached.
- 3 Jet fan shall be installed firmly, and the fan shield shall be intact.
- 4 After the installation and commissioning of all the equipment, the jet fan shall be maintained in proper working condition.

9.11.2 The measurement items of jet fan shall conform to Table 9.11.2.

**Table 9.11.2 Measurement Items of Jet Fan**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Clearance height	Meet design requirements	By theodolite
2	anticorrosive coating thickness of control box	Meet design requirements, or comply with the current GB/T 18226 if no requirements.	By coating thickness gauge
3	Insulation resistance	Strong current terminal to the case $\geq 50 \text{ M}\Omega$	By 500V megohmmeter
4	ground connection of control case	Ground wires of case shall be firmly connected to the tunnel ground busbar.	Visual inspection
5	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester

6	Average wind speed of tunnel section during fan operation	Meet design requirements	By anemometer
7	Tunnel noise at full speed running of fan	Meet design requirements	By sound level meter
8	Responding time	From sending the control command to starting the fan to drive the impeller to rotate, the time is $\leq 5s$ , or meet the design requirements.	By stopwatch
9	Direction controllability	Change air flow direction through controlling the fans manually or automatically.	Operation inspection
10	Mode of operation	Fan has manual and automatic operation modes.	Operation inspection
11	Remote control mode	Under automatic operation mode, the starting, stop and air flow direction of fans are controlled by receiving information from local controller or tunnel management station through standard serial port.	Operation inspection

**9.11.3** The appearance of the jet fan shall comply with the following requirements.

1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## **9.12 Axial Flow Fan**

**9.12.1** Axial flow fans shall meet the following basic requirements.

1 Model, specification and quantity of axial fan equipment and accessories shall be in accordance with the contract requirements, and the components shall be complete.

2 Axial fan shall be installed firmly with the correct position.

3 After the installation and commissioning of all the equipment, the axial flow fan shall be maintained in proper working condition.

9.12.2 The measurement items of axial flow fan shall conform to Table 9.12.2.

**Table 9.12.2 Measurement Items of Axial Flow Fan**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Anticorrosive coating thickness of control box	Meet design requirements, or comply with the current GB/T 18226 if no requirements.	By coating thickness gauge
2	Insulation resistance	Strong current terminal to the case $\geq 50 \text{ M}\Omega$	By 500V megohmmeter
3	Ground connection of control case	Ground wires of case are firmly connected to the tunnel ground busbar.	Visual inspection
4	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester
5	Average wind speed of tunnel section during fan operation	Meet design requirements	By anemometer
6	Environmental noise in fan room	Meet design requirements	By sound level meter
7	Responding time	From sending the control command to starting the fan to drive the impeller to rotate, the time shall be $\leq 5\text{s}$ , or meet the design requirements.	By stopwatch
8	Wind valve opening and closing function	Meet design requirements	Operation inspection
9	Mode of operation	Fan has manual and automatic operation modes.	Operation inspection
10	Remote control mode	Under automatic operation mode, the starting, stop and air flow direction of fans are controlled by receiving information from local controller or tunnel management station through standard serial port.	Operation inspection
11	Wind speed adjustment function	Receive the manual and automatic control signals to adjust ventilation	Function verification
12	Blade angle adjustment and control function	When the fan is static, the blade angle shall be adjustable and controllable, showing its actual angle.	Function verification
13	Air duct opening and closing function	The air duct shall be provided with switch device to fully open and close the duct.	Function verification

9.12.3 The appearance of axial flow fan shall comply with the following requirements.

1 There shall be no unacceptable defects listed in Appendix C to this Standard.

## 9.13 Lighting Facilities

9.13.1 Lighting facilities shall meet the following basic requirements.

1 Model, specification and quantity of lighting equipment and accessories shall conform to the contract requirements, and the components shall be complete.

2 The structural dimensions, embedded parts, installation position and installation spacing of the mounting bracket for lighting luminaires shall conform to the design requirements.

3 After the installation and commissioning of all the equipment, the lighting facilities shall be maintained in proper working condition.

9.13.2 Measurement items of lighting facilities shall be in accordance with Table 9.13.2.

**Table 9.13.2 Measurement Items of Lighting Facilities**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Insulation resistance	Strong current terminal to case $\geq 50$ M $\Omega$	By 500V megohmmeter
2	Ground connection of control case	Ground wires of case are firmly connected to the tunnel ground busbar.	Visual inspection
3	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance tester
4	Average brightness of pavement (entrance, transition, intermediate section, exit)	Meet design requirements	By luminometer
5	Average brightness of emergency parking strip	Meet design requirements	By luminometer

6	Color rendering index of emergency parking strip	Meet design requirements, or $\geq 80$ in case of no requirement	By spectral radiometer
7	Total brightness uniformity of pavement	Meet design requirements, or $\geq 0.3$ in case of no requirement	By luminometer
8	Longitudinal brightness uniformity of road	Meet design requirements, or $\geq 0.5$ in case of no requirement	By luminometer
9	Correlated color temperature of lighting	Meet design requirements, or $\leq 6500\text{K}$ in case of no requirement	By spectral radiometer
10	Lighting color rendering index at 50% (20%) reduction of basic lighting	$\geq 65$	By spectral radiometer
11	Brightness ratio between pavement and wall	The average brightness of the left and right sides wall of the pavement within 2 m height $\geq 60\%$ of the pavement average brightness	By luminometer
12	Luminaires turn on/off adjustable	The starting time and interval of each lighting circuit group are adjustable	Operation inspection
13	Lighting control mode	It has two control modes of automatic and manual, or meet design requirements.	Operation inspection
14	Emergency lighting	The emergency lighting can be turned on automatically when the main power supply circuit is cut off.	Operation inspection
15	Dimming function of lighting luminaires	For tunnel using LED and electrodeless fluorescent lamps, functions of manually or automatically adjusting the luminous brightness of lamps shall be provided.	Function verification

**9.13.3** The appearance of lighting facilities shall comply with the following requirements.

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.
- 2 Lighting luminaires shall be installed firmly with correct position. Lighting contour alignment shall be artistic and be harmonious with tunnel.

## 9.14 Firefighting Facilities

**9.14.1** Firefighting facilities shall meet the following basic requirements.

1 Fire alarm controllers, fire hydrants, fire extinguishers, pressurizing facilities, water supply facilities and special connection cables, pipes, accessories and other equipment for firefighting facilities shall comply with the relevant national or industry standards.

2 Model, specification and quantity of equipment and accessories for firefighting facilities shall be in accordance with the contract requirements, and the components shall be complete.

3 Installation supports, embedded anchors, embedded pipelines, installation holes in tunnels and installation spacing of firefighting facilities shall meet the design requirements.

4 The protective measures of cable and pipeline shall meet the design requirements.

5 All equipment shall be installed in place with correct position, and shall not intrude into the highway clearance profile.

6 After the installation and commissioning of all the equipment, the firefighting facilities shall be maintained in proper working condition.

**9.14.2** The measurement items of firefighting facilities shall comply with Table 9.14.2.

**Table 9.14.2 Measurement Items of Firefighting Facilities**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Air pressure of pressurizing facilities	Meet design requirements	By barometer data
2	Water pressure of water supply facilities	Meet design requirements	By water pressure gauge
3	Effective capacity of fire water tank	Meet design requirements	By measuring tape
4	Water level display function of fire water tank	A local water level display device shall be provided and the water level information can be transmitted to the computer system of the tunnel management station.	Function verification



5	Function of fire hydrant	Reach the specified flow rate within specified time after opening valve	Function verification
6	Function of aqueous film forming foam fire extinguishing device	Meet design requirements	Function verification
7	Function of electric heat tracing	Meet design requirements	Function verification
8	Function of fireproof door in pedestrian crosswalk	Normally, the fireproof door is closed and the opening direction is the evacuation direction. It can be opened on both sides of the door, and has an automatic closing function.	Function verification
9	The function of fireproof rolling shutter in vehicle cross passage	The rolling curtain can be opened and closed on site and remotely, of which the opening or closing status could be monitored by the tunnel management station.	Function verification
10	Linkage function between fire detector and automatic fire extinguishing facility	Meet design requirements	Function verification, or verification of construction records and historical records

**9.14.3** The appearance of firefighting facilities shall comply with the following requirements.

- 1 There shall be no unacceptable defects listed in Appendix C to this Standard.
- 2 Fire water tanks shall be filled with water in place, and the pipeline is unblocked. The anti-corrosion treatment of pipeline and accessories is qualified.

## **9.15 Local Controller**

**9.15.1** The local controller shall meet the following basic requirements.

- 1 Model, specification and quantity of local controller equipment and accessories shall conform to the contract requirements, and the components shall be complete.
- 2 The local controller shall be installed in correct position without intruding the highway clearance profile.

3 The protection measures of visible laying cable shall conform to the design requirements.

4 The connection of the local controller to the control center and the downstream equipment of the tunnel shall conform to the design requirements. Cables shall be arranged in order without cross twisting, and the identifications shall be complete and clear.

5 After the installation and commissioning of all the equipment, the local controller shall be maintained in proper working condition.

**9.15.2** The measurement items of the local controller shall comply with Table 9.15.2.

**Table 9.15.2 Measurement items of the Local Controller**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Levelness and verticality of installation	Horizontal: $\pm 3\text{mm/m}$ Vertical: $\pm 3\text{mm/m}$	By verticality meter
2	Anti-corrosion coating thickness of case	Meet the design requirements, or in accordance with the current GB/T18226 in case of no requirement.	By coating thickness gauge
3	Insulation resistance	Strong current terminal to the case $\geq 50\text{M}\Omega$	By 500V megohmmeter
4	Ground connection of case	The ground wire of case is firmly connected to the ground busbar of tunnel	Visual inspection
5	Common ground resistance of tunnel	$\leq 1\Omega$	By ground resistance meter
6	IP network throughput	Meet design requirements, or comply with the current GB/T 21671 if no requirements.	By IP network performance analyzer
7	IP network delay	Meet design requirements, or comply with the current GB/T 21671 if no requirements.	By IP network performance analyzer
8	IP network packet loss rate	Meet design requirements, or comply with the current GB/T 21671 if no requirements	By IP network performance analyzer
9	Communication function with computer	It can communicate with the computer of tunnel management station	Function verification
10	Control function of downstream device within	According to the design cycle or controlled by the tunnel management	Function verification

	the jurisdiction area	station, the data of each downstream device are collected and processed.	
11	Local control function	In case of management computer or communication link failures, all downstream devices shall be controlled and returned to work normally.	Function verification
12	Restore function in case of electricity black-out	Upon power on or system rebooting, the original preset control programme can be automatically operated.	Function verification

**9.15.3** The appearance of the local controller shall comply with the following requirements.

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.

## **9.16 Equipment and Software of Tunnel Management Station**

**9.16.1** The equipment and software of tunnel management station shall meet the following basic requirements.

Model, specification and quantity of all equipment and accessories shall meet the contract requirements, and the components shall be complete.

- 2 Upon the installation and commissioning, the auxiliary facilities such as lightning protection, plumbing, power supply and fire fighting in the tunnel management station shall be maintained in proper working condition.

- 3 The computer room of the tunnel management station shall be clean and tidy with good ventilation, lighting and environmental temperature and humidity conditions.

- 4 Upon the installation and commissioning, all the equipment and software of the tunnel management station shall be maintained in proper working condition.

- 5 The tunnel management station software includes system software and application software, of which the system software shall be legally authorized and

a formal authorization certificate shall be submitted, and the application software shall bear software development and test documents.

**9.16.2** The measurement items of tunnel management station equipment and software shall comply with Table 9.16.2.

**Table 9.16.2 Measurement Items of Tunnel Management Station Equipment and Software**

Item No.	Inspection items	Technical requirements	Inspection methods
1	Insulation resistance	Strong current terminal to the case $\geq 50$ M $\Omega$	By 500V megohmmeter
2	Reliability of installation and connection of system equipment	The installation and connection of system equipment shall be reliable. After vibration test, the system has no alarm or wrong action.	Observe the vibration condition (striking properly with a rubber hammer) for 15 minutes
3	Ground connection	Ground wire of protective ground and lightning protection ground shall be firmly connected to the ground busbar.	Visual inspection, or measured by ground resistance tester if necessary.
4	Common ground resistance	$\leq 1\Omega$	By ground resistance tester
5	Communication function with the local controller	Be able to communicate with local controller normally	Function verification
6	Communication function with computer of monitoring center	Accurate data transmission	Function verification
7	Server function	Complete network management, data backup, resource sharing and other functions required by design	Function verification
8	Function of central management computer	Coordinate and manage other computers according to design requirements	Function verification
9	Function of traffic control computer	Receive the information from the downstream vehicle detector and execute the control plan set by the design	Function verification
10	Function of ventilation and lighting computer	Receive the information from the downstream environmental detection equipment, and execute the control plan set by the design	Function verification

11	Function of alarm control computer	Receive the information from the downstream fire alarm controller, and execute the control plan set by the design.	Function verification
12	Function of image control computer	It can switch and control CCTV images and display them on the large screen	Function verification
13	Function of emergency telephone console	Able to respond to calling from the extension	Function verification
14	Statistics management and printing function of report	Tunnel management station computer system can quickly and correctly query, count, print various reports	Function verification
15	Tunnel contingency plan	Meet design requirements	Operation inspection

**9.16.3** The appearance of the tunnel management station equipment and software shall comply with the following requirements.

- 1 There shall be no unacceptable defects listed in Appendix C of this Standard.
- 2 The console, seats and equipment in the management station shall be neat and orderly, and the identification shall be correct and clear.

## **9.17 Computer Network of Tunnel Management Station**

**9.17.1** The inspection and evaluation of sub-division work of the computer network of the tunnel management station shall be carried out in accordance with Section 4.9 of this Standard.

## **9.18 Power Supply and Distribution Facilities**

**9.18.1** The inspection and evaluation of sub-division work of power supply and distribution facilities shall be conducted in accordance with Chapter 7 of this Standard.

# Appendix A

## Work Classification of Electrical and Mechanical Works

**A.0.1** Table A.0.1 shows the hierarchical structure and sampling unit of highway electrical and mechanical works. During inspection and evaluation, the whole project shall be sampled and measured according to this table.

**Table A.0.1 Work Classification of Electrical and Mechanical Works**

Types of Work	Division of Work	Subdivision of Work	Sampling Unit	Remark
Electrical and mechanical works	Monitoring facilities	4.1 Vehicle detector	Control box	
		4.2 Weather detector	Control box	
		4.3 Closed circuit television (CCTV) monitoring system	Take the camera as the sampling unit for field equipment, and take the center (sub-center) as the sampling unit for indoor equipment.	
		4.4 Changeable signs	Field equipment	
		4.5 Road video traffic incident detection system	Central Processing Unit board	
		4.6 Traffic survey facilities	Control box	
		4.7 Monitoring center (sub-center) equipment and software	Monitoring center (sub-center)	
		4.8 Large screen display system	A full screen	
		4.9 Computer network of monitoring system	Take the center as the sampling unit for network performance, and take each cable as the sampling unit for network cable performance.	

Communication facilities	5.1 Communication conduit works	The sampling unit is 1000m, and, and take each hole as sampling unit for manhole (hand hole).	
	5.2 Communication optical fiber cable and electric cable works	Relay section	All relay sections shall be inspected for acceptance quality inspection. 10% of the total number of fibers with no less than 3 measuring points shall be inspected for each relay section.
	Synchronous Digital System (SDH) optical fiber transmission system	ADM, OLT, ONU of communication terminal and center	
	5.4 IP network system	Communication center and station	
	5.5 Wavelength division multiplexing (WDM) fiber transmission system	Communication center and station	
	5.6 PSTN system	Communication center	
	5.7 Communication power system	Communication center and station	

Table A.0.1 (Continued)

Types of Work	Division of Work	Sub-division of Work	Sampling Unit	Remark
Electrical and mechanical works	6 Toll collection facility	6.1 Equipment and software of ETC/MTC entrance lane	Toll lane	
		6.2 Equipment and software of ETC/MTC exit lane	Toll lane	
		6.3 Equipment and software of ETC (Electronic Toll Collection) lane	Toll lane	
		6.4 ETC gantry system	ETC gantry	
		6.5 Toll station equipment and software	Toll station	50% shall be inspected during the acceptance quality inspection, with a minimum of 3 measuring points.

		6.6 Toll sub-center equipment and software	Toll sub-center	All to be inspected	
		6.7 Networked toll management center (Toll center) equipment and software	Toll center		
		6.8 IC card issuing and coding system	Toll center	All to be inspected	
		6.9 Wired intercom and emergency alarm system	Toll station		
		6.10 Transfinite detection system	Lane		
		6.11 Closed-circuit television (CCTV) monitoring system	Take the camera as the sampling unit for field equipment, and take the station as the sampling unit for indoor equipment.		
		6.12 Optical fiber cable and electric cable within toll station area	Relay section	All relay sections shall be inspected for acceptance quality inspection. 10% of the total number of fibers with no less than 3 measuring points shall be inspected for each relay section.	
		6.13 Computer network for toll system	Take the center (station) as the sampling unit for network performance, and take each cable as the sampling unit for network cable performance.		
		7 Power supply and distribution facilities	7.1 Medium-voltage distribution equipment	Switchyard	
			7.2 Power cable for medium-voltage equipment	Distribution box	
	7.3 Low voltage distribution equipment in the center (station)		Switchyard		
	7.4 Power cable for low-voltage equipment		$\pi$ connecting box		



		7.5 Wind/solar power supply system	Control box		
		7.6 Electric vehicle charging system	Charging pile		
		7.7 Power monitoring system	Monitoring center		
	8 Lighting facility		8.1 Road lighting facility	For luminaire, take the lamppost as the sampling unit; for the luminance index, take the distance between two lampposts as the unit measuring point.	
			8.2 Toll plaza lighting facility	Toll plaza	
			8.3 Service area lighting facility	Service area	
			8.4 Toll-gate ceiling lighting facility	Toll lane	

Table A.0.1 (Continued)

Types of Work	Division of Work	Sub-division of Work	Sampling Unit	Remark
Electrical and mechanical works	9 Electrical and mechanical facility for highway tunnel	9.1 Vehicle detector	Same as 4.1	
		9.2 Closed-circuit television (CCTV) monitoring system	Same as 4.3	
		9.3 Emergency telephone and cable broadcasting system	Extension telephone in field	
		9.4 Environmental detection equipment	Control box	
		9.5 Manual fire alarm system	alarm button	
		9.6 Automatic fire alarm system	Alarm host	
		9.7 neon and electric signs	Light box	
		9.8 Luminescent guiding facilities	Control box	
		9.9 Changeable signs	Field equipment	
		9.10 Tunnel video traffic incident detection system	Processor board of tunnel management station	
		9.11 Jet fan	A set of fans	
		9.12 Axial flow fan	Blower fan, exhaust fan	

		9.13 Lighting facility	The brightness of entrance section, transition section and exit section shall be measured in one measurement area for each section. Each 100m section shall be taken as the brightness sampling unit for middle section, and the control box is sampled by each one.	
		9.14 Firefighting device	Field equipment	
		9.15 Local controller	Field equipment	
		9.16 Equipment and software of tunnel management station	Management station	
		9.17 Computer network of tunnel management station	Take the station as the sampling unit for network performance, and take each cable as the sampling unit for network cable performance.	
		9.18 Power supply and distribution facility	Same as 7	

# Appendix B Project Quality Inspection and Evaluation Form

## Appendix B-1 Quality Inspection and Evaluation Form of Sub-division Work

Name of sub-division work:

Name of division work:

Serial number of sub-division work:

Project location:

Types of work:

Name of project (package number):

Contractor:

Item No.	Basic requirements	Inspection items	Specified value or tolerance	Measurement value or measurement deviation										Quality evaluation				
				1	2	3	4	5	6	7	8	9	10	Average value, representative value	Percentage of pass (%)	Qualification criteria		
Appearance quality																		
Project quality evaluation level																		
Quality assurance documents																		

Inspection director:

Inspected by:

Recorded by:

Confirmed by:

Date:

**Appendix B-2 Quality Inspection and Evaluation Form for Division of Work**

Name of division of work:

Serial number of division of work:

Types of work:

Project location:

Name of project (package number):

Contractor:

Sub-division of work			Remarks
Serial number	Name	Quality level	
Appearance quality			
Evaluation documents			
Quality level			
Evaluation Conclusion			

Inspection director:

Recorded by:

Confirmed by:

Date:

**Appendix B-3 Quality Inspection and Evaluation Form for Type of Work**

Name of types of work:                      Serial number of types of work:

Project location and stake number:

Name of project (package number):

Contractor:

Type of works			Remarks
Serial number	Name	Quality level	
Appearance quality			
Evaluation documents			
Quality level			
Evaluation conclusions			

Inspection director:                      Recorded by:                      Confirmed by:                      Date:

# Appendix C

## Visual Appearance Quality Unacceptable Defects for Electrical and Mechanical works

C.0.1 Unacceptable defects of appearance of mechanical and electrical works shall be determined by Table C.0.1.

**Table C.0.1 Unacceptable Defects of Appearance of Electrical and Mechanical works**

Item No.	Name	Limitation Defects
1	Foundation of field equipment	For honeycomb, pockmark, crack and other defects on the surface, the defect area exceeds 1% of the surface area or the depth exceeds 10 mm. For the damaged edges and broken corners, the length exceeds 20mm. For the corrosion, bare metal matrix is larger than 1cm <sup>2</sup> .
2	External connection wire of field chassis enclosure	The metal chassis is not connected to the ground wire, and the junction between the inlet and outlet pipes and the chassis is not sealed.
3	Surface of chassis and column	For defects of coating peeling or surface rust, the single area is larger than 1cm <sup>2</sup> or total area larger than 5cm <sup>2</sup> . The single scratch length is greater than 5cm or total scratch length greater than 10cm.
4	Inside the chassis	Components are not fixed or fixed insecurely; cables are not marked properly. No permanent wiring diagram; sundries and waterlogging in the chassis.
5	Indoor and outdoor equipment and wiring	There are sundry things in the chassis, the light and power cables are not arranged neatly; the binding is not firm; the inlet and outlet pipes are not plugged or identified; the power wires and signal wires are not separated and not protected.

# Appendix D

## Inspection and Evaluation of Communication Conduit Commissioning

D.0.1 Hole trial-through inspection for communication conduit works shall comply with the following provisions.

1 Hole trial-through of the straight-line conduit shall be carried out with a pulling rod 5 mm smaller than the nominal diameter of the test pipe, and 900 mm longer than the length of the test pipe. For steel pipe and other communication conduit group with single holes, one spot check shall be conducted from every five holes. If the number of holes is less than 5, it shall be taken as 5.

2 For the conduit curvature radius less than 36 m, the trial-through shall be carried out with a pulling rod 6 mm smaller than the nominal diameter of test pipe, and 900 mm longer than the length of test conduit. One spot shall be inspected every five holes. If the number of holes is less than 5, it shall be taken as 5.

3 The inspection method for the hole trial-through of the encapsulation conduit shall be performed as per the instructions in the first and second paragraphs above.

D.0.2 Evaluation of hole trial-through for communication conduit works shall conform to the following provisions.

1 Hole trial-through shall be deemed as qualified upon the condition that all conduit trial tests pass the provisions of Article D.0.1 of this Standard, or, the number of standard pulling rod that cannot pass is less than 5% of the total trials but can pass the pulling rod with diameter of 1 mm smaller than that of the standard pulling rod.

2 Other results are deemed as unqualified, and shall be repaired to qualified by the Contractor prior to the next inspection and evaluation.

# Wording Explanation for the Standards

1 The strictness in execution of the *Standards* is expressed by using the wording as follows:

- 1) MUST—A very restrict requirement in any circumstances.
- 2) SHALL—A mandatory requirement in normal circumstances.
- 3) SHOULD—An advisory requirement.
- 4) MAY—A permissive condition. No requirement is intended.

2 Expressions used for reference to standards are explained as follows:

- 1) The standards for which a year is added to the standard number shall be the specific versions to be used. Otherwise they shall be the latest available versions.

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## Background to Provisions

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# 1 General Provisions

This chapter is formulated by referring to Chapter 1 of *Standards for Quality Inspection and Verification of Highways, Part 1 Civil Engineering Works* (JTG F80/1-2017) and in combination with the characteristics of highway electrical and mechanical works. The supplementary explanation is as follows.

**1.0.3** In accordance with the principle of self-inspection by the Contractor, spot checks by the Supervisor and supervision by the Client, the frequency of spot check for subdivision work of highway mechanical and electrical works shall be conducted as follows: percentage of self-inspection by the Contractor shall be 100%; percentage of sampling inspection by the Supervisor shall not be less than 30%; percentage of handing-over quality inspection by governmental agency shall not be less than 30%; percentage of completion quality inspection shall not be less than 10%. All inspections shall be rounded up according to the principle of strictness. When the number of measuring points is 4 ~ 10, 3 spot inspections shall be conducted while all points shall be checked if the number of measuring points is less than 3.

# 3 Basic Requirements

This chapter is formulated by referring to Chapter 3 of *Standards for Quality Inspection and Verification of Highways, Part 1 Civil Engineering Works* (JTG F80/1-2017) and in combination with the characteristics of highway electrical and mechanical works. The supplementary explanation is as follows.

## 3.2 Quality inspection

**3.2.5** Highway electrical and mechanical works quality is decided by the quality control results of multiple steps including equipment transportation, storage, installation, commissioning, and other procedures. Meanwhile, the technical parameters and indexes of electrical and mechanical works are determined by systematic and coordinated operation of all relevant facilities. Thus the complexity, integrity, systematicness of electrical and mechanical works quality control are extraordinarily obvious and prominent. Compared to civil engineering, it is more imperative and essential to improve the qualification rate of inspection items of electrical and mechanical works. Therefore, in order to ensure the project quality, it is stipulated that the qualification rate of key items of highway electrical and mechanical works is 100%, and that of general items is not less than 90%.

**3.2.7** Quality assurance data are the true records reflecting the construction quality during the construction process. Accuracy and completeness of quality assurance data will directly impact the quality grade evaluation of the types of work as well as maintenance and reconstruction during project operation. The quality assurance data includes a lot of content. The content in this article is to record the information that affects the key points of the project quality, which should be paid more attention to in the quality assurance data verification. Besides the records of abnormal conditions encountered in the construction, other relevant industries inspection and acceptance documents shall also be available according to the actual situation of the project, such as the fire inspection and acceptance

opinion of tunnel and building construction, inspection report of anti-pulling ability of embedded parts of tunnel fans, and calibration certificate of toll weighbridge, etc.

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# 4 Monitoring Facilities

## 4.1 Vehicle detector

For the error calculation of speed and traffic flow, the index of relative error is adopted in this standard, as shown in formula (4-1).

$$\text{relative error} = \frac{|X - X_0|}{X_0} \times 100\% \quad (4-1)$$

In the formula:

$X$  — Indication value of the tested equipment, such as speed or traffic flow;

$X_0$  — Indication value of manual or higher level detection equipment, such as the speed measured by a radar gun or the traffic flow counted manually.

When measuring the vehicle speed error, one vehicle is used as a sample, and the relative error between the radar gun measurement value and the detector measurement value of the instantaneous speed of each vehicle is calculated according to formula (4-1). After measuring the specified sample size, take the average of all samples, instead of adding up the detection speeds of all the vehicles under test and subtracting the average speed detected by the radar gun.

## 4.2 Meteorological detector

According to the meteorological detecting elements (temperature, humidity, visibility, wind speed, precipitation, dry, wet, logged water, accumulated snow, icing and other road surface situation), meteorological detectors are divided into the single-element and multi-element meteorological detectors. Single-element meteorological detectors include the example of visibility detector, and multi-element meteorological detectors include those that can simultaneously detect temperature, humidity, wind speed and direction, and precipitation.

### 4.3 Closed circuit television (CCTV) monitoring system

This edition adds the technical requirements of high-definition digital television monitoring system. Meanwhile, channel transmission index refers to the current *Technical Requirements and Measurement Methods of Encoders and Decoders for the Standard Definition Digital Television* (GY/T 212), *Technical Requirements and Measurement Methods of Digital Cable Television Set Top Box for High Definition* (GY/T 241), *Technical Requirements and Measurement Methods of AVS+ HDTV Encoder* (GY/T 271) and other relevant standards.

### 4.4 Changeable signs

Changeable signs include traffic information devices such as changeable message signs, variable speed limit signs, LED lane control signs, traffic signal lights and other traffic information providing devices.

For the color coordinate (x,y) of the light emitting unit of the changeable signs, five colors of red, green, blue, white and yellow shall be measured according to the requirements of *Light-emitting Diode Changeable Message Signs of Expressway* (GB/T 23828-2009), namely, measuring red and yellow for changeable speed limit signs as required by *Light-emitting Diode Changeable Speed Limit Signs of Expressway* (GB 23826-2009), measuring red and green for LED lane control signs as required by *Specification for LED Lane Control Signs* (JT/T 597-2004), and measuring red, green, and yellow for traffic lights as required by *Road Traffic Signals* (GB 14887-2011).

### 4.5 Road video traffic incident detection system

The road video traffic incident detection system performs real-time analysis and processing on the video images collected by the closed-circuit television monitoring system, thereby automatically detecting traffic incidents that occur on the road and issuing alarm messages. The detection content and indicators in this section refer to the *Video Traffic Incident Detector* (GB/T 28789-2012), which mainly regulates the detection functions and detection rates of incidents such as stop, counterflow driving, pedestrian, and scattered objects.

#### **4.7 Monitoring center (sub-center) equipment and software**

The conditions of the monitoring room have enormous impact on the normal operation of equipment and software in the monitoring (sub) center. In addition to the impact on the equipment, it has psychological and physiological impact on the staff who are in charge of monitoring, such as temperature of too cold or hot will affect the person's work efficiency and decision-making ability. To include the environmental conditions of the monitoring room as motoring facilities inspection evaluation parameters is to remind the Client to pay full attention to this, and to provide a good working environment for monitoring equipment to make it stable and reliable.

#### **4.9 Computer network of monitoring system**

Referring to the relevant provisions of *Acceptance Test Specification for Local Area Network (LAN) Systems Based on Ethernet Technology* (GB/T 21671-2008), the Ethernet system performance requirements and the Ethernet link layer health inspection are added as inspection items, for which the LAN system is the inspection object.

# 5 Communication Facilities

## 5.1 Communication conduit works

This section is formulated by referring to *Code of Construction and Acceptance for Communication Conduit Engineering* (GB 50374-2006) and relevant standards, mainly includes inspection items such as conduit foundation, conduit laying, backfill tamping, manhole (hand hole), conduit burial, manhole (hand hole) position, bifurcation type and internal dimensions, communication conduit transverse position, hole trial-through of main pipeline, hole trial-through of silicon core plastic pipe, and pipe-hole plugging, etc. Some of these items are concealed works and are required to provide records during the acceptance and follow-up acceptance.

## 5.3 Synchronous Digital System (SDH) optical fiber transmission system

At present, the transmission performance of synchronous digital system (SDH) optical fiber transmission system is determined by error code, dither, drift and other technical indexes. According to the actual testing experience, as long as the error code performance meets the requirements, the jitter and drift performance will also generally meet the requirements. Therefore, inspection of the transmission quality of SDH mainly considers the error performance. In this Standard, 2M branch port is used to reflect the bit error index of the whole transmission system, and this principle shall be followed in the testing.

## 5.4 IP network system

The network system based on IP technology has been applied on a large scale at present. The IP network can be MSTP based on SDH, or based on WDM or ATM technology. No matter what kind of communication technology the IP network is based on, the service interface of IP network system is consistent, so the system shall also meet the relevant technical requirements of IP network. The principles for the selection of measurement items are as follows.



1 The measurement parameters shall reflect the actual operation of end-to-end transmission link characteristics.

2 The measurement parameters themselves can affect the high-level application, and users can perceive it.

3 The measurement parameters shall not rely on the specific network technology and topology.

4 The measuring of measurement parameters shall be repeatable, and the same results can be obtained by measuring multiple times under the same conditions.

5 The measurement results of measured parameters cannot represent differences for networks with the same technology, but it can show differences for networks with different technologies

6 The selection of measurement parameters shall be convenient for measuring on site.

According to the above principles, three types of measurement parameters of IP network system are selected, namely optical interface, network management and network performance.

### **5.5 Wavelength division multiplexing (WDM) fiber transmission system**

In recent years, the application of optical fiber transmission system based on WDM technology in highway communication facilities has been gradually in large extent, of which the typical system is optical transmission network (OTN). The core technology of WDM is optical wavelength division multiplexing, so the key items of optical WDM are included as measured items such as center wavelength, center frequency offset, Side Mode Suppression Ratio, insertion loss, and adjacent channel isolation, etc. According to the different service interfaces, if WDM carries SDH service, the service performance shall meet the relevant requirements of SDH transmission; if WDM carries IP service, the

service performance shall meet the relevant requirements of IP network system.

## **5.6 Public Service Telephone Network (PSTN)**

At present, fixed telephone switching network is usually based on two technologies of TDM and soft-switching with corresponding equipment types of digital programmed switching system and IP switching system. In 2014, Ministry of Information Industry merged and revised the original *Accepting Specification for PSTN Exchange Installation Engineering* (YD/T 5077-2005) and *Acceptance Specification for Fixed Softswitch Engineering* (YD/T 5154-2007) into *Accepting Specification for PSTN Installation Engineering* (YD/T 5077-2014). The original YD/T 5077-2005 is mainly applicable to the digital program-controlled exchange system based on TDM technology, while the original YD/T 5154-2007 is mainly applicable to the IP switching system based on soft-switching technology. No matter what kind of switching technology is used, the requirements for basic function, performance, reliability, malfunction rate, call completion rate and other indexes of the fixed-line telephone switching network are consistent. At the same time, some indexes of soft-switching system need to be further tested, such as network performance parameters of soft-switching system and the end-to-end quality of service for voice in soft-switching network.

End-to-end quality of service for voice in soft-switching network usually adopts the method of subjective scoring or objective evaluation. The subjective score refers to the MOS (Mean Opinion Score) method, which is convenient to implement on site. Generally, the average value is taken after scoring by no less than three testers. When objective evaluation is adopted, the voice quality evaluation function of IP voice telephone testing system is used to test the average value of PSQM or PESQ.

## **5.7 Communication power supply system**

Communication power supply system generally includes AC power supply system and DC power supply system. The communication load needs to be uninterrupted and non-transient, and the AC power supply system needs to be equipped with UPS power, and the DC power supply system needs to be equipped with storage batteries. The measurement items are respectively specified for DC output power supply system and AC input power supply system. Some inspection items are adjusted with reference to *High Frequency*

*Switch-mode Power Supply for Communications* (YD/T 1058-2015). The communication terminals are generally built with toll stations on the same location, sharing generator sets and uninterruptible power supply. Therefore, the relevant technical indexes are stipulated uniformly in power supply and distribution facilities.

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# 6 Toll Collection Facilities

## 6.1 Access lane equipment and software

Driven by the cancellation of provincial boundary toll stations of expressways in China, the previous manual lane of toll stations has been transformed into the mixed-lane with ETC mode and CPC mode at the same time. The content of this section is formulated with reference to the *General Technical Scheme for Canceling Provincial Boundary Toll Stations on Expressways* (Ref.: MoT Highway [2019] No. 320) and the *Construction Scheme for Canceling Provincial Boundary Toll Stations on expressway* (Ref.: MoT Highway [2019] No. 387), covering the traffic transaction demand of ETC vehicles and CPC vehicles. As some toll stations carry the functions of ETC gantry system, the toll function inspection items of ETC gantry are added for the toll lanes of such toll stations. During the test of various vehicle traffic and transaction process, the inspection method of real vehicle test shall refer to the *Technical Guide for Real Vehicle Test of Expressway Network Toll System* (Ref.: MoT Highway [2020] No. 291).

## 6.2 Exit lane equipment and software

For vehicles without CPC, or with broken card, no entrance information in CPC or card information inconsistent with the actual vehicle type and plate, the process workflow shall comply with the current *Network Charge Operation and Service Rules of Toll Road* when the toll is to be calculated according to plate number, vehicle type and other information.

## 6.3 ETC lane equipment and software

ETC lane is a special lane for ETC vehicles. This section is formulated with reference to the *Technical Requirements for Networking Electronic Toll Collection on Toll Road* (Ministry of Transport Announcement No. 13 of 2011), the *General Technical Scheme for Canceling Provincial Boundary Toll Stations on Expressways* (Ref: MoT Highway [2019] No. 320), and the *Construction Scheme for Canceling Provincial Boundary Toll Stations*

on expressway (Ref: MoT Highway [2019] No. 387), which covers the normal traffic demand of ETC vehicles.

#### **6.4 ETC gantry system**

Driven by the cancellation of provincial boundary toll stations of expressways in China, the road section gantry and provincial boundary gantry toll collection system has been built on expressways to implement sectional charge by ETC and CPC to achieve accurate toll collection. The contents of this section are formulated with reference to the *General Technical Scheme for Canceling Provincial Boundary Toll Stations on Expressways* (Ref: MoT Highway [2019] No. 320), the *Construction Scheme for Canceling Provincial Boundary Toll Stations on expressway* (Ref: MoT Highway [2019] No. 387), the *Technical Requirements for ETC Gantry System of Expressway* (Ref: MoT Highway [2019] No. 856), and the *Inspection Specification for ETC Gantry System and Key Equipment of Expressway*, which cover the requirements of the sectional toll for vehicles with ETC and CPC and the safe and stable operation of ETC gantry system.

#### **6.7 Network Toll Management Centre (Toll center) equipment and software**

With the development of networking toll technology, each province in the country has established regional centers and provincial centers to carry out parameter issuing, toll clearing and billing, toll settlement and toll allocation. This section is formulated in accordance with the *Technical Requirements of Network Toll Collection for Toll Road* (Ministry of Transport Announcement No. 35 of 2007).

#### **6.9 Internal wired intercom and emergency alarm system**

In recent years, in addition to the traditional wired intercom system that is still in use, fixed-line telephone system and IP telephone system have been widely used, and monitoring devices have been installed in toll booths. Therefore, this section adds the content of voice telephone system and voice monitoring function as inspection items.

#### **6.10 Transfinite detection system**

In order to further standardize the work of transfinite control at the entrance of

expressways, optimize the business environment, and better protect the safety of people's lives and property, the Ministry of Transport issued the *Notice of the general office of the Ministry of Transport on Further Standardizing the Work of Transfinite Control at the Entrance of Expressway* (MoT highway [2019] No. 29), and this section is formulated with reference to the notice.

### **6.13 Computer network of toll system**

The network security performance test, if there are no design requirements, shall comply with the provisions of the *Network Security Management Interim Procedure for Network Charge System of Toll Road* (Ref.: MoT science and technology [2019] No. 86), the *Basic Technical Requirements of Network Security for Provincial System Integrating into Network Toll System* (Ref: MoT science and technology [2019] No. 338), and the *Network Security Detection Methods for Provincial System Integrating into Network Toll System* (Ref.: MoT science and technology office [2019] No. 1459).

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# 7 Power Supply and Distribution Facilities

## 7.1 Medium-voltage distribution equipment

The sub-division work of medium-voltage equipment is added in this edition. This section is formulated with reference to the current *Code for Design Electric Power Supply and Distribution System (GB50052)*, the *Code for Design of 10kV & under Electric Substation (GB50053)*, the *Code for Design of Relaying Protection and Automatic Device of Electric Power Installations (GB50062)*, *Electric Equipment Installation Engineering-Standard for Hand-over Test of Electric Equipment (GB50150)*, *Preventive Test Code for Electric Power Equipment (DL/T596)* and other related standards, and combines the characteristics of road power supply and distribution facilities.

## 7.2 Power cable for medium-voltage equipment

The sub-division work of medium-voltage power cable equipment is added in this edition. This section is formulated with reference to the current *Standard for Design of Cables of Electric Power Engineering (GB50217)*, *Electric Equipment Installation Engineering-Standard for Hand-over Test of Electric Equipment (GB50150)*, *Conductors of Insulated Cables (GB/T3956)* and other relevant standards in combined with the characteristics of highway power supply and distribution facilities.

During the inspection, special attention shall be paid to the consistency of the cable model and specification and design requirements. The appearance inspection shall focus on concealed works. At present, the power cable of medium-voltage equipment basically adopts the way of underground laying, which shall be constructed according to the requirements of the *Standard for Design of Cables of Electric Power Engineering (GB50217)*.

### **7.3 Low voltage distribution equipment in the center (station)**

In order to avoid the equipment damage, life reduction and power waste caused by the poor power quality of highways, this edition stipulates the power quality and is formulated with reference to the current *Power Quality - Admissible Deviation of Supply Voltage (GB/T12325)*, *Power Quality - Voltage Fluctuation and Flicker (GB/T12326)*, *Power Quality - Interharmonics in Public Supply Network (GB/T14549)*, *Three-phase Voltage Imbalance of Power Quality (GB/T15543)*, *Power Quality - Frequency Deviation for Power System (GB/T15945)* and other relevant standards. The measurement items of the parameter-regulated voltage power supply, UPS, and EPS are stipulated with reference to the current *AC Uninterruptible Power Systems for Telecommunications (YD/T1095)* and *Emergency Power Supply with Inverter (GB/T21225)* and other relevant standards.

### **7.4 Power cables for low-voltage equipment**

In this edition, the power cable line of field equipment is changed to the low-voltage equipment power cable. A common problem in highway power supply and distribution facilities is the insulation failure caused by improper sealing process when the cables are connected or branched. Therefore, it is very important to conduct insulation test for the cables.

### **7.5 Wind/solar power supply system**

The measurement items of wind/solar power supply system are formulated by referring to the current *The Off-grid Wind/solar Hybrid Power Supply System for Telecommunications (YD/T1669)*, which are measured mainly by function verification, and the output parameters are tested according to the design indexes.

### **7.6 Electric vehicle charging system**

The measurement items of the electric vehicle charging system are stipulated in accordance with the current *Electric Vehicle Conductive Charging System (GB/T18487)*, which are measured mainly by function verification, and the output parameters are tested according to the design indexes.



## 7.7 Power Monitoring System

The measurement items of the power monitoring system are determined by referring to the design documents and practical application of the highway power monitoring system in recent years, mainly focusing on functional verification.

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# 8 Lighting Facilities

## 8.1 Lighting Facilities for Road

The measurement items such as average pavement brightness, total brightness uniformity and longitudinal brightness uniformity of road lighting facilities in this section are stipulated by referring to *Specification for Highway Lighting (GB/T24969-2010)*. Compared with the illuminance index, the pavement brightness and evenness index can more accurately and effectively reflect the influence of highway lighting on drivers' identification of road conditions and traffic flow information under driving conditions. In view of the high speed and large traffic flow of vehicles on the expressways, the value of relevant brightness indexes is set with reference to the requirements of the first-grade road in *Specification for Highway Lighting (GB/T24969-2010)*.

In this section, lighting facilities for road refer to the conventional road lighting facilities, excluding the highway intersection lighting facilities. As an important part of highways, the technical indexes of bridge lighting facilities could refer to the relevant contents of *Specification for Highway Lighting (GB/T24969-2010)* while inspection methods could refer to the relevant contents of this section.

## 8.2 Lighting Facilities of Toll Plaza

The lighting facilities of toll plaza generally adopt the form of high lamp-post lighting, and the high lamp-post lighting is added in the measurement items.

The measurement items of illumination and uniformity of toll plaza are formulated by referring to the technical requirements of toll plaza in *Specification for Highway Lighting (GB/T24969-2010)*.

## 8.3 Lighting Facilities in Service Area

The lighting facilities in service area generally adopt the form of high lamp-post lighting, and the high lamp-post lighting is added in the measurement items.

The measurement items of illumination and uniformity in service area are formulated by referring to the relevant requirements of service area in *Specification for Highway Lighting (GB/T24969-2010)*, and the median value of the standard technical requirements shall be selected for the lower limit of the average value of illumination.

#### **8.4 Lighting Facilities for Toll-gate Canopy**

Lighting facilities for toll canopy are generally installed under the toll canopy, so the relevant inspection items of the lamp-post are not specified in this section.

According to the different lighting quality requirements in various areas within the toll canopy, the technical requirements of the inspection items of total illumination uniformity, total brightness uniformity and longitudinal uniformity of the toll lane are slightly higher than that of lighting facilities for general road sections.

The inspection items of average color rendering index of lane are added considering the need of recognition of people, vehicle appearance and license plate within toll lanes.

# 9 Electrical and Mechanical Facilities for Highway Tunnel

## 9.2 Closed circuit television (CCTV) monitoring system

9.2.1 Low illumination fixed focus lens are mostly used for cameras in tunnels. Measurement items of some control functions in Section 4.3 of this Standard, such as horizontal rotation angle of PTZ (Pan/Tilt/Zoom), vertical rotation angle of PTZ, focusing function, zoom function, foundation, column are not applicable to the closed-circuit television (CCTV) monitoring system of tunnel, so attention should be paid.

## 9.3 Emergency telephone and cable broadcasting system

At present, the emergency telephones in the tunnel are generally equipped with the cable broadcasting system at the same time, so the relevant detection content is added in this edition. The equipment is generally installed in the pre-excavated hole of the tunnel wall. During inspection, pay attention that the equipment shall not intrude into the road boundary.

The inspection methods of two items of "Extension volume" and "radio volume", are stipulated with reference to the current *Wired-emergency Telephone System of Expressway (GB/T 19516)*, the *Acoustics - Measurement Method of Environmental Noise (GB/T3222)*, the *Methods of Noise Measurement for Fans Blowers Compressors and Roots Blowers (GB/T 2888)*, other related standards and actual site conditions

## 9.4 Environmental detection equipment

The technical requirements for the measurement error of the illuminometer are  $\pm 2\%$  or comply with the design requirements, which means that the measured value of the sensor is required to be within  $\pm 2\%$  of the measured value of the illuminometer or meet the

design requirements.

### **9.5 Manual fire alarm system**

This section is compiled mainly based on how the on-site staff alarm in case of fire, and the automatic fire alarm system will be stipulated in another section.

Referring to the current *Audible and /or Visual Fire Alarm Signaling Appliances (GB 26851)*, the inspection method for the alarm volume of the tunnel management station is to take the alarm as the center of the circle with 3 m as the radius, and measure the points from 15° to 165° with sound level meter respectively with the interval of 30° on the semi-circle of horizontal and vertical planes.

### **9.6 Automatic fire alarm system**

First of all, the function verification is to detect the fire and activate the alarm. The measurement of the automatic alarm response time of the fire detector is added in this edition. The test method of the brazier method shall refer to the relevant provisions in the current *Technical Requirements and Test Methods for Highway Tunnel Fire Alarm Equipment (JT / T610)*.

### **9.7 Neon and electric signs**

The neon and electric signs mainly include the evacuation indicatory signs, firefighting equipment indicatory signs that guide people to evacuate to the safe zone in case of fire. The measurement items are formulated with reference to the current *Specifications for Design of Highway Tunnels Volume II Traffic Engineering and Affiliated Facilities (JTG D70/2)*.

### **9.8 Luminescent guiding facilities**

Luminescent guiding facilities refer to LED light-emitting inducement facilities installed in highway tunnels, which play the role of driving safety inducement.

### **9.9 Changeable signs**

**9.9.1** The changeable signs outside the tunnel mainly refer to the variable message signs and traffic lights, and the changeable signs inside the tunnel are mainly LED lane control signs and suspending changeable message signs.

### **9.10 Tunnel video traffic incident detection system**

The video traffic incident detection system in the tunnel is mainly used to detect traffic events. Unlike the road video traffic incident detection system, it does not include inspection items of traffic parameter.

### **9.11 Jet fan**

The jet fan has a large volume and weight and is installed directly above the carriageway. Its installation quality is very important. It is necessary to check the construction data and test report of concealed works of embedded parts. When measuring the average wind speed of tunnel cross-section during fan operation, the fan shall be turned on under the working conditions as required by the design.

### **9.12 Axial flow fan**

When measuring the average speed of wind passing through the tunnel cross-section during fan operation, the fan needs to be turned on under working condition as required by the design.

### **9.13 Lighting facilities**

In recent years, new types of lighting luminaires such as LED lamp, electrodeless fluorescent lamp have been widely used in highway tunnel lighting facilities. In view of their performance indexes and the requirements for safety and energy saving, the dimming function requirements of lighting luminaires have been added in this revision. The dimming function of the luminaires can be operated manually, or automatically adjusted by triggering variables such as the brightness of the tunnel entrance, the traffic flow of the tunnel and other parameters.

At the same time, based on the visual perception of highway users, this revision adds the indexes for the average lighting brightness, total brightness uniformity, longitudinal uniformity, color temperature and road-wall brightness ratio of highway tunnel.

Color temperature and road-wall luminance ratio mainly affect the physiological and psychological perception of highway users in the closed environment of tunnel. In the calculation of road-wall luminance ratio, the average luminance measurement method of tunnel wall could refer to that of road surface.

The allowable value range of the color temperature index is relatively large, but the upper limit is stipulated, mainly because the current high-power LED lighting products often increase the proportion of blue light in the emission spectrum when pursuing high luminous efficiency, and the excessive blue light composition will significantly increase the color temperature of the lamps, forming a cold white lighting environment, and affecting the visual comfort.

As stipulated in the *Guidelines for Design of Lighting of Highway Tunnels (JTG/T D70/2-01-2014)*, when the color rendering index is  $\geq 65$ , and the LED/ single ended electrodeless fluorescent lamp with color temperature between 3500K and 6500k are used for basic tunnel lighting, the brightness could take the value as 50% / 80% of the general brightness standard. Therefore, in the design stage, if the brightness reduction lighting scheme is adopted according to this guideline, in addition to the color temperature, the lighting color rendering index shall also be measured. When measuring the color rendering index, different measurement positions shall be selected as much as possible with no less than 9 selected points in each measuring area.

#### **9.14 Firefighting facilities**

The measurement items of fire-fighting facilities are formulated with reference to the *Specifications for Design of Highway Tunnels Volume II Traffic Engineering and Affiliated Facilities (JTG D70/2)*, the *Code for Fire Protection Design of Buildings (GB 50016)* and other relevant standards. The inspection shall focus on the equipment protection and the water pressure of water facilities. Function verification is mainly to assure the firefighting facilities (various fire extinguishers and hydrants) in normal working conditions (automatic start of automatic sprinkler system and fire extinguishing

function of manual fire-fighting equipment).

### **9.15 Local controller**

The safety protection, sealing and moisture-proof of the local controller are the key points of inspection, either checked by visual inspection, or on the other hand, to check the product inspection report.

### **9.17 Computer network of tunnel management station**

**9.17.1** This section is compiled with Local Area Network (LAN) as the main inspection items, of which the content is the same as Section 4.9 of this Standard.

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# Technical Terms in Chinese and English

序号	英文词汇	中文词汇
1	air duct	风道
2	air valve	风阀
3	alarm	告警
4	amplitude-frequency characteristics	幅频特性
5	antenna	天线
6	appearance quality	外观质量
7	aqueous film forming foam Fire Extinguishing Device	水成膜泡沫灭火装置
8	armored layer	铠装层
9	arrester	避雷器
10	audio cable	音频电缆
11	automatic fire alarm system	自动火灾报警系统
12	Automatic fire alarm system	自动火灾报警系统
13	automatic license plate recognition function	车牌自动识别功能
14	average value, representative value	平均值、代表值
15	axial flow fan	轴流风机
16	axial flow fan	轴流风机
17	basic requirement	基本要求
18	bit error	误码
19	bit-error tester	误码仪
20	black and white rolling blink	黑白滚道
21	blade	叶片
22	bounce	跳动
23	broadcasting section	音区
24	bus	母线
25	cable analyzer	电缆分析仪
26	cable laying in conduit	穿管敷设
27	cable splicing box	电缆接续箱
28	call simulator	模拟呼叫器

29	capacitor	电容器
30	car-following interference	跟车干扰
31	casing	套管
32	CCTV (closed circuit television) monitoring system	闭路电视监视系统
33	CCTV monitoring System	闭路电视监视系统
34	CCTV(Closed Circuit Television) monitoring system	闭路电视监视系统
35	changeable sign	可变标志
36	changeable sign	可变标志
37	changeable sign	可变标志
38	changeable sign	可变标志
39	channel transmission index	传输通道指标
40	charging pile	充电桩
41	Chromaticity coordinates	色度坐标
42	circular broadcasting	循环广播
43	clock synchronization	时钟同步
44	closed circuit television (CCTV) monitoring system	闭路电视监视系统
45	color rendering index	显色指数
46	commissioning	试运行
47	common grounding resistance	共用接地电阻
48	communication center	通信中心
49	communication conduit work	通信管道工程
50	communication conduit works	通信管道工程
51	communication facility	通信设施
52	communication optical cable and electric cable line works	通信光缆、电缆线路工程
53	communication performance analyzer	通信性能分析仪
54	communication power supply system	通信电源系统
55	communication terminal	通信站
56	completion acceptance evaluation	竣工质量鉴定
57	computer network of monitoring system	监控系统计算机网络
58	computer network of monitoring system	监控系统计算机网络
59	computer network of toll collection system	收费系统计算机网络
60	computer network of tunnel management station	隧道管理站计算机网络

61	computer network of tunnel management station	隧道管理站计算机网络
62	concealed work	隐蔽工程
63	construction quality verification	工程质量评定
64	contract package	合同段
65	control box	控制机箱
66	control box	控制机箱
67	CRI (color rendering index)	显色指数
68	crosstalk	串音
69	data transmission	数据传输
70	data transmission performance	数据传输性能
71	delay	时延
72	delay inequality	时延偏差
73	demultiplexer	分波器
74	differential gain	微分增益
75	differential phase	微分相位
76	dispersion analyzer	色散分析仪
77	display terminal	显示终端
78	distortion	失真
79	distortion rate	畸变率
80	distribution box	配电箱
81	distribution box	配线箱
82	distribution frame	配线架
83	division of work	分部工程
84	dominant item	关键项目
85	drift	漂移
86	echo E	回波 E
87	echo return loss	回波损耗
88	effective detection range	有效检测范围
89	electric electrodeless fluorescent lamp (EEFL)	无极荧光灯
90	electric heat tracing	电伴热
91	electric railing	电动栏杆
92	electric vehicle charging system	电动汽车充电系统
93	electrical and mechanical facilities for highway tunnel	隧道机电设施

94	electrical and mechanical facilities for highway tunnel	隧道机电设施
95	electrical interface	电接口
96	Electronic Toll Collection (ETC)	ETC
97	electro-optic sign	电光标志
98	electro-optic sign	电光标志
99	embedded parts	预埋件
100	emergency telephone and cable broadcasting system	紧急电话与有线广播系统
101	emergency telephone and cable broadcasting systems	紧急电话与有线广播系统
102	environmental detection equipment	环境检测设备
103	Environmental detection equipment	环境检测设备
104	environmental detection performance	环境检测性能
105	Equipment and software of ETC (Electronic Toll Collection) lane	ETC 专用车道设备及软件
106	Equipment and software of ETC/MTC entrance lane	入口混合车道设备及软件
107	Equipment and software of ETC/MTC exit lane	出口混合车道设备及软件
108	equipment and software of Toll station	收费站设备及软件
109	equipment and software of tunnel management station	隧道管理站设备及软件
110	equipment and software of tunnel management station	隧道管理站设备及软件
111	ETC gantry system	ETC 门架系统
112	Ethernet	以太网
113	evaluation	评定
114	Evaluation comments	评定意见
115	Evaluation document	评定资料
116	external connection wire of field chassis enclosure	外场机箱外部连接线
117	extinction coil	消弧线圈
118	extruded insulation power cable	挤包绝缘电力电缆
119	Factory inspection certificate	产品出厂检验合格证明
120	far-end crosstalk	远端串音
121	fastener	紧固件
122	feeder line	馈电线路
123	field	外场
124	fire alarm controller	消防控制器
125	fire extinguisher	灭火器

126	fire hydrant	消火栓
127	firefighting facilities	消防设施
128	firefighting facilities	消防设施
129	fireproof rolling shutter	防火卷帘
130	flash alarm	闪光报警器
131	foundation of field equipment	外场设备基础
132	frame	帧
133	frame skip	跳帧
134	frequency of spot check	抽样检查频率
135	general item	一般项目
136	ground resistance tester	接地电阻测量仪
137	grounding busbar	接地汇流排
138	Handling of ETC denied vehicle	特情车辆处理
139	harmonics	谐波
140	high mast lighting system with raising and lowering equipment	升降式高杆照明装置
141	high voltage fuse	高压熔断器
142	Highway electrical and mechanical works	公路机电工程
143	Hub	集线器
144	IC card issuing and coding system	IC 卡发卡编码系统
145	input jitter	输入抖动
146	inspection	检查
147	inspection items	检查项目
148	inspection method	检查方法
149	instrument transformer	互感器
150	insulation resistance	绝缘电阻
151	insulation resistance of lane equipment	车道设备绝缘电阻
152	Internet Protocol (IP) network system	IP 网络系统
153	inverter emergency output voltage	逆变应急输出电压
154	isolator	隔离开关
155	jet fan	射流风机
156	Jet fan	射流风机
157	jitter	抖动
158	lane camera	车道摄像机

159	lane image snapshot	车道图像抓拍
160	large screen display system	大屏幕显示系统
161	large-screen display system	大屏幕显示系统
162	lighting facilities	照明设施
163	lighting facilities	照明设施
164	lighting facility for road	路段照明设施
165	lighting facility of service area	服务区照明设施
166	lighting facility of service area	服务区照明设施
167	lighting facility of toll canopy	收费天棚照明设施
168	lighting facility of toll canopy	收费天棚照明设施
169	lighting facility of toll plaza	收费广场照明设施
170	lighting facility of toll plaza	收费广场照明设施
171	lightning protection grounding resistance	防雷接地电阻
172	linear response of luminance channel	亮度通道的线性响应
173	line-to-line measurement	线对线测量
174	load switch	负荷开关
175	local controller	本地控制器
176	local controller	本地控制器
177	loop vehicle detector	环形线圈车辆检测器
178	loss of frame	帧失步
179	loss of multi-frame	复帧丢失
180	low-voltage distribution equipment of Centre station	中心（站）内低压配电设备
181	luminance nonlinearity	亮度非线性
182	Luminescent guiding facility	发光诱导设施
183	luminometer	亮度计
184	Luminous guiding facility	发光诱导设施
185	magnetic vehicle detector	地磁车辆检测器
186	manhole (handhole)	人（手）孔
187	manual fire alarm system	手动火灾报警系统
188	Manual fire alarm system	手动火灾报警系统
189	measurement item	实测项目
190	measurement items	实测项目
191	measurement value or measured deviation	实测值或实测偏差值

192	Medium voltage distribution equipment	中压配电设备
193	medium-voltage distribution equipment	中压配电设备
194	microwave traffic flow detector	微波交通流检测器
195	modem	调制解调器
196	monitor picture index	监视器画面指标
197	monitoring center	监控室
198	monitoring center	监控中心
199	monitoring center (sub-center) equipment and software	监控（分）中心设备及软件
200	monitoring facilities	监控设施
201	monitoring facility	监控设施
202	monitoring range	监视范围
203	mosaic	马赛克
204	multi-channel switching	多路切换
205	multi-mode optical fiber	多模光纤
206	multiplexer	合波器
207	multi-window display	多视窗显示
208	near-end crosstalk	近端串音
209	negative sequence imbalance	负序不平衡
210	netlike winkle	网纹
211	network authentication tester	网络认证测试仪
212	networking toll Management Centre (Toll Centre) equipment and software	联网收费管理中心（收费中心）设备及软件
213	Neutral current	N 线电流
214	noise suppression	噪声抑制
215	nominal voltage	标称电压
216	nonlinear distortion of signal	信号的非线性失真
217	operating mechanic	操动机构
218	optical cable and power cable within Toll station area	收费站区光缆、电缆线路
219	optical power meter	光功率计
220	optical signal-to-noise ratio	光信噪比
221	optical time-domain reflectometer	光时域反射计
222	output jitter	输出抖动
223	output quantization error of signal	信号输出量化误差
224	Over-limit detection system	超限检测系统

225	packet loss rate	丢包率
226	packet loss rate	丢包率
227	packet loss rate of IP network	IP 网络丢包率
228	parameter management	参数管理
229	patron external display of toll collection	专用费额信息显示屏
230	percentage conformity	合格率
231	percentage conformity	合格率
232	phase color	相色
233	phase current	相电流
234	phase line	相线
235	plumbing	水暖
236	polarization mode dispersion	偏振模色散
237	power cable for low-voltage equipment	低压设备电力电缆
238	power cable for medium-voltage equipment	中压设备电力电缆
239	power monitoring system	电力监控系统
240	power sum	功率和
241	power supply and distribution facilities	供配电设施
242	Power supply and distribution facilities	供配电设施
243	power supply and distribution facilities	供配电设施
244	power supply and distribution facility	供配电设施
245	power transformer	电力变压器
246	precipitation detection function	降雨检测功能
247	pressurizing facilities	加压设施
248	printed circuit board	板卡
249	project quality grading evaluation	工程质量等级评定
250	protective grounding resistance	保护接地电阻
251	PSTN (Public Service Telephone Network)	固定电话交换系统
252	PSTN (Public Service Telephone Network)	固定电话交换系统
253	qualification criteria	合格判定
254	qualified	合格
255	quality assurance data	质量保证资料
256	quality assurance data	质量保证资料
257	quality evaluation	质量评定



258	quality grade	质量等级
259	quality inspection and evaluation form for division of work	分部工程质量检验评定表
260	quality inspection and evaluation form for type of work	单位工程质量检验评定表
261	Quality inspection and evaluation form for works	工程质量检验评定用表
262	quality of appearance	外观质量
263	rack	机架
264	random spot check	随机抽样检验
265	reactive power compensation	无功补偿
266	reactor	电抗器
267	receiving and updating of toll parameters	收费参数接收与更新
268	relative error	相对误差
269	relay section	中继段
270	remarks	备注
271	remote access	远端接入
272	reset function	复原功能
273	RMS (Root Mean Square)	方均根值
274	road lighting facility	路段照明设施
275	road surface condition detection function	路面状况检测功能
276	road video traffic incident detection system	道路视频交通事件检测系统
277	road video traffic incident detection system	道路视频交通事件检测系统
278	router	路由器
279	Sample size	抽样单位
280	SDH (synchronous digital system) optical fiber transmission system	同步数字体系 (SDH) 光纤传输系统
281	self-check function	自检功能
282	sensitivity	灵敏度
283	sensor	传感器
284	setting	整定
285	SF6 (Sulphur Hexafluoride) circuit breaker	六氟化硫断路器
286	SF6 (Sulphur Hexafluoride) GIS (Gas Insulated Switchgear)	六氟化硫封闭式组合电器
287	shielding sheath	屏蔽护套
288	side-mode suppression ratio	边模抑制比
289	Sight distance	视认距离

290	signal generator	信号发生器
291	signal latency	信号时延差
292	sine square wave	正弦平方波
293	single-mode optical fiber	单模光纤
294	snowflake	雪花
295	sound level	声级计
296	special keyboard	专用键盘
297	specified value or allowable deviation	规定值或允许偏差
298	Spectral radiometer	光谱辐射计
299	spectrograph	光谱仪
300	standard-definition analog composite video signal	标清模拟复合视频信号
301	strong current terminal	强电端子
302	strong current terminal	强电端子
303	sub-division of work	分项工程
304	Sub-division Work Quality Inspection and Evaluation Form	分项工程质量检验评定表
305	substation	变配电所
306	switch	交换机
307	switchyard	配电站
308	synchronization pulse amplitude	同步脉冲幅度
309	synchronous digital hierarchy (SDH)	同步数字体系
310	Taking-over quality inspection	交工质量检测
311	technical requirements	技术要求
312	telecontrol	遥控
313	telemetry	遥测
314	telesignal	遥信
315	throughput	吞吐率
316	throughput rate of IP network	IP 网络吞吐率
317	toll collection facility	收费设施
318	toll collection sub-center equipment and software	收费分中心设备及软件
319	toll lane	收费车道
320	toll station	收费站
321	traffic flow	车流量
322	traffic information collection	交通信息采集

323	traffic light	道路交通信号灯
324	traffic survey facility	交通情况调查设施
325	traffic survey facility	交通情况调查设施
326	trailing	拖尾
327	transmission delay	传输时延
328	transmission delay of IP network	IP 网络传输时延
329	transmission performance	传输性能
330	tunnel video traffic incident detection system	隧道视频交通事件检测系统
331	tunnel video traffic incident detection system	隧道视频交通事件检测系统
332	type of work	单位工程
333	ultrasonic thickness gauge	超声波测厚仪
334	unacceptable defect	限制缺陷
335	uniformity	均匀度
336	unqualified	不合格
337	vacuum circuit breaker	真空断路器
338	Vehicle classification error	机动车分类或分型误差
339	vehicle detector	车辆检测器
340	vehicle detector	车辆检测器
341	vehicle detector	车辆检测器
342	vehicle information collection	车辆信息采集
343	video level	视频电平
344	video signal-to-noise ratio (SNR)	视频信噪比
345	video traffic-incident detector	视频交通事件检测器
346	video vehicle detector	视频车辆检测器
347	visibility	能见度
348	Visual appearance quality unacceptable defect for electrical and mechanical works	机电工程外观质量限制缺陷
349	water supply facilities	供水设施
350	wavelength division multiplexing (WDM) fiber transmission system	波分复用 (WDM) 光纤传输系统
351	wavelength-division multiplexing (WDM)	波分复用
352	weather detector	气象检测器
353	weather detector	气象检测器
354	wind/ solar power supply system	风/光供电系统
355	wind/solar power supply system	风/光供电系统

356	winding with casing	绕组连同套管
357	wired intercom and emergency alarm system	内部有线对讲及紧急报警系统
358	Π connecting cabinet	π 接柜

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