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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Power feeding and energy storage

Evaluation method of safety operations and energy saving for power supply systems in telecommunication rooms or buildings

Recommendation ITU-T L.1240

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Recommendation ITU-T L.1240

Evaluation method of safety operations and energy saving for power supply systems in telecommunication rooms or buildings

Summary

Recommendation ITU-T L.1240 specifies, for telecommunication rooms or buildings, the overall evaluation framework, classification, reliability grading, evaluation items and evaluation methods for power supply systems. Recommendation ITU-T L.1240 applies to the evaluation of power supply systems, maintenance capability, safety operations and energy saving of various telecommunication rooms or buildings.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Energy saving, evaluation method, power supply system, safety operations.

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FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation ITU-T L.1240

Evaluation method of safety operations and energy saving for power supply systems in telecommunication rooms or buildings

1 Scope

This Recommendation establishes evaluation methods of safety operations and energy saving for power supply systems in telecommunication rooms or buildings.

This Recommendation specifies:

- overall safety operations evaluation;
- energy-saving evaluation;
- classification of telecommunication rooms or buildings;
- reliability grading;
- evaluation methods for power supply system in telecommunication rooms or buildings.

This Recommendation applies to the evaluation of power supply systems, maintenance capability, safety operations and energy saving of various telecommunication room or building configurations.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1210] Recommendation ITU-T L.1210 (2019), *Sustainable power-feeding solutions for 5G networks*.

[ITU-T L.1320] Recommendation ITU-T L.1320 (2014), *Energy efficiency metrics and measurement for power and cooling equipment for telecommunications and data centres*.

[ITU-T L.1350] Recommendation ITU-T L.1350 (2016), *Energy efficiency metrics of a base station site*.

[ITU-T L.1380] Recommendation ITU-T L.1380 (2019*), Smart energy solution for telecom sites*.

[ITU-T L.1381] Recommendation ITU-T L.1381 (2020), *Smart energy solutions for data centres*.

[ITU-T L.1382] Recommendation ITU-T L.1382 (2020), *Smart energy solution for telecommunication rooms*.

[ITU-T L.1383] Recommendation ITU-T L.1383 (2021), *Smart energy solutions for city and home applications*.

[ETSI EN 300 019-2-4] ETSI EN 300 019-2-4 V2.5.1 (2018), *Environmental engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-4: Specification of environmental tests; Stationary use at non-weather protected locations*.

[IEC 60068-2-11] IEC 60068-2-11:2021, *Environmental testing – Part 2-11: Tests – Test Ka: Salt mist*.

[IEC 60529] IEC 60529;2013, *Degrees of protection provided by enclosures (IP code)*.

[IEC 61000-4-2] IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*.

[IEC 61000-4-5] IEC 61000-4-5:2017, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*.

[IEC 62619] IEC 62619:2022, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*.

[IEC CISPR 32] IEC CISPR 32 (2019), *Electromagnetic compatibility of multimedia equipment – Emission requirements*.

[ISO 10289] ISO 10289:1999, *Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*.

[ISO 16750-4] ISO 16750-4:2010, *Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 4: Climatic loads*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 energy [b-ISO 80000-5]: Ability of a system to do work.

NOTE – In telecommunication systems, the primary source is electrical energy, which is measured in joules or watt hours.

3.1.2 energy savings [b-ISO/IEC 13273-1]: Reduction of energy consumption following implementation of an energy performance improvement action.

NOTE – See [b-ITU-T L.1315] for a complete discussion on energy efficiency terms.

3.1.3 functional unit [b-ITU-T L.1310]: A performance representation of the system under analysis. For example, for transport equipment, the functional unit is the amount of information transmitted, the distance over which it is transported and its rate in Gbit/s. Sometimes the term is used to indicate useful output or work.

NOTE – This definition is based on that in ISO 14040.

3.1.4 idle mode [b-ITU-T L.1310]: A network element with no user data traffic (it is not zero traffic, as service and protocol supporting traffic are present) being used, although it is ready to be used.

3.1.5 low power (sleep) mode [b-ITU-T L.1310]: For small networking equipment, this means a state that happens after the device detects no user activity for a certain period of time and reduces energy consumption. For this state, no user-facing LAN ports are connected; the Wi-Fi is active but no clients are connected. The WAN port may be inactive. The device will reactivate on detecting a connection from a user port or device.

3.1.6 reliability [b-ITU-T Y.3514]: The ability of a system, product or component to perform and maintain under stated conditions as required for a specified period of time.

3.1.7 small networking device [b-ITU-T L.1315]: A networking device with fixed hardware configuration, designed for home/domestic or small office use, with less than 12 wired ports. This device can have wireless functionality implemented. Wireless functionality is not considered a port.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 active mode of small networking equipment: Operational mode where all ports (wide access network and local area network) are connected, with at least one wireless fidelity (Wi-Fi) connection, if a Wi-Fi function is available.

3.2.2 useful output: The useful work carried out by the equipment, e.g., delivered bits or output energy from wireless equipment.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
BMS	Battery Management System
DC	Direct Current
ESD	Electrostatic Discharge
HSL	Hazard Safety Level
ICT	Information and Communication Technology
SOC	State Of Charge
UPS	Uninterruptible Power Supply
Wi-Fi	Wireless Fidelity

5 Conventions

In this Recommendation, safety operations mean maintenance of system reliability at the initial designed level.

The symbol I_{10} A (the equivalent in industry is C_{10}) is used for the current rate for 10 h of backup equivalent to one-10th of nominal capacity.

6 Introduction

There are many problems in current urban energy management. Smart energy solves existing problems of urban energy management through clean, regional, intelligent and Internet-based urban energy. Smart solutions can promote the conversion of all kinds of energy, especially electrical. For energy, smart solutions increase the proportion of that which is clean, as well as promoting its development and utilization, optimize urban structure, and improve utilization efficiency, to implement green and environmentally friendly management at local and national government levels. Solutions based on smart power developed in [ITU-T L.1210], [ITU-T L.1380], [ITU-T L.1381], [ITU-T L.1382] and [ITU-T L.1383] shall be considered.

6.1 Classification of telecommunication rooms or buildings

Telecommunication installations in a network can be classified in different ways and called by different names, such as central office, primary site and aggregation site, depending on the country.

Telecommunication rooms or building are classified based on the service and interconnection types derived from [b-CCSA-YD/T 1051] with some adjustment.

All telecommunication rooms or buildings are classified into classes I to IV:.

- class I: with international and national network services, which provide services and support for the entire country, with large-sized data centre computer rooms, etc;
- class II: with local network service room, centralized service room and support room for local network, medium-sized data centre, etc;
- class III: local telecommunication rooms or buildings with regional services and support in local network, small data centre, etc;
- class IV: computer room, base station, indoor distribution telecommunication room and other telecommunication rooms or buildings with network terminal access services.

6.2 Reliability grading of power supply system

There are four levels of potential power supply reliability risk, which are determined by the importance of its system installation and the degree of damage caused to its entire system and to information and communication technology (ICT) load when faults occur.

Table 1 lists descriptions and grading criteria for reliability risk levels.

Table 1 – Descriptions and grading criteria for reliability risk levels

Graded	Description	Grading criteria
Level 1	The reliability of the power supply system and communications has been or will be jeopardized and should be handled as soon as possible.	Faults occur frequently or have occurred and affect the power supply system and communication reliability.
Level 2	The power supply system may be out of service or operating performance deterioration, affecting equipment and communication reliability.	In violation of system requirements, equipment and communication reliability may be affected if a fault occurs.
Level 3	Equipment component failure in the power supply system may affect the system and communication reliability but does not affect the overall system performance.	If a fault occurs, the equipment and communication reliability may be affected. If the fault is not handled, the fault would become a level 1 or level 2 risk.
Level 4	General hidden troubles that do not affect the normal operation of the power supply system.	If a fault occurs, it will not affect the power supply of the system and will not be upgraded if the fault is not handled.

6.3 Necessity of evaluation for reliability not impacting operations and energy saving

The power supply system is the foundation of a telecommunication network and quality guarantee of the whole network. With the rapid development of the communication business and the continuous expansion of network scale, the capacity and structure complexity of power supply systems in telecommunication buildings are increasing, and the requirements of reliability need to be improved.

However, in recent years, power supply interruptions caused by improper design, construction and maintenance of the power supply system occur from time to time, which affect the availability and the operation time of telecommunication systems that are susceptible to influence from the power supply system.

Comprehensive, objective and effective evaluation of the power supply system of the whole network in telecommunication buildings from the aspects of external power supply, medium- and low-voltage power distribution, generator sets, uninterruptible power supply (UPS), switching power supply and battery strings is the focus of maintenance and management for power supply systems.

Statistical analysis of power supply system failure in recent years has identified the causes as follows.

a) The importance of power supply system is not well understood. Reliable operation of the power supply system is the basis of ensuring network reliability. Due to lack of attention and effective management methods, the maintenance and management of a power supply system is relatively passive, and its operation is not optimized. Problems such as capacity expansion, non-synchronous monitoring, insufficient redundancy, equipment aging failure, equipment operation with faults and insufficient emergency capacity directly affect network reliability.

b) The maintenance and management methodology of power supply systems need to be improved. At present, there is no effective method suitable for functionality and system health condition inspection of power supply systems in telecommunication buildings. In addition, there is no reliability evaluation standard for power supply systems, which leads to inadequate evaluation of operation management and implementation of key performance indicators of power supply in telecommunication buildings.

c) There are potential reliability hazards in the operation and maintenance of power supply systems. There are many types of power equipment in telecommunication centres, which have a wide range of technologies, involve complicated maintenance work and difficult management. With continuous expansion of network scale, maintenance problems of power supply systems are becoming more prominent. Work on power supply reliability s lagging behind. Surge interference, harmonic interference, unreliable equipment quality, improper installation and use, inadequate equipment protection, mismatching of breaker capacity, poor protection selectivity and other hidden dangers threaten the safe operation of telecommunication systems.

d) Insufficiently trained personnel, employed for maintenance, lack basic theoretical knowledge and practical operation experience on site. In addition, engineering and original data are incomplete, which causes difficulties in equipment maintenance and fault analysis. The supporting management system is imperfect, which causes loss of operational data.

Energy saving and efficiency of power supply systems is an important aspect to be considered in future implementation and modernization of actual telecommunication rooms or buildings. The efficiency requirements specified in [ITU-T L.1210], [ITU-T L.1350], [ITU-T L.1380], [ITU-T L.1381], [ITU-T L.1382] and [ITU-T L.1383] need to be considered in the design of power systems. The measurement methodology for the energy efficiency of power system is specified in [ITU-T L.1320].

6.4 Battery hazard safety level description

Table 2 lists hazard safety levels (HSLs) of cell and battery systems. If any of the criteria are met, the test or failure is assigned to the corresponding HSL.

Table 2 – Safety and reliability risk level description

Hazard safety level	Description	Criteria
HSL0	Intrinsic safety without functional impairment	1) Test samples are not affected in the environmental reliability test and functions are normal. 2) The target cell of battery system is not thermal runaway. 3) The box of the unit under test is free of deformation, liquid leakage (Note 1). There is no gas leakage, smoke, fire, crack or explosion. 4) The maximum temperature of the tested unit (T_{max}) is less than or equal to the upper limit of the operating temperature (T_{up}) (except for the thermal diffusion test).
HSL1	Reversible function failure or reversible protection action, thermal runaway without diffusion	1) Reversible function failure in the environmental reliability test (including action of recoverable protection device). 2) The thermal diffusion test does not extend to cells adjacent to the target cell. 3) The box of the tested unit has no deformation, leakage of liquid or gas, smoke, crack, fire or explosion. 4) T_{max} is less than or equal to T_{up} (except for the thermal diffusion test).
HSL2	Irreversible function failure, thermal runaway without expansion, slight gas leakage, slight smoke	1) The environment reliability test shows that the irreversible function fails (including activation of a passive protection device or functional component damage). 2) Slight liquid leakage from the tested unit (Note 2). Gas leakage, slight smoke or white smoke (Note 3). 3) The thermal diffusion test does not extend to cells adjacent to the target cell. 4) T_{max} is greater than T_{up} (except for the thermal diffusion test). 5) The tested unit has no deformation, ignition, carbonization, cracking and explosion.
HSL3	Carbonization, thermal runaway expansion in the battery, serious liquid leakage or gas leakage, and a large amount of smoke	1) Serious liquid leakage from the tested unit (Note 4). Gas leakage, serious smoke (black or grey) emission. 2) In the thermal diffusion test, the target cell is triggered by thermal runaway, which extends to adjacent cells. However, the whole test sample is not subject to thermal runaway. 3) The carbonized area of structural or electrical components in the tested unit is ≤20%, and no ignition occurs. 4) The box in the unit under test is slightly deformed (Note 5). There is no crack or no explosion.
HSL4	Ruptured	1) The case of the tested unit is severely deformed, cracked and free of explosion. 2) The unit under test catches fire, and the surface temperature of the epoxy resin plate 100 mm away from the unit under test undergoes a rise δT exceeding 97°C for more than 3 s. 3) Thermal diffusion test: The cell is subject to thermal runaway, as well as the unit; however, it does not extend to the adjacent battery system.

Table 2 – Safety and reliability risk level description

Hazard safety level	Description	Criteria
HSL5	Fire, battery thermal runaway	1) The battery system of the tested unit is on fire. 2) Thermal diffusion test: The cell and battery under test are subject to thermal runaway. 3) The box in the tested unit is severely deformed (Note 6). Slightly cracked, no solid matter or debris are ejected, and no explosion. 4) The surface temperature of the epoxy resin board 100 mm away from the tested unit rises $\delta T > 97°C$ for more than 3 s.
HSL6	Explosions	1) Thermal runaway explosion of the unit under test. 2) Thermal diffusion test: The tested cell and battery system are subject to thermal runaway, which extends to the adjacent battery system.
NOTE 1 – Except for the pre-set air leakage device, the battery module or battery system shell is mechanically damaged and cracked. NOTE 2 – Slight leakage: volume loss before and after the test of the unit under test ≤50% of the total liquid injected. NOTE 3 – Smoke: guidance is contained in [b-UL9540A] smoke release rate test method. NOTE 4 – Serious liquid leakage: The volume loss before and after the test of the unit is greater than 50% of the total liquid injected. NOTE 5 – Slight deformation: the maximum deformation of the unit under test in any direction is <15%, and no structural damage is found. NOTE 6 – Severe deformation: the maximum deformation in any direction of the unit under test is ≥15% or the shell structure is cracked.		

7 Evaluation of reliability and correct operations of power supply items

This evaluation shall include maintenance management, external power supply, medium-voltage power supply system, transformer, low-voltage power supply system, battery backup system, UPS power supply system (including storage battery), related evaluation methods are derived from [b-CCSA-YD/T 3569].

The main purposes of establishing the power supply reliability evaluation method for telecommunication rooms are: use as an evaluation tool; means for systematic, comprehensive and effective inspection of the power supply system of existing telecommunication rooms or buildings to expose hidden dangers, and propose improvements in the power supply reliability of telecommunication rooms or buildings. In this Recommendation, the power supply reliability evaluation items are classified into different categories. Each category is divided into several evaluation items based on the system composition and key indicators.

7.1 External alternating current mains power reliability evaluation

The reliability evaluation of the alternating current (AC) power supply system in telecommunication rooms includes its category and capacity. AC power system capacity should meet the existing power demand of telecommunication rooms or buildings.

The evaluation of AC power supply categories are shown in Table 3.

Table 3 – Evaluation of the supply categories and system capacity of alternating current power

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
External AC mains power	In principle, class I telecommunication rooms or buildings shall employ class I AC mains power. Class II telecommunication rooms or buildings shall employ in class II AC mains power, when the external AC power conditions are met and the investment growth is under control, class I AC mains power shall be considered. Class III telecommunication rooms or buildings shall employ in class II mains power when the conditions are met; and class III AC mains power can be used when the conditions are not met. Reliable 380 V or 220 V power supply can be used for class IV local telecommunication rooms or buildings.	AC power supply category	The category of external AC mains power shall meet the requirements of various telecommunication rooms or buildings, and the power supply mode shall meet standard requirements. Check the completion acceptance report of external AC mains power according to the power supply scheme signed with the power supply department.	Level 2
External mains unavailability	The unavailability key indicators of external mains depend on various telecommunication room or building requirements.	AC power supply category	The unavailability of mains power refers to the ratio of the time of mains power failure in the statistical period to the time of the statistical period (not less than 1 year).	Level 2
AC main connection modality	Two medium-voltage cables shall not enter telecommunication rooms or buildings at the same point.	AC power supply category	Check the completion acceptance report of the external AC mains power according to the power supply scheme signed with the power supply responsible department.	Level 4

Table 3 – Evaluation of the supply categories and system capacity of alternating current power

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Whether power demand is met	1) The introduction capacity of class I AC mains power to two AC mains power (or two mains power not meeting class I AC mains power capacity) shall meet maximum working load demand of all telecommunication rooms and ICT loads. 2) For the communication machine room introducing one circuit of external mains power, the introduction capacity of external mains power shall meet maximum working load demand of all telecommunication rooms and ICT loads.	AC power system capacity	1) Check the power capacity of one or two AC mains power in the existing communication room, and the input power capacity shall be subject to the power supply scheme signed with the power supply department. 2) If the power input capacity of two mains power (standby for each other) is inconsistent, the input power capacity of one mains power with smaller input power capacity must meet the "maximum working load" demand of telecommunication rooms and ICT loads.	Level 1

7.2 Medium-voltage power supply system reliability evaluation

7.2.1 Medium-voltage distribution system

The reliability evaluation of the medium-voltage distribution system in the communication room includes two main contents: equipment performance and equipment configuration (switching capacity, distribution level, standby automatic switching, and switch interlocking relay protection and detection report). The evaluation contents are shown in Table 4.

Table 4 – Evaluation of medium-voltage distribution system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Equipment performance	1) The service life of medium-voltage distribution equipment can refer to the relevant requirements. 2) The equipment renewal cycle in the maintenance procedures are specified by the local power supply department.	Fault definition Service life	1) Equipment performance evaluation shall be conducted according to the definition of equipment failure. 2) The service life shall be calculated based on the estimated operation time of the equipment.	Level 3
Switching capacity	Medium-voltage distribution equipment should be configured according to long-term maximum load: the rated capacity of incoming line and tie switch shall meet the capacity demand of AC power input, and shall meet the maximum capacity demand of AC mains power.	Switching capacity	1) Check the completion acceptance data and verify the capacity of the incoming line and switch on site capability. 2) The capacity of the incoming line and tie switch shall match the capacity of mains input power availability. 3) The capacity of the incoming line and tie switch shall meet the maximum capacity demand of AC power input.	Level 2
Distribution series	The number of medium-voltage distribution stages of the same voltage level in the building (from the mains power to the medium-voltage distribution equipment to the transformer input) should not be more than two stages.	Distribution series	According to the structure of the distribution system, check the distribution stages from the introduction of mains power into the medium-voltage distribution system to the input end of the terminal transformer.	Level 4
Standby automatic switching function	When two lines of mains power supply are configured in power supply mode of main and standby operation, the two incoming lines of the medium-voltage system shall be equipped with automatic input device of standby mains power supply and shall have manual operation function	Standby automatic switching device	Check the input function of standby power supply according to the power supply scheme approved by the power supply department and blueprints.	Level 4

Table 4 – Evaluation of medium-voltage distribution system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
	(the specific requirements shall be subject to the requirements of the local power supply department. If the power supply department has no special requirements, it should be equipped with automatic input device).			
Switch interlock	1) When the high-voltage power supply system has the function of two-way AC mains power supply, and the mains power supply is not allowed to operate in parallel, the main incoming switch and interconnection switch of the two-way AC mains power supply shall be interlocked. 2) For the medium-voltage power supply system with medium-voltage standby generator set, the main incoming switch and interconnection switch of the mains power supply and standby generator set shall be interlocked.	–	Check the interlocking mode according to the power supply scheme approved by the power supply department and blueprints.	Level 1
Relay protection	The medium-voltage equipment with relay protection device shall be powered off every year for parameter correction. The protection parameters shall be set comprehensively and reasonably to match the protected equipment.	–	Check the relay protection parameters, calculation sheet and test verification report of medium-voltage equipment.	Level 3

Table 4 – Evaluation of medium-voltage distribution system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Test report	Qualified professional departments shall regularly test the medium-voltage distribution system (including insulation resistance and withstand voltage of main components, verification of relay protection devices, lightning protection and grounding, etc.), and issue relevant test reports.	–	Inspect test report.	Level 4

7.2.2 Power supply safety operations evaluation

The safety operations evaluation for power supply of the medium-voltage distribution system includes three parts: AC power supply, Insulation and battery performance. The evaluation contents are shown in Table 5.

Table 5 – Evaluation of power supply safety operations

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Equipment performance	The equipment operates normally, and relevant monitoring, detection and alarm functions are in normal condition.	–	Check whether the operating power supply works normally on site.	Level 3
AC power supply	The operation power supply shall have two-way power input, and the two incoming lines shall have automatic and manual switching function, in which one power supply shall be set first. The two-way incoming switch room shall have mechanical and electrical interlocking function.	Dual channel power supply	Check whether the operation power supply has dual power input. Check the switching function and interlocking function of two incoming lines.	Level 3

Table 5 – Evaluation of power supply safety operations

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Insulation monitoring device	Direct current (DC) operating power supply shall be equipped with an insulation monitoring device for on-line monitoring the insulation of positive and negative buses to the earth.	–	Check whether the high-voltage DC operating power supply is equipped with insulation monitoring device.	Level 2
	1) According to the requirements of maintenance procedures, regularly check whether the insulation condition of the system is good, check whether the insulation inspection device records are abnormal, and the operation monitoring signal of each branch is intact, and the indication is normal. 2) Regularly use the insulation monitoring tester to check the reliability and data accuracy of the insulation monitoring device configured for the up to 400 V DC system.	–	1) Check the maintenance records and whether the system insulation is checked regularly. 2) Check the maintenance records, and check the insulation monitoring device of up to 400 V DC system regularly with insulation monitoring tester.	Level 3
Battery performance	If the storage battery has operated for more than 6 years, the capacity test shall be carried out every year. If the actual test capacity is lower than 80% of the rated capacity, it shall be replaced in time.	Battery capacity	Check the production date of the battery pack, check the battery pack, check the discharge test and capacity test record data.	Level 2

Table 5 – Evaluation of power supply safety operations

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Battery management	Check whether the setting of battery management parameters by the monitoring module of DC power supply system meets the working requirements of the battery pack.	Equalizing voltage. Floating charge voltage	Refer to the battery parameter setting requirements, check whether the settings of the monitoring module for the battery average charging voltage, floating charging voltage, charging current limit, battery capacity and battery down voltage are within a reasonable range.	Level 2

7.2 Transformer reliability evaluation

The reliability evaluation of transformer in telecommunication rooms or buildings includes three points: equipment performance, equipment configuration and operation performance (transformer load, three-phase load balance, harmonic influence, transformer temperature control system and temperature rise, transformer oil). The evaluation are shown in Table 6.

Table 6 – Evaluation of transformer

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Equipment performance	The service life of transformer equipment can be related to the relevant requirements, the equipment renewal cycle in the maintenance regulations or the provisions of the local power supply department.	Service life	The service life shall be calculated based on the operation time of the equipment.	Level 3
Equipment configuration	Two or more transformers should be used for class I and class II local telecommunication rooms or buildings. When one transformer fails or is overhauled, the other transformers shall meet the guaranteed load power consumption.	–	Check the completion acceptance data and verify the transformer configuration. The configuration of transformer and low-voltage distribution system shall meet the functions required by the relevant standard.	Level 2

Table 6 – Evaluation of transformer

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Transformer load	The "maximum common load" of transformer bearing communication load shall not exceed 80% of its rated capacity.	Maximum common load	The load value shall be subject to the data of low-voltage incoming cabinet of transformer.	Level 3
	When the "maximum working load" of the transformer reaches 95% of its rated capacity, the load increase of the transformer shall be strictly controlled, and it is not allowed to exceed the rated capacity or temperature rise limit of the transformer.	Maximum working load	See the definitions of "maximum common load" and "maximum working load" of transformer.	Level 2
Three phase load balance	The three-phase load of transformer should be balanced. When the transformer of y.yn0 wiring group is adopted, the neutral line current shall not exceed 25% of the rated current of low-voltage winding.	Neutral current	The power quality test instrument is used on site to measure the neutral line current of the incoming cabinet at the low-voltage side of the transformer and calculate the percentage with the rated current.	Level 2
Harmonic effect	When the total current harmonic content of the power supply system is greater than 10%, the transformer shall be used with reduced capacity.	Total current. Harmonic factor	The power quality analyser is used to measure the total current harmonic content of transformer low-voltage incoming cabinet on site. The influence degree of harmonics on the transformer is determined according to the transformer rerating curve. When no calculation is made, the regular operation load rate of ordinary distribution transformer shall not be higher than 75%.	Level 3
Transformer temperature control system and temperature rise	The temperature control system shall operate normally, and the fan of forced air-cooled transformer shall operate well.	–	Check the display function of the temperature control system of the air-cooled transformer, whether the fan operates normally, and whether the temperature rise of the transformer is within the specified range.	Level 2

Table 6 – Evaluation of transformer

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
	1) Under normal operation conditions of dry-type transformer, the winding temperature rise limit under rated current shall comply with the relevant standard. The temperature rise under non rated current shall not exceed the nominal temperature rise. 2) The top oil temperature of oil immersed transformer shall not often exceed 85°C, and the maximum top oil temperature shall not exceed 95°C.	Winding temperature rise	Based on the data displayed by the transformer temperature control system, check whether the transformer temperature rise is abnormal, and the winding temperature rise of dry-type transformer shall be within the value specified in the standard.	Level 2
Oil-immersed power transformer	Before the equipment is put into operation, after overhaul and during operation, it shall be in accordance with related guidelines for maintenance and management of operating transformer oil stipulates that the quality of transformer oil shall be evaluated at different inspection cycles. During normal operation, the oil level shall be within the marked range, and the colour of desiccant shall be normal.	–	Inspect the transformer oil according to the manufacturer's regulations or annex requirements. If the oil level is abnormal, confirm whether there is oil leakage, oil leakage, etc. The colour of desiccant is normal.	Level 3

7.3 Low-voltage power supply system reliability evaluation

The reliability evaluation of low-voltage power supply system in telecommunication rooms or buildings include two contents: equipment performance and equipment configuration (reactive power compensation, power switching device, distribution level, shunt use, transformer installation, switch matching and setting).

The evaluation contents are shown in Table 7.

Table 7 – Evaluation of low-voltage power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Equipment performance	1) Performance evaluation of low-voltage distribution equipment. 2) The service life of low-voltage distribution equipment can refer to the relevant requirements, the equipment renewal cycle in the maintenance regulations or the provisions of the local power supply department.	Service life Fault definition	1) Equipment performance evaluation shall be based on equipment fault definition. 2) The service life shall be calculated based on the operation time of the equipment. It should be noted that the service life of distribution equipment, capacitor and active filter is different.	Level 3
Equipment configuration	In the low-voltage power supply system, the main incoming switch and bus of transformer and oil engine shall be configured according to the long-term load of the low-voltage bus of this section.	–	Check the completion acceptance data and verify the sectional area and current carrying capacity of the bus bar. The capacity of the main switch of the incoming line shall match the capacity of the bus bar.	Level 2
Static volt-ampere reactive compensator	When the harmonic of the line where the compensation capacitor is located is serious, the compensation capacitor cabinet shall be equipped with a certain proportion of reactor according to the harmonic content.	–	Check the completion data, check whether the capacitor bank is connected in series with reactance, and determine whether the reactor proportion is reasonable according to the harmonic content of the system.	Level 2
	Main inspection contents of low-voltage capacitor cabinet: 1) whether all devices have abnormal vibration, abnormal sound and peculiar smell; 2) check whether the capacitor has liquid leakage and bulging.	–	Check the working condition of low-voltage capacitor cabinet, capacitor and reactor on site.	Level 3

Table 7 – Evaluation of low-voltage power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Power switching device	The power supply (mains or generator set) switching device can adopt automatic or manual switching mode, and shall have an interlocking function. It can adopt automatic switching switch with middle position, double throw knife switch or double air circuit breaker for interlocking. It is forbidden to use the overlapping switch of double contactors to switch the two power supplies.	–	Check whether the power switching device meets the regulations, and test and verify whether the switching function is correct; The hidden danger level of power switching devices set in the first and second level distribution systems is level 2. The hidden danger level of the power switching device set in the third level distribution system is level 3.	Level 2/ Level 3
Distribution series	The wiring of low-voltage power supply systems shall be simple and reliable. The power distribution level from the output end of transformer to UPS, DC system and other machine room power supply equipment or machine room air conditioner shall not exceed three levels.	–	Check the wiring of low-voltage power supply system. For a power distribution device, the main incoming switch and outgoing switch are closed separately, which is called primary power distribution.	Level 4
Shunt use	Two distribution shunts with smaller capacity shall not be connected in parallel and used as distribution shunts with larger capacity. One distribution shall not be shunted to directly supply power to multiple equipment at the same time.	–	Check whether the shunting of power distribution system meets the requirements on site.	Level 2

Table 7 – Evaluation of low-voltage power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Current transformer	For the installation of transformer, overlapping installation (i.e., overlapping of shells) shall be avoided for three-phase transformers A, B and C. the wiring mode of transformer shall consider later maintenance to avoid open circuit during maintenance.	–	Observe whether the installation mode of transformer meets the requirements.	Level 3
Switch matching and setting	The parameters of distribution switches at all levels shall be set according to the load conditions, and there shall be selectivity between upper and lower switches. With the expansion of communication load, the tripping setting value of the switch shall be adjusted accordingly.	–	Check the parameter setting and load matching of distribution switches at all levels. The parameter setting of distribution switches at all levels of low-voltage power supply system shall comply with relevant standard.	Level 3

7.4 Battery string reliability evaluation

Considering the safety and reliability of telecommunication rooms or buildings, the 48 V lithium-ion battery energy storage system is used in telecommunication rooms or buildings, and the lithium-ion battery cell with the metal shell of the lithium iron phosphate chemical system is preferred. The safety and reliability evaluation of the battery system in the telecommunication rooms or buildings covers the following items: appearance, charging and discharging capability, IP protection, paralleling, battery management system (BMS), electromagnetic compatibility, fire-extinguishing function, northbound communication, electrical safety, thermal reliability, mechanical reliability, and environmental reliability, the evaluation criteria are reported in Table 8, the HSL for battery are reported in clause 6.4.

If not stated in table verification description, all verification is performed at room temperature 25 ± 3°C and if state of charge (SOC) is not stated, the verification is performed at 50% SOC.

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Appearance	a) The surface of the battery system should be clean without obvious deformation or mechanical damage, and the interface contacts should not be rusty. b) The surface of the battery system shall have necessary product labels that are clear and free from dirt. c) The positive and negative terminals and polarity of the battery system shall be marked clearly. d) Interfaces for power and communication (or alarm) of the battery system shall be clearly marked.	–	Check the appearance by visual inspection, check the polarity with a voltage-measuring instrument, and confirm that the mark is consistent with the actual polarity.	Level 3

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Charge and discharge capacity	1) The charging and discharging current of the battery system is not less than $10I_{10}$ A. 2) The BMS shall have the function of autonomous current limiting. When the charging current is greater than the charging current limiting value of the battery system, the charging current shall remain at the charging current limiting value without increasing, and the charging and discharging current limiting point shall be set. The current limiting point can be set within the range of $1I_{10}$ A to the maximum allowable charge or discharge current. 3) The battery system supports constant voltage discharge. The discharge voltage ranges from 48 V to 57 V which can be set based on the site requirements. The battery system has a load capacity of not less than 4 800 W. 4) The power terminal of the battery system should meet the requirements for connecting cables with a current carrying capacity of not less than $10I_{10}$ A. The temperature rise of the power terminals must not exceed 50°C when the power terminals are discharged at a temperature of at least 4 800 W.	–	1) The battery system discharges at $10I_{10}$ A and detects the actual discharge current. 2) The battery system is charged to the full charge state at the default current limit value ($1.5I_{10}$ A), and the current value during charging is detected. Randomly select a current value (non-factory default current limit value) from $1I_{10}$ A to maximum allowable discharge current, set the random current value to the charging current of the test sample, and set the current value of the charging device to be greater than that of the test sample, and charge the device to the full charge state. Detects the current value during charging. 3) The battery system discharges 4 800 Wh at 57 V constant voltage and detects the output voltage. 4) Set battery's discharging capacity not less than 4 800W. Measure the temperature rise of the power output port during the entire process.	Level 1

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
IP protection	The protection level of the battery system must be ingress protection 20 (IP20) or higher. The battery system shall be able to prevent the intrusion of liquid drop from the top. After verification as required, no safety risk above HSL2 will occur.		Perform the test according to the method required by IP20 in [IEC 60529]. According to the IPx1 test method in [IEC 60529], the top drip time reference [ETSI EN 300 019-2-4] shall be kept for 30 min and maintained for 48 h.	Level 2
Corrosion	The enclosure of the mechanical and electrical unit container of the battery system shall be made of metal with certain protective coating. After the salt spray test in environmental reliability, check the appearance of the test sample and the surface of each level for defects such as corrosion, blistering, cracking (crack). A small amount of corrosion is allowed (the length and diameter of the defect not to exceed 1 mm). The corrosion area does not exceed 0.5%. The corrosion area meets the requirements of class 7 of [ISO 10289].		For details about the test methods, can refer to Salt Spray Test Methods in Environmental Reliability.	Level 2
Parallelling	The battery system should be able to meet the requirements of at least 32 groups parallel use. When the parallel battery system discharges with the maximum discharge power, the parallel output power shall not be degraded, i.e., the 32 parallel battery strings shall not be lower than the maximum discharge power of a single battery string times 32.		Charge the battery system to the full charge state according to the standard charging and discharging method agreed between the manufacturer and customer. Take 32 parallel battery strings for test samples and test the load capacity after the battery is connected.	Level 1

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Equalization	In constant voltage mode, batteries of the same manufacturer are discharged in parallel, and the remaining SOC of the other battery string is <5% after one battery string is discharged, regardless of whether monitoring and management are enabled.		Two battery systems are connected in parallel. Set the SOC to 70% and 100%, respectively. Set the discharge output voltage to 57 V. Discharge 60% of the sum of the rated power of the two battery systems. Record the remaining SOC of battery system 2 when battery system 1 terminates discharge.	Level 2
Battery management system	**1 Information collection** Each battery system must be equipped with BMSs, and the BMS temperature collection must be at least six groups. At least four groups of battery temperature collection, at least one group of battery system internal ambient temperature collection, and at least one group of power metal oxide semiconductor temperature collection. Sample the voltage and current of each battery cell, battery pack voltage and current, and the voltage and current of the BMS power output port. The sampling frequency for the current, voltage, and temperature must be not less than 2 Hz, 2 Hz, and 0.5 Hz, respectively.		**1 Information collection** Connect the battery system to the host computer software, and check the temperature, voltage, current collection function, number of information collection, and information collection frequency of the BMS. **2 Sampling precision** Keep the battery system at the ambient temperature for at least 12 h, and start the BMS to collect the cell voltage and battery system voltage. The battery system is charged and discharged according to the standard charging and discharging method agreed between the manufacturer and the customer. (Only the discharge test can be performed at −20°C.) Connect an external device to collect current data. Export the BMS background data and check the charging and discharging status records, current, and temperature parameters. Compare the precision of the sampled data of the external high-precision device with that of the BMS.	Level 1

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
	2 Sampling precision When the ambient temperature is 25 ± 3°C, the battery voltage error must be ≤5 mV, the battery system voltage accuracy must be ≤0.5%, the current error during charging and discharging must be ≤1% (20% to 100% rated power), and the temperature error must be ≤2°C. When the ambient temperature is 45 ± 3°C, the battery voltage error must be ≤10 mV, the battery system voltage accuracy must be ≤0.5%, the current error during charging and discharging must be ≤1% (20% – 100% rated power), and the temperature error must be ≤2°C. When the ambient temperature is −20 ± 3°C, the battery voltage error must be ≤10 mV, the battery system voltage accuracy must be ≤0.5%, the current error during discharge must be ≤1% (20% to 100% rated power), and the temperature error must be ≤2°C.		**3 SOC calculation** Place the battery system in a constant temperature environment of 15°C ± 3°C and 45 ± 3°C for 12 h, and perform a charge and discharge cycle according to the standard charge and discharge current test agreed between the manufacturer and the customer. In addition, an external battery capacity tester is connected to measure the charging and discharging capacities to verify the SOC accuracy of the BMS. **4 Reverse connection protection** Reversely connect the positive and negative terminals of the charging device to the positive and negative terminals of the battery system in the hibernation state to verify the reverse connection protection function of the BMS.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
	3 SOC calculation The BMS shall have the function of calculating the SOC. The difference between the calculated value and the actual battery capacity must be ≤5% when the ambient temperature is 15°C to 60°C. **4 Reverse connection protection** When the positive and negative polarities of the external charging device and the positive and negative polarities of the BMS are reversed, the BMS is not damaged and is in the cut-off protection state. After the battery is powered on, Onsite alarms can be generated after the power-on button is pressed.			
Ripple voltage	During constant voltage discharge, the peak-to-peak ripple voltage within the frequency band of 0 MHz to 20 MHz should be ≤200 mV.		Set the discharge output voltage of the battery system to 57 V, discharge the battery at the rated power, set the oscilloscope bandwidth to 20 MHz, and set the scanning rate to <0.5 s. Use the AC coupling mode of the input channel of the oscilloscope to measure the maximum peak-to-peak ripple voltage at the output port of the battery system.	Level 3

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Charge-to-discharge voltage drop	During charging-to-discharging, the maximum voltage drop of the power port must be ≤8%.		The SOC of the battery system is 50%, the output voltage of the external charging device is set to 57 V, and the charging current limit of the charging device is greater than the sum of the charging current limit of the battery system and the load. The discharge output voltage of the battery system is set to 55 V, and the load is 20% and 100% of the rated power of the battery system. Disconnect the AC power from the external charging device, calculate the difference between the minimum output voltage of the battery system and the preset value, and calculate the ratio of the voltage drop to the preset value.	Level 1
Overshoot and undershoot of discharge dynamic loads	When switching from no load to full load, the undershoot amplitude of the power port voltage should not be greater than 8%. When switching from full load to no load, the undershoot of the power port voltage shall not exceed 5%.		Set the discharge output constant voltage of the battery system to 57 V and the load change slope to 0.1 A/us. Measure the difference between the configured value and the lowest voltage of the power port during the single switchover from no-load to full-load of the battery system as the undershoot. During the single switching from full load to no load, the difference between the maximum voltage of the power port and the set value is used as the overshoot. The ratio of the overshoot and undershoot to the set value is calculated.	Level 1

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Electromagnetic compatibility	**a) Electrostatic discharge (ESD) immunity** The battery system shall meet the requirements of grade 4 of [IEC 61000-4-2]. **b) Conducted disturbance limit** The battery system conduction disturbance limits shall be in accordance with clause 5.1 of [IEC CISPR 32]. **c) Radiation disturbance limit** The radiation disturbance limits of the battery system shall be in accordance with the requirements in Table 6 of [IEC CISPR 32]. **d) Surge (shock)** The communication port and power port of the battery system shall adopt corresponding isolation measures. The wire-to-wire of the communication port shall meet the requirements of grade 2 (open circuit test voltage 0.5 kV) of [IEC 61000-4-5], and the wire-to-ground shall meet the requirements of grade 2 (open circuit test voltage 1 kV) of [IEC 61000-4-5]; The power port wire-to-wire shall meet the requirements of grade 4 (open circuit test voltage 2 kV) of [IEC 61000-4-5], and the wire-to- ground shall meet the requirements of grade 4 (open circuit test voltage 4 kV) of [IEC 61000-4-5].		**a) ESD immunity** The battery system shall be tested according to the method specified for grade 4 of [IEC 61000-4-2]. **b) Conducted disturbance** Under the condition that the equalized charging voltage is 56.4 V and the charging current is $1I_{10}$ A and $10I_{10}$ A, the battery system discharges at 53.5 V constant voltage and the load is not less than 4 800 W, and the test is conducted according to the test method specified in grade A of [IEC CISPR 32]. **c) Radiated disturbance limit** The battery system shall be tested according to the method specified in grade B of [IEC CISPR 32]. **d) Surge** The battery system shall be tested according to the relevant clauses of [IEC 61000-4-5] and shall meet the corresponding requirements.	Level 2

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Northbound communication	The battery system shall provide the following functions: **a) Status information** The operating status, temperature, current, voltage, SOC, and state of health of the battery system can be reported to the monitoring system. **b) Alarm and protection** The alarms and protection information about the battery system, such as overvoltage, undervoltage, overcurrent, and high and low temperature, can be reported to the monitoring system. **c) Information reporting** The battery system information can be reported. The electronic label must contain the battery system code, name, production time, and manufacturer name. **d) Software upgrade** Supports the software upgrade function.		**a) Status information** Connect the battery system to the north-bound monitoring system and adjust the battery system to the normal operating state. The battery system is charged and discharged according to the standard charging and discharging current agreed by the manufacturer and the customer. Check the battery system status on the monitoring system. **b) Alarm and protection** Connect to the northbound monitoring unit and check the information reported by the battery system to the monitoring unit. **c) Information reporting** When the battery system communicates with the monitoring unit and is running properly, check the battery system information on the monitoring unit. **d) Software upgrade** The battery system communicates with the monitoring system. The monitoring system loads the battery system software upgrade.	Level 2

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Fire-extinguishing function	A fire-extinguishing device must be integrated inside the battery box to implement automatic fire suppression and all-weather fire protection. The fire-extinguishing agent in the device shall be stored in a non-pressure vessel at room temperature and stored in air without corrosion. After the fire-extinguishing agent is released, it shall be well insulated to avoid secondary disasters or hazards to the environment and products. During the verification of electrical safety, thermal reliability, mechanical reliability, and environmental reliability, the battery system shall meet the corresponding HSL level, and the fire-extinguishing device shall not operate incorrectly during the verification, and there shall be no leakage of extinguishing agent when there is no thermal runaway or fire. If a fire occurs during the test, the fire-extinguishing device shall be able to: start in time to eliminate the fire; and spray the fire-extinguishing agent normally.		**1 Thermal diffusion** Heat or overcharge the battery system information on this test are available in Appendix C of [b-GB 38031]. a) Use one of heating or overcharging. See [b-GB 38031] for internal temperature monitoring points of the battery system. Monitor and record the sample quality before and after the test, target battery voltage and total battery voltage. b) Thermal runaway triggered by heating: The power of heating devices such as heating plate or heating rod is heated to 300°C by see [b-GB 38031], and is maintained until the heating of the battery cell is stopped after thermal runaway triggered, or is maintained for 4 h at this temperature. If no heat runaway occurs, the battery stops heating. c) Overcharge triggering thermal runaway: the triggering battery is charged at the maximum charging current declared by the battery manufacturer, and the constant current is charged to 200% SOC or the maximum charging voltage of the battery that may be reached under the single fault state, and the charging is stopped or the battery protection device acts to cut off the charging.	Level 1

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
	Trigger the fire-extinguishing device by the corresponding triggering method. After the fire-extinguishing agent is sprayed out of the battery system, test that the resistance and strength of insulation meet the corresponding requirements. During the verification of electrical, thermal, mechanical, and environmental safety and reliability, the battery system shall meet the corresponding HSL rating, and the fire-extinguishing device shall also meet the requirements of no mis-operation and no leakage of extinguishing agent when there is no heat runaway or fire. If fire occurs during the experiment, the fire-extinguishing device shall be able to: start to eliminate the fire in time; and spray fire-extinguishing agent normally.		e) If fire or explosion occurs during heating, the test shall be terminated and HSL shall be recorded according to the phenomenon evaluation; If no ignition or explosion occurs at the end of heating, observe for 1 h. **2 Thermal runaway determination method** a) The voltage drop of the battery cell is triggered and the voltage drop exceeds 25% of the initial voltage. b) The temperature of the monitoring point reaches the maximum operating temperature specified by the manufacturer. c) Temperature rise rate of monitoring point $dT/dt \geq 1°C/s$ for more than 3 s. When a) + c) or b) + c) occurs, the battery unit is determined to be in thermal runaway.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
	Thermal diffusion The battery system must be able to meet the thermal diffusion test. The battery in the battery system cannot be diffused to adjacent battery systems. If the battery system is ignited after thermal runaway, the fire-extinguishing device shall be able to extinguish the fire of the thermal runaway battery system in time. The fire shall not spread to the outside of the cabinet, i.e., if a thermal runaway fire occurs during the test, the fire-extinguishing device shall be able to extinguish the fire of the thermal runaway battery system. The HSL of the battery system thermal diffusion test shall not exceed HSL3. **Thermal diffusion ignition** For a battery system with fire-extinguishing components located inside the battery system, the battery system must meet the fire-extinguishing test that simulates an external fire of the battery system. The fire-extinguishing components can extinguish the fire of the battery system.		**3 Thermal diffusion ignition** At room temperature, the test shall be conducted at a wind speed of no more than 3 m/s or indoors. The shell and busbar of the sample to be tested are allowed to be damaged. If the IP protection is affected due to a new hole added in the test, certain sealing measures can be taken to make the IP protection level consistent with the normal product. In the test sample, at least the temperature of the thermally runaway cell, the thermally runaway neighbouring cell, and the edge cell should be collected, and an external charging device should be used to overcharge one cell in the battery system until the thermal runaway cell is overcharged by 10 I_{10} A. After hearing the valve opening sound of battery heat runaway or seeing smoke, use a fire source to ignite the battery near the passage or smoke overflowing place where the battery system communicates with the outside environment. Record the voltage, temperature, and time from the start of the fire-extinguishing component setup to extinction of the.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
	Off-cabinet ignition thermal diffusion battery system For the battery system with fire-extinguishing components located inside the battery system, the cabinet shall be used according to the actual delivery. At least three battery system samples shall be placed inside the cabinet, and the three samples shall be installed adjacently in the cabinet. The battery system shall meet the fire-extinguishing test of simulating fire outside the cabinet. The fire-extinguishing device extinguishes the fire of the battery system.		**4 Off-cabinet ignition thermal diffusion battery system** Place at least three battery system samples adjacent to each other in the cabinet. After the samples are fully charged according to the standard charging and discharging method agreed by the manufacturer and the customer, perform an overcharge to trigger a thermal diffusion test on the sample in the middle. Disconnect the external charging device after the valve opening sound is heard or smoke overflows. Use an external fire source to ignite the battery near the aisle or at the smoke overflow place where the cabinet is connected to the external environment until an open flame occurs on the battery. Record the voltage, temperature, and time from the start of the fire-extinguishing component setup to extinction of the fire.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Electrical safety	a) Except the insulation strength and insulation resistance test, the hazard severity level of other electrical safety tests shall not exceed HSL2. b) The insulation strength test of the battery system shall be conducted without breakdown and arcing, and the hazard severity level shall not exceed HSL1. c) Conduct insulation resistance test for the battery system. The insulation resistance between the positive and negative terminals of the battery and the metal shell of the battery system shall be not less than 2 MΩ, and the hazard severity level shall not exceed HSL1.		**1 Overcharge** After the cell is fully charged according to the standard charging and discharging method agreed between the manufacturer and the customer, charge the cell with a constant current of $1I_1$ A to 1.1 times of the termination voltage or 115% SOC, and then stop charging. After the preceding test steps are completed, observe the cell in the experimental environment for 1 h. **2 Over-discharge** After the cell is fully charged according to the standard charging and discharging method agreed between the manufacturer and the customer, discharge the cell at a current of $1I_1$ A for 90 min. After the preceding test steps are completed, observe the cell in the experimental environment for 1 h. **3 External short circuit** After the cell is fully charged according to the standard charging and discharging method agreed between the manufacturer and the customer, short-circuit the positive and negative terminals of the test object for 10 min. The external circuit resistance is <30 ± 10 mΩ. After the preceding steps are completed, observe the test object in the test environment for 1 h.	Level 1

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
			4 Overcharge protection After the battery system is fully charged in accordance with the standard charging and discharging method agreed between the manufacturer and the customer, adjust the SOC of the test object to the middle of the normal operating range recommended by the battery system manufacturer (e.g., using external charging and discharging equipment), as long as the test object can be operated. No precise adjustment is required. Before the test starts, all protective equipment affecting the function of the test object and related to the test result shall be in normal operation, and all relevant main contactors for charging shall be closed (e.g., relevant relays in the battery system loop). The charging process is as follows. The external charging equipment shall be connected to the main terminal of the test object and the charging control restrictions of the external charging equipment shall be disabled. The test object shall be charged by external charging equipment at a rate not less than $1.5I_{10}$ A.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
			The charge shall continue until the test is completed when any of the following conditions are met: a) the test object automatically terminates the charging current; b) the test object sends a signal to terminate the charging current. When the overcharge protection control of the test object does not work or does not have the function, the test object is charged so that the temperature of the test object exceeds the maximum operating temperature of the battery system by 10°C. When the charging current is not terminated and the temperature of the test object is below the maximum operating temperature of 10°C, the charging shall continue for 12 h. After the preceding test steps are completed, observe the temperature at the test environment for 1 h.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
			5 Insulation resistance After the battery system is fully charged according to the standard charging and discharging method agreed between the manufacturer and the customer, use an insulation resistance tester to test the battery system metal shell with the positive and negative terminals of the tested battery at the DC test voltage of 500 V. Removal of the BMS surge protection device is allowed. The insulation resistance between the positive and negative terminals of the battery system and the metal enclosure of the battery system is not less than 2 MΩ. **6 Insulation strength** After the battery system is fully charged according to the standard charging and discharging method agreed between the manufacturer and the customer, use a voltage withstand tester to test the positive and negative terminals of the battery and the metal shell of the battery system at 50 Hz and an AC voltage of 500 V effective value or 710 V DC voltage. Removal of BMS surge protection devices is allowed.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Mechanical reliability	The mechanical reliability test of the battery system hazard severity level shall not exceed HSL2.		**1 Impact test** Test the cell by referring to clause 7.2.2 of [IEC 62619]. **2 Vibration** Test the battery system vibration according to section 38.3 of [b-UN]. **3 Drop** Prior to the start of the test, adjust the SOC of the test subject to not less than 50%. Place the simulated battery system in the cabinet or packing box. Drop the battery system from a height of 1 m to the concrete table for one time. **4 Shocks** Test the battery system according to section 38.3 of [b-UN].	Level 1
Thermal reliability	During the thermal safety test of the battery system, the hazard severity level should not exceed HSL2.		**1 Heating** After the cell is fully charged according to the standard charging and discharging method agreed between the manufacturer and the customer, place the test object in a warm chamber, and increase the ambient temperature from 5°C/min to (130 ± 2)°C for 30 min.	Level 1

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
			2 Overheat protection At the beginning of the test, all protective equipment affecting the function of the test object and related to the test results shall be in normal operation. Attach the point thermometer probe with continuous memory function to the surface of the battery, place the battery into the temperature chamber for testing, charge the battery system, adjust the temperature of the temperature chamber to rise to the high temperature protection point at 3°C/min, maintain it for 10 min, and then decrease the temperature to the high temperature recovery point. The test shall be terminated when any of the following conditions are met: a) automatic termination or restriction of charge or discharge of the test object; b) the test object sends a signal to terminate or limit the charge or discharge; c) the temperature of the test object is stable, and the temperature change is <6°C within 2 h. After the preceding test steps are completed, observe the temperature at the test environment for 1 h.	

Table 8 – Evaluation of batteries in power supply system

Evaluation item	Evaluation criteria	Key indicators	Evaluation method	Risk level
Environment reliability	The environmental reliability test of the battery system shall not exceed HSL2.		After the battery system is fully charged according to the standard charging and discharging method agreed between the manufacturer and the customer, the test shall be conducted according to the method specified in clause 5.5.2 of [ISO 16750-4] under the test conditions of [IEC 60068-2-11]. The salt solution is prepared from sodium chloride (analytical grade) and distilled or deionized water, at a concentration of 50 ± 10 g/l and a pH value of 6.5 to 7.2 at 35 ± 5°C. Put the test object into a salt spray chamber for test over two cycles, i.e., 48 h. The test subjects are sprayed at 35 ±5°C for 8 h, then allowed to stand for 16 h, and the BMS turned on between the fourth and fifth hours of a cycle to test the battery status.	Level 2

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