电子电气零部件环境可靠性规范

Electrical and Electronic Component Environmental Reliability Specification

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华人运通（山东）科技有限公司 发布

前言

Preface

本标准主要用于规范车辆电子电器零部件的环境可靠性设计和测试工作。

本标准主要包括电气负荷、机械负荷、气候负荷、化学负荷、防护等级、寿命耐久等内容。

本标准不涉及电磁兼容性、连接器性能、ELV、VOC 等要求。

本标准由中英文版本组成，若英文版本与中文版本内容有异，以中文版本内容为准。

This standard specifies requirements is mainly used to ensure the environmental reliability design and validation of vehicle electronic and electrical component.

This standard mainly includes electrical load, mechanical load, climatic load, chemical load,IP grade, life endurance test and so on.

This standard does not cover electromagnetic compatibility, connector performance, ELV, VOC and other requirements.

This standard is composed of Chinese and English versions, Should there be any inconsistencies between Chinese and English versions, the Chinese version shall prevail.

修订历史 Revision History

版本 Rev.	日期 Date	修订描述 Change Description
1.0	2018/12/30	初始发布 Initial Release
1.1	2020/11/11	更新了电性能部分，updated for electrical performance 更新了环境部分，盐雾试验，机械冲击试验，机械耐久试验 Updated for salt spray test，mechanical shock test，mechanical endurance test
1.0	2022/2/28	企标编号变更为 Q/HH-TS002-2022 Standard No. change to Q/HH-TS002-2022

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1 范围 Scope

本标准规定了乘用车 12V 电子电气零部件产品的环境可靠性技术要求和试验方法。

本标准适用于华人运通公司开发的全部车型。

This document provides technical requirements and test methods for environmental reliability of 12V electronic and electrical component for road vehicles.

This document applies to all models developed by Human Horizons.

2 规范性引用文件 Referenced standards

下列文件对于本企业标准的应用是必不可少的。凡是注日期的引用文件，仅注日期的版本适用于本标准。凡是不注日期的引用文件，其最新版本（包括所有修改单）适用于本标准。

GB/T 28046.1-2011 道路车辆 电气及电子设备的环境条件和试验 第 1 部分一般规定

GB/T 28046.2-2011 道路车辆 电气及电子设备的环境条件和试验 第 2 部分电气负荷

GB/T 28046.3-2011 道路车辆.电气和电子设备的环境条件和试验_第 3 部分机械负荷

GB/T 28046.4-2011 道路车辆.电气和电子设备的环境条件和试验_第 4 部分气候负荷

GB/T 28046.5-2013 道路车辆.电气和电子设备的环境条件和试验_第 5 部分化学负荷

GB/T 2423.1-2008 电工电子产品环境试验 第 2 部分试验方法 试验 A 低温

GB/T 2423.22-2002 电工电子产品环境试验 第 2 部分： 试验方法 试验 n： 温度变化

GB/T 2423.17-2008 电工电子产品环境试验+第 2 部分：试验方法+试验 Ka：盐雾

GB/T 2423.18-2000 电工电子产品环境试验+第 2 部分：试验方法+试验 Kb：盐雾,交变

GB/T 2423.4-2008 电工电子产品环境试验 第 2 部分：试验方法 试验 Db： 交变湿热(12h＋12h 循环)

GB/T 2423.2-2008 电工电子产品环境试验 第 2 部分：试验方法 试验 B：高温

GB/T 2423.3-2006 电工电子产品环境试验 第 2 部分：试验方法 试验 Cab：恒定湿热试验

GB/T 2423.34-2005 环境试验 第 2 部分：试验方法 试验 Z/AD：温度湿度组合循环试验

GB/T 2423.51-2000 电工电子产品环境试验 第 2 部分试验方法 试验 Ke：流动混合气体腐蚀试验

ISO 16750-1-2018 道路车辆 电气和电子设备的环境条件和试验 第 1 部分：总则

ISO 16750-2-2012 道路车辆 电气和电子设备的环境条件和试验 第 2 部分：电气负荷

ISO 16750-3-2012 道路车辆 电气及电子设备的环境条件和试验 第 3 部分：机械负荷

ISO 16750-4-2010 道路车辆 电气和电子设备的环境条件和试验 第 4 部分：气候负荷

ISO 16750-5-2010 道路车辆 电气及电子设备的环境条件和试验 第 5 部分：化学负荷

ISO 12103-1 道路车辆 过滤器评价用的试验灰尘 第 1 部分：亚利桑那试验灰尘

ISO 20567-1-2017 涂层材料 涂层的耐碎石冲击试验 第 1 部分：多重击打试验

ISO 20653-2013 道路车辆 防护等级(IP 代号) 针对异物、水及接触的电气设备防护

ISO/IEC 17025-2017 检测和校准实验室能力的通用要求

IEC 60068-2-1-2007 环境影响 第 2-1 部分：试验 试验 A：低温

IEC 60068-2-2-2007 环境影响 第 2-2 部分：试验 试验 B：干热

IEC 60068-2-11-1981 环境试验第 2-11 部分：试验 试验 Ka：盐雾试验

IEC 60068-2-14-2009 环境试验第 2-14 部分：试验 试验 N：温度交变试验

IEC 60068-2-27-2008 环境影响第 2-27 部分：试验 试验 Ea 及其指导：冲击
IEC 60068-2-30-2005 环境影响第 2-30 部分：试验 试验 Db：“湿热，循环”
IEC 60068-2-38-2009 环境试验第 2-38 部分：试验 试验 Z/AD：“组合试验，温度/潮湿，循环”
IEC 60068-2-52-2017 环境试验第 2-52 部分：试验 试验 Kb 循环盐雾(氯化钠溶液)
IEC 60068-2-60-2015 环境试验第 2-38 部分：试验 试验 Ke：流动混合气体腐蚀试验
IEC 60068-2-64-2008 环境试验第 2-64 部分：试验 试验 Fh：振动、宽带随机和指南
IEC 60068-2-78-2012 环境试验第 2-78 部分：试验 试验 Cab：温度/潮湿，恒定
DIN 75220-1992 汽车零件在阳光模拟系统中的老化

The following documents are essential to the application of the enterprise specification.A dated version of any referenced document is applicable to this standard.For undated reference documents, the latest version (including all amendments) applies to this document.

ISO 16750-1-2018 Road vehicle—Environmental conditions and testing for electrical and electronic equipment—Part 1：General
ISO 16750-2-2012 Road vehicle—Environmental conditions and testing for electrical and electronic equipment—Part 2: Electrical loads
ISO 16750-3-2012 Road vehicle—Environmental conditions and testing for electrical and electronic equipment—Part 3: Mechanical loads
ISO 16750-4-2010 Road vehicle—Environmental conditions and testing for electrical and electronic equipment—Part 4: Climatic loads
ISO 16750-5-2010 Road vehicle—Environmental conditions and testing for electrical and electronic equipment—Part 5: Chemical loads
ISO 12103-1 Road vehicles -- Test contaminants for filter evaluation -- Part 1: Arizona test dust
ISO 20567-1-2017 Paints and varnishes -- Determination of stone-chip resistance of coatings -- Part 1: Multi-impact testing
ISO 20653-2013 Road vehicles -- Degrees of protection (IP code) -- Protection of electrical equipment against foreign objects, water and access
ISO/IEC 17025-2017 General requirements for the competence of testing and calibration laboratories
IEC 60068-2-1-2007 Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2-2007 Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-11-1981 Basic environmental testing procedures - Part 2-11: Tests - Test Ka: Salt mist
IEC 60068-2-14-2009 Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-27-2008 Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock
IEC 60068-2-30-2005 Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic
IEC 60068-2-38-2009 Environmental testing - Part 2-38: Tests - Test Z/AD: Composite temperature/humidity cyclic test
IEC 60068-2-52-2017 Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution)

IEC 60068-2-60-2015 Tests - Test Ke: Flowing mixed gas corrosion test

IEC 60068-2-64-2008 Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance

IEC 60068-2-78-2012 Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state

IEC 60068-2-5-2018 Environmental testing - Part 2-5: Tests - Test S: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering

DIN 75220-1992 Ageing automobile components in solar simulation units

3 术语和定义 Terms and definitions

3.1 缩略语 Abbreviations

本标准涉及的常用缩略语定义见表 1。Common abbreviations for this documents are defined in table 1

表 1 常用缩略语 Table 1 Common abbreviations

缩写 Abbreviation	定义 Definition
DUT	被测件 Device Under Test
FPSC	功能状态分类 Functional Performance Status Classification
PSD	功率谱密度 Power Spectrum Density
CTS	零部件技术规范 Component Technical Specification
DVP	开发验证计划 Development Validation Plan

3.2 电压和电流 Voltages and currents

本标准涉及的电压和电流符号定义见表 2。The voltage and current involved in this document are defined in table 2.

表 2 电压和电流符号定义 Table 2 Abbreviations for voltages and currents

缩写 abbreviation	定义 Definition
U_N	额定电压 Nominal voltage
U_{min}	试验期间可能出现的最低电压 Minimum voltage that may occur during a test
U_{max}	试验期间可能出现的最高电压 Maximum voltage that may occur during a test
U_B	工作电压 Operating voltage
U_{Bmin}	工作电压下限值 Lower operating voltage limit
U_{Bmax}	工作电压上限值 Upper operating voltage limit
U_A，U_T，U_S，U_R	启动电压脉冲的电压水平 Voltage level of the start voltage pulse
U_{test}	试验电压 Test voltage
U_{pp}	峰峰电压 Peak-peak voltage
U_{eff}	电压有效值 RMS value of a voltage
I_N	额定电流 Nominal current
GND	接地端 Device ground

3.3 温度 Temperatures

本标准涉及的温度符号定义见表 3。The temperature involved in this document are defined in table 3.

表 3 温度符号定义 Table 3 Abbreviations for temperature

缩写 abbreviation	定义 Definition
T_{RT}	室温 Room temperature
T_{min}	最低工作温度 Minimum operating temperature
T_{max}	最高工作温度 Maximum operating temperature
T_{test}	试验温度 Test temperature
$T_{op,min}$	最低工作温度（对于有温度保护功能的 DUT）Minimum operating temperature for component with overload protection/low-temperature protection
$T_{op,max}$	最高工作温度（对于有温度保护功能的 DUT）Maximum operating temperature for component with overload protection/over-temperature protection

3.4 时间 Times/durations

本标准涉及的时间符号定义表 4。The time involved in this document are defined in table 4.

表 4 时间符号定义 Table 4 Abbreviations for Time

缩写 abbreviation	定义 Definition
t_{test}	试验持续时间 Test duration
T_{oper}	使用寿命期间的工作小时数 Operating hours over service life
t_r	上升时间/Risetime
t_f	下降时间/Falltime

3.5 其它 Others

本标准涉及的其它符号定义表 5。The others involved in this document are defined in table 5.

表 5 其它符号定义 Table 5 Abbreviations for others

缩写 abbreviation	定义 Definition
R_i	电源（包括供电线束）的内电阻 Internal resistance of the power supply (including the power supply wiring harness)
f	频率 Frequency

4 一般要求 General requirements

测试必须按照以下测试条件进行，相关的偏离项应该在测试报告中进行备注。

The test must be conducted in accordance with the following test conditions, and relevant deviations should be noted in the test report.

4.1 测试环境 Temperature specifications

除非本标准另有明确定义，所有试验温度值定义均为 DUT 周围空气温度。

除非本标准另有明确定义，DUT 环境温度和湿度应满足下述要求：

——相对湿度范围（25%~75%）RH

——室温 T_{RT}=（23±5） ℃

——试验温度 $T_{test}=T_{RT}$

Unless otherwise specified, all temperature specifications as per the ambient air of the DUT.

Unless otherwise indicated, the standard values as below apply.

——Humidity：Hrel = 25%~75% relative humidity

——Room temperature：T_{RT}=（23±5）℃

——Test temperature：$T_{test}=T_{RT}$

4.2 标准公差 Standard tolerances

如果没有不同说明，适用表 6 中所述公差（公差均参照测量值）。

Unless otherwise indicated, the tolerances as per Table 6 apply.(The tolerances as per the required measured value.)

表 6 标准公差 Table 6 Standard tolerances

频率 Frequencies	±1%	电压 Voltages	±2%
温度 Temperatures	±2°C	电流 Currents	±2%
湿度 Humidity	±5%	振动 Vibrations	±3dB
时间 Times/durations	±1%	振动（功率谱密度）PSD	±5%

4.3 供电电源 Power supply

除非本标准另有明确定义，电子电气零部件工作电压范围，依据其 CTS 定义。

除非本标准另有明确定义，DUT 测试电压规定如下：

——12V 系统电源的供电电压：（13.5±0.5）V。

Unless otherwise indicated, the standard values for electrical and electronic component as CTS apply.

Unless otherwise indicated, the standard values for DUT as below apply.

——Supply voltage of 12V system power supply：（13.5±0.5）V.

4.4 测试样件 Sample

产品设计验证（DV）测试，除非本标准另有明确定义，原则上 DUT 数量需求如下：

——电气负荷测试，至少需要验证同批次生产的 3 个 DUT。

——机械负荷测试，至少需验证同批次生产的 6 个 DUT（其中 M03 自由跌落仅需验证 3 个 DUT）。
——气候负荷测试，至少需要验证同批次生产的 6 个 DUT。
——化学负荷测试，每种化学试剂对应 1 个 DUT。
——寿命耐久测试，至少需要验证同批次生产的 6 个 DUT。
DUT 数量的具体需求，由供需双方协商确定。
Product design verification (DV) testing, unless otherwise clearly defined in this standard, in principle the DUT quantity requirements are as follows:
——For electrical loads test，at least 3 DUT of the same type need to be test.
——For mechanical loads test，at least 6 DUT of the same type need to be test.
——For climatic loads test，at least DUT pcs of the same type need to be test.
——For chemical loads test，1 DUT per chemical,multiple use of a DUT for several chemicals is possible in consultation with the purchaser.
——For life test，at least 6 DUT of the same type need to be test.

4.5 测试实验室 Test laboratory

产品 ENV 测试，应在华人运通公司认可的第二/三方实验室进行。
原则上实验室应通过 CNAS/ ISO 17025 认可，华人运通公司有权对认可实验室进行定期审核。
For production ENV testing shall be conducted in the second/third party laboratory approved by HUMAN HORIZONS.
In principle, the laboratory should be approved by CNAS/ ISO 17025, and HUMAN HORIZONS has the right to conduct periodic audit the laboratory.

4.6 测试需求文档 Test requirements document

以下文档必须在零部件测试规范审核前，由供应商提交：
——系统功能描述的系统设计的描述文件
——系统原理图，零部件安装位置图，和 ENV 相关的材料描述
——涉及 DUT 操作顺序的描述文件
——电路部件描述（子系统，传感器，执行器）
——系统运行/工况模拟需设置的参数
——与车辆其它零部件的接口
——系统的故障处理及诊断功能
——相关的 ENV 改善措施说明
以下文档必须在零部件测试工作正式启动前，由供应商提交：
——详细的测试时间表和测试地点/实验室
——和华人运通公司已批准的 ENV 测试规范若存在差异，需提供偏差/不符合项说明文档
——被测件的详细描述，包括样品阶段、零件号、软/硬件版本等。
The following documents must be submitted by the supplier before the component test specification is audited:
--System function and system design description file

--System schematic diagram, component mounting location diagram, and ENV related description document
--A description file involving the DUT operations
--Description of component (subsystem, sensor, actuator)
--Configuration parameters of system operation/working condition simulation
--Interface with other component of the vehicle
--System troubleshooting and diagnosis functions
--Related instructions of ENV improvement measures
The following documents must be submitted by the supplier before the component testing work is officially started:
--Detailed test schedule and test site/laboratory
--If there is any deviation in the approved ENV test specification by HUMAN HORIZONS, the deviation/nonconformity specification documents shall be provided
--Detailed description of tested component, including sample phase, part number, software/hardware version, etc.

4.7 验证计划 Validation plan

供应商提交的产品设计验证计划（DVP）应包含 ENV 要求，并需通过华人运通公司 ENV 工程师的审核。
供应商应该根据华人运通公司的相关产品开发验证流程和零件开发计划，制定详细的验证计划，包括但不限于下述内容：检测项目、依据标准、样件类型、样件数量、DV 时间计划等。
试验分支和顺序，原则上应满足附录 B 定义的要求，具体由供需双方协商确定，并在 DVP 里注明。
The product design validation plan (DVP) submitted by the supplier shall contain the ENV requirements and shall be approved by Subsystem Validation Engineer (SVE) of HUMAN HORIZONS.The supplier shall make a detailed validation plan according to the component development and validation process and the component development plan of HUMAN HORIZONS, including but not limited to the following contents: test items, standards, sample type, sample quantity, DV time schedule, etc.
The test leg and sequence shall be meet the specifications as defined in appendix B, which can be determined by the two parties through negotiation and document in the DVP.

4.8 测试计划 Test plan

供应商提交的产品 ENV 测试计划，需通过华人运通公司 ENV 工程师的审核。
任何与本标准不同的技术要求和试验方法，均应在产品 ENV 测试计划中注明。
产品 ENV 的 DV 和 PV 测试，需严格依据华人运通公司签署发布的产品 ENV 测试计划执行。
产品 ENV 测试计划电子档文件名，按下述规则命名：
（项目代码_专业代码_产品编号_版本号）_产品名称_ENV 测试计划_提交/发布日期。
例如：（XXX_XXX_XXXX_ R1.0）_VCU_ENV 测试计划_ 2018-05-30.doc
产品 ENV 测试计划必须至少包含以下内容：
——样件描述资料，如系统/产品原理描述、功能描述、接口定义描述、产品结构描述等等
——测试需求资料，如样件数量、测试项目、测试模式等等

——功能监控、失效模式定义及符合性判定准则
——测试子系统构建描述、模拟负载、外部激励/触发信号等等
——测试布置、测试线束、详细的测试要求（含测试等级）等等

The ENV test plan submitted by the supplier shall be approved by the engineer of HUMAN HORIZONS.
Any technical requirements and test methods different from this documents shall be indicated in the ENV test plan of the product.
The DV and PV tests of the ENV shall be performed strictly in accordance with the ENV test plan signed and issued by HUMAN HORIZONS.
The documents of product ENV test plan, named according to the following rules:
(project code _department code _ product code _ version number) _ Product name _ENV test plan _ submission/release date.
Example :(xxx_xxx_xxxx_r1.0) _VCU_ENV test plan _ 2018-05-30.doc
The product ENV test plan must contain as following:
-- Sample description documents, such as system/product principle description, function description, interface definition description, product structure description, etc
-- Test requirements information, such as number of samples, test projects, test model, and so on
-- Functional monitoring, failure mode definition and compliance criteria
-- Test subsystem configuration descriptions, simulated loads, external excitation/trigger signals, etc
-- Test layout, test harness, detailed test requirements (including test grade), etc

4.9 测试报告 Test report

供应商提交的产品 ENV 测试报告，需通过华人运通公司 ENV 工程师的审核。
为了能在开发过程中进行历史追溯，所有产品测试相关的原始数据及其它验证资料，对华人运通公司都是非保密的，华人运通公司有权现场跟踪产品测试过程。
ENV 测试报告必须至少包含以下内容：
——DUT 生产厂商、样件阶段（A 样/B 样/C 样）、样件序号、软/硬件版本信息
——测试现场的布置照片，样品试验前后状态的照片。
——测试设备及其校准数据。如包括设备名称、型号、校准日期等等。
——测试数据、符合性判定/结果
——测试报告授权签字、盖章

The ENV test report submitted by the supplier shall be approved by the ENV engineer of HUMAN HORIZONS.
In order to ensure traceability during the development process, all original data and other verification data related to product testing are not confidential to HUMAN HORIZONS, and HUMAN HORIZONS has the right to audit the product testing process on site.
The ENV test report must contain at least the following:
--DUT manufacturer, sample type (A sample /B sample /C sample), sample serial number, software/hardware version information

--Photos of the test setup， photos of sample before and after test.

--Test equipment and calibration infermation.Such as equipment name, model, and calibration date and so on.

--Test data, conformity determination/result

--Authorized signature and seal of test report

4.10 参数测试 Parameter test

必须在测试计划中定义一组关键参数，如试验温度、湿度、静态电流消耗、工作电流、输出电压、接触电阻、输入阻抗、信号频率（上升时间和下降时间），及数据总线信号、非电参数（马达扭矩、灯光亮度）等，在每个试验流程开始之前和结束之后，必须检查这些关键参数是否符合相关设计要求，并且需要把检查结果记录在试验报告中。

除非本标准另有明确定义，原则上每个 DUT 的分支试验开始前和结束后需进行五点参数测试，每个 DUT 的每个试验项试验开始前和结束后需进行单点参数测试。

五点参数测试主要验证 DUT 在三种工作电压和三种工作温度条件下的工作状态，仅包括下述五种组合条件：（U_B，T_{RT}）、（U_{Bmin}，T_{min}）、（U_{Bmin}，T_{max}）、（U_{Bmax}，T_{min}）、（U_{Bmax}，T_{max}）。

单点参数测试主要验证 DUT 在一种工作电压和一种工作温度条件下的工作状态，组合条件为：（U_B，T_{RT}）。

Must define a set of key parameters in the test specification, such as test temperature, humidity, static electricity current, working current, output voltage, contact resistance and the input impedance and signal frequency (rise time and fall time), and the data bus signal and non-electric parameters (such as motor torque and lighting levels), after each test process prior to the start and end, you have to check these key parameters conform to design requirements, and need to check the results recorded in the test report.

Unless otherwise clearly defined in this document, in principle, five-point parameter tests shall be performed at the beginning and at the end of all test legs, and single-point parameter tests shall be performed before and after each test item of each DUT.

The five-point parameter test mainly verifies the working state of DUT under three operating voltages and three operating temperatures, including only the following five combination conditions :(UB, T_{RT}), (UBmin, Tmin), (UBmin, Tmax), (UBmax, Tmin) and (UBmax, Tmax).

The single-point parameter test mainly verifies the working state of DUT under a working voltage and a working temperature condition, and the combination condition is :(UB, T_{RT}).

4.11 参数连续监控 Continuous Monitoring

在整个试验期间，通过参数连续监控获取的数据，可以进行变化趋势和漂移情况检查，以识别部件的异常、老化或者功能故障。如果涉及带故障存储器的部件，必须对故障存储器实施连续监控并记下故障存储器记录。

Continuous Monitoring shall detect the functional status of the component during and after exposure to the test environment. Continuous Monitoring shall detect false actuation signals, erroneous serial data messages, fault codes, or other erroneous Input/Output (I/O) commands or states. This shall be documented in test report.

4.12 可视化检查 Visual Inspection and Dissection

可视化检查的目的是识别由环境测试引起的任何结构故障、材料/部件降解或残余物以及接近失效的情况。目视检查和解剖是在零部件环境可靠性试验流程中规定的测试后完成，对组件外壳、内部部件和电气连接的微观层面进行目视检查。在试验之前还应进行检查，并将其作为基准用于比较。

如 DUT 有任何异常，额外的样品或额外的分析方法应得到华人运通的同意，并将额外的样品或额外的分析方法，必须在测试报告中记录过程和评估结果。

通常该方法是在相关检测项目测试之前以及测试之后执行，可视化检查内容应在产品测试规范中注明，一般检查内容至少需覆盖下述项：

——检查零件的结构完成性，是否具有裂缝、磨损、融化、老化、焊接或紧固件松动。

——检查零件焊接是否出现裂纹、电解电容泄漏、芯片管脚积碳等。

——检查零件表面和内部 PCB 是否出现枝状生长的毛刺。横切应检查该电路板焊接接头的质量和焊接件的金属间隙的质量，并识别焊点相关的问题，如裂纹和空洞，可能导致组件在产品生命周期的问题。此外，还将检查线路，通孔电镀和通孔的质量。

测试计划应包括 PCB 板的图形，其横断面的标识、编号和描述。

——检查零件在电气负荷测试后是否出现过热、积碳、焊锡融化。

——检查零件的密封性能，测试完成后内部无明显粉尘或水。

This activity shall identify any structural faults, material/component degradations or residues, and near-to-failure conditions caused by environmental testing. The Visual Inspection and Dissection is a visual review down to the microscopic level of the component's housing, internal parts, and electrical connections at the completion of testing as specified in the Component Environmental Reliability Test Flows. Examinations are also made before testing to inspect the build quality and use as a baseline for comparison purposes.

If there is any abnormality in DUT, additional analysis shall be conducted in consultation with HUMAN HORIZONS.Additional samples or additional analysis methods should be added as necessary and the results must be recorded and evaluated in the test report.

This method is usually performed before and after testing of related test items. The visual inspection content should be indicated in the product test plan, and the general inspection content should cover at least the following items:

-- check the structural completeness of the component, and see if there is any signs of degradation, cracks, melting, wear, fastener failures, etc.

-- check whether component welding cracks, electrolytic capacitance leakage, and chip pin carbon, etc.

-- check the surface of the component and the inner PCB for burr.Cross sectioning shall inspect the quality of the solder joints and intermetallic bonds of the parts to the circuit board, and identifies solder joint concerns such as cracks and voids that may result in issues over a lifetime of component usage. Also, this will inspect for the quality of via and through-hole plating and drilling.

The Test Plan shall include a pictorial of the PCB board with the intended cross-sections identified, numbered, and described.

-- Check the component there shall be no evidence for overheating, carbon deposition and solder melting after electrical load test.

-- check the sealing performance of the component, and there shall be no evidence for dust or water inside after the test.

4.13 工作模式 Operating Types

DUT 在其使用寿命期间，一般会存在不同的工作运行方式，这些运行方式必须在试验中进行相应的模拟。供需双方应协商产品工作模式、运行参数以及必要的边界条件，并在产品测试规范中注明。

工作模式 1：DUT 未通电

——工作模式 1.a：DUT 未连接到线束。

——工作模式 1.b：DUT 模拟在车辆上的安装位置，连接到线束

工作模式 2：DUT 通电运行

——工作模式 2.a：DUT 在无运行负载的情况下工作。

——工作模式 2.b：DUT 在最小运行负载的情况下工作。

——工作模式 2.c：DUT 在最大运行负载的情况下工作。

The electric, electronic and mechatronic component and systems are operated in different operating modes during service life, which must be simulated correspondingly during the tests. Details concerning the operating modes, operating loads (e.g., activation, bus activity, bus messages, original sensors, original actuators, or replacement circuitry), and the required boundary conditions must be agreed upon between the contractor and the purchaser and must be documented.

Operating mode I - DUT not electrically connected

--Operating mode 1.a：The DUT is not electrically connected, without plug and harness.

--Operating mode 1.b：The DUT is not electrically connected, but with connected plugs and harness.

Operating mode II - DUT electrically connected

--Operating mode 2.a：The DUT must be operated without operating load.

--Operating mode 2.b：The DUT must be operated with minimal operating load.

--Operating mode 2.c：The DUT must be operated at maximum load (power user, but no misuse).

4.14 功能状态分类 Functional Status Classification (FPSC)

用于描述了 DUT 在测试中和测试后的功能状态。

依据 DUT 在测试中和测试后的功能状态，对其分类进行定义。

——Class A：试验中和试验后，DUT 所有功能满足设计要求。

——Class B：试验中 DUT 所有功能满足设计要求，但是其中一项或多项超出了规定的公差。试验后所有功能自动恢复到规定限值。存储器功能应符合 Class A。

——Class C：试验中 DUT 的一项或多项功能不满足设计要求，但是在试验后能自动恢复正常运行。

——Class D：试验中 DUT 的一项或多项功能不满足设计要求，并且在试验后不能自动恢复正常运行，需要对 DUT 进行简单的操作重新激活才能正常运行。

——Class E：试验中 DUT 的一项或多项功能不满足设计要求，并且试验后不能自动恢复正常运行，需要对 DUT 进行修复或更换才能正常运行。

This section describes the functional status of the DUT during and after the test. The functional status of the DUT is to be specified for each test.

--Class A： All functions of the device/system perform as designed during and after the test.

--Class B： All functions of the device/system perform as designed during the test. However, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after the test. Memory functions shall remain class A.

--Class C： One or more functions of a device/system do not perform as designed during the test, but return automatically to normal operation after the test.

--Class D： One or more functions of a device/system do not perform as designed during the test and do not return to normal operation after the test until the device/system is reset by simple “operator/use” action.

--Class E： One or more functions of a device/system do not perform as designed during and after the test and cannot be returned to proper operation without repairing or replacing the device/system.

5 检测项目适用性 Test applicability

电子电气零部件需要开展的电气负荷检测项目的适用性参考表 7，ENV 检测项目参考表 8~表 10 选择。任何与表 7~表 10 定义不符的选择，需获得华人运通公司 ENV 工程师的同意。

The applicability of electrical loads test items to be carried out for electronic and electrical component as per table 7，for environmental test items refer table 8 to table 10.

Any inconsistent with the definition in table 7 to table 10 shall be approved by the engineer of HUMAN HORIZONS.

表 7 电气负荷检测项目适用性 Table 7 Electrical load test item applicability

条款 No.	检测项目 Test item	适用对象 Applicable to	备注 Comments
6.1	E01 辅助启动过电压 E01 Jump start	车载 12V 电气网络供电的零部件 Components supplied via the 12 V electric system	
6.2	E02 长时过电压 E02 Long-term overvoltage	车载 12V 电气网络供电的零部件 Components supplied via the 12 V electric system	
6.3	E03 瞬时过电压 E03 Transient overvoltage	车载 12V 电气网络供电的零部件 Components supplied via the 12 V electric system	
6.4	E04 抛负载 E04 Load dump	车载 12V 电气网络供电的零部件 Components supplied via the 12 V electric system	
6.5	E05 瞬态欠电压 E05 Transient undervoltage	车载 12V 电气网络供电的零部件 Components supplied via the 12 V electric system	
6.6	E06 电压缓降缓升 E06 Slow decrease and increase of the supply voltage	所有零部件 All components	
6.7	E07 电压缓降快升 E07 Slow decrease, quick increase of the supply voltage	所有零部件 All components	
6.8	E08 电压骤降复位 E08 Reset behavior	所有零部件 All components	
6.9	E09 反向电压 E09 Reverse polarity	可能出现反极性电压的零部件 Components that can be subjected to reverse polarity in the vehicle	
6.10	E10 叠加交流电压 E10 Superimposed alternating voltage	车载 12V 电气网络供电的零部件 Components supplied via the 12 V electric system	
6.11	E11 参考地偏移	所有零部件	

条款 No.	检测项目 Test item	适用对象 Applicable to	备注 Comments
	E11 Ground offset	All components	
6.12	E12 引脚中断 E12 Pin interruption	所有零部件 All components	
6.13	E13 接插件中断 E13 Connector interruption	所有零部件 All components	
6.14	E14 短路保护 E14 Short circuit in signal circuit and load circuits	所有零部件 All components	
6.15	E15 绝缘电阻 E15 Insulation resistance	带有电隔离单元的零部件 Components with galvanically isolated portions	
6.16	E16 静态电流 E16 Closed-circuit current	持续供电的零部件 Components that are continuously supplied with voltage	
6.17	E17 过电流 E17 Overcurrents	至少拥有一个供电输出端的零部件 Components that have an output	
6.18	E18 短时中断 E18 Brief interruptions	所有零部件 All components	
6.19	E19 击穿强度 E19 Dielectric strength	感性元件或控制感性元件零部件 Components with inductive parts	
6.20	E20 反馈 E20 Backfeeds	接 KL15 或有唤醒功能零部件 Components that are electrically connected to KL15 or to other terminals with a wake-up function	
6.21	E21 多电源均衡电流 E21 Equalizing currents of multiple supply voltages	多电源独立供电 Components supplied via an independent KL30	

表 8 机械负荷检测项目适用性 Table 8 Mechanical load test item applicability

条款 No.	检测项目 Test item	适用对象 Applicable to	备注 Comments
7.1	M01 机械振动 M01 Vibration test	所有部件 All components	
7.2	M02 机械冲击 M02 Mechanical shock	所有部件 All components	

条款 No.	检测项目 Test item	适用对象 Applicable to	备注 Comments
7.3	M03 自由跌落 M03 Free fall	所有部件（对于在试验中明显会受到损坏的部件比如玻璃件，高敏感性测量传感器等等，双方协商。）All components（For the parts easily damaged in the test, such as glass parts, high-sensitivity sensors and so on, both parties shall negotiate and decide it）	
7.4	M04 砂石轰击 M04 Stone impact test	所安装区域可能遭受石击的部件 All surfaces that are freely accessible on the vehicle	

表 9 气候负荷检测项目适用性 Table 9 Climate load test item applicability

条款 No.	检测项目 Test item	适用对象 Applicable to	备注 Comments
8.1	C01 高温低温储存 C01 High-/low-temperature storage	所有部件 All components	
8.2	C02 温度梯度 C02 Temperature steps	所有部件 All components	
8.3	C03 低温运行 C03 Low-temperature operation	所有部件 All components	
8.4	C04 补漆温度 C04 Repainting temperature	安装在外部范围并且补漆时可能产生较高温度的部件。 the component which maybe impacted by thermal load during repainting	
8.5	C05 温度冲击（带壳体） C05 Temperature shock (with housing)	所有部件 All components	
8.6	C06 温度冲击（无壳体） C06 Temperature shock (without housing)	所有部件 All components	
8.7	C07 盐雾试验（外部） C07 Salt spray test with operation, exterior	装配在外部区域、底板或者电机舱的部件 the component which is assembled in the external area	

8.8	C08 盐雾试验（内部） C08 Salt spray test with operation, interior	装配在内部空间中暴露位置的部件（比如行李箱中的侧面凹槽、车门潮湿空间，备用车轮槽） the component which is assembled in the interior area	
8.9	C09 恒定湿热 C09 Damp heat, constant	所有部件 All components	
8.10	C10 湿热循环 C10 Damp heat, cyclic	所有部件 All components	
条款 No.	检测项目 Test item	适用对象 Applicable to	备注 Comments
8.11	C11 湿热循环-结霜 C11 Damp heat, cyclic (with frost)	所有部件 All components	
8.12	C12 有害气体试验 C12 Harmful gas test	带无气密性开关触点的部件 there is particularly onto its plug contacts and switches	
8.13	C13 阳光辐射 C13 Solar radiation	在安装位置直接遭受阳光照射的部件 the component which will impacted by solar radiation	
8.14	C14 防尘 C14 Dust test	所有部件 All components	
8.15	C15 防水 C15 Water protection（IPX0~IPX6K）	所有部件 All components	
8.16	C16 飞溅冰水冲击 C16 Temperature shock with splash water	安装在外部的部件，位置考虑到喷溅水（比如驶过小水坑时）the component which is assembled in the external area，which will exposed to splash water.	
8.17	C17 浸入冰水冲击试验 C17 Temperature shock – immersion	安装在涉水深度之下的部件，其中必须考虑到部件短时浸入（盐）水中的情况（比如驶过水域时）（IPX7）	

		the component which is assembled in the external area， which will immersed into water.（IPX7）	
8.18	C18 高压/蒸汽喷射 C18 High-pressure cleaning	可以直接经受高压/蒸汽喷射清洁或者底板冲洗的部件（IPX9K）the component which will be subjected to water during cleaning（IPX9K）	

表 10 化学负荷及寿命耐久检测项目适用性

Table 10 Chemical load and life test item applicability

条款 No.	检测项目 Test item	适用对象 Applicable to	备注 Comments
9.1	H01 化学试验 H01 Chemical tests	所有部件 All components	
10.1	L01 机械/液压耐久 L01 mechanical/hydraulic endurance test	存在机械/液压操作/功能循环（如制动操作、座椅调节循环、开关/按键操作）的部件 There are parts of mechanical/hydraulic operation/functional cycle (such as brake, seat adjustment cycle, switch/key operation)	
10.2	L02 高温耐久 L02 high-temperature endurance test	所有部件 All components	
10.3	L03 温度交变耐久 L03 temperature cycle endurance test	所有部件 All components	

6 电气负荷 Electrical requirements and tests

6.1 E01 辅助起动过电压 E01 Jump start

本项测试主要模拟辅助起动的工况。

Jump starting of the vehicle is simulated. The maximum test voltage results from commercial vehicle systems and their elevated electric system voltages.

6.1.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于车辆启动过程需正常工作的零部件，FPSC 至少需满足 Class B。

——其它零部件，FPSC 至少需满足 Class C。

DUT test results should meet the following requirements:

--Components relevant to starting (e.g., starter): Functional status B

--All other components: Functional status C

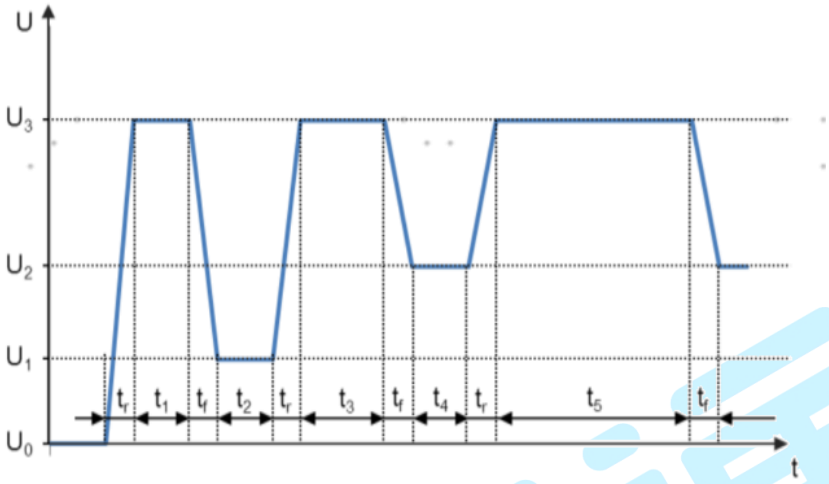
6.1.2 试验 Test

E01 试验参数需满足表 11 规定的要求。

E01 test parameters should as per the requirements in table 11.

表 11 E01 辅助起动过电压 试验参数 Table 11 E01 Test parameters, jump start

工作模式 DUT operating mode	2.c
U_0	0V
U_1	3V（+4%，0%）
U_2	10.8V（+4%，0%）
U_3	26V（+4%，0%）
t_1	1s
t_2	0.5s
t_3	5s
t_4	1s
t_5	60s
t_r	<2ms
t_f	<100ms
试验温度 Temperature	T_{RT}
循环数量 Test cycles	1



6.2 E02 长时过电压 E02 Long-term overvoltage

本项测试主要模拟因发电机电压调节失效导致的长时间过电压工况。

The component's resistance to long-term overvoltage is tested. A generator control fault during driving operation is simulated.

6.2.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于行驶过程需正常工作的零部件：FPSC 至少需满足 Class B。

——其它零部件，FPSC 至少需满足 Class C。

The evaluation of the test results depends on the use of the component. A distinction is made between:

--Components necessary for driving operation: Functional status B

--For all other components: Functional status C

6.2.2 6.2.2 试验 Test

E02 试验参数需满足表 12 规定的要求。

E02 test parameters should as per the requirements in table 12.

表 12 E02 长时过电压 试验参数 Table 12 E02 Test parameters, Long-term overvoltage

工作模式 DUT operating mode	2.c
U_{min}	13.5V
U_{max}	17V（+4%，0%）
U_{max} 持续时间 U_{max} duration time	60 分钟 60 min
试验温度 Temperature	T_{max} -20k
循环数量 Test cycles	1

6.3 E03 瞬时过电压 E03 Transient overvoltage

本项测试主要模拟大功率负载关断和短时急加速工况。

Transient overvoltages may occur in the electric system due to the switching off of loads and due to short accelerator tip-ins. These overvoltages are simulated by means of this test.

6.3.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件：FPSC 需满足 Class A。

DUT test results should meet the following requirements:

--For all components: Functional status A

6.3.2 试验 Test

E03 试验参数需满足表 13 规定的要求，试验脉冲电压波形见图 1。

E03 test parameters should as per the requirements in table 13, and the test profile is shown in figure 1

表 13 E03 瞬时过电压 试验参数 Table 13 E03 Test parameters, Transient overvoltage

工作模式 DUT operating mode	2.c
U_{min}	16V（+4%，0%）
U_1	17V
U_{max}	18V（+4%，0%）
t_r	1ms
t_f	1ms
t_1	400ms
t_2	600ms
测试序列 1 Test case 1	
试验温度 Temperature	T_{max}
循环次数 Number of cycles	3
t_3	2s
测试序列 2 Test case 2	
试验温度 Temperature	T_{min}
循环次数 Number of cycles	3
t_3	2s
测试序列 3 Test case 3	
试验温度 Temperature	T_{RT}

循环次数 Number of cycles	100
t_3	8s

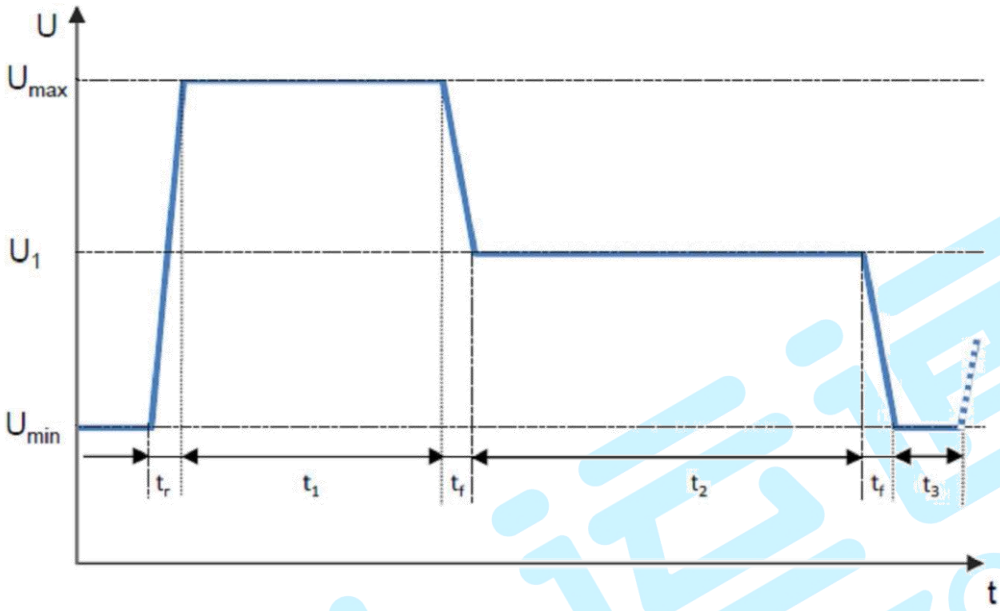


图 1 试验脉冲-E03 Figure 1 Test profile- E03

6.4 E04 抛负载 E04 Load dump

本项测试主要模拟由于发电机内在特性产生的过电压工况。

Dumping of an electric load, in combination with a battery with reduced buffering ability, results in an energy-rich overvoltage pulse due to the generator characteristics. This pulse is simulated by means of this test.

6.4.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于涉及安全性的零部件，FPSC 至少需满足 Class B。

——其它的零部件，FPSC 至少需满足 Class C。

DUT test results should meet the following requirements:

——Safety-relevant components: Functional status B

——All other components: Functional status C

6.4.2 试验 Test

E04 试验参数需满足表 14 要求，试验脉冲电压波形见图 2。

E04 test parameters should as per the requirements in table 14, and the test profile is shown in figure 2.

表 14 E04 抛负载 试验参数 Table 14 E04 Test parameters, Load dump

工作模式 DUT operating mode	2.c
U_{min}	13.5
U_{max}	27V（+4%，0%）
t_r	＜ 2ms
t_1	300ms
t_f	＜ 30ms
循环间隔时间 Cycle interval	1 分钟 1 min
循环数量 Number of cycles	10

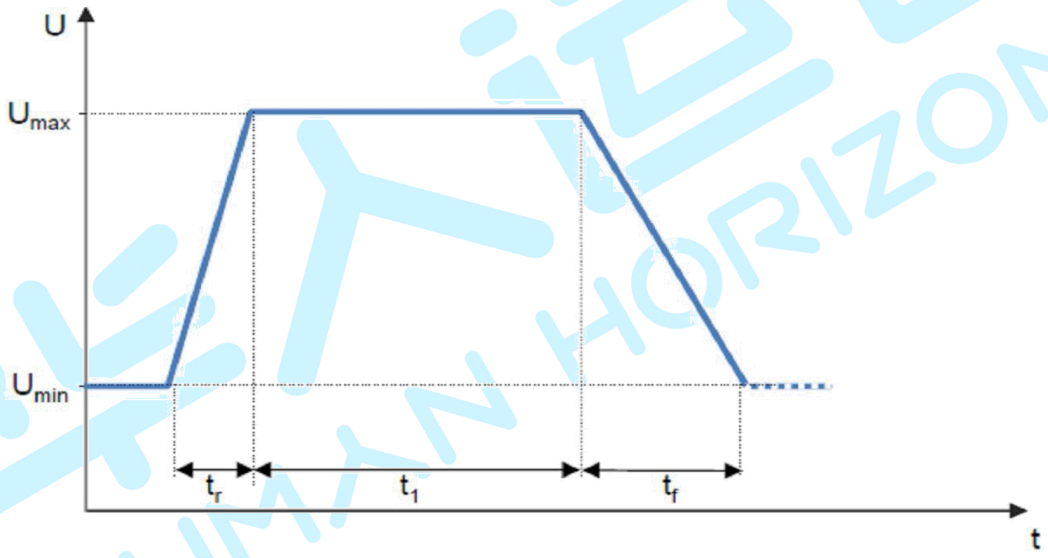


图 2 试验脉冲-E04 图 2 Test profile -E04

6.5 E05 瞬态欠电压 E05 Transient undervoltage

本项测试主要模拟大功率负载开启的工况。

Transient undervoltages in the electric system may occur due to switching on of loads. These undervoltages are simulated by means of this test.

6.5.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件：FPSC 需满足 Class A 或满足 CTS 要求。

DUT test results should meet the following requirements:

--For all components: Functional status A or meet CTS requirements

6.5.2 试验 Test

E05 试验参数需满足表 15 表 16 要求，试验脉冲电压波形见图 3a 图 3b。

E05 test parameters should as per the requirements in table 15 table 16, and the test profile is shown in figure 3a figure 3b

表 15 E05 瞬态欠电压 试验参数 Table 15 E05 Test parameters, Transient undervoltage

工作模式 DUT operating mode	2.c
U_{min}	9V（0%，-4%）
U_{max}	10.8V（+4%，0%）
t_r	1.8ms
t_f	1.8ms
t_1	500ms
t_2	1s
测试序列 1 Test case1	
试验温度 Temperature	T_{max}
循环次数 Number of cycles	10
测试序列 2 Test case2	
试验温度 Temperature	T_{min}
循环次数 Number of cycles	10

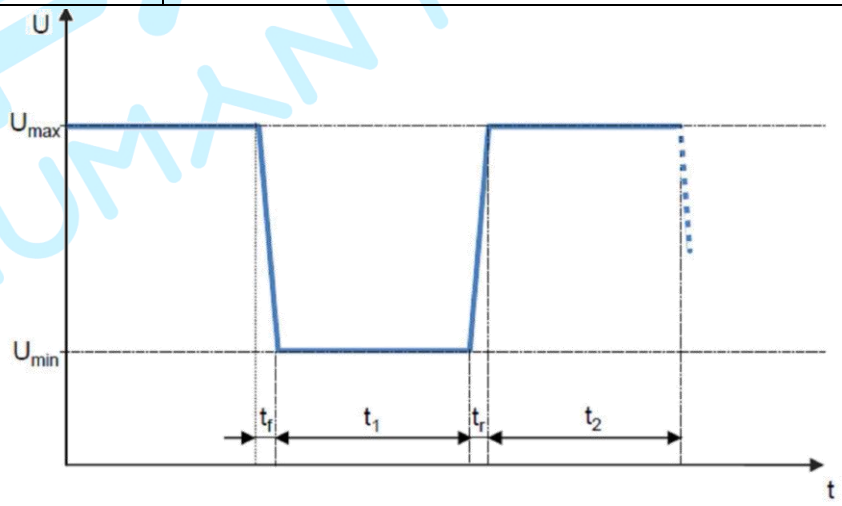


图 3a 试验脉冲-E05 Figure 3a Test profile -E05

表 16 E05 瞬态欠电压 试验参数 Table 16 E05 Test parameters, Transient undervoltage

工作模式 DUT operating mode	2.c
U_1	10.8V
U_2	6V
U_3	8V
U_4	9V
t_1	5ms
t_2	20ms
t_3	2ms
t_4	180ms
t_5	1ms
t_6	300ms
t_7	2ms
t_8	1s
测试序列 1 Test case1	
试验温度 Temperature	T_{max}
循环次数 Number of cycles	10
测试序列 2 Test case2	
试验温度 Temperature	T_{min}
循环次数 Number of cycles	10

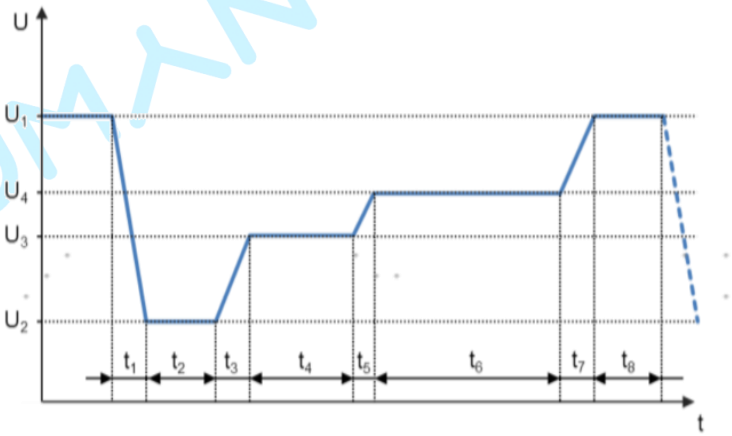


图 3b 试验脉冲-E05 Figure 3b Test profile -E05

6.6 E06 电压缓降缓升

本项测试主要模拟蓄电池慢速充放电导致的电压缓升和缓降工况。

The slow decrease and increase of the supply voltage is simulated as it occurs during the slow decharging and charging procedure of the vehicle battery.

6.6.1 要求 Requirement

DUT 测试结果应满足下述要求：

——在零部件规定的工作电压范围之内，FPSC 至少需满足 Class A。

——在零部件规定的工作电压范围之外，FPSC 至少需满足 Class C。

DUT test results should meet the following requirements:

--Within the defined operating voltage of the component: Functional status A.

--Outside of the defined operating voltage of the component: Functional status C.

6.6.2 试验 Test

E06 试验参数需满足表 17 要求，试验脉冲电压波形见图 4。

E06 test parameters should as per the requirements in table 17, and the test profile is shown in figure 4.

表 17 E06 电压缓降缓升 试验参数

Table 17 E06 Test parameters, Slow decrease and increase of the supply voltage

起始&结束电压 Start & final voltage	U_{Bmax}（+4%，0%）
电压变化速率 Voltage change speed	0.5V/分钟 0.5V/min
U_1 & U_2	U_{Bmin}
t_1 & t_2	直到故障存储器被完全读出 Holding time until event memory has been completely read out
最低电压 Minimum voltage	0V
测试序列 1 Test case1	
工作模式 DUT operating mode	2.a
循环次数 Number of cycles	1
测试序列 2 Test case2	
工作模式 DUT operating mode	2.c
循环次数 Number of cycles	1

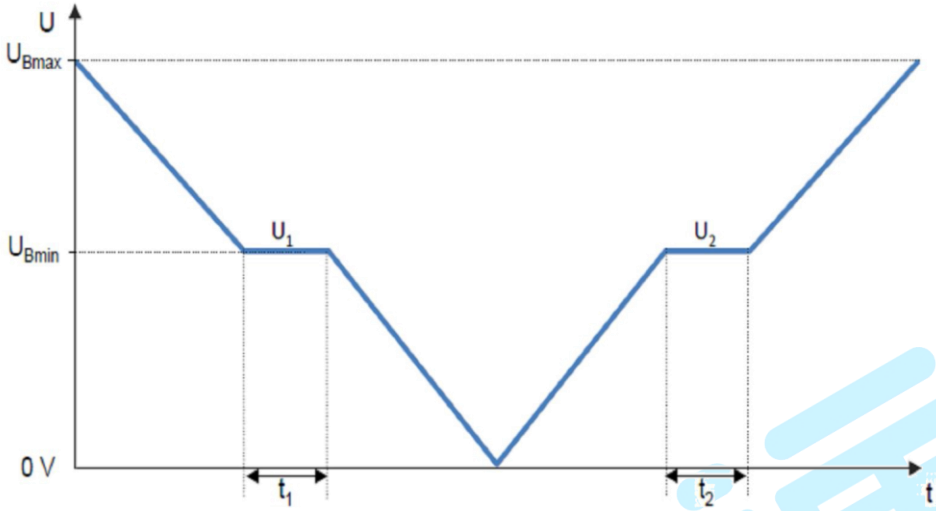


图 4 试验脉冲-E06 Figure 4 Test profile -E06

6.7 E07 电压缓降快升 E07 Slow decrease, quick increase of the supply voltage

本项测试主要模拟电池电压缓慢下降至 0 V，然后由于外接电源突然上升的工况。

This test simulates the slow decrease of the battery voltage to 0 V and the sudden reapplication of the battery voltage, e.g., by applying a jump start source.

6.7.1 要求 6.7.1 Requirement

DUT 测试结果应满足下述要求：

——在零部件规定的工作电压范围之内，FPSC 至少需满足 Class A。

——在零部件规定的工作电压范围之外，FPSC 至少需满足 Class C。

DUT test results should meet the following requirements:

--Within the defined operating voltage of the component: Functional status A.

--Outside of the defined operating voltage of the component: Functional status C.

6.7.2 试验 Test

E07 试验参数需满足表 18 要求，试验脉冲电压波形见图 5。

E07 test parameters should as per the requirements in table 18, and the test profile is shown in figure 5.

表 18 E07 供电电压缓降快升 试验参数

Table 18 E07 Test parameters, Slow decrease, quick increase of the supply voltage

起始&结束电压 Start & final voltage	U_{Bmax}（+4%，0%）
电压变化速率 Voltage change speed	0.5V/min
U_1 & U_2	U_{Bmin}
t_1	直到故障存储器被完全读出 Holding time until event memory has been completely read out

t_f	＜ 30ms
最低电压 Minimum voltage	0V
t_2	至少一分钟，DUT 内部电容应完全放电 At least 1 min; however, as long as internal capacity is completely discharged
t_r	＜ 0.5s
测试序列 1 Test case1	
工作模式 DUT operating mode	2.a
循环次数 Number of cycles	1
测试序列 2 Test case2	
工作模式 DUT operating mode	2.c
循环次数 Number of cycles	1

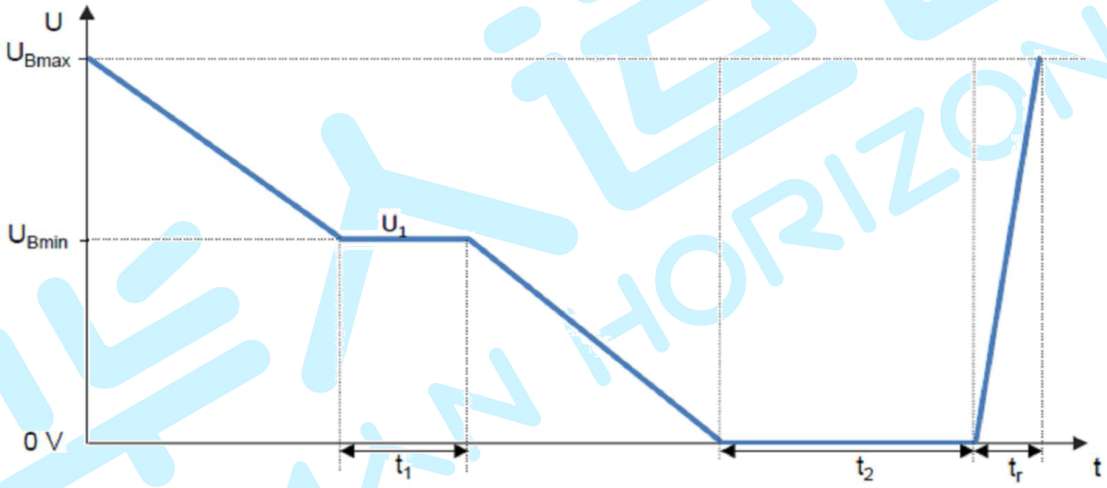


图 5 试验脉冲-E07 Figure 5 Test profile -E07

6.8 E08 电压骤降复位 E08 Reset behavior

本项测试主要模拟零部件的复位工况。

The reset behavior of a component in its environment is simulated and tested.

6.8.1 要求 Requirement

DUT 测试结果应满足下述要求：

——在零部件规定的工作电压范围之内，FPSC 至少需满足 Class A。

——在零部件规定的工作电压范围之外，FPSC 至少需满足 Class C。

DUT test results should meet the following requirements:

--Within the defined operating voltage of the component: Functional status A.

--Outside of the defined operating voltage of the component: Functional status C.

6.8.2 试验 Test

E08 试验参数需满足表 19 要求，试验脉冲电压波形见图 6。

E08 test parameters should as per the requirements in table 19, and the test profile is shown in figure 6.

表 19 E08 电压骤降复位 试验参数 Table 19 E08 Test parameters, Reset behavior

工作模式 DUT operating mode	2.c
U_{max}	U_{Bmin}（0%，-4%）
U_{th}	6V
ΔU_1（范围 U_{max} 至 U_{th}） ΔU_1（range from U_{max} to U_{th}）	0.5V
ΔU_2（范围 U_{th} 至 0V） ΔU_2（range from U_{th} to 0V）	0.2V
t_2	大于 10s，直到 DUT 重新启动完成 At least ≥10 s and until the DUT has returned to 100% operability (all systems rebooted without error).
t_r	＜ 10ms
t_f	＜ 10ms
测试序列 1 Test case1	
t_1	5s
循环数量 Number of cycles	2.a 2.b 2.c 各一次 each cycle for 2.a 2.b 2.c
测试序列 2 Test case2	
t_1	100ms
循环数量 Number of cycles	2.a 2.b 2.c 各一次 each cycle for 2.a 2.b 2.c

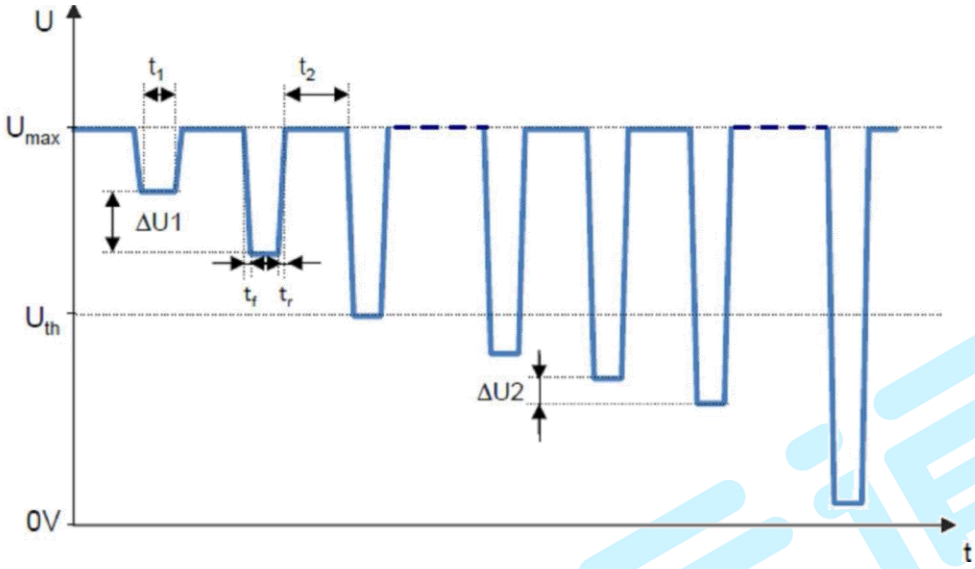


图 6 试验脉冲-E08 Figure 6 Test profile -E08

6.9 E09 反向电压 E09 Reverse polarity

本项测试主要模拟各种反极性电压的工况。

The resistance of the DUT against reverse-polarity battery connection during jump starting is simulated.

6.9.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 至少需满足 Class C。

——在反极性测试过程中，对安全性具有重要意义的功能的零部件（如电动车窗玻璃升降器、电动天窗、起动机等），和安全性相关的功能不允许被激活。

注：发电机可豁免此项测试。

DUT test results should meet the following requirements:

--For all components: Functional status C

--When reverse polarity is applied, no safety-relevant functions must be triggered, e.g., for electric window lifts, electric sunroof, starter.

Note： Generators are exempt from this test.

6.9.2 试验 Test

E09 试验参数需满足表 20 表 21 要求，试验脉冲电压波形见图 7a 7b。

E09 test parameters should as per the requirements in table 20 and table 21, and the test profile is shown in figure 7a and figure 7b.

表 20 E09 反向电压 试验参数 Table 20 E09 Test parameters, Reverse polarity

工作模式 DUT operating mode	2.b

U_{max}	0V
U_{min}	-14V
ΔU_1	-1V
严酷度 1 Test grade 1	R_i ＜100mΩ
严酷度 2 Test grade 2	R_i ＜30mΩ
t_1	60s（通过继电器关断反向电压的部件，适用于 8ms） 60s For a component for which the operating voltage is switched off by a relay in the event of reverse polarity, the following deviating value applies: 8 ms
t_2	＞60s
t_r & t_f	＜10ms
循环数量 Number of cycles	1

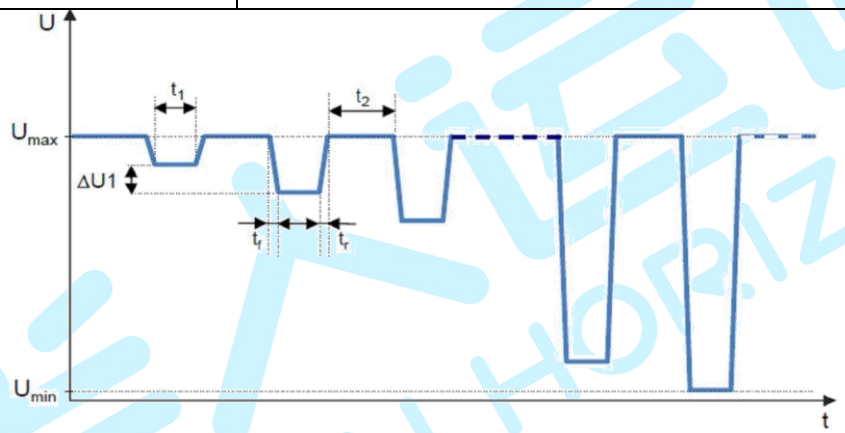


图 7a 试验脉冲-E09 Figure 7a Test profile -E09

表 21 E09 反向电压 试验参数 Table 21 E09 Test parameters, Reverse polarity

工作模式 DUT operating mode	2.c
U_{max}	10.8V
U_{min}	-4V
严酷度 1 Test grade 1	R_i ＜100mΩ
严酷度 2 Test grade 2	R_i ＜30mΩ
t_1	60s（通过继电器关断反向电压的部件，适用于 8ms） 60s For a component for which the operating voltage is switched off by a relay in the event of reverse polarity, the following deviating value applies: 8 ms
t_2	≤5min
t_r & t_f	＜10ms

循环数量 Number of cycles	3

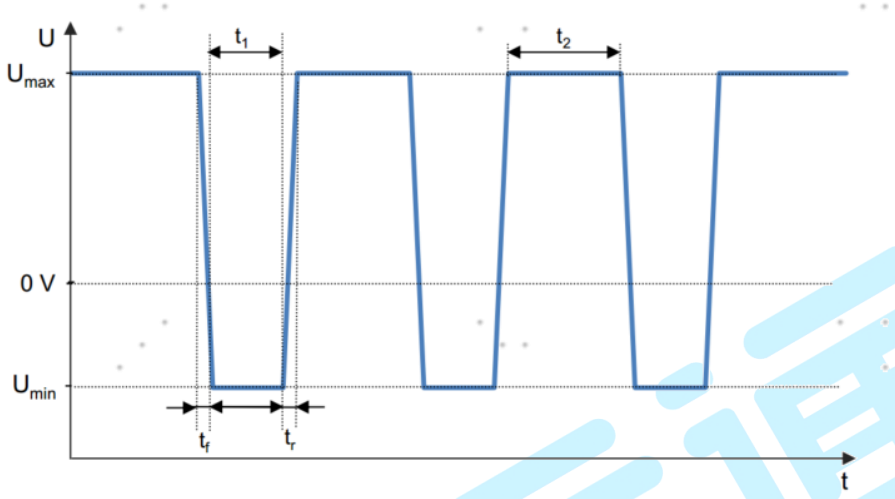


图 7b 试验脉冲-E09 Figure 7b Test profile -E09

6.10 E10 叠加交流电压 E10 Superimposed alternating voltage

本项测试主要模拟直流供电下的电压纹波工况。

Voltages may be superimposed to the electric system. The superimposed alternating voltage may be applied during the entire running time of the engine. This situation is simulated by means of these tests.

6.10.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

--For all components: Functional status A.

6.10.2 试验 Test

E10 试验参数需满足表 22 要求，试验脉冲电压波形见图 8。

E10 test parameters should as per the requirements in table 22, and the test profile is shown in figure 8.

表 22 E10 叠加交流电压 试验参数 Table 22 E10 Test parameters, Superimposed alternating voltage

工作模式 DUT operating mode	2.c
U_{max}	U_{Bmax}
R_i	＜100mΩ
扫频类型 Type sweep	三角波，对数 Triangle, logarithmic
循环数量 Number of cycles	15
情况 1 Test case1	2V, 15Hz-30kHz, 2min

情况 2 Test case2	3V, 15Hz-30kHz, 2min
情况 3 Test case3	6V, 15Hz-30kHz, 2min
情况 4 Test case 4	1V, 30kHz-200kHz, 10min

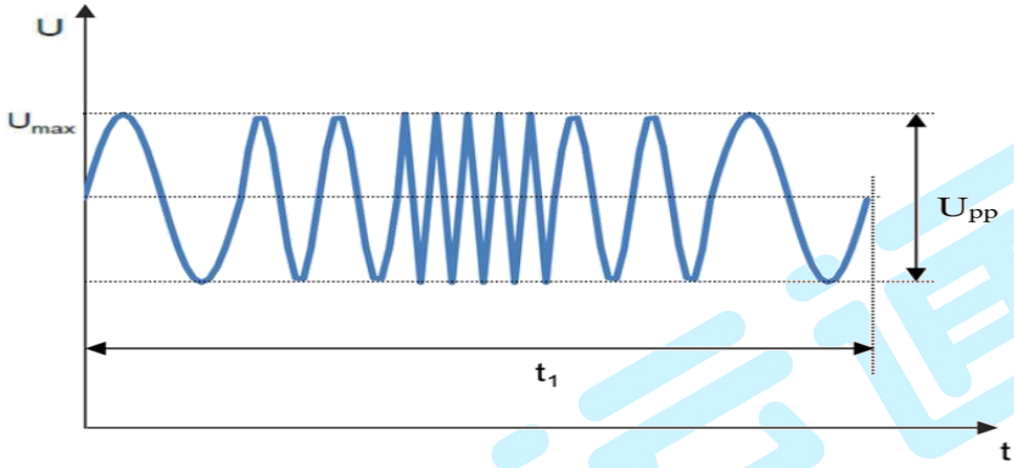


图 8 试验脉冲-E10 Figure 8 Test profile -E10

6.11 E11 参考地偏移 E11 Ground offset

本项测试主要模拟多个不同接地点之间存在电位差的工况。

Potential differences between various ground connection locations can cause signal distortions between components at these connection locations.

6.11.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

--For all components: Functional status A.

6.11.2 试验 Test

E11 试验参数需满足表 23 要求，试验布置见图 9。

如果 DUT 具有多个接地连接端，应为每个连接点进行单独试验。

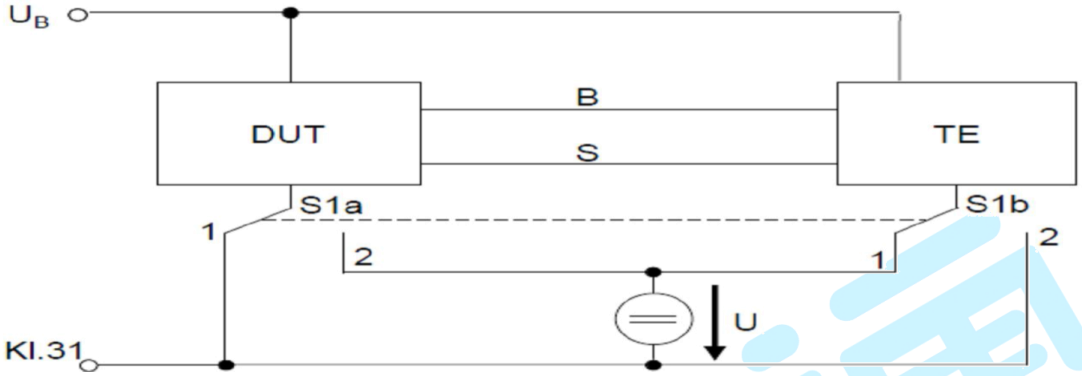
E11 test parameters should as per the requirements in table 23, and the test setup is shown in figure 9

If the DUT has several voltage and ground connections, the test must be performed individually for each connection point.

表 23 E11 参考地偏移 试验参数 Table 23 E11 Test parameters, Ground offset

工作模式 DUT operating mode	2.c
地偏移电压 Offset voltage	1V

持续时间 Test duration	≥60s
循环数量 Number of cycles	两个连接位置 Both switching positions



说明：

B-数据总线系统　　S-信号线路　　S1-两极（a/b）转换开关

TE-其他部件，比如：试验台、模拟控制器、执行器、传感器、负载

Legend：

B- Bus system　　S- Signal line　　S1- Two-pin (a/b) change-over switch

TE- Other component, e.g., test reference, test bed, simulation electronic control unit, actuator, sensor, or load

图 9 电路原理图-E11 Figure 9 Schematic circuit-E11

6.12 E12 引脚中断 E12 Pin interruption

本项测试主要模拟单个引脚接触不良或者持续性断路导致电路中断的工况。

The supply line interruption of individual pins is simulated.

6.12.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

DUT test results should meet the following requirements:

--For all components: Functional status C.

6.12.2 试验 Test

E12 试验参数需满足表 24 要求。

E12 test parameters should as per the requirements in table 24.

表 24 E12 引脚中断 试验参数 Table 24 E12 Test parameters, Pin interruption

工作模式 DUT operating mode	2.c
Z1	状态 1：引脚连接 Condition 1: pin connected
Z2	状态 2：引脚中断 Condition 2: pin connected
t_r & t_f	＜ $(0.1*t_1)$

循环数量 Number of cycles	2.b, 2.c 各 3 次 3 cycles with 2.b and 3 cycles with 2.c
测试序列 1 Test case1	每个引脚拔出 t=10s，并重新复位（长间隔） Each pin must be removed for t = 10 s and then replaced (slow interval).
测试序列 2 Test case2	在每个引脚上施加脉冲组（见图 10） Burst on each pin in order to simulate a loose contact (Figure 10)
脉冲组中的脉冲 t_2 数量 Number of pulses t_2 in the burst	4000
a	脉冲组 Burst
t_1	0.1ms
t_2	1ms
t_3	10s

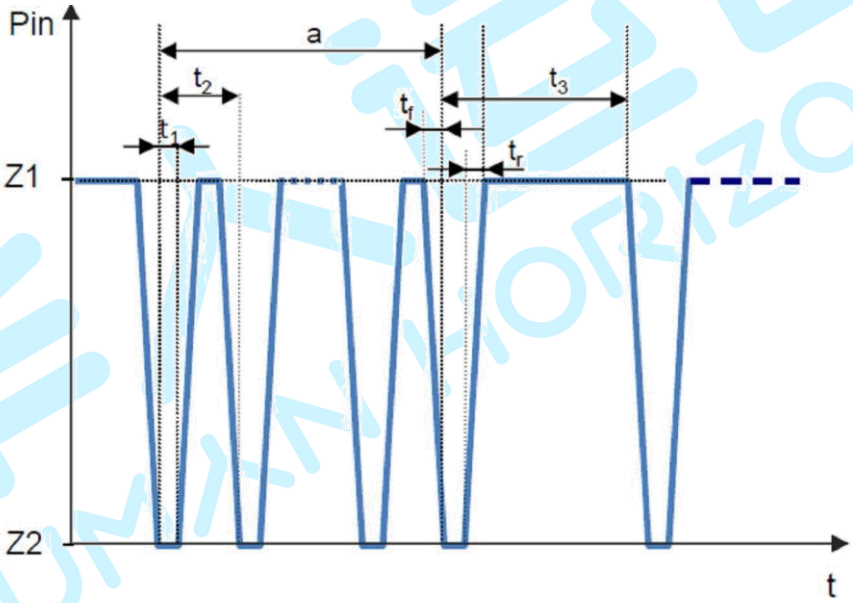


图 10 试验脉冲-E12 Figure 10 Test profile -E12

6.13 E13 接插件中断 E13 Connector interruption

本项测试主要模拟接插件中断的工况。

The line interruption of connectors is simulated.

6.13.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

DUT test results should meet the following requirements:

--For all components: Functional status C.

6.13.2 试验 Test

E13 试验参数需满足表 25 要求。

试验程序要求：从 DUT 中拔出插头 10 s，然后重新插上连接好。如果 DUT 有多个插头，先对对每个接插件单独进行试验，然后不同接插件之间再重新进行组合插拔试验。

E13 test parameters should as per the requirements in table 25.

Each connector must be removed from the DUT for 10 s and then replaced. If the DUT has several connectors, each connector must be tested individually. The test sequence must be variable. If there are several connectors, their combinations must also be tested.

表 25 E13 接插件中断 试验参数 Table 25 E13 Test parameters, Connector interruption

工作模式 DUT operating mode	2.a and 2.c
循环数量 Number of cycles	每个接插件分别在两种工作模式下各插拔一次 Each connector must be removed once in both operating modes

6.14 E14 短路保护 E14 Short circuit in signal circuit and load circuits

本项测试主要模拟所有输入端和输出端以及负载电路短路的工况。

Short circuits on all device inputs and outputs and in the load circuit are simulated.

6.14.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于图 11 中的输入端和输出端（E 和 A）：功能状态 C

——对于图 11 中的并联供电电压端（PWR）：功能状态 D

——对于图 11 中的接地端（GND）：功能状态 E

DUT test results should meet the following requirements:

--For inputs and outputs (E and A): Functional status C

--For looped-through supply voltages (PWR): Functional status D

--For device ground (GND): Functional status E

6.14.2 试验 Test

E14 试验参数需满足表 26 要求。

测试使用的试验电源，应能够提供零部件可能承受的短路电流。也允许通过汽车蓄电池对电源进行缓冲（在这种情况下 U_{Bmax} 等于最高充电电压）。

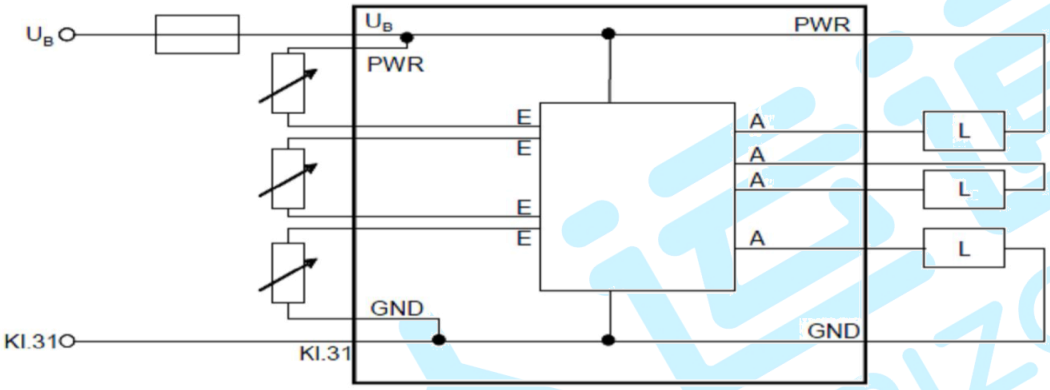
E14 test parameters should as per the requirements in table 26。

The power supply unit used for the test must be able to supply the short-circuit currents to be expected by the component. If this is not possible, buffering of the power supply unit by means of a car battery is permissible (U_{Bmax} is the maximum charging voltage in this case).

表 26 E14 短路保护 试验参数

Table 26 E14 Test parameters, Short circuit in signal circuit and load circuits

工作模式 DUT operating mode	2.c
短路持续时间 Duration time	每个引脚分别对地和对 U_B 短路 60s Short circuit of each pin individually for 60 s to ground and to U_B.
试验电压 Test voltages	U_{Bmin} 和 U_{Bmax} U_{Bmin} and U_{Bmax}
试验方式 Test method	每个引脚交替对 U_B 和部件接地端短路一次 Each pin alternately to U_B and GND.



说明

L-负载 E-输入端 A-输出端

PWR-U_B 输出端 GND-输入/输出端（端子 31）

Legend L-Load E-Input A-Output PWR-Output U_B GND-Input/output（T.31）

图 11 电路原理图-E14 Figure 11 Schematic circuit-E14

6.15 E15 绝缘电阻 E15 Insulation resistance

本项测试主要目的是测量采取电隔离措施元件之间的绝缘电阻。

The insulation resistance between parts without galvanic connection is determined.

6.15.1 要求 Requirement

恒定湿热和湿热循环测试后必须验证绝缘电阻。其中恒定湿热试验后需对 DUT 通风 30 分钟后再测试绝缘电阻。湿热循环试验结束后立即测试绝缘电阻。

DUT 测试结果应满足下述要求：

——绝缘电阻至少达到 10MΩ

——试验后 FPSC 应满足 Class A

This test must be performed after the tests "Damp heat, constant" and "Damp heat, cyclic."

After the "Damp heat, constant" test, the DUTs must be ventilated for 30 min before the measurement of the insulation resistance is carried out. The insulation resistance must be measured immediately after the "Damp heat, cyclic" test.

DUT test results should meet the following requirements:

--The insulation resistance must be at least 10MΩ.

--After the test, functional status A must be verified.

6.15.2 试验 Test

E15 试验参数需满足表 27 要求。

E15 test parameters should as per the requirements in table 27.

表 27 E15 绝缘电阻 试验参数 Table 27 E15 Test parameters, Insulation resistance

工作模式 DUT operating mode	1.a
试验电压 Test voltage	500VDC
测试持续时间 Test duration	60s
测试点 Test points	在以下位置施加试验电压：-不存在电连接的连接端-连接引脚和导电壳体（不存在电连接）之间-连接引脚和围绕不导电壳体的电极之间 Application of the test voltage - To terminals without a galvanic connection- Between connection pins and conductive housing without a galvanic connection- Between connection pins and an electrode around the housing if the housing is non-conductive
循环数量 Number of cycles	必须经过 1 个循环，其中上述每个试验点都必须至少试验一次 1 cycle must be performed, in which each of the points defined above must be tested at least once.

6.16 E16 静态电流 E16 Closed-circuit current

本项测试主要目的是测量零部件的静态电流。

The closed-circuit current consumption must be determined.

6.16.1 要求 Requirement

DUT 测试结果应满足下述要求：

DUT 测试时必须连接相关外围零部件和电路

——对于接蓄电池常电工作的 DUT，静态电流值≤ 0.1 mA（相当于 1.2 mAh）

——对于接蓄电池常电工作的 DUT，当温度高于＋40°C 时，静态电流值≤0.2 mA。

任何与上述静态电流要求不符的 DUT 设计，应获得华人运通公司 ENV 工程师的同意。

DUT test results should meet the following requirements:

The component must be measured with the associated peripherals and circuitry.

——For DUTs that must be operated after T.15 OFF, a closed-circuit current equivalent (average over 12 h) of ≤0,1 mA (corresponding to 1,2 mAh) applies in the idle phase.

——For DUTs that must be operated after T.15 OFF, a closed-circuit current equivalent (average over 12 h) of ≤0,2 mA above + 40°C applies in the idle phase.

Any deviations from the requirement above shoud be agreed with engineers from Human Horizons.

6.16.2 试验 Test

E16 试验参数需满足表 28 要求。

E16 test parameters should as per the requirements in table 28.

表 28 E16 静态电流 试验参数 Table 28 E16 Test parameters, Closed-circuit current

工作模式 DUT operating mode	2.b
试验电压 Test voltage	12.5V（+4%，0%）
测试时间 Test time	12h
测试序列 1 Test case1	
T	T_{min}
测试序列 2 Test case2	
T	T_{RT}
测试序列 3 Test case3	
T	T_{max}

6.17 E17 过电流 E17 Overcurrents

本项测试主要为了验证机械开关、电子输出端和触点的耐过电流性能。

The overcurrent protection of mechanical switches, electronic outputs and contacts is tested.

6.17.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于没有熔断器设计的零部件，FPSC 应满足 ClassA。

——如果负载电路中存在保险设计，允许该保险熔断/激活。

——对于具有过载识别（电流、电压、温度）功能的电子输出端，FPSC 应满足 ClassC。

DUT test results should meet the following requirements:

——Functional status A for mechanical components without fuse.

——If fuse elements are available in the load circuit, these may be triggered.

——Functional status C for electronic outputs with overload detection (current, voltage, temperature).

6.17.2 试验 Test

E17 试验参数需满足表 29 要求。

E17 test parameters should as per the requirements in table 29.

表 29 E17 过电流 试验参数 Table 29 E17 Test parameters, Overcurrents

工作模式 DUT operating mode	2.c
温度 Temperature	T_{max}
电子输出端试验条件 Test conditions for electronic outputs	输出端能够承受至少三倍的标准负荷，负荷持续时间：30 分钟 The output must withstand at least the triple value of the nominal load without damage.Load duration 30 min
开关输出端的试验条件 Test conditions for switched outputs	对于 I_N≤10 A 的部件：3xI_N；对于 I_N＞10 A 的部件：2xI_N，但至少为 30A，最大为 150A，负荷持续时间 10 分钟，涉及多触点继电器和开关时，每个触点单独进行试验。 For components with I_N≤10 A: 3xI_N;For components with I_N＞10 A: 2xI_N，but at least 30A and at most 150A,Load duration 10 min.Each contact must be tested individually in the case of multiple-contact relays and multiple-contact switches.

6.18 E18 短时中断 E18 Short interruptions

本项测试主要目的是模拟各种情况下短时中断的情况。

The component's behavior at short interruptions of different durations is simulated.

6.18.1 要求 Requirement

测试前需分别用 100Ω(±5%)和 1Ω(±5%)作为 DUT 进行测试，用于确认验证波形是否满足要求，将得到的结果和波形记录在报告中。

One reference measurement each with 100 Ω (±5%) and 1 Ω (±5%) as a DUT substitute must be performed and documented. Verification of the edge steepness must be provided with this test setup.

DUT 测试结果应满足下述要求：

在 t1<100µs 时，需满足 Class A；在 t1≥100µs 时，需满足 Class C

DUT 偏离出 Class A 时的 t1 必须记录在报告中。

DUT test results should meet the following requirements:

For t1 <100 µs: Functional status A. For t1 ≥100 µs: Functional status C

It must be documented as of which time value t1 the DUT leaves functional status A for the first time.

6.18.2 试验 Test

E18 试验参数需满足表 30 要求。

E18 test parameters should as per the requirements in table 30.

表 30 E18 短时中断 试验参数 Table 30 E18 Test parameters, Short interruptions

工作模式 DUT operating mode	2.c
试验电压 Test voltage	11V

Z1	S1 关闭 S1closed	
Z2	S1 开启 S1open	
t_r	≤(0,1 * t_1)	
t_f	≤(0,1 * t_1)	
S1 动作序列 Switch S1 must be switched with the following sequences:	t_1	步进 Increments
	10 µs to 100 µs	10 µs
	100 µs to 1 ms	100 µs
	1 ms to 10 ms	1 ms
	10 ms to 100 ms	10 ms
	100 ms to 2 s	100 ms
t_2	>10s 直到 DUT 和外围设备达到 100%正常工作 >10s The test voltage Vtest must be held at least until the DUT and the periphery have reached 100% operability again.	
循环数 Number of cycles	1	
情况 1 Test case 1	S1 动作时，S2 保持打开 S1 switched, S2 statically open	
情况 2 Test case 2	S1 动作时，S2 状态与 S1 相反 S1 switched, S2 opposite S1	

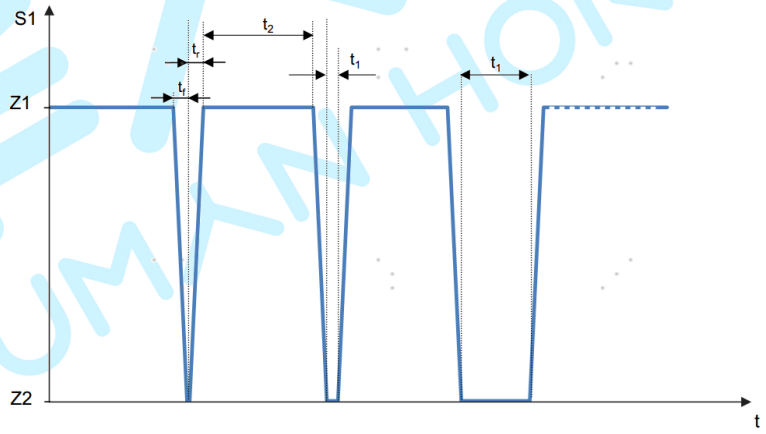


图 12 试验脉冲-E18 Figure 10 Test profile -E18

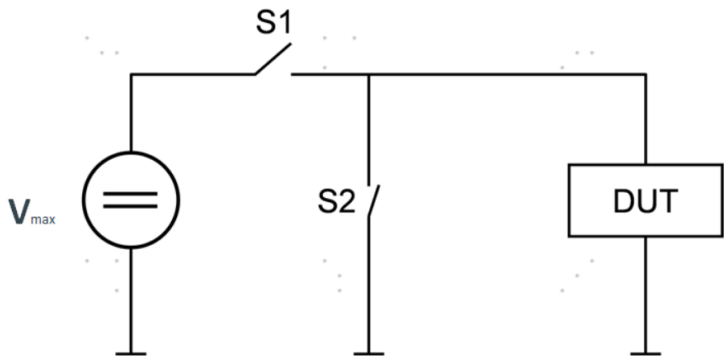


图 13 测试电路-E18 Figure 13 Schematic circuit -E18

S2 闭合时，其线上及其他必要线上必须串联一个<100 mΩ 电阻

The closed switch S2 including the necessary lines must have a series resistance <100 mΩ.

6.19 E19 击穿强度 E19 Dielectric strength

本项测试主要目的是测量电流隔断部件之间的击穿强度，如插头插脚，继电器，绕组或者线路。感性元件或控制感性元件的零件必须测试。

This test simulates the dielectric strength between components of the DUT that are galvanically isolated from each other, e.g., connector pins, relays, windings, or lines. The test must be performed on components that contain or control inductive subcomponents.

6.19.1 要求 Requirement

恒定湿热和湿热循环测试后必须验证绝缘电阻。其中恒定湿热试验后需对 DUT 通风 30 分钟后再测试绝缘电阻。湿热循环试验结束后立即测试绝缘电阻。

DUT 测试结果应满足下述要求：

FPSC 应满足 Class C，击穿及电弧不允许产生。

This test must be performed after the tests "Damp heat, constant" and "Damp heat, cyclic."

After the "Damp heat, constant" test, the DUTs must be ventilated for 30 min before the measurement of the insulation resistance is carried out. The insulation resistance must be measured immediately after the "Damp heat, cyclic" test.

DUT test results should meet the following requirements:

Functional state C, Dielectric breakdowns and electric arcs are not permissible.

6.19.2 试验 Test

E19 试验参数需满足表 31 要求。

E19 test parameters should as per the requirements in table 31.

表 31 E19 击穿强度 试验参数 Table 31 E19 Test parameters, Dielectric strength

工作模式 DUT operating mode	2.b
试验电压 Test voltage VRMS	500 V AC, 50 Hz, sinusoidal
测试持续时间 Test duration	60s
测试点 Test points	在以下位置施加试验电压：-不存在电连接的连接端-连接引脚和导电壳体（不存在电连接）之间-连接引脚和围绕不导电壳体的电极之间 Application of the test voltage -To terminals without galvanic connection.-Between connection pins and conducting housing without galvanic connection.-Between connection pins and conducting housing without galvanic connection.
循环数量 Number of cycles	必须经过 1 个循环，其中上述每个试验点都必须至少试验一次 1 cycle must be performed, in which each of the points defined above must be tested at least once.

6.20 E20 反馈 E20 Backfeeds

本项测试主要目的是保证 DUT 没有反馈给开关节点，保证开关节点的独立性，如 kl15 等。

The independence of switched terminals must be ensured. This test verifies that the DUT is free of backfeeds to switched terminals.

6.20.1 要求 Requirement

将 DUT 按照实车情况进行连接，包括传感器及负载，并正常工作，通过切断开关开测试电压变动波形。如存在其他可能的电压源，如 kl30，在试验期间不允许切断（参照实车实际情况）。测试需采用一台输入电阻≥ 10 MΩ的设备，如示波器

The DUT must be connected according to the circuitry in the vehicle (including sensors, actuators, etc.) and operated in normal operation. Switches S1 and S2 are closed. The voltage curve at the terminal being tested must be measured during switch-off of the terminal. To do this, the switches must be opened as per Table 32. The terminal must be switched off, e.g., by means of a relay or a switch (Rswitch_open → ∞). Other possible voltage sources, such as t.30, must not be disconnected or switched off during the test (according to the behavior in the vehicle). The voltage curve at the terminal being tested must be measured using a measuring device (V) with an input resistance of ≥ 10 MΩ (e.g., oscilloscope).

开关关断后，反馈电压必须在 20ms 内达到 1V 以下。电压波形必须为连续下降，不允许由于正脉冲存在不连续的下降。

Voltage backfeeds to the terminal being tested are permissible only up to a maximum level of 1 V. This voltage range must be achieved within t = 20 ms from the time of the switch-off.

The voltage curve over time must continuously fall. Discontinuity of the curve due to positive pulses is not permitted.

6.20.2 试验 Test

E20 试验参数需满足表 32 要求。

E20 test parameters should as per the requirements in table 32.

表 32 E20 反馈 试验参数 Table 32 E19 Test parameters, Backfeeds

工作模式 DUT operating mode	2.c	
试验电压 Test voltage	V_{max}-0.2V	
测试温度 Test Temperature	T_{max}, T_{RT}, and T_{min}	
情况 1 Test case 1	严酷度 1 Severity 1	严酷度 2 Severity 2
R	/	≥10 kΩ
S1	开 Open	开 Open
S2	关 Closed	关 Closed
情况 2 Test case 2		
R	≥10 kΩ	
S1	开 Open	
S2	开 Open	

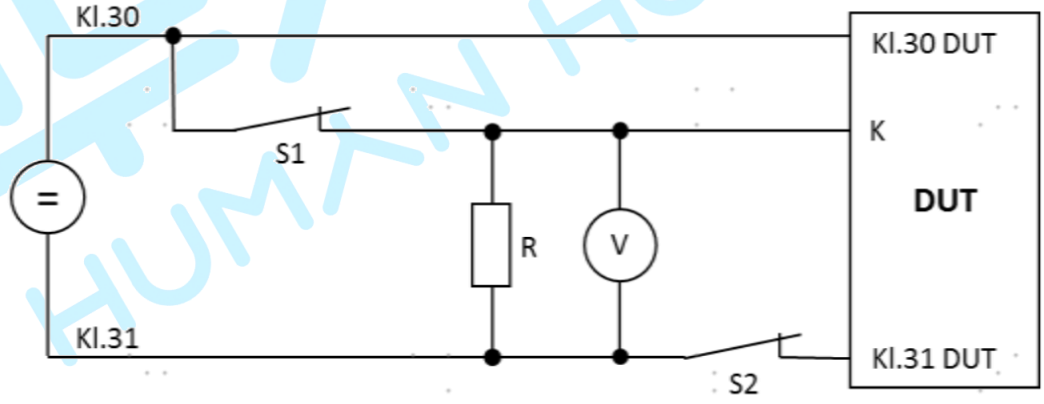


图 14 测试电路-E20 Figure 14 Schematic circuit –E20

6.21 E21 多电源供电均衡电流 E21 Equalizing currents of multiple supply voltages

本项测试主要目的是对于多独立电源供电线的零部件，测试其多电源之间的独立性。

For components with multiple supply voltage inputs independent of each other, e.g., if voltage is supplied by 12-V electric subsystems independent of each other, this test determines the internal independence of these supply branches.

6.21.1 要求 Requirement

在试验中测得的均衡电流不得超过 100μA，故障不得覆盖或损害电源间的独立性。
试验后必须验证功能 Class A。
The equalizing current measured in the test setup must not exceed 100 μA. A single fault must not override or jeopardize the independence of the supply branches. Functional state A must be verified after the test.

6.21.2 试验 Test

E21 试验参数需满足表 33 要求。
E21 test parameters should as per the requirements in table 33.

表 33 E21 反馈 试验参数 Table 33 E21 Test parameters, Equalizing currents of multiple supply voltages

工作模式 DUT operating mode	1.b
t_{test}	60s
测试点 Test Point	所有供电线上以及其他额外需要的测试点 Application of the test voltage between — Both supply connections — Additional test points agreed upon with the appropriate department
循环数 Number of cycles	1
情况 1 Test case 1	
V_{test}	32V
情况 2 Test case 2	
V_{test}	-32V

7 机械负荷 Mechanical loads

7.1 M01 机械振动 M01 Vibration test

本项试验依据标准 ISO16750-3 或 GB/T 28046.3 执行，主要模拟车辆运行过程中承受的机械振动。
对于全部振动试验，DUT 应安装于三个不同的空间方向分别进行测试。对安装位置和方向的敏感的 DUT，测试需覆盖实车设计的安装空间方向。DUT 应使用和实际装车相同的线束和连接插头，对于集成了线束的样件，除非特别说明，在固定后线束应该有额外的 150mm 自由活动长度。
正弦振动的扫频速率要求：对数方式，1oct/min。
全部振动试验过程中的温度变化应满足表 34 要求，温度变化曲线图示见图 15 所示。
The test is carried out as per ISO16750-3 or GB/T 28046.3, these tests simulate the vibrational load of the component during driving operation.
For all vibration tests, DUT should be installed in three different spatial directions for testing. For DUT sensitive to mounting position and direction, the test should cover the mounting space direction of the actual vehicle design. The DUT shall use the same wire harness and connection plug as the actual loading vehicle. For the sample parts with the wire harness integrated, the wire harness shall have an additional 150mm free running length after fixation unless otherwise specified.
Frequency sweep rate requirements for sinusoidal vibrations: logarithmic mode, 1 Oct/min.
All temperature changes during the vibration test should meet the requirements in table 34, and the diagram of the temperature change curve is shown in figure 15.

表 34 振动时间与温度对应关系 Table 34 Temperature curve for vibration

时间 Time(min)	温度 Temperature ℃
0	T_{RT}=20
60	T_{min}
150	T_{min}
210	T_{RT}=20
300	T_{max}
410	T_{max}
480	T_{RT}=20

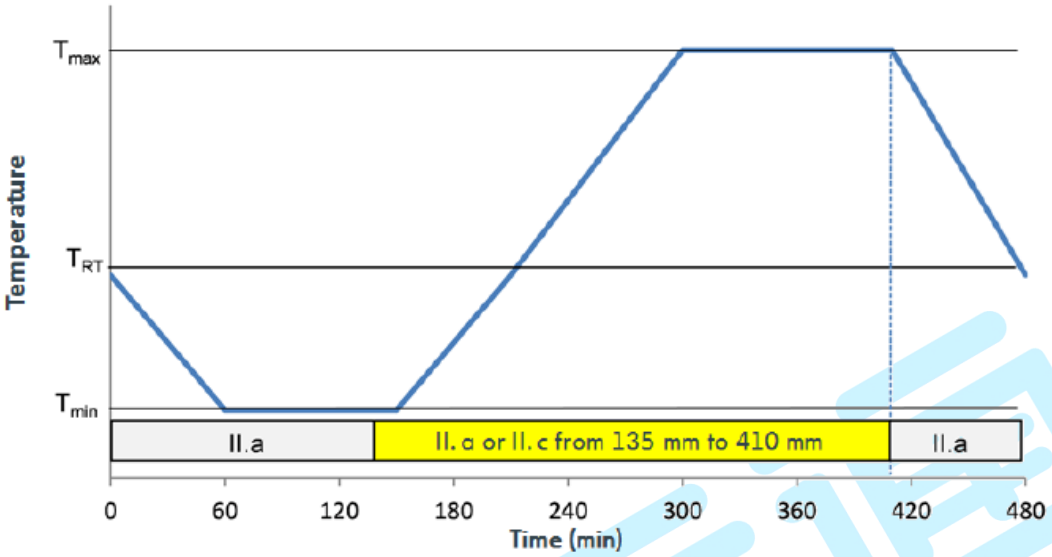


图 15 振动试验温度变化曲线 Figure 15: Temperature curve for vibration

DUT 的振动测试要求，依据其在整车上安装固定的位置进行选择。DUT 适用的机械振动测试时间要求，应依据表 35 选择执行。

The vibration test requirements of DUT are selected according to its fixed position on the vehicle. The time requirements of mechanical vibration test applicable to DUT shall be selected and executed according to table 35.

表 35 M01 机械振动测试时间要求 Table 35 M01 Test duration for mechanical vibration test

检测项目 Test item		每个轴向测试的持续时间（X 轴,Y 轴,Z 轴）Test duration for each spatial axis
M01-1 发动机位置 M01-1 for engine-mounted parts	正弦振动 Sinusoidal	22h
	随机振动 Random vibration	22h
M01-2 变速器位置 M01-2 for gearbox-mounted parts	正弦振动 Sinusoidal	22h
	随机振动 Random vibration	22h
M01-3 柔性气室位置 M01-3 for flexible plenum chamber	正弦振动 Sinusoidal	22h
M01-4 传动装置位置 M01-4 On-Transmission/In-Transmission	随机振动 Random vibration	16h
M01-5 弹性体位置 M01-5 for component installed on sprung masses	随机振动 Random vibration	8h
M01-6 非弹性体位置 M01-6 for unsprung masses	随机振动 Random vibration	8h

M01-1 发动机位置 M01-1 for engine-mounted parts

7.1.1 M01-1 适用于固定在发动机装置上的零部件。

发动机振动主要分由气缸质量不平衡作用于连杆产生的正弦振动和由发动机其它振动产生的随机振动。

M01-1 is used for component fixed to the engine.

The vibration of the engine is mainly divided into sinusoidal vibration caused by the unbalance mass force in the cylinders and random vibration caused by other vibration schemes of the engine.

7.1.1.1 要求 Requirements

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.1.1.2 试验 Test

对于正弦振动，试验参数应满足表 36 要求，试验曲线见图 16 所示。

——若 DUT 安装在不超过 5 缸（含 5 缸）的发动机上，适用表 36 定义的曲线 1。

——若 DUT 安装在 6 缸以上（含 6 缸）的发动机上，适用表 36 定义的曲线 2。

——若 DUT 可能安装在上述两种发动机上，适用表 36 定义的曲线 1+曲线 2。

对于随机振动，试验参数应满足表 37 要求，试验曲线见图 17 所示。

For sinusoidal vibration, the test parameters should meet the requirements of table 36, and the test profile is shown in figure 16. For random vibrations, as per table 37 and figure 17, the R.M.S. acceleration value shall be 181 m/s2.

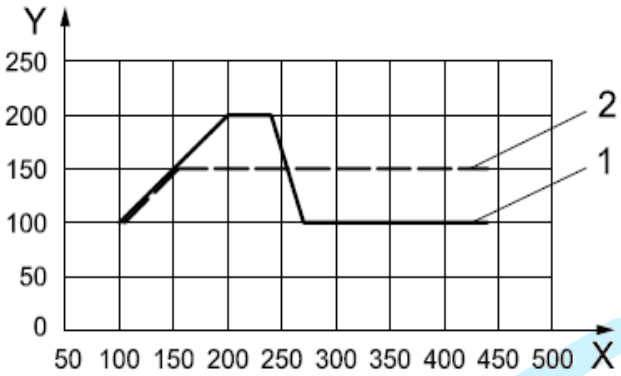
-- Use curve 1 in Table 36 for DUT intended for mounting on engines with five cylinders or less.

-- Use curve 2 in Table 36 for DUT intended for mounting on engines more than five cylinders or more.

-- Both curves maybe combined to cover all engine types on one test.

表 36 M01-1 发动机位置 正弦振动试验参数 Table 36 M01-1 Maximum acceleration versus frequency

曲线 Curve 1		曲线 Curve 2		曲线 Curve 1+曲线 Curve 2	
频率 Frequency,Hz	加速度 Acceleration,m/s^2	频率 Frequency,Hz	加速度 Acceleration,m/s^2	频率 Frequency,Hz	加速度 Acceleration,m/s^2
100	100	100	100	100	100
200	200	150	150	150	150
240	200	440	150	200	200
270	100	/	/	240	200
440	100	/	/	255	150
/	/	/	/	440	150

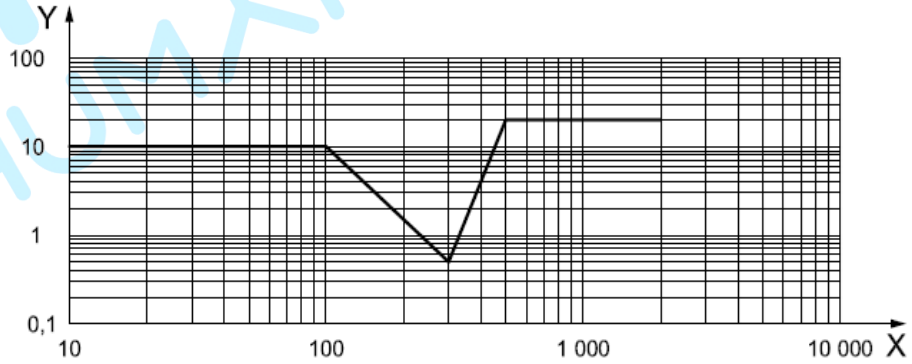


Key
X frequency, Hz
Y maximum acceleration, m/s^2
1 curve 1 (≤ five cylinders)
2 curve 2 (> five cylinders)

图 16 M01-1 发动机位置 正弦振动试验曲线 Figure 16 M01-1 Vibration severity curve

表 37 M01-1 发动机位置 随机振动试验参数 Table 37 M01-1 Test profile, engine-mounted parts

频率 Frequency,Hz	功率谱密度 PSD, $(m/s^2)^2/Hz$	加速度有效值 Acceleration RMS, m/s^2
10	10	181
100	10	
300	0.51	
500	20	
2000	20	



Key
X frequency, Hz
Y power spectral density, $(m/s^2)^2/Hz$

图 17 M01-1 发动机位置 随机振动试验曲线 Figure 17 M01-1 Test profile, engine-mounted parts

7.1.2 M01-2 变速器位置 M01-2 for gearbox-mounted parts

M01-2 适用于固定在变速器装置上的零部件。

变速器振动主要分为由质量不平衡产生的正弦振动和由齿轮摩擦产生的随机振动。

M01-2 is used for component fixed to the gearbox.The vibration of gearbox is mainly classified as sinusoidal vibration caused by mass imbalance and random vibration caused by gear friction.

7.1.2.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.1.2.2 试验 Test

对于正弦振动，试验参数应满足表 38 要求，试验曲线见图 18 所示。

对于随机振动，试验参数应满足表 39 要求，试验曲线见图 19 所示。

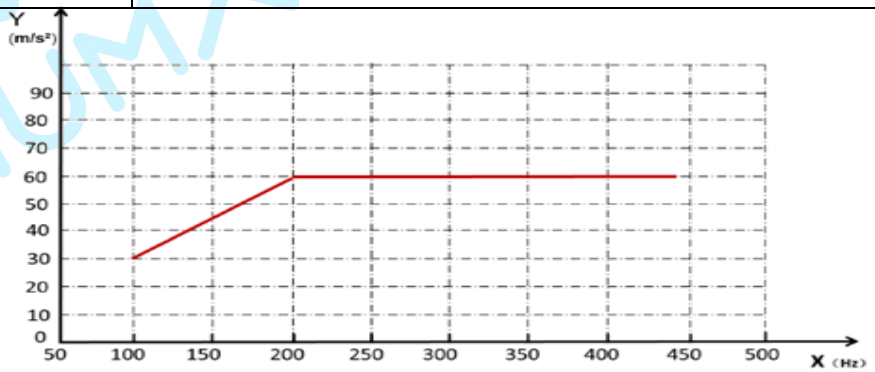
For sinusoidal vibration, the test parameters should as per the requirements of table 38, and the test profile is shown in figure 14.

For random vibration, the test parameters should as per the requirements in table 39, and the test profile is shown in figure 15.

表 38 M01-2 变速器位置 正弦振动试验参数

Table 38 M01-2 Values for maximum acceleration versus frequency

频率 Frequency,Hz	加速度 Acceleration,m/s^2
100	30
200	60
440	60



Key
X frequency, Hz
Y maximum acceleration, m/s^2

图 18 M01-2 变速器位置 正弦振动试验曲线 Figure 18 M01-2 Test profile, gearbox-mounted parts

表 39 M01-2 变速器位置 随机振动试验参数 Table 39 M01-2 Values for frequency and PSD

频率 Frequency, Hz	功率谱密度 PSD, ($m/s^2)^2$/Hz	加速度有效值 Acceleration RMS, m/s^2
10	10	96.6
100	10	
300	0.51	
500	5	
2000	5	

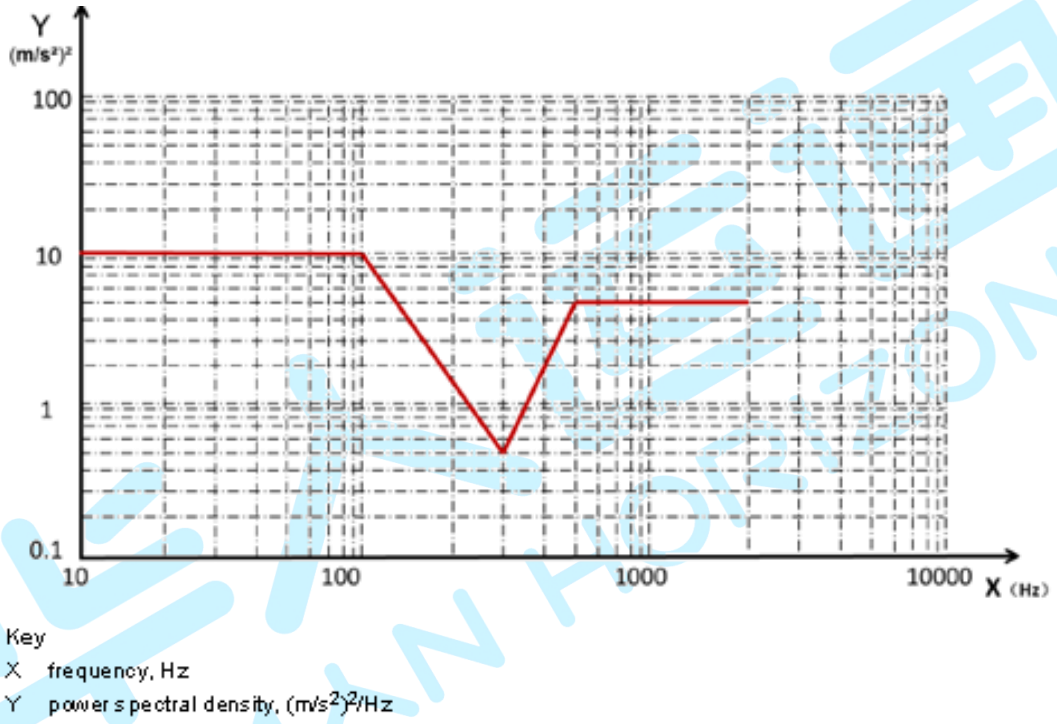


图 19 M01-2 变速器位置 随机振动试验曲线 Figure 19 M01-2 Test profile, gearbox-mounted parts

7.1.3 M01-3 柔性气室位置 M01-3 for flexible plenum chamber-mounted parts

M01-3 适用于非刚性安装固定在柔性气室装置上的零部件。

柔性气室振动主要是由入口气体颤动引起的正弦振动。

M01-3 is used for component fixed to the flexible plenum chamber. The vibration of flexible plenum chamber is mainly caused by the vibration of inlet gas.

7.1.3.1 要求 Requirements

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.1.3.2 试验 Test

试验参数应满足表 40 要求，试验曲线见图 20 所示。

The test parameters should as per the requirements in table 40, and the test profile is shown in figure 20.

表 40 M01-3 柔性气室位置 正弦振动试验参数

Table 40 M01-3 Values for maximum acceleration versus frequency

频率 Frequency,Hz	加速度 Acceleration,m/s²
100	90
200	180
325	180
500	80
1500	80

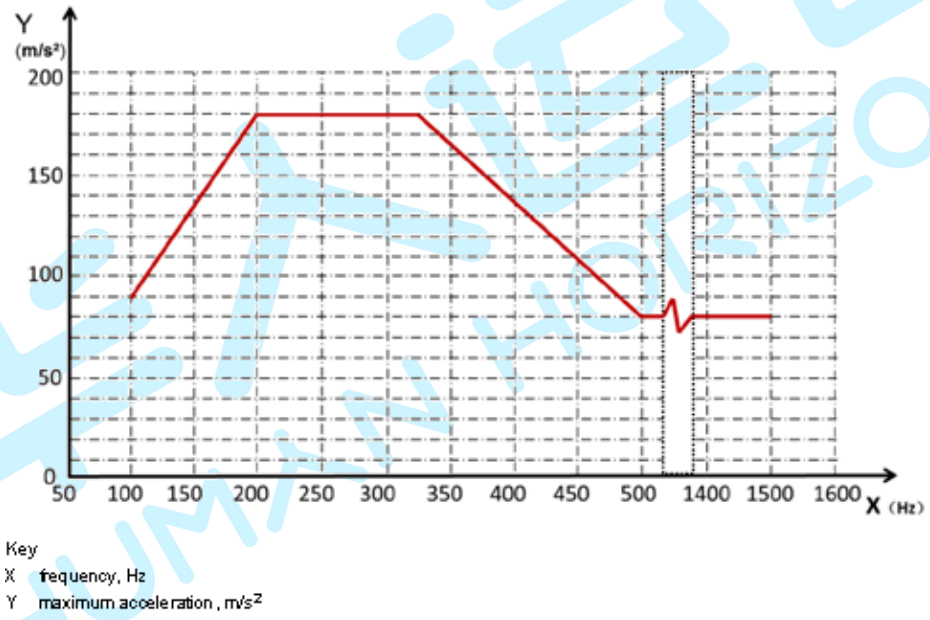


图 20 M01-3 柔性气室位置 正弦振动试验曲线

Figure 20 M01-3 Test profile, flexible plenum chamber-mounted parts

7.1.4 M01-4 传动装置位置 M01-4 for Transmission/In-Transmission-mounted parts

M01-4 适用于安装固定在电驱动车辆传动装置上的零部件。

传动装置上的振动类型主要为随机振动。

M01-4 is used for component fixed to transmission/in transmission for electric drive vehicle.

The vibration type on the transmission device is mainly random vibration.

7.1.4.1 要求 Requirements

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.1.4.2 试验 Test

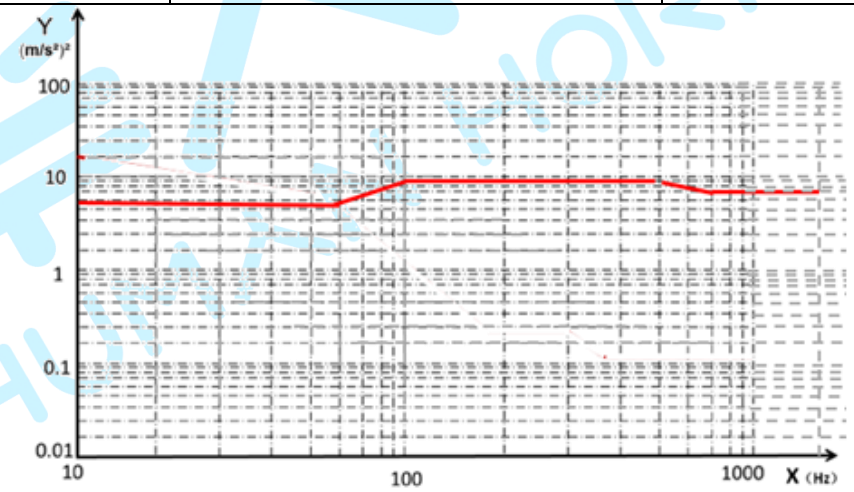
试验参数应满足表 41 要求，试验曲线见图 21 所示。

The test parameters should as per the requirements in table 41, and the test profile is shown in figure 21.

表 41 M01-4 传动装置位置 随机振动试验参数

Table 41 M01-4 Values for maximum acceleration versus frequency

频率 Frequency, Hz	功率谱密度 PSD, ($m/s^2)^2$/Hz	加速度有效值 Acceleration RMS, m/s^2
10	5.8	127
60	5.8	
100	9.6	
500	9.6	
700	7.7	
2000	7.7	



Key

X frequency, Hz

Y power spectral density, $(m/s^2)^2$/Hz

图 21 M01-4 传动装置位置 随机振动试验曲线 Figure 21 M01-4 Test profile, Transmission parts

7.1.5 M01-5 弹性体位置 M01-5 for sprung masses-mounted parts（vehicle body）

M01-5 适用于安装固定在（车身）弹性体上的零部件。

车身的振动主要是粗糙路面行驶引起的随机振动。

M01-5 is used for component fixed to sprung masses（vehicle body），The vibration of car body is mainly random vibration caused by rough road.

7.1.5.1 要求 Requirements

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.1.5.2 试验 Test

试验参数应满足表 42 要求，试验曲线见图 22 所示。

The test parameters should as per the requirements in table 42, and the test profile is shown in figure 22.

表 42 M01-5 弹性体位置 随机振动试验参数

Table 42 M01-5 Test parameters, random vibration for sprung masses

频率 Frequency, Hz	功率谱密度 PSD, $(m/s^2)^2/Hz$	加速度有效值 Acceleration RMS, m/s^2
5	0.884	30.8
10	20	
55	6.5	
180	0.25	
300	0.25	
360	0.14	
1000	0.14	
2000	0.14	

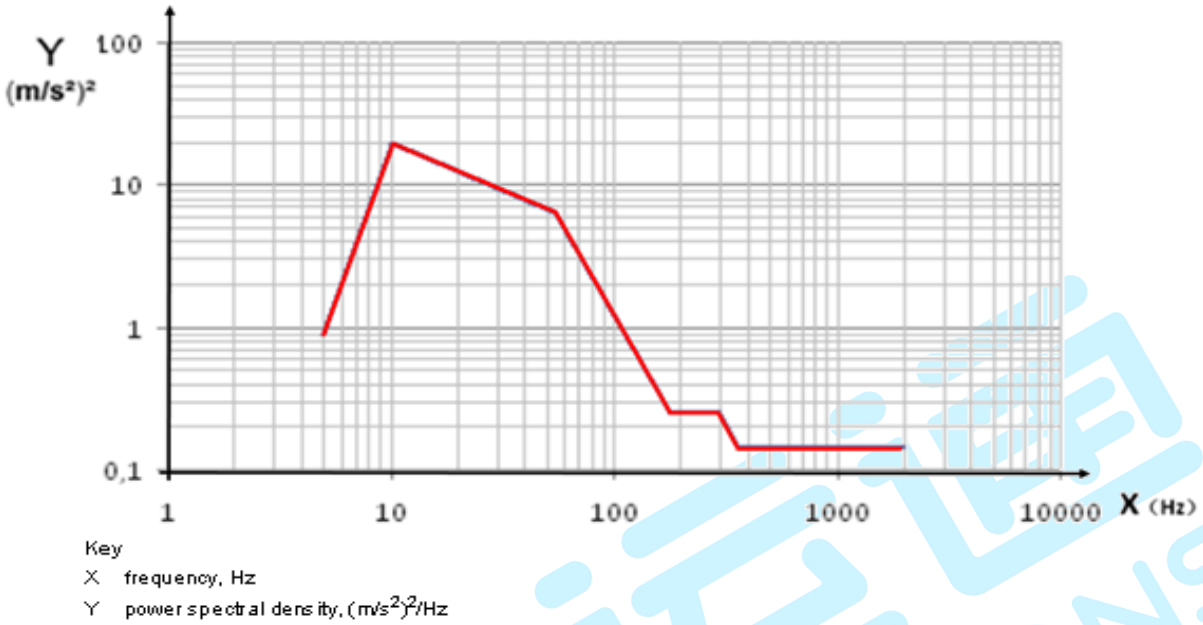


图 22 M01-5 弹性体位置 随机振动试验曲线 Figure 22 M01-5 Test profile, sprung masses parts

7.1.6 M01-6 非弹性体位置 M01-6 for unsprung masses-mounted parts（wheel，wheel suspension）

M01-6 适用于安装固定在（车轮，悬挂）非弹性体上的零部件。

非弹性体的振动主要是粗糙路面行驶引起的随机振动。

M01-6 is used for component fixed to unsprung masses（wheel，wheel suspension）.The vibration of unsprung masses is mainly random vibration caused by rough road.

7.1.6.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.1.6.2 试验 Test

试验参数应满足表 43 要求，试验曲线见图 23 所示。

The test parameters should as per the requirements in table 43, and the test profile is shown in figure 23.

表 43 M01-6 非弹性体位置 随机振动试验参数

Table 43 M01-6 Test parameters, random vibration for unsprung masses

频率 Frequency, Hz	功率谱密度 PSD, ($m/s^2)^2$/Hz	加速度有效值 Acceleration RMS, m/s^2
20	200	107.3
40	200	
300	0.5	
800	0.5	
1000	3	
2000	3	

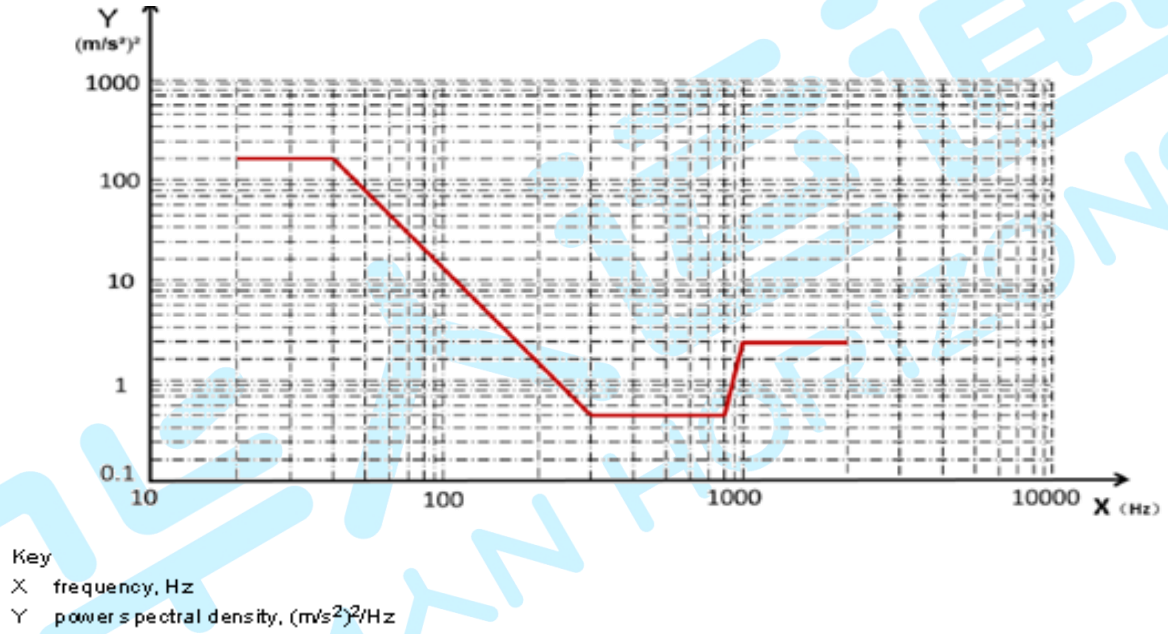


图 23 M01-6 非弹性体位置 随机振动试验曲线 Figure 23 M01-6 Test profile, unsprung masses parts

7.2 M02 机械冲击 M02 Mechanical shock

本项试验依据标准 ISO16750-3 或 GB/T 28046.3 执行，主要模拟车辆运行过程中承受的机械冲击。
The test is carried out as per ISO 16750-3 or GB/T 28046.3, it mainly simulates the mechanical impact of vehicle movement.

7.2.1 M02-1 所有电子电气零件 M02-1 All EE components

适用于所有电子电气零部件，模拟类似车辆越过路缘石或事故的情况下获得的高加速冲击工况。
This test simulates the mechanical load on the component, e.g., when driving over curbs or in the case of car accidents.

7.2.1.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.2.1.2 试验 Test

试验参数应满足表 44 要求。

The test parameters should as per the requirements in table 44.

表 44 M02-1 机械冲击试验参数

Table 44 M02-1 Test parameters for the body and frame

工作模式 DUT operating mode	2.a or 2.c
峰值加速度 Peak acceleration	500 m/s^2
冲击持续时间 Shock duration	6ms
冲击形式 Shock form	半正弦 Half-sina
每个方向上的冲击数量 （±X，±Y，±Z） Number of shocks per direction （±X，±Y，±Z）	10

7.2.2 M02-2 车门和盖板位置 M02-2 For doors and flap

M02-2 适用于固定在车门、前舱盖、行李舱盖位置的零部件，模拟车门和盖板在开启和关闭时获得的高加速冲击工况。

This test simulates the acceleration forces of component that are installed in doors, hoods or liftgates and which are subjected to high accelerations during opening and closing.

7.2.2.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.2.2.2 试验 Test

试验参数应满足

表 45 要求。

The test parameters should as per the requirements in table 45.

表 45 M02-2 车门和盖板位置 机械冲击试验参数

Table 45 M02-2 Test parameters for door and flap

工作模式 DUT operating mode	2.c
峰值加速度 Peak acceleration	300 m/s² *
冲击持续时间 Shock duration	6ms
冲击形式 Shock form	半正弦 Half-sina
冲击方向 Shock direction	模拟实车冲击方向 Simulate the impact direction of the vehicle
安装位置 Installation position	模拟实车安装位置 As per the installation conditions in the vehicle
安装区域 Installation area	冲击次数 Number of shocks
驾驶员门，货仓门 Driver's door	100000 *
乘客门 Passenger's door	50 000 *
行李箱盖，车尾门 Liftgats/rear gates	30 000 *
发动机舱盖，电机舱盖 Engine hood，Motor hood	3 000 *
注：若 DUT 装配在多个安装位置，应选择最高冲击次数。*如有其他要求，依据 CTS. Notes:If the component is installed in several installation areas, the highest number of shocks must be applied. *If there are others requirements，as per CTS.	

7.2.3 M02-3 变速器位置 M02-3 For the gearbox

M02-3 适用于固定在变速器位置的零部件，模拟类似发生在气动助力换挡操作中获得的高加速冲击工况。

This test simulates the acceleration forces of component that are installed in the position in or on the gearbox and which are subjected to high acceleration during pneumatic powered gear-shifting operations.

7.2.3.1 要求 Requirements

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

7.2.3.2 试验 Test

试验参数应满足表 46 要求。

The test parameters should as per the requirements in table 46.

表 46 M02-3 变速器位置 机械冲击试验参数 Table 46 M02-3 Test parameters for the gearbox

工作模式 DUT operating mode	2.a or 2.c
峰值加速度 Peak acceleration	供需双方协商定义 to be agreed between customer and supplier.
冲击持续时间 Shock duration	1ms
冲击形式 Shock form	半正弦 Half-sina
每个方向上的冲击数量 （±X，±Y，±Z） Number of shocks per direction （±X，±Y，±Z）	供需双方协商定义 to be agreed between customer and supplier.

7.3 M03 自由跌落 M03 Free fall

模拟 DUT 自由坠落到地面上的情况。

This test simulates the free fall of a component to the floor.

7.3.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

——必须通过裸眼查看的方式对 DUT 进行检查，并通过摇晃检查是否存在松动或者发出异响。

——如果 DUT 出现外部损坏，应将损坏情况记录在试验报告中。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class C.

--the DUT must be evaluated visually with the naked eye and tested for loose or rattling parts by means of shaking.

-- If DUT has external damage, the damage should be recorded in the test report.

7.3.2 试验 Test

本项试验依据标准 ISO16750-3 或 GB/T 28046.3 执行，试验参数应满足表 47 要求。

The test is carried out as per ISO 16750-3 or GB/T 28046.3 with the following parameters as Table 47.

表 47 M03 自由跌落试验参数 Table 47 M03 Test parameters for Free fall

工作模式 DUT operating mode	1.a
跌落高度 Drop height	1m
DUT 跌落撞击面 Impact surface	混凝土地面 Concrete floor
循环数量 Test cycle	3 个 DUT 依次在每轴的两个方向跌落一次。For each of the DUT one drop in both directions of a spatial axis (DUT: 1st±X,2nd: ±Y, 3rd: ±Z)

7.4 M04 砂石轰击 M04 Stone impact test

模拟安装在暴露位置的零部件，受到碎石击打的情况。

This test Simulate the parts installed in the exposed position, which are subjected to stone impact.

7.4.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

——必须通过裸眼查看的方式对 DUT 进行检查，并通过摇晃检查是否存在松动或者发出异响。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class C.

--the DUT must be evaluated visually with the naked eye and tested for loose or rattling parts by means of shaking.

7.4.2 试验 Test

根据标准 ISO 20567-1 中的试验方法 B 测试，试验参数应满足表 48 要求。

The test is carried out as per ISO 20567-1, test method B, with the following parameters as Table 48.

表 48 M04 砂石轰击试验参数 Table 48 M04 Test parameters for Stone impact test

工作模式 DUT operating mode	I.b
喷射材料质量 Quantity of blasting medium	500g
试验压力 Test pressure	2 bar
喷射材料 Blasting material	冷硬铸铁颗粒，符合标准 ISO 11124-2，粒度 4mm 至 5mm Hard-cast granular material as per ISO 11124-2, grain size 4 to 5 mm
砂石冲击面 Test surface on DUT	所有可自由接近的面 All surfaces that are freely accessible on the vehicle
冲击角度 Impact angle	与喷砂方向呈 54°夹角 54° to blasting direction
试验装置 Test equipment	多用途碎石冲击试验装置，符合标准 ISO 20567-1 Multi-stone impact test device as per ISO 20567-1

循环数量 Test cycles	2

8 气候负荷 Climatic loads

8.1 C01 高低温储存 C01 High-/low-temperature storage

模拟存储储存和运输过程中部件承受的温度负荷。

This test is Simulates the temperature load on the component during storage and transportation.

8.1.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class C.

8.1.2 试验 Test

根据标准 ISO 16750-4 或 GB/T 28046.4 中的试验方法测试，C01 试验参数应满足表 49 要求。

CI01 高低温储存测试结束后，需进行五点参数测试。

The test is carried out as per ISO 16750-4 or GB/T 28046.4, with the following parameters as Table 49, after this test, five-point parameter test shall be conducted.

表 49 C01 高低温存储 试验参数 Table 49 C01 Test parameters for High-/low-temperature storage

工作模式 DUT operating mode	1.a
试验持续时间和试验温度 Test duration and test temperature	2 个循环，每个循环时间 24 小时 （各包含 12 小时的 T_{min} 温度储存和 12 小时的 T_{max} 温度储存） 2 cycles for 24 h each (consisting of 12 h storage at Tmin and 12 h storage at Tmax each)

8.2 C02 温度梯度 C02 Temperature steps

模拟部件在不同环境温度下的运行状态。

This test simulates the working state of the component at different ambient temperatures.

8.2.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

8.2.2 试验 Test

根据标准 ISO 16750-4 或 GB/T 28046.4 中的试验方法测试，C02 试验参数应满足表 50 要求。

The test is carried out as per ISO 16750-4, with the following parameters as Table 50.

表 50 C02 低温运行 试验参数 Table 50 C02 Test parameters for Temperature steps

工作模式 DUT operating mode	参考测试期间 2.c，其他情况下 2.a During the parameter test (functional test) operating mode 2.c, otherwise operating mode 2.a
试验温度 Test temperature	按照图 24 所示温度变化曲线向 DUT 施加温度负荷。 每个等级的温度变化为 5℃。 A temperature profile as per Figure 24 must be applied to the DUTs. The temperature change per increment is 5 °C.
试验流程 Test sequence	DUT 在每个温度等级保持到完全恒温化，然后再进行参数测试（功能测试） The DUT must be held at every temperature increment until it completely maintains the temperature, Then a parameter test (functional test) must be performed.

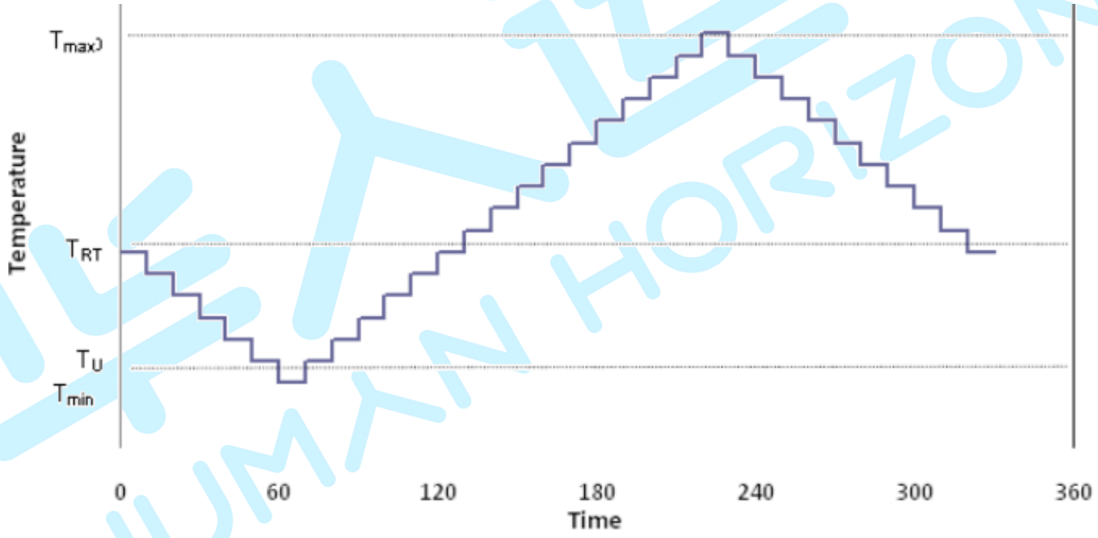


图 24 C04 试验温度变化曲线-温度梯度 Figure 24 C04 Temperature profile for Temperature steps

8.3 C03 低温运行 C03 Low-temperature operation

模拟拟部件在低温条件下承受的负荷。

This test simulates the temperature load of the component under low temperature.

8.3.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

8.3.2 试验 Test

试验依据标准 IEC 60068-2-1 或 GB/T 2423.1 执行，C03 试验参数应满足表 51 要求。

The test is carried out as per IEC 60068-2-1 or GB/T 2423.1, with the following parameters as Table 51.

表 51 C03 低温运行 试验参数 Table 51 C03 Test parameters for Low-temperature operation

工作模式 DUT operating mode	12 小时 2.a→12 小时 2.c（U_{Bmin}）→12 小时 2.a→12 小时 2.c（U_B） 12 h II.a→12 h II.c（U_{Bmin}）→12 h II.a→12 h II.c（U_B）
持续时间 Test duration	48 h
试验温度 Test temperature	T_{min}

8.4 C04 补漆温度 C04 Repainting temperature

模拟补漆作业过程中部件承受的负荷。

This test simulates the temperature load of the component during repainting.

8.4.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

8.4.2 试验 Test

根据标准 ISO 16750-4 或 GB/T 28046.4 中的方法执行，C04 试验参数应满足表 52 要求。

The test is carried out as per ISO 16750-4 or GB/T 28046.4, with the following parameters as Table 52.

表 52 C04 补漆温度 试验参数 Table 52 C04 Test parameters for Repainting temperature

工作模式 DUT operating mode	2.a
试验持续时间和试验温度 Test duration and test temperature	130℃条件下 15 分钟，110℃条件下 1 小时 15 min at 130℃，1 h at 110℃

8.5 C05 温度冲击（带壳体）C05 Temperature shock (with housing)

模拟汽车运行过程中冲击式温度交变对部件施加的温度负荷。

This test simulates the thermal load of a component imposed through shock-type temperature changes during vehicle operation.

8.5.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

——涉及介质-介质试验时，液体不得浸入。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class C.

-- If the test medium is fluid, the fluid shall not be immersed after the test.

8.5.2 试验 Test

试验依据标准 IEC 60068-2-14 或 GB/T 2423.22 执行，C05 试验参数应满足表 53 要求。

The test is carried out as per IEC 60068-2-14 or GB/T 2423.22, with the following parameters as Table 53.

表 53 C05 温度冲击（带壳体） 试验参数

Table 53 C05 Test parameters for Temperature shock (with housing)

工作模式 DUT operating mode	1.b
最低温度 Lower temperature	T_{min}
最高温度 Upper temperature	T_{max}
温度停留时间 Dwell time	完全恒温化之后 15 分钟 15 min after the component has achieved the temperature condition
转换时间（空气-空气，介质-介质） Transfer duration (air - air, medium -medium)	＜30 秒 ＜30 s
用于试验 Nc 的试验液体 Test fluid for test Nc	部件在汽车中运行所处的液体 Fluid in which the component is operated in the vehicle
试验 Test	对于不总是在液体中工作的 DUT，根据 IEC 60068-2-14 Na 进行试验。对于总是在液体中工作的 DUT（IPX8），根据 IEC 60068-2-14 Nc 进行试验（试验中要将 DUT 浸入，使得 DUT 所有侧面至少被 25 mm 的试验液体围绕）。 As per DIN EN 60068-2-14 NA for components that are not permanently operated in a fluid.As per DIN EN 60068-2-14 Nc for components that are permanently operated in a liquid (IP X8).The DUT must be immersed so that all sides of the DUT are covered by at least 25 mm of the test fluid.
循环数量 Test cycles	100 *
注*如有其他要求，依据 CTS。Notes：If there are others requirements，as per CTS.	

8.6 C06 温度冲击（无壳体）C06 Temperature shock (without housing)

模拟部件在无壳体情况下，通过急剧变化温度后的可靠性。

本试验仅适用于不带壳体的零件组件。

This test simulates the reliability of a component without housing subjected to a rapid change in temperature.

This test is to be applicable to component without housing and mechanical parts.

8.6.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class C.

8.6.2 试验 Test

试验依据标准 IEC 60068-2-14 或 GB/T 2423.22 执行，C06 试验参数应满足表 54 要求。

The test is carried out as per IEC 60068-2-14 or GB/T 2423.22, with the following parameters as Table 54.

表 54 C06 温度冲击（无壳体） 试验参数

Table 54 C06 Test parameters for Temperature shock (without housing)

工作模式 DUT operating mode	1.a
最低温度 Lower temperature	T_{min}
最高温度 Upper temperature	T_{max}
停留时间 Dwell time	恒温化之后 15 分钟 15 min after the component has achieved the temperature condition
转移时间 Transfer duration	≤10 s
循环数量 Test cycles	300 *
注*如有其他要求，依据 CTS。Notes：If there are others requirements，as per CTS.	

8.7 C07 盐雾试验（外部）C07 Salt spray test with operation, exterior

模拟含盐空气和含盐水对于部件施加的负荷。

This test simulates the load of the component imposed by air and water containing salt.

8.7.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——产品标志、标签等应清晰可见。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

-- Product identification and labels shall be clearly visible.

8.7.2 试验 Test

试验依据标准 IEC 60068-2-11 或 GB/T 2423.17 执行，C07 试验参数应满足表 55 要求。

The test is carried out as per IEC 60068-2-11 or GB/T 2423.17, with the following parameters as Table 55.

表 55 C07 盐雾试验（外部） 试验参数

Table 55 C07 Test parameters for Salt spray test with operation, exterior

工作模式 DUT operating mode	在喷洒阶段：间歇采用 1 小时运行方式 2.a 和 1 小时运行方式 2.c 在静止阶段：运行方式 2.a During the spray phase: 1 h of operating mode 2.a and 1 h of operating mode 2.c intermittently， During the rest period: operating mode 2.a.
试验温度 Test temperature	35℃
试验循环 Test cycle	每个试验循环包含 8 小时喷洒时间和 4 小时静止时间（图 25） Each test cycle consists of a spray phase of 8 h and a rest phase of 4 h as per Figure 25.
循环数量 Number of test cycles	12 个循环*
注*如有其他要求，依据 CTS。Notes：If there are others requirements，as per CTS.	

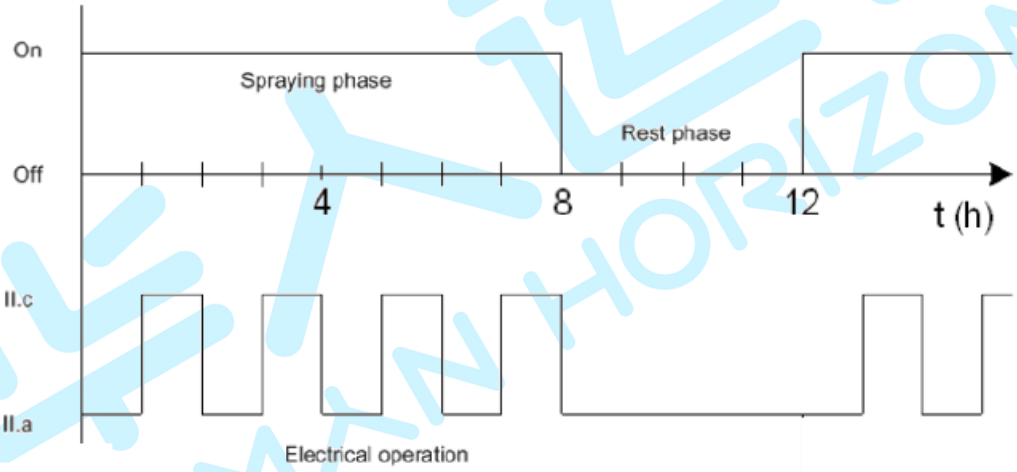


图 25 盐雾试验（外部）-喷洒阶段

Figure 25 Salt spray test with operation, exterior – spray phases

8.8 C08 盐雾试验（内部）C08 Salt spray test with operation, interior

模拟含盐空气和盐水对于部件施加的负荷。

This test simulates the load of the component imposed by air and water containing salt.

8.8.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——不得有盐水进度壳体

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

-- No salt water is allowed to enter the product

8.8.2 试验 Test

试验依据标准 IEC 60068-2-52 或 GB/T 2423.18 执行，C08 试验参数应满足表 56 要求。

The test is carried out as per IEC 60068-2-52 or GB/T 2423.18, with the following parameters as Table 56.

表 56 C08 盐雾试验（内部）试验参

Table 56 C08 Test parameters for Salt spray test with operation, interior

工作模式 DUT operating mode	在喷洒阶段：间歇采用 55 分钟的运行方式 2.a 和 5 分钟的运行方式 2.c 在静止阶段：运行方式 2.a During the spray phase: 55 min of operating mode 2.a and 5 min of operating mode 2.c intermittently During rest phase: operating mode 2.a
试验温度 Test temperature	35℃
试验循环 Test cycle	每个试验循环包含 8 小时喷洒时间，4 小时静置时间（图 26） Each test cycle consists of a spray phase of 8 h,a rest period of 4 h and 12h humidity as per Figure 26
试验循环数量 Number of test cycles	2 个循环*
注*如有其他要求，依据 CTS。Notes：If there are others requirements，as per CTS.	

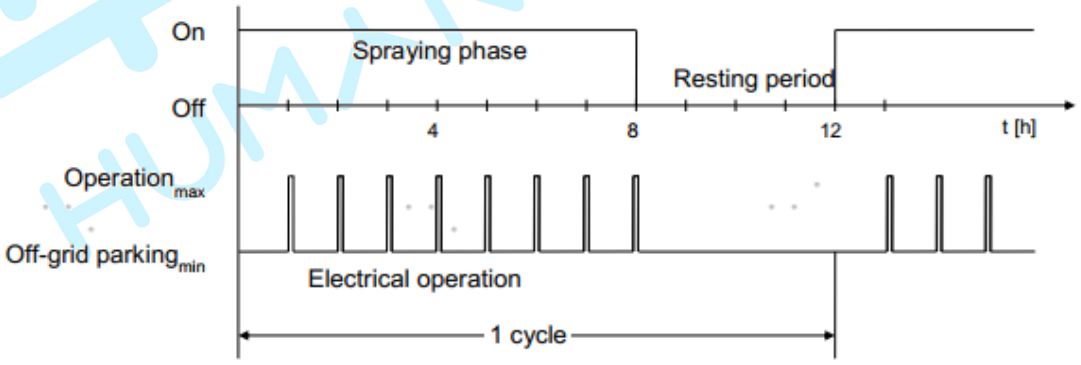


图 26 盐雾试验（内部）-喷洒阶段 Figure 26 Salt spray test with operation, interior – spray phases

8.9 C09 恒定湿热 C09 Damp heat, constant

模拟部件承受的湿热负荷。

This test simulates the load of the component through damp heat.

8.9.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——每 7 天进行一次参数测试。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

--a parameter test must be carried out every 7 days.

8.9.2 试验 Test

试验依据标准 IEC 60068-2-78 或 GB/T 2423.3 执行，C09 试验参数应满足表 57 要求。

The test is carried out as per IEC 60068-2-78 or GB/T 2423.3, with the following parameters as Table 57.

表 57 C09 恒定湿热 试验参数 Table 57 C09 Test parameters for Damp heat, constant

工作模式 DUT operating mode	2.a
试验温度 Test temperature	40℃
空气湿度 Humidity	93% RH
试验持续时间 Test duration	21 Days

8.10 C10 湿热循环 C10 Damp heat, cyclic

模拟汽车行驶过程中高空气湿度条件下循环性温度变化对部件施加的热负荷。

This test simulates the thermal load of the component imposed through cyclic temperature changes at high humidities during vehicle operation.

8.10.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——在最高试验温度和最低试验温度阶段，各进行一次参数测试。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

--a parameter test must be carried out after the test temperature have been reached.

8.10.2 试验 Test

试验依据标准 IEC 60068-2-30 或 GB/T 2423.4 执行，C10 试验参数应满足表 58 要求。

The test is carried out as per IEC 60068-2-30 or GB/T 2423.4, with the following parameters as Table 58.

表 58 C10 湿热循环 试验参数 Table 58 C10 Test parameters for Damp heat, cyclic

工作模式 DUT operating mode	2.a
试验时间 Test duration	144 h

试验变体 Test variant	变体 1 Variant 1 as per Figure 27
试验温度 Upper test temperature	55℃
试验循环数量 Test cycles	6

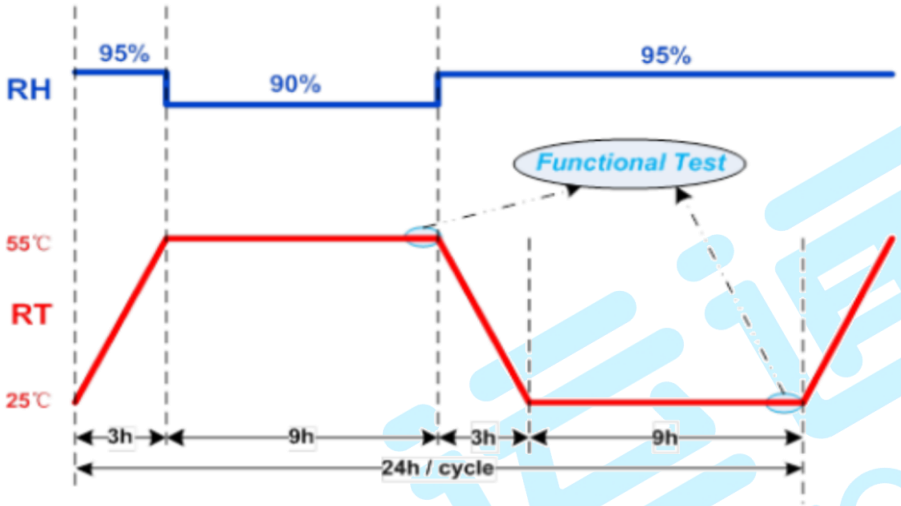


图 27 湿热循环试验温度变化曲线 Figure 27 Test profile for Damp heat，cyclic

8.11 C11 湿热循环-结霜 C11 Damp heat, cyclic (with frost)

模拟汽车行驶过程中高空气湿度条件下循环性温度变化对部件施加的热负荷。

This test simulates the thermal load (including frost) of the component imposed through cyclic temperature changes at high humidities during vehicle operation.

8.11.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

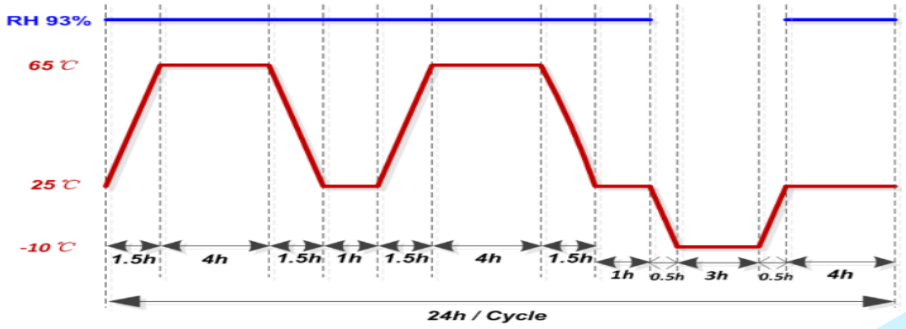
8.11.2 试验 Test

试验依据标准 IEC 60068-2-38 或 GB/T 2423.34 执行，C11 试验参数应满足表 59 要求。

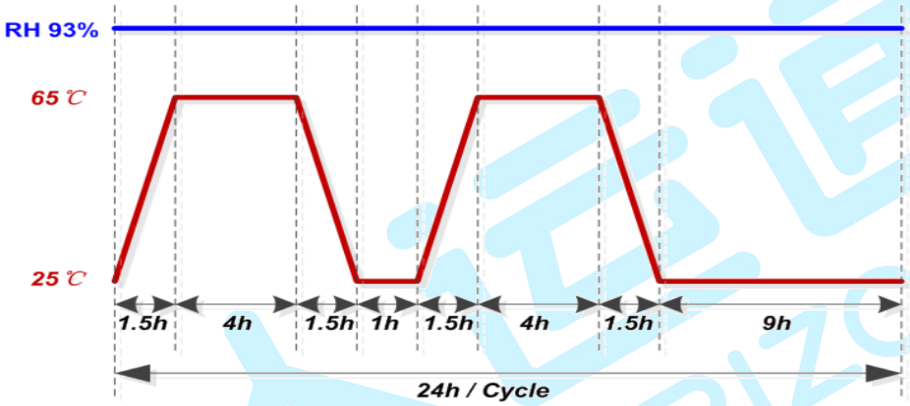
The test is carried out as per IEC 60068-2-38 or GB/T 2423.34, with the following parameters as Table 59.

表 59 C11 湿热循环-结霜 试验参数 Table 59 C11 Test parameters for Damp heat, cyclic (with frost)

工作模式 DUT operating mode	间歇性，40 分钟 2.a 和 10 分钟 2.cIntermitting 40 min operating mode II.a and 10 min.operating mode II.c each
试验总时间 Test duration	240 h
循环数量 Test cycles	10（见图 28 要求）（as per Figure 28）



a）前 5 个循环温度变化曲线 a）Profile for first five cycles



b）后 5 个循环温度变化曲线 b) Profile for last five cycles

图 28 湿热循环（结霜）试验 Figure 28 Test profile for Damp heat, cyclic (with frost)

8.12 C12 有害气体腐蚀 C12 Harmful gas test

模拟有害气体对于部件（主要是对于部件插头触点和开关）的抗腐蚀性。

This test simulates the influence of harmful gases onto the component, particularly onto its plug contacts and switches.

8.12.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

——试验前后需测量开关触点和内部触点（如有）的接触电阻，测量值必须位于规定范围内。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class C.

--the contact resistances of switches and contacts must be measured. The measured values must meet the specifications.

8.12.2 试验 Test

试验依据标准 IEC 60068-2-60 或 GB/T 2423.51 执行，C12 试验参数应满足表 60 要求。

The test is carried out as per IEC 60068-2-60 or GB/T 2423.51, with the following parameters as Table 60.

表 60 C12 有害气体腐蚀 试验参数 Table 60 C12 Test parameters for Harmful gas test

工作模式 DUT operating mode	I.b	
温度 Temperature	T_{RT}	
空气湿度 Humidity	75%RH	
有害气体浓度 Harmful gas concentration	SO_2	0.2ppm
	H_2S	0.01ppm
	NO_2	0.2ppm
	Cl_2	0.01ppm
试验持续时间 Test duration	21days	

8.13 C13 阳光辐射 C13 Solar radiation

模拟阳光照射和紫外线对于部件的影响，主要针对材料的抗晒特性。

This test simulates the influence of sun radiation and UV light onto the component. It is mainly aimed at the resistance to sunlight of the material.

8.13.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class C。

——试验后需通过裸眼查看的方式对 DUT 进行检查，若有改变/损坏情况，须记录在试验报告中并与委托方一起进行评估。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class C.

--the DUT must be evaluated visually with the naked eye.Changes or damage must be documented in the test report and evaluated with customer.

8.13.2 试验 Test

试验依据标准 DIN 75220 执行，C13 试验参数应满足表 61 要求。

The test is carried out as per DIN 75220, with the following parameters as Table 61.

表 61 C13 阳光辐射 试验参数 Table 61 C13 Test parameters for Solar radiation

工作模式 DUT operating mode	1.a
试验模式 Test profile	根据部件的安装空间应用 DIN 75220 所规定试验模式。 The test profiles as per DIN 75220 must be used depending on the installation location of the component.
安装在外部空间的部件 Components in the exterior	应用 DIN 75220 表 2 和表 5 所述试验模式 Z-Out Use of the Z-OUT profile as per Table 2 and Table 5 of DIN 75220
安装在内部空间的部件	应用 DIN 75220 所述试验模式 Z-IN1

Components in the interior	Use of the Z-IN1 profile as per DIN 75220
试验持续时间 Test duration	25 天 （15 天干燥，10 天潮湿）25 days （15 days dry，10 days humid）
循环数量 Test cycles	1

8.14 C14 防尘 C14 Dust test

模拟汽车行驶过程中对部件产生的灰尘负荷。

This test simulates the dust load of the component during vehicle operation.

8.14.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

8.14.2 试验 Test

试验依据标准 ISO 20653 执行，C14 试验参数应满足表 62 要求。

The test is carried out as per ISO 20653, with the following parameters as Table 62.

表 62 C14 防尘 试验参数 Table 62 C14 Test parameters for Dust test

工作模式 DUT operating mode	For electrical/electronic components：2.a.For mechatronic components：2.c and 2.a intermittently.
试验装置 Test setup	垂直流动方向，根据 ISO-20653。Vertical flow direction as per ISO 20653.
要求的防尘等级 Degree of protection to be achieved	按照 CTS 规定（防护等级见表 57）。具体的防护等级需满足华人运通公司的要求，并获得华人运通工程师的同意。As specified in the CTS （protection degree as per Table 57）。The protection degrees should meet the requirements and be approved by HUMAN HORIZONS engineers.
试验持续时间 Test duration	20 个循环，每个循环 20 分钟 20 cycles of 20 minutes each
试验周期 Test sequence	5 分钟工作→5 秒粉尘→15 分钟静止 5 min 2.c→5 sec dust →15 min 2.a

表 63 防护等级代码定义

Table 63 Definition for protection degree

防尘代码 Protection code	防止固体异物 Protection against ingress	防止接触危险部件 Protection against contact

0	无防护 not protected	无防护 not protected
1	≥ϕ50mm 固体颗粒 ≥ϕ50mm solid foreign objects	手背 Back of hand
2	≥ϕ12.5mm 固体颗粒 ≥ϕ12.5mm solid foreign objects	手指 finger
3	≥ϕ2.5mm 固体颗粒 ≥ϕ2.5mm solid foreign objects	工具 tool
4	≥ϕ1.0mm 固体颗粒 ≥ϕ1.0mm solid foreign objects	金属线 wire
5K	防尘 dust	金属线 wire
6K	尘密 dust	金属线 wire

8.15 C15 防水（IPX0~IPX6K）C15 Water protection（IPX0~IPX6K）

模拟汽车行驶过程中，水对部件施加的负荷。

This test simulates the load of the component when subjected to water.

8.15.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——产品内部不允许有水进入。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

-- The ingress of water is not permissible.

8.15.2 试验 Test

试验依据标准 ISO 20653 执行，C15 试验参数应满足表 64 要求。

The test is carried out as per ISO 20653, with the following parameters as Table 64.

表 64 C15 防水 试验参数 Table 64 C15 Test parameters for Water protection

工作模式 DUT operating mode	间歇性，1 分钟 2.a 和 1 分钟 2.c Intermitting 1 min II.a and 1 min II.c each
要求的防水等级 Required degree of protection	按照 CTS 规定（防护等级定义见表 59） 具体的防护等级需满足华人运通公司的要求，并获得华人运通工程师的同意。As specified in the CTS（protection degree as per Table 59） The protection degrees should meet the requirements and be approved by

	HUMAN HORIZONS engineers.

表 65 防水等级代码定义 Table 65 Definition for protection degree of water

防水代码编号 Protection code	防水要求 Protection against ingress	防水代码编号 Protection code	防水要求 Protection against ingress
0	无防护 not protected	5	高速喷水 high-velocity water
1	垂直滴水 water drips	6	强高速喷水 strong high-velocity water
2	15°滴水 water drips with enclosure inclined by 15°	6K	增压高速喷水 strong high-velocity water with increased pressure
3	喷水 water spray	7	短时间浸水 temporary immersion in water
4	溅水 splash water	8	连续浸水 continuous submersion in water
4K	增压溅水 splash water with increased pressure	9K	高压/蒸汽喷射清洗 water during highpressure/steam-jet

8.16 C16 飞溅冰水冲击 C16 Temperature shock with splash water

模拟汽车驶过水坑时喷溅水对部件施加的负荷。

This test simulates the load of the component when exposed to splash water as it occurs when driving through puddles.

8.16.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——液体不得浸入。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

-- The ingress of water is not permissible.

8.16.2 试验 Test

试验依据标准 ISO 16750-4 或 GB/T 28046.4 执行，C16 试验参数应满足表 66 要求。

The test is carried out as per ISO 16750-4 or GB/T 28046.4, with the following parameters as Table 66.

表 66 C16 飞溅冰水冲击 试验参数

Table 66 C16 Test parameters for Temperature shock with splash water

工作模式	如果汽车行驶时部件在无运行负荷的情况下工作：2.a

DUT operating mode	如果汽车行驶时部件在承受运行负荷的情况下工作：间歇性 2.a&2.c If the component is not operated with operating load during driving operation:2.a during the entire test.If the component is operated with operating load during driving operation:2.a and 2.c intermittently.
试验方法 Test procedure	将 DUT 加热至试验温度，然后向 DUT 循环喷水 Heating of the DUT to test temperature.Then cyclical exposure of the DUT with splash water.
循环持续时间 Cycle duration	30 分钟（见图 29 要求）30 min（as per figure 29）
试验温度 Test temperature	T_{max}
喷射用液体 Test medium for splashing	自来水，含有重量含量为 3% 的亚利桑那细灰尘（根据 ISO 12103-1）。必须确保混合比例保持不变。 Tap water containing Arizona dust in a weight percentage of 3%, fine as per ISO 12103-1. Permanent mixing must be ensured.
喷溅水温度 Water temperature	0 至＋4℃ 0 to ＋4℃
喷溅时间 Splashing time	3 s
水的流量 Water flow	每个喷嘴每次喷 3 至 4 升 3 to 4 liters per splash/nozzle
喷嘴与 DUT 之间的距离 Distance between nozzle and DUT	300mm 至 350 mm 300mm to 350 mm
循环数量 Test cycles	100
注：进行试验时应模拟部件在汽车中的安装位置。 Notes：When performing the test, the as-installed position of the component in the vehicle must be simulated.	

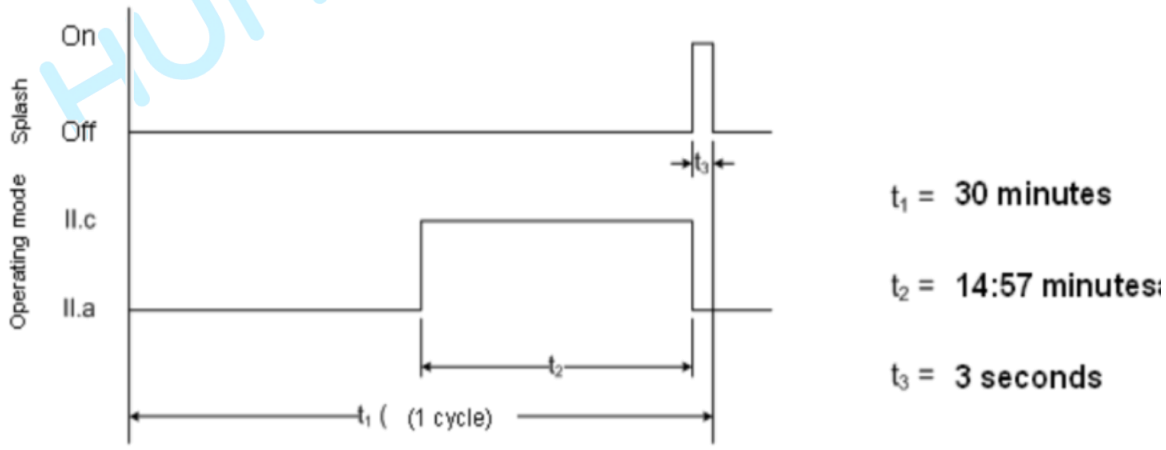


图 29 喷溅水试验-喷溅时间 Figure 29 Splash water test splashing times

8.17 C17 浸没冰水冲击 C17 Temperature shock – immersion

模拟部件浸入水中时承受的负荷。

This test simulates the load of the component when immersed into water.

8.17.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——根据 ISO 20653 必须达到防护程度 IP X7。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

--The degree of protection IP X7 as per ISO 20653 must be achieved.

8.17.2 试验 Test

试验依据标准 ISO 20653 执行，C17 试验参数应满足表 67 要求。

The test is carried out as per ISO 20653, with the following parameters as Table 67.

表 67 C17 浸没冰水冲击 试验参数 Table 67 C17 Test parameters for Temperature shock – immersion

工作模式 DUT operating mode	如果汽车行驶时部件在无运行负荷的情况下工作：2.a 如果汽车行驶时部件在承受运行负荷的情况下工作：2.c If the component is not operated with operating load during driving operation:2.a.If the component is operated with operating load during driving operation:2.c.
试验方法 Test procedure	将 DUT 加热到 $T_{op,max}$ 温度条件下保持 15 分钟后完全浸入试验介质中 5 秒，使得 DUT 的所有侧面都被至少 25 mm 试验介质包围。 Heat the DUT to $T_{op,max}$, hold at Top,max until the DUT completely maintains its temperature plus 15 min.Completely immerse the DUT into the test medium within five seconds so that all sides of the DUT are covered by at least 25 mm of the test medium.
试验介质 Test medium	5%的 0℃低温盐水 0 °C cold water with a salt content of 5%
浸没时间 Immersion time	5 min
循环数量 Test cycles	20

8.18 C18 高压/蒸汽喷射 C18 High-pressure cleaning

模拟汽车清洁过程中水对部件施加的负荷 。

This test simulates the load of the component when subjected to water during vehicle cleaning.

8.18.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

——根据 ISO 20653 必须达到防护程度 IP X9K。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

--The degree of protection IP X9K as per ISO 20653 must be achieved.

8.18.2 试验 Test

试验依据标准 ISO 20653 执行，C18 试验参数应满足表 68 要求。

The test is carried out as per ISO 20653, with the following parameters as Table 68.

表 68 C18 高压/蒸汽喷射 试验参数 Table 68 C18 Test parameters for High-pressure cleaning

工作模式 DUT operating mode	2.a
水压 Water pressure	蒸汽流的最低压力为 10000 kPa（100 bar），紧靠喷嘴处测量。 The minimum pressure of the pressure washer is 10 000 kPa (100 bar), measured directly at the nozzle.
水温 Water temperature	80℃
试验方法 Procedure	必须从汽车上每个可以自由接近的空间方向对 DUT 进行喷射。 The DUT must be subjected to the water jet from any freely accessible spatial direction of the vehicle.

9 化学负荷 Chemical loads

9.1 H01 化学试验 H01 Chemical tests

该试验模拟部件对不同化学试剂的抗腐蚀性。
试验开始前和结束后，DUT 功能必须完全正常并且所有参数都位于规定范围内。
试验后 DUT 标签应保持清晰可见，表面无明显变化。
This test simulates the load of the component when subjected to different chemicals. Before and after the test, DUT function must be completely normal and all parameters must be within the specified range，the DUT label should be clearly visible with no obvious changes on the surface.

9.1.1 要求 Requirement

DUT 测试结果应满足下述要求：
——对于全部零部件，FPSC 需满足 Class C。
——试验后 DUT 标签应清晰可见，无明显变化。
DUT test results should meet the following requirements:
-- For all DUT, FPSC needs to satisfy Class C.
-- The DUT label should be clearly visible without obvious changes.

9.1.2 试验 Test

试验依据标准 ISO 16750-5 或 GB/T 28046.5 执行，H01 试验参数应满足表 69 要求。
The test is carried out as per ISO 16750-5 or GB/T28046.5, with the following parameters as Table 69.

表 69 化学试验 试验参数 Table 69 Test parameters for Chemical tests

工作模式 DUT operating mode	1.a
调整 Conditioning	如果没有不同规定，DUT 和化学品要在标准气候条件下放置 Unless otherwise specified, the DUTs and the chemicals must be aged in standard climate.
试验 Test	试验根据 ISO 16750-5 第 5 部分进行： 1、化学品必须在 T_{RT} 条件下涂敷到 DUT 上。如果 CTS 没有不同规定，必须为每种化学品选择一个适合的应用方式（应用方式表 71）。所选择应用方式要在试验报告中记录。必须确保 DUT 被化学品充分覆盖。 2. 然后必须在表 70 所述温度按照规定的作用持续时间放置 DUT。 The test is performed on the basis of ISO 16750, part 5: 1、The chemical must be applied to the DUT at TRT. Unless otherwise defined in the CTS, an appropriate type of application must be selected for each chemical as per Table 71. The selected type of application must be documented in the test report. It must be ensured that the DUT is sufficiently covered with the chemical.2. The DUT must then be aged at the temperature indicated in Table 70 for the specified exposure time.
化学试剂 Chemical type	典型化学品要求见表 70。As per Table 70.
DUT 数量 DUT number	每种化学试剂一个 DUT。1 DUT per chemical.

表 70 化学试剂一览 Table 70 Overview of chemicals

ID	Chemical agents	Mounting location [code][a]					Exposure conditions	
		Engine compartment [A][b]	Passenger compartment [B][b]	Luggage compartment [C][b]	Mounting on the exterior [D][b]	Other require-ments [Z][b]	Test tempe-rature °C	Test duration
AA	Diesel fuel	I, III, IV, V	c	c	c	As agreed	T_{max}[d]	22 h
AB	"Bio" diesel	I, III, IV, V	c	c	c	As agreed	T_{max}[d]	22 h
AC	Petrol/gasoline unleaded	I, III, IV, V	c	c	c	As agreed	RT	10 min
AD	Kerosene	c	c	II, III, IV, V	c	As agreed	RT	10 min
AE	Methanol	II, III, IV, V, VI	c	c	c	As agreed	RT	10 min

DB	Vehicle washing chemicals	I, II, III, IV, V	c	c	I, II, III, IV, V	As agreed	RT	2 h
DC	Interior cleaner	c	I, III	I, III	c	As agreed	RT	2 h
DD	Glass cleaner	c	I, III	I, III	I, III	As agreed	RT	2 h
DE	Wheel cleaner	c	c	c	I, II, III, IV	As agreed	RT	2 h
DF	Cold cleaning agent	I, II, III, IV, V, VI	c	I, II, III, IV, V, VI	I, II, III, IV, V, VI	As agreed	RT	22 h
DG	Acetone	c	I, II, III	c	c	As agreed	RT	10 min

ID	Chemical agents	Mounting location [code][a]					Exposure conditions	
		Engine compartment [A][b]	Passenger compartment [B][b]	Luggage compartment [C][b]	Mounting on the exterior [D][b]	Other require-ments [Z][b]	Test tempe-rature °C	Test duration

DH	Cleaning solvent	I, II, III	c	c	c	As agreed	RT	10 min
DJ	Ammonium-containing cleaner	c	II, III, V	II, III, V	II, III, V	As agreed	RT	22 h
DK	Denatured alcohol	I, II, III, IV, V	I, II, III, IV, V	I, II, III, IV, V	I, II, III, IV, V	As agreed	RT	10 min
EA	Contact spray	I, II, III	c	c	c	As agreed	T_{max} [d]	22 h
EB	Transpiration	c	II, III, V	c	c	As agreed	RT	22 h
EC	Cosmetic products, e.g. creams	c	II, III	c	c	As agreed	RT	22 h
ED	Refreshment containing caffeine and sugar	c	III, IV	c	c	As agreed	RT	22 h
EE	Runway de-icer	I, II, IV	c	c	I, II, IV	As agreed	RT	2 h
EF	Cream, coffee whitener	c	III, IV	c	c	As agreed	RT	22 h
YY	Additional agents	c	c	c	c	As agreed	—	—

[a] See Table 2 for the preferred application method of agents (I, II, III, IV, V and VI).

[b] Depending on the mounting location, choose code A, B, C or D. Chemical loading can vary significantly depending on the type and use of the vehicle. For other requirements agreed between customer and supplier, choose code Z and mark all agents to be tested. Additional agents may be agreed between customer and supplier.

[c] Chemical agents are not applied.

[d] Test temperature: for maximum operating temperature, T_{max}, see ISO 16750-4.

表 71 应用方式 Table 71 Type of application

代码 Code number	应用方法 Application methods
I	喷洒 Spraying
II	刷涂 Brushing
III	擦拭（如使用棉毛巾）Wiping with cotton cloth
IV	倾倒 Pouring
V	短时浸入 Dipping
VI	浸入 Immersion

10 寿命耐久 Service life tests

10.1 L01 机械/液压耐久 L01 mechanical/hydraulic endurance test

该试验模拟汽车使用寿命期间部件的功能循环/操作循环。

This test simulates the functioning/actuation cycles of the component during vehicle service life.

10.1.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

当部件功能在试验期间不能进行充分的监控时，需要在试验持续时间达到 25%、50%和 75%时，实施中间测量或根据试验流程图进行参数测试。

需要评估连续参数监控数据的漂移性、变化趋势、突出性或者异常性。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

When the functional parameters of components cannot be continuously monitored during the test, it is necessary to carry out intermediate measurement and do parameter test according to the test sequence when the test duration reaches 25%, 50% and 75%.

The data of the continuous parameter monitoring must be examined with respect to drifts, trends and irregularities.

10.1.2 试验 Test

L01 试验参数应满足表 72 要求。

Test details must be defined in the CTS as per the functioning/actuation cycle, and test parameters shall meet the requirements of table 72.

表 72 机械/液压耐久 试验参数 Table 72 Test parameters for mechanical/hydraulic endurance test

工作模式 DUT operating mode	2.c,根据功能循环/操作循环 2.c as per functioning/actuation cycle
温度 Test temperature	执行周期必须在温度谱中所示的温度下进行，时间根据其百分比 The functioning/actutation cycles must be performed at the temperatures indicated in the temperature spectrum, the duration depending on its percentage.
循环数量 Test cycles	按照 CTS 规定 As specified in CTS

10.2 L02 高温耐久性 L02 high-temperature endurance test

该试验模拟汽车使用寿命期间部件所承受热负荷。

This test simulates in compact form the thermal load of the component during vehicle service life.

10.2.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

当部件功能在试验期间不能进行充分的监控时，需要在试验持续时间达到 25%、50%和 75%时，实施中间测量或根据试验流程图进行参数测试。

需要评估连续参数监控数据的漂移性、变化趋势、突出性或者异常性。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

When the functional parameters of components cannot be continuously monitored during the test, it is necessary to carry out intermediate measurement and do parameter test according to the test sequence when the test duration reaches 25%, 50% and 75%.

The data of the continuous parameter monitoring must be examined with respect to drifts, trends and irregularities.

10.2.2 试验 Test

试验依据标准 IEC 60068-2-2 或 GB/T 2423.2 执行，L02 试验参数应满足表 73 要求。

The test is carried out as per IEC 60068-2-2 or GB/T2423.2, with the following parameters as Table 73.

表 73 高温耐久 试验参数 Table 73 Test parameters for high-temperature endurance test

工作模式 DUT operating mode	间歇性，47 小时 2.c 和 1 小时 2.a Intermitting，47 h 2.c and 1 h 2.a
试验持续时间 Test duration	阿伦尼乌斯模型（见附录 A.2），应在 CTS 中明确定义试验时间。 Arrhenius model (as per appendix A.2), Test duration should be defined in CTS.
试验温度 Test temperature	T_{max}

10.3 L03 温度交变耐久性 L03 temperature cycle endurance test

该试验模拟汽车使用寿命期间温度交变对于部件施加的热机械负荷。

This test simulates in compact form the thermal load of the component during temperature changes that occur during vehicle service life.

10.3.1 要求 Requirement

DUT 测试结果应满足下述要求：

——对于全部零部件，FPSC 需满足 Class A。

当部件功能在试验期间不能进行充分的监控时，需要在试验持续时间达到 25%、50%和 75%时，实施中间测量或根据试验流程图进行参数测试。

需要评估连续参数监控数据的漂移性、变化趋势、突出性或者异常性。

DUT test results should meet the following requirements:

-- For all DUT, FPSC needs to satisfy Class A.

When the functional parameters of components cannot be continuously monitored during the test, it is necessary to carry out intermediate measurement and do parameter test according to the test sequence when the test duration reaches 25%, 50% and 75%.

The data of the continuous parameter monitoring must be examined with respect to drifts, trends and irregularities.

10.3.2 试验 Test

试验依据标准 IEC 60068-2-14 或 GB/T 2423.22 执行，L03 试验参数应满足表 74 要求。

The test is carried out as per IEC 60068-2-14 or GB/T2423.22, with the following parameters as Table 74.

表 74 温度交变耐久 试验参数 Table 74 Test parameters for temperature cycle endurance test

工作模式 DUT operating mode	间歇性 2.a&2.c （见图 30）Intermitting 2.a& 2.c （as per figure 30）
温度变化曲线 Temperature profile	依据图 30 定义 As per figure 30
最低试验温度 Minimum test temperature	T_{min}
最高试验温度 Maximum test temperature	T_{max}
在 T_{min} 和 T_{max} 的保持时间 Holding time at Tmin and Tmax	30 min
循环数量 Test cycles	科芬-曼森模型（见附录 A.3），应在 CTS 中明确定义试验时间。Coffin-Manson model (as per appendix A.3), Test duration should be defined in CTS.

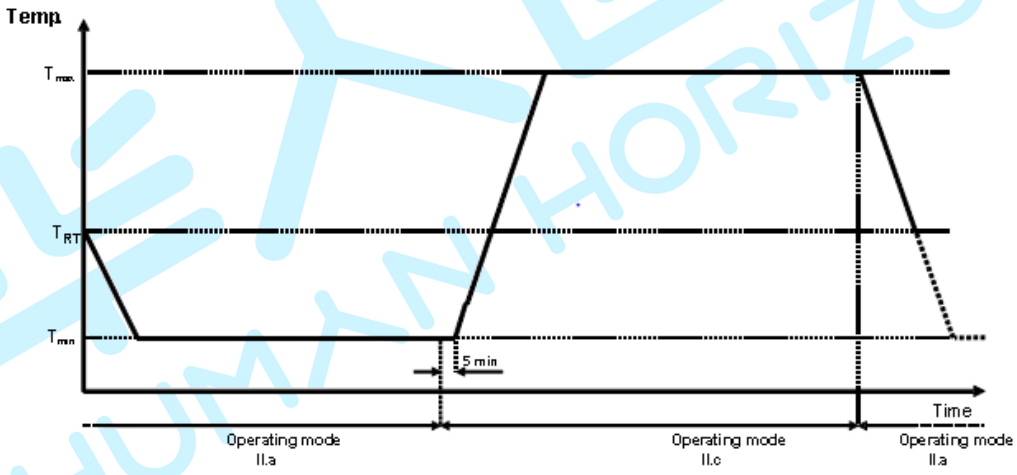


图 30 温度变化曲线 Figure 30 Temperature profile for temperature cycle endurance test

附录 A 典型温度谱和寿命计算模型 Appendix A Typical temperature spectrums and Computation models

A.1 典型的温度谱 A.1 Typical temperature spectrums

不同安装位置的零部件，其适用的温度谱定义见表 A-1，详细温度谱参数见表 A-2。

Table A-1 for the applicable temperature spectrum of components at different installation locations, and table A-2 for the detailed temperature spectrum parameters.

表 A-1 安装空间、典型温度谱和温度行程一览

Table A-1 Overview of installation locations, typical spectrums, and temperature rises

部件安装空间 Installation location of the component	温度谱代码 Spectrum no.	温度行程，单位 Temperature rise in K
没有特殊要求的内部空间 Interior, without special requirement	1	36
没有特殊要求的车身安装位置 Hang-on part, without special requirements	1	36
受到阳光照射的内部空间 Interior exposed to sun radiation	2	46
车身安装位置-顶盖 Hang-on part, roof	2	46
电机舱，但不安装在电驱上 Motor compartment, but not on the Motor	2	46
发动舱，但不安装在发动机上 Engine compartment, but not on the engine	3	60
散热器上的安装位置 On the radiator	3	60
发动机位置零部件 Engine-mounted parts	4	75
变速箱位置零部件 Gearbox-mounted parts	4	75

表 A-2 温度谱定义 Table A-2 Temperature spectrum

温度谱 1 Temperature spectrum 1		温度谱 2 Temperature spectrum 2	
温度 Temperature（℃）	分布 Distribution（%）	温度 Temperature（℃）	分布 Distribution（%）
-40℃	6%	-40℃	6%
23℃	20%	23℃	20%
40℃	65%	50℃	65%
75℃	8%	100℃	8%
85℃	1%	105℃	1%
温度谱 3 Temperature spectrum 3		温度谱 4 Temperature spectrum 4	
温度 Temperature（℃）	分布 Distribution（%）	温度 Temperature（℃）	分布 Distribution（%）
-40℃	6%	-40℃	6%
23℃	20%	23℃	20%
65℃	65%	85℃	65%
115℃	8%	135℃	8%
120℃	1%	140℃	1%

A.2 阿伦尼乌斯模型 A.2 Arrhenius model

A.2.1 为了计算零部件使用寿命试验—高温耐久性试验的持续时间，应考虑温度谱百分比。

A.2.1 The calculation of the test duration of the high-temperature endurance test life test is based on the temperature spectrum percentage.

$$A_{T,i} = e^{\left[-\left(\frac{E_A}{k}\right)\left(\frac{1}{T_{Test}+273,15} - \frac{1}{T_{Field,i}+273,15}\right)\right]}$$

其中 Where：

$A_{T,i}$ 阿伦尼乌斯模型加速因子 Acceleration factor of the Arrhenius model

E_A 活化能 E_A＝0，45 eV Activation energy E_A=0，45eV

K 波兹曼常数 Boltzmann constant（k＝8.617 x 10-5 eV/K）

T_{test} 试验温度（单位：℃），通常为 T_{max} Test temperature（℃），generally Tmax

$T_{field,i}$ 应用场所温度（单位：℃） Field temperature (°C) according to the temperature spectrum as per use profile

高温耐久性试验的总持续时间，通过加速系数根据以下方程得出。

The total test duration for the high-temperature endurance test results from the acceleration factor as per the following equation.

$$t_{test} = t_{oper.} \cdot \sum_i \frac{p_i}{A_{T,i}}$$

其中 Where：

t_{test} 使用寿命试验－高温耐久性试验持续时间（小时）Test duration (hours) of the high-temperature endurance test life test

t_{oper} 在相应分区的工作时间（小时）Operating time (hours) in the field

P_i 工作时间段百分比 Percentage of the operating time

$A_{T,I}$ 温度为 $T_{feld,i}$ 时的加速因子 Acceleration factor for temperature TFeld,i

A.2.2 用于带冷却回路的零部件,典型冷却系统温度谱见表 A-3。

A.2.2 For components with a connection to the coolant circuit，the temperature spectrum specified in the following table.

表 A-3 典型冷却系统温度谱

Table A-3 Sample spectrum for coolant temperature

温度 Temperature（℃）	分布 Distribution（%）
-40	6
23	20
40	65
75	8
85	1

试验时间对应各温度谱区间计算。

The test duration was calculated according to the temperature spectrum.

1,$t_{test,T\_Field,5}=t_{oper}*P5$

2,$t_{test,T\_Field,4}=t_{oper}*P4$

3,$t_{remanining}=t_{test}-(t_{test,T\_Field,5}+t_{test,T\_Field,4})$..

A.3 科芬-曼森模型 A.3 Coffin-Manson model

为了计算零部件使用寿命试验—温度交变耐久性试验的持续时间，应考虑零部件在应用场所的平均温度变化，以及在应用场所的使用寿命期间温度循环次数。

The calculation of the test duration for the "temperature cycle test" life test is based on the average temperature change of the component in the field and the number of temperature cycles during the service life in the field.

A.3.1 关于应用场所温度循环次数，可以将每天两次温度变化作为典型值。因而得出：

A.3.1 Two temperature cycles per day can typically be assumed for the number of temperature cycles in the field. This results in:

$N_{tempcyclefield}$ = 2 * 365 * 15 （年 years） = 10950 个循环 cycles

根据应用场所平均温度变化按照以下公式计算出科芬-曼森模型加速系数：

Depending on the average temperature change in the field, the acceleration factor of the Coffin-Manson model is calculated as follows:

其中 Where：

A_{cm} 科芬-曼森模型加速因子 Acceleration factor of the Coffin-Manson model

ΔT_{test} 一个试验循环期间的温度差 Temperature difference during a test cycle($\Delta T_{test}=T_{max}-T_{min}$)

ΔT_{field} 在应用场所的使用寿命期间平均温度差 Average temperature difference during service life in the field

C 科芬-曼森模型参数 Parameter of the Coffin-Manson model (C=2.5)

试验循环总数量根据以下公式算出

The total number of test cycles is calculated as per

其中 Where：

N_{test} 需要的试验循环数量 Number of test cycles

$N_{tempcyclefield}$ 在应用场所的使用寿命期间温度循环数量 Number of temperature cycles during service life in the field

A_{CM} 科芬-曼森模型加速因子 Acceleration factor of the Coffin-Manson model

A.3.2 用于带冷却回路的零部件。

A.3.2 For components with a connection to the coolant circuit.

实验循环数量需按照三个温度范围计算：

The number of test cycles is calculated as below temperature:

1，$\Delta T_{test,\ 1}=T_{CC,max}$-Tcc,min

2，$\Delta T_{test,\ 2}=T_{RT}$-Tcc,min

3，$\Delta T_{test,\ 3}=T_{CC,max}-T_{RT}$

4,各温度范围循环数量根据以下公式算出：

4, The each number of test cycles is calculated as per

$$x_{environment} = \frac{N_{TempCyclesField} - \frac{N_{Prüf,Mode,i}}{2} \cdot \left(A_{CM,environment,2} + A_{CM,environment,3}\right)}{A_{CM,environment,1} - \frac{1}{2} \cdot \left(A_{CM,environment,2} + A_{CM,environment,3}\right)}$$

附录 B 零部件试验分支 Appendix B Test sequence

推荐的零部件试验分支见图 B-1。

The recommended component test sequence is shown as figure B-1.

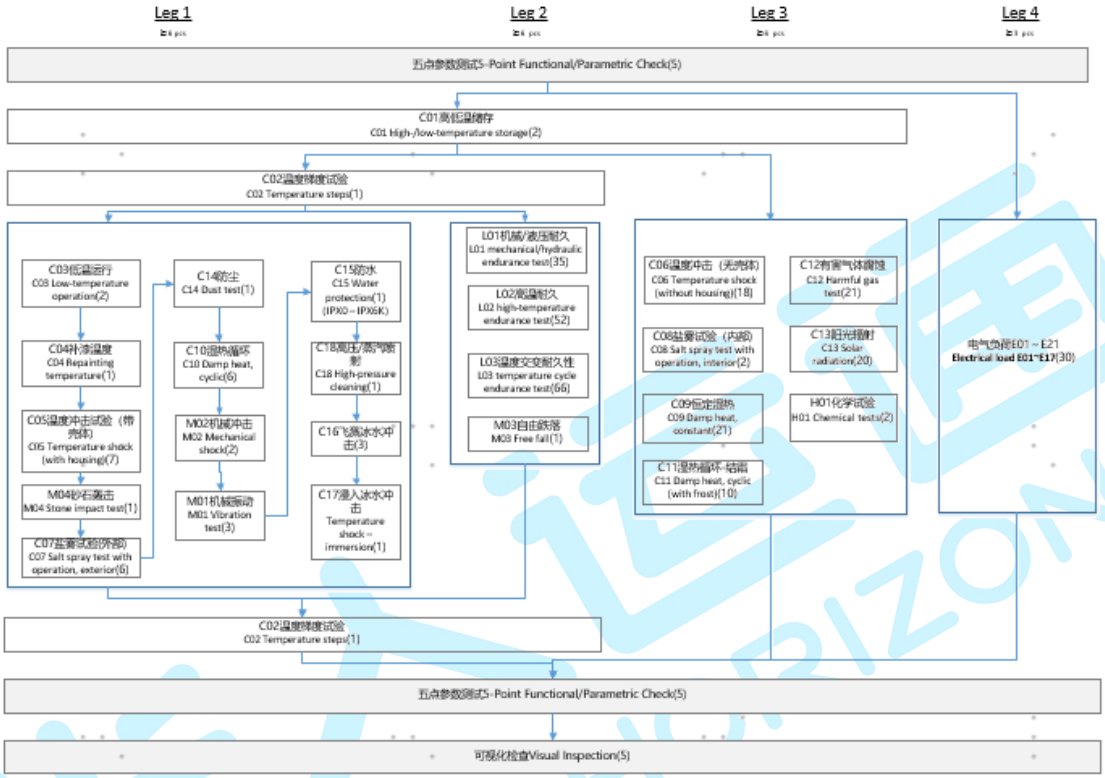


图 B-1 基本的测试流程图 Figure B-1 Test sequence plan

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