

KET NOx Sensor Test Report

V1.0

KET 科瑞信

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R&D and Production System

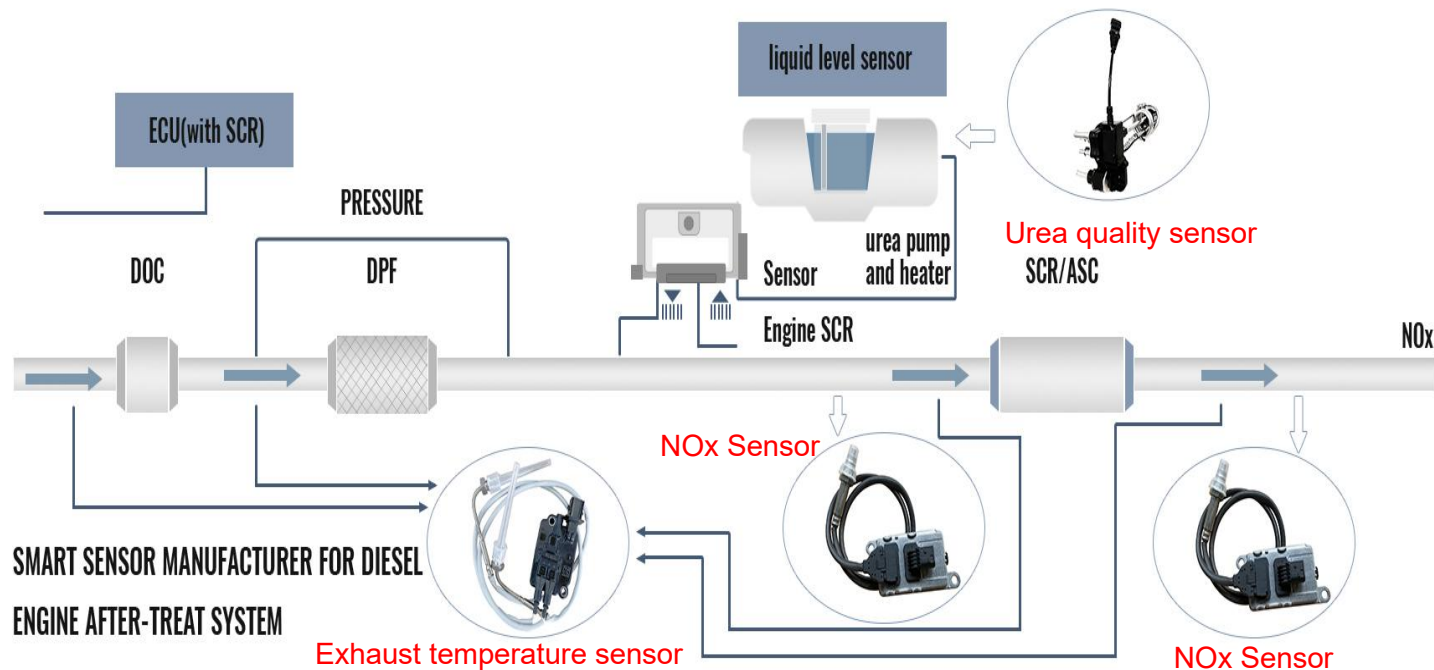
7

Important Customer



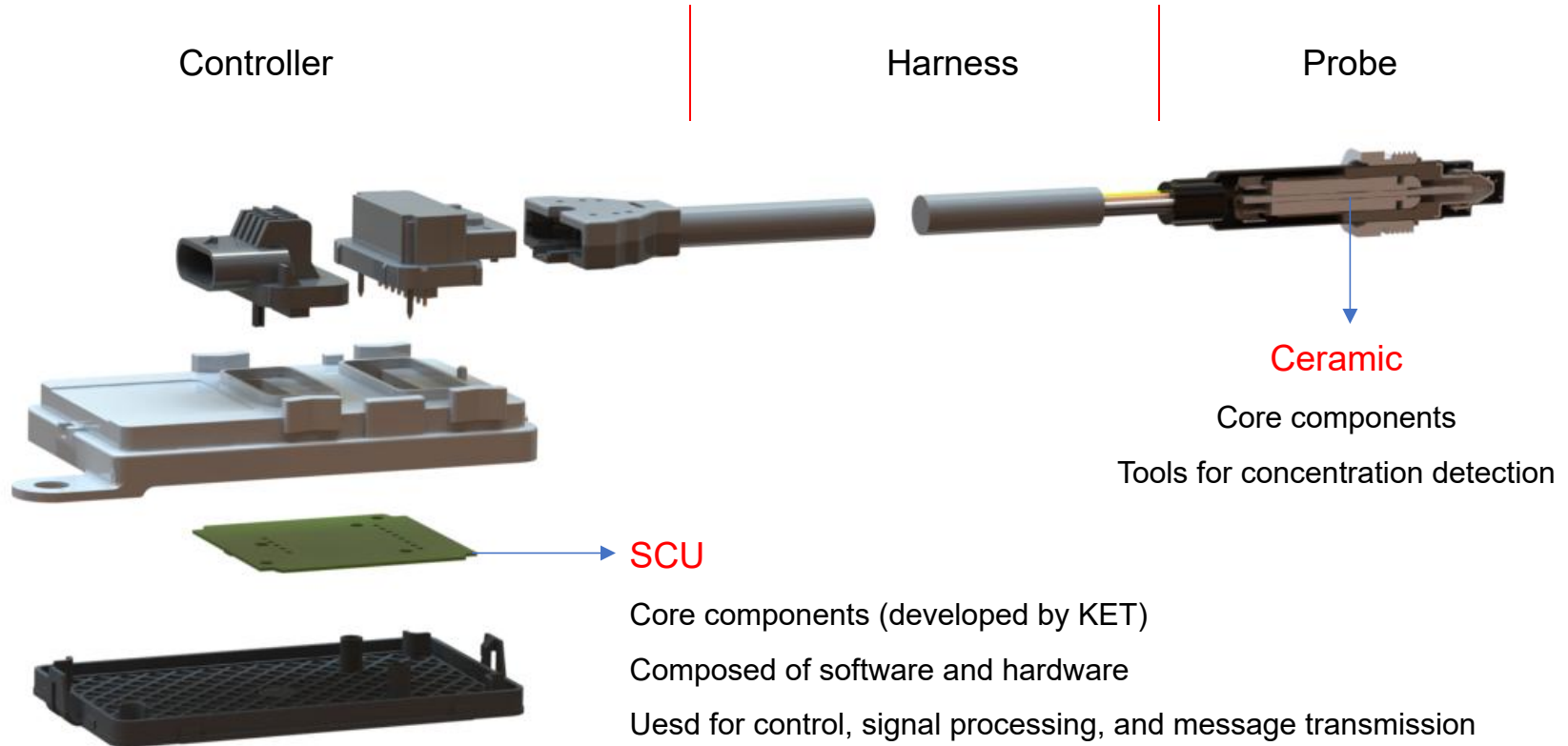
1-NOx Application

After-Treatment System



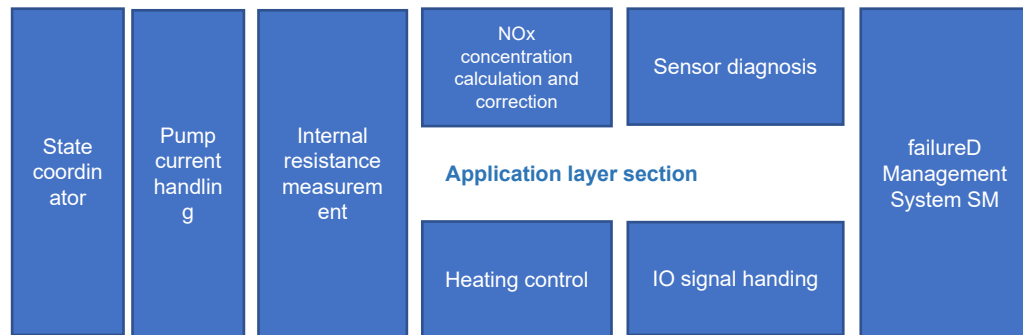
Application of NOx sensor: Measure the NOx concentration in the exhaust gas and send it to the ECU (or DCU) via the CAN bus to control the amount of urea injection.

Composition of NOx Sensor

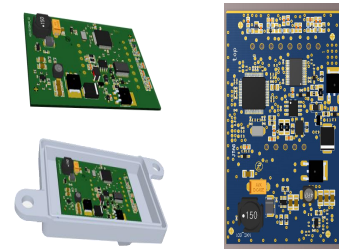


Composition of SCU

SCU

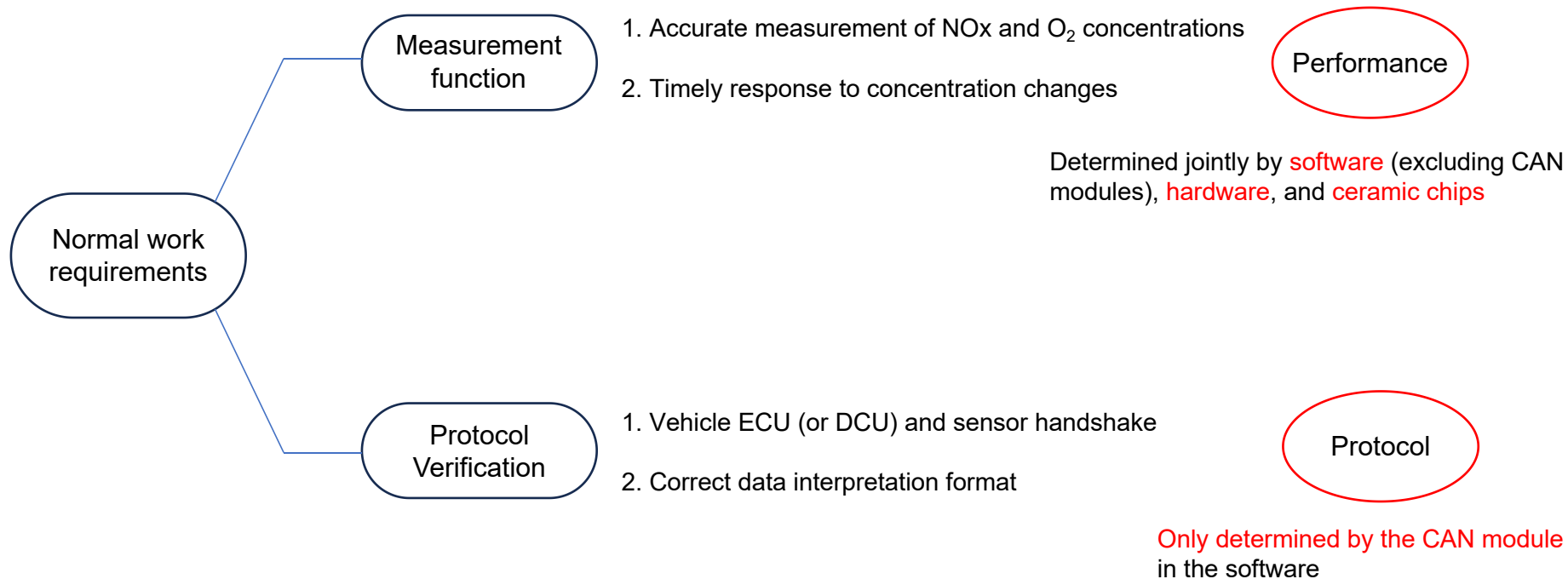


Software



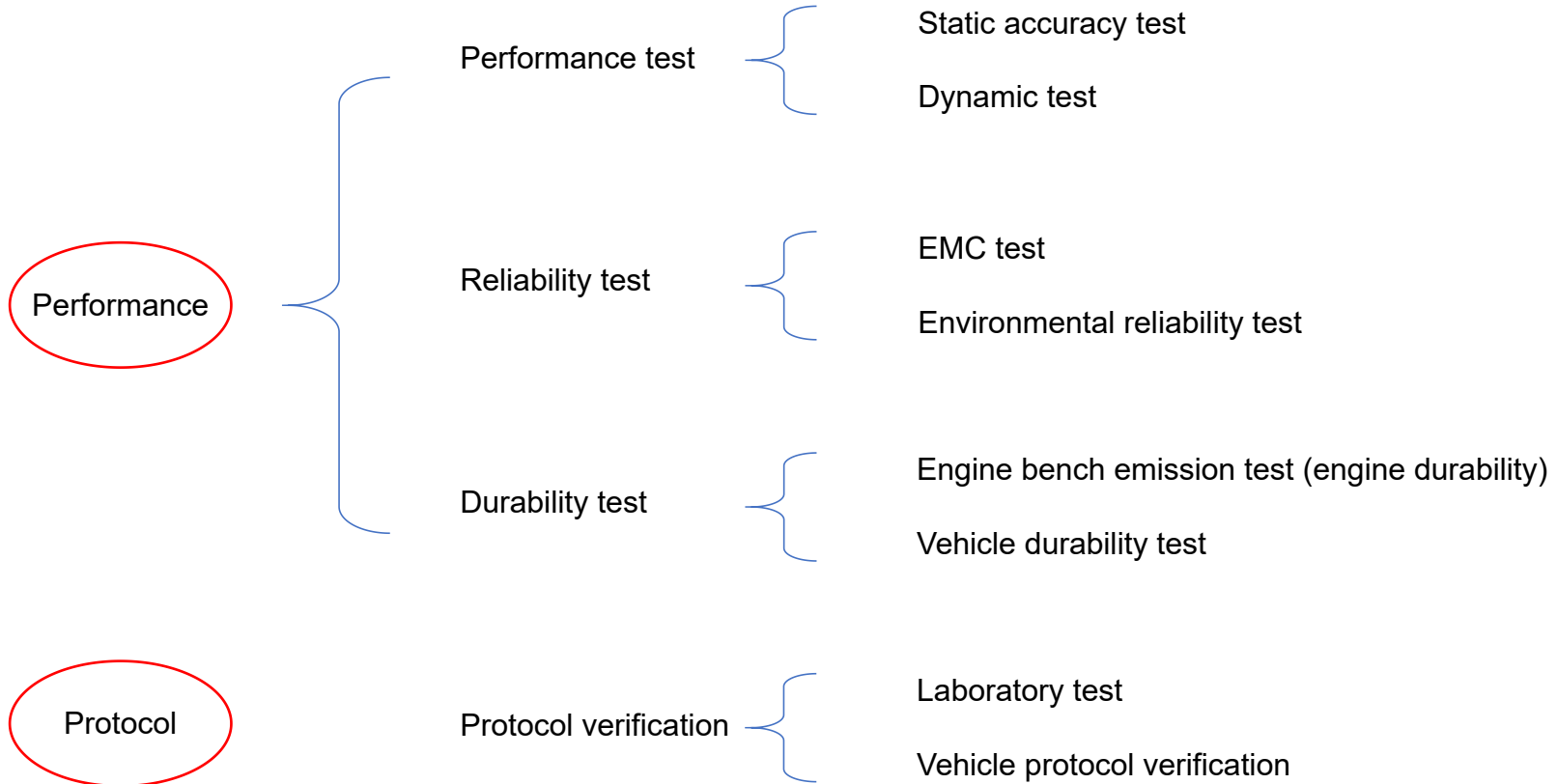
Hardware (PCB)

For NOx sensors of different models, only the CAN protocol differs, which is accounted for only 5% of the software.



- The product performance is independent of the protocol, and different models do not require repeated performance test.
- Different models **only** require **verification of protocols**.

Product Testing Items



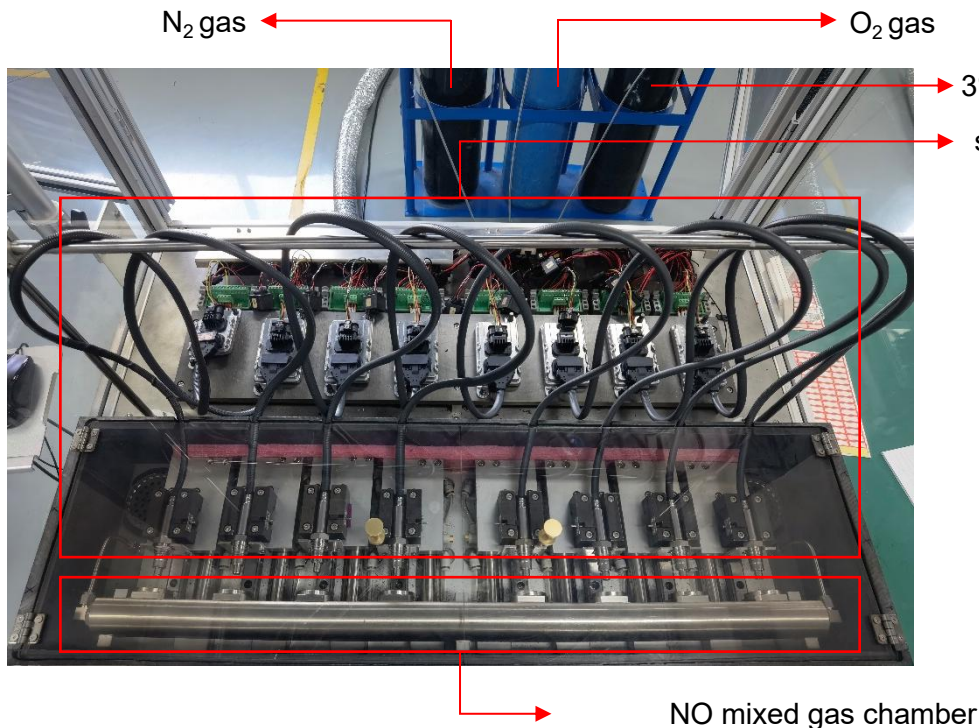


2-Performance Test

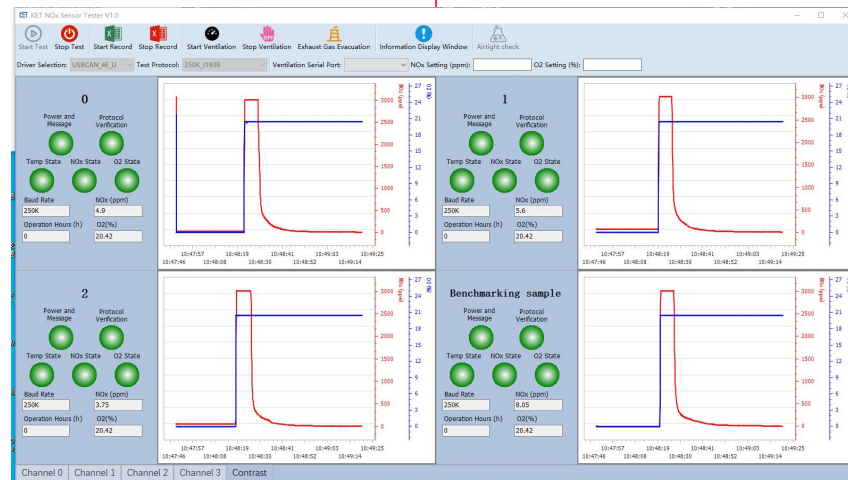
Static Accuracy Test



Static accuracy test, testing the measurement accuracy of the test sample in a static environment.



GUI
Software developed by KET



Static Accuracy Test



As can be seen from the figure below, these two samples have **high measurement accuracy performance**.

Probe number	Environment1	Environment2	Environment3	Environment4	Environment5	Environment6
NOx Concentration Value (ppm)						
KET_MY-01-29	93	293	479	983	1468	93
KET_MY-01-69	94	294	478	978	1460	94
Conti_Benchmarking	94	290	486	978	1482	94
NOx Concentration Deviation						
KET_MY-01-29	-1.1%	1.0%	-1.4%	0.5%	-0.9%	-1.1%
KET_MY-01-69	0.0%	1.4%	-1.6%	0.0%	-1.5%	0.0%

	KET	Conti (Gen3.5)
NOx Accuracy Requirements	0~100ppm: ±10ppm 100~500ppm: ±10% 500~1500ppm: ±15% 1500~2500ppm: ±30%	0~100ppm: ±10ppm 100~500ppm: ±10% 500~1500ppm: ±15% 1500~2500ppm: ±30%

Dynamic Test



By mounting the **Kreation sample** and **Conti sample** on the **same section** of the vehicle's Exhaust pipe, compares the NO_x and O₂ curves of the two during vehicle operation.

The higher the curve overlap, the better the product **responsiveness and dynamic measurement accuracy**.



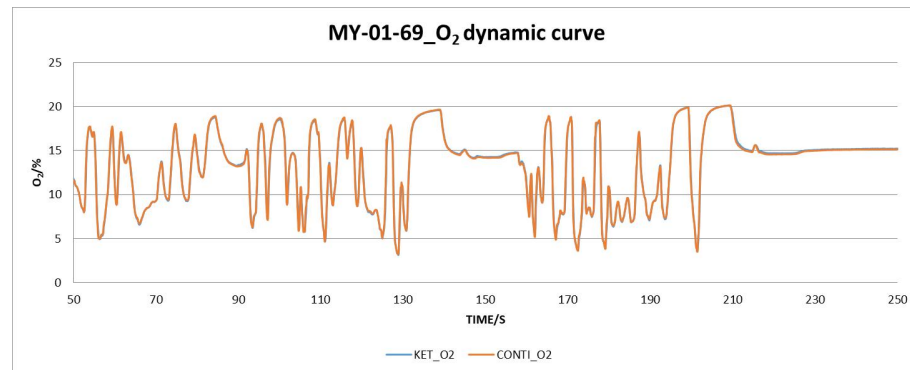
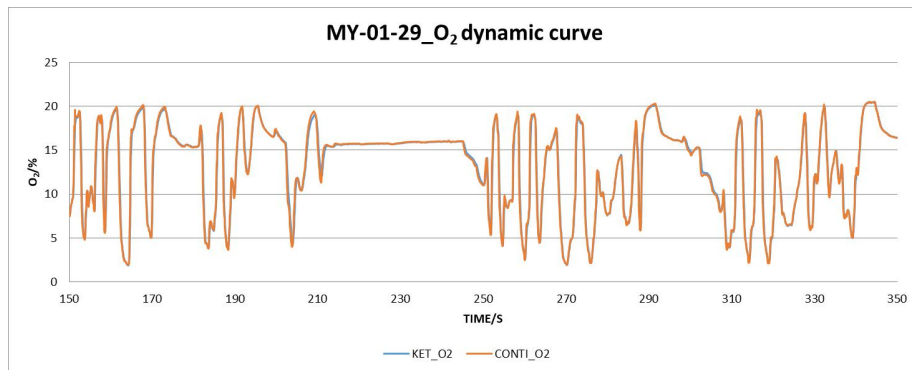
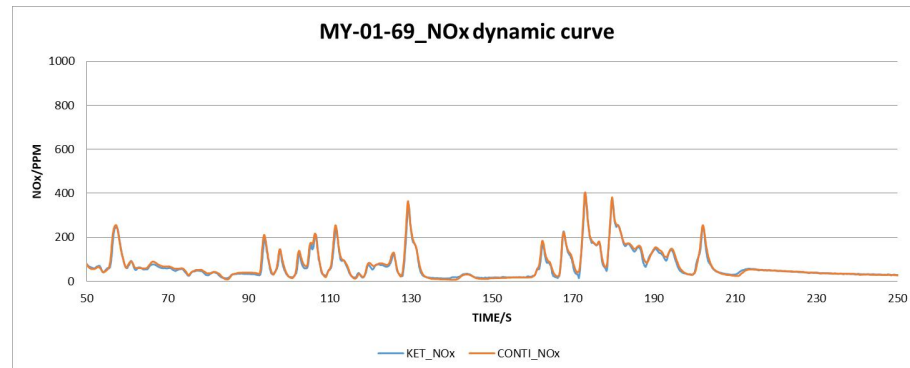
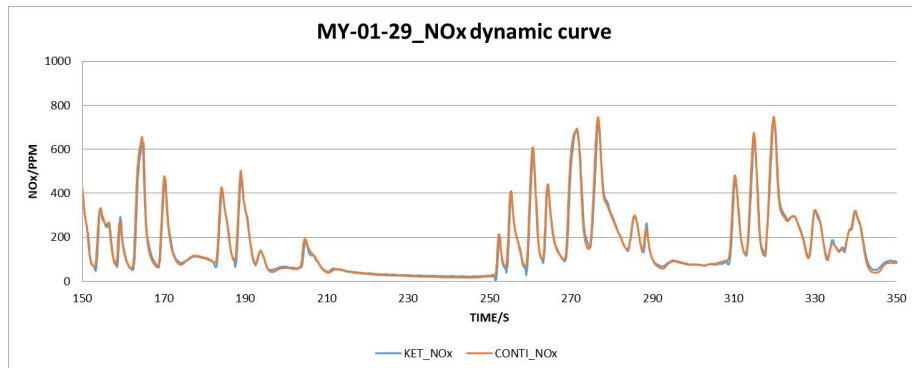
Installation position of test sample

Installation
position of
Conti sample

Dynamic Test



As shown in the figure below, KET NOx sensors have **excellent dynamic accuracy and responsiveness**.





3-Reliability Test

Project	Standard	State	Evaluate	
			Competitor 3.5	KET
Electromagnetic disturbance characteristics - Conducted emissions	CISPR 25 voltage method, severity level Class 3	A	Qualified	Qualified
Electromagnetic disturbance characteristics - Radiation emissions	According to GB 34660-2017 ALSE method	A	Qualified	Qualified
Transient emission - Power line	ISO 7637-2 Severity Level III	A	Qualified	Qualified
Radiation immunity - Magnetic field	ISO 11452-8 Severity Level III	A	Unqualified	Qualified
Radiation immunity - BCI	ISO 11452-4	A	Qualified	Qualified
Radiation Immunity - ALSE	According to GB 34660-2017	A	Qualified	Qualified
Transient Immunity - Non Power cord	Conduct fast electrical transient disturbance and slow electrical transient disturbance tests according to ISO 7637-3	A	Qualified	Qualified
Transient immunity - Power cord	According to GB/T 21437.2, pulse 1, 2a, 2b, 3a, 3b, 4, and 5a anti-interference tests shall be conducted Pulse 1 and pulse 2b are required to be in functional state C, and other functional states are required to be in A state	A	Unqualified	Qualified
Electrostatic immunity (charged)	Perform electrostatic immunity testing in powered mode according to ISO 10605.	A	Qualified	Qualified
Electrostatic immunity (uncharged)	Perform electrostatic immunity testing in non powered mode according to ISO 10605	C	Qualified	Qualified

Note: This testing standard is more stringent than the CE system standard.

Environmental Reliability Test



Project	Standard	State	Evaluate	
			Competitor 3.5	KET
Low Temperature Test	-40 °C low-temperature storage and low-temperature operation test for 72 hours according to GB/T 2423-2008	A (After the experiment is completed and restored to room temperature)	Qualified	Qualified
High Temperature Test	72 hours of 85 °C high temperature storage and 96 hours of 85 °C high temperature operation test according to GB/T 2423-2008	A (After the experiment is completed and restored to room temperature)	Qualified	Qualified
Temperature change test	According to ISO 16750-4:2006	C	Qualified	Qualified
Temperature/humidity combined cycle test	According to GB/T 2423.34-2012	A (After the experiment is completed) ; The overall appearance should have no defects such as rust	Qualified	Qualified
Three comprehensive tests	According to ISO16750-3:2007	A	Qualified	Qualified
Salt spray test	According to ISO16750-4:2006	A (After the experiment is completed)	Qualified	Qualified
Industrial solvent resistance test	According to GB/T 2423.30-1999	A (After the experiment is completed)	Qualified	Qualified

Environmental Reliability Test



Project	Standard	State	Evaluate	
			Competitor 3.5	KET
Waterproof test	According to ISO16750-4:2006, IP6K9K requirements	C	Qualified	Qualified
Foreign object prevention test	According to ISO16750-4:2006, IP6K9K requirements	C	Qualified	Qualified
Free fall test	According to GB/T 2423.8-1995	A (After the experiment is completed)	Qualified	Qualified
Wire tensile strength test	Test conditions: Apply a tensile force of 80N between the connector of the sensor and the probe	There is no looseness at the wire connection; The sample can work normally during the experiment; Meet functional status requirements: A	Qualified	Qualified
Flying Stone Test	Flying stone condition: Free fall of 100g steel ball from a height of 1.5m onto the sensor, producing an impact of approximately 1.5Nm, 60 impacts per point	A (After the experiment is completed)	Qualified	Qualified



4-Durability Test

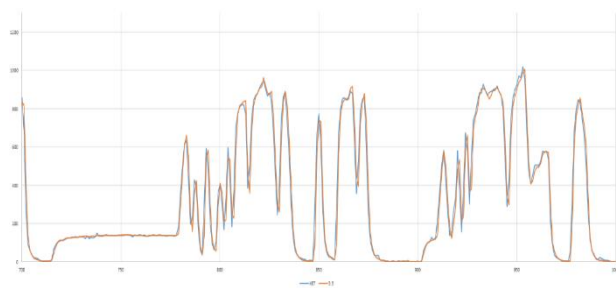
Engine Bench Emission Test



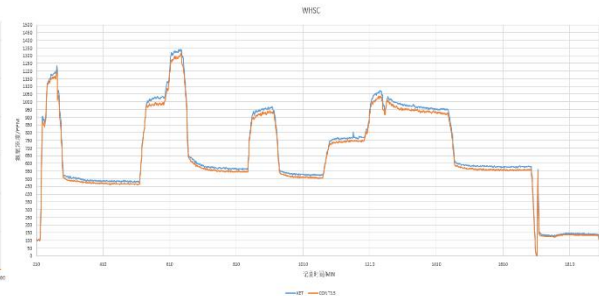
Diesel engine **China VI (Equals to Euro VI)** emission test result.



AVL gas analyzer & engine bench test



WHTC Test Cycle Data



WHSC Test Cycle Data

WHTC Emission	KET	Germany G3.5	China VI Limitation
NOx (g/kWh)	0.113	0.121	0.46
THC (g/kWh)	0.034	0.021	0.16
CO (g/kWh)	0.019	0.019	4
PM (g/kWh)	0.002	0.001	0.01

WHSC Emission	KET	Germany G3.5	China VI Limitation
NOx (g/kWh)	0.216	0.297	0.4
THC (g/kWh)	0.014	0.016	0.13
CO (g/kWh)	0.022	0.022	4
PM (g/kWh)	0.001	0	0.01

Vehicle Durability Test



From 2022 to 2024, KET has gradually equipped over ten LD trucks (with China VI emission standard, equals to Euro 6) with KET NOx sensors and continuously track driver usage:

Vehicle brand	License plate number	Engine brand	Engine model	Mount time	Accumulated verification mileage
JAC	皖AV80F5	Quanchai	Q25-152E60	2022	98469.62 km
Beijing Foton	浙AW5A16	Cummins	F2.8NS6B150	2022	79922.5 km
Beijing Foton	粤B95TE2	Cummins	F2.8NS6B150	2022	81223.88 km
FAW	浙EU186E	Yunnei	D25TCIF1	2022	25873 km
FAW	浙ES689W	/	/	2022	39846 km
SINOTRUK	浙A69Y5C	Weichai	WP2.3NQ130E61	2022	97518 km
DFM	浙AX076E	Quanchai	Q23-115E60	2022	93317 km
Shacman Light Truck	浙AL56Z8	Weichai	WP2.3NQ130E61	2023	3089.62 km
Howo	浙EX319T	Yunnei	/	2023	60976 km
DFM	浙AB805R	Quanchai	Q23-136E60	2023	76246 km
Shacman	皖AM83E5	Yunnei	D25TCIF1	2023	45570 km
FAW	冀AG3885	Bowei	CA6DLD-25E6	2024	Newly installed



Durability testing (cloud data tracking)

- Implementation method: Install a Tbox monitoring box on a vehicle equipped with a KET nitrogen oxygen sensor, which can monitor the vehicle real time transmission of dynamic data to cloud platform (Zlink) .
- Testing and tracking LD trucks : LD trucks with China VI emission standard .
- Expected life cycle of KET NOx sensor : 5000h-7000h.

The ZLink remote service platform can monitor real-time vehicle dynamic data, mainly including front and rear NOx concentration data and fault code information. KET engineers can record and analyze relevant data to verify the long-term durability of sensors.

Tbox monitoring box



Vehicle Durability Test



Cloud platform interface

LD truck information

NOx sensor related data

Functional constituencies

服务运营平台

中文 | 帮助 | 消息 | krx

选择设备类型 | 设备SN/发动机编号/ICCID/物联卡号 | 查询

☐	设备类型	序列号	发动机编号	车辆厂家	ICCID当前值	物联卡号当前值	在线时间	TCP连接状态	数据在线状态	服务器/客户端IP	操作
☐	E3	976896001438	Q23-115E60	东风重卡	B986112126503555849	5	2023-04-13 16:06:14	上线	上线	86-0536-001001 ::ffff:117.61.17.227:50888	盒子管理 ECU管理 数据监控 数据分析

[最新GPS](#) [最新故障码](#) [最新数据流](#) [紧急事故报警](#) [历史GPS](#) [历史故障码](#) [历史数据流](#) [历史报警信息](#) [里程](#) [开始里程](#) [历史总里程](#) [查看系统信息](#)

查看数据流信息

☐	设备类型	序列号	发动机编号	进气流量	kg/h	2023-04-13 08:10:29	2023-04-13 16:10:29	E8	操作				
☐	E3	976896001512	未启用	☐	5	J000132	进气流量	99.30	kg/h	2023-04-13 08:10:29	2023-04-13 16:10:29	E8	ECU管理 数据监控 数据分析
☐	E3	976896001481	WP2.3NQ130E	☐	6	J0004360	后处理上游排气温度	269.59	°C	2023-04-13 08:10:29	2023-04-13 16:10:29	E8	ECU管理 数据监控 数据分析
☐	E3	976896001374	F2.8N56B15	☐	7	J0004363	后处理下游排气温度	247.69	°C	2023-04-13 08:10:29	2023-04-13 16:10:29	E8	ECU管理 数据监控 数据分析
☐	E3	976896001297	WP2.3NQ130E	☐	8	J0003216	后处理上游氮氧浓度	349.00	ppm	2023-04-13 08:10:29	2023-04-13 16:10:29	E8	ECU管理 数据监控 数据分析
☐	E3	976896001178	Q25-152E60	☐	9	J0003226	后处理下游氮氧浓度	13.60	ppm	2023-04-13 08:10:29	2023-04-13 16:10:29	E8	ECU管理 数据监控 数据分析
☐	E3	976896001582	A3K2100140	☐	10	J0003699	DPF被动再生状态	3	-	2023-04-13 08:10:29	2023-04-13 16:10:29	E8	ECU管理 数据监控 数据分析

☐	E3	976896001516	A1N21071994	陕汽	B986112126503555866	9	2023-04-02 03:13:47	下线	下线	86-0536-001001 ::ffff:117.61.25.111:49800	盒子管理 ECU管理 数据监控 数据分析
☐	E3	976896001198	Q210801183D	东风	B986112126503555910	5	2023-03-22 16:32:12	下线	下线	86-0536-001001 ::ffff:117.61.24.139:63554	盒子管理 ECU管理 数据监控 数据分析
☐	E3	976896001544	D25TCIF1	长春一汽	B986112126503555527	7	2023-03-08 12:57:40	下线	下线	86-0536-001001 ::ffff:117.61.24.89:6669	盒子管理 ECU管理 数据监控 数据分析

Specific functions

Vehicle Durability Test



Vehicle brand	License plate number	Engine brand	Engine model	Loading time	Accumulated verification mileage
DFM	浙AX076E	Quanchai	Q23-115E60	2022	93317 km

Testing accuracy before loading (December 2022)						Testing accuracy after loading 93000 kilometers (December 2023)					
Probe number	100ppm	300ppm	500ppm	1000ppm	1500ppm	Probe number	100ppm	300ppm	500ppm	1000ppm	1500ppm
0KM10060026	96.5	275.8	462.7	909.2	1376.1	0KM10060026	84.7	248.7	412.4	871	1343.7
0KM10060018	98.3	285.6	485.4	939.6	1411.7	0KM10060018	88.1	268.3	438.7	901.8	1396.3
Benchmark sample	101.84	281.87	471.52	935.12	1408.66	Benchmark sample	98.91	274.76	444.91	931.59	1407.24
Precision deviation						Precision deviation					
0KM10060026	-5.3	-2.2%	-1.9%	-2.8%	-2.3%	0KM10060026	-14	-9.5%	-7.3%	-6.5%	-4.5%
0KM10060018	-3.5	1.3%	2.9%	0.5%	0.2%	0KM10060018	-11	-2.3%	-1.4%	-3.2%	-0.8%

Accuracy change
after driving 93000
kilometers

The above KET NOx sensors have not added any aging correction strategy, and although the accuracy has significantly decreased after driving 93000 kilometers (without faults), it still meets the level of After loading installation.



5-Protocol Verification

Vehicle Protocol Verification

Protocol
development
and verification
process

① Obtain the original factory sample of this model

② Interpreting the message information of original factory sample

③ Develop based on interpretation, and complete the testing in the laboratory

④ Verified through vehicle mounting testing

Change the development status of the model to "Tested"

Change the development status of the model to "Verified"



Time	Tx/Rx	Channel	Msg	ID	Message	DLC	Data Byte(s)
11:31:54.2507	Rx	1	x	0x10B0F52	0x10B0F52	8	A2 40 44 16 00 44 00 00
11:31:54.5007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.5107	Rx	1	x	0x10B0F52	0x10B0F52	8	00 01 D3 D3 00 00 00 FF
11:31:54.5507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.6007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.6507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.7007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.7507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.8007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.8507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.9007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:54.9507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.0007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.0507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.1007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.1507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.2007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.2507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.3007	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.3507	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.4006	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.4506	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.5006	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF
11:31:55.5106	Rx	1	x	0x10B0F52	0x10B0F52	8	00 FF FF FF FF FF FF FF



Vehicle Protocol Verification

Two criteria for passing the protocol verification test:

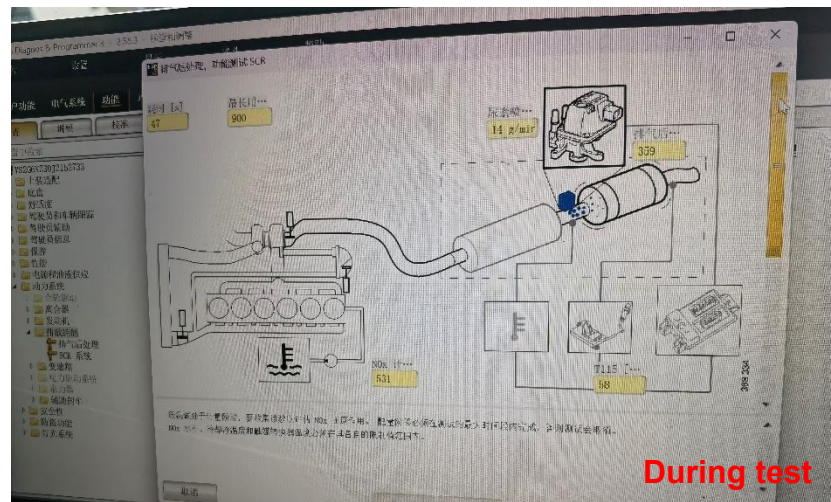
1. Installed on the vehicle, there is still no malfunction after several driving cycles;

The definition of a driving cycle: powering on, starting, accelerating, maintaining a high speed for a certain period of time, decelerating, turning off the engine, and powering off.

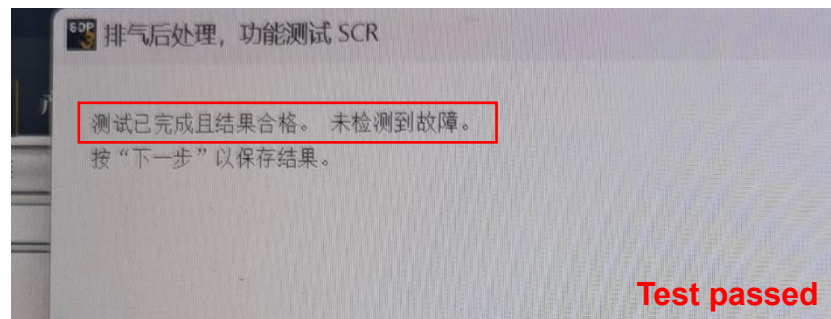
2. Passed the after-treatment cycle test (only some vehicles have it).

Either method can prove the correctness of the protocol.

The right figure shows **Scania's SCR testing program**, which can be used for dynamic performance test and protocol verification of NOx sensors.



During test



Test passed

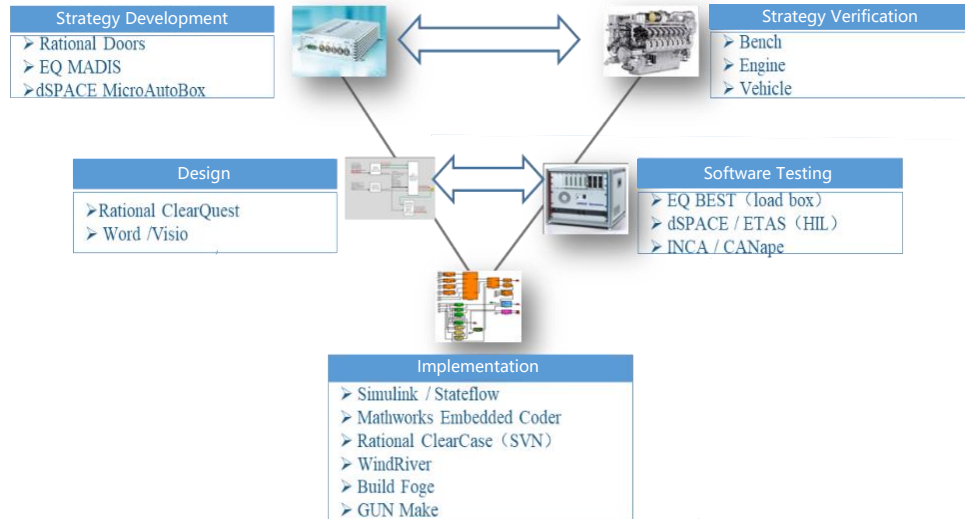


6-R&D and Production System

R&D Process System



International advanced “V” process development, CMMI quality assurance system.



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04-Jul-22

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General Manager

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Smart Factory



- Annual capacity: 200,000pcs, two shifts.
- IT management platform: ERP+MES+WMS
- All smart testing equipments are self-developed



德国莱茵TUV认证
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Automatic feeding



Automatic detection



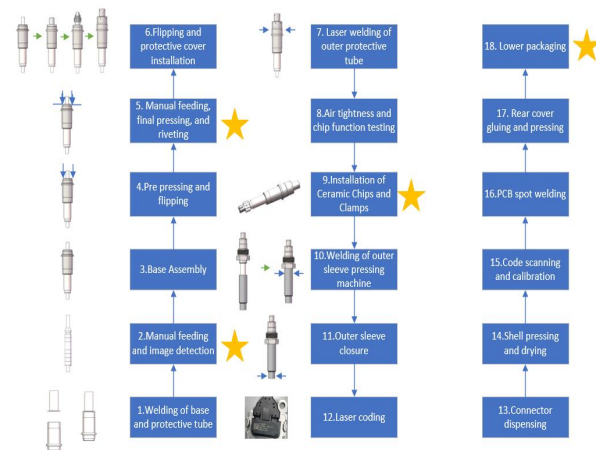
Automatic production line



Automatic press fit



Automatic offline



Manufacture Process

检测报告 报告编号: 20181011231		图 1 样品		图 2 样品		图 3 样品		图 4 样品		图 5 样品		图 6 样品		图 7 样品		图 8 样品		图 9 样品		图 10 样品		图 11 样品		图 12 样品		图 13 样品		图 14 样品		图 15 样品	
产品名称: NXC 型号规格: / 委托单位: 中山市智创科技发展有限公司 检测项目: 委托检测		3.1 检测 测试项目: / 测试结果: /		3.2 检测 测试项目: / 测试结果: /		3.3 检测 测试项目: / 测试结果: /		3.4 检测 测试项目: / 测试结果: /		3.5 检测 测试项目: / 测试结果: /		3.6 检测 测试项目: / 测试结果: /		3.7 检测 测试项目: / 测试结果: /		3.8 检测 测试项目: / 测试结果: /		3.9 检测 测试项目: / 测试结果: /		3.10 检测 测试项目: / 测试结果: /		3.11 检测 测试项目: / 测试结果: /		3.12 检测 测试项目: / 测试结果: /							
江苏省电子信息产品质量监督检验所 (江苏省无线电监测评价中心)		3.13 检测 测试项目: / 测试结果: /		3.14 检测 测试项目: / 测试结果: /		3.15 检测 测试项目: / 测试结果: /		3.16 检测 测试项目: / 测试结果: /		3.17 检测 测试项目: / 测试结果: /		3.18 检测 测试项目: / 测试结果: /		3.19 检测 测试项目: / 测试结果: /		3.20 检测 测试项目: / 测试结果: /		3.21 检测 测试项目: / 测试结果: /		3.22 检测 测试项目: / 测试结果: /		3.23 检测 测试项目: / 测试结果: /									

Item	Tested by	Aera	Standard	Result
EMC/COP	VCA	European Union	ECE R10 (E-mark)	100%
EMC	Institute qualificated by CNAS	European Union	EN IEC61326(CE)	100%
EMC and Environmental Reliability	Institute qualificated by CNAS	China	OEM Standard(VS Conti)	100%
EMC	self declaration	UK	UKCA	



7-Important Customer



Customer Audit



Customer	Product	Market	Comments	State
YuChai	EGTS (Exhaust Gas Temperature Sensor)	OEM	Chinese top3 Engine manufactory -OEM	Supplied for three years, nearly 200000 sets
Niterra	Smart Oxygen sensor	OEM	NTK Ceramic + KET SCU	Under development, mass production by the end of 2024
Dinex	NOx sensor	OEM		Supplied for one year, nearly 10000 sets
Eminox	NOx sensor	OEM and Aftermarket		Supplied for three years, nearly 20000 sets
Dorman	NOx sensor	Aftermarket		Completed factory audit, in the durability test
Vierol	NOx sensor	Aftermarket		Complete factory audit
YuChai	NOx sensor	Achievement 97%	Chinese top3 Engine manufactory -OEM	Complete factory audit, sample testing in progress
YTO GROUP	NOx sensor	OEM	Chinese top2 farm machinery manufactory -OEM	Sample testing in progress

KET 科瑞信

THANK YOU