

# 中国重型车排放测试

## China Heavy Vehicle Emission Testing

Vehicle Emission Control Centre, CRAES

March, 2021

# Outline



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**Main content of Phase VI standards and analysis of differences with Europe**

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# 1

## 第六阶段标准主要内容及与欧洲差异分析

Main content of Phase VI standards and analysis of differences with Europe

# 中国第六阶段排放标准概要

## Summary of China's Phase VI Emission Standards

	国六重型车 Phase VI heavy vehicles
测试循环 Test environment	WHTC, WHSC, WNTe
污染物 Pollutants	CO, THC, NMHC, CH4, NOx, PM, PN, NH3
排放限值 Emission limits	限值与欧VI相同, NOx 削减 77%, PM 削减 67% PM=10mg/kWh, PN=6*10 <sup>11</sup> (8*10 <sup>11</sup> for WHSC), NH3=10ppm Limits are identical to Euro VI: NOx is reduced by 77%, PM is reduced by 67% PM=10mg/kWh, PN=6*10 <sup>11</sup> (8*10 <sup>11</sup> for WHSC), NH3=10ppm
排放和油耗 联合管控 (CO2 控制) Emissions and fuel consumption Joint control (CO2 control)	燃油消耗量试验必须同时测量排放并达标 Fuel consumption tests must also measure emissions and meet standards
PEMS	6b阶段: 海拔扩展到2400m, 温度范围: -7~38 (25°C), 实验负载: 10%-90%, NOx: 690mg/kWh, PN=1.2*10 <sup>12</sup> Phase 6b: The altitude extends to 2400m, the temperature range: -7 - 38 (25°C); the experimental load: 10%-90%, NOx : 690mg/kWh, PN=1.2*10 <sup>12</sup>
质保期 Warranty period	M1, N1, M2: 80,000km/5年, M3, N2, N3: 160,000km/5年 M1, N1, M2: 80,000km/5 years, M3, N2, N3: 160,000km/5 years
耐久性 Durability	M1, N1, M2: 200,000km/5年, N2, N3 (≤16t), M3 (I, II): 300,000km/6年 N3 (>16t), M3 (III): 700,000km/7年 M1, N1, M2 : 200,000km/5 years, N2, N3 (≤16t), M3 (I, II) : 300,000km/6 years N3 (>16t), M3 (III) : 700,000km/7 years
OBD, NOx控制 OBD, NOx control	基于Euro VI, 额外增加OBD永久故障代码, OBD整车测试方法, 超OBD阈值限扭以及远程监控要求 Based on Euro VI, additional OBD permanent malfunction codes and OBD vehicle test methods exceeding OBD threshold torque limit and remote monitoring requirements were added

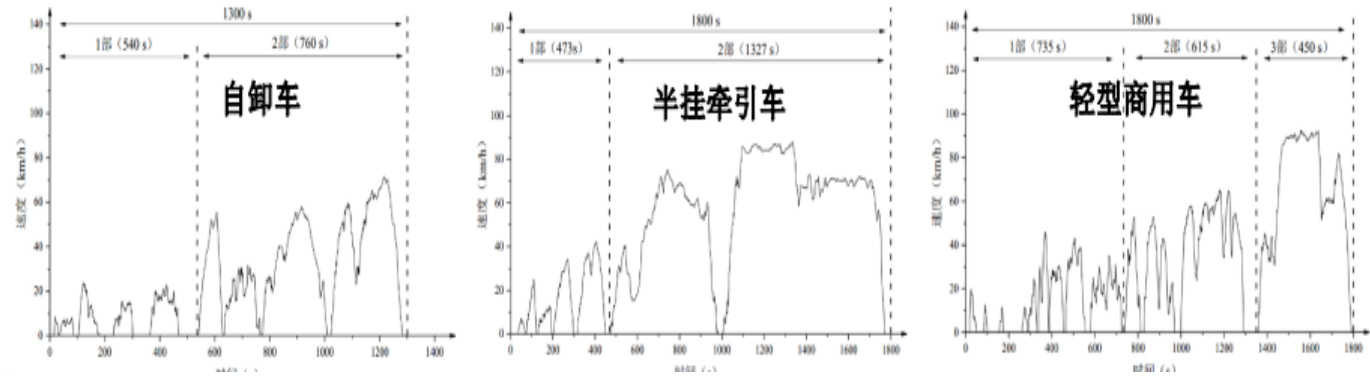
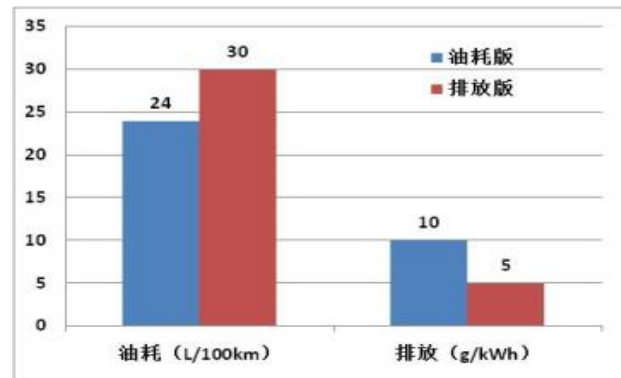
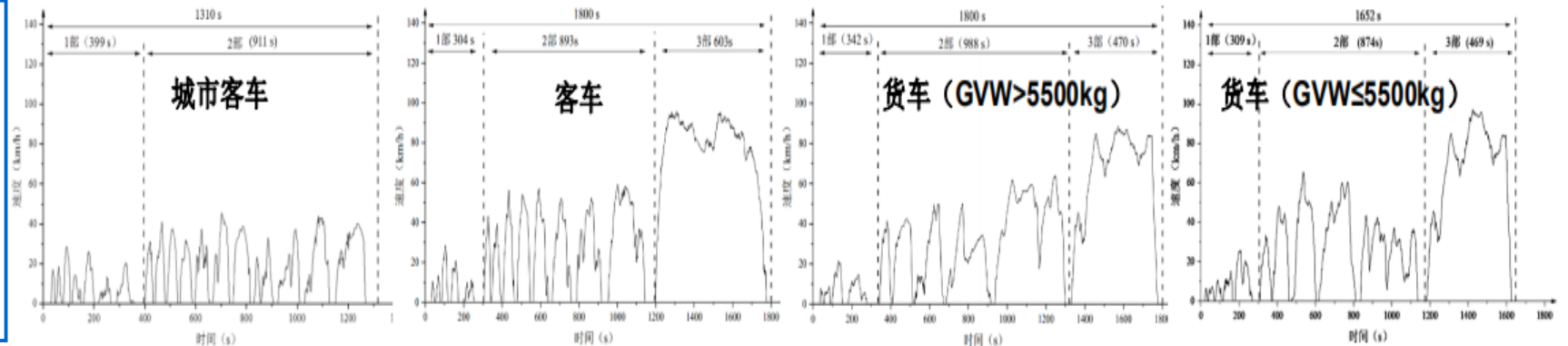
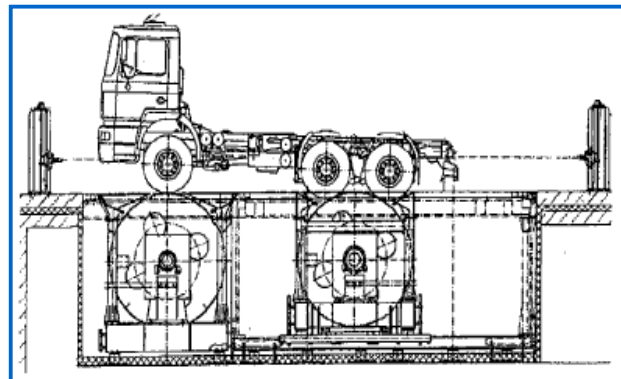
# 与欧洲差异分析

## Analysis of Differences with Europe

### ■ 排放油耗联合测试

#### Joint emission-fuel consumption testing

- **油耗测试：整车转鼓方法；按车辆类型不同，规定不同的测试循环（C-WTVC）**  
Fuel consumption tests: entire vehicle drum method; according to different vehicle types, different test cycles are specified (C-WTVC)
- **排放要求：满足车载法排放限值**  
Emission requirements: To meet emission limits the vehicle laws



# 与欧洲差异分析(高海拔排放要求)

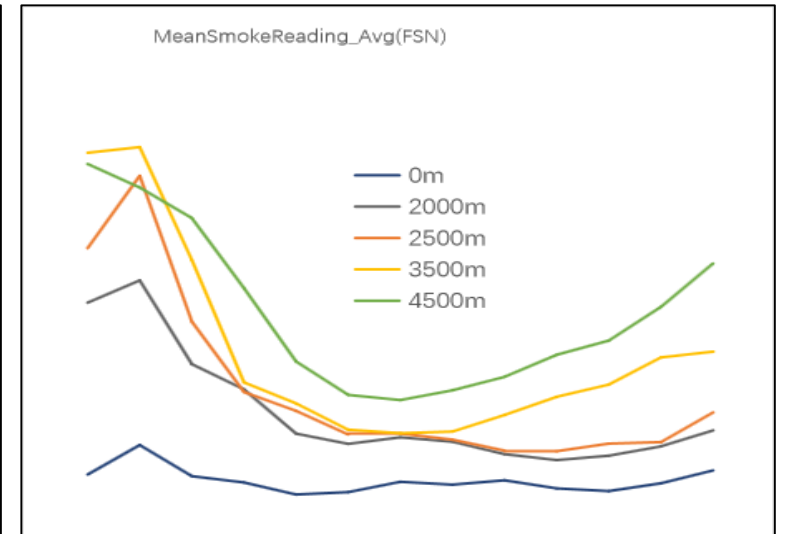
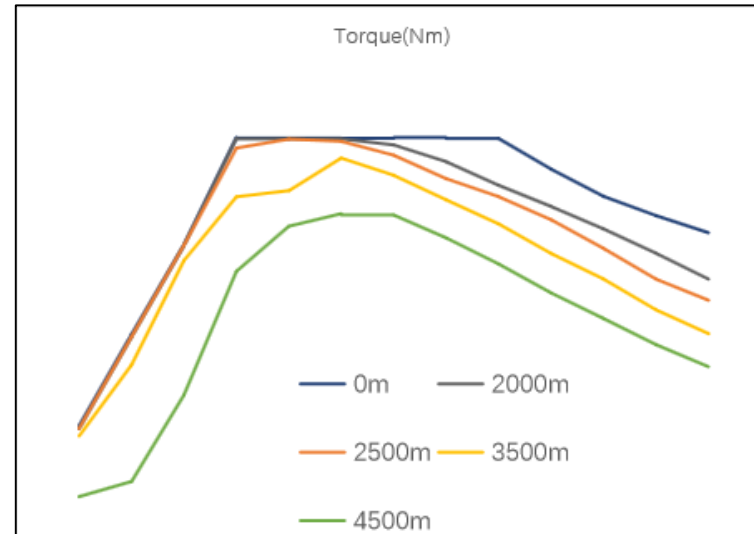
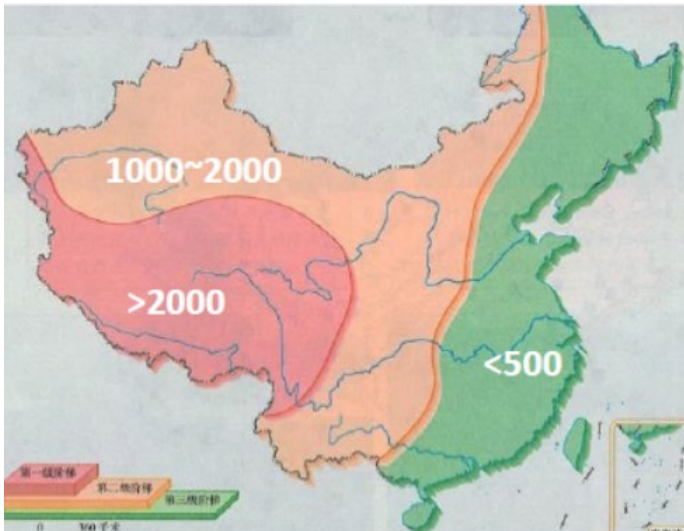
## Analysis of differences with Europe (high altitude emission requirements)

### ■ 增加高海拔排放达标要求 Increased high-altitude emission compliance requirements

- 中国高原地区幅员辽阔，海拔高度在1000米以上地区约占国土面积65%；  
The plateau region of China is vast, with an altitude above 1,000 meters accounting for about 65% of the land area;
- 高原地区汽车保有量在4500万辆以上，主要分布在中西部地区；  
There are more than 45 million cars in the plateau area, mainly in the central and western regions;
- 高原公路占全国总公路的35%以上，且是西部地区货物运输、人员流通的重要途径  
Plateau highways account for more than 35% of the country's total highways, and they are an important means for the transportation of goods and people in the western regions.

### ■ 在高原地区机动车面临的问题： Problems faced by motor vehicles in plateau areas:

- 燃烧恶化、动力性、经济性下降  
Deterioration of combustion, decline in power and economy
- 热负荷增大，可靠性下降  
Heat load increases and reliability decreases
- EGR的控制协调  
EGR control coordination
- 排气温度升高  
Increased exhaust temperature
- 增压器超速  
Supercharge accelerated
- ...



# 与欧洲差异分析

## Analysis of Differences with Europe

### ■ OBD远程排放监控要求 | OBD remote emission monitoring requirements

重型柴油车污染物排放限值及测量方法从6b阶段开始，生产企业应保证车辆在全寿命期内，进行数据发送，由生态环境主管部门和生产企业进行接收。

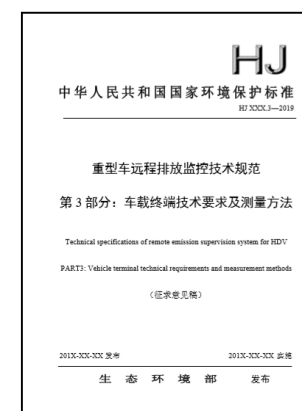
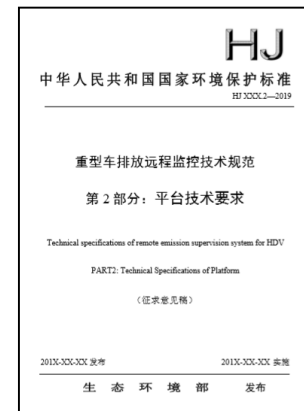
Pollutant emission limits and measurement methods for heavy diesel vehicles start from Phase 6b. Manufacturers should ensure that data is sent during the entire life of the vehicle and received by the ecological and environmental authorities and production companies.



SCR+DPF技术车辆
车速
大气压力(直接测量或估计值)
发动机净输出扭矩, 或发动机实际扭矩/指示扭矩
摩擦扭矩
发动机转速
发动机燃料流量
NOx传感器输出
SCR入口温度
SCR出口温度
DPF压差
进气量
反应剂余量
油箱液位
发动机冷却液温度
经纬度
累计里程

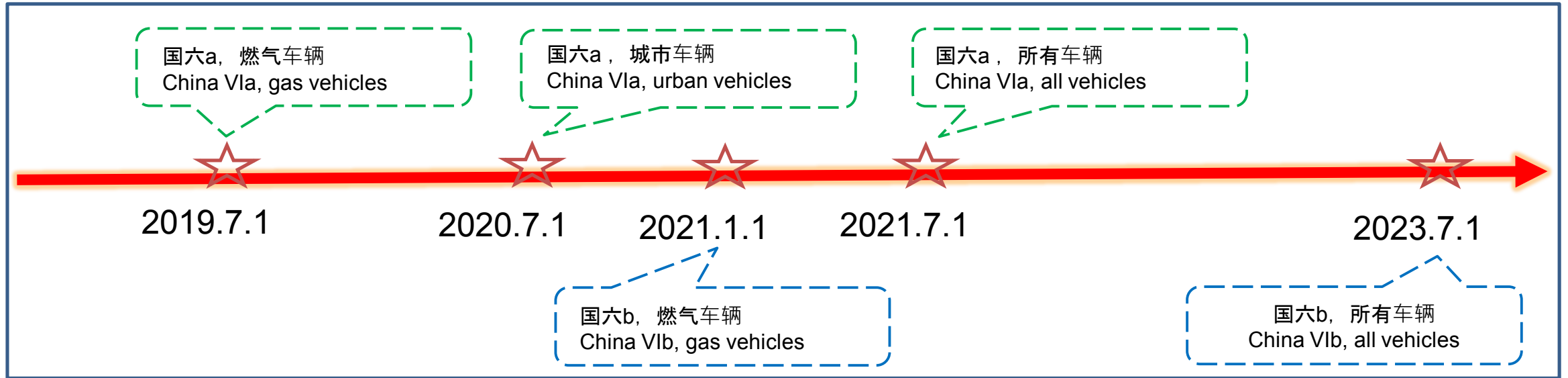
TWC技术车辆
车速
大气压力(直接测量或估计值)
发动机净输出扭矩或发动机实际扭矩/指示扭矩
摩擦扭矩 (作为发动机最大基准扭矩的百分比)
发动机转速
发动机燃料流量
前氧传感器输出
后氧传感器输出
进气量
前温度传感器
发动机冷却液温度
经纬度
累计里程

OBD数据项
OBD诊断协议
MIL状态
诊断支持状态
诊断就绪状态
车辆识别码
软件标定识别号
标定验证码
IUPR值
故障码总数
故障码信息列表



# 分阶段实施

## Phased implementation



### PEMS-Altitude:

- 6a: conditions  $\leq 700\text{m}$ ;
- 6b: conditions:  $\leq 2400\text{m}$



### PEMS-Vehicle load

- 6a: 载荷范围50%-100% | Load range 50%-100% ;
- 6b: 载荷范围: 10%-100% | Load range 10%-100% ;



### PEMS-PN

- 6a: 仅记录结果 | Only recorded results
- 6b: 限值要求  $\text{PN}=1.2 \times 10^{12}$
- 6b: Limit requirements  $\text{PN}=1.2 \times 10^{12}$



### OBD remote supervision system

- 6a: 终端安装要求 | Terminal installation requirement
- 6b: 数据发送要求 | Data transmission requirement



# 2

第六阶段标准实施及测试情况

Implementation and testing of Phase VI standards

# 排放控制技术应用

## Application of Emission Control Technology

到第六阶段，各项污染物限值收严90%以上

By Phase VI, all pollutant limits will be tightened by more than 90%

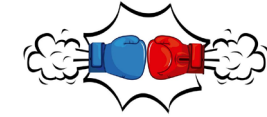
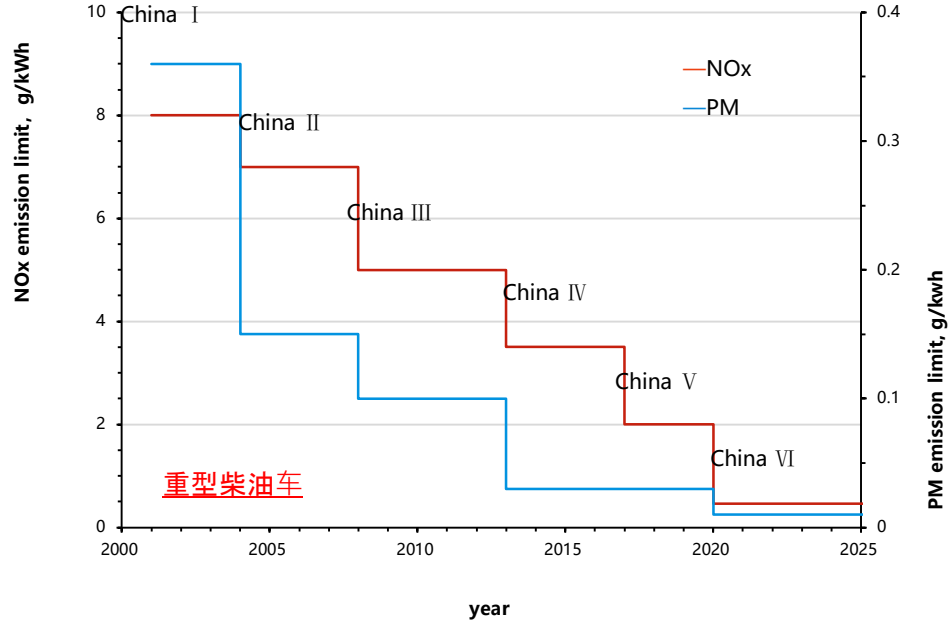
截至2020年底，重型柴油车23万辆、重型燃气车17

万辆完成了国六环保信息公开

As of the end of 2020, 230,000 heavy diesel vehicles and 170,000

heavy gas vehicles had completed the disclosure of China VI

environmental protection information



国五  
China V

柴油车  
Diesel vehicles

PK  
Vs.

国六  
China VI

柴油车  
Diesel vehicles

92%: SCR  
0.02%: DPF+SCR

燃气车  
Gas vehicles

基本: 稀燃+DOC  
Base: Lean burn + DOC

100%: DPF+SCR

燃气车  
Gas vehicles

全部:  
Base: 当量燃烧+三元催化器  
Equivalent combustion + 3-way catalytic converter

# 车载法排放

## On-board emission

- 车载法型式检验测试：国六NO<sub>x</sub>比排放较国五显著降低

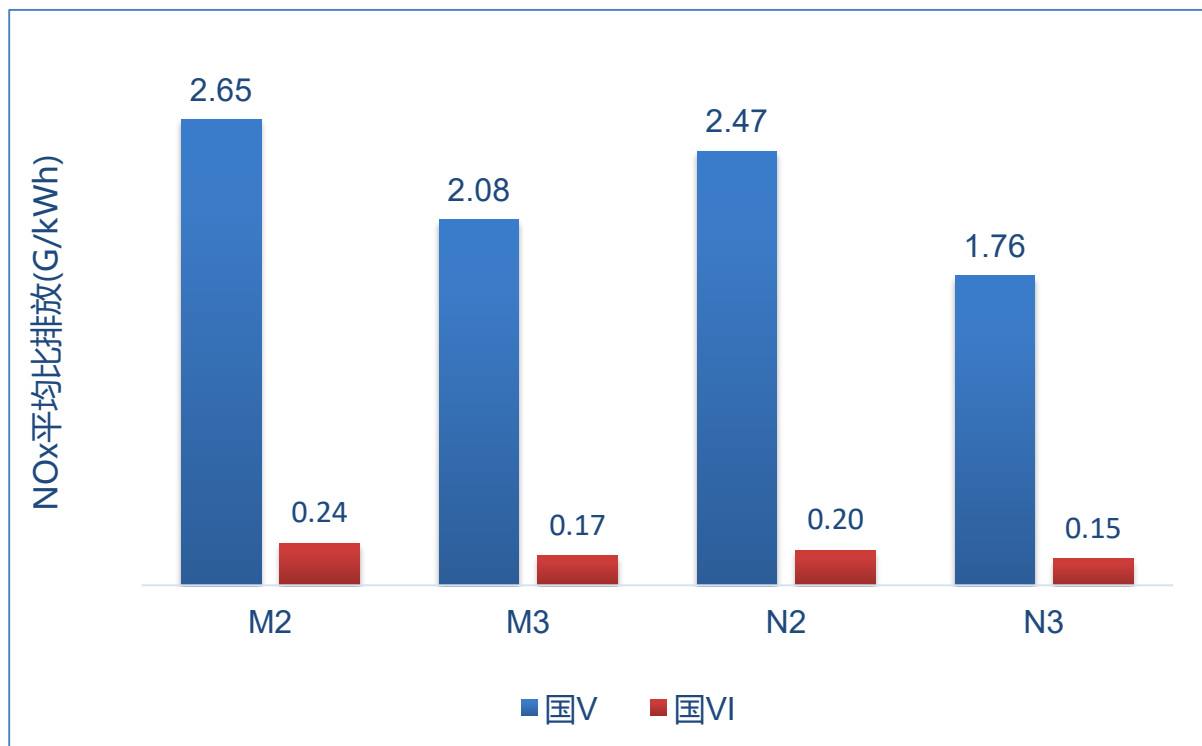
**Vehicle-mounted method inspection test:** NO<sub>x</sub> emissions in China VI are significantly lower than that of China V

- M2、M3、N2和N3四类车，NO<sub>x</sub>降低幅度均超过90%

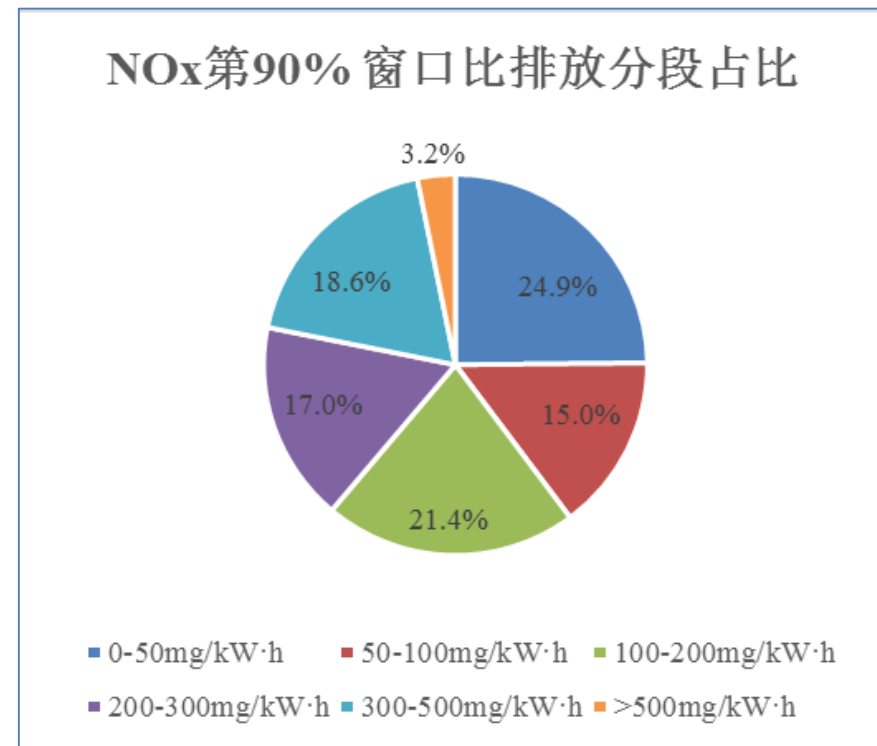
M2, M3, N2 and N3 of four types of vehicles, **NO<sub>x</sub> reduction rate exceeds 90%**

- 近80%车型的PEMS测试结果低于300mg/kWh，远低于排放限值（690mg/kWh）

**PEMS test results of nearly 80% of models are below 300mg/kWh, which is far below the emission limit (690mg/kWh)**



China V      China VI



第六阶段重型车PEMS测试结果分布统计

Distribution statistics of PEMS test results for heavy vehicles in Phase VI

# NOx排放浓度

## NOx emission concentrations

■ 车载法型式检验测试:

Inspection test by vehicle type

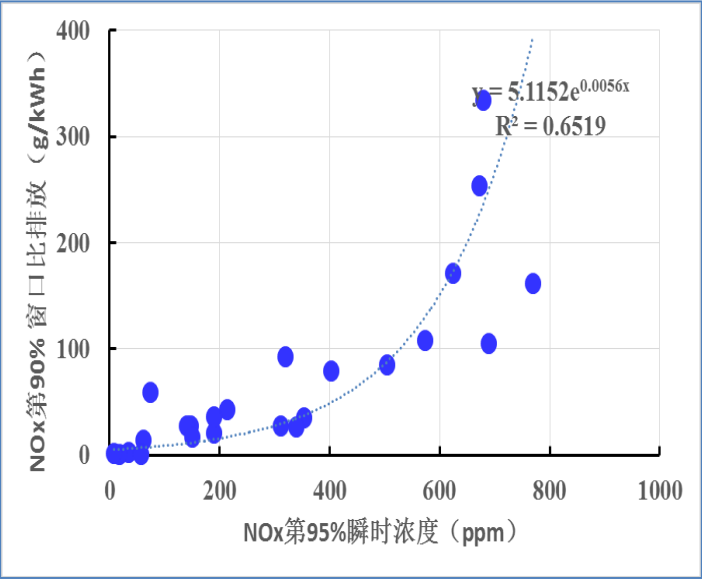
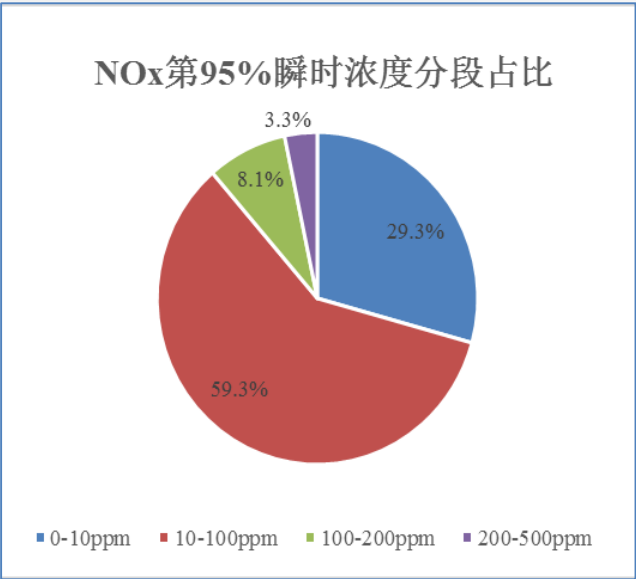
■ 95百分位NOx排放浓度远低于限值要求

The 95th percentile NOx emission concentrations are far below the limit requirement

■ 近90%车型的95百分位NOx浓度值低于100ppm, 远低于排放限值 (500ppm)

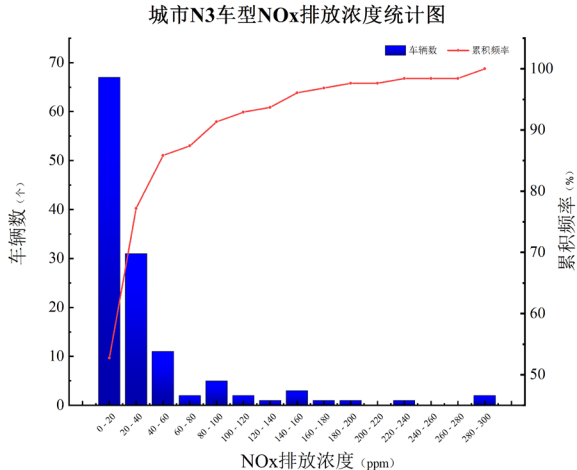
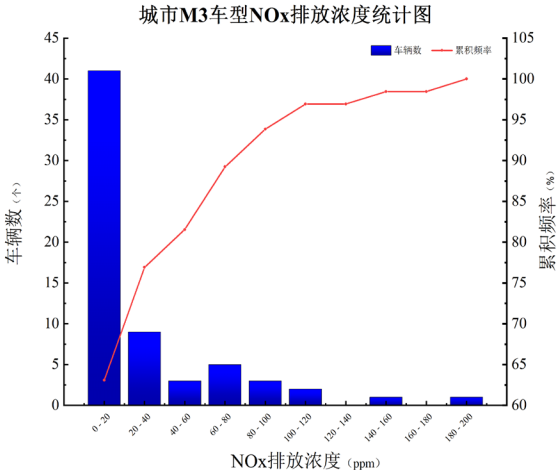
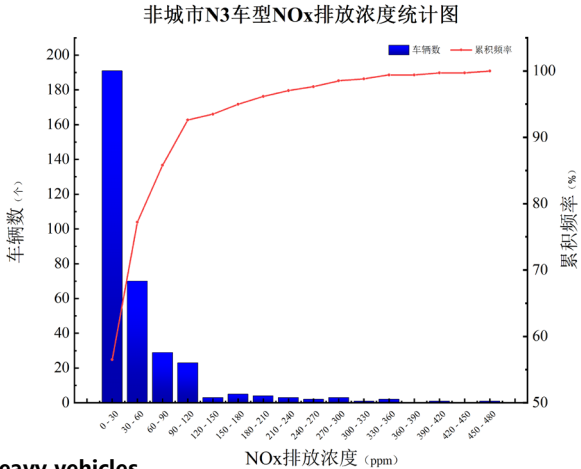
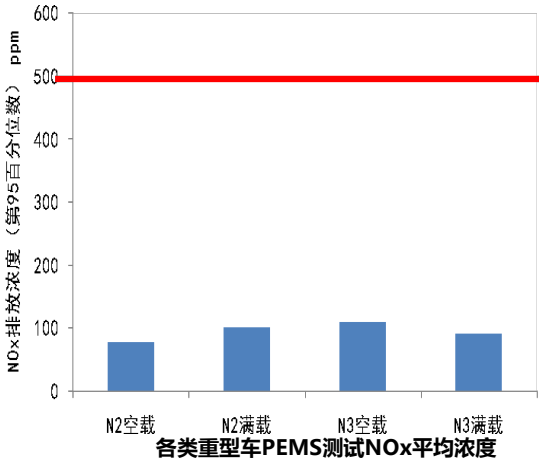
The 95th percentile NOx concentration values of nearly 90% of the models are below 100ppm, which is far below the emission limit

(500ppm)



第六阶段重型车PEMS测试结果分布统计  
Distribution statistics of PEMS test results for heavy vehicles in Phase VI

PEMS测试NOx浓度和比功率排放相关性  
PEMS tests the correlation between NOx concentration and specific power emissions



Average concentrations of NOx in PEMS test of various heavy vehicles

# NOx排放浓度

## NOx emission concentrations

### ■ 车载法型式检验测试:

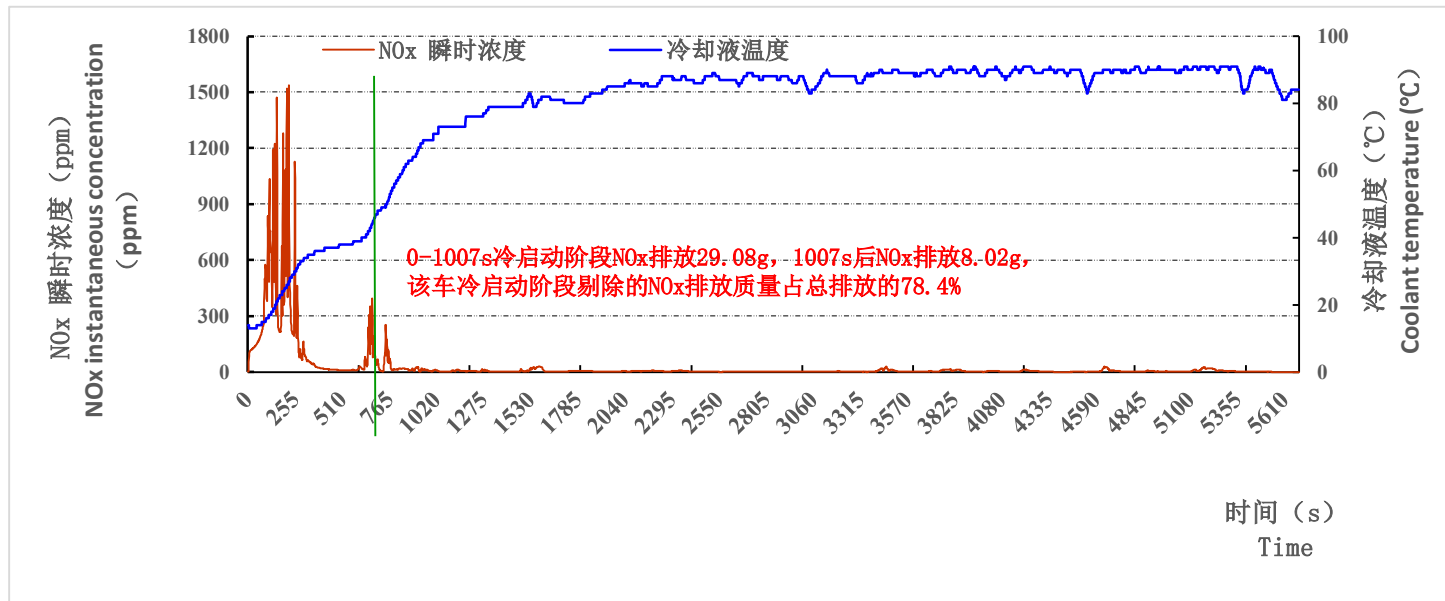
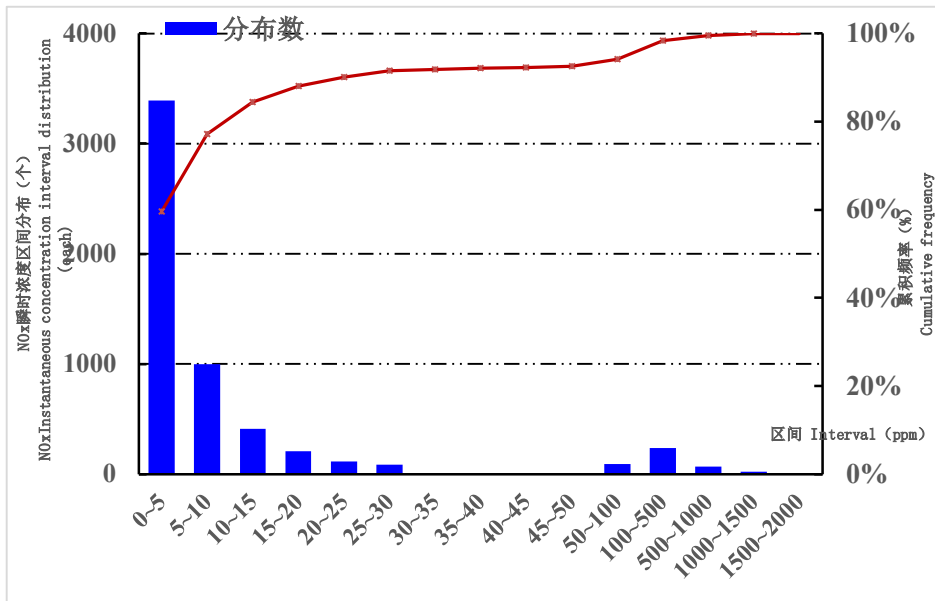
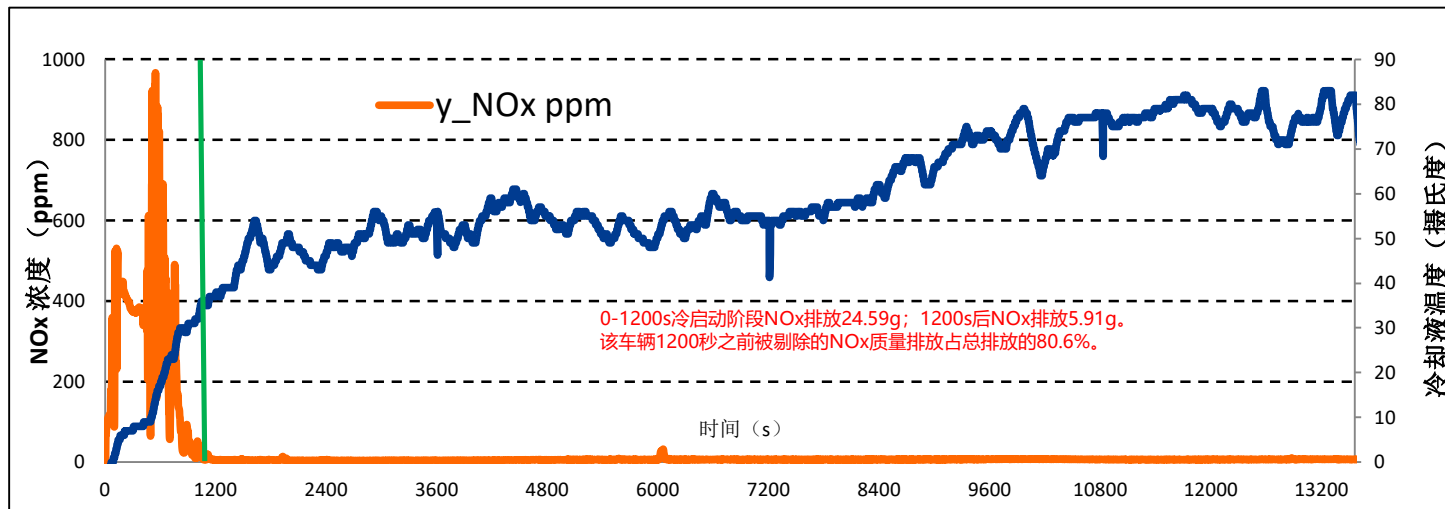
#### Inspection test by vehicle type

### ■ 冷启动条件下NOx排放占比最高可达到80%

Under cold start conditions, NOx emissions can account for up to 80%

### ■ NOx瞬时浓度绝大比例集中在100ppm以内

Most of the instantaneous concentration of NOx is concentrated within 100ppm



# NOx排放浓度

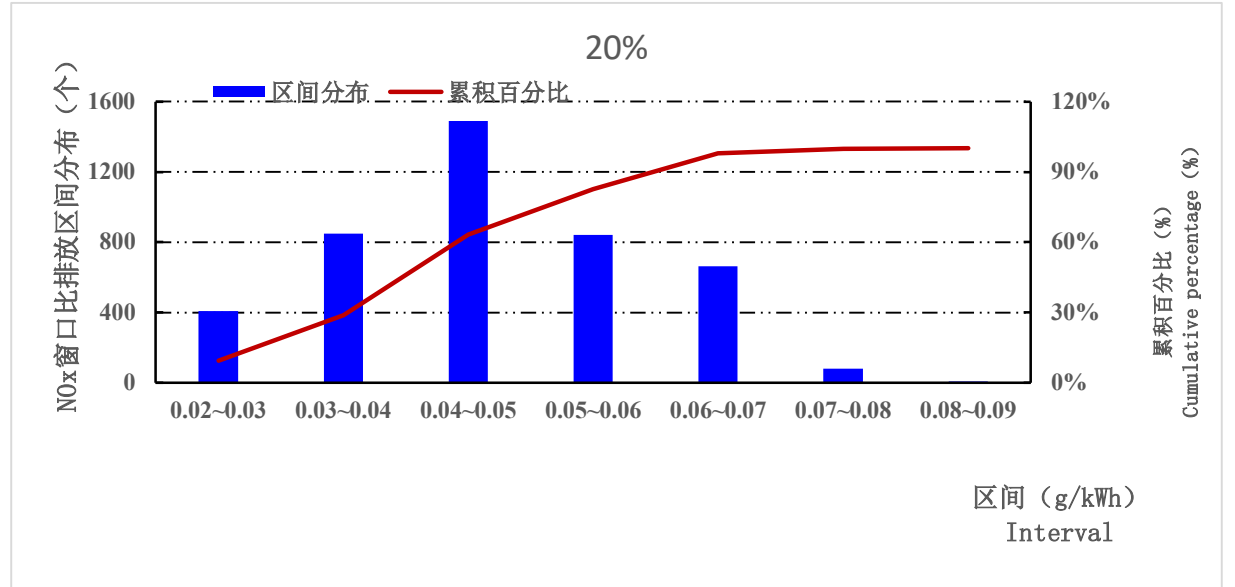
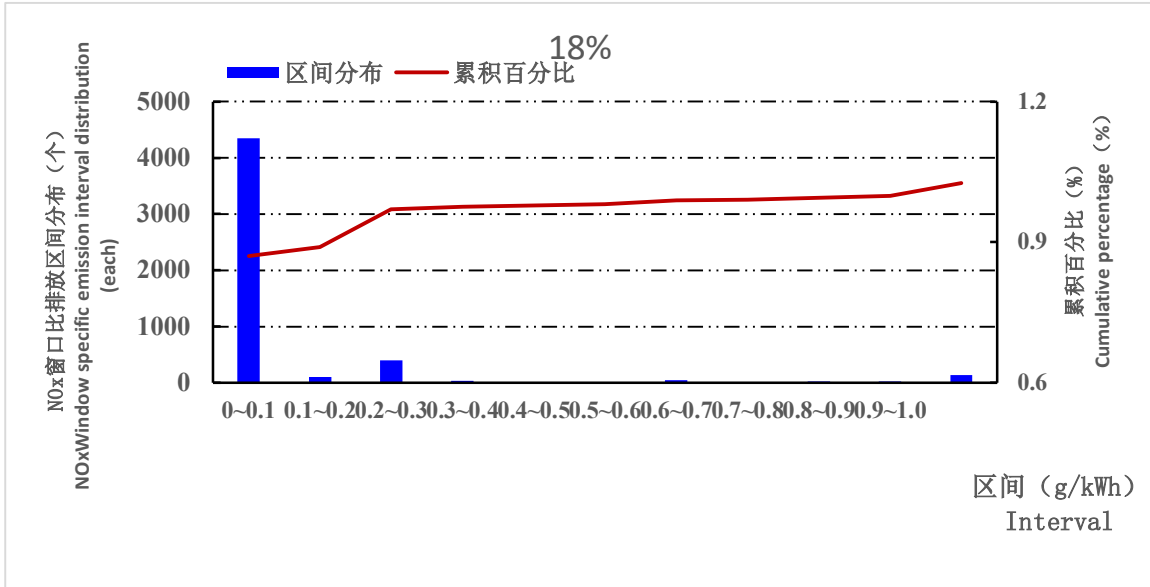
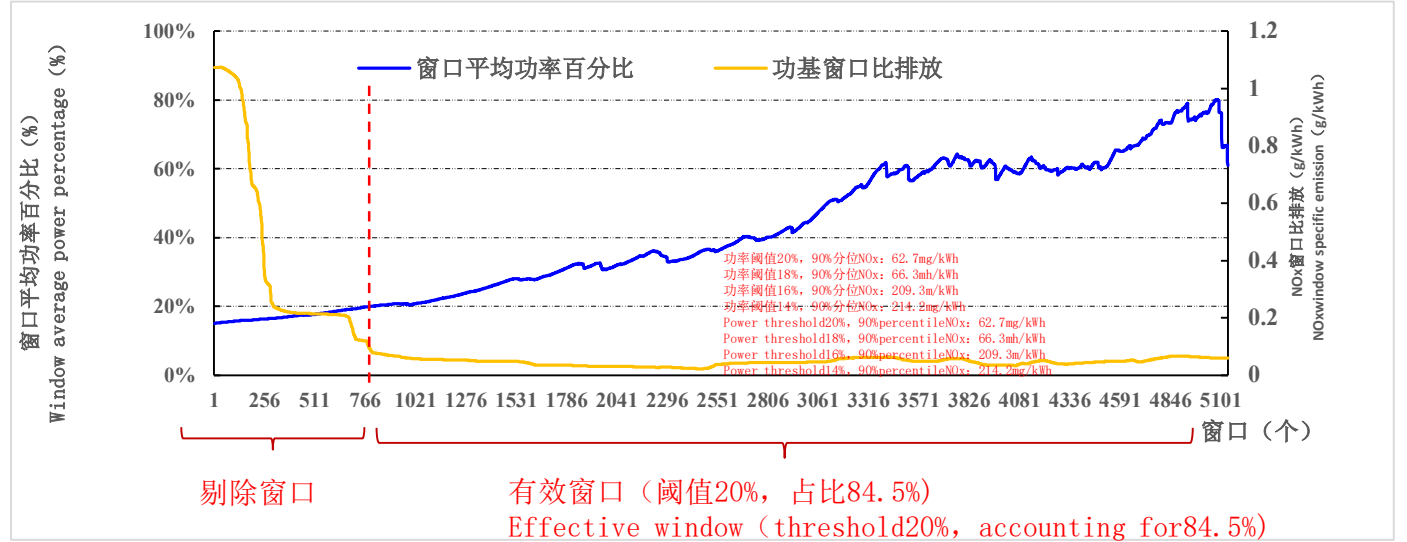
## NOx emission concentrations

- **车载法型式检验测试**: 有效窗口平均功率比例阈值降低, NOx平均比排放迅速增高

**Vehicle-mounted method inspection tests**: the effective window average power ratio threshold is lowered, and the average specific NOx emissions increase rapidly

- **不同功率阈值下, 窗口比排放区间分布规律有较大差别**

**Under different power thresholds, the distribution of windows is quite different than the emission interval**

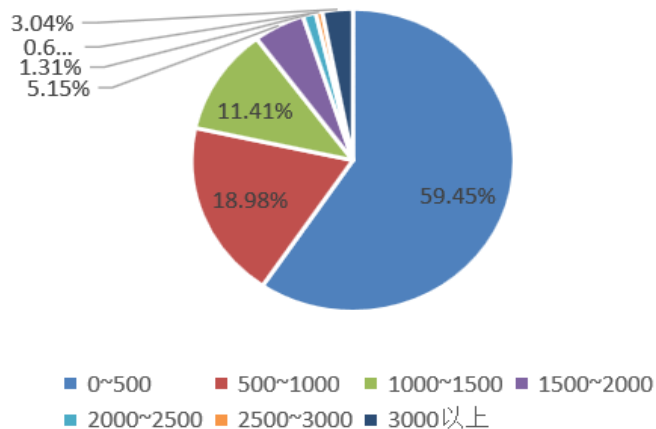


# 远程监控

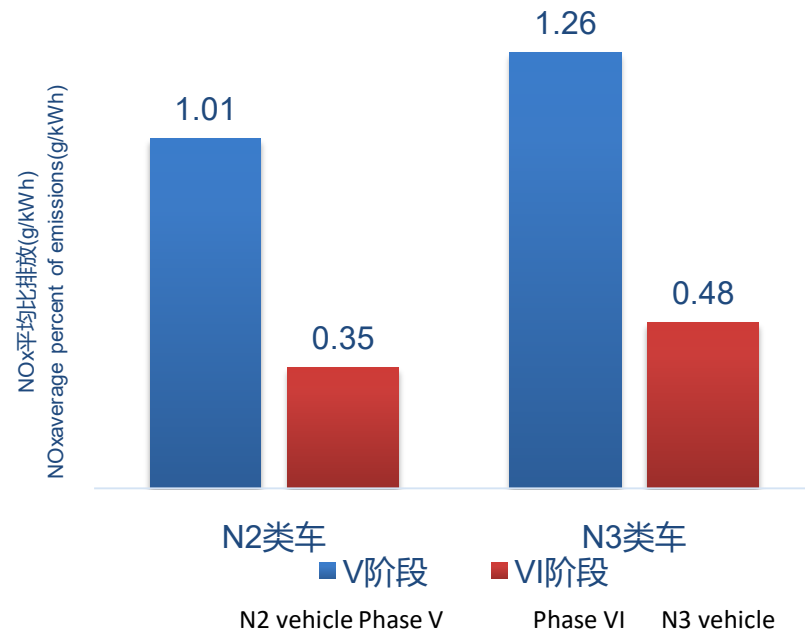
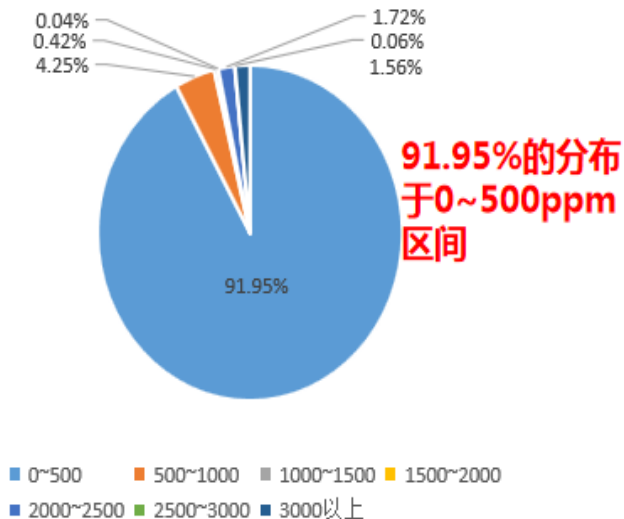
## Remote monitoring

- N2类车：降低65%；  
N2 vehicles: 65% reduction;
- N3类车：降低62%。  
N3 vehicles: 62% reduction;

国五车辆工作时下游氮氧化物浓度ppm分布



国六车辆工作时下游氮氧化物浓度ppm分布



# 远程监控

## Remote monitoring

### PEMS功基法

#### PEMS work-based method

##### 原理

##### Principles

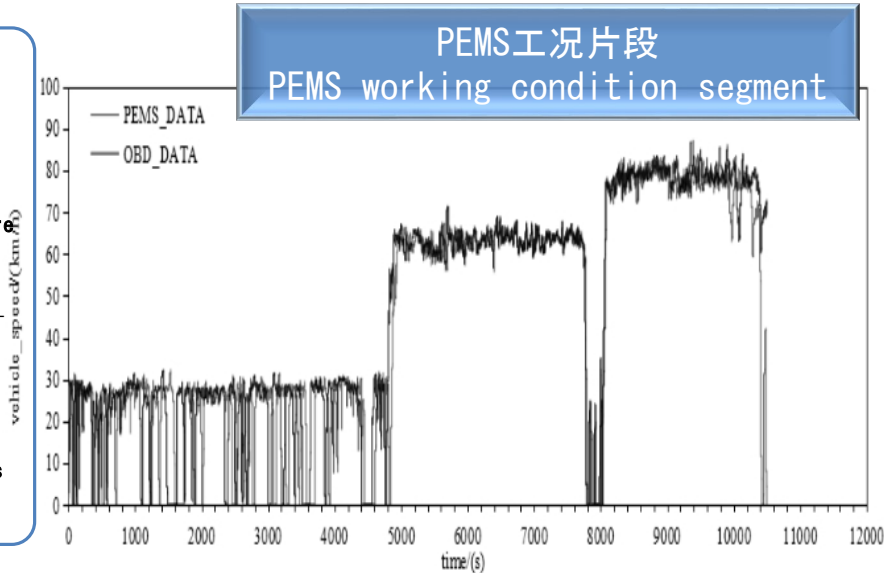
PEMS功基法通过让重型车行驶在“低速-中速-高速”三种不同工况占比的环境下，统计整车的窗口通过率，即每个循环功下对应比排放与限值比值小于1出现的频率。当窗口通过率大于90%时，且在测试片段中95%以上氮氧化物有效数据点小于标准浓度排放限值，车辆判定为通过整车排放测试。

The PEMS work-based method calculates the window pass rate of the entire vehicle by allowing heavy vehicles to travel under three different operating conditions: "low speed-medium speed-high speed"; i.e., the frequency at which the ratio of the corresponding emission to the limit value is less than 1 under each cycle power. When the window pass rate is greater than 90%, and more than 95% of the effective data points of nitrogen oxides in the test segment are less than the standard concentration emission limit, the vehicle is judged to have passed the vehicle emission test.

##### 难点

##### Difficulties

- ✓ 重型车运行工况复杂，难以保证与PEMS算法工况相似；  
Operating conditions of heavy vehicles are complex, and it is difficult to ensure that they are similar to PEMS algorithm operating conditions;
- ✓ 重型车运行工况不连贯，提取低-中-高工况片段的方法是难点。  
Operating conditions of heavy vehicles are inconsistent, and the method of extracting low-medium-high operating conditions is difficult.



##### 建立标准化工况

- ✓ 依据当日车辆运行数据，对工况片段重新组合，构建PEMS工况

##### Establishes standard chemical conditions

Based on the vehicle operating data of the date, recombines the working condition segments to construct PEMS working conditions

原始工况片段示例  
Example of original operating condition segment



组合后的标准化工况片段示例  
Examples of combined standard chemical condition segments





# 远程监控

## Remote monitoring

### PEMS功基法

#### PEMS work-based method

#### ➤ 算法验证

- 设计实车PEMS测试的试验方法验证算法可靠性，再由从平台中选取了同样车型（使用行业不同）采用功基窗口法与PEMS测试试验进行误差比对。

#### Algorithm verification

The test method of real vehicle PEMS tests is designed to verify the reliability of the algorithm, and then select the same model from the platform (using different industries) and use the power-based window method to compare the error with the PEMS test.

#### ➤ 结果分析

经对比试验验证，其余车辆平均误差均在**5%**左右，考虑到实际行驶的车辆实际载荷、运行道路路线跟试验车辆存在差异的因素，该误差在允许范围内。

#### Result analysis

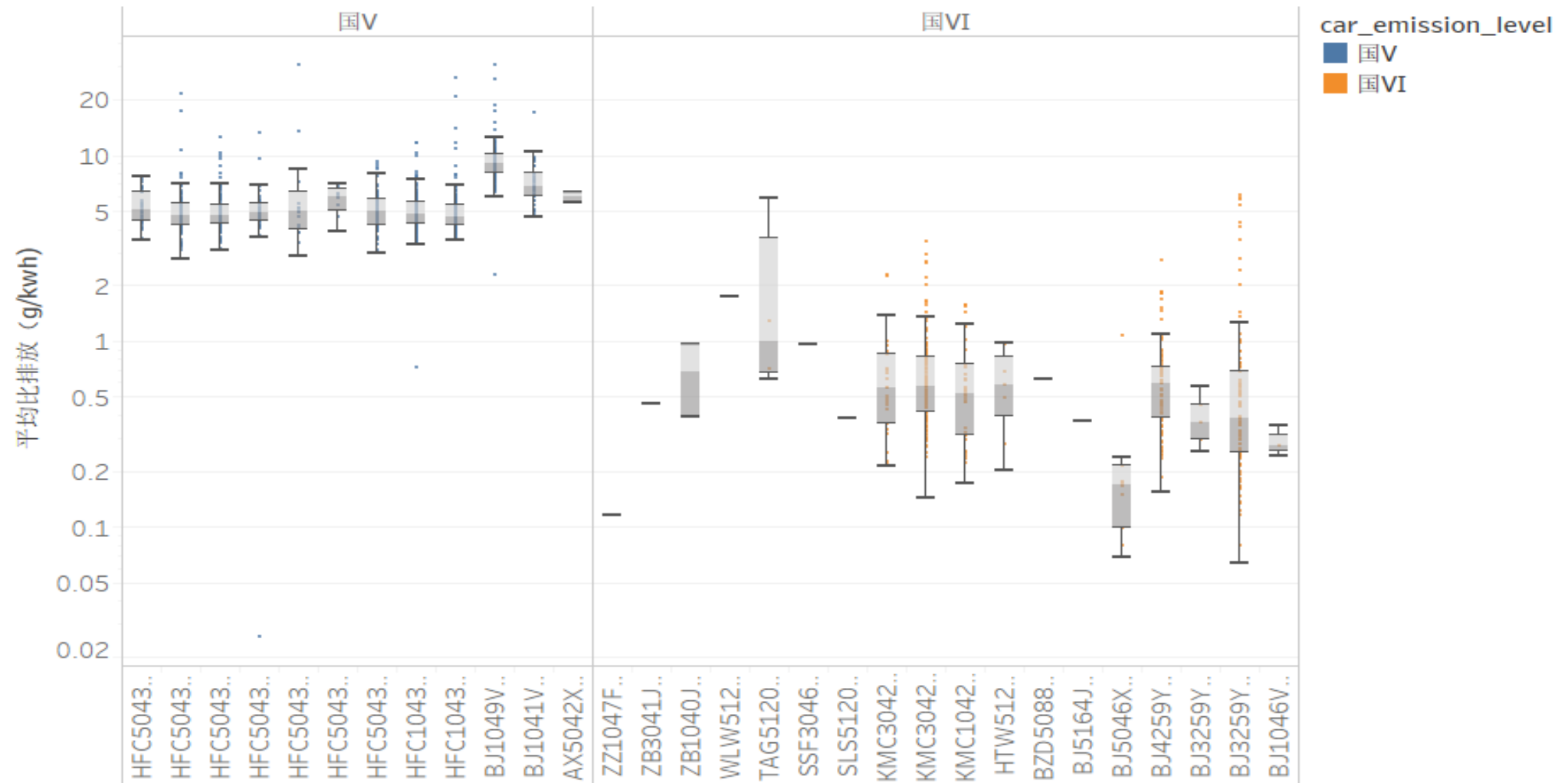
The comparison test verifies that the average error of the remaining vehicles is about **5%**. Considering the actual load of the actual vehicle and the difference between the operating road route and the test vehicle, the error is within an allowable range.

行业类型 Industry type	平均比排放-平台 (g/kwh) Average specific emission-platform (g/kwh)	平均比排放- PEMS试验 (g/kwh) Average specific emission-PEMS test (g/kwh)	统计车辆(辆) Vehicle statistics (vehicles)	绝对平均误差 (%) Absolute average error (%)
环卫 Sanitation	6.42	6.74	6	4.7%
渣土 Waste	4.82	5.19	6	7.1%
渣土 Waste	6.92	6.74	5	2.7%
货车 comm. transp.	0.33	0.34	34	2.9%
邮政 Post	0.32	0.34	22	5.9%
渣土 Waste	<b>0.37</b>	<b>0.34</b>	<b>125</b>	<b>8.8%</b>
环卫 Sanitation	0.33	0.34	3	2.9%

# 远程监控 (甄凯: 去掉车型号, 改为车型编号)

Remote monitoring (Eliminate car model and change to model number)

PEMS功基法筛选高排车型



# 高海拔排放

## High altitude requirements

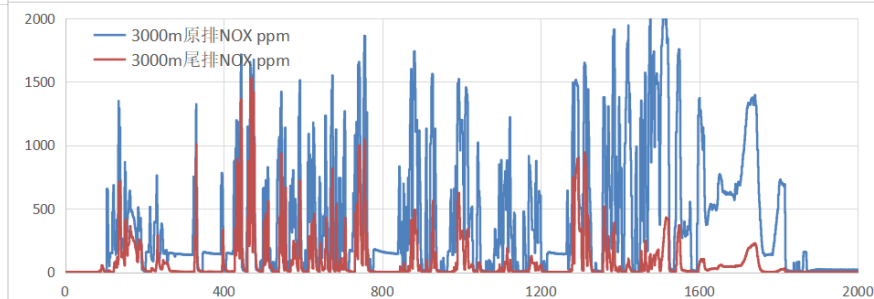
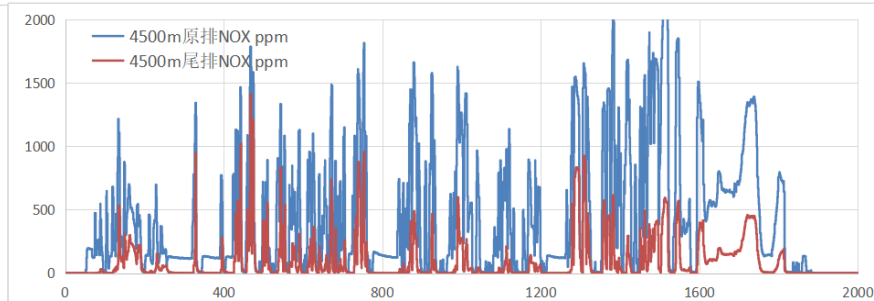
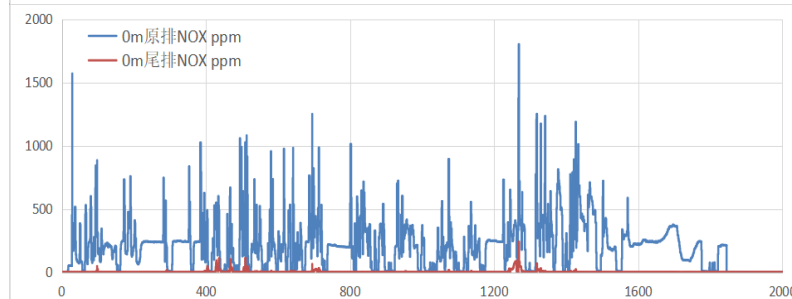
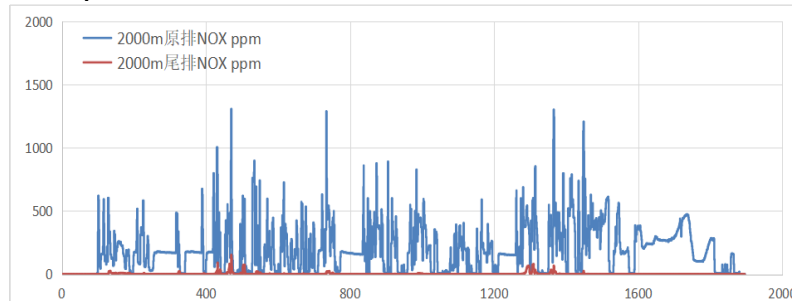
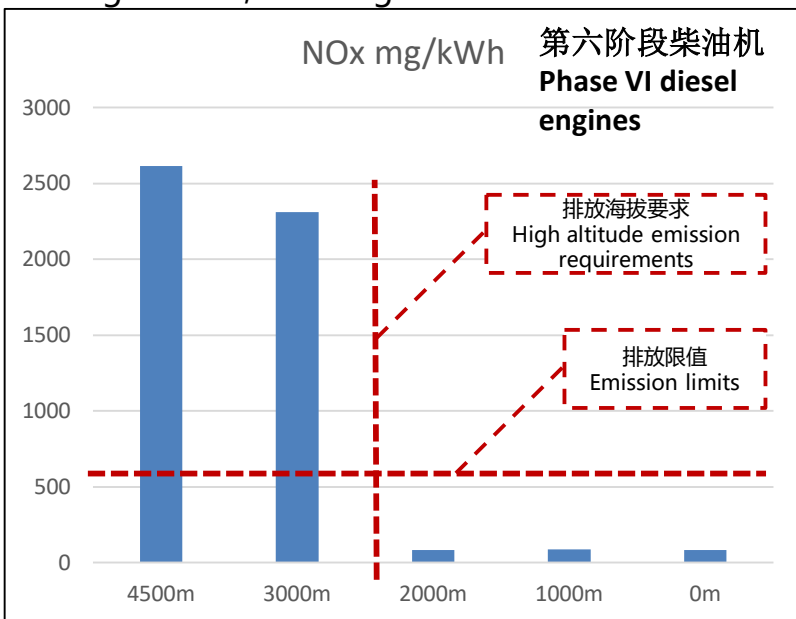
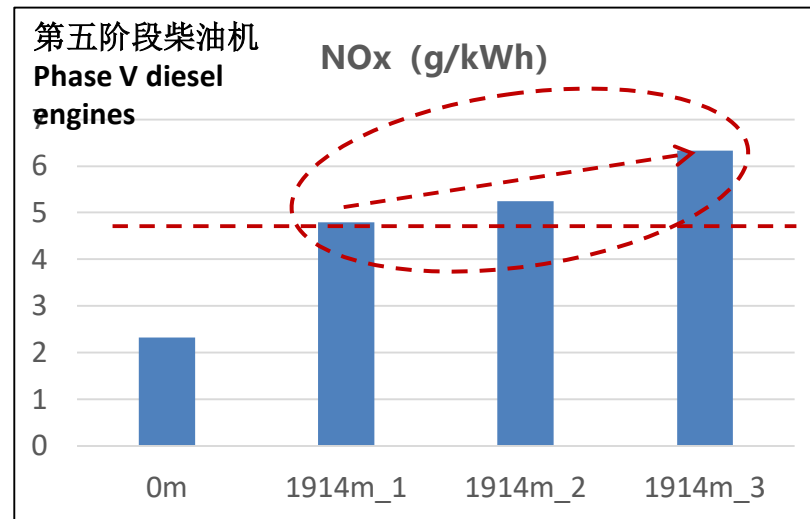
各气态污染物对海拔变化的敏感性不尽相同，其中：

The sensitivity of each gaseous pollutants to altitude changes is different, including:

✓ 第五阶段柴油机高海拔NOx排放显著升高（相比低海拔升高100%以上）；  
In Phase V, NOx emissions of diesel engines at high altitudes increased significantly (compared to low altitudes by more than 100%);

✓ 第六阶段柴油机NOx排放要求在排放海拔要求范围内都非常小，但超过排放法规要求海拔后急剧升高，达到平原排放的20多倍。

Phase VI diesel NOx emissions are very low within the emission altitude requirement range; however, they increase sharply after exceeding the altitude required by emission regulations, reaching more than 20x the emissions at plain level.



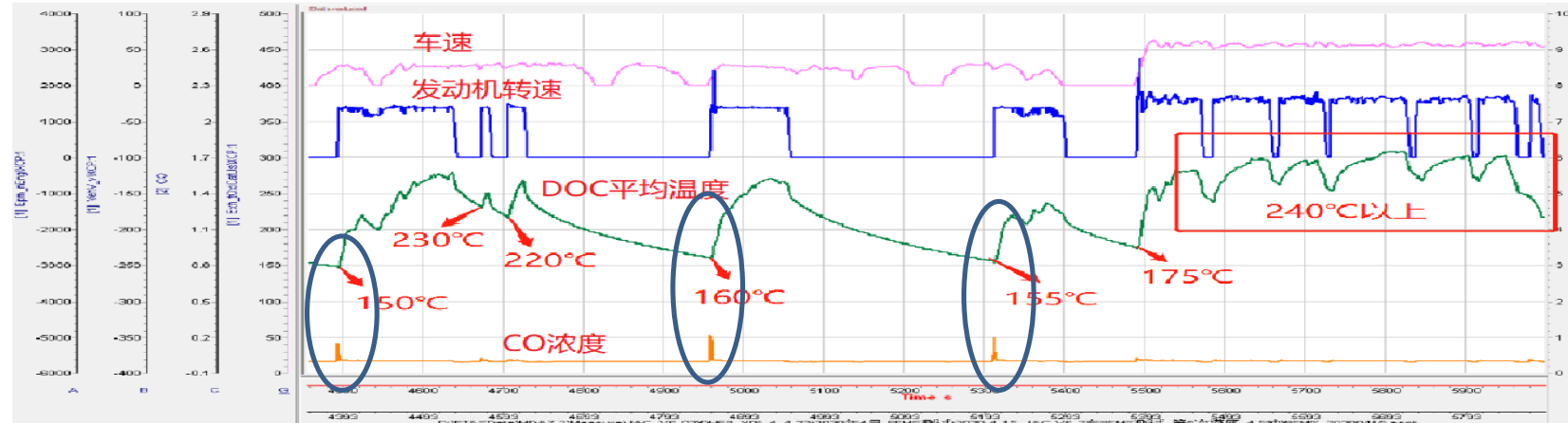
# 重型混合动力车测试

## Heavy Hybrid Vehicles Testing

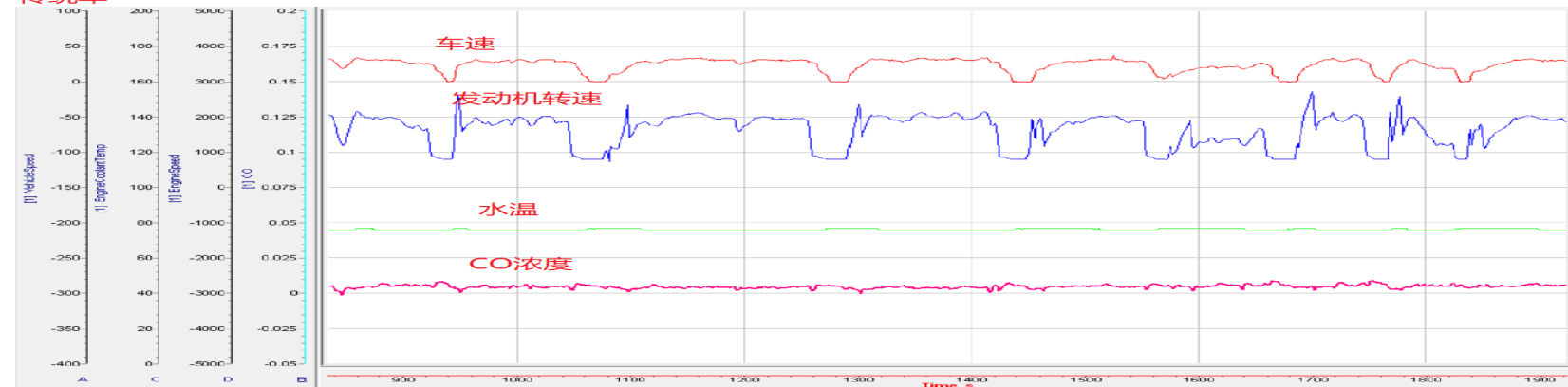
CO排放特征：发动机反复停机，对DOC温度影响较大，停机后启动，CO排放突然增加，CO浓度曲线出现“尖峰”（后处理温度降低导致），此特征主要集中在城市工况。

CO emission characteristics: repeated engine shutdowns have a greater impact on DOC temperature. After shutdown, CO emissions suddenly increase, and the CO concentration curve appears "spike" (caused by lower post-treatment temperature). This feature is concentrated

混动车



传统车

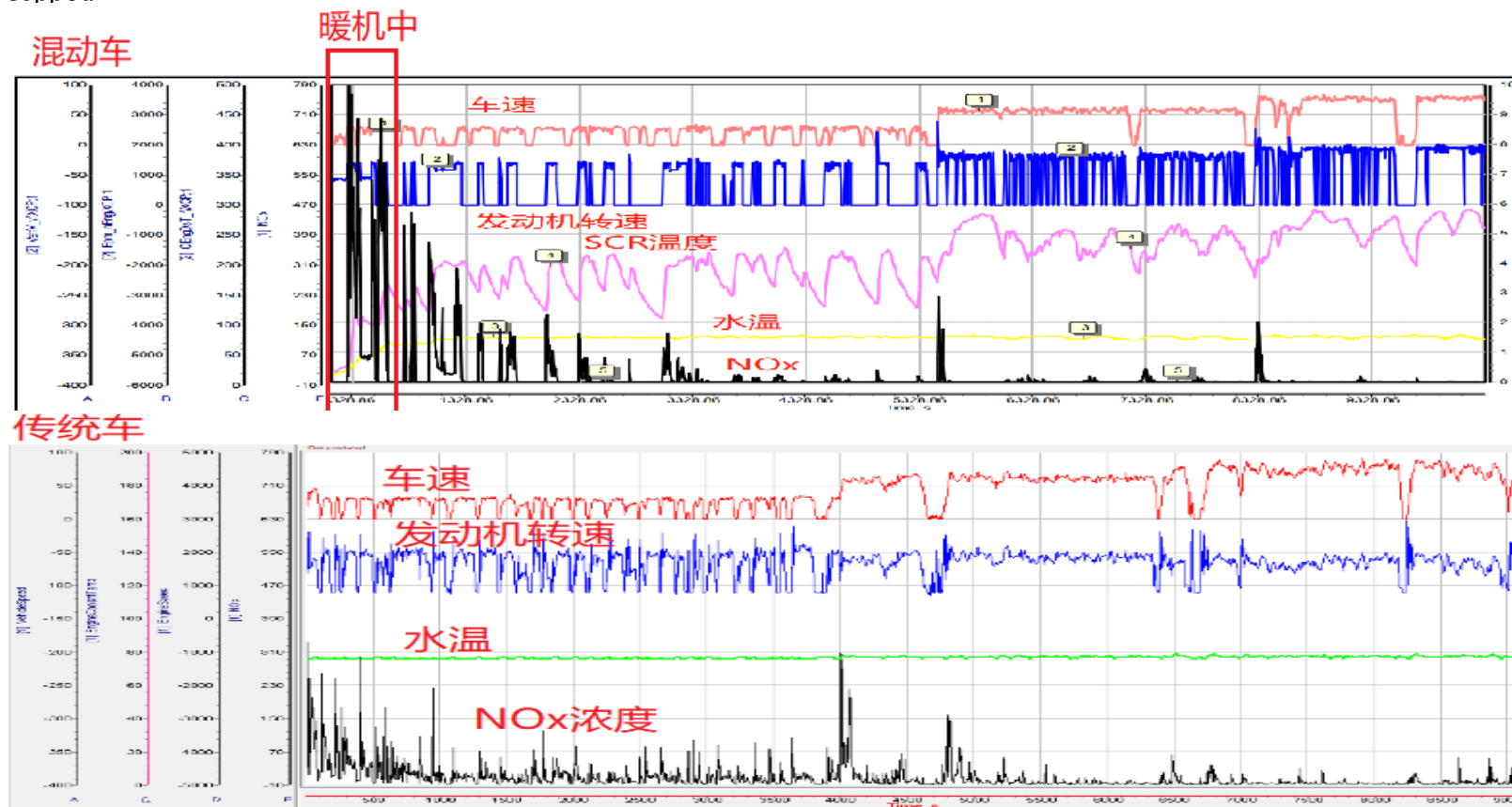


# 重型混合动力车测试

## Heavy Hybrid Vehicles Testing

NOx排放特征：SCR温度变化波动大，暖机过程NOx排放较高，暖机后，发动机停机再启动，NOx排放下降较明显。

NOxEmission characteristics: SCR temperature fluctuates greatly; NOx emissions are relatively high during warm-up process. After warm-up, the engine is stopped



# 3

总结

Conclusion

# 总结

## Conclusion

- 第六阶段标准实施效果显著，控制技术全面升级，减排收益大幅增长

The sixth phase of implementation of the standards has achieved significant results, the control technology has been fully upgraded, and the emission reduction benefits have increased significantly

- 大部分车型PEMS排放远低于排放限值（690mg/kWh, 500ppm）

PEMS emissions of most models are far below the emission limit (690mg/kWh, 500ppm)

- 有效窗口功率阈值下探，窗口比功率排放迅速升高

The effective window power threshold has been lowered, and emissions' window specific power has risen rapidly

- 冷启动过程持续时间短，但总NOx排放占比最高可达到80%以上

The cold start process lasts for a short time, but the total NOx emissions can account for up to 80% or more

- 利用远程监控数据构建PEMS工况模型的NOx排放结果与实际运行差异可控制在10%以内，可用于筛查高排放车型

Using remote monitoring data to build a PEMS operating condition model, the difference between the NOx emission results and actual operation can be controlled within 10%, which can be used to screen high-emission vehicles

- 高海拔排放要求的提出，显著降低了2400m以下海拔条件下的重型车排放

High-altitude emission requirements have significantly reduced the emissions of heavy vehicles at altitudes below 2400m

- 混动车反复启停工况对后处理温度影响显著

The repeated start and stop conditions of the hybrid vehicle have a significant impact on the post-processing temperature

**Thank you !**