



机动车排污监控中心

Vehicle Emission Control Center

2021

中国非道路移动机械排放法规： 聚焦整机实际使用减排

China's Non-Road Mobile Machinery Emission Regulations: Focus on their actual use to reduce emissions

机动车排污监控中心 | Vehicle Emission Control Center

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非道路移动机械排放控制现状

Current Control of Non-road Mobile Machinery

非道路移动机械成为大气污染控制重点 Non-road mobile machinery has become a key point of air pollution control

非道路移动机械大气污染物排放分担率高

Non-road mobile machinery makes up a large percentage of air pollutant emissions

- 2019年，非道路移动机械 NOx排放量超过 333.5万吨，占全国NOx 排放总量18.5%，占移动源NOx排放总量29.5%

In 2019, the NOx emissions of non-road mobile machinery exceeded 3.335 million tons, accounting for 18.5% of the country's total NOx emissions and for 29.5% of total NOx emissions from mobile sources.

- 颗粒物排放量超过17.4万吨，约为机动车颗粒物排放量的2.4倍，约占移动源颗粒物排放总量的55.4%

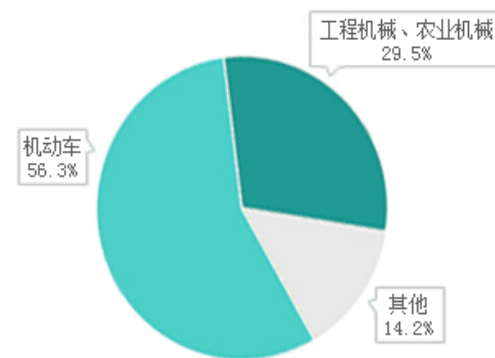
Particulate matter emissions exceeded 174,000 tons, which was approximately 2.4 times that of motor vehicle particulate matter emissions, accounting for about 55.4% of the total particulate matter emissions from mobile sources

2020年底，生态环境部发布国四标准修改单及其技术要求标准

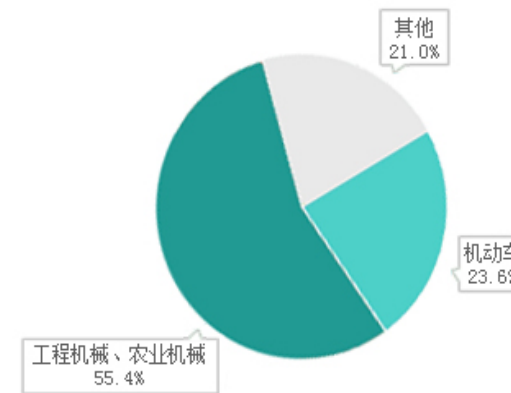
At the end of 2020, the Ministry of Ecology and Environment issued amendments to the China IV Standards and their technical requirement standards

- 2022年12月全面实施国四标准

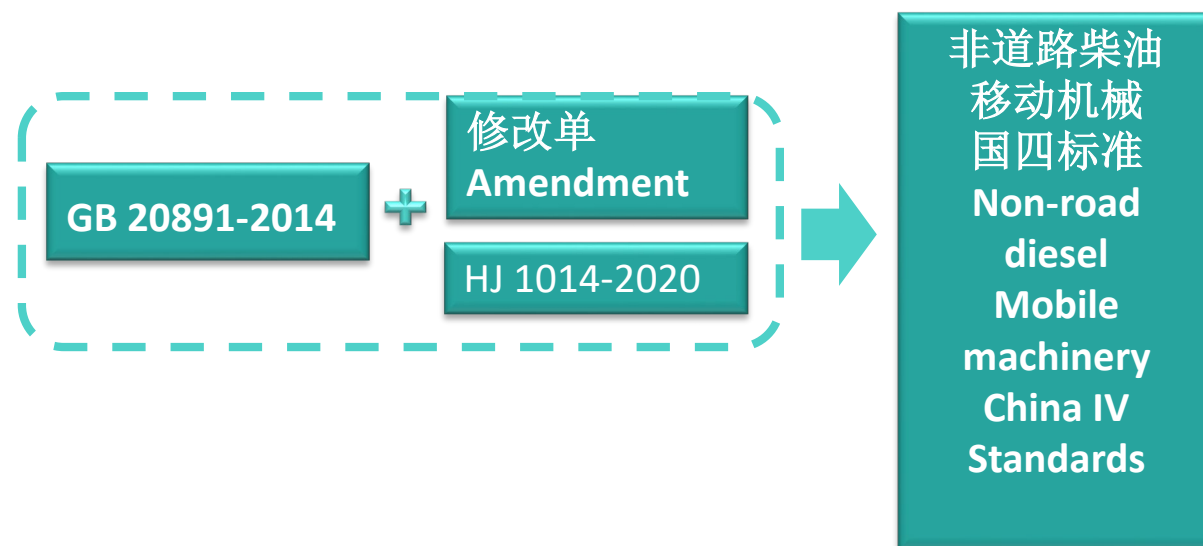
Full implementation of the China IV Standards will be in December 2022



移动源NOx排放分担率



移动源颗粒物排放分担率



第N

2

部分 | Section

非道路移动机械国四标准要点

Key Points of National 4 Standards for
Non-road Mobile Machinery

1、提出整机排放控制要求 (PEMS)

Proposed requirements for entire machine emission control (PEMS)

适用于37kW以上非道路移动机械，NO_x和CO排放限值为台架限值2.5倍

Applicable to non-road mobile machinery of 37kW and above, NO_x and CO emission limits are 2.5x bench limits

国三标准之前无整机排放测试要求，整机实际排放偏高

Before the China III Standards there were no requirements for entire machine emission testing; actual emissions of the entire machine are relatively high

12台市售国三发动机，采用标准工况测试，排放均满足限值要求

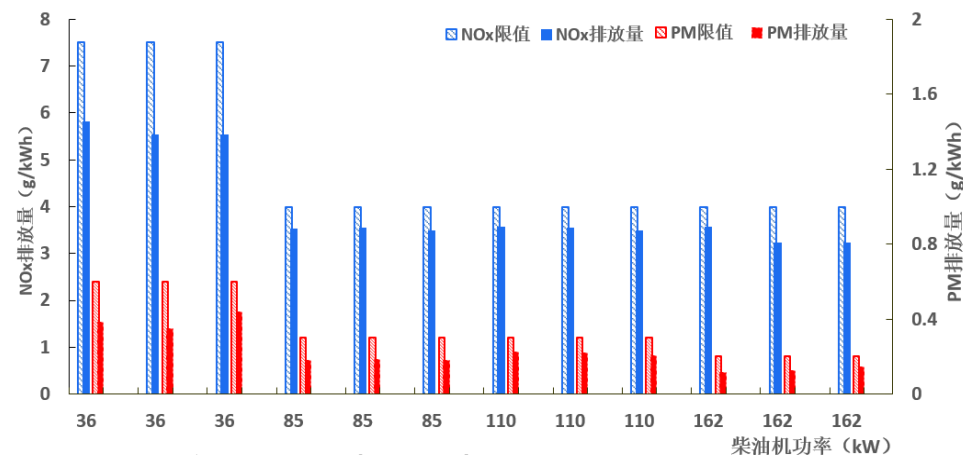
Twelve commercially available China III engines were tested under standard operating conditions, and all emissions met the required limit

9台国三非道路移动机械，采用PEMS方法测试，排放值为发动机限值1.5-2.25倍

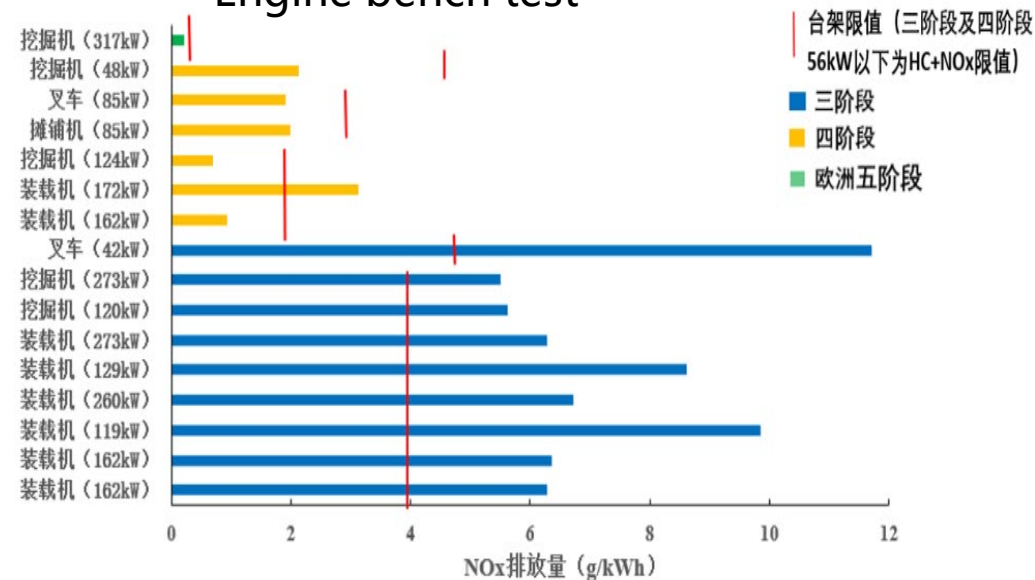
Nine China III non-road mobile machines were tested with the PEMS method, and the emission amount was 1.5–2.25x the engine limit values

国四提出整机排放控制要求，整机实际排放明显改善

China IV proposed requirements for emission control of the entire machine, and actual emissions of the whole machine have been significantly improved



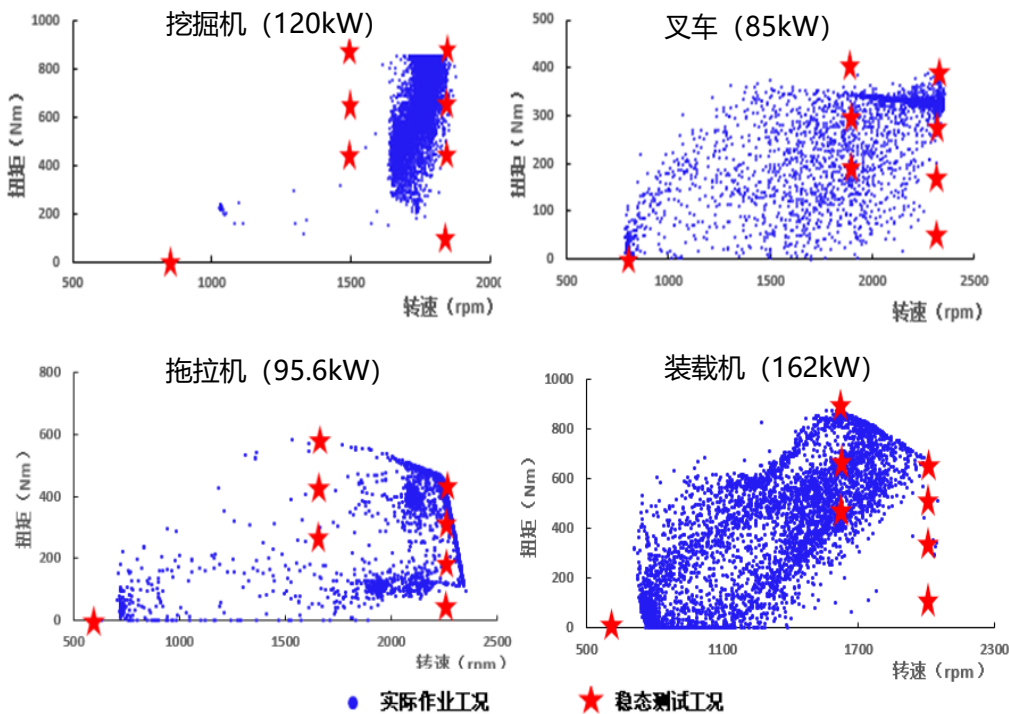
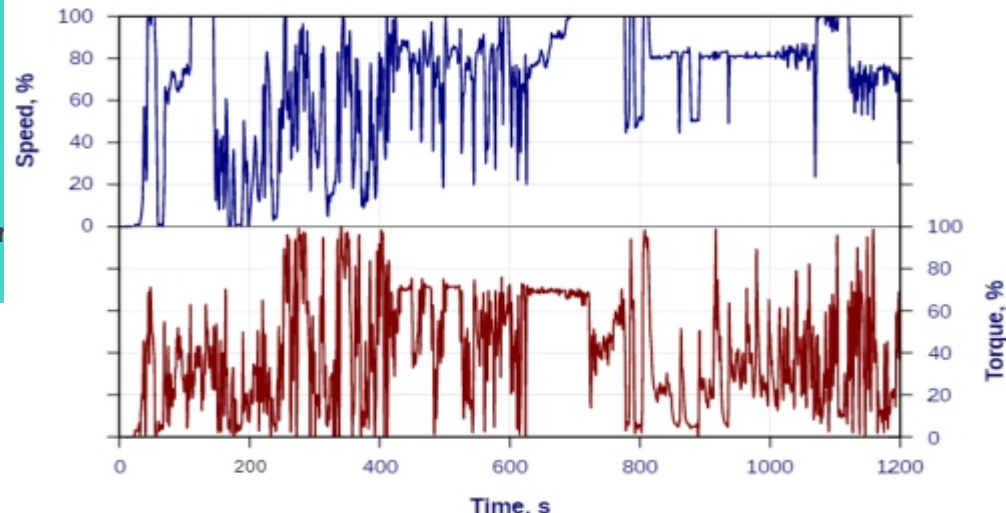
发动机台架测试
Engine bench test



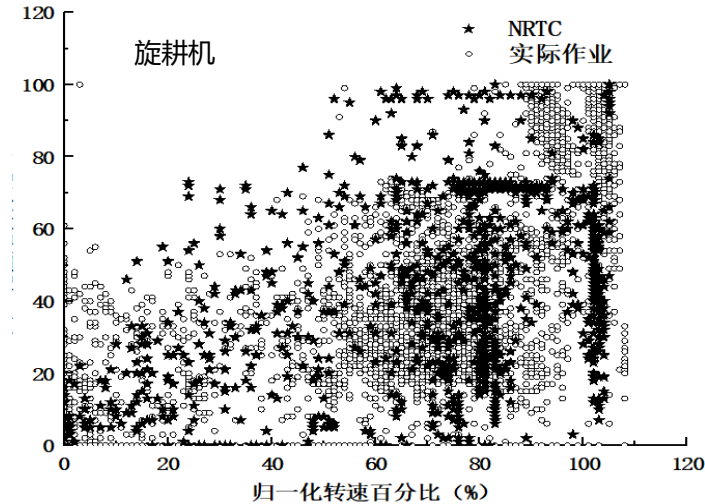
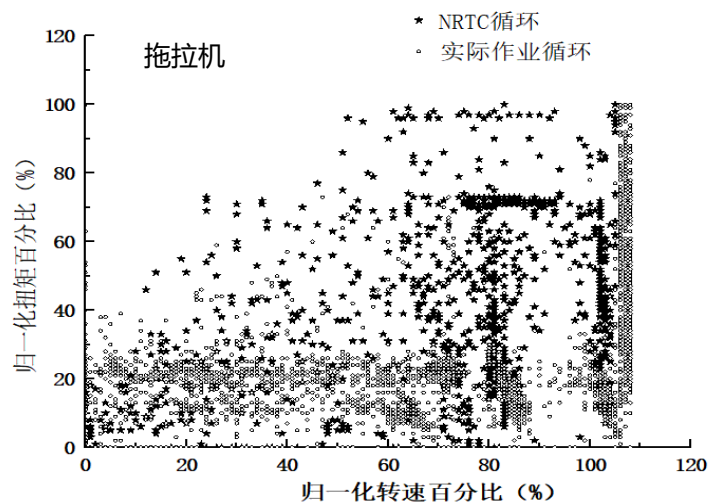
整机PEMS测试 | Whole machine PEMS test

2、增加瞬态测试循环 (NRTC) Increase transient test cycle (NRTC)

- 适用于560kW以下非恒定转速柴油机 (不包括19kW以下单缸柴油机)
Suitable for non-constant speed diesel engines below 560kW (not including single-cylinder diesel engines below 19kW)
- 国三标准之前采用稳态工况 (NRSC), 与部分机械实际工况差别较大
Before the China III Standard, the steady state operating condition (NRSC) was used, which is quite different from the actual operating conditions of some machinery
- 国四标准, 稳态工况+瞬态工况, 可以更好的表征实际使用工况
The China IV Standard can better characterize actual working conditions for steady state conditions + transient working



NRTC试验循环
NRTC Test cycle



部分机械作业工况与NRSC对比
Comparison of partial mechanical working conditions with NRSC

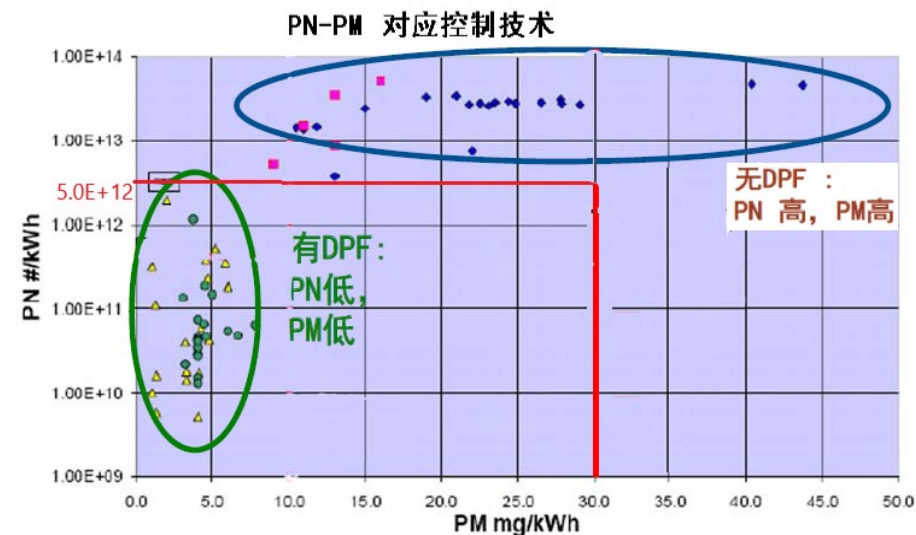
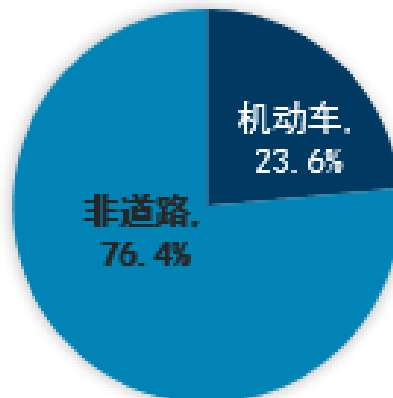
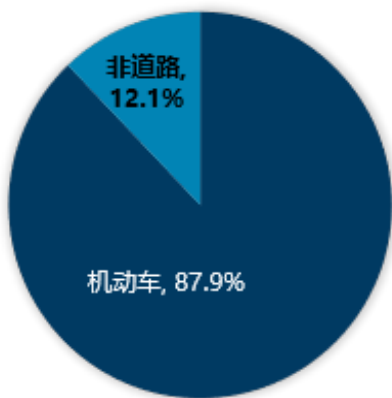
部分机械作业工况与NRTC对比
Comparison of partial mechanical working conditions with NRTC

3、增加颗粒物粒子数量 (PN) 限值 Increase in particle number (PN) limit

- 粒子数量限值 5×10^{12} 个/kWh, 适用于 $130 \leq P_{max} \leq 560$ 的柴油机, 且机械DPF再生时不能有目视明显可见烟
The particle number limit is 5×10^{12} /kWh, which is suitable for diesel engines with $130 \leq P_{max} \leq 560$; there should be no visible smoke when the machine DPF is regenerated



- 非道路机械在移动源中颗粒物排放占比达55.4%, 非道路移动源占比为76.4%
Non-road machinery accounted for 55.4% of particulate matter emissions from mobile sources, and non-road mobile sources accounted for 76.4%
- 在用非道路移动机械冒黑烟情况较常见
Black smoke is more common when using non-road mobile machinery
- PN限值的提出, 将促进DPF及更高效排放控制技术的采用
The proposed PN limit will promote the adoption of DPF and more efficient emission control technologies



不同技术路线PN排放结果
PN emission results from different technical routes

保有量占比 | Ownership percentage

PM排放量占比 | Percentage of PM emissions

4、提出远程排放监控及定位要求

Proposed requirements for remote emission monitoring and positioning

- 基于排放控制监测系统（NCD/PCD）提出远程排放监控要求，适用于37 kW及以上的工程机械

Proposed remote emission monitoring requirements suitable for construction machinery of 37 kW and above based on the emission control monitoring system (NCD/PCD)

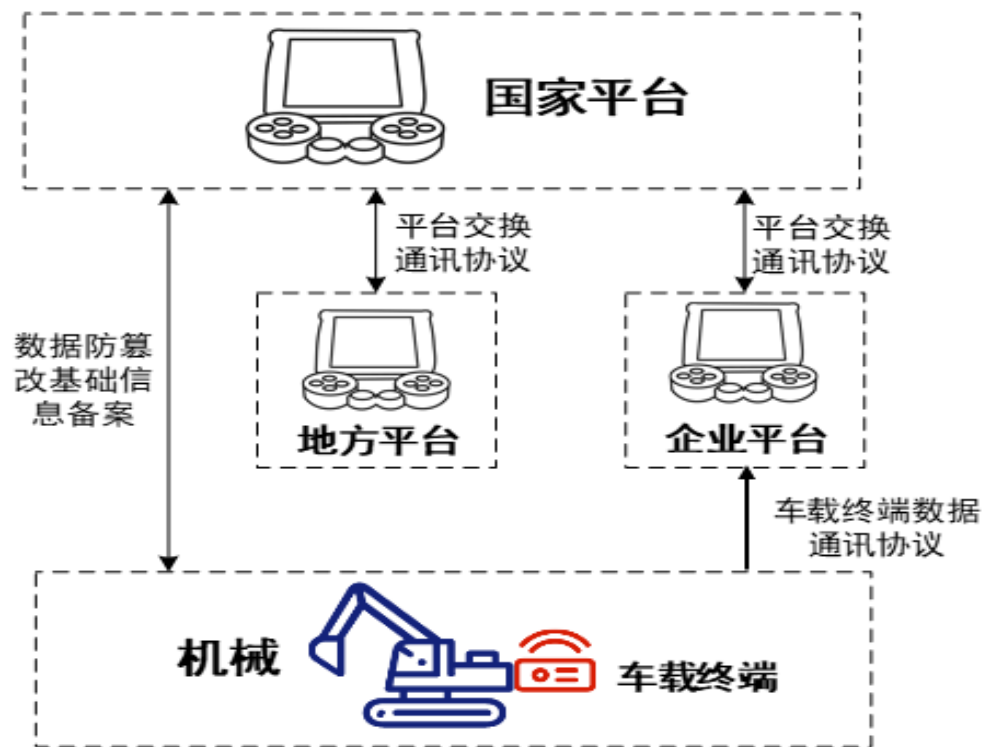
- 定位要求适用于37 kW及以上的非道路移动机械

Positioning requirements applicable to non-road mobile machinery of 37 kW and above

- 发动机运行数据上传周期：至少10 min；诊断数据采集：24 h内至少上传一次

Engine operating data upload cycle: at least 10 min; diagnostic data collection: upload at least once within 24 hours

| 发动机运行数据项（如适用） Engine operating data items (if applicable) | |
|---|--|
| 车速 Speed | 进气量 Air intake |
| 大气压力（直接测量或估计值） Atmospheric pressure (directly measured or estimated) | SCR入口温度 SCR inlet temperature |
| 发动机净输出扭矩 Engine net output torque | SCR出口温度 SCR outlet temperature |
| 摩擦扭矩 Friction torque | DPF压差 DPF pressure difference |
| 发动机转速 Engine speed | 发动机冷却液温度 Engine coolant temperature |
| 发动机燃料流量 Engine fuel flow amount | 油箱液位 Fuel tank level |
| SCR上游NO _x 传感器输出值 SCR upstream NO _x sensor output value | 实际EGR阀开度 Actual EGR valve opening |
| SCR下游NO _x 传感器输出值 SCR downstream NO _x sensor output value | 设定的EGR阀开度 Set EGR valve opening |
| 反应剂余量 | |



5、提出排放质保期要求

Proposed requirements for emission warranty period

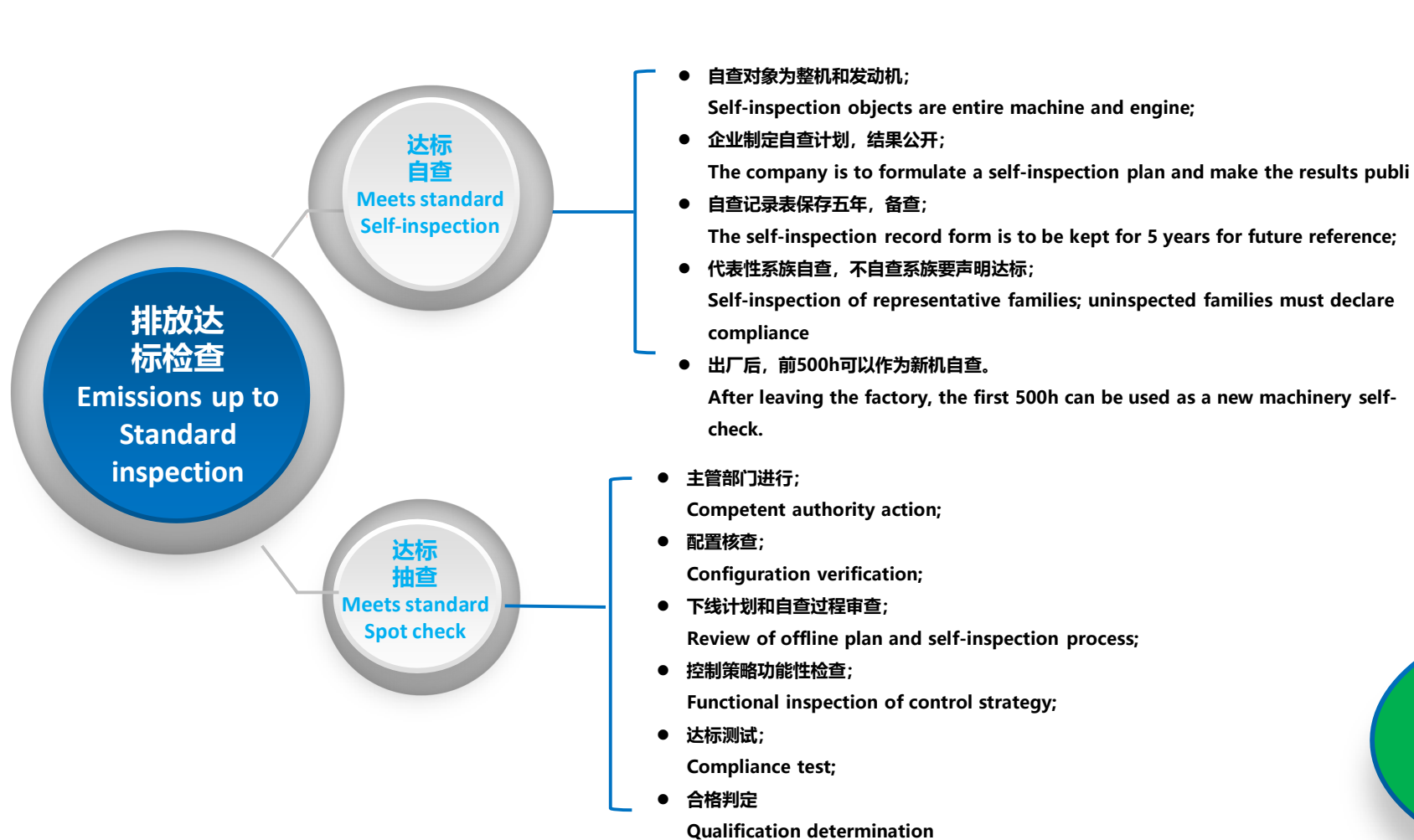
- 与机械排放控制相关的零部件在质保期内由于其自身质量问题出现损坏，导致机械排放控制系统失效或排放超过标准要求，生产企业应当对损坏的零部件进行免费更换或维修
If parts related to mechanical emission control are damaged because of their own quality problems during the warranty period, this can cause the mechanical emission control system to fail or the emission to exceed standard requirement and so manufacturers should replace or repair damaged
- 信息公开时，应公开排放相关零部件名单及其相应的质保期，并将以上信息在产品说明书中进行说明
At information disclosure, the list of emission-related parts and their corresponding warranty period should be disclosed; in addition, this information should be explained in the product manual.

| 柴油机功率段 (kW) Diesel engine power section (kW) | 转速 Rotation speed | 质保期 ¹ Warranty period | |
|---|------------------------------------|-------------------------------------|--------------------------------|
| | | 时间 (小时) Period (h) | 年限 (年) Service life (years) |
| $P_{\max} \geq 37$ | 任何转速 Any speed | 3000 | 5 |
| $19 \leq P_{\max} < 37$ | 非恒速 Non-constant speed | | |
| | 恒速 < 3000 Constant speed < 3000 | | |
| $P_{\max} < 19$ | 恒速 ≥ 3000 Constant speed ≥ 3000 | 1500 | 2 |
| | 任何转速 Any speed | 1500 | 2 |

¹ 质保期从销售之日起计算。
Warranty period is calculated from date of sale.

6、提出新生产排放达标检查的要求

Proposed requirements for new production emission compliance inspection



一致性检查是排放达标检查的一种
A consistency check is a type of emission compliance check

难点
Difficulties

无诊断接口或无法访问, 判定不合格。
If there is no diagnostic interface or access, the judgment will be "unqualified".

7、提出在用符合性的要求

Proposed requirements for in-use compliance



- 按系族开展自查;
Conduct self-examination by family;
- 销售一年半内开展自查计划、自查结果应公开 (各自);
The self-inspection plan is to be carried out within 1.5 years of sales and the results are to be made public (each self basis)
- 500h以上;
≥500h
- 代表性系族自查, 不自查系族声明达标;
Self-inspection of representative families; for uninspected families compliance is to be declared.
- 柴油机企业也应进行自查, 尽可能选择不同的整机企业。
Diesel engine companies should also conduct self-inspection and choose different complete engine companies to the extent possible.

- 主管部门进行;
Competent authority action;
- 车载终端的功能性检查;
Functional inspection of vehicle terminal;
- 诊断系统功能性检查;
Functional inspection of diagnostic system;
- 达标测试;
Compliance test;
- 合格判定;
Qualification determination;
- 整改措施。
Corrective measures.

| 样本数, n No. of samples, n | 超标机械数量 No. of machines exceeding standard | |
|-----------------------------|--|--|
| | 合格判定数 (≤) No. judged qualified (≤) | 不合格判定数 (≥) No. judged unqualified (≥) |
| 3 | - | 3 |
| 4 | 0 | 4 |
| 5 | 0 | 4 |
| 6 | 1 | 4 |
| 7 | 1 | 4 |
| 8 | 2 | 4 |
| 9 | 2 | 4 |
| 10 | 3 | 4 |

与欧美相关标准对比

Compared with relevant European & US standards

| 实施年限 Implementation period | 2011 | 2014 | 2019 | 2008-2012 | 2012-2013 | 2014 | 2021 |
|-------------------------------|-----------|-----------|------------|---------------|--------------|----------------|---------------|
| 功率段 Power section | IIIB | IV | V | 美4I US 4I | 美4I US 4I | 美4F US 4F | 国四 US IV |
| P<8 | | | 7.5/0.4 | 7.5/0.4 | | | 7.5/0.6 |
| 8≤P<19 | | | | 7.5/0.4 | | | |
| 19≤P<37 | | | 4.7/0.015 | 7.5/0.3 | | | 4.7/0.025 |
| 37≤P<56 | 4.7/0.025 | | | 4.7/0.3 | 4.7/0.03 | | |
| 56≤P<75 | 3.3/0.025 | 0.4/0.025 | 0.4/0.015 | | 4.7/0.02 | 4.7/0.03 | 2.0/0.025 |
| 75≤P<130 | | | | | | | |
| 130≤P<224 | 2.0/0.025 | | | | 4.0/0.02 | 0.4/0.02 | |
| 224≤P<450 | | | | | | | |
| 450≤P<560 | | | | | | | |
| 560≤P<900 | | | 0.67/0.035 | 3.5(0.67)/0.1 | | 3.5(0.67)/0.04 | 3.5(0.67)/0.1 |
| P>900 | | | | 3.5/0.1 | | | |

| 技术要求 Technical requirements | | 中国 China | 欧盟 EU | 美国 US |
|---|--------------------------------------|----------------------|----------|----------|
| | | 第四阶段 Fourth Stage | V | Tier4-F |
| 控制范围 Control range | 柴油机 Diesel engines | √ | √ | √ |
| | 气体发动机 Gas engine | × | √ | √ |
| | 双燃料发动机 Dual fuel engine | × | √ | √ |
| | 非道路移动机械 Non-road mobile machinery | √ | × | × |
| 测试循环 Testing cycle | 稳态测试 Steady state test | √ | √ | √ |
| | 瞬态测试 Transient state test | √ | √ | √ |
| | 非标准循环 Non-standard cycle | √ | √ | NTE |
| 排放控制策略 Emission control strategy | | √ | √ | √ |
| 曲轴箱污染物要求 Crankcase contamination requirements | | × | √ | √ |
| CO ₂ 排放量要求 CO ₂ emissions requirements | | √ | √ | × |
| 烟度要求 Smoke requirements | | √ | × | √ |
| PEMS要求 PEMS requirements | | √ | √ | × |
| 远程监控 Remote monitoring | | √ | × | × |
| 精准定位 Precise positioning | | √ | × | × |
| 高海拔要求 High altitude requirements | | √ | | √ |

第 No. **3** 部分 | Section

未来标准展望

Outlook for future standards

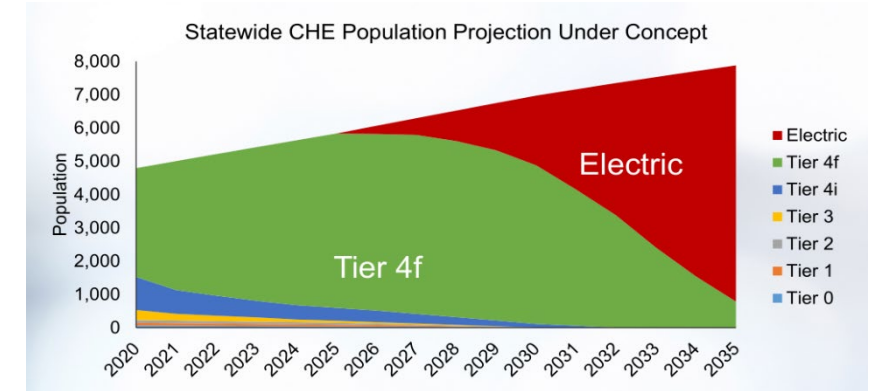
1、推进污染物超低排放技术

Promotion of ultra-low pollutant emission technology

重点关注NOx和PM减排，研究推进先进排放控制技术：

Focus on NOx and PM emission reduction, research and promote advanced emission control technologies:

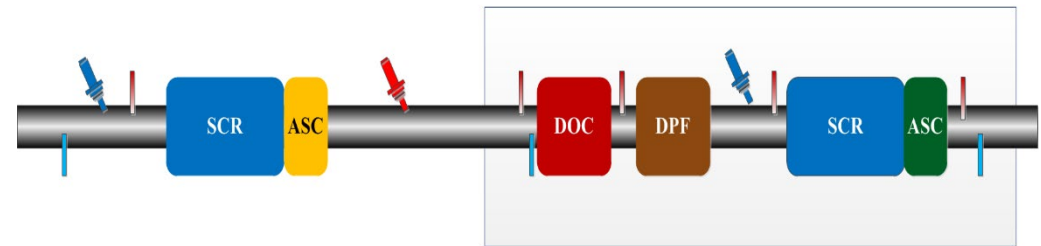
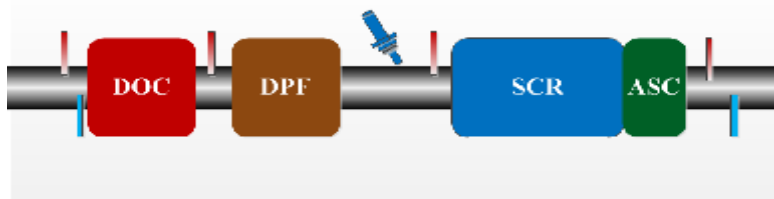
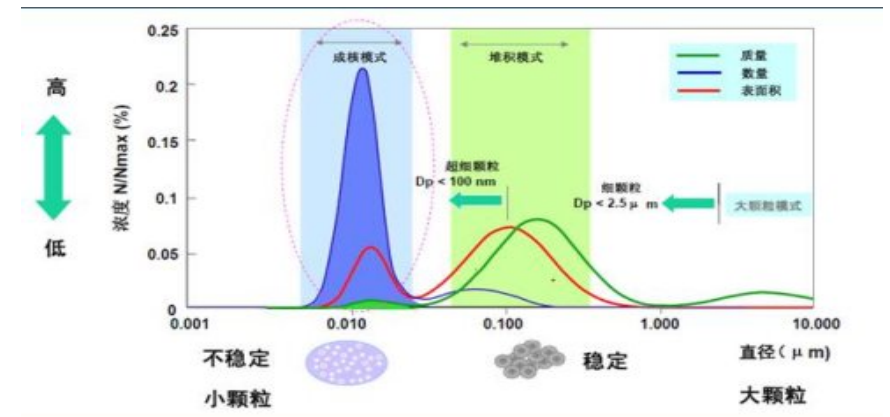
- 推进零排放和近零排放技术的应用
Promote the application of zero emission and near zero emission technologies
- 新能源与传统内燃机根据应用场景合理配置
New energy and traditional internal combustion engines are to be reasonably configured according to application scenarios
- 23nm→10nm颗粒物检测技术及限值达标
23nm→10nm Particle detection technology and limit compliance
- 注重实际使用中的污染物减排
Pay attention to the emission reduction of pollutants in actual use
 - OBD在线监控排放控制系统
OBD online monitoring emission control systems
 - PEMS实际工作状态排放测试
PEMS actual working state emission testing
 - 远程监控等
Remote monitoring, etc.



美国加州已率先提出零排放路线图：

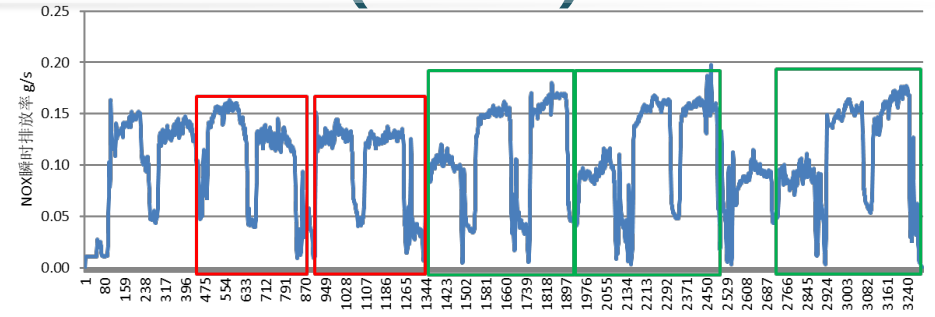
California has taken the lead in proposing a zero-emission roadmap:

- 2026年开始，货物装卸设备将逐步实现全部电动化
Beginning in 2026, cargo handling equipment will gradually be fully electrified
- 2026年开始，小型机械设备实施零排放标准，2028年全部销售产品为零排放
Beginning in 2026, zero emission standards will be implemented for small machinery and equipment. and all products sold in 2028 will be zero emission



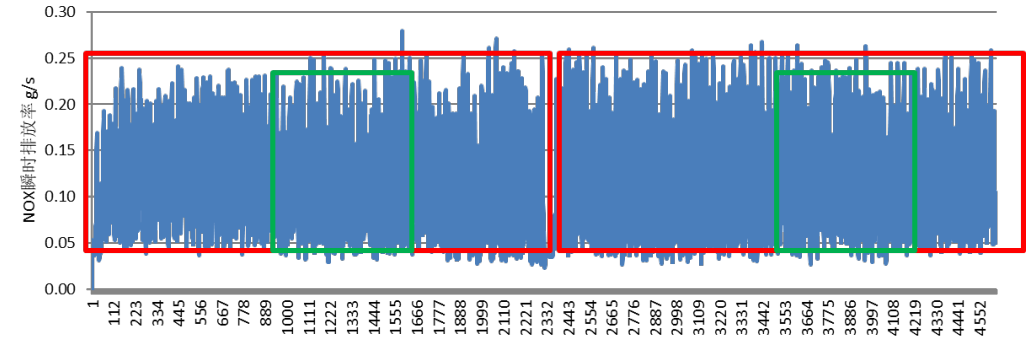
2、优化整机排放测试要求 (PEMS) Optimize emission test requirements (PEMS)

- 5-7倍NRTC循环功测量时长的必要性
Requirement for 5-7x the NRTC cycle power measurement time
 - 缩短时间, 提高效率可行性分析
Shorten time and improve efficiency feasibility analysis
 - 恒定转速柴油机无NRTC循环功概念
Constant speed diesel engine without NRTC cycle power concept



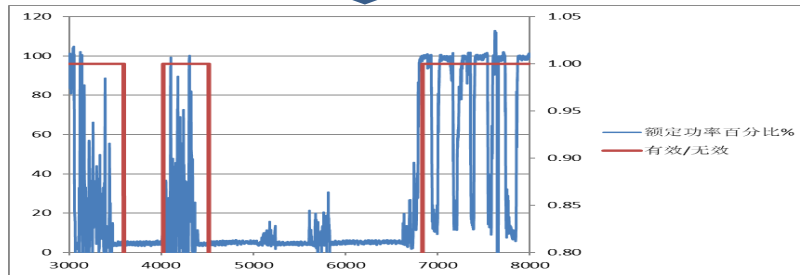
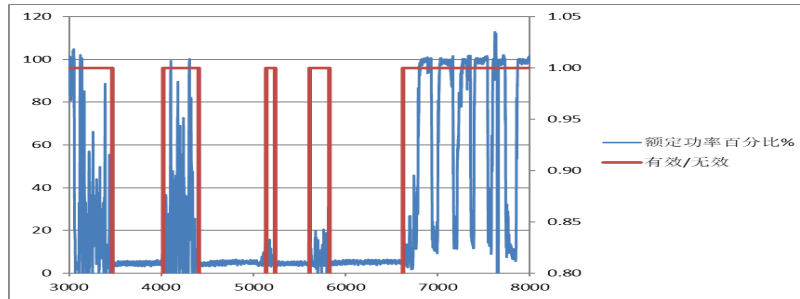
| 工况起始点 | 工况结束点 | 时间 s | 功率 kWh | NOx g/kWh |
|---------|---------|---------|--------|-----------|
| 454.00 | 869.00 | 415.00 | 8.66 | 5.505 |
| 870.00 | 1311.00 | 441.00 | 7.90 | 5.631 |
| 1312.00 | 1912.00 | 600.00 | 11.71 | 5.617 |
| 1913.00 | 2495.00 | 582.00 | 11.44 | 5.757 |
| 2708.00 | 3280.00 | 572.00 | 11.16 | 5.821 |
| 1.00 | 3286.00 | 3285.00 | 62.33 | 5.624 |

- 增加冷启动过程污染物排放的必要性分析
Analysis of the need for increasing pollutant emission during cold start
 - 一个作业循环, 冷启动时间占比的调研
Studies on the proportion of cold start time in a work cycle
 - 冷启动排放情况测试
Cold start emission test
 - 冷启动减排解决方案
Cold start emission reduction plan



| 工况起始点 | 工况结束点 | 事件 s | 功率 kWh | NOx g/kWh |
|---------|---------|---------|--------|-----------|
| 1.00 | 2321.00 | 2320.00 | 43.33 | 6.044 |
| 2364.00 | 4637.00 | 2273.00 | 41.24 | 6.374 |
| 960.00 | 1560.00 | 600.00 | 10.87 | 6.062 |
| 3500.00 | 4100.00 | 600.00 | 10.91 | 6.401 |
| 1.00 | 4637.00 | 4636.00 | 85.51 | 6.216 |

- 优化数据剔除原则
Optimize data rejection principles



3、完善远程排放控制要求 Improve remote emission control requirements

- 基于国四标准实施，进一步分析远程监控数据采集及应用存在的问题及技术解决方案

Based on the implementation of China IV Standards, further analyze the problems and technical solutions in remote monitoring data collection and application
- 利用在用机械排放检验数据联网、机械远程排放监控，以及现场监督抽测，构建一体化的非道路移动机械排放监管系统

Use of in-use machinery emission inspection data networking, machinery remote emission monitoring, and on-site supervision and sampling to build an integrated non-road mobile machinery emission monitoring system
- 通过大数据的分析，溯源机械生产企业、发动机制造企业、后处理装置制造企业

Through the analysis of big data, traceable machinery manufacturers, engine manufacturers, and post-processing device manufacturers
- 溯源机械注册地、所属单位，实现联合惩戒，建立严惩重罚制度。

Tracing of registration place and affiliated units of machinery to realize joint punishment and establish a severe punishment system.

车载终端数据采集技术
On-board terminal data collection technology

互联网数据传输技术
Internet data transmission technology

数据安全传输和加密技术
Technology for secure transmission & encryption of data

数字签名和防篡改技术
Digital signature and anti-tampering technology



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