the 9th VERT forum

Demonstration Project of Diesel Particulate Filter Retrofit in Shenzhen

WANG Yanjun

Vehicle Emission Control Center
Ministry of Environmental Protection

March,15,2018

Outline

- **Background**
- **Preparatory Work**
- **Project Progress**
- **Policy Proposal**

Background(1)

- Shenzhen aims to reach the second phase of WHO in 2020. To achieve this goal, PM2.5 needs to drop 1 ug/m³ per year from the current 29.8 ug/m³(in 2015) to 25 ug/m³ in 2020.
- Shenzhen has formulated “Key measures for prevention and control of air pollution in 2016 - 2020 ", adopted 23 key measures for 8 major areas, paying more attention on vehicles;

Shenzhen Ecosystem

8 Major Areas
Population Control
Clunker Replacement
DPF Retrofit
New Energy Vehicle
Emission Control for Ports and Vessels
Boiler Retrofit
Denitrification Retrofit for gas power plant
VOC Control

Background(2)

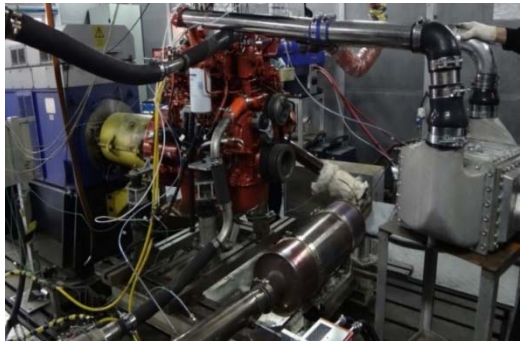
- April 2015, atmospheric PM2.5 source analysis result announced by Shenzhen Municipal Government shows that motor vehicle emission is the primary source of pollution in Shenzhen, accounting for about 41% of total;

- Shenzhen port cargo developed (the world's third largest container port), the population of diesel vehicles is relatively more, mainly in the freight logistics and other industries, which is one of the important sources of PM2.5.

Off-road machineries

- Old diesel engine occupied 60% of total; Only 30% could meet China StageⅡ emission standard.
- July 1, 2016, Shenzhen began to implement the "Limits and measurement methods exhaust smoke from in-use diesel engine of non-road mobile machinary", the optical absorption coefficient of non-road mobile machinery shall not exceed 0.5 / m- 1;
- According to the relevant provisions of Special Economic Zone, unqualified non-road mobile machinery shall not enter Shenzhen, Offenders will be punished by ¥10,000 to ¥ 100,000(RMB).

Retrofit Procedure



select 200 diesel vehicles from transport, postal, and other industries, 40 NRMMs from ports and construction sites.

bench test for after treatment products (before the project bidding)

initial PN test (after DPF installation)

DPF monitoring and PN durability test for a operating period of 3 months or 5000 km

data analysis, comprehensive plan and technology methods for large-scale retrofit in Shenzhen

Preparatory Work

6 months

Step1
- Vehicle / NRMM Screening
- Diesel Engine Emission Analysis

Step2
- Monitoring Platform
- Vehicle Files

Step3
- DPF Manufacture Investigation

Step4
- Bench Test for DPF products
- Performance Analysis

Step5
- Technology Choice
- Vehicle Allocation

Preparatory Work

Vehicle / NRMM Screening

- Vehicles mainly involved in public transport, postal, and other industries;
- NRMM included excavators, loaders, rollers, bulldozers and other construction machinery;

Information Collection:

- fleet information
- vehicle models
- emission technology
- initial exhaust test (smoke at free acceleration)
- fuel consumption
- oil consumption

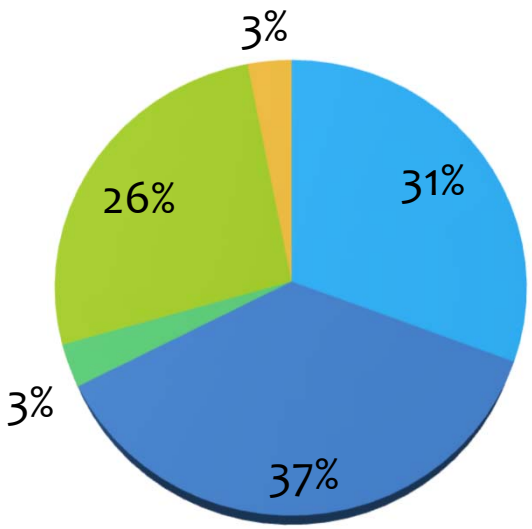
Objectives:

scientific and rational choice of after treatment devices under different operating conditions

Vehicle Screening

- Initial smoke test: total 283 diesel vehicles, 153 qualified
- Screening Standard: optical absorption coefficient < 2.0 / m- 1
- Vehicle information: basic information, smoke at idle, smoke at free acceleration, etc.
- Photos: installation Space, test data, vehicle nameplate, etc.

Screening Results

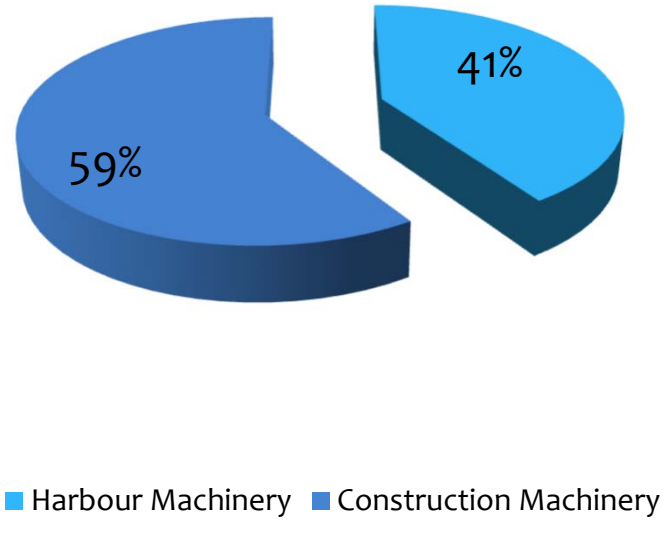


Vehicle Type

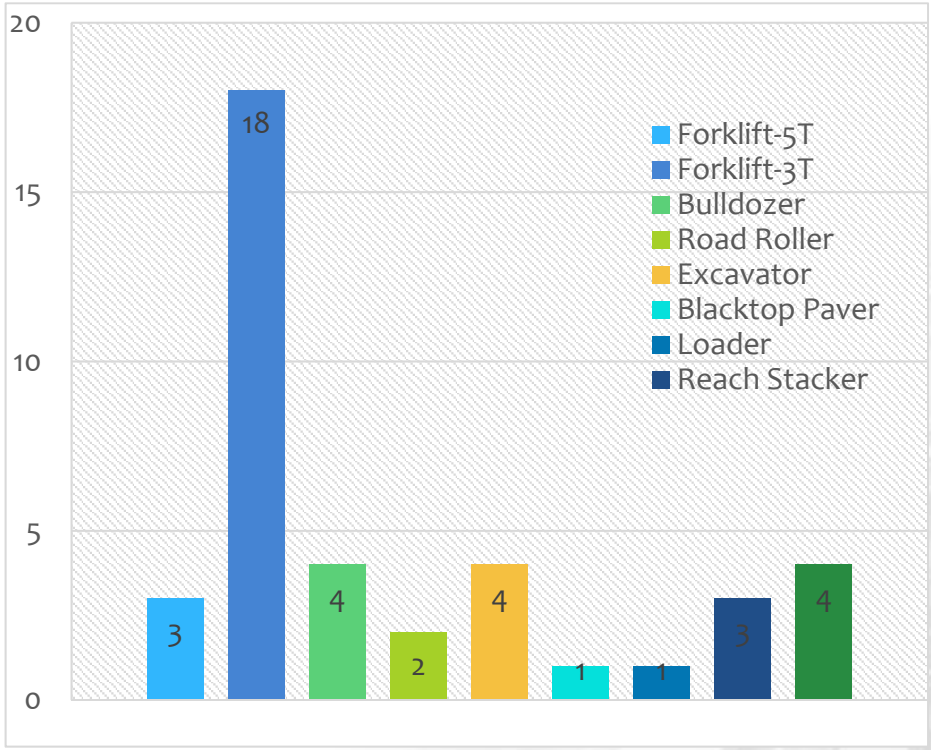
Machinery Screening

- Initial smoke test: total 127, 52 qualified
- Screening Standard: optical absorption coefficient < 2.5 / m- 1
- Machinery information: basic information, smoke at idle, smoke at free acceleration, etc.
- Photos: installation space, test data, machinery nameplate, etc.

Screening Results



Machinery Type



Machinery Category

Online Monitoring Platform

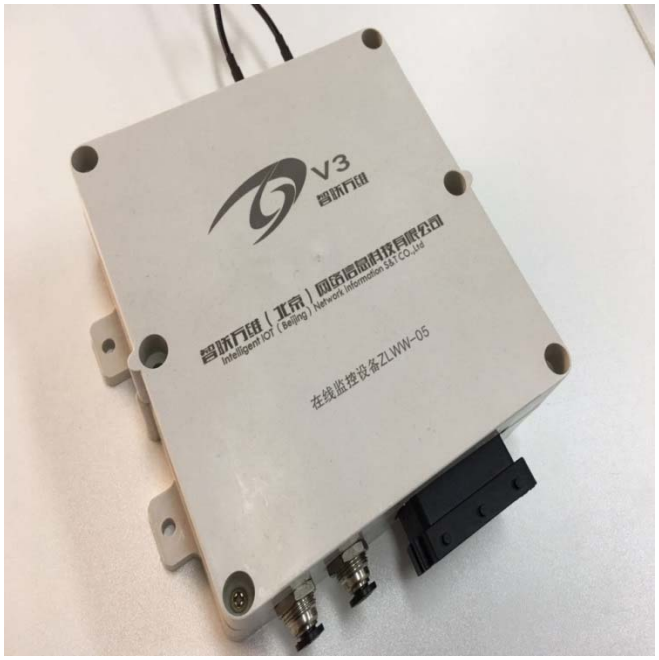
Website: http://jk.vecc-mep.org.cn/monitor/indexLogin.jsp

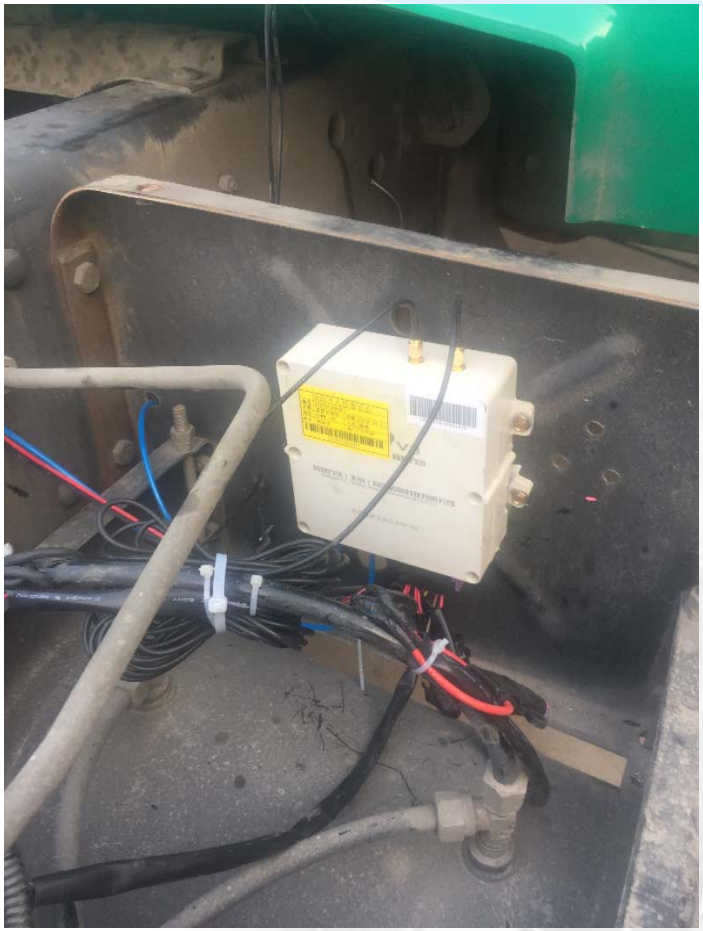
Main function

- anti-dismantle, anti-cheating
- Evaluation of Emission Reduction
- Driving Condition Analysis
- Data Calibration

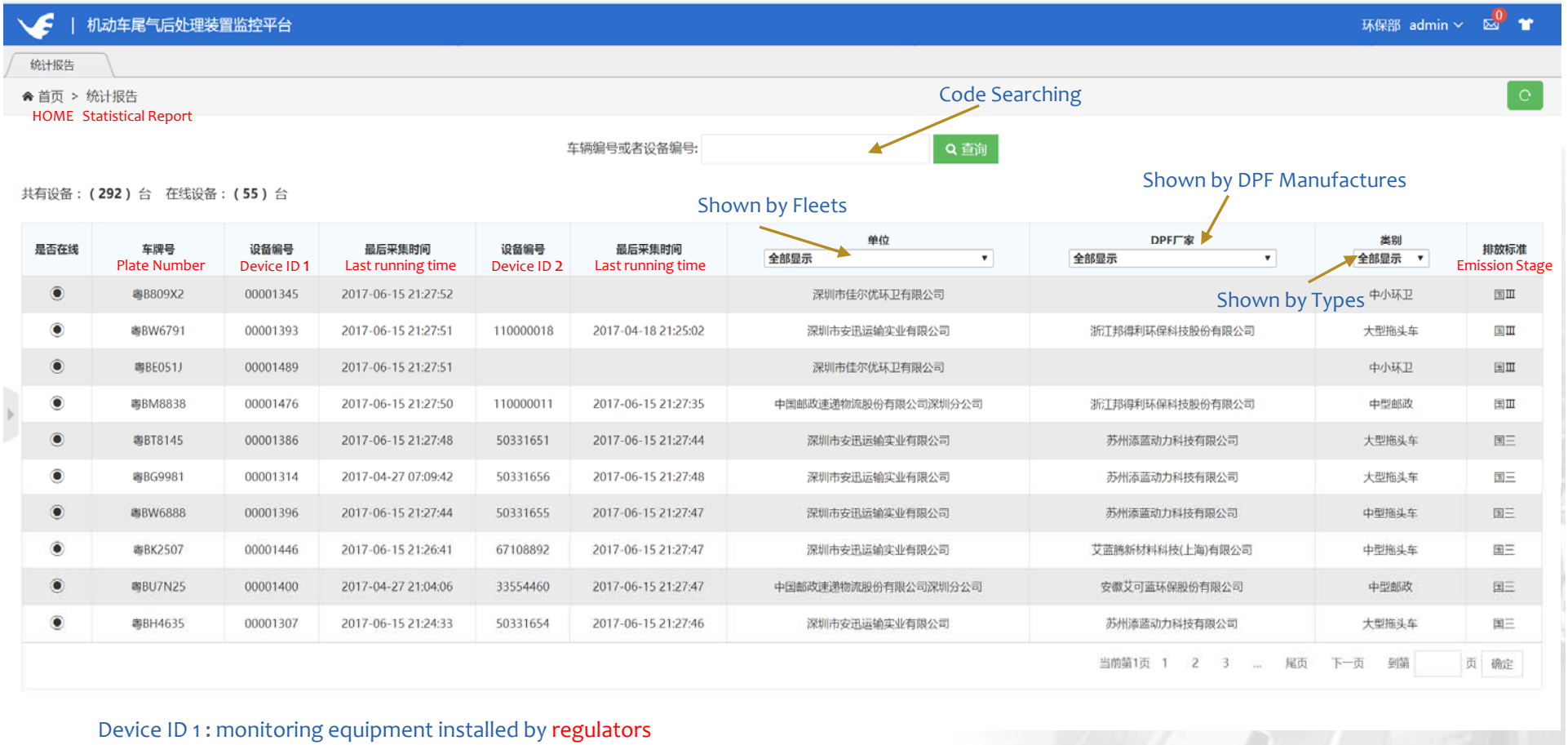
Monitoring Equipment

- Monitoring equipment was installed in a relatively fixed, concealed place to prevent the effects of contaminants or other factors on the equipment.





Main Interface



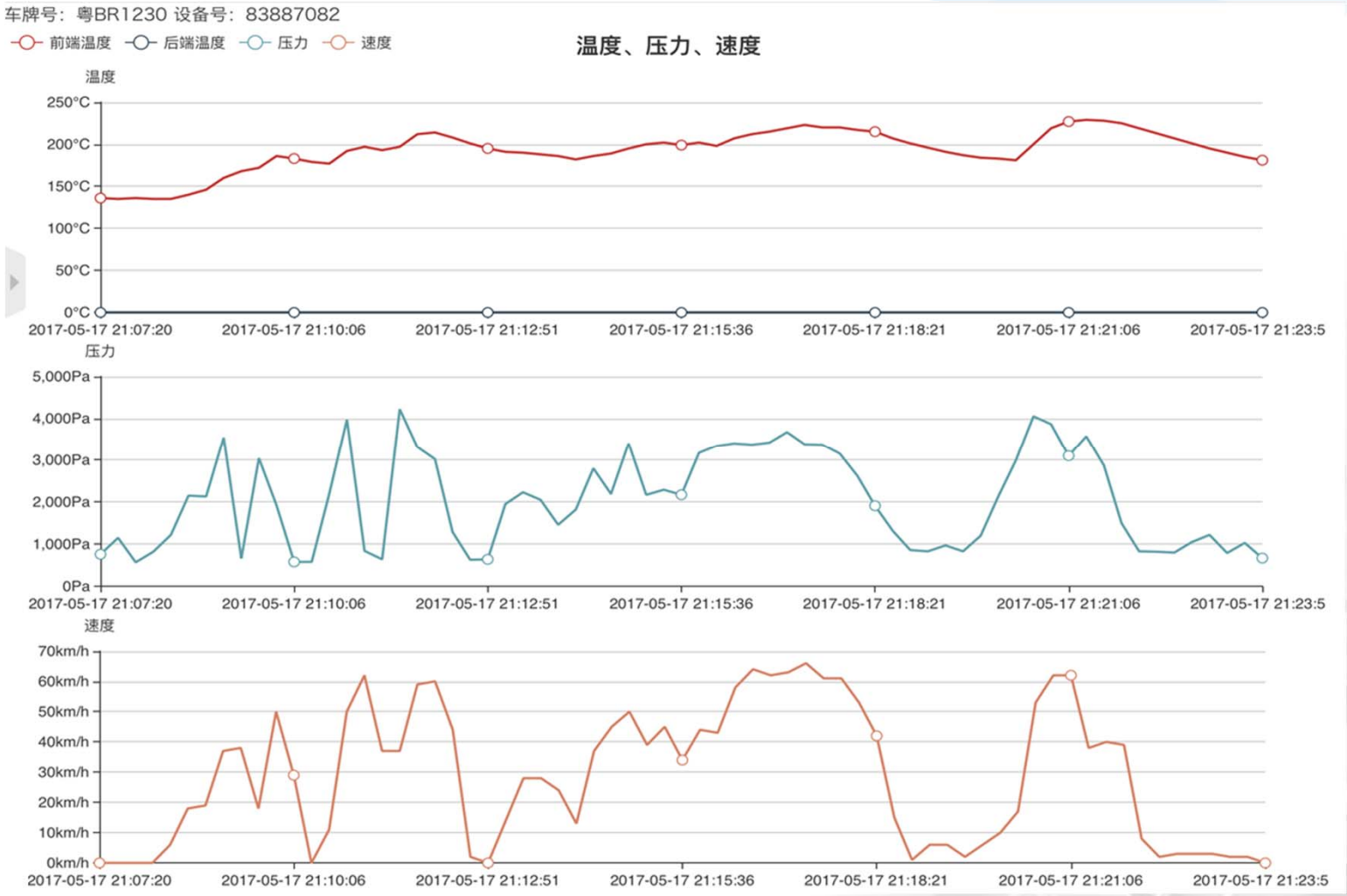
Device ID 1 : monitoring equipment installed by regulators

Device ID 2 : monitoring equipment installed by DPF manufactures

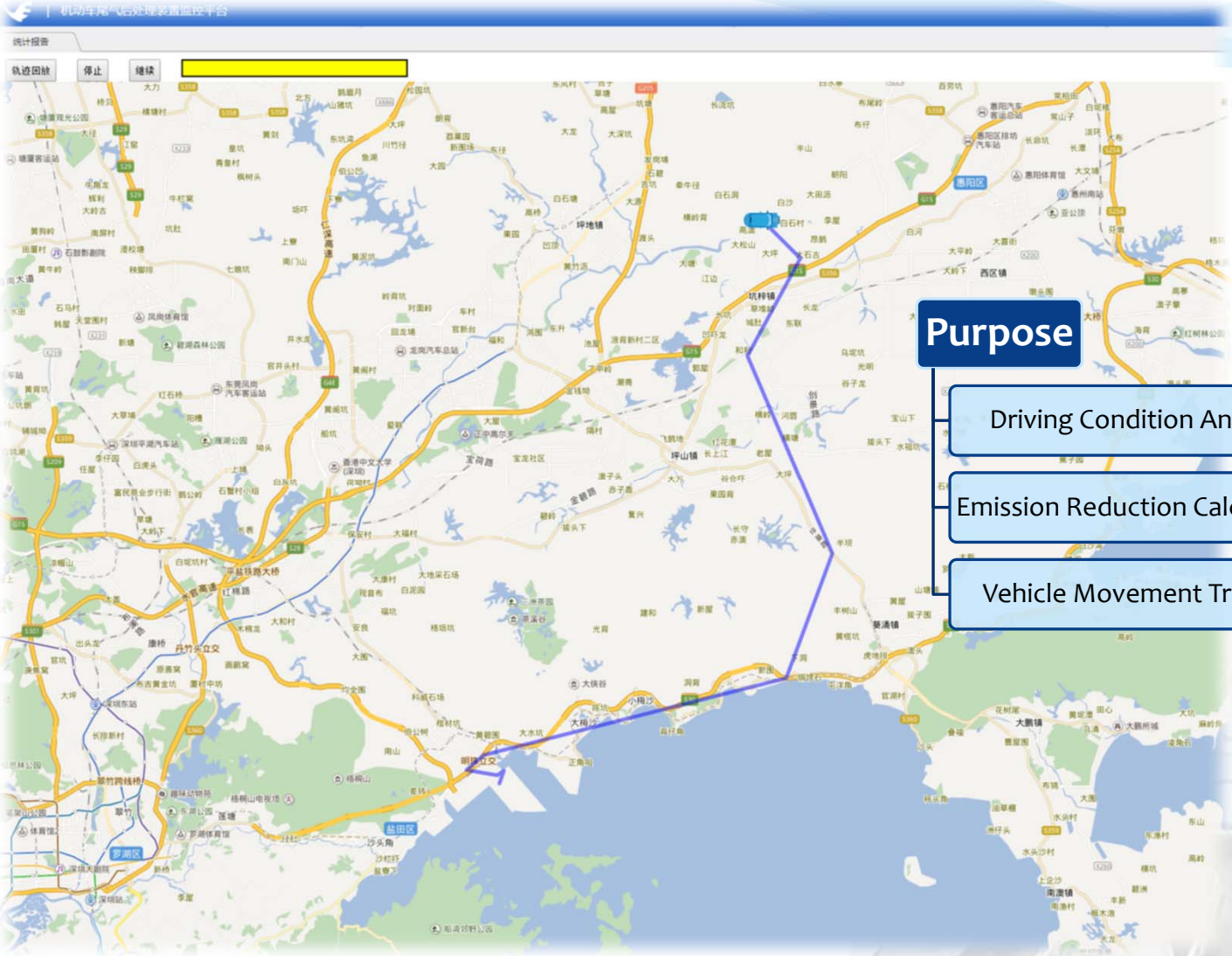
Trip Interface

- ✓ Enter the trip interface to display the single trip information of selected vehicles.
- ✓ In the rightmost operation column, the parameter change curve during vehicle travel is obtained by checking the temperature, pressure and speed options,
- ✓ and the vehicle travel track can be tracked in the map

Parameter Curve



Travel Path



Purpose

- Driving Condition Analysis
- Emission Reduction Calculations
- Vehicle Movement Tracking

Vehicle Files

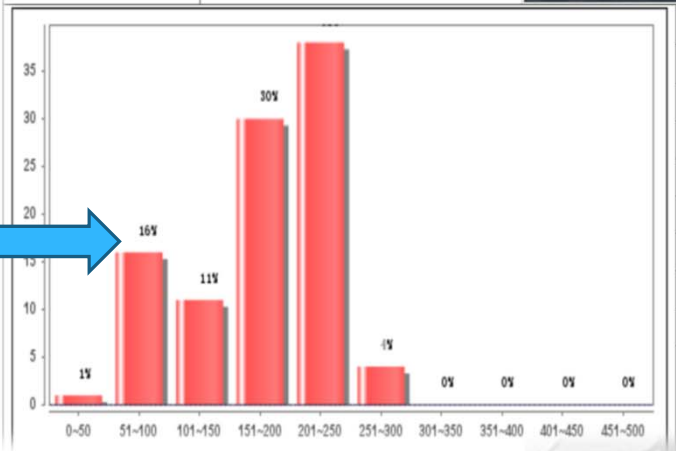
Vehicle Information

Temperature Distribution

粤BW7026 2017年02月07日-2017年02月13日统计信息

车牌号码:	粤BW7026
设备编号:	00001451
车辆品牌:	黄河
车辆类型:	重型半挂牵引车
排放标准:	国III
发动机型号:	A1016D00254
发动机厂家:	黄河
初始烟度值:	
车辆注册时间:	2013-12-26
车辆所属单位:	深圳市安讯运输实业有限公司
行驶里程:	222382
车辆负责人:	孙
联系电话:	138-2651-5112

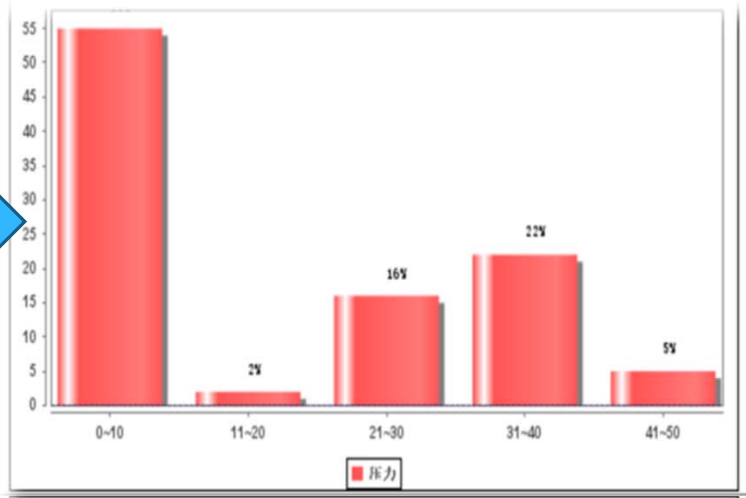
车辆照片:



0°C-50°C	1%	平均值	173°C
51°C-100°C	16%	方差	3400.2
101°C-150°C	11%		
151°C-200°C	30%		
201°C-250°C	38%		
251°C-300°C	4%		
301°C-350°C	0%		
351°C-400°C	0%		
401°C-450°C	0%		
451°C-500°C	0%		

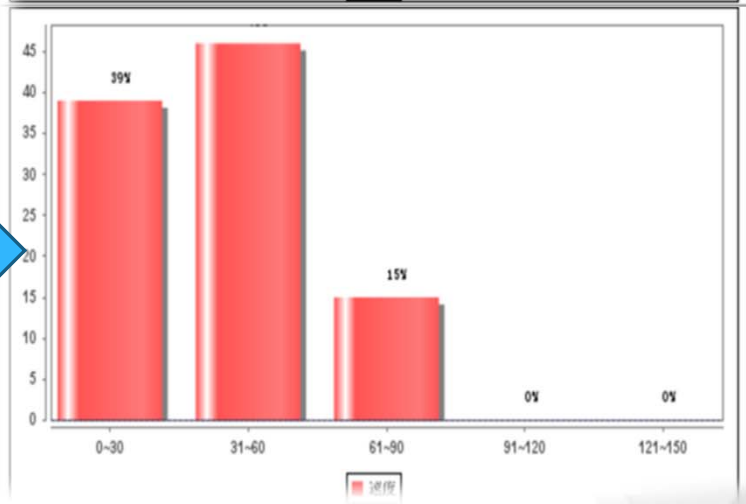
Vehicle Files

Pressure Distribution



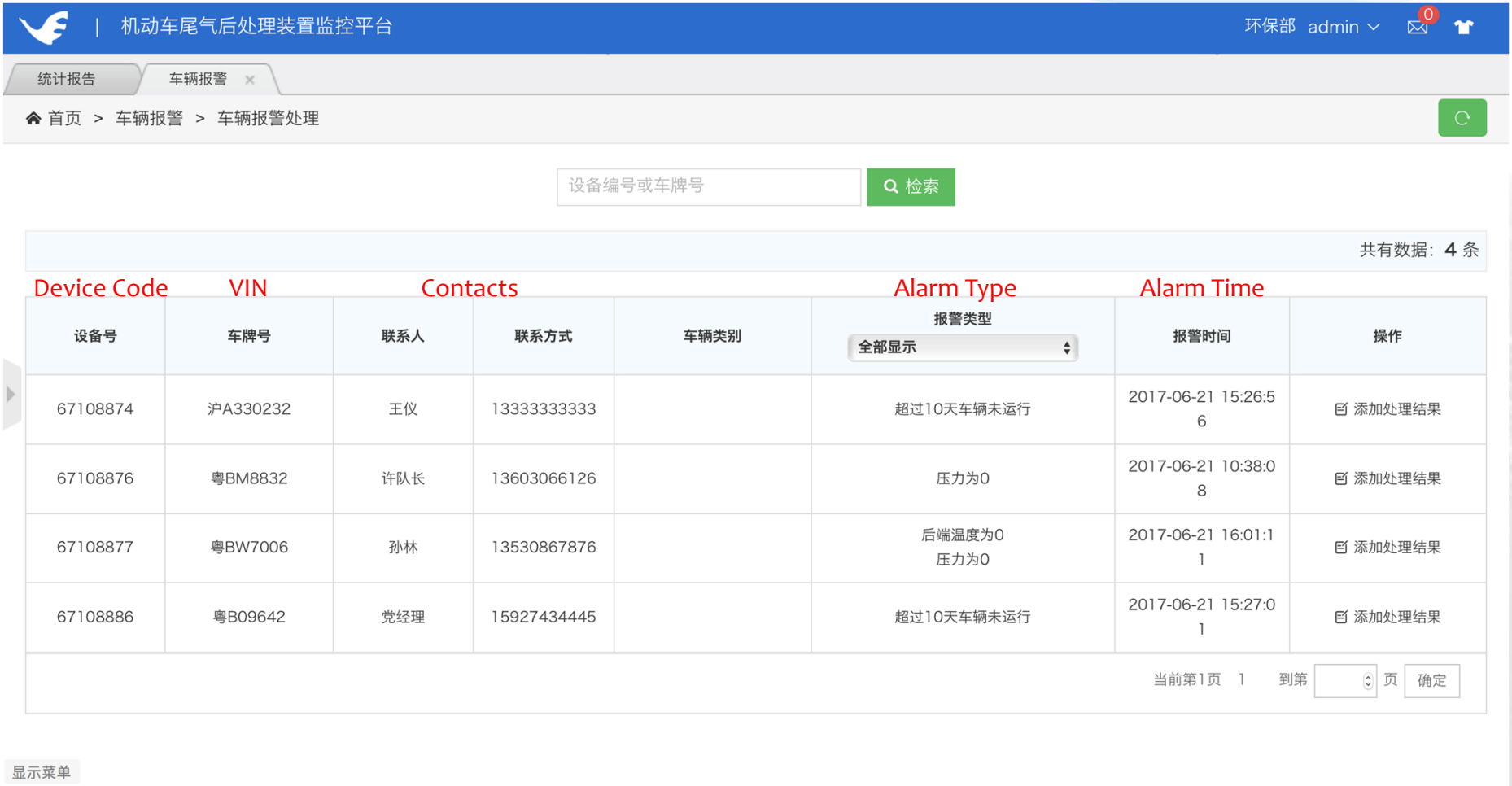
0Pa-10Pa	55%	平均值	17Pa
11Pa-20Pa	2%	方差	24613.7
21Pa-30Pa	16%		
31Pa-40Pa	22%		
41Pa-50Pa	5%		

Speed Distribution

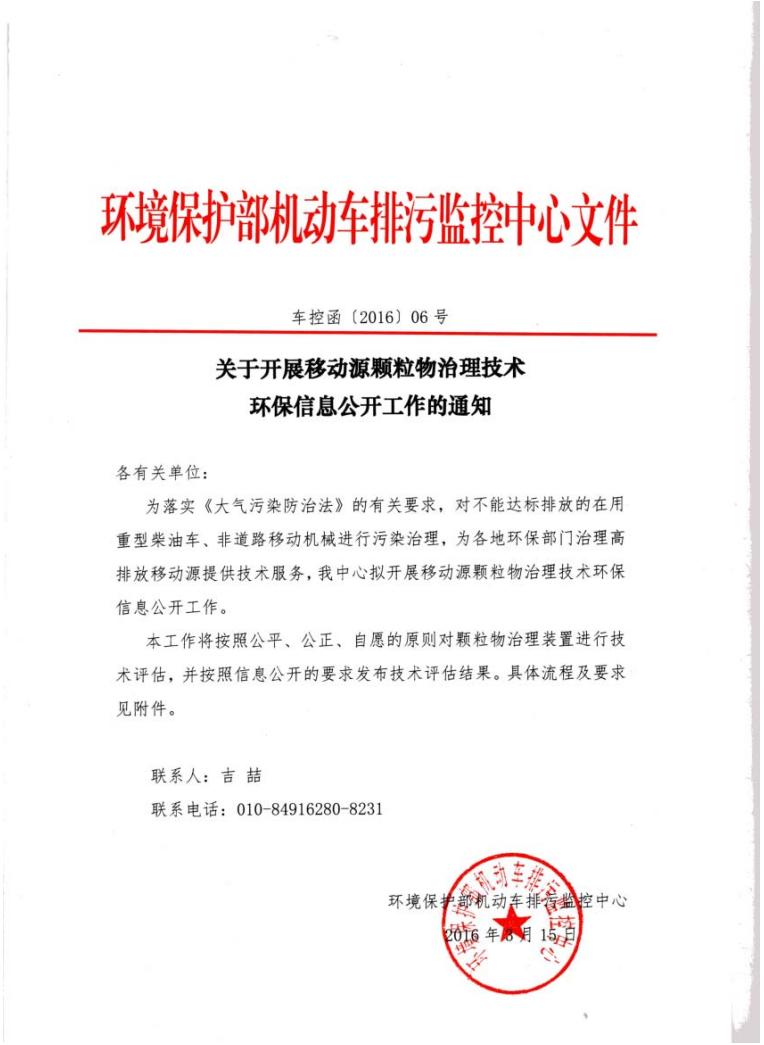


0-30(Km/h)	39%	平均值	35.4(Km/h)
31-60(Km/h)	46%	方差	3499.7
61-90(Km/h)	15%		
91-120(Km/h)	0%		
121-150(Km/h)	0%		

Vehicle Alarming



Manufacture Investigation



环境保护部机动车排污监控中心文件

车控函〔2016〕06号

关于开展移动源颗粒物治理技术环保信息公开工作的通知

各有关单位：

为落实《大气污染防治法》的有关要求，对不能达标排放的在用重型柴油车、非道路移动机械进行污染治理，为各地环保部门治理高排放移动源提供技术服务，我中心拟开展移动源颗粒物治理技术环保信息公开工作。

本工作将按照公平、公正、自愿的原则对颗粒物治理装置进行技术评估，并按照信息公开的要求发布技术评估结果。具体流程及要求见附件。

联系人：吉 喆

联系电话：010-84916280-8231

环境保护部机动车排污监控中心

2016年3月15日

The Letter of Manufacture Investigation Program

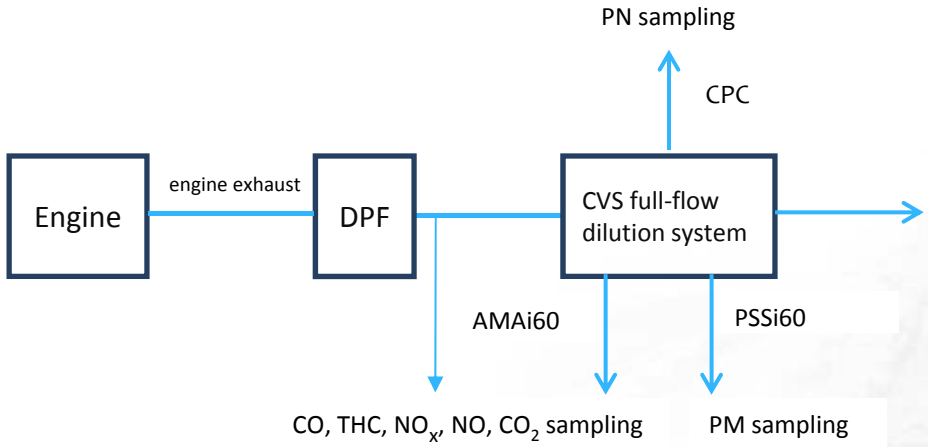
Focus

- ✓ DPF Manufacturers Research (production capacity, R&D capability, quality assurance and after-sales service, etc.);
- ✓ DPF Performance Indicators (PN, PM, NO_2, normal pollutant, secondary pollutant, etc.);
- ✓ Equipment Bidding (business, maintenance terms, etc);

Investigation for DPF quality control ability

Bench Test for DPF performance

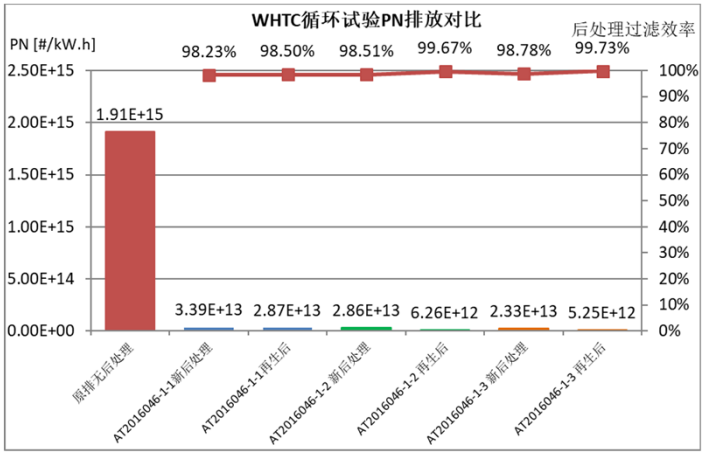
Product Installation



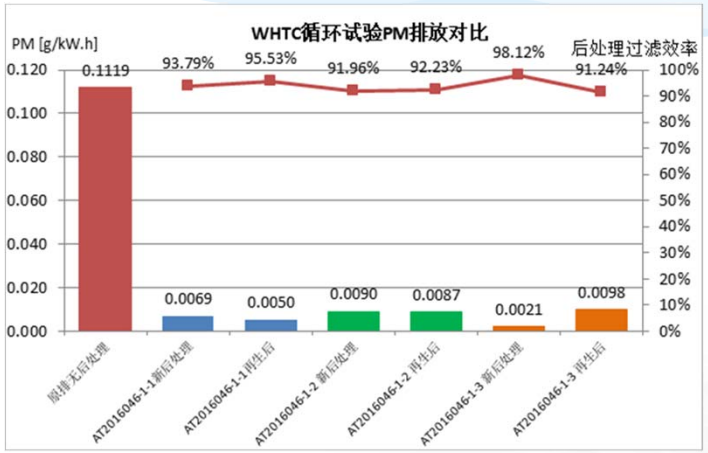
Exhaust Sampling

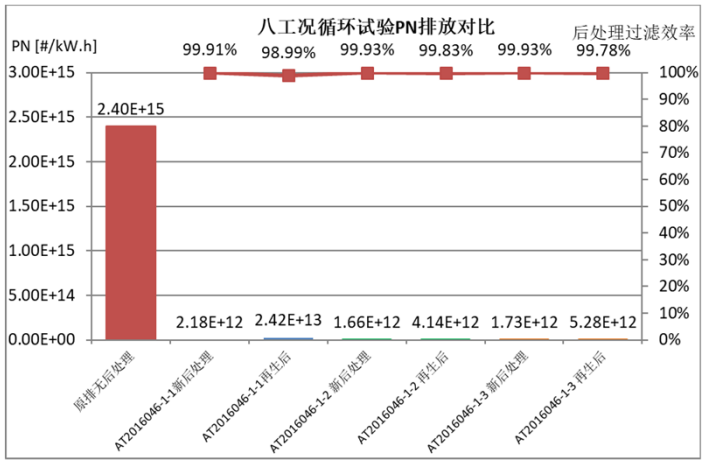
PM and PN Emissions

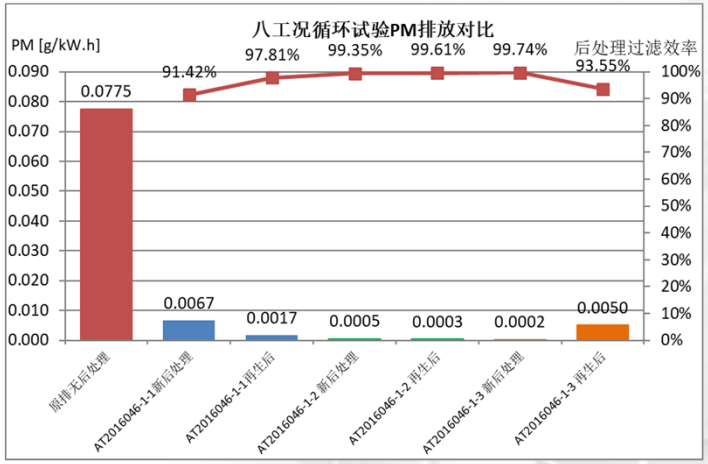
PN



PM

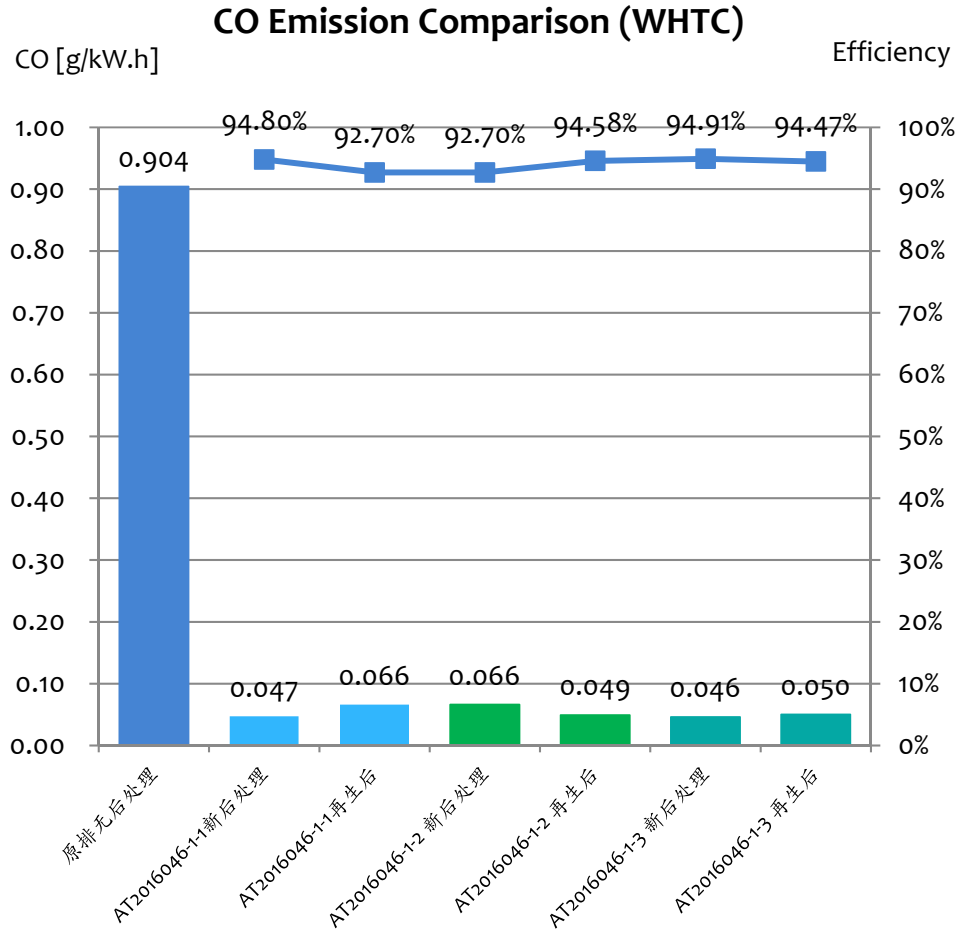


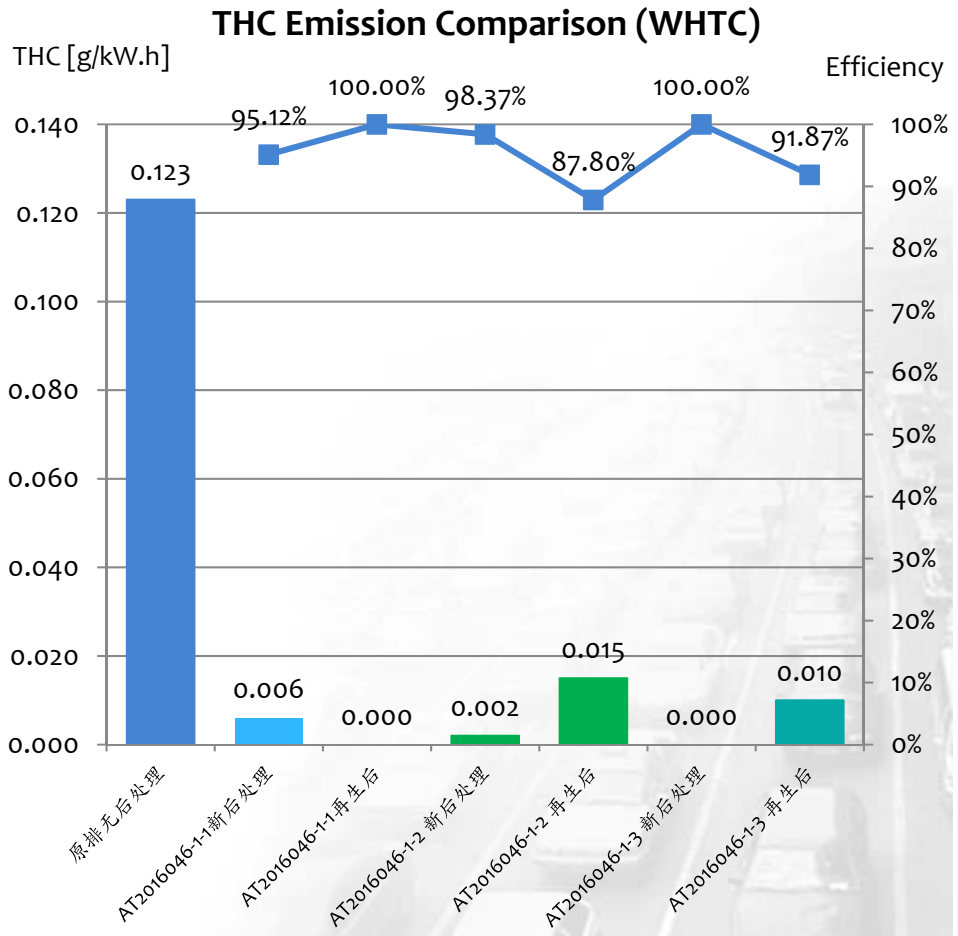




more stable

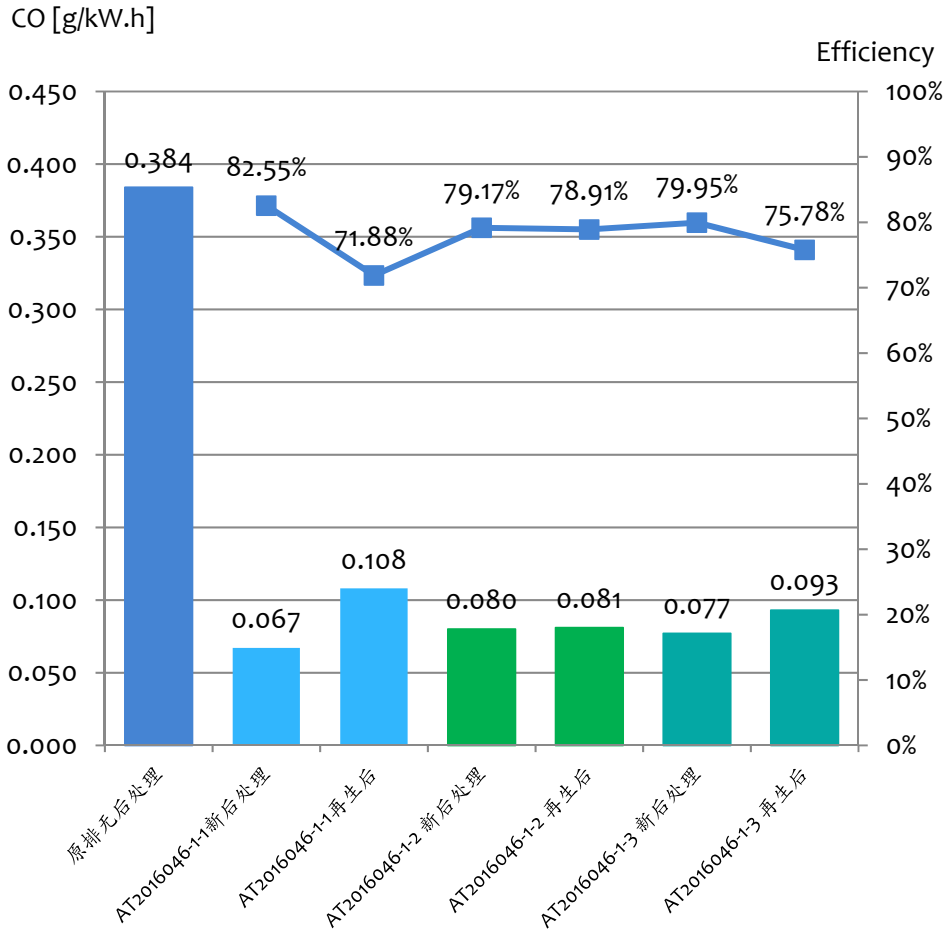
CO and THC Emissions



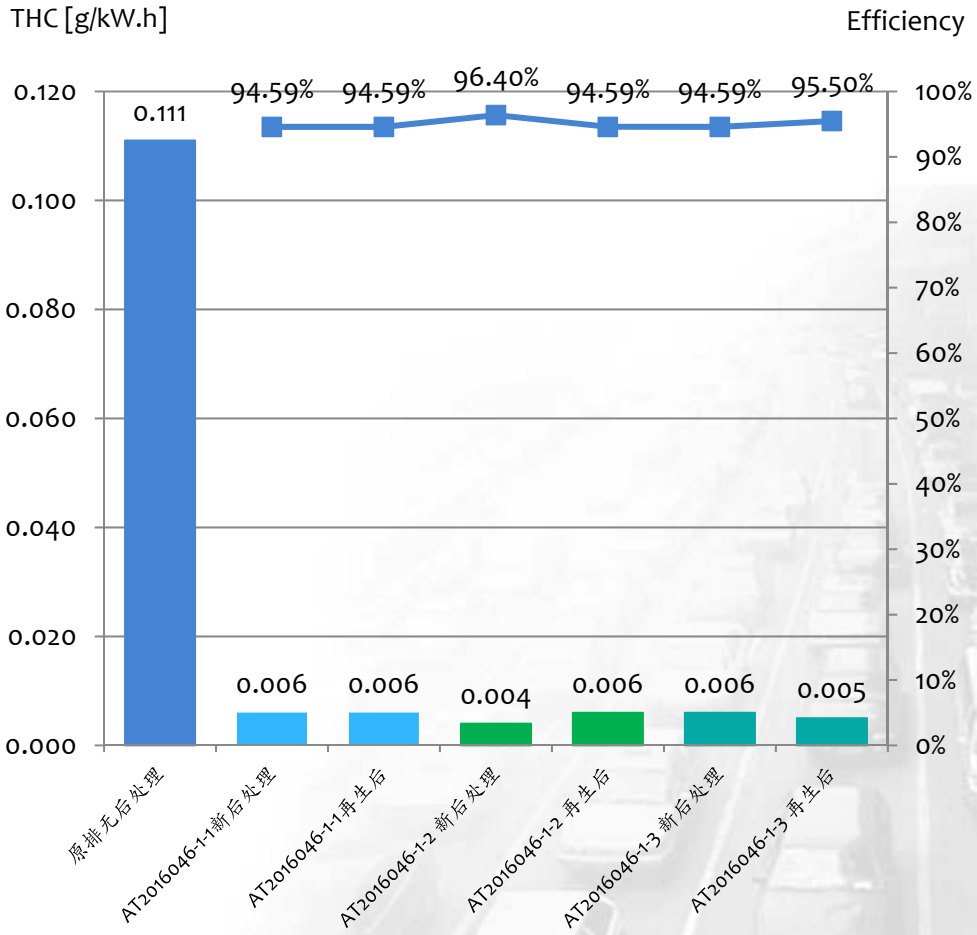


Bench Test

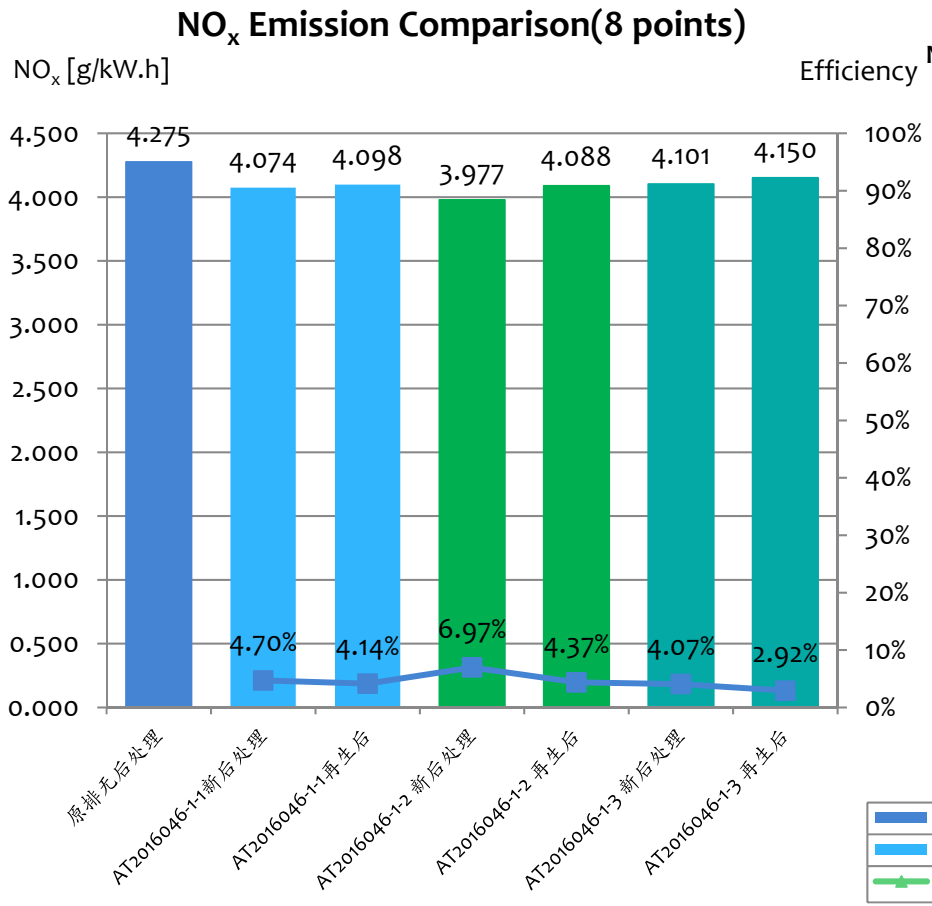
CO Emission Comparison(8 points)

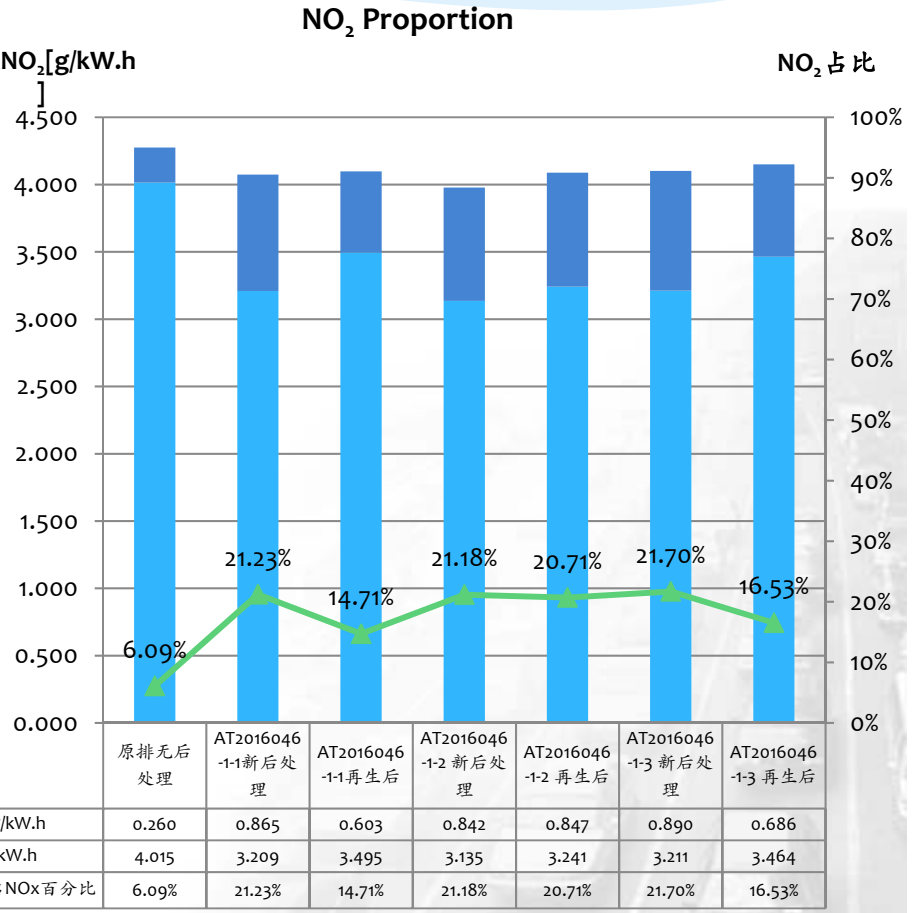


THC Emission Comparison(8 points)



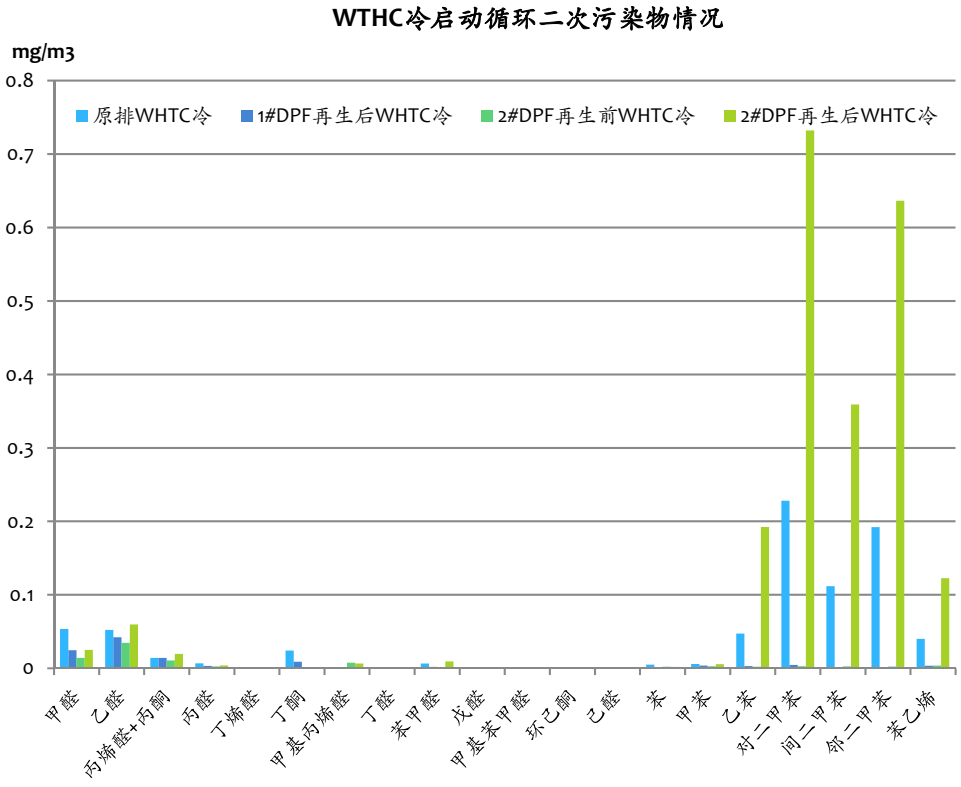
NOx and NO2 Emissions



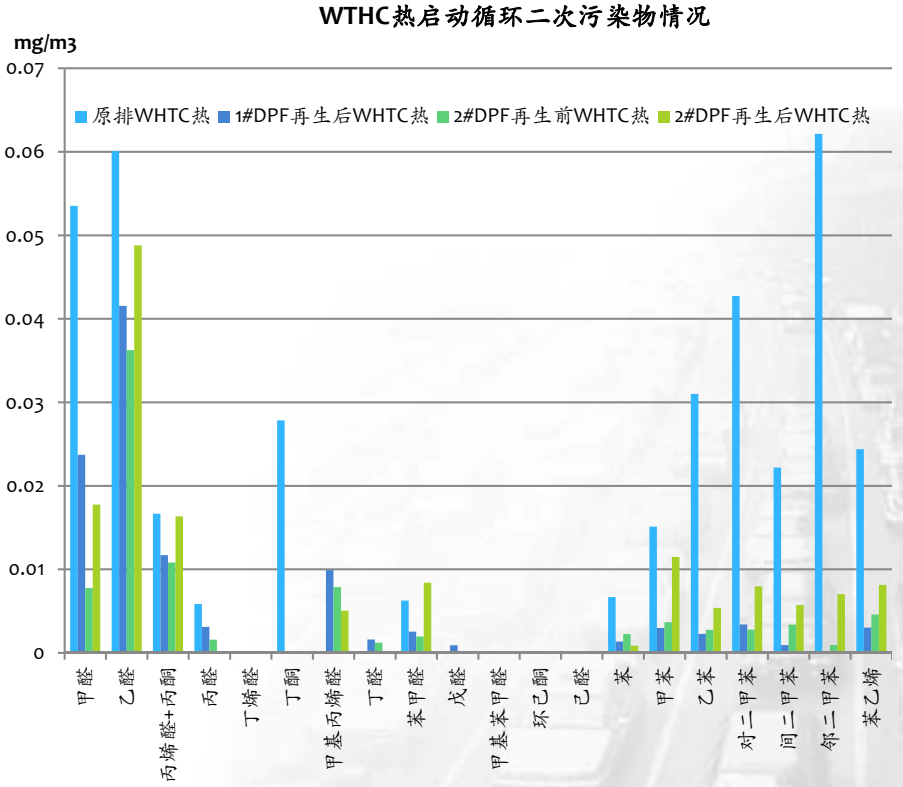


	原排无后处理	AT2016046-1-1新后处理	AT2016046-1-1再生后	AT2016046-1-2 新后处理	AT2016046-1-2 再生后	AT2016046-1-3 新后处理	AT2016046-1-3 再生后
NO2 g/kW.h	0.260	0.865	0.603	0.842	0.847	0.890	0.686
NO g/kW.h	4.015	3.209	3.495	3.135	3.241	3.211	3.464
NO2占NOx百分比	6.09%	21.23%	14.71%	21.18%	20.71%	21.70%	16.53%

Secondary Pollutants Emissions



Secondary pollutants in cold start cycle



Secondary pollutants in hot start cycle

DPF Allocation Meeting

Meeting Site

- Vehicle Emission Control Center, local EPB, DPF manufacturers and other related people participated in the meeting,
- completed vehicle allocation,
- defined project implementation requirements, test requirements, follow-up supervision and other issues.

DPF Installation-Vehicle

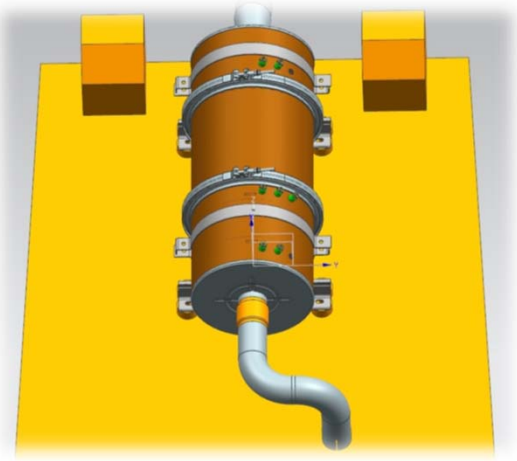
DPF Installation-NRMM

Issues

- Refuse Landfill:
  - high methane concentration that may lead to potential security problems
- Forklift:
  - installation space
  - driver's sight
  - aesthetic requirement
- Road Roller: vibration reducing measure
- Poor fuel quality

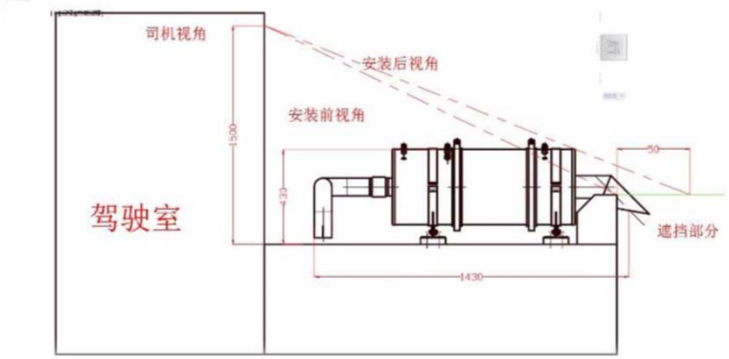
Poor fuel sample from the tank

Installation Scheme



3D Diagram

Pre-installed location



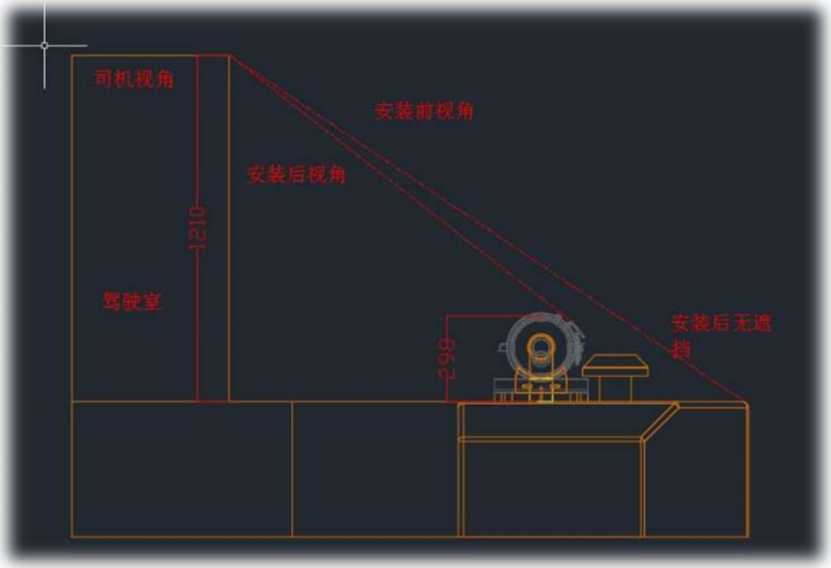
Profile

Focus

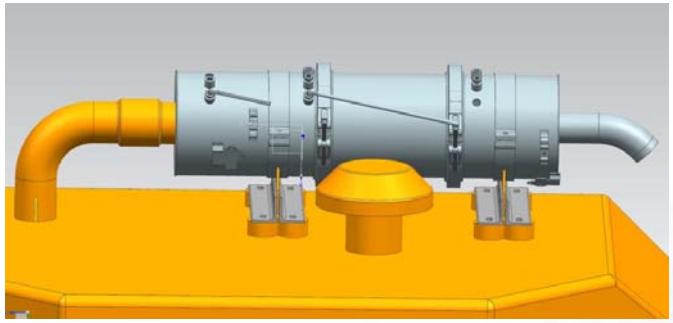
- Safety
- Heat Insulation Measures
- Driver's Sight

Bulldozer

Installation Scheme



Profile



3D Diagram

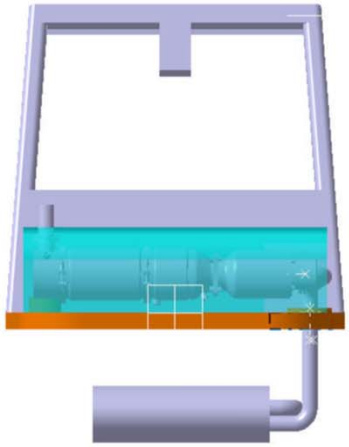
Pre-installed location

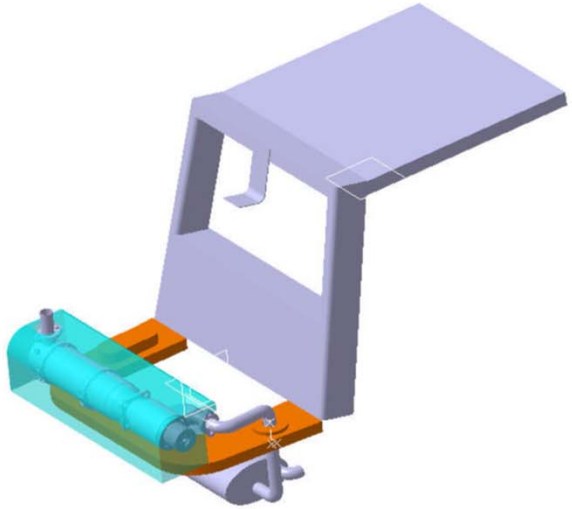
Focus

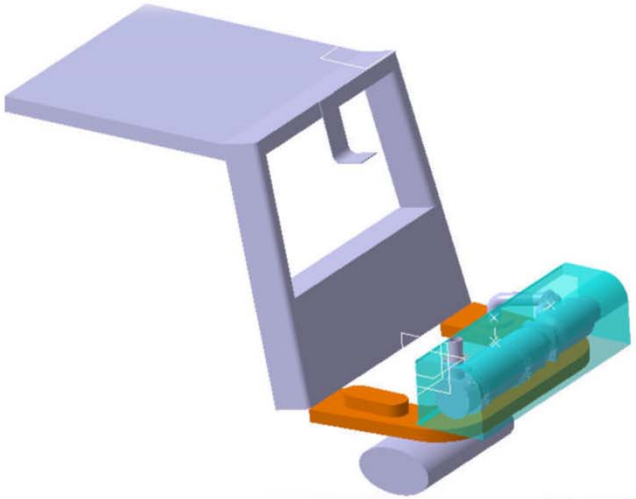
- Safety
- Heat Insulation Measures
- Vibration Reducing Measure
- Driver's Sight

Road Roller

Installation Scheme

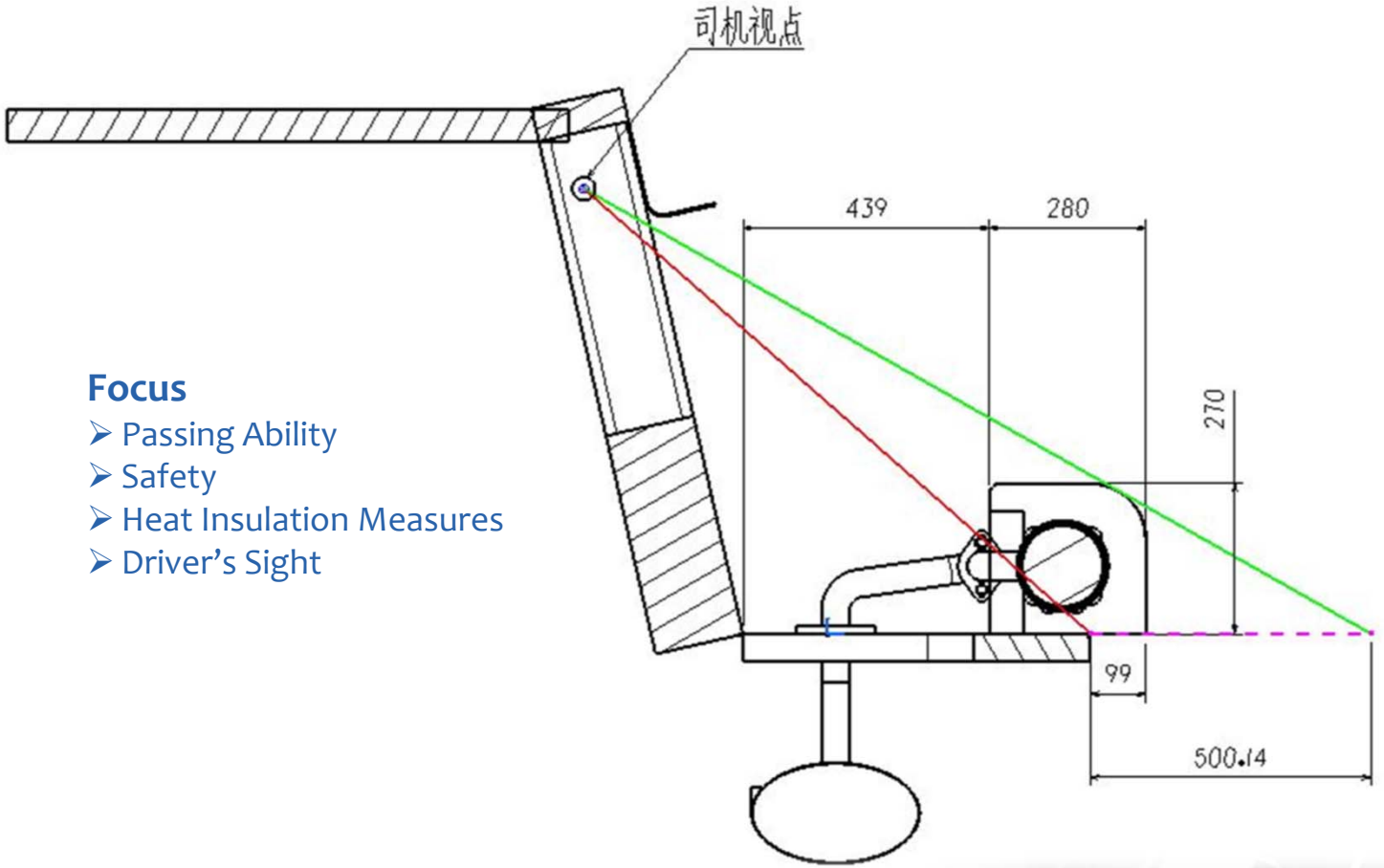






Forklift

Installation Scheme



Focus

- Passing Ability
- Safety
- Heat Insulation Measures
- Driver's Sight

Forklift

DPF Installation and Agreement between DPF providers and Vehicle Owners

柴油机/车后处理装置改造产品安装单

车辆基本情况					
号牌		生产厂家		出厂日期	
最大总质量		车辆性质、型号		发动机型号	
排放等级		排放（L）		功率（kW）	
喷油方式		自由加速烟度		原车PN排放	
安装车辆行驶证（复印件/照片）：					
后处理产品及安装情况					
DPF序列号		产品型号		生产厂家	
安装日期		安装地点		安装负责人	
远程监控序号		再生策略简要描述			
车辆安装DPF后照片：					
安装后车辆检查、测试情况					
外观检查		密封性检查			
DPF后PN数量		初次安装后PN效率			
自由加速烟度		DPF初次PN净化效率			
车辆所有者签字：		产品供应商代表（签字）			

年　　月　　日

Receiving Report

车辆 DPF 改造示范试验合作协议

甲方：_____

乙方：_____

一、基本情况介绍

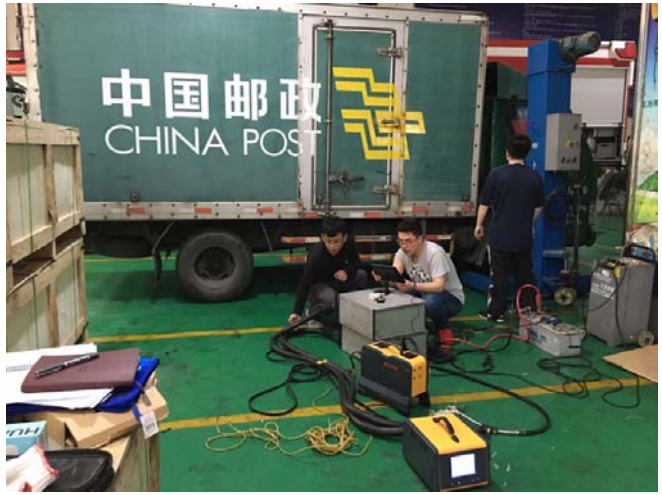
为有效治理机动车污染，加大空气污染治理力度，落实市政府办公厅《关于研究大气环境质量提升工作的会议纪要》（2015 年第 72 号）要求，深圳市人居环境委委托环境保护部机动车排污监控中心开展柴油颗粒捕集器（DPF）安装示范评估项目，通过该项目将建立一套有效柴油车污染控制技术评估方法和体系，为深圳柴油车污染后处理控制技术选择和评估提供技术支撑。示范实验包括了在用柴油车和非道路移动机械改造示范试验工作。通过该评估项目，将逐步划定深圳市移动污染源低排放控制区域，逐步实现在深圳市范围活动的所有柴油车或非道路工程机械必须加装 DPF 工作。

二、参与示范试验各方职责和义务

此次深圳市柴油颗粒捕集器安装示范评估项目共有管理部门、DPF 供应商、车辆所有者/设备使用者三方参与，并以自愿合作的形式进行。

User Agreement

PEMS Test for PN



- ✓ According to the "*Limits and measurement methods for exhaust smoke from C.I.E.(Compression Ignition Engine) and vehicle equipped with C.I.E.* "(National Standard: GB3847-2005),
- ✓ PEMs equipments (Nanomet3, TSI3795, Semtech) were used to measure the particulate number of exhaust from all vehicles and NRMMs that involve in the project.
- ✓ Initial PN test after DPF installation
- ✓ Durability test after a operation period of 3 months or 5000km.
- ✓ The removal efficiency shall not be less than 95%

Nanomet3

FEATURES AND BENEFITS

- The portable particulate matter test system is used to measure the amount and size of nanoparticles in the range of 10-700nm.
- Compact, easy to car, durable;
- Equipped with 12V DC battery operation function, low power consumption;
- Suitable for vehicle exhaust particle emission concentration measurement (1000-300,000,000 particles/cm3), short response time, suitable for transient testing;

Typical Applications

- The testo NanoMet3 portable particle counter offers high-precision measurements over a large concentration range and is therefore very suitable for a wide range of applications:
- Particle measurement according to RDE for type approval in accordance with Euro 6c
- Particle determination for the research and development of particle filters
- Characterization of particle emissions from gasoline and diesel engines

TSI 3795

FEATURES AND BENEFITS

- ✓ Sampling probe with integrated dilution
- ✓ Water removal via water trap and silica desiccant dryer
- ✓ Built-in catalytic stripper for volatile particle removal
- ✓ Wide environmental operating range
  - ➢ -10° C to 40° C
  - ➢ 0 - 3,000 m
- ✓ Concentrations up to 5,000,000 particles/cm3
- ✓ Two measurement modes:
  - ➢ General: Real-time data logging
  - ➢ Official: Swiss Regulation SR 941.242 certification

APPLICATIONS

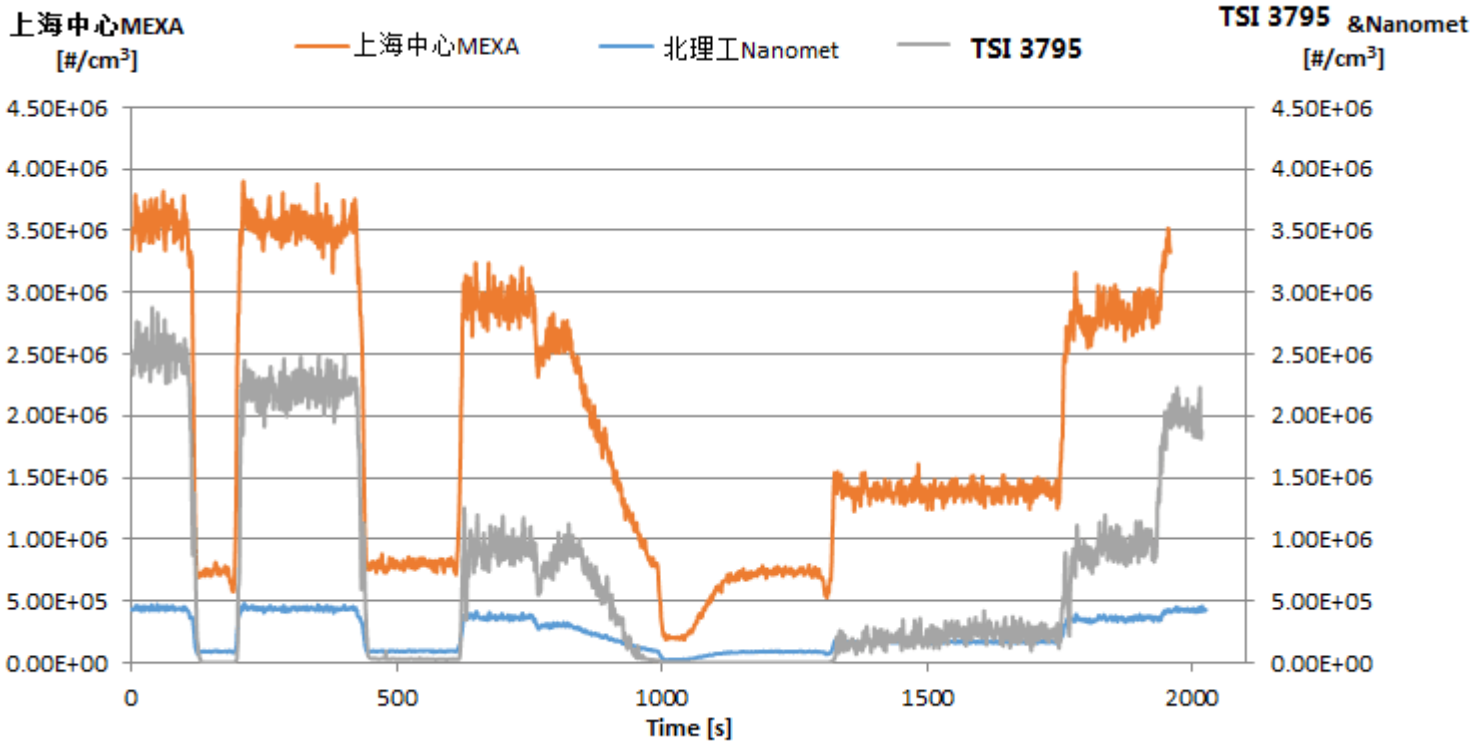
The Nanoparticle Emission Tester is suitable for a variety of applications, including:

- ✓ Engine exhaust research
- ✓ Combustion emissions research
- ✓ Aftertreatment inspection and maintenance
- ✓ Diesel Particulate Filter (DPF) compliance certification
- ✓ Fleet emissions profiling
- ✓ Particle volatility research

Comparison of Particle Counters

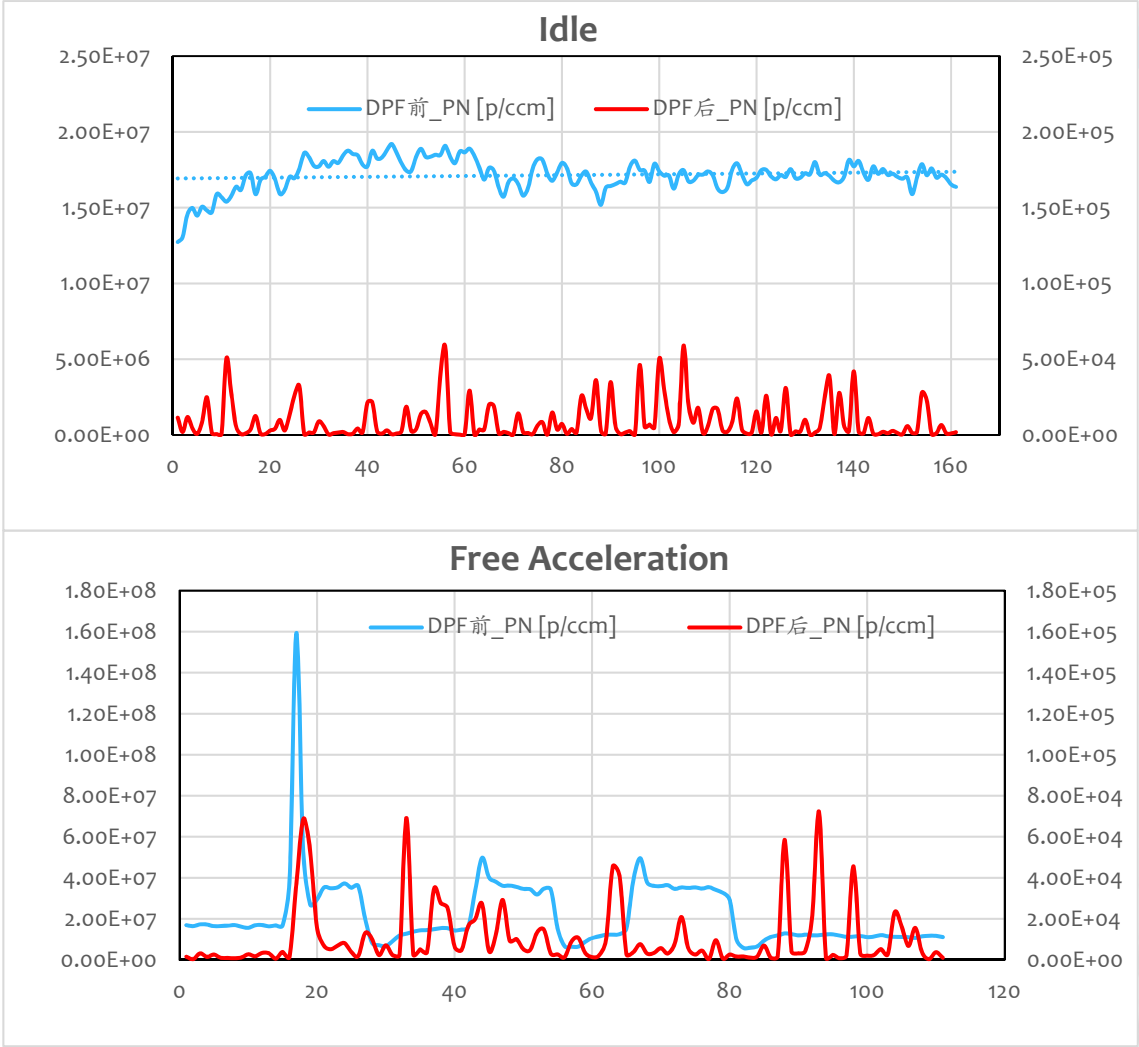
Parameter	Particle Counters from NMVIC	Particle Counters from VECC	
Equipment Name	HORIBA MEXA-2000SPC S (TSI CPC 100)	TSI CPC 3795	Matter Aerosol Nanomet 3-PS
Measurement Range of Partical Size	23nm~3000nm(3μm)	23nm~1000nm(1μm)	10nm~700nm(0.7μm)
Measurement Range of PN	0~1E4 #/cm3	1E3~5E6 #/cm3	1E4~3E8#/cm3
Removal efficiency of volatile particulate matter	≥99%	> 99% of 30nm	✓ the sampling tube heated to 300 ℃ to remove volatile particulate matter, ✓ the equipment without removal rate indicators
Dilution Ratio	Level1: 10~200 Level2: 15	—	10, 100, 300

Comparison of Particle Counters



* The experiment was conducted to compare the correlation among Nanomet3, HORIBA MEXA-2000 and TSI 3795. In the steady-state condition, the data trend of the 3 devices is similar, however, the particle numbers measured by the 3 devices vary widely.

Test Data

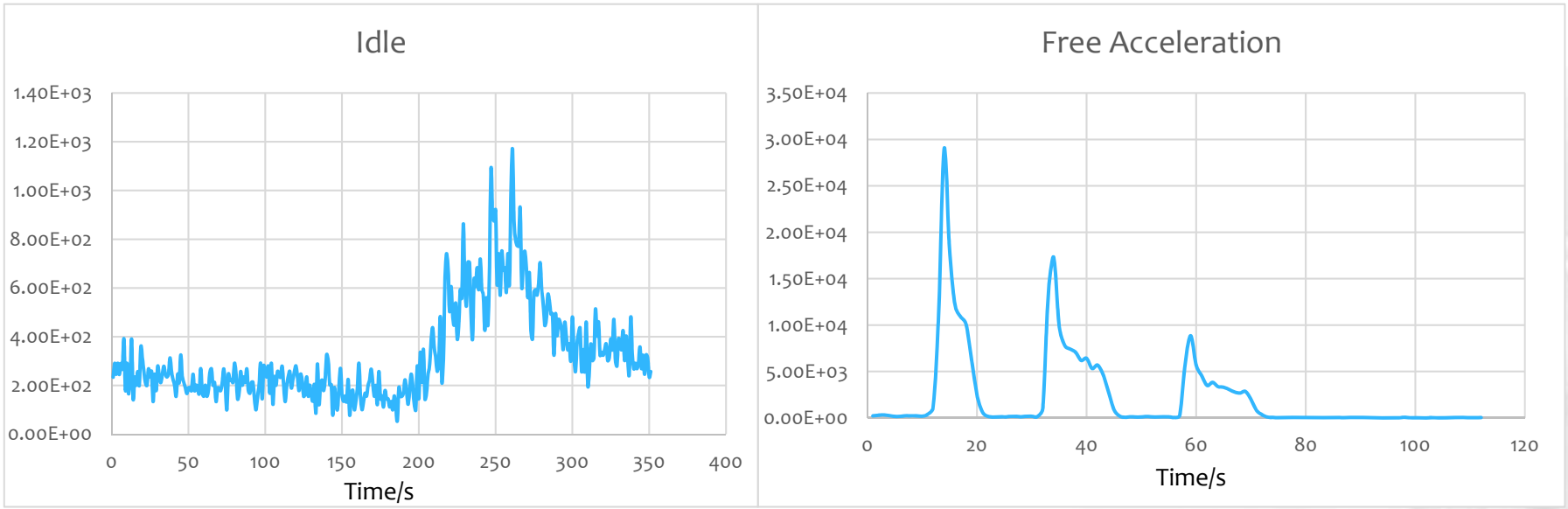


PN efficiency:
over 99%

Nanomet3 test data

粤B.M0302

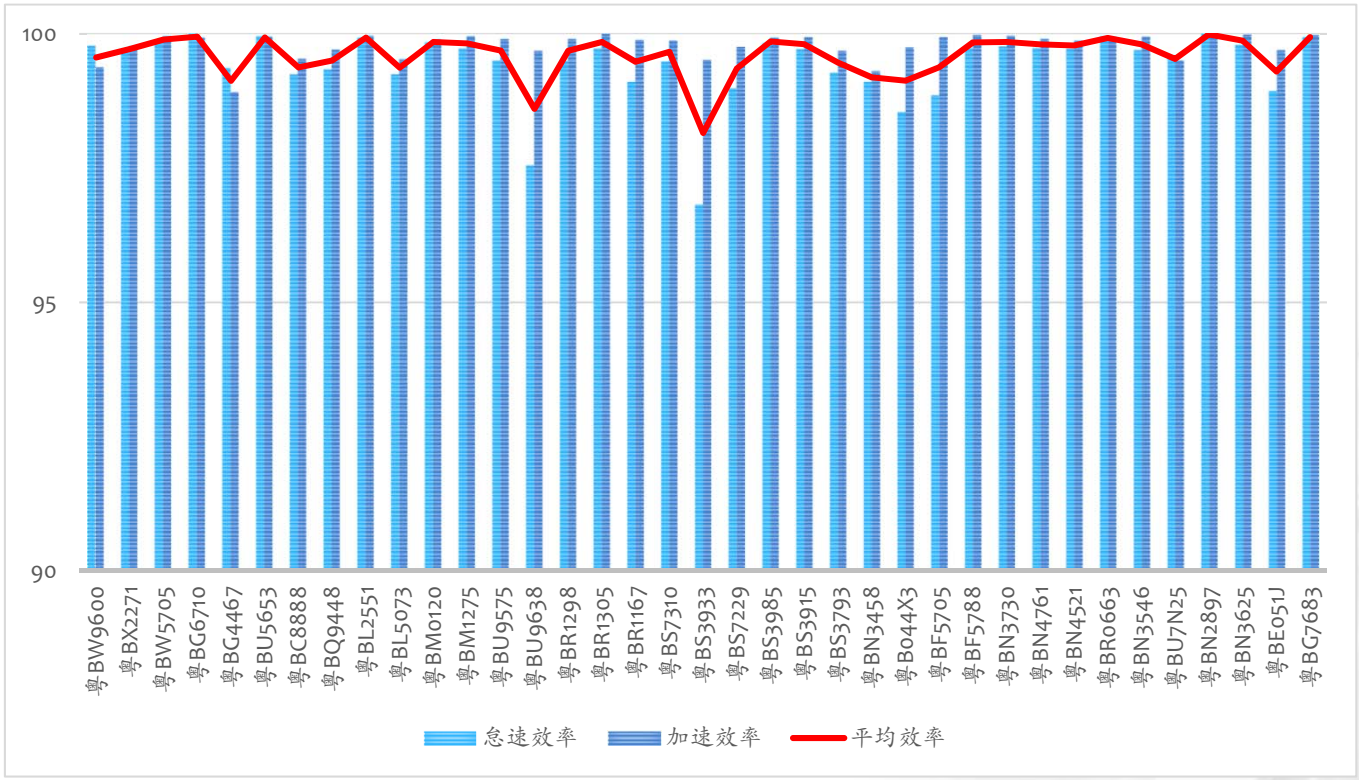
Test Data of PN emissions



TSI 3795 test data

粤B.M0302

DPF durability test for PN reduction efficiencies



DPF product sampling on the market of Shenzhen

- VETC of Xiamen test results:

Reduction efficiencies Comparison between the claims of bidding documents and the sampled products

WHTC Pollutants reduction efficiencies under WHTC cycle	Bidding documents	Product sampled on market test results	differences
CO	96.87%	99.32%	2.45%
THC	100.00%	100.00%	0.00%
NOx	1.28%	3.01%	1.73%
PM	87.24%	98.35%	11.11%
PN	99.65%	99.67%	0.02%

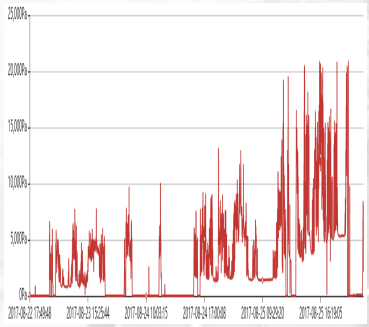
Some failures

Poor fuel quality leads to injector clogging

Poor Vehicle conditions

Passive regeneration DPF unmatched with the vehicles

Front side of a passive regeneration DFF



Pressure increase beyond the limits

DPF damage during running because the installation dimension outreach the machinery

Policy Proposal

- Monitoring platform for real-time DPF monitoring is to an important mean to ensure the success of the retrofit;
- Understanding of vehicle emission level and driving conditions is necessary for DPF technology choices;
- Local governments need to introduce supportive policies including tax cuts, green freight to encourage retrofit;
- Oil quality assurance during the retrofit process;
- The local need to build a professional team for DPF maintenance.

Thank you !

Dr.Wang Yanjun

wangyj@vecc-mep.org.cn