Sino-Swiss Cooperation on Clean Air and Climate Change Legislation and Policy Program

DPF Retrofit Program in Project "Reduction of Black Carbon Emissions from Mobile Sources"

WANG Yanjun

Vehicle Emission Control Center of MEP, China

March 19, 2015

Outline

- VECC Introduction
- Sino-Swiss Project Background
- Main Works
- DPF retrofit program in Nanjing and Xiamen
- Future Cooperation Suggestions

Vehicle Emission Control Center (VECC)

Director General : Bao Xiaofeng
Deputy Director: Ding Yan
Deputy Director: Cui Jianxiang

Vehicle Emission Testing Center (VETC)

Administrative Office

Technical Advisory Committee

Department of Policy and Regulation research

Department of New Vehicle Management

Department of In-use Vehicle Management

Department of Technology Assessment

Department of Information and Database

Department of Training and Education

- Vehicle Emission Control Center (VECC) was founded by the Ministry of Environmental Protection in 1997, operating the functions under the Chinese Research Academy of Environmental Sciences(CRAES).

Vehicle Emission Testing Center (VETC)

Director : Lin Yongming

BC Reduction from Mobile Sources

- 2010: Memorandum of understanding between MEP and SDC on clean air and climate change legislation & policy program(CCLP): BC control policies and implementation guidelines was included;

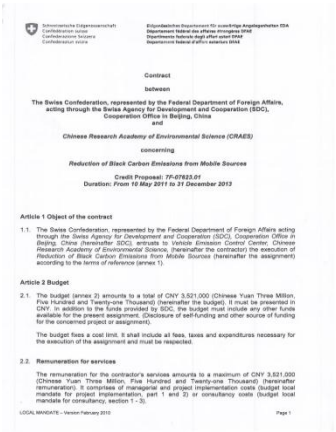
MEMORANDUM OF UNDERSTANDING
BETWEEN
THE MINISTRY OF ENVIRONMENTAL PROTECTION,
PEOPLE'S REPUBLIC OF CHINA
AND
THE SWISS CONFEDERATION, REPRESENTED BY THE SWISS
FEDERAL DEPARTMENT OF FOREIGN AFFAIRS, ACTING THROUGH
THE
SWISS AGENCY FOR DEVELOPMENT AND COOPERATION
ON
SINO-SWISS COOPERATION ON
CLEAN AIR LEGISLATION & POLICY PROGRAMME
AND CLIMATE CHANGE

The Ministry of Environmental Protection, People's Republic of China, (hereinafter referred to as "MEP") and the Swiss Confederation, represented by the Swiss Federal Department of Foreign Affairs, acting through the Swiss Agency for Development and Cooperation (hereinafter referred to as "SDC"), both of them hereinafter referred to as the "Parties";

The Parties are AWARE of the regional and global nature of the environmental issues and the need to find cost-effective and long-term solutions in addressing these issues through international cooperation and the importance of coordinating the joint activities of the two countries;

CCLP MOU

- 2011: a project of BC reduction from mobile sources was subsided by SDC to introduce the international experience, policies, know-hows of BC reduction to China from May of 2011 to May of 2015;



Contract
between
The Swiss Confederation, represented by the Federal Department of Foreign Affairs, acting through the Swiss Agency for Development and Cooperation (SDC), Cooperation Office in Beijing, China
and
Chinese Research Academy of Environmental Science (CRAES)
concerning
Reduction of Black Carbon Emissions from Mobile Sources
Credit Proposal: 7F-07823.01
Duration: From 10 May 2011 to 31 December 2013

Article 1 Object of the contract

1.1. The Swiss Confederation, represented by the Federal Department of Foreign Affairs acting through the Swiss Agency for Development and Cooperation (SDC), Cooperation Office in Beijing, China (hereinafter SDC), entrusts to Vehicle Emission Control Center, Chinese Research Academy of Environmental Science, (hereinafter the contractor) the execution of Reduction of Black Carbon Emissions from Mobile Sources (hereinafter the assignment) according to the terms of reference (annex 1).

Article 2 Budget

2.1. The budget (annex 2) amounts to a total of CNY 3,521,000 (Chinese Yuan Three Million, Five Hundred and Twenty-one Thousand) (hereinafter the budget). It must be presented in CNY. In addition to the funds provided by SDC, the budget must include any other funds available for the present assignment. (Disclosure of self-funding and other source of funding for the concerned project or assignment).

The budget fixes a cost limit. It shall include all fees, taxes and expenditures necessary for the execution of the assignment and must be respected.

2.2. Remuneration for services

The remuneration for the contractor's services amounts to a maximum of CNY 3,521,000 (Chinese Yuan Three Million, Five Hundred and Twenty-one Thousand) (hereinafter remuneration). It comprises of managerial and project implementation costs (budget local mandate for project implementation, part 1 and 2) or consultancy costs (budget local mandate for consultancy, section 1 – 3).

LOCAL MANDATE – Version February 2010 Page 1

Contract

BC Impacts on Environment, Climate and Health

Main Works

- Investigate and summarize the experience of PM/ BC control from mobile sources, suggestions submitted to support the policies/guidelines making for vehicle emission control;
- BC control tools and models further developed and disseminated;
- BC control technologies piloted in Beijing(non-road) and Nanjing, Xiamen(on-road);
- Diesel retrofit policy and management frameworks exchanged at city level;
- National after-treatment guideline for on-road vehicles proposed and submitted to MEP;

Project Outcomes

- Seminar and workshop:

  - October 2010:Technical workshop on DPF in Xiyuan Hotel; November 2011: Diesel vehicle retrofit workshop in Xindadu hotel;

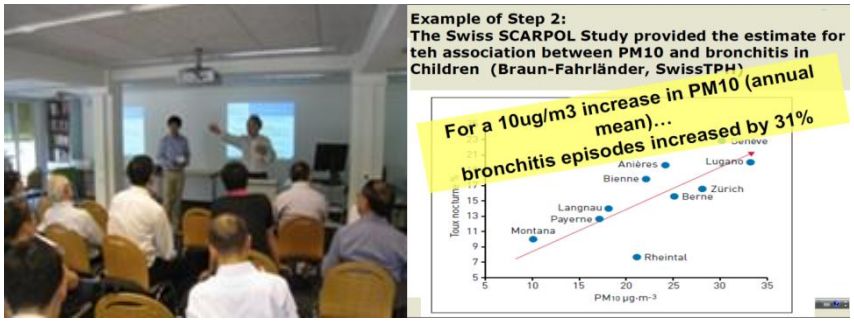
- Research on vehicle emission factors and inventory model development of in-use diesel vehicles

  - Mario Keller introduced the international vehicle emission factors; BC emission testing in China;

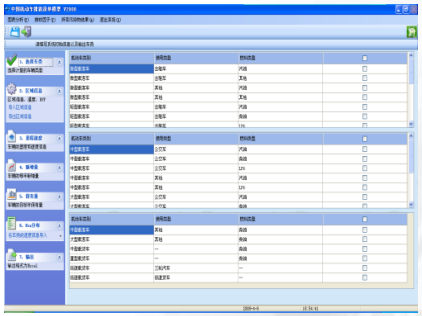
- Professor Nino Künzli of Swiss Tropical and Public Health Institute gave reports on urban air pollution and traffic-related air pollution on human health;

Forum on DFP retrofit

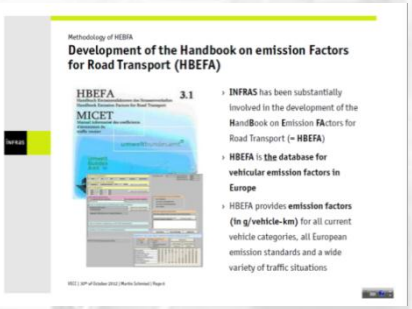
Emission Testing in VETC



Professor Kunzli gave presentations



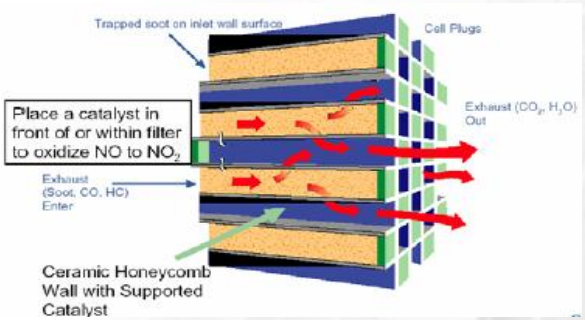
CVEM for BC inventor development



HBEFA

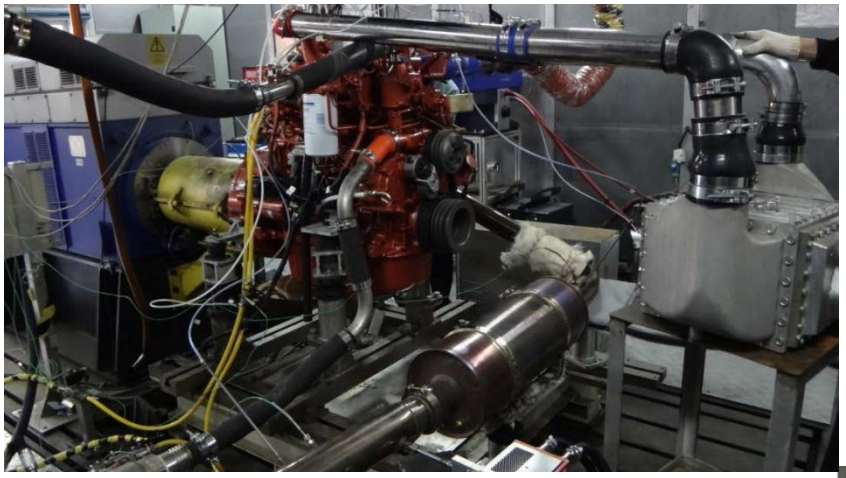
DPF Retrofit Program

- 20 on-road vehicles in Nanjing and Xiamen for 30,000km running; 25 construction machineries in Beijing;
- Lab evaluation of BC reduction technologies (on-road and off-road) in Xiamen and Jinan;
- National diesel vehicle aftertreatment guideline is drafted based on experience learned through test bench evaluation and pilot tests and international retrofit experiences;

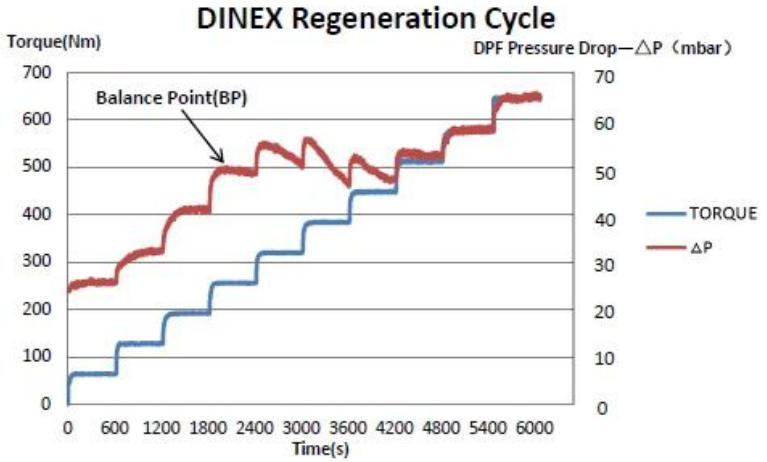


Wall-flow DPF

DPF Evaluation Test Bench



DPF Test Bench



Regeneration Test

Specification of Test Engine

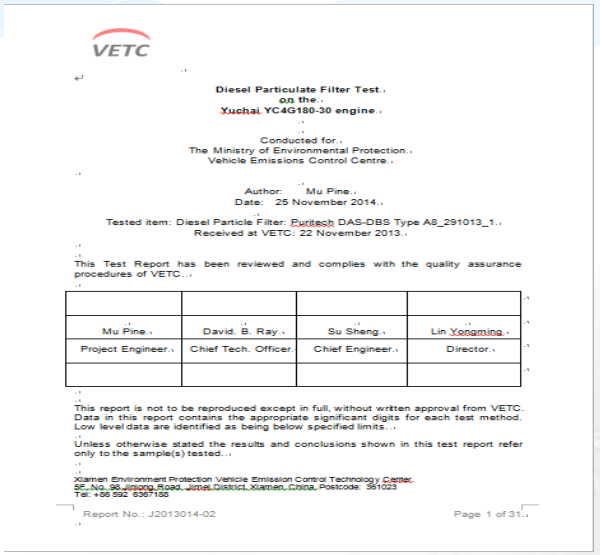
Manufacturer / type	YC4G180-30
Emission legislation level	GUO3 (=EU3)
Cylinder number and configuration	4 cylinders in-line
displacement	5.424 [L]
Compression ratio	17.5 [-]
Cooling medium (air,	Water
	direct injection
	None
	None
	.32[kW] @ 2300 [min^{-1}]

Test Protocol Discussion with Swiss Experts

Bench Evaluation(1)

Puritech DAS-DBS(Active Regeneration)

PMFE	Ref	New	Reg.	New	Reg
	PM	PM	PM	PMFE	PMFE
	[g/kWh]	[g/kWh]	[g/kWh]	[%]	[%]
1500rpm,645Nm	0.044	0.016	0.012	62.5	73.7
1500rpm,322Nm	0.074	0.018	0.007	75.3	90.7
2300rpm,273Nm	0.084	0.013	0.007	84.0	91.7
2300rpm,544Nm	0.097	0.014	0.012	85.8	87.8
1500rpm,645Nm	0.057	0.009	0.008	83.7	86.1



VETC

Diesel Particulate Filter Test
on the
Yuchai YC4G180-30 engine

Conducted for
The Ministry of Environmental Protection
Vehicle Emissions Control Centre

Author: Mu Pine
Date: 25 November 2014

Tested item: Diesel Particle Filter: Puritech DAS-DBS Type A8_291013_1
Received at VETC: 22 November 2013

This Test Report has been reviewed and complies with the quality assurance procedures of VETC.

Mu Pine	David. B. Ray	Su Sheng	Lin Yongming
Project Engineer	Chief Tech. Officer	Chief Engineer	Director

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Unless otherwise stated the results and conclusions shown in this test report refer only to the sample(s) tested.

Xiamen Environment Protection Vehicle Emission Control Technology Center
SF, No. 98 Jinsong Road, Jimei District, Xiamen, China, Postcode: 361023
Tel: +86 592 6367188

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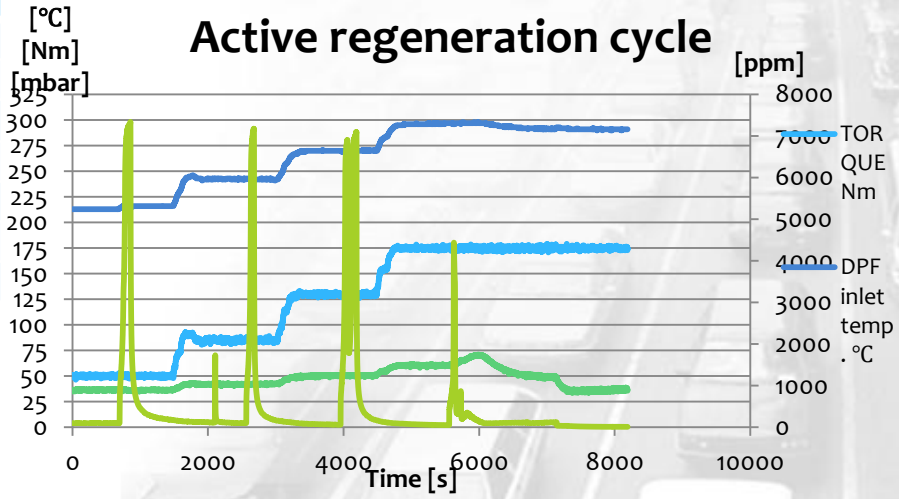
PNFE ViPR	Ref	New	Reg.	New	Reg
	PN	PN	PN	PNFE	PNFE
	[#/ccm]	[#/ccm]	[#/ccm]	[%]	[%]
1500rpm,645Nm	1.53E+07	3.06E+06	2.40E+06	80.0	84.4
1500rpm,322Nm	2.06E+07	1.99E+06	2.18E+06	90.3	89.4
2300rpm,273Nm	2.68E+07	2.38E+06	2.50E+06	91.1	90.7
2300rpm,544Nm	3.20E+07	3.90E+06	4.13E+06	87.8	87.1
1500rpm,645Nm	1.60E+07	1.78E+06	1.76E+06	88.9	89.0

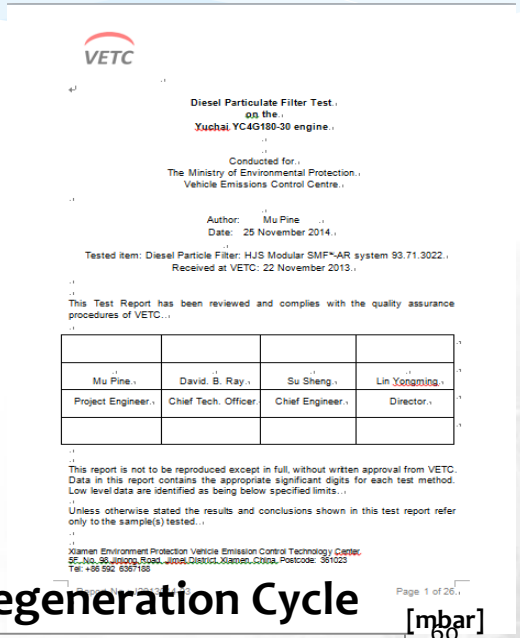


Bench Evaluation(2)

HJS Modular SMF®-AR system

PMFE	Ref	New	Reg.	New	Reg
	PM	PM	PM	PMFE	PMFE
	[g/kWh]	[g/kWh]	[g/kWh]	[%]	[%]
1500rpm,645Nm	0.044	0.009	0.009	78.84	80.52
1500rpm,322Nm	0.074	0.016	0.006	78.83	91.74
2300rpm,273Nm	0.084	0.014	0.002	83.69	97.92
2300rpm,544Nm	0.097	0.010	0.011	90.06	88.48
1500rpm,645Nm	0.057	0.009	0.007	84.79	88.09

*PNFE ViPR	Ref	New	Reg.	New	Reg
	PN	PN	PN	PNFE	PNFE
	[#/ccm]	[#/ccm]	[#/ccm]	[%]	[%] [℃]
1500rpm,645Nm	1.53E+07	2.99E+04	9.71E+03	99.805	99.94
1500rpm,322Nm	2.06E+07	3.94E+03	7.92E+02	99.981	100.00
2300rpm,273Nm	2.68E+07	2.47E+03	5.18E+02	99.991	100.00
2300rpm,544Nm	3.20E+07	2.18E+04	5.45E+03	99.932	99.98
1500rpm,645Nm	1.60E+07	1.02E+04	1.55E+02	99.936	100.00



VETC

Diesel Particulate Filter Test
on the
Yuchai YC4G180-30 engine

Conducted for
The Ministry of Environmental Protection
Vehicle Emissions Control Centre

Author: Mu Pine
Date: 25 November 2014

Tested item: Diesel Particle Filter: HJS Modular SMF®-AR system 93.71.3022
Received at VETC: 22 November 2013

This Test Report has been reviewed and complies with the quality assurance procedures of VETC.

Mu Pine	David. B. Ray	Su Sheng	Lin Yongming
Project Engineer	Chief Tech. Officer	Chief Engineer	Director

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Tel: +86 592 6367186

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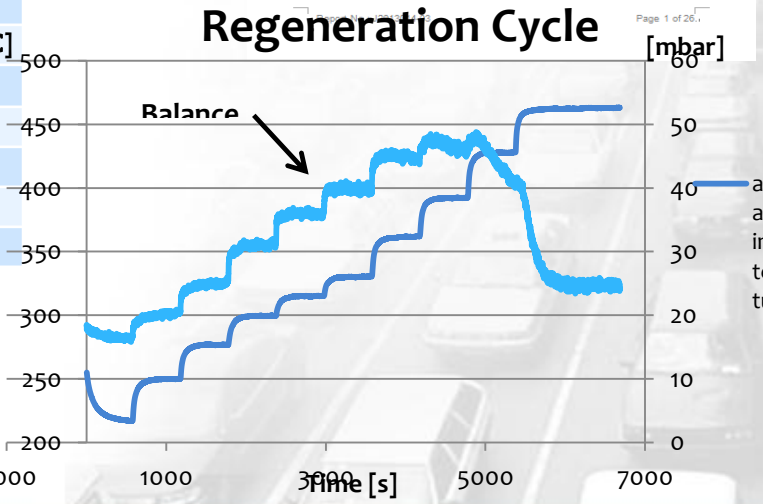
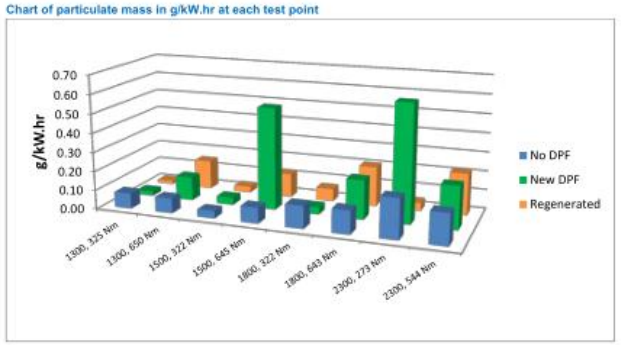
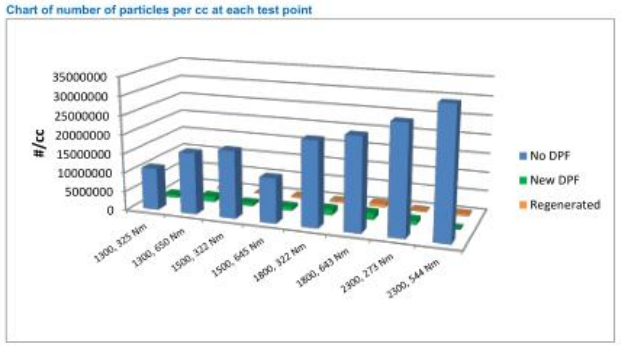


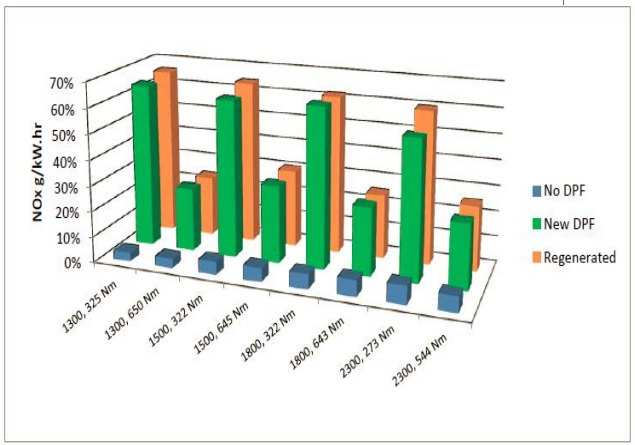
Bench Evaluation(3)

Dinex (coated and uncoated)

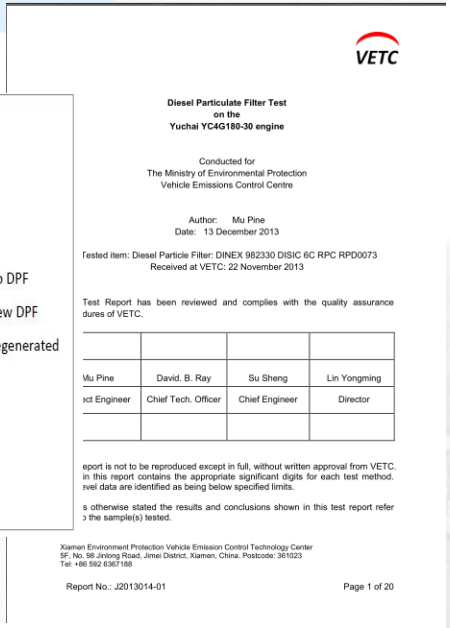


There was no consistent reduction in Particulate Mass with either the new filter or with the filter following regeneration. At two test points (1500 rev/min 322 Nm and 2300 rev/min 273 Nm) the measured particulate mass with the new filter was significantly higher than with no filter installed. This is in contrast to the Particle Number (PN) determinations where the filter reduced the particle count to a much lower level.





NO2 increase with Pt coated DPF



VETC

Diesel Particulate Filter Test on the Yuchai YC4G180-30 engine

Conducted for
The Ministry of Environmental Protection
Vehicle Emissions Control Centre

Author: Mu Pine
Date: 13 December 2013

Tested item: Diesel Particle Filter: DINEX 982330 DISIC 6C RPC RPD0073
Received at VETC: 22 November 2013

Test Report has been reviewed and complies with the quality assurance dures of VETC.

Mu Pine	David. B. Ray	Su Sheng	Lin Yongming
ect Engineer	Chief Tech. Officer	Chief Engineer	Director

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Tel: +86 592 6367188

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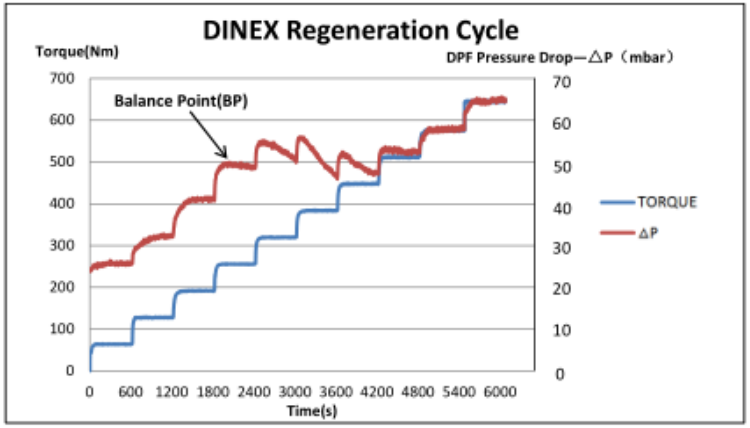
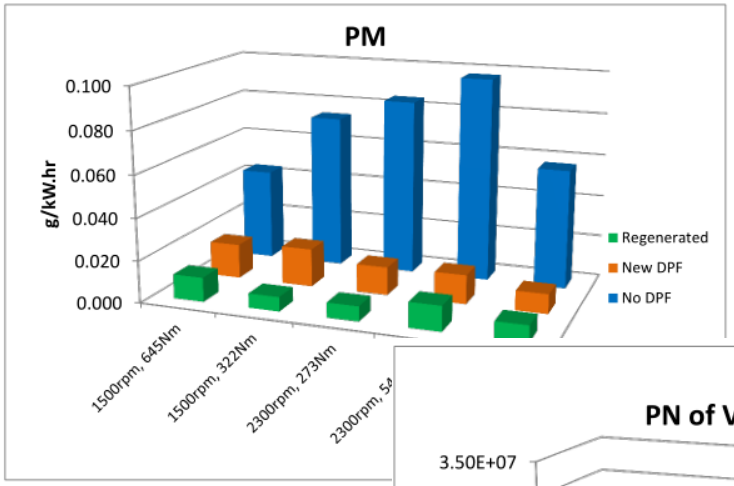
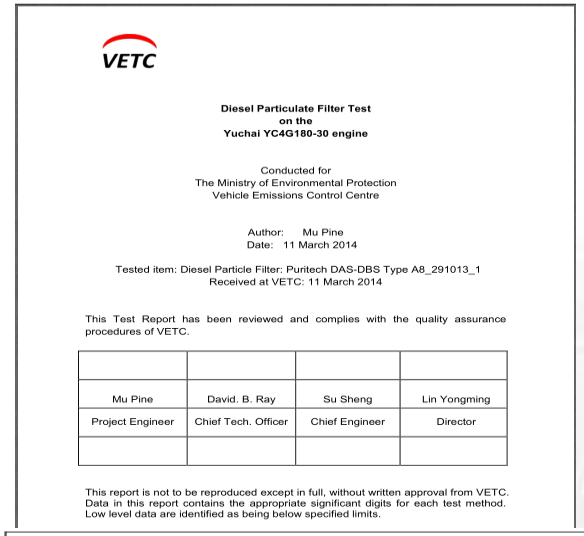


Bench Evaluation(4)

Puritech DAS-DBS(Passive Regeneration);





VETC

Diesel Particulate Filter Test
on the
Yuchai YC4G180-30 engine

Conducted for
The Ministry of Environmental Protection
Vehicle Emissions Control Centre

Author: Mu Pine
Date: 11 March 2014

Tested item: Diesel Particle Filter: Puritech DAS-DBS Type A8_291013_1
Received at VETC: 11 March 2014

This Test Report has been reviewed and complies with the quality assurance procedures of VETC.

Mu Pine	David. B. Ray	Su Sheng	Lin Yongming
Project Engineer	Chief Tech. Officer	Chief Engineer	Director

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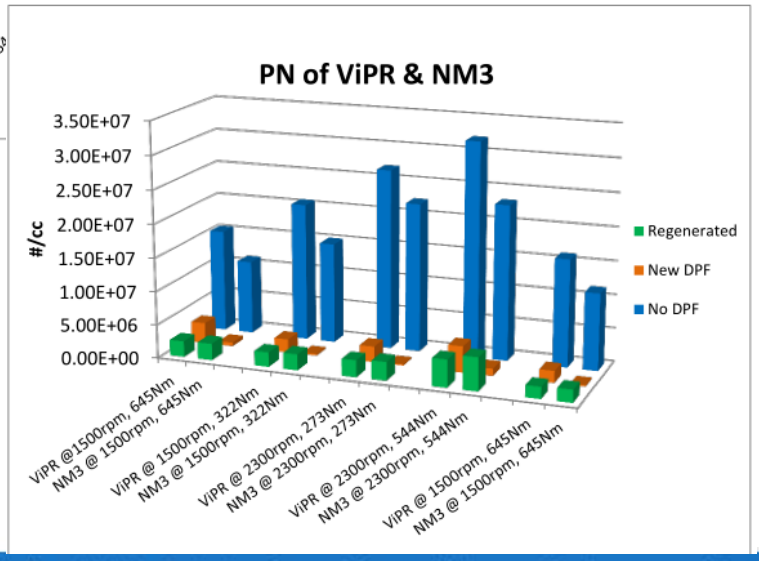
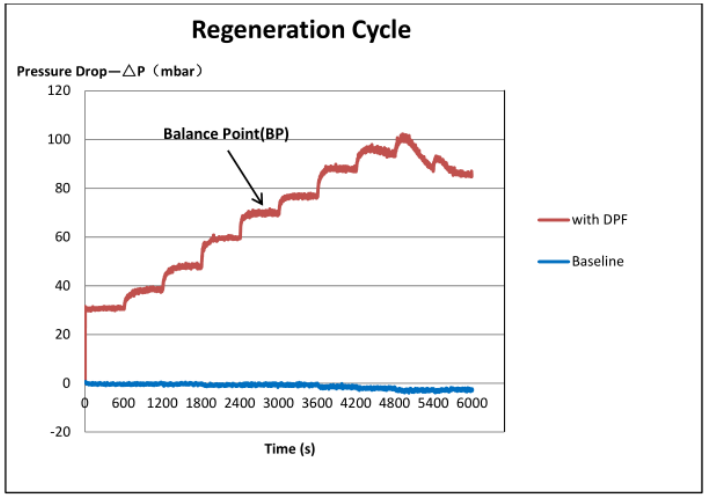




Fleet Selected for DPF Pilot Test

车辆选择

Subject: Vehicle Description and Evaluation

车辆描述和评价

Test vehicle name: 苏 A-32293. 测试车辆.	Test fleet code: [redacted]. NJ-007.

Contacts.	
Owner company. 所属公司. contact person / e-mail / mobile phone. 联系人/电子邮箱/联系电话.	JiangSu KuaiLu Trans Mr Zhou Peidong KLzp
Operator company. 驾驶员公	
contact p 联系人/电	
Operatio 工作地点	
Inspectio 检查日期	

Test phase: 3.1 Selection of Test V
车辆选

Subject: Vehicle Description and
车辆描述

Test vehicle name: 测试车辆: 闽 D89330.	Tes XM

Conta	
Owner company. 所属公司. contact person / e-mail / mobile phone. 联系人/电子邮箱/联系电话.	Xia Ch
Operator company. 驾驶员公司. contact person / e-mail / mobile phone. 联系人/电子邮箱/联系电话.	Xia Ch
Operation site. 工作地点.	Xia
Inspection date and site. 检查日期及地点.	Xia

Vehicle Spec	
Type of usage. 使用类型.	☐ s
Vehicle manufacturer ("brand") and vehicle type. 车辆厂家和车辆类型.	King[illegible] KLQ6830. large passenger vehicle.
Vehicle identification or registration number. 车辆识别码及号牌.	闽 D89330；LKLR1DS9XAA550105.
Engine manufacturer and engine type. 发动机厂家及类型.	Yuchai Machinery YC4G180-30.
Engine emissions standard. 排放阶段.	China III.
Engine displacement & cylinder number. 发动机排量&汽缸数.	5200ML；4cylinder.
Engine production year & op. time [hrs] or [km]. 发动机生产年份&行驶里程或运行时间.	2010 October，11000KM.
Rated power [kW] at nominal RPM [1/min]. 额度转速下的额度功率.	132KW.
Fuel injection (common rail, unit pump?). 燃油喷射系统(高压共轨或者单体泵).	common rail.
Turbocharging & intercooling. 涡轮增压&中冷.	Turbocharging.
EGR, water-cooled?. 废气再循环，是否水冷？.	否.
Fuel supplier, type & sulfur content [ppm]. 柴油供含量.	350ppm.
Fuel consumption [l/h] or [l/100km].	

Vehicle Information of Nanjing

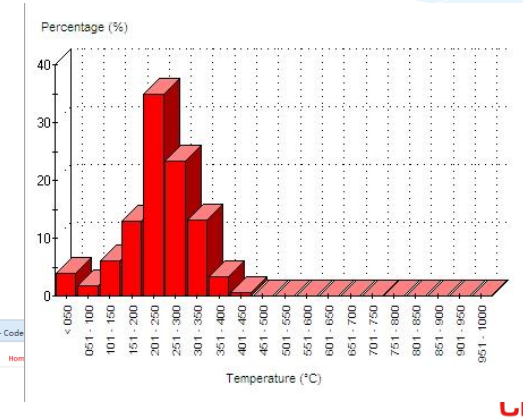
No.	Licence No.	Vehicle Kind	Year /Mileage	Vehicle Brand & Model	Engine Model	Power kW	Displacement dm^3	Emission Class	Opacity 1/m	DPF selected
1	A32292	Long distance coach	2001/233 731	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	0.81	Dinex
2	A33751	Long distance coach	2002/210 6343	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	0.7	Dinex
3	A34568	Long distance coach	2002/206 1034	XiAn/VOLVO B10M	VOLVO DH 10	210	9.6	China Ⅱ	0.42	Dinex
4	A31695	Long distance coach	2001/226 5342	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	1.39	Dinex
5	A33377	Long distance coach	2001/222 5117	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	1.57	Dinex
6	A33742	Long distance coach	2002 1.95 Mio.	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	1.56	Puritech
7	A33694	Long distance coach	2002 2.17 Mio.	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	1.23	Puritech
8	A33753	Long distance coach	2002 2.23 Mio.	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	1.33	Puritech
9	A33755	Long distance coach	2002 2.21 Mio.	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	1.45	Puritech
10	A39358	Long distance coach	2002 1.81 Mio.	XiAn/VOLVO B10M	VOLVO THD 102	210	9.6	China Ⅱ	0.25	Puritech

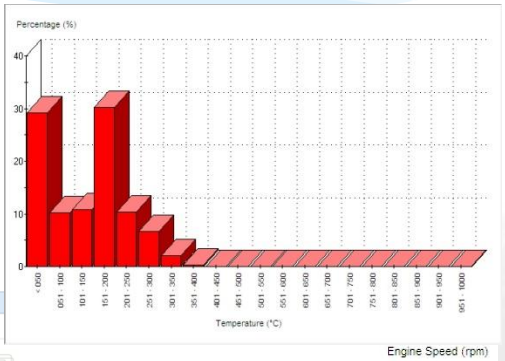
Vehicle Information of Xiamen

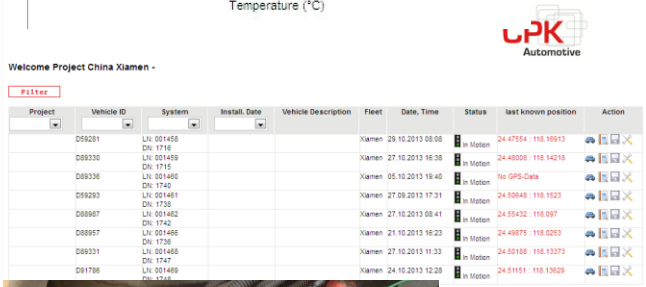
No.	Vehicle Licence No.	Vehicle Kind	Year Mileage [km]	Vehicle Brand & Model	Engine Brand	Power [kW]	Displacement [dm³]	Opacity [1/m] PN [#/cc]	Emissi Class	Filter
1	D59289	City-Bus	2010 193286	Suzhou HIGER KLQ 6856E3	YUCHAI YC4G 200-30	147	5.2	0.19 2.9×10^6	China 3	DINEX active
2	D88987	City-Bus	2010 249623	King Long LKQ 8656	YUCHAI YC4G 180-30	132	5.2	0.16 2.9×10^6	China 3	DINEX active
3	D59293	City. Bus	2010 85711	Suzhou HIGER KLQ 6856E3	YUCHAI YC4G 200-30	147	5.2	0.35 2.9×10^6	China 3	DINEX active
4	D59281	City-Bus	2010 145929	Suzhou HIGER KLQ 6856E3	YUCHAI YC4G 200-30	147	5.2	0.45 2.9×10^6	China 3	DINEX active
5	D88957	City-Bus	2010 140507	King Long LKQ 8656	YUCHAI YC4G 180-30	132	5.2	0.33 2.9×10^6	China 3	DINEX active
6	D89330	City-Bus	2010 148709	King Long LKQ 8656	YUCHAI YC4G 180-30	132	5.2	0.25 2.9×10^6	China 3	Puritech active
7	D89336	City-Bus	2010 121535	King Long LKQ 8656	YUCHAI YC4G 180-30	132	5.2	0.22 2.9×10^6	China 3	Puritech active
8	D89331	City-Bus	2010 155383	King Long LKQ 8656	YUCHAI YC4G 180-30	132	5.2	0.14 2.9×10^6	China 3	Puritech active
9	D59290	City-Bus	2010 147140	King Long LKQ 8656	YUCHAI YC4G 180-30	132	5.2	0.5 2.9×10^6	China 3	Puritech active
10	D59283	City-Bus	2010 202543	King Long LKQ 8656	YUCHAI YC4G 180-30	132	5.2	0.5 2.9×10^6	China 3	Puritech active

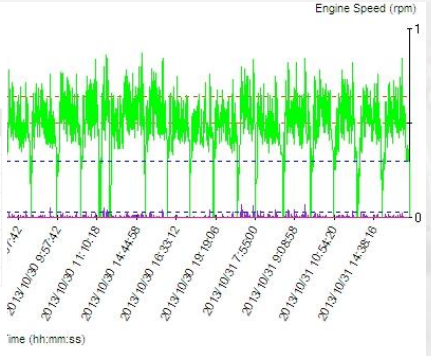
DPF Selection Based on Running Condition Monitoring

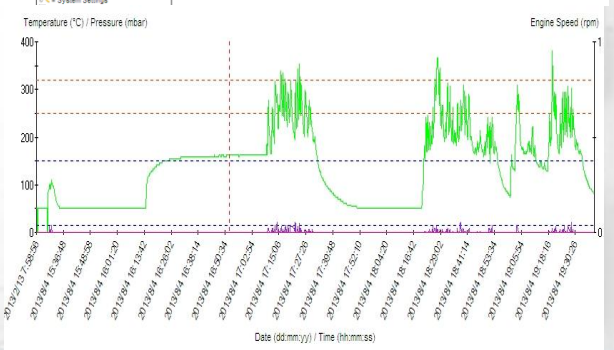
- Running Condition was monitored with CPK software vehicle by vehicle.
- With the feedback information from the datalogger, Puritech , Dinex,HJS DPFs were allocated to different vehicles and machineries.
- VECC and Swiss experts check the vehicles for the DPF preparation and DPF installed in July and August, 2013.











DPF Test

- Focused on PN efficiency testing ;
- Measurement with 2 NanoMet3 in parallel;
- Nanjing:

  -Measurement 1: August 2014 DPF installation

  -Measurement 2: January 2015 after about 100'000 km of operation
- Xiamen:

  -Measurement 1: September 2014 after DPF installation

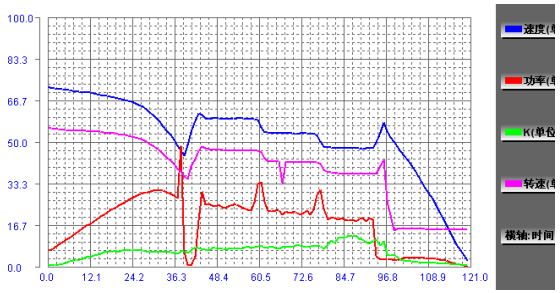
  -Measurement 2: January 2015 after about 30'000 km of operation (estimate)
- Test Method:

  -PN concentration testing using LUGDOWN mode cycle on Chassis dynameters;

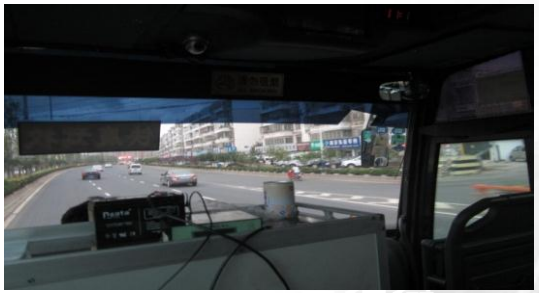
  -Real-world running testing with instruments equipped on vehicles;

DPF installation

DPF Test on Chassis Dyno.



LUGDOWN Running Mode

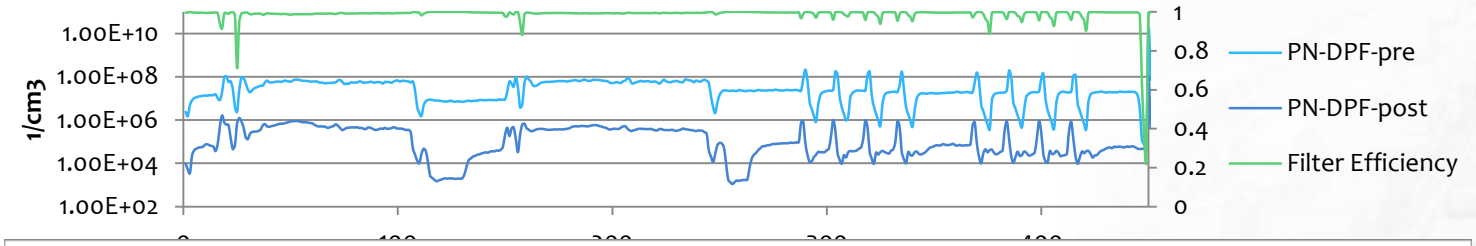


Real world PN Testing

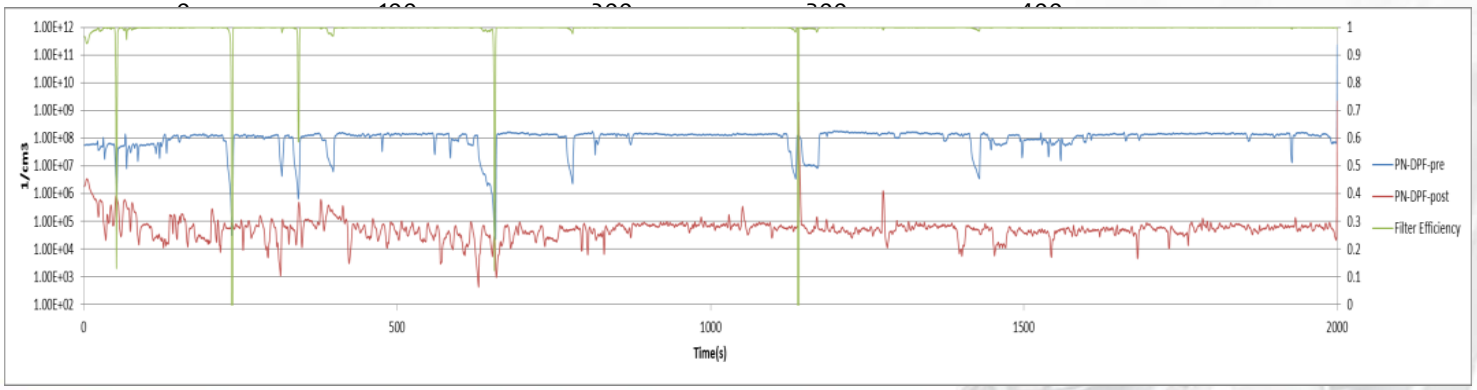
Test Results in Nanjing

Vehicle	1 A34568 DINEX	2 A31695 DINEX	3 A32292 DINEX	4 A33377 DINEX	5 A33751 DINEX	6 A33694 Puritech	7 A33742 Puritech	8 A33753 Puritech	9 A33755 Puritech	10 A39358 Puritech
1 - Dyno	99.91	99.94	-	99.91	90.39	-	91.45	-	99.45	99.86
1 - Road	99.96	99.38	99.94	99.92	86.00	99.81	97.76	-	99.95	99.15
2 - Dyno	58.43	69.65	99.35	97.12	96.93	79.48	83.01	97.82	95.56	95.72
2 - Road	99.78	48.83	99.11	82.85	93.22	21.85	63.01	99.14	97.44	79.20

Dyno



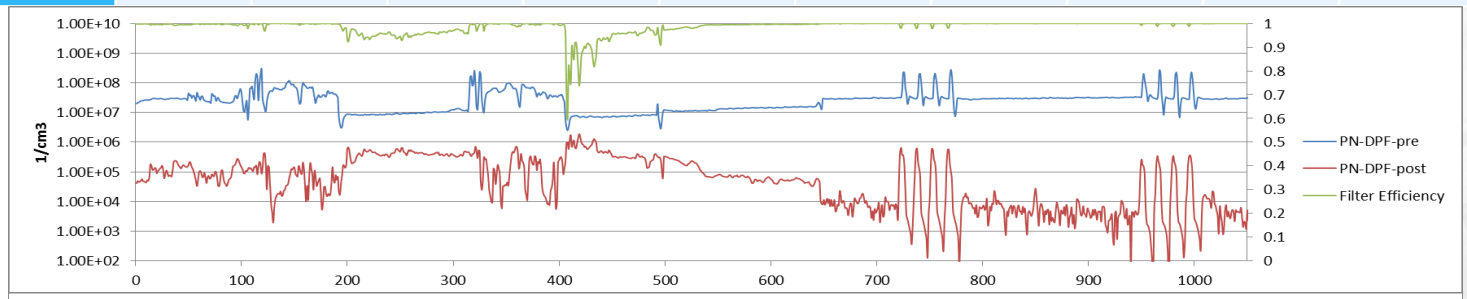
Road



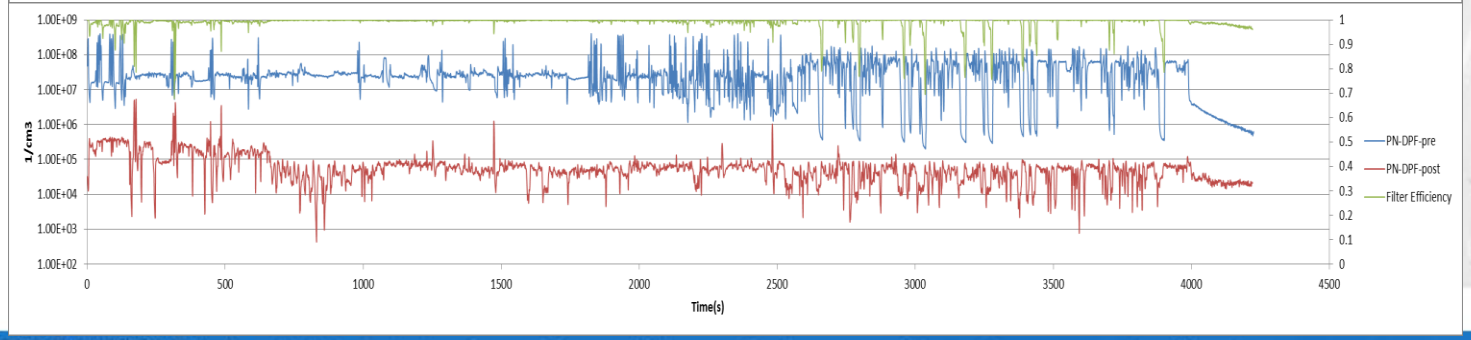
Test Results in Xiamen

Vehicle	1 D59281 DINEX	2 D59289 DINEX	3 D59293 DINEX	4 D88987 DINEX	5 D88957 DINEX	6 D89330 Puritech	7 D89331 Puritech	8 D89336 Puritech	9 D59290 Puritech	10 D59283 Puritech
1 - Dyno	98.76	99.50	99.08	98.85	96.96	97.20	98.67	97.42	94.17	91.03
1 - Road	99.20	99.82	98.34	97.65	99.54	98.06	98.47	98.97	96.76	-
2 - Dyno	94.98	98.20	85.92	91.11	94.75	99.14	95.60	93.91	93.72	77.93
2 - Road	99.55	99.78	97.92	80.92	94.05	99.91	99.57	99.24	95.02	62.48

Dyno



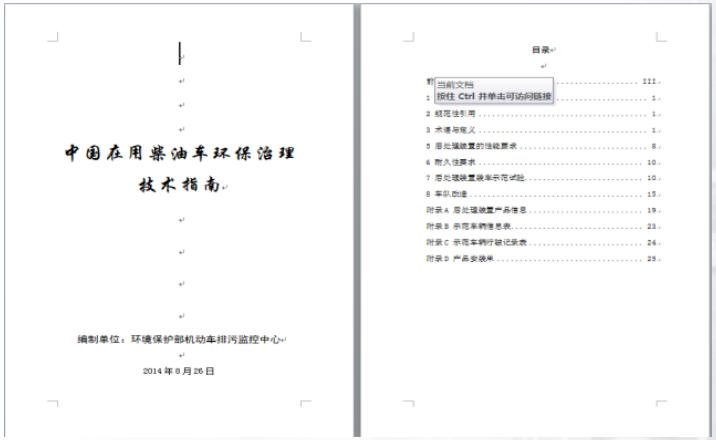
Road



Technical Guideline

- National diesel vehicle after-treatment guideline drafted for opnions;

- Scope of application
  Normative reference
  Terms and definitions
- Performance requirements for after-treatment device
- Requirement of durability
- Loading demonstration test of after-treatment device
- Fleet retrofit
- Appendix A: Information of after-treatment device
- Appendix B Information table of demonstrative vehicle
- Appendix C Tachograph of demonstrative vehicle
- Appendix D Product installation form

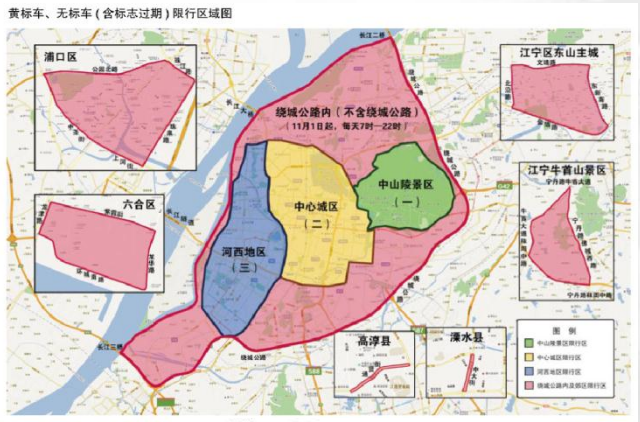


National Guideline

Nanjing Retrofit Program

First Stage of Retrofit program:2013.8.1~2014.8.1

- Large driving restriction areas for yellow labeled vehicles;
- Green labels applied to original yellow labeled vehicles after retrofitted;
- No subsidies from the government;
- So far, there are more than 2000 vehicles (bus\ heavy duties) be retrofitted;



Xiamen is considering the similar policies on diesel vehicle PM control.

Suggestions

- DPFs show high PMPN reduction potentials;
- Retrofit guideline is necessary for DPF evaluation and durability check ;
- Related policies is needed to improve the owner’s incentives ;
- Development of DPF promotion and application mechanism in a large scale;
- non-road mobile sources of pollution prevention and control strengthen needed;

Thanks for

your attention!