

Exhaust Emission Test Result of Heavy-duty Gasoline Engine with WHDC Test Procedure

JASIC

**Prepared for WHDC-WG Beijing
October, 2008**

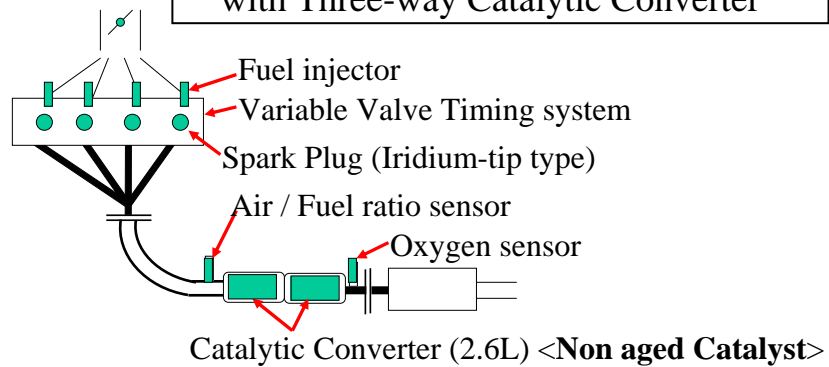
Contents

1. Test engine
2. Test condition
3. Modification in the definition of High Speed (Nhi)
for WHDC (WHTC+WHSC) test cycle
4. Test result
5. Issues for expanding the scope for gasoline
engine

1. Test engine

- Type : L4 ● Displacement : 2.7 L
- Max. Power : 108 kW@ 4,800 r/min
- Fuel : Petrol

- Multi-point Fuel Injection
- Closed-loop Air/Fuel Feedback system with Three-way Catalytic Converter



2. Test condition

	Transient Cycle	Steady State Cycle
UN-GTR	WHTC	WHSC
Japan	JE05	—
Europe	ETC	ESC

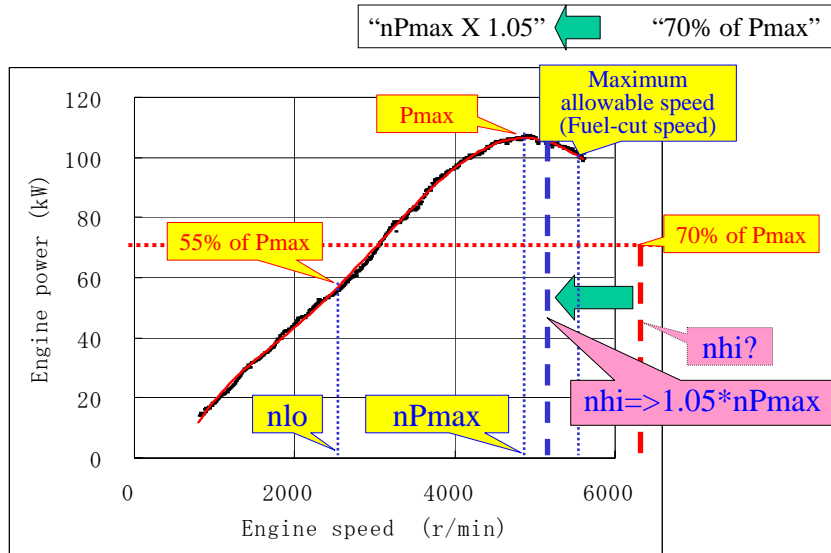
For emissions measurement full flow dilution system (CVS system) are used except ESC cycle.

For ESC cycle direct measurement of raw exhaust gas are used.

3. Modification in the definition of High Speed (Nhi) for WHDC (WHTC+WHSC) test cycle

5

Definition of "nhi". is modified to 1.05* Max .power speed



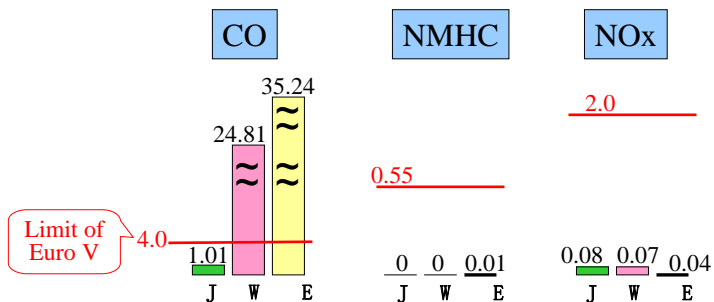
4. Test result

6

4.1. Transient cycle

<Unit:g/kWh>

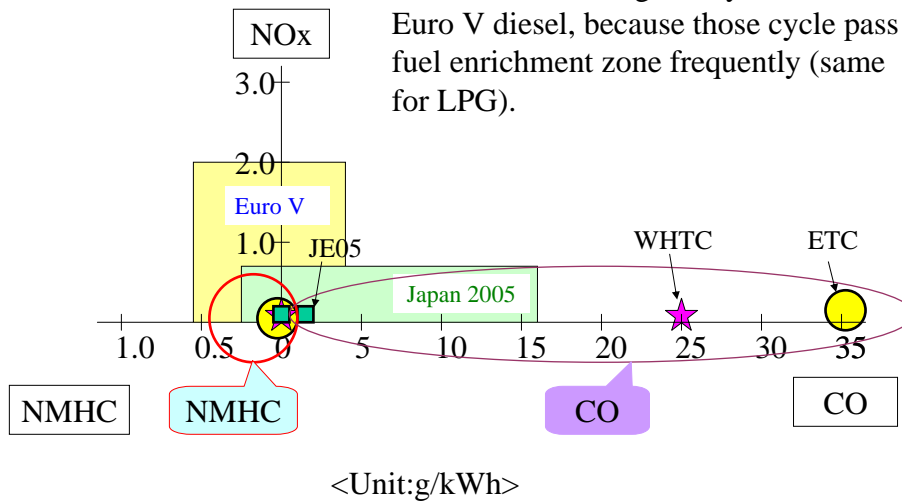
	CO	THC	NMHC	NOx	CO2	Work load <kWh>
JE05	1.01	0.00	0.00	0.08	1259	4.2
WHTC	24.81	0.00	0.00	0.07	979	8.7
ETC	35.24	0.04	0.01	0.04	877	13.3



4. Test result (Transient cycle ; Continued)

7

In the case of WHTC and ETC, CO emission exceed regulatory limit for Euro V diesel, because those cycle pass fuel enrichment zone frequently (same for LPG).



4.1. Transient cycle <Engine driving map>

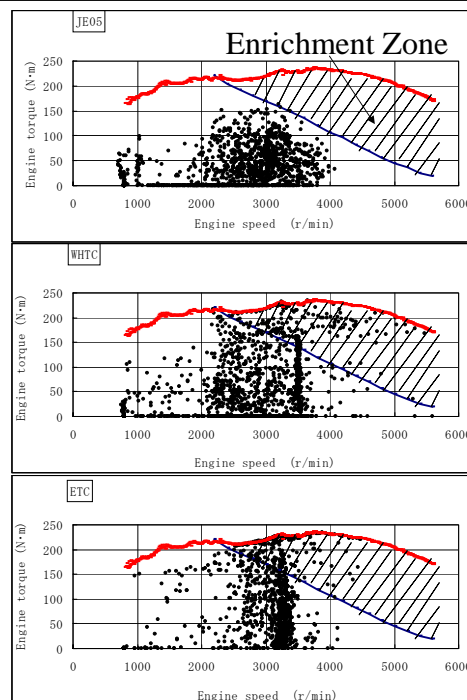
8

JE05 does not pass the enrichment zone

JE05

WHTC

ETC

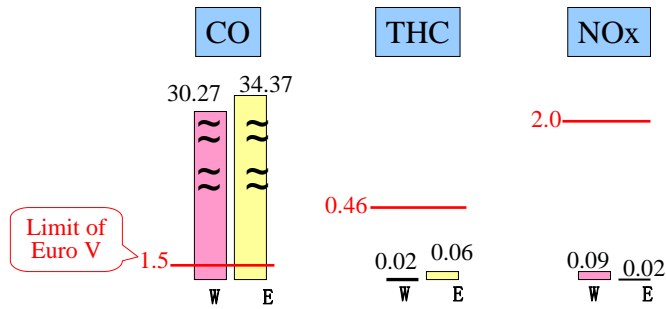


4. Test result

4.2 Steady state cycle

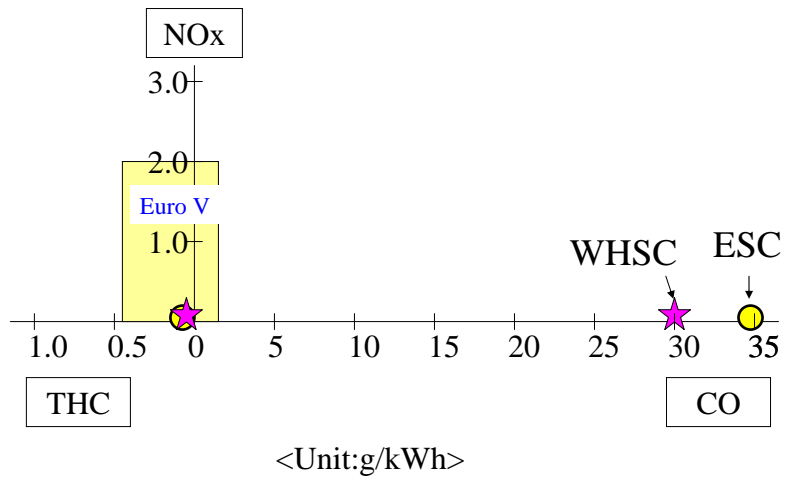
<Unit:g/kWh>

	CO	THC	NMHC	NO _x	CO ₂	Work load <kWh>
WHSC	30.27	0.02	0.01	0.09	915	12.2
ESC	34.37	0.06	—	0.02	—	—



4. Test result

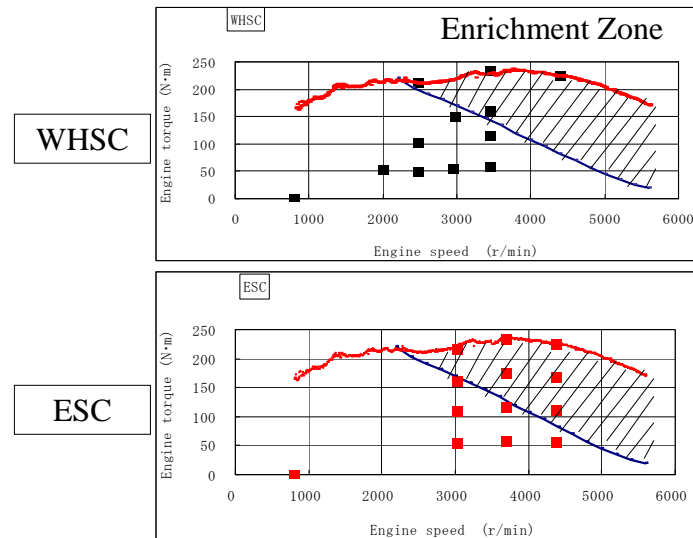
4.2. Steady state cycle



4.2. Steady state cycle

11

< Engine driving map >



12

5. Issues for WHDC to gasoline (and LPG, CNG) engines

- A) Need to redefine the zone for test cycle. N_{hi} defined by 70% of max power curve may exceed maximum allowable speed (fuel cut speed) of the engine.
- B) In Japan those Otto-cycle engines are mainly for in-city short-haul delivery use, resulting fairly low speed operation. And so Japan recommend N_{hi} definition less than 1.05* maximum power speed. It is preferable to examine the actual driving pattern for those Otto-cycle powered commercial vehicle of GVW>3.5ton.

5. Issues for WHDC to gasoline (and LPG, CNG) engines; (Cont'd)

- C) To meet tighter emission regulations Otto-cycle engine need stoichio-metric combustion with 3-way catalyst and fuel enrichment control which is necessary for catalyst/engine protection.
- D) CO emission will increase by enrichment.
- E) It will be necessary for Otto-cycle engines with enrichment, to examine;
- (1) Need for steady-state emission testing
 - (2) Need to redefine WWH-OCE protocol for example WNTe zone and factor.

Heavy-Duty Engine Emission Regulatory Limit (Unit; g/kwh) (Except Diesel Engine and PM limit)

	Fuel type			Test Cycle	Regulation	CO	THC	NMHC	NOx	NMHC +NOx
	Gasolin	LPG	NG							
JAPAN (average limit)	X	X			2005	16.0		0.23	0.7	
			X	JE05	2005	16.0	NA	0.17	1.0	NA
			X		2009	16.0		0.17	0.5	
EU (Manufacturer can chose THC or NMHC)	X	X			EURO III	5.45	0.78	0.78	5.0	
	X	X		ETC	EURO IV	4.0	0.55	0.55	3.5	
	X	X			EURO V	4.0	0.55	0.55	2.0	NA
				ESC	EURO III	2.1	0.66		5.0	
					EURO IV	1.5	0.46	NA	3.5	
US (GVW of up to 14,000 lbs.)					EURO V	1.5	0.46		2.0	
	X	X			1991	19.3	1.48		6.71	NA
	X	X			1998	19.3	1.48	NA	5.36	
	X	X			2005	19.3			NA	1.34
	X	X		US	2008	19.3	NA	0.19	0.27	NA
			X	FTP	1991	19.3		1.21	6.71	NA
			X		1998	19.3	NA	1.21	6.71	NA
			X		2005	19.3		NA	NA	1.34
		X		2008	19.3		0.19	0.27	NA	

Thank you for your attention