

# Development of Heavy-Duty On-Highway Engine Regulations in the U.S.

The 4<sup>th</sup> SINO-US Workshop on Motor Vehicle Pollution Prevention and Control

U.S. Environmental Protection Agency  
Office of Transportation and Air Quality

## Heavy-Duty On-Highway Industry

- Heavy-duty vehicles in the U.S. have gross vehicle weight ratings (GVWR) of 8501 pounds and greater
  - Some vehicles in the 8501 – 14,000 GVWR can optionally certified to passenger car and light-duty truck test procedures
    - Heavy-duty pick up trucks and cargo vans which are similar to light-duty vehicles
  - Engine testing for all vehicles with GVWR > 14,000 pounds
    - Vocational Vehicles
      - Small delivery trucks, dump trucks, school and transit buses
    - Line Haul
      - Long haul tractor trailers
- 10 -12 manufacturers who certify in the U.S.
  - Typically 400,000-500,000 engines a year
  - 30 to 40 engine families
  - Accounts for approximately 20% of PM, 35% of NOX inventories in the U.S.

**Intended Service Classes  
Covered by Emission  
Standards**

**Light Heavy-Duty Diesel  
Engines**  
8,500 – 19,500 lbs GVWR



Pickups



Step Vans

**Medium Heavy-Duty Diesel Engines**

19,500 – 33,000 lbs GVWR



Utility Trucks



Parcel Delivery Trucks

**Heavy Heavy-Duty Diesel Engines**

> 33,000 lbs GVWR



Refuse Haulers



Line-haul Trucks

**Timeline for Heavy-Duty Diesel Engine  
Standards**

- 1970-1973 Only smoke opacity standard for diesel engines over test cycle still used today
- 1974 – For emission standard for HC+NOx (16 g/hp-hr) and CO (40 g/hp-hr) over 5 year and 100,000 mile useful life
  - 13 mode, 10 non-idle modes, steady state test
- 1978 Lower steady state NOx, HC and CO emissions
  - Also provisions for optional lower NOx but higher CO standard
- 1985 10.7 g/hp-hr NOx, 1.3 g/hp-hr HC, and 15.5 g/hp-hr CO standard measured over new transient test cycle
  - Useful lives
    - Heavy-heavy engines in vehicles with GVWR > 33,000 pounds - 8 years, 290,000 miles
    - Medium-heavy engines in vehicles with GVWR between 19,500 and 33,000 pounds - 8 years, 185,000 miles
    - Light-heavy engines in vehicle with GVWR < 19,500 pounds – 8 years, 110,000 miles
- 1988 first PM standard for diesel engines - 0.60 g/hp-hr
- 1988-1990 Development of first electronically controlled diesel heavy-duty engines

## Timeline for Heavy-Duty Diesel Engine Standards

- 1990 - NOx lowered from 10.7 to 6.0 g/hp-hr
- 1991 - 5.0 NOx Standard, 0.25 PM standard
  - New low sulfur, 300-500 ppm diesel fuel
  - Averaging, Banking and Trading (ABT) for NOx and PM Emissions
- 1994 - New 0.10 g/hp-hr PM standard
  - First Diesel Oxidation Catalyst (DOCs)
- 1998 – New 4.0 g/hp-hr NOx standard
  - End of mechanically fuel injected engines
- 1998 Heavy-Duty Consent Decree
  - A large number of manufacturers controlling emissions to standard only in the test cell, NOx emissions 2-3 times higher in-use
  - Led to develop of Not-to-Exceed (NTE) standards and use of Supplemental Emissions test
  - Consent decree manufacturers required to certify early to 2004 standards

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## Timeline for Heavy-Duty Diesel Engine Standards

- 2002 - Consent Decree manufacturers pull ahead 2.5 NMHC +NOx standard
  - First use of Exhaust Gas Recirculation (EGR) on heavy-duty diesel engines
    - Introduction of common rail fuel injection
    - Allows some engines to meet the standard with DOC but no EGR
- 2004 – All manufacturers must meet 2.5 NMHC +NOx standard
  - Useful life for heavy-heavy engines increases to 10 years, 435,000 miles or 22,000 hours
    - Light-heavy and medium heavy duty useful live increase to 10 years with same mileages
- 2007 – 0.01 PM and 0.14 g/hp-hr standards and phase-in of 0.20 g/hp-hr NOx standard
  - Wall flow DPFs
  - All manufacturers certify to a NOx standard mid way between 2004 and 2010
    - Higher EGR flow rates
    - Up to a 3% fuel economy penalty
  - Supplemental Emissions Test and NTE in addition to transient test
- 2007 - Manufacturer run in-use testing program begins for gaseous pollutants
  - Uses Portable Emissions Measurement System (PEMs) on in-use vehicles versus NTE standards

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## Timeline for Heavy-Duty Diesel Engine Standards

- 2010 – NO<sub>x</sub> standard 0.20 g/hp-hr 100% phased in
  - Selective Catalytic Reduction (SCR)
    - Heavy-duty vehicles limited to 5 miles per hour if SCR not working
- 2010 – Heavy-duty On-Board Diagnostics (OBD) begin
- 2014 – Heavy-duty Greenhouse Gas Standards for engines and vehicles
  - Separate standards for vocational and tractor trailer engines and vehicles
  - Vehicle standards are model based reduction not actual measurements from vehicles
    - Applied technologies result in modeled reduction in greenhouse gases

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## Heavy-Duty Diesel Emission Standards

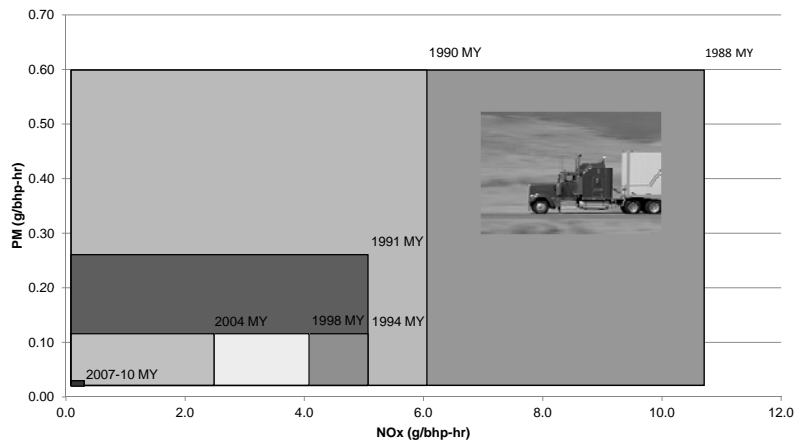
Year	NO <sub>x</sub>	HC+NO <sub>x</sub>	HC	PM	CO	Emission Controls	Diesel fuel
1974		16			40		2000-5000 ppm sulfur
1979		10	1.5		25		
1985	10.7		1.3		15.5		
1988	10.7		1.3	0.60	15.5		
1990	6.0		1.3	0.60	15.5		
1991	5.0		1.3	0.25	15.5		300-500 ppm sulfur
1994	5.0		1.3	0.10	15.5	Diesel Oxidation Catalyst	
1998	4.0		1.3	0.10	15.5	Electronic Control	
2004		2.5		0.10	15.5	Common rail fuel injection, EGR	
2007	0.20 50%	2.5 50%	0.14	0.01	15.5	Diesel Particulate Filter	<15 ppm sulfur
2010	0.20		0.14	0.01	15.5	SCR	

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## Heavy-Duty Diesel Emission Standards



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## 2007-2010 Standards Were a Major Step Change

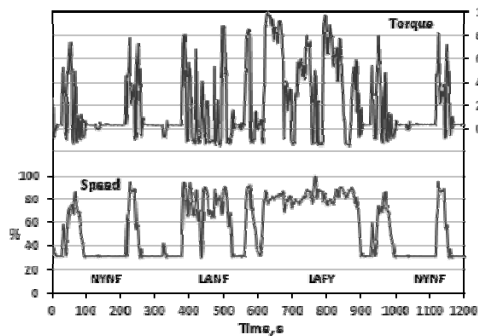
- Previous standards focused only on engine improvements
- A new approach: regulate vehicle and fuel as a system to gain order-of-magnitude reductions
- Low sulfur fuel enables advanced aftertreatment technology
  - Diesel particulate filters
  - NOx catalysts
- 95%+ emission reductions in PM and NOx
- Also very large secondary benefits
  - Truck program provided springboard for parallel programs
    - Nonroad diesels (farm, construction), locomotives, marine vessels, voluntary retrofits of older trucks
  - Low sulfur highway diesel fuel also enabled light-duty diesels to meet stringent passenger car standards

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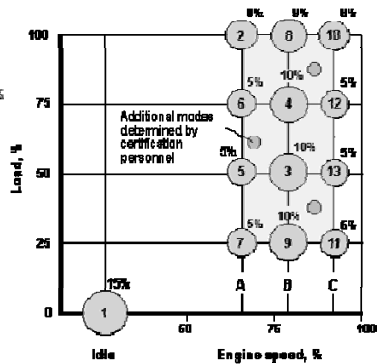
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## Certification Test Cycles



FTP



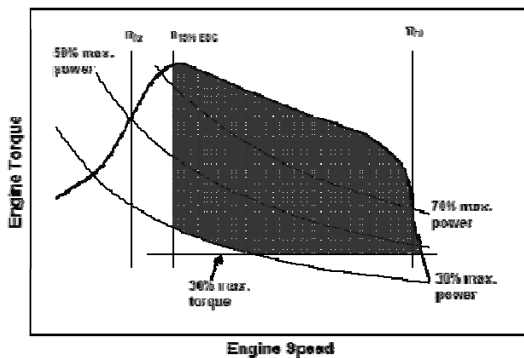
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## NTE Control Area



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