ECT 2015

Panel Four

Emissions From Locomotives And Power Generation.

To review / Discuss Global Perspective on Emission Control From Locomotive & Power Generation

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Source : IDEMA, Diesel Net

Generator Industry's expectations

1. There should be next 10- Year road map available in advance.
2. Align / Harmonize with existing international regulations
3. Future norms should be known well in advance - 4 years -
   This will help for product development, switch-over, certification tests etc.
4. Norms should last for minimum four years.
5. Fuel Specifications : Fuel specifications should be decided and the same should be available at least one year in advance, *across* the country.

Current Scenario

- Norms exist for Auto, Genset, Construction Equipment Vehicles, Agricultural Tractors and Power Tillers.
- No norms for Mining, Locomotives, Non-wheeled construction equipment, Inland marine engines etc. as on date.
- Fuel Efficiency Standards developed for Gensets upto 19 kW by BEE/PCRA.
- Regulations for LPG/CNG Genset engine emission norms expected shortly.

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Current Emission Regulation Summary

Application	Current Emission Norms	Controlling Body
	In select Cites : BS IV In rest India : BS III	MoRTH
	CPCB 2 (Upto 800 kW)	CPCB / MoEF
	No norms for Natural Gas *	CPCB / MoEF
	CPCB Stack 3 (Above 800 kW)	CPCB / MoEF
	BS III (CEV)	MoRTH
	TREM III A	MoRTH
	TREM III	MoRTH
	TIER II	IMO

Voluntary Energy Efficiency Labeling Program for Diesel Generator Sets

Scope

- It applies to A. C. generating sets driven by RIC engines for land and marine use being manufactured, imported or sold in India.
- Diesel Generating (DG) Sets up to 19 kW ratings are covered under phase 1 of energy labeling scheme for DG Sets, used to generate electrical power for continuous, peak-load and standby applications.
- This document applies to new DG sets. Existing & Retrofitted DG sets shall not be required to be modified to conform to this schedule.

The Star Rating Plan for DGs upto 19 kW

Star Level	Specific Fuel Consumption (gm/kWh)		Units per liter (Diesel Density 0.84 gm/cc)	
	>	<=	>	<=
1 Star	302	336	2.78	2.50
2 Star	272	302	3.09	2.78
3 Star	245	272	3.43	3.09
4 Star	220	245	3.82	3.43
5 Star		220		3.82

Unit is KWh electrical at Power Factor of 0.8

Note - Different (more stringent) values expected for higher ratings

Fuel Quality Requirements for Emissions

		Commercial Fuel
Emission norms		Sulpher content in diesel
BS-II /Euro-II	On highway	500 ppm
BS-III / Euro-III	On highway	350 ppm
BS-IV / Euro-IV	On highway	50 ppm
BS-V / Euro-V	On highway	10 ppm
BS-VI / Euro-VI	On highway	10 ppm
Euro-Stage-I	Off Highway	~2500 ppm
Euro-Stage-II	Off Highway	500 ppm
Euro-Stage-III A / Tier -3	Off Highway	300 ppm
Euro-Stage-III B / Tier-4 interim	Off Highway	10-15 ppm
Euro-Stage-IV / Tier 4 final	Off Highway	10-15 ppm

NONROAD EMISSION REGULATION SCHEDULES

NOx / HC[2] / CO / PM (g/kW-hr)
(NOx+NMHC) / CO / PM (g/kW-hr) [Conversion: (g/kW-hr) x 0.7457 = g/bhp-hr]

U.S. EPA

kW	(HP)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0 - 7	(0 - 10)					(10.5) / 8.0 / 1.0					(7.5) / 8.0 / 0.80			(7.5) / 8.0 / 0.40									
8 - 18	(11 - 24)					(9.5) / 6.6 / 0.80					(7.5) / 6.6 / 0.80			(7.5) / 6.6 / 0.40									
19 - 36	(25 - 48)				(9.5) / 5.5 / 0.80					(7.5) / 5.5 / 0.60				(7.5) / 5.5 / 0.30					(4.7) / 5.0 / 0.03				
37 - 55	(49 - 74)			9.2 / -- / -- / --						(7.5) / 5.0 / 0.40				Opt T4i 0.30 PM: 37-55 kW				Note 6					
56 - 74	(75 - 99)													(4.7) / 5.0 / 0.40: 37-74 kW				3.4 / 0.19 / 5.0 / 0.02		0.40 / 0.19 / 5.0 / 0.02			
75 - 129	(100 - 173)		9.2 / -- / -- / --						(6.6) / 5.0 / 0.30				(4.0) / 5.0 / 0.30										
130 - 224	(174 - 301)	9.2 / 1.3 / 11.4 / 0.54							(6.6) / 3.5 / 0.20			(4.0) / 3.5 / 0.20					2.0 / 0.19 / 3.5 / 0.02			0.40 / 0.19 / 3.5 / 0.02			
225 - 449	(302 - 602)	9.2 / 1.3 / 11.4 / 0.54					(6.4) / 3.5 / 0.20				(4.0) / 3.5 / 0.20												
450 - 560	(603 - 751)	9.2 / 1.3 / 11.4 / 0.54						(6.4) / 3.5 / 0.20			(4.0) / 3.5 / 0.20												
>560[a]	(>751)[a]					9.2 / 1.3 / 11.4 / 0.54						(6.4) / 3.5 / 0.20					3.5 / 0.40 / 3.5 / 0.10 0.67 / 0.40 / 3.5 / 0.10[a]				3.5 / 0.19 / 3.5 / 0.04 0.67 / 0.19 / 3.5 / 0.03[b]		
		Tier 1							Tier 2			Tier 3				Tier 4 Interim				Tier 4 Final			

a. Applies to portable power gen engines >900kW (>1207hp).
b. Applies to portable power gen engines >560kW (>751hp).

EUROPE

kW	(HP)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
18 - 36	(24 - 48)						8.0 / 1.5 / 5.5 / 0.8						(7.5) / 5.5 / 0.6										
37 - 55	(49 - 74)				9.2 / 1.3 / 6.5 / 0.85					7.0 / 1.3 / 5.0 / 0.4				(4.7) / 5.0 / 0.4					(4.7) / 5.0 / 0.025				
56 - 74	(75 - 99)																	3.3 / 0.19 / 5.0 / 0.025			0.4 / 0.19 / 5.0 / 0.025[7]		
75 - 129	(100 - 173)				9.2 / 1.3 / 5.0 / 0.70				6.0 / 1.0 / 5.0 / 0.3				(4.0) / 5.0 / 0.3					3.3 / 0.19 / 5.0 / 0.025				
130 - 560	(174 - 751)				9.2 / 1.3 / 5.0 / 0.54			6.0 / 1.0 / 3.5 / 0.2				(4.0) / 3.5 / 0.2					2.0 / 0.19 / 3.5 / 0.025			0.4 / 0.19 / 3.5 / 0.025			
		Stage I						Stage II				Stage IIIA					Stage IIIB				Stage IV		

US emission standards for railway locomotives

Test Cycles

Two steady-state test cycles which represent two different types of service including
(1) *line-haul* *(Long haul locomotives powering long distance trains)*
(2) *switch* locomotives. *(Only operate in rain-yards to build / deconstruct long haul trains)*

- **Different weighting factors for each of the 8 throttle notch modes, representing locomotive engines at different power levels, as well as idle and dynamic brake modes.**
- **The switch operation involves much time in idle and low power notches, whereas the line-haul operation is characterized by a much higher percentage of time in the high power notches, representing high-speed, long distance operations.**

Fuels.

- **Tier 4 – Low Sulphur Diesel for locomotive engines.**
- **500 ppm as of June 2007, 15 ppm from June 2012.**

Tier 0-2 Standards

Three separate sets of emission standards

Tier 0

- For locomotives Manufactured from 1973 to 2001.

Tier 1

- For locomotives Manufactured from 2002 to 2004

Tier 2

- For locomotives Manufactured from 2005 onwards.

0-2 Locomotive Emission Standards

Tier 0-2 Locomotive Emission Standards, g/bhp·hr				
Duty Cycle	**HC***	**CO**	**NOx**	**PM**
Tier 0 (1973 - 2001)				
Line-haul	1.0	5.0	9.5	0.60
Switch	2.1	8.0	14.0	0.72
Tier 1 (2002 - 2004)				
Line-haul	0.55	2.2	7.4	0.45
Switch	1.2	2.5	11.0	0.54
Tier 2 (2005 and later)				
Line-haul	0.3	1.5	5.5	0.20
Switch	0.6	2.4	8.1	0.24
Non-Regulated Locomotives (1997 estimates)				
Line-haul	0.5	1.5	13.5	0.34
Switch	1.1	2.4	19.8	0.41
* HC standard is in the form of THC for diesel engines				

Locomotive Smoke Standards, % opacity (normalized)			
	Steady-state	**30-sec peak**	**3-sec peak**
Tier 0	30	40	50
Tier 1	25	40	50
Tier 2 and later	20	40	50

Tier 3-4 Standards

- Tier 3 standards—
  - Near-term engine-out emission standards for newly-built and remanufactured locomotives.
  - Tier 3 standards are to be met using engine technology.

- Tier 4 standards—
  - Longer-term standards for newly-built and remanufactured locomotives.
  - **Tier 4 standards are expected to require the use of exhaust gas After-treatment Technologies**
    - **particulate filters for PM control**
    - **urea-SCR for NO_x emission control.**

Line-Haul & Switch Locomotive Emission Standards

Table 3
Line-Haul Locomotive Emission Standards, g/bhp·hr

Tier	MY	Date	HC	CO	NOx	PM
Tier 0[a]	1973-1992[c]	2010[d]	1.00	5.0	8.0	0.22
Tier 1[a]	1993[c]-2004	2010[d]	0.55	2.2	7.4	0.22
Tier 2[a]	2005-2011	2010[d]	0.30	1.5	5.5	0.10[e]
Tier 3[b]	2012-2014	2012	0.30	1.5	5.5	0.10
Tier 4	2015 or later	2015	0.14[f]	1.5	1.3[f]	0.03

a - Tier 0-2 line-haul locomotives must also meet switch standards of the same tier.

b - Tier 3 line-haul locomotives must also meet Tier 2 switch standards.

c - 1993-2001 locomotive that were not equipped with an intake air coolant system are subject to Tier 0 rather than Tier 1 standards.

d - As early as 2008 if approved engine upgrade kits become available.

e - 0.20 g/bhp-hr until January 1, 2013 (with some exceptions).

f - Manufacturers may elect to meet a combined NOx+HC standard of 1.4 g/bhp-hr.

Table 4
Switch Locomotive Emission Standards, g/bhp·hr

Tier	MY	Date	HC	CO	NOx	PM
Tier 0	1973-2001	2010b	2.10	8.0	11.8	0.26
Tier 1a	2002-2004	2010b	1.20	2.5	11.0	0.26
Tier 2a	2005-2010	2010b	0.60	2.4	8.1	0.13c
Tier 3	2011-2014	2011	0.60	2.4	5.0	0.10
Tier 4	2015 or later	2015	0.14d	2.4	1.3d	0.03

a - Tier 1-2 switch locomotives must also meet line-haul standards of the same tier.
b - As early as 2008 if approved engine upgrade kits become available.
c - 0.24 g/bhp-hr until January 1, 2013 (with some exceptions).
d - Manufacturers may elect to meet a combined NOx+HC standard of 1.3 g/bhp-hr.

Thank You