Caterpillar Emissions Solutions (CES)

Emissions Repower and Upgrade Group Overview

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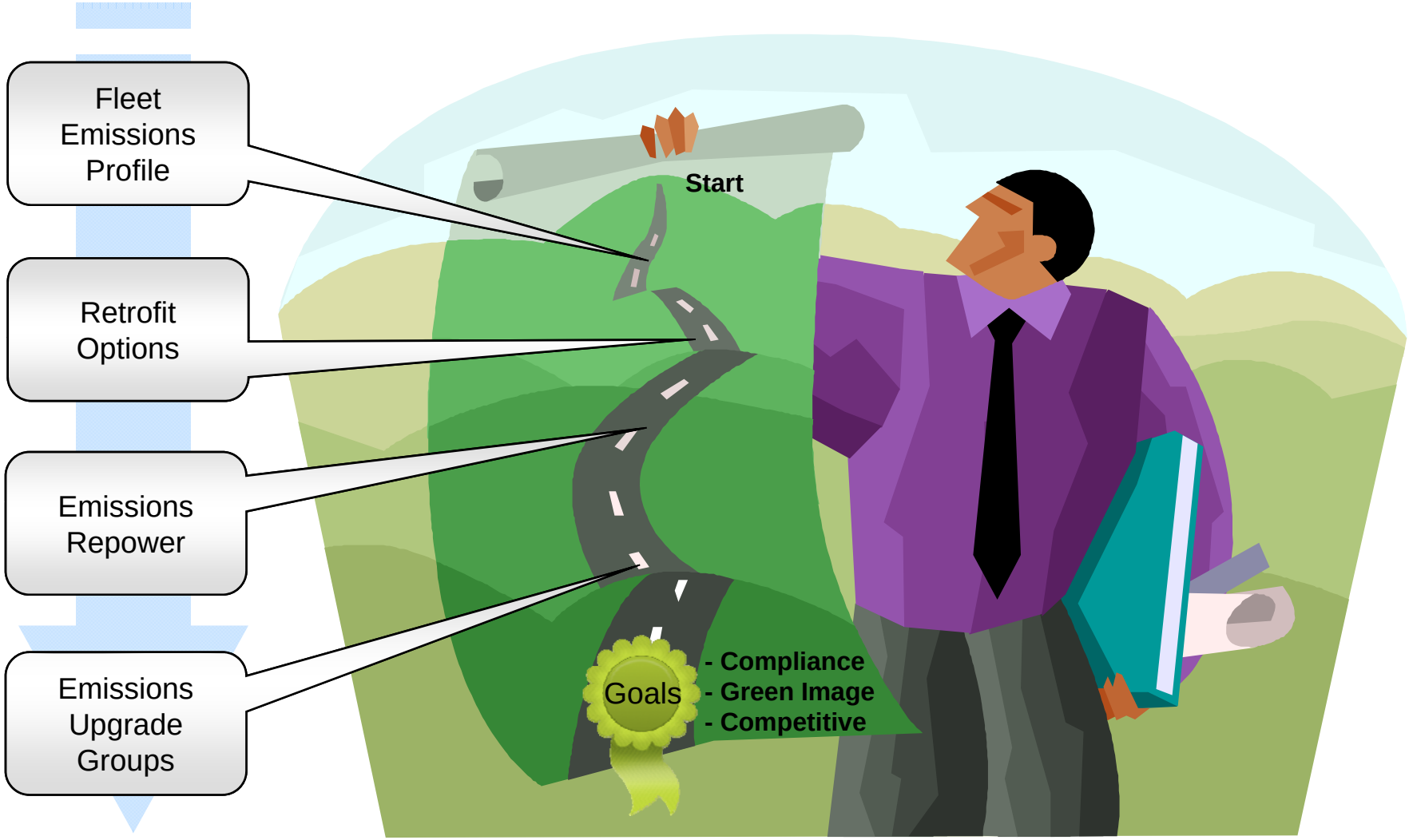
Northeast Emissions Territory Manager

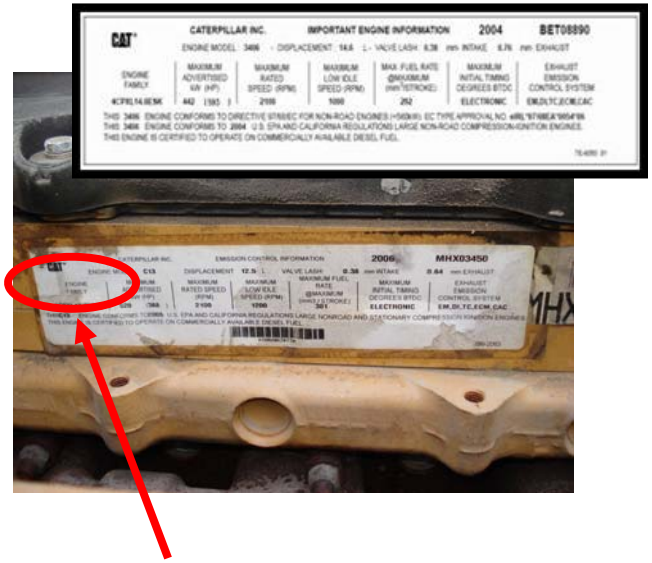
Objective



Fleet Emissions Profile

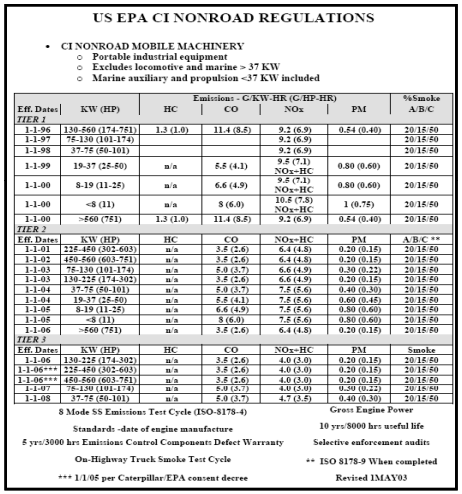
Understand the emissions status of your fleet

Emissions Certificates



Emissions Family Code

Regulations Table



US EPA CI NONROAD REGULATIONS

- CI NONROAD MOBILE MACHINERY
  - Portable industrial equipment
  - Excludes locomotive and marine > 37 KW
  - Marine auxiliary and propulsion <37 KW included

Eff. Dates	KW (HP)	Emissions - G/KW-HR (G/HP-HR) HC	CO	NOx	PM	%Smoke A/B/C
TIER 1						
1-1-96	130-560 (174-751)	1.3 (1.0)	11.4 (8.5)	9.2 (6.9)	0.54 (0.40)	20/15/50
1-1-97	75-130 (101-174)			9.2 (6.9)		20/15/50
1-1-98	37-75 (50-101)			9.2 (6.9)		20/15/50
1-1-99	19-37 (25-50)	n/a	5.5 (4.1)	9.5 (7.1) NOx+HC	0.80 (0.60)	20/15/50
1-1-00	8-19 (11-25)	n/a	6.6 (4.9)	9.5 (7.1) NOx+HC	0.80 (0.60)	20/15/50
1-1-00	<8 (11)	n/a	8 (6.0)	10.5 (7.8) NOx+HC	1 (0.75)	20/15/50
1-1-00	>560 (751)	1.3 (1.0)	11.4 (8.5)	9.2 (6.9)	0.54 (0.40)	20/15/50
TIER 2						
Eff. Dates	KW (HP)	HC	CO	NOx+HC	PM	A/B/C **
1-1-01	225-450 (302-603)	n/a	3.5 (2.6)	6.4 (4.8)	0.20 (0.15)	20/15/50
1-1-02	450-560 (603-751)	n/a	3.5 (2.6)	6.4 (4.8)	0.20 (0.15)	20/15/50
1-1-03	75-130 (101-174)	n/a	5.0 (3.7)	6.6 (4.9)	0.30 (0.22)	20/15/50
1-1-03	130-225 (174-302)	n/a	3.5 (2.6)	6.6 (4.9)	0.20 (0.15)	20/15/50
1-1-04	37-75 (50-101)	n/a	5.0 (3.7)	7.5 (5.6)	0.40 (0.30)	20/15/50
1-1-04	19-37 (25-50)	n/a	5.5 (4.1)	7.5 (5.6)	0.60 (0.45)	20/15/50
1-1-05	8-19 (11-25)	n/a	6.6 (4.9)	7.5 (5.6)	0.80 (0.60)	20/15/50
1-1-05	<8 (11)	n/a	8 (6.0)	7.5 (5.6)	0.80 (0.60)	20/15/50
1-1-06	>560 (751)	n/a	3.5 (2.6)	6.4 (4.8)	0.20 (0.15)	20/15/50
TIER 3						
Eff. Dates	KW (HP)	HC	CO	NOx+HC	PM	Smoke
1-1-06	130-225 (174-302)	n/a	3.5 (2.6)	4.0 (3.0)	0.20 (0.15)	20/15/50
1-1-06***	225-450 (302-603)	n/a	3.5 (2.6)	4.0 (3.0)	0.20 (0.15)	20/15/50
1-1-06***	450-560 (603-751)	n/a	3.5 (2.6)	4.0 (3.0)	0.20 (0.15)	20/15/50
1-1-07	75-130 (101-174)	n/a	5.0 (3.7)	4.0 (3.0)	0.30 (0.22)	20/15/50
1-1-08	37-75 (50-101)	n/a	5.0 (3.7)	4.7 (3.5)	0.40 (0.30)	20/15/50

8 Mode SS Emissions Test Cycle (ISO-8178-4) — Gross Engine Power

Standards -date of engine manufacture — 10 yrs/8000 hrs useful life

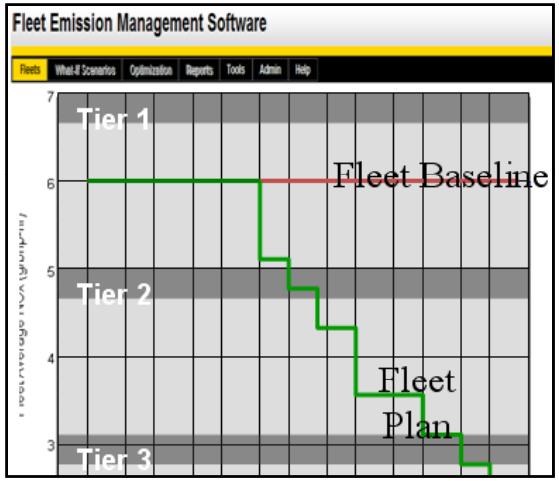
5 yrs/3000 hrs Emissions Control Components Defect Warranty — Selective enforcement audits

On-Highway Truck Smoke Test Cycle — ** ISO 8178-9 When completed

*** 1/1/05 per Caterpillar/EPA consent decree — Revised 1MAY03

Handout

Cat Fleet Tool



See your Cat Dealer

CARB Certificates

www.arb.ca.gov/msprog/offroad/cert/cert.php

Product Overviews

Potential Retrofits

Emissions

HC/CO

- Oxidation Catalyst

NOx

- Urea SCR

Particulates

- SOF
  - Oxidation Catalyst

- Solids
  - Diesel Particulate Filter (DPF)
    - Active

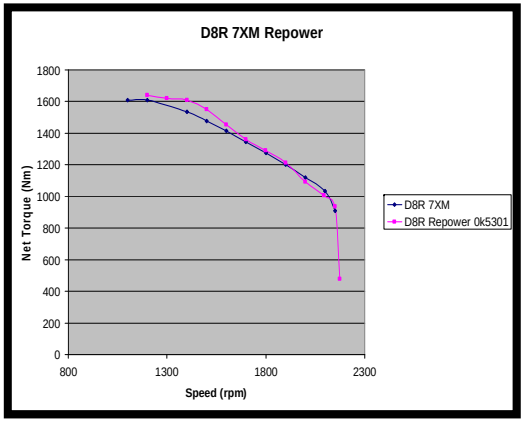
    - Passive

Repower, Emissions Upgrade Groups, New Machine

Product Overviews

Repower

- Replace existing engine with a newer engine SYSTEM
- **NOx**, PM, HC, CO, Reduction option
- Tier 1 is often the most cost effective
- 90+ Emissions repower options
- Potential enabler for passive DPFs



Emissions Repowers – Tier 1

EPA Nonroad Engine Phase-In

1990 Model Year 285 HP Dozer Repowered to Tier 1
Annual Emissions Results

	NOx	PM	HC	CO
Percent Reduced	**33%**	**38%**	**55%**	**74%**
Amount (ton/year)	**0.51**	**0.05**	**0.08**	**0.69**

From EPA Quantifier: www.epa.gov/quantifier

Tier 1 includes straightforward engine changes (fuel rates, timing,…etc.)

Emissions Repowers – Tier 3

EPA Nonroad Engine Phase-In

1990 Model Year 285 HP Dozer Repowered to Tier 3

Annual Emissions Results

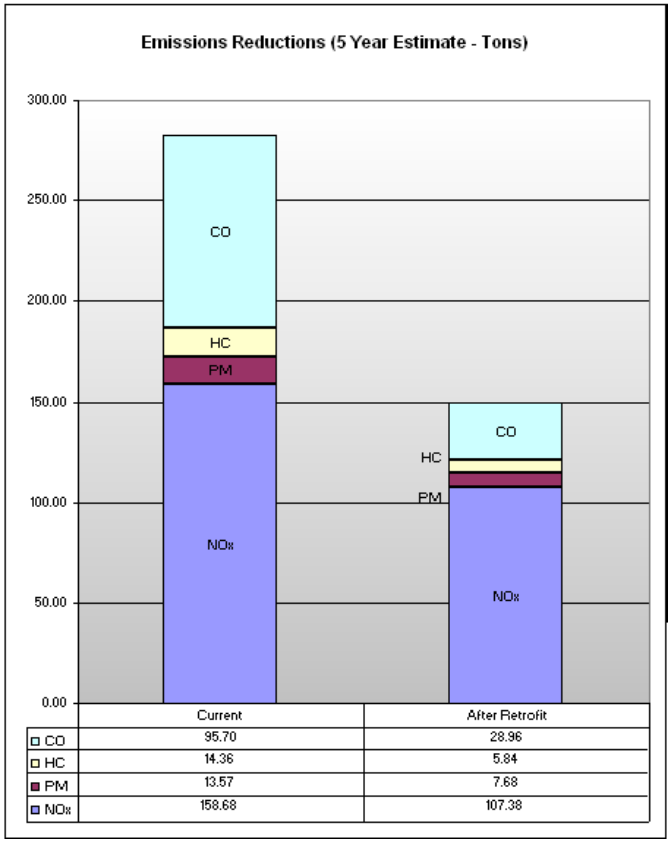
	NOx	PM	HC	CO
Percent Reduced	**67%**	**66%**	**74%**	**76%**
Amount (ton/year)	**0.84**	**0.07**	**0.08**	**0.57**

From EPA Quantifier: www.epa.gov/quantifier

Tier 3 reduces emissions for off-highway engines by integrating support systems into engines (ACERT ® technology) and machines

Product Overviews

Repower – Fleet Example



52 tons Reduced

Total Cost Effectiveness $3652/ton

Machine Model	Vehicle Class	Vehicle Count	Engine Model Year	Technology	HP
966D	Rubber Tire Loaders	3	1986	Tier 1 Engine Repower	200
D8N	Crawler Tractors	1	1987	Tier 1 Engine Repower	285
970F	Rubber Tire Loaders	2	1994	Tier 1 Engine Repower	230
980F	Rubber Tire Loaders	1	1993	Tier 1 Engine Repower	275
769C	Off-highway Trucks	2	1986	Tier 1 Engine Repower	450
14G	Graders	1	1983	Tier 1 Engine Repower	212
140G	Graders	1	1984	Tier 1 Engine Repower	150
966D	Rubber Tire Loaders	1	1986	Tier 1 Engine Repower	200
14G	Graders	1	1993	Tier 1 Engine Repower	200
		13			2202

The DEQ emissions reductions were used along with the estimated project costs to determine the Capital Cost Effectiveness and Total Cost Effectiveness using a generally accepted discount rate of 4 percent and capital recovery factors based on a 5 year life for aftertreatment and 7 year for repowers and engine upgrades. The cost effectiveness calculations using the DEQ emissions reductions are consistent with funding programs like the Carl Moyer program in California. The cost effectiveness calculations are conservative because the actual engine life, and corresponding emissions reductions, typically far exceeds the engine life used in the calculations.

Product Overviews

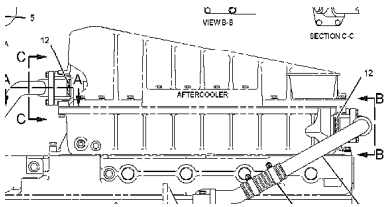
Emissions Upgrade Groups (EUG)

- Overhaul option
- **NOx** , PM, HC, CO, Reduction
- Dealer installed
- Proven technology
- Emissions label
- Achieves Tier 1 Level emissions
- EPA Verified for 3306

Turbocharger
Increased air flow and boost.

Nozzle
Orifice number and size changed for improved atomization.

Aftercooler



Fuel Pump / Governor
Pre-assembled and tested. Increased line pressure. Improved injection timing.

Cylinder Pack
Optimized compression ratio.

EPA Verification List

Manufacturer	Technology	Applicability
Caterpillar, Inc.	Emissions Upgrade Group	Caterpillar model 3306 diesel engines for nonroad applications with model years from 1988 to 1995 with mechanical direct fuel injection.

http://www.epa.gov/otaq/retrofit/verif-list.htm

Recap and Recommendations

Fleet Emissions Profile

Retrofit Options

Emissions Repower

Emissions Upgrade Group