

New Technologies in Tug and Tow Industry



Rob Robins

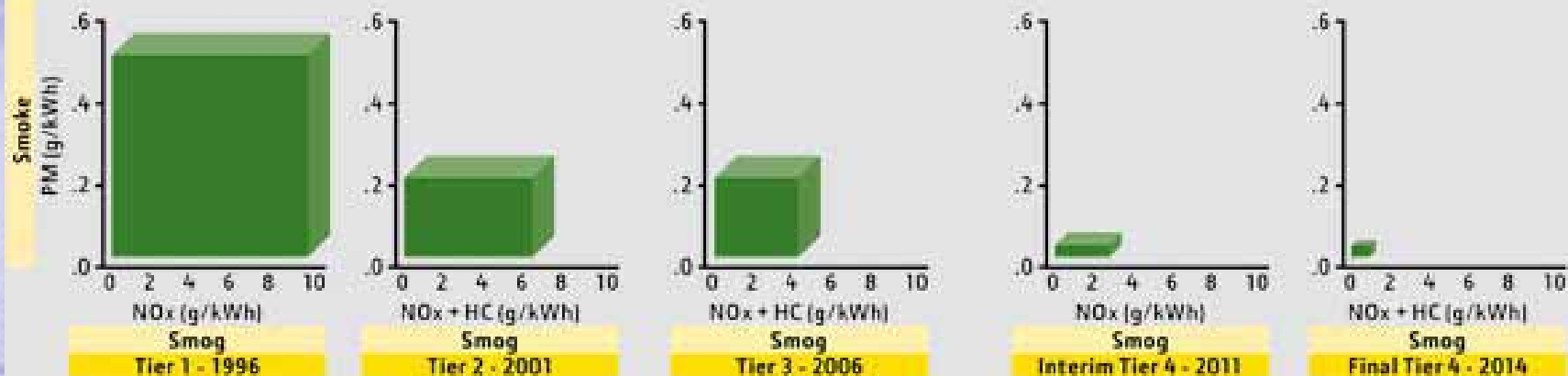
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EPA non-road emissions regulations: 174 - 750 Engine hp



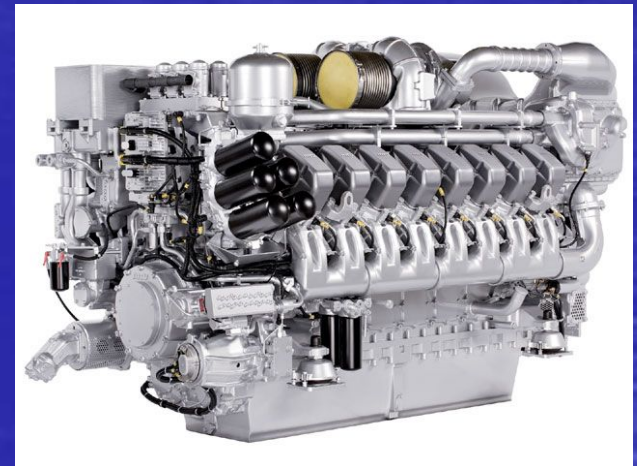
The move to Interim Tier 4 emissions regulations is unquestionably the most significant to date. The regulations call for a 90-percent reduction in particulate matter (PM) and a 50-percent drop in oxides of nitrogen (NOx). Final Tier 4 emissions regulations will take PM and NOx to near-zero levels by 2014.

Marine Diesel Engine Categories

Category 1 – less than 7 liters / cylinder
- 60 to 5,000 HP

Category 2 – 7 through 30 liters / cylinder
- 1,400 to 5,000 HP

Category 3 – greater than 30 liters /cylinder
- 5,000 to 100,000 HP



Caterpillar Engines

Commercial Marine EPA Regulations

Platform	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
C7 - C15	EPA Tier 2					EPA Tier 3					
C18 (<600 kW)	EPA Tier 2					EPA Tier 3					
C18 (≥600 kW) - C32	EPA Tier 2					EPA Tier 3					
3500 (600 ≤ kW < 1400)	EPA Tier 2					EPA Tier 3					
3500 (1400 ≤ kW < 2000)	EPA Tier 2					EPA Tier 3					
3500 (2000 ≤ kW < 3700)	EPA Tier 2					EPA Tier 3					
C280 (<2000 kW)	EPA Tier 2					EPA Tier 3					
C280 (≥2000 kW)	EPA Tier 2					EPA Tier 3					

Worldwide - IMO

kW	(HP)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
> 130	> 174	Tier I				Tier II				Tier III*			

* In emission control areas only

U.S. EPA - Tier 2 and Tier 3**

Displacement (L/cyl)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
< 0.9 > 75 kW	Tier 2					Tier 3						
0.9 - 1.2	Tier 2					Tier 3						
1.2 - 2.5	Tier 2					Tier 3						
2.5 - 3.5	Tier 2					Tier 3						
3.5 - 7.0	Tier 2					Tier 3						

** EPA Tier 2 and Tier 3 implementation based on displacement

U.S. EPA Tier 4***

kW	(HP)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
600 - 1399	805 - 1876											Tier 4	
1400 - 1999	1877 - 2681											Tier 4	
2000 - 3700	2682 - 4962											Tier 4	

*** EPA Tier 4 implementation based on maximum engine power

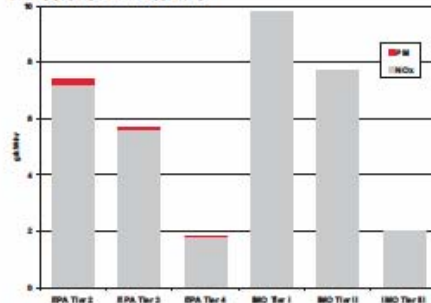
IMO Tier II

Representing a 20% reduction in NOx compared to the IMO Tier I regulation, IMO Tier II goes into effect in January 2011 in existing IMO areas. Cummins engines already certified to EPA Tier 2 meet the NOx levels mandated by IMO Tier II.

IMO Tier III

Representing an 80% reduction in NOx compared to existing Tier I levels, IMO Tier III goes into effect in January 2016 for vessels operating in designated Emission Control Areas (ECA) only. Currently, the Baltic and the North Sea are designated as ECA, but additional areas are expected to apply for this designation.

Emissions: EPA v/s IMO



THE CUMMINS SOLUTION

Cummins Tier 2 strategies provide a key building block as we move forward to the next level of marine emissions. We have invested significantly in a broad technology portfolio which extends from air intake to exhaust aftertreatment. Because of this investment, we are able to leverage our broad experience in other engine markets.

Cummins remains focused on providing outstanding customer value while meeting the toughest emissions standards. As we face these unprecedented technological hurdles, customers can be assured Cummins will be ready with a full product line certified to future EPA and IMO standards.

For more information on EPA Tier 3 and Tier 4, please visit www.epa.gov/otaq/marine.htm.

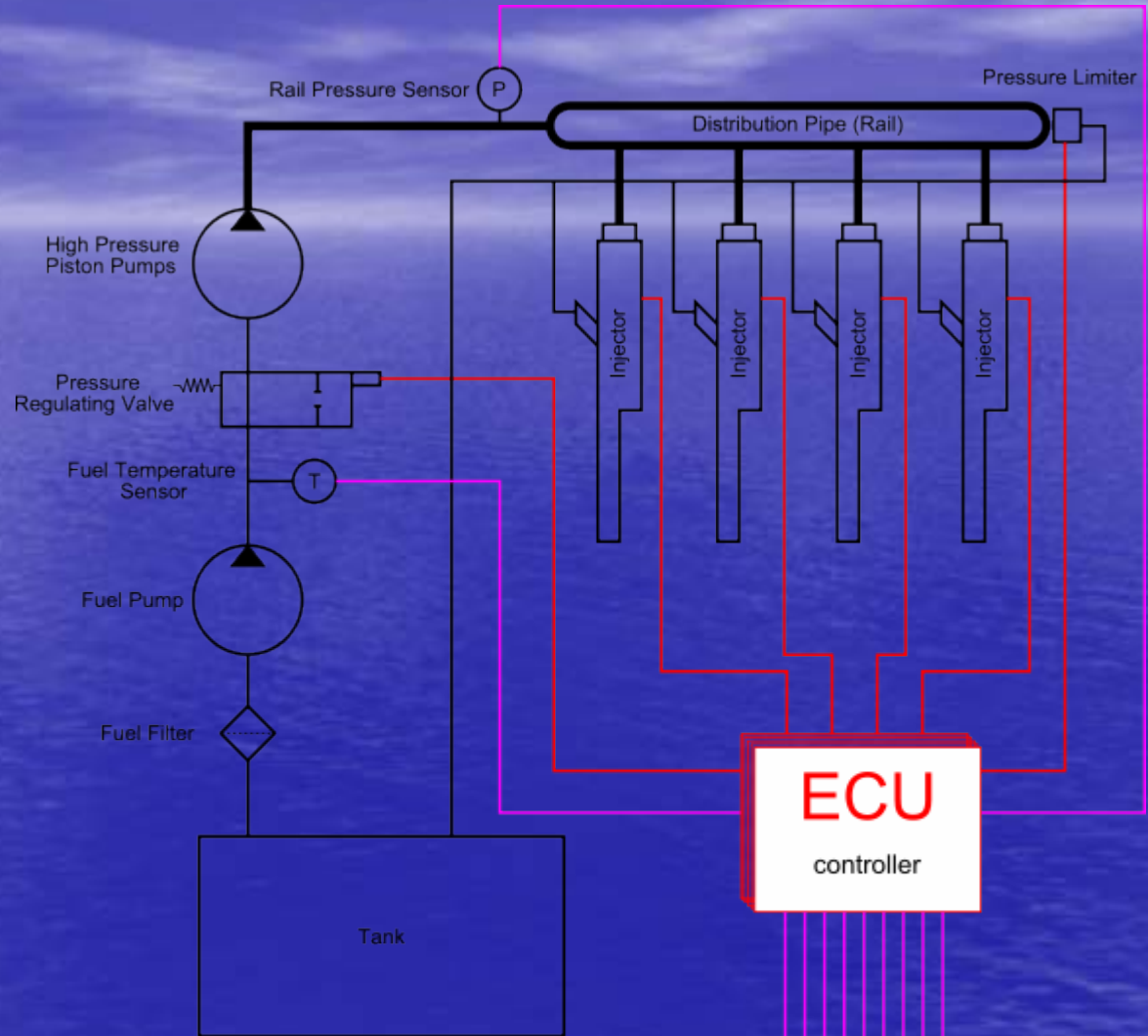
The charts above are displayed for reference purposes only and do not depict the various options available to engine manufacturers. See the appropriate regulation for specific details and options related to emission standards and implementation dates.

Tier 3 – January 2012

Tier 4 – January 2014

Tier 3 Engine Improvements

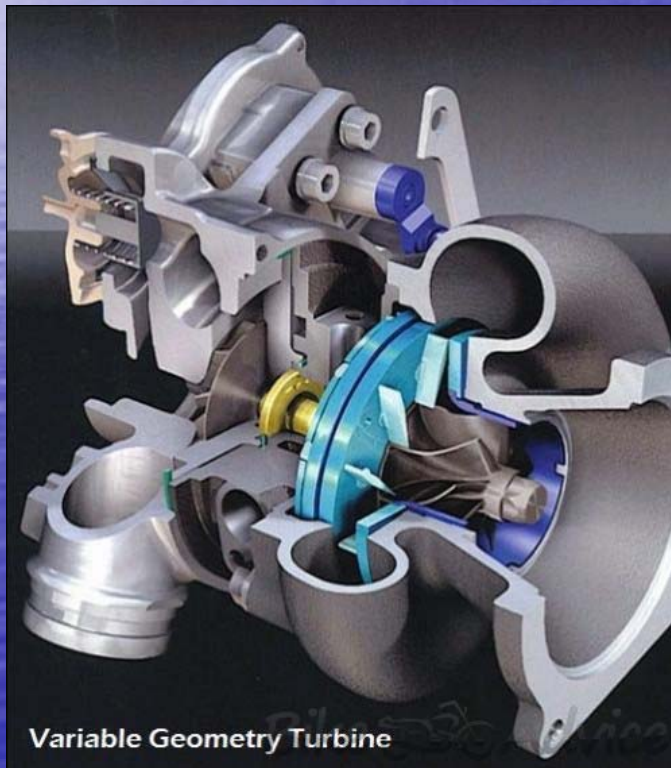
- Electronics
 - Precisely controlling fuel delivery and air management
- Fuel Delivery
 - Injecting fuel in a series of microbursts, pre, during and post combustion, providing maximum power and fuel efficiency with minimum emissions



- Other Sensors
- Reference Mark, Engine Speed
 - Accelerator Pedal Position, Load Pressure
 - Radiator and Air Temperature Sensor

Tier 3 Engine Improvements

- Air Management
 - Cross flow cylinder heads, wastegate turbochargers and variable valve timing
 - Larger aftercoolers to provide cooler intake air temperatures
 - Variable geometry turbochargers and Cooler Exhaust Gas Recirculation (EGR)



Tier 4

After treatment Technologies

- Particulate Matter Filter (PMF)
 - Active
 - Passive
- Selective Catalytic Reduction (SCR)
 - Ammonia, Urea
 - Reductant injection
 - Produces Nitrogen and Water
 - 90% reduction in NO_x
- Diesel Oxidation Catalyst (DOC)

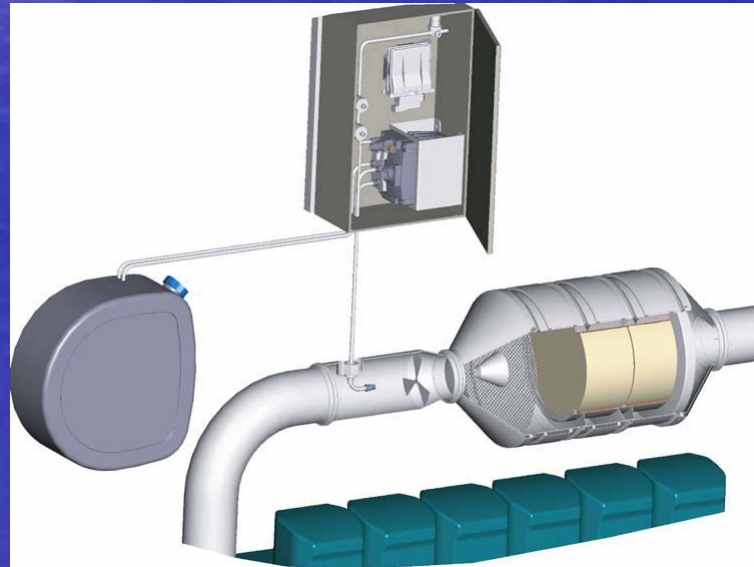
Particulate Matter Filter (PMF)

- Removes Particulate Matter through physical filtration
- Uses hot exhaust gas to regenerate and clean the filter
- Difficult to regenerate properly with variable duty cycles of marine application
- Needs ULSD fuel
- Must be regenerated properly or it will clog
- Cost \$100,000 for a 2,000 HP engine



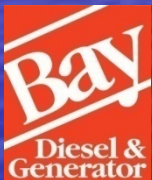
Selective Catalytic Reduction (SCR)

- Eliminates NO_x using a chemical reaction
- Pros
 - Effective at eliminating 90% of NO_x when used properly
- Cons
 - Cost, \$450,000 for a 2,000 HP engine
 - Size, 2 times the displacement of the engine
 - Maintenance, is there UREA available where you operate

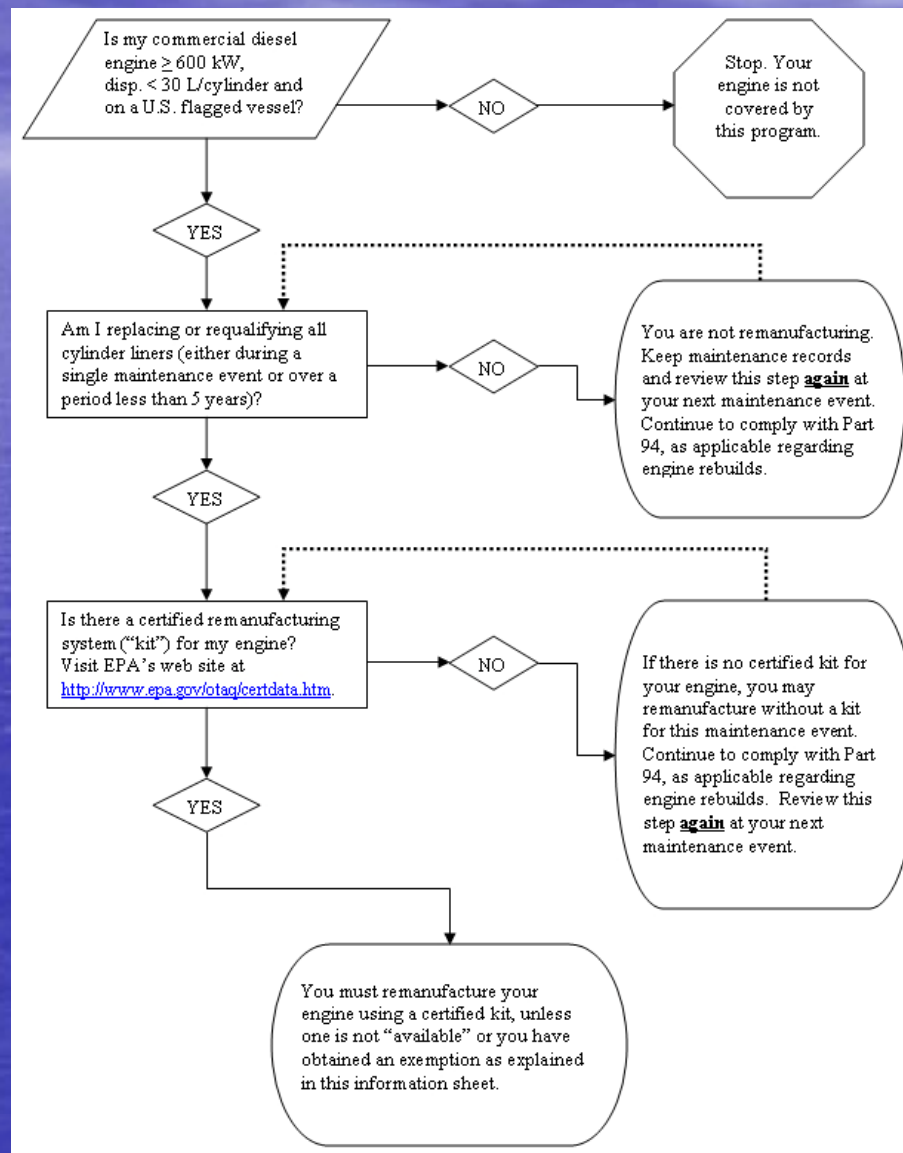


EPA Marine Remanufacture Program

- It is a commercial marine diesel engine
- It was manufactured between 1973 and the last Tier 2 model year
- It has power at or above 600 kilowatts (800 HP)
- It has a displacement of less than 30 liters per cylinder
- It is installed on a vessel that is flagged or registered in the United States
- EXEMPT if your company has annual sales less than \$5,000,000

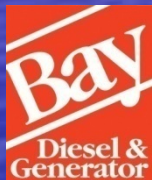


EPA Marine Remanufacture Program



Kits

- Cylinder packs, turbo or blower, injectors and charge air cooler
- Turn in paperwork to kit supplier for EPA registration and sticker
- Adds 20-30% to your overhaul cost
- NREC, EMD, GE for EMD engines
- CAT for their own engines
- EPA web-site has a listing of all approved kits



EMD - 16 645 E 7



Unknowns

- Who is policing this EPA, USCG, ABS?
- When will the EPA catch up?
- Ultra low sulfur diesel – June 1st, 2012
 - Loss of power?
 - Increased fuel consumption?

Looking Ahead

- Need additional space on tugs for systems
- Fuel economy
- Paperwork
- Exhaust sampling, monitoring and recording
- Fuel sampling
- More expensive engines
- More complex and sensitive engines
 - Low tolerance for dirty fuel
 - Sensitive to back pressure changes
- Less options on engine adjustments
- OEM or EPA kits only on overhauls and maintenance

Looking Ahead

- Where will my vessels be operating?
 - INTL, CA, TX, NY
- No used engines or rebuilds on re-powers or new construction unless up to current tier
- Is there room on my vessel for a post treatment system?
- Are there any State or Federal funds available?



Bottom Line



Get to know this guy!



QUESTIONS

THANK YOU

