

US EPA ARCHIVE DOCUMENT

Locomotive Engine Re-Power Emission Review

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Purpose

- Evaluate new locomotive EPA Tier regulations and provide examples of Locomotive Repowers using Tier 2 Certified Engines.



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Agenda

- EPA Locomotive Tier Regulations
- Future EPA Locomotive Tier levels
- Tier 2 Re-Power Locomotive Examples
- Future Locomotive Engine Products
- Conclusion

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EPA Locomotive Tier Regulations

- In the past decade, the EPA has introduced the following mandated marine emission regulations for locos greater than 1006 hp.
 - Tier 1 Expired End 2004
 - Tier 2 Expires End 2010 for Switcher and End 2011 for Line Haul
 - Tier 3
 - Tier 4
- Switcher Locomotive definition: 1006 -2300 bhp
- Line Haul Locomotive definition: 2301 bhp & above

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Not regulated under locomotive rule
(probably less than 1006hp and not diesel)



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EPA Locomotive Tier Regulations

- US EPA Locomotive 1997 Ruling 40 CFR 92 introduced Tier 1 & 2 Regulations:
 - EPA Tier I Locomotive Regulation effective Jan. 2002
 - EPA Tier II Locomotive Regulation effective Jan. 2005
- US EPA Locomotive 2008 Ruling 40 CFR 1033 introduced Tier 3 & 4 Regulations
 - EPA Tier 3 Switcher Regulation effective Jan. 2011
 - EPA Tier 3 Line Haul Regulation effective Jan. 2012
 - EPA Tier 4 Locomotive Regulation effective Jan. 2015

* Above regulations at time of new build

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LOCOMOTIVE EMISSION REGULATION SCHEDULES

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

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Line-haul (NOx / HC / CO / PM) (g/bhp-hr)

Originally Built Between	Standards at time of build	Standards if remanufactured between			
		January 1, 2000 - July 6, 2008	July 7, 2008 - December 31, 2009	January 1, 2010 - December 31, 2012	January 1, 2013 and beyond
Pre-January 1, 1973	None	None ^a	None ^a	None ^a	None*
January 1, 1973 - December 31, 1992	None	9.5 / 1.00 / 5.0 / 0.60	9.5 / 1.00 / 5.0 / 0.60	8.0 / 1.00 / 5.0 / 0.22	8.0 / 1.00 / 5.0 / 0.22
January 1, 1993 - December 31, 1999	None	9.5 / 1.00 / 5.0 / 0.60	7.4 / 0.55 / 2.2 / 0.45 ^b	7.4 / 0.55 / 2.2 / 0.22	7.4 / 0.55 / 2.2 / 0.22
January 1, 2001 - December 31, 2001	None	9.5 / 1.00 / 5.0 / 0.60	7.4 / 0.55 / 2.2 / 0.45 ^b	7.4 / 0.55 / 2.2 / 0.22	7.4 / 0.55 / 2.2 / 0.22
January 1, 2002 - December 31, 2004	7.4 / 0.55 / 2.2 / 0.45	7.4 / 0.55 / 2.2 / 0.45	7.4 / 0.55 / 2.2 / 0.45 ^b	7.4 / 0.55 / 2.2 / 0.22	7.4 / 0.55 / 2.2 / 0.22
January 1, 2005 - December 31, 2011	5.5 / 0.30 / 1.5 / 0.20	5.5 / 0.30 / 1.5 / 0.20	5.5 / 0.30 / 1.5 / 0.20 ^c	5.5 / 0.30 / 1.5 / 0.20 ^c	5.5 / 0.30 / 1.5 / 0.10
January 1, 2012 - December 31, 2014	5.5 / 0.30 / 1.5 / 0.10	n/a		5.5 / 0.30 / 1.5 / 0.10	5.5 / 0.30 / 1.5 / 0.10
January 1, 2015 and beyond	1.3 / 0.14 / 1.5 / 0.03	n/a			

Tier 0 ^e (a)	Tier 0 ^e (b)	Tier 1 ^e (a)	Tier 1 ^e (b)	Tier 2 ^e	Tier 3 ^f	Tier 4 ^d
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- a) Unless significantly upgraded
- b) For MY 2008-2009 only if no remanufacture system is available. Otherwise must meet Tier 1 (b) standards
- c) For MY 2008-2012 only if no remanufacture system is available. Otherwise must meet Tier 3 standards
- d) May elect to meet a combined NOx + HC standard of 1.4 g/bhp-hr instead of applicable Tier 4 NOx and HC standards
- e) Line-haul locomotives subject to Tier 0 through Tier 2 emission standards must also meet switch standards of same tier
- f) Tier 3 line-haul locomotives must also meet Tier 2 switch standards

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Switch (NOx / HC / CO / PM) (g/bhp-hr)

Originally Built Between	Standards at time of build	Standards if remanufactured between			
		January 1, 2000 - July 6, 2008	July 7, 2008 - December 31, 2009	January 1, 2010 - December 31, 2012	January 1, 2013 and beyond
Pre-January 1, 1973	None	None ^a	None ^a	None ^a	None*
January 1, 1973 - December 31, 1999	None	14.0 / 2.10 / 8.0 / 0.72	14.0 / 2.10 / 8.0 / 0.72	11.8 / 2.10 / 8.0 / 0.26	11.8 / 2.10 / 8.0 / 0.26
January 1, 2000 - December 31, 2001	None	14.0 / 2.10 / 8.0 / 0.72	14.0 / 2.10 / 8.0 / 0.72	11.8 / 2.10 / 8.0 / 0.26	11.8 / 2.10 / 8.0 / 0.26
January 1, 2002 - December 31, 2004	11.0 / 1.20 / 2.5 / 0.54	11.0 / 1.20 / 2.5 / 0.54	11.0 / 1.20 / 2.5 / 0.54 ^b	11.0 / 1.20 / 2.5 / 0.26	11.0 / 1.20 / 2.5 / 0.26
January 1, 2005 - December 31, 2010	8.1 / 0.60 / 2.4 / 0.24	8.1 / 0.60 / 2.4 / 0.24	8.1 / 0.60 / 2.4 / 0.24 ^c	8.1 / 0.60 / 2.4 / 0.24 ^c	8.1 / 0.60 / 2.4 / 0.13
January 1, 2011 - December 31, 2014	5.0 / 0.60 / 2.4 / 0.10	n/a		5.0 / 0.60 / 2.4 / 0.10	5.0 / 0.60 / 2.4 / 0.10
January 1, 2015 and beyond	1.3 / 0.14 / 2.4 / 0.03	n/a			

Tier 0 (a)	Tier 0 (b)	Tier 1 ^e (a)	Tier 1 ^e (b)	Tier 2 ^e (a)	Tier 2 ^e (b)	Tier 3	Tier 4 ^d
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- a) Unless significantly upgraded
- b) For MY 2008-2009 only if no remanufacture system is available. Otherwise must use Tier 1 (b) standards
- c) For MY 2008-2012 only if no remanufacture system is available. Otherwise must use Tier 2 (b) standards
- d) May elect to meet a combined NOx + HC standard of 1.4 g/bhp-hr instead of applicable Tier 4 NOx and HC standards
- e) Switch locomotives subject to Tier 1 through Tier 2 emission standards must also meet line-haul standards of same tier

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Future EPA Locomotive Tier Levels

- In 2008, the US EPA signed the final rule for locomotive Tier 3 and Tier 4.
- Tier 3 is enforceable January 2011 for new Switcher Locomotives.
- Looking ahead, new locomotive EPA Tier 3 & 4 regulations represent the most dramatic reduction of emission levels to date for the industry.

Switcher	Phase-in beginning	NOX Reduction*	PM Reduction*
Tier 3	2011	38%	58%
Tier 4	2015	84%	88%

* Compared to Tier 2 standards

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Passenger Excursion Locomotive

White Pass & Yukon Route Railroad – Skagway, AK

- Engine + Alternator Skid
- Refurbished Loco



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Tier 2 Locomotive Re-Powers

- CSX 2100 hp Switcher
- G&W 1400 hp Switcher
- WP&YR 1400 hp Locomotive



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Switcher Re-Power to Tier 2

CSX 2100 hp Switcher Repowers – Various Locations

- CSX EMD SD40-2 Repower
- Original Power 1974:
 - EMD 16-645E3 3000 HP non-cert.
- Re-Power in 2010 by **National Railway Equipment Co.**
 - 3X T2 Cummins QSK19-L, 700 HP ea = 2100 hp total
- Customer savings: 25-50% fuel, 85% noise, 35% maintenance



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Switcher Re-Power to Tier 2

G&W 1400 hp Switcher Repower – Butler, PA

- G&W EMD SW-series Repower Kit
- Original Power 1950s:
 - EMD 12-567 1500 HP non-certified
- Re-Power in 2010 by **Brookville Equipment Co.**
 - 2X T2 Cummins QSK19-L, 700 HP ea = 1400 hp total
- Customer savings: 20%+ fuel, 58% NOx, 80% Particulate Matter



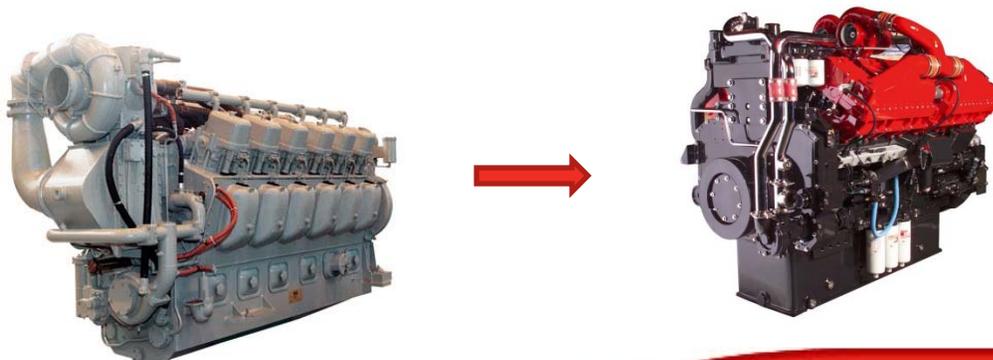
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Passenger Excursion Locomotive

White Pass & Yukon Route Railroad – Skagway, AK

- WP & YR GE GEX3341 Shovel Nose
- Original Power 1950s:
 - Alco 6-251 990 HP
- Re-Power in 2010 by **Global Locomotive**:
 - Cummins QSK45-L1, 1500 HP
- Customer savings: 30% fuel, 85% consumables, 1 less loco per train



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Passenger Excursion Locomotive

White Pass & Yukon Route Railroad – Skagway, AK

- Engine + Alternator Skid
- Refurbished Loco



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Benefits for the customer

- Reduced Emissions
- Reduced Fuel Consumption
- Improved light load fuel efficiency
- Reduced required Idle Time
- Improved Oil Drain intervals
- Improved Service Intervals
- Improved Traction Controls
- Reduced Noise

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Challenges of Locomotive Repowers

- **Medium Speed (900 rpm) to High Speed (1800 rpm)**
 - Requires different alternator capable of 1800 rpm
 - Multiple engine installation requires new controls to share power
- **Packaging**
 - Adding Charge Air Cooling
 - Requires robust rail-duty mounting
 - Making the engine power module easy to remove
- **Electronic controls**
 - Integrating existing machine controls and safeties designed for a mechanical engine into an electronic engine

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Future Locomotive Products

- Cummins product plan is designed to implement the right technology for each market we serve
- As we approach each set of implementation dates, Cummins plans to offer a complete line-up of engines certified to the new emission standards for Locomotive Re Powers and New Build projects

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Rail Engine Product Lineup



QSK19



410-597 kW
550-800 hp
Tier 3 pending

QSK23



567-709 kW
760-950 hp
EU stage 3a: 670 kW

QST30



709-895 kW
950-1200 hp
Tier 3 pending

QSK38



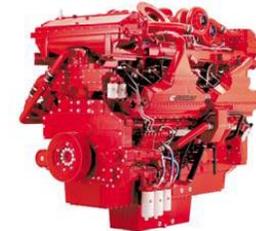
933-1119 kW
1250-1500 hp
EU stage 3a pending
Tier 3 pending

QSK50



1119-1492 kW
1800-2000 hp
EU stage 3a: 1492 kW
Tier 3 pending

QSK60



1640-2015 kW
2200-2700 hp
EU stage 3a: 1864 kW
Tier 3 pending

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Conclusion

- Cummins is committed to meeting or exceeding clean air standards worldwide
- New locomotive emission regulations present a significant technological hurdle for engine manufacturers
- You can count on Cummins to provide information on the regulations for Re Power opportunities
- Cummins will have the Right product, utilizing the Right technology at the Right time.

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Additional Information

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