Engine Manufacturing Industry Perspective on Emissions Regulations

Marine Vessels & Air Quality Conference

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Outline of Presentation

- About EMA
- Overview of EPA Marine Rule
  - Features of Commercial Engine Rule
  - EMA Concerns
  - Comparison with NR Rule
- Technological Responses
- Key Issues To Address
- Conclusion

Profile of EMA

- Not-for-profit trade association (created in 1968)
- Global voice of the engine manufacturing industry
- Many engine applications including marine
- All fuel types
- Wide range of engine sizes, from 1 hp to 20000+ hp

EMA Member Companies

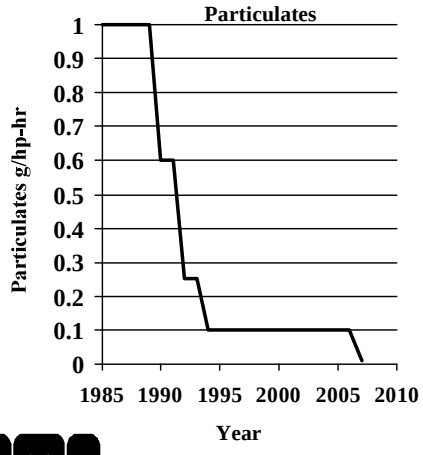
Briggs & Stratton Corporation
Case New Holland
Caterpillar, Inc.
Cummins Engine Company
DaimlerChrysler Corporation
DaimlerChrysler AG Powertrain
Deere & Company
Detroit Diesel Corporation
Deutz Corporation
Ford Motor Company
General Electric Company
General Motors Corporation
Hino Motors, Ltd.
International Truck & Engine Co.
Isuzu Motors America, Inc.
Kohler Company
Komatsu Ltd.
Kubota Engine America Corporation
Mack Trucks, Inc.
Mitsubishi Engine North America, Inc
Mitsubishi Fuso Truck of America, Inc.
Onan Corporation
Scania CVAB Inc.
Tecumseh Products Company
Volkswagen of America, Inc.
Volvo Truck Corporation
Waukesha Engine Division
Yamaha Motor Corporation
Yanmar Diesel Engine Company, Ltd.

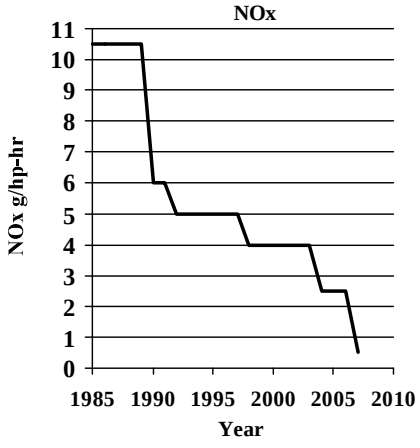
Overview

- Manufacturers have limited resources to develop and implement emission control technologies
- Essential that emission standards allow for orderly transfer of technologies
- Current marine standards are “out-of-step”
- Has resulted in significant leadtime and harmonization concerns

Overview

- **On-highway standards drive emission control technologies**
- **Technologies in other applications are derivative and more limited**





EPA Commercial Rule Overview

- Rule applies to commercial marine engines
- Pleasure craft/recreational marine covered in separate ANPRM (comments due 2/5/01)
- All vessels over 100 gross tons considered commercial
- All vessels that carry more than 6 paying passengers considered commercial
- “Commercial” definition is over-broad; includes larger yachts and charter boats
- National security exemption provided

EPA Commercial Rule Overview

- Category I (< 5.0 liters/cyl)
  - Majority of engines @ 7.2 g/kW-hr NOx (5.4 g/bhp-hr)
  - Effective Date for most engines is 2004
  - 2004 is only 1-3 years after Nonroad (NR) Rule Tier 2 standards (6.4-7.5 g/kW-hr NMHC & NOx)
  - Not to Exceed (“NTE”) standards applicable in 2007

EPA Commercial Rule Overview

- Category II (> 5.0-30 liters/cyl)
  - NOx levels similar to IMO levels (7.8-9.8 g/kW-hr) (IMO @ 9.8 g/kW-hr)
  - Effective Date for most engines is 2007
  - "NTE" Requirements effective in 2007
- Category III (>30 liters/cyl)
  - NPRM by April 2002
  - Final Rule by February 2003

EPA Commercial Rule Overview

- Timeline
  - Final Rule -- published on December 29, 1999
  - EMA filed petition -- February 24, 2000
  - DC Circuit Court of Appeals likely to hear arguments in 2001
  - Appeal coordinated with appeals from 2004 Rule for heavy-duty on-highway engines

EPA Commercial Rule
(EMA Concerns)

- Over-estimates technology transfer for Category I engines
- Provides inadequate leadtime
  - In most cases, only 1-3 years' leadtime from NR effective dates
  - In some cases, no leadtime or negative leadtime -- some marine engines must comply with Tier 2 standards before NR counterparts
- "NTE" Requirements
  - Not applicable to on-highway engine until 2007
  - Not applicable to NR engines and vehicles at all
  - Compliance @ broad range of test conditions (w/o correction)
  - Regulates engine outside of normal engine operation ranges (30 sec. intervals)
  - Resulting marine standards far more stringent than NR!

Comparison with NR Rule

- Number of Engines
  - On-Highway -- hundreds of thousands annually
  - Nonroad -- tens of thousands annually
  - Marine -- thousands per year
    - Cannot warrant or accommodate separate development and testing programs

Comparison with NR Rule

- EPA intent: Base Marine Rule on Nonroad technology BUT
  - NTE in Marine Rule but not in NR Rule
  - NTE makes Marine Rule much more stringent
- Result: Can't simply "marinize" a certified NR engine to meet Marine Rule

EPA Marine Rule
Technological Responses

- On-Highway Engine Technology
  - Manufacturers make greatest investments/ advancements here
  - Transferability to marine an issue
    - Some technologies can't work -- air to-air charge cooling
    - Some can work but less effectively -- inherent limitations

EPA Marine Rule
Technological Responses

- Potential NOx Technologies
  - Retard timing of fuel injection
    - Proven technology
    - Incurs fuel penalty
    - Increases PM & smoke
  - Charge air cooling/turbocharging
    - SWAC not viable; installation and maintenance issues
    - Must utilize JWAC or SCAC
    - Significant cost issues

EPA Marine Rule
Technological Responses

- Potential NOx Technologies (cont.)
  - Electronic Controls
    - Injection rate shaping (timing and amount of fuel charge)
    - More effective with transient operations
    - Marine applications primarily steady-state
  - Combustion Chamber Modifications
    - Optimize "induction swirl"
  - Increase Injection Pressure
    - Improved atomization ³ improved combustion
  - Water Injection
    - Not viable for Category 1 engines

EPA Marine Rule
Technological Responses

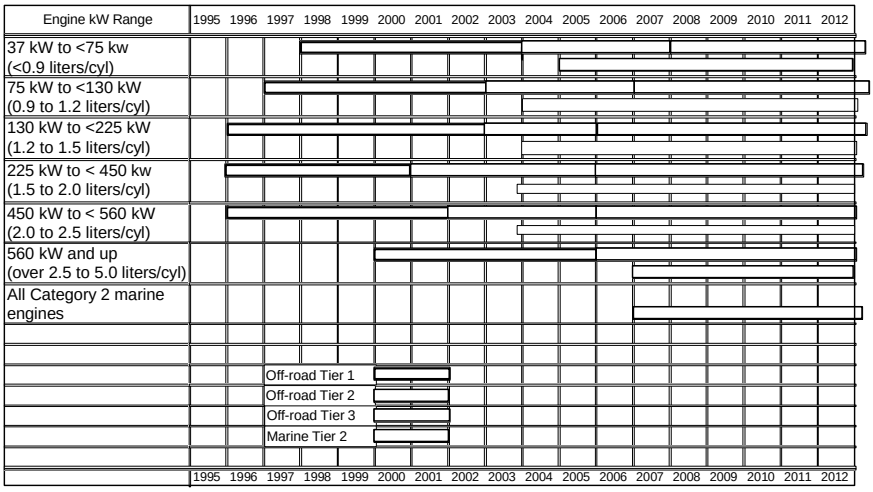
- Future
  - Utilize current options
  - EGR
    - On-Highway applications to meet 2004 2.0g NOx standard
    - Too early to tell if suitable for marine
    - Weight/size/durability/fuel compatibility concerns
    - Cost impacts
  - After-Treatment?
    - SCR ineffective in smaller marine engine environment with wet exhaust outlets
    - Space/high temperature/safety constraints
    - Other devices still in development phase
    - Cost impacts
    - Fuel quality issues

Key Issues:
Leadtime

- Better coordination of standards required

  HDOH ³ NR ³ Comm. Marine ³ Rec. Marine
- Minimum 2-year leadtime required from implementation dates
- NTE requirements unwarranted and “out-of-step”
- Derivative technologies forced to lead

Off-Road & Marine Emissions Dates



Key Issues:
"NTE" Requirements

- Throughout "zone" engine must meet caps (% of standards) for <u>all</u> pollutants, not just NOx
  - 120% @ 45%+ power
  - 150% @ below 45% power
- Compliance required @ extreme conditions without correction factors (water: 41°-81° F; air: 55°-95° F)
- Enforcement liability at infinite points of theoretical engine operations, not reflective of likely real-world operations

Key Issues:
"NTE" Requirements

- Feasibility not demonstrated
  - Of compliance
  - Of conducting/reproducing tests
- Need not demonstrated
  - Intended to control "off cycle" emissions
    BUT
    - Marine engines operate close to a defined prop curve
    - Transient operations excluded
    - Alternative means available to assure compliance

Key Issues:
"NTE" Requirements

- Amounts to another set of more stringent standards without demonstration of feasibility or cost-effectiveness
- Regulation based on "worst case" scenarios
- ➡ Engine Re-design?
- ➡ Vessel Re-design?

Key Issues:
"NTE" Impact

- Could impact entire marine industry
  - Higher cost engines
  - Availability concerns
  - Performance concerns
  - Competitive concerns
- Minimal Environmental Benefit

Key Issues:
Harmonization

- **IMO regulation has higher numerical NOx standards and no NTE (9.8 g/kW-hr v. 7.2 g/kW-hr)**
- **NTE in Marine Rule but not in NR Rule**
- **IMO engines cannot be used to meet EPA marine rule requirements**
- **Can't simply "marinize" a certified NR engine to meet Marine Rule**
- **US manufacturers at competitive disadvantage; untenable prospect of two product lines, domestic and international (the OMC saga)**

Conclusions

- Better coordination of technology phase-ins and transfers is necessary
- NTE standards and requirements are not warranted in marine applications
- Need to ensure harmonization with European “Stage II” standards

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