Emissions Reduction Products for Off-Road >25 hp SI Engines

California Air Resources Board

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Outline

- Industry Experience
- Products
- Vehicle Integration
- Exhaust Temperature Issues
- Durability
- UL Testing Requirements
- Summary

Industry Experience

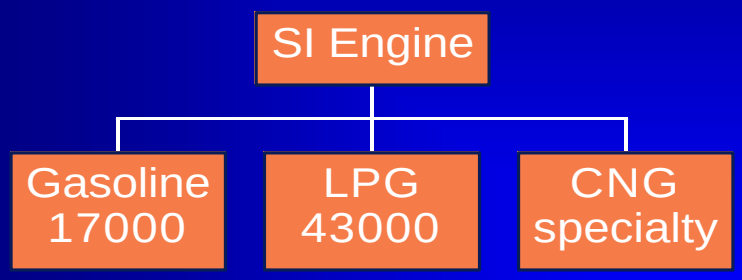
- Emissions Control Systems have been marketed for over 25 years
  - to reduce indoor CO levels
  - to help companies to meet OSHA limits
- >150,000 direct fit systems sold
- Closed Loop LPG systems marketed for over four years

Current System Use

- Systems have been traditionally used to reduce CO emissions of vehicles working indoors and in confined areas
- System use aids OSHA compliance
- System use increases productivity
- System use can reduce vehicle accidents due to operator exposure

Fuel Options

Forklifts

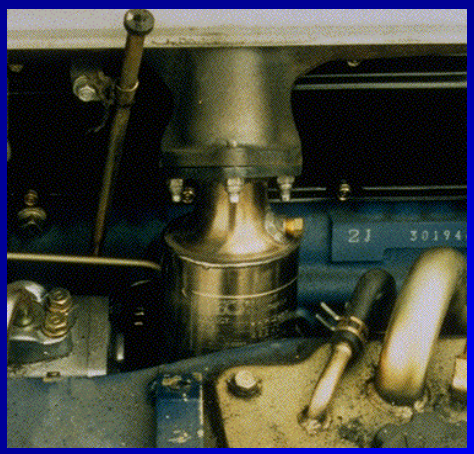


Source: Nonroad NPRM

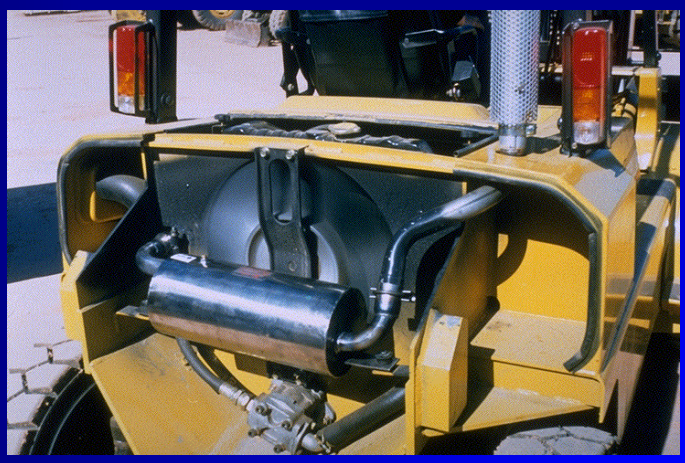
Current Industry Technologies

- Fuel Specific In-Line Converters and Integrated Converter Mufflers
  - Oxidation Catalysts
  - 3-way Catalysts
- Closed Loop Fuel Management Systems
- Electronic Safety Packages for Open Loop systems

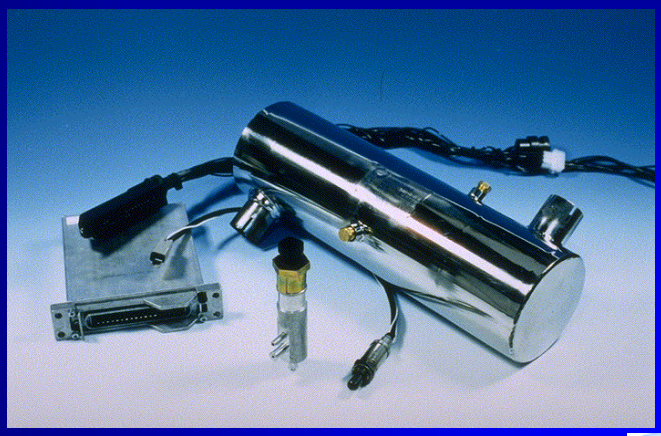
Direct Fit In-line Converter



Integrated Converter Muffler



Closed Loop LPG/CNG Emissions Control Systems



3-way Performance: LPG

45hp; 2L engine ISO 8 Mode (g/bhp-hr)	CO	HC	NOx
Baseline -open loop; lean	109	3.11	8.75
Standard ECM -closed loop, stoich.	14	1.99	18.57
Std ECM w/ Catalyst	0.16	0.01	3.28
Optimized ECM w/ Catalyst	0.78	0.04	1.10

Source: Environment Canada

Electronic Safety Packages for Open Loop Systems

Issue: Catalyst Overheating with Open Loop Fuel Systems

- Causes
  - Overfueling / poor air / fuel ratio control
  - Timing Misadjustment/Misfires
  - Dirty air intake systems
  - Weak ignition system

Issue: Catalyst Overheating with Open Loop Fuel Systems

- Solutions
  - 2-way systems include venturis
  - Electronic Safety Packages will warn of excessive exhaust heat & need for maintenance

Issue: Catalyst Inactivity due to Excessive Idle /Cold Start

- Electronic Safety Package indicates when exhaust temperatures are below catalyst light-off
- Many forklifts idle at exhaust temperatures above catalyst light-off
- Industry is looking at generating data on this issue

UL 558 Safety Standard

- Applies to internal combustion engine powered industrial trucks
- Covers tractors, platform lift trucks, fork-lift trucks and other specialized vehicles for industrial use

UL 558 Safety Standard

- Types of Approval
  - G, D, LP and G/LP
    - shall not rupture under backfire conditions
  - GS, DS, LPS, GS/LPS
    - shall not emit sparks or rupture under backfire conditions

UL 558 Safety Standard

- 2 approval options
  - build truck using UL approved parts
  - build truck and certify the whole vehicle
- UL approved exhaust components can be installed on a UL approved truck without re-certifying the vehicle

UL 558 Safety Standard

- Over 40 different UL approved converter mufflers supplied by MECA member companies

Summary

- Catalyst technology has been applied for over 25 yrs on off-road >25 hp SI engines
- Optimized closed loop emissions control system can significantly reduce CO, HC and NOx emissions