Powertrains and Fuels for Locomotives

Marti Lenz – Electro-Motive Diesel
Director, Engine Systems
April 23, 2014
EMD Has Served the Rail Industry for More Than 90 Years

Chicago Great Western M-300
Santa Fe FP45
Burlington Zephyr
JT42CW (Class 66)
Louisville & Nashville E8A
Union Pacific SD70ACe
SD70M
…Along with the Power Products Market
EMD Tier 4 Program Overview

- Broad development program for T4 emissions
  - Combined expertise of EMD and Caterpillar engineers
  - Locomotive and marine applications

- Locomotive will meet T4 regulations without the use of urea

- We have demonstrated T4 levels in our research facilities and test engines

- We are committed to providing the best emissions solution...together with life cycle cost optimization in safety, reliability, fuel efficiency, maintainability
  - Proven reliable and robust to the demanding standards of EMD, Caterpillar and our customers
Experimental Exhaust Gas Recirculation (EGR) on EMD SD59MX Diesel-Electric Freight Locomotives

ASME ICEF2012-92167
Biodiesel for our engines and locomotives

- Biodiesel fuel can reduce greenhouse gases, hydrocarbons and particulates
- We’re evaluating use of biodiesel for EMD’s engines and locomotives with no changes to the engine or existing rail infrastructure
  - Currently allow blends to B5 (5% biodiesel) with no impact on warranty
  - Durability test program with Norfolk Southern for blends up to B20 (20% renewable biodiesel) showed some impact on lube oil life
Natural Gas for Locomotives
A Current Reality ... Driven by Customer Value

- Markets that will ‘GO GAS’
  - Large fuel burn - $$ savings
- Industry transformation driven by market forces
- Achieving Scale
  - OEM supply of equipment
  - LNG supply of fuel and infrastructure

Gas engine development is well underway at EMD
Gas Product Definitions

SPARK-IGNITED
• Spark-ignited reciprocating engines only burn gas. The gas is ignited with a spark plug.
• They are typically used in applications like electric power (continuous speed) and gas compression (variable speed).
• Most of the current Caterpillar production portfolio of gas engine products are spark-ignited.

DUAL-FUEL
• Dual-Fuel engines burn both gas and diesel at the same time. The gas is ignited by compression of the diesel. Full diesel mode is available at all times.
• Caterpillar has available dual-fuel engines and kits with Dynamic Gas Blending™ technology for petroleum applications.

HIGH PRESSURE DIRECT INJECTION (HPDI)
• Well suited for highly transient or very power dense applications like rail and mining trucks.
• Caterpillar currently developing HPDI options for mining trucks and locomotives.
**LNG Technologies**

**DYNAMIC GAS BLENDING™ SYSTEMS AND KITS**

**BUILDING CONFIDENCE**

- **DGB™** provides lower fuel costs - up to 60% replacement of diesel with gas for rail applications
- Use gas when it is available and diesel when it is not
- Continuous adjustment to fuel quality and pressures
- Wide variety of fuels from associated gas to gasified LNG
- Maintain diesel power and transient response
- Maintain service intervals and component life
- Improved display performance and troubleshooting
- Reduce gas flaring by consuming dry field gas
- Maintain original emissions certification with retrofit kit

Dual-Fuel Engines and Retrofit Kits

[Images of Dual-Fuel Engines and Retrofit Kits for Oil & Gas, Rail, Marine, and Mining]

3512 Land Electric Drilling Module
Dynamic Gas Blending for Locomotives

- Leverages Caterpillar experience with DGB
- Retrofits to existing 710 engines
- Tier 3 emissions
- Able to run full power on diesel
- Fast to market…locomotive test units running in North America in 2013
- Drives infrastructure for natural gas
  - Fueling depots & liquefaction plants
  - LNG tender experience
DGB Test Locomotive Running at EMD
LNG Technologies

HIGH PRESSURE DIRECT INJECTION (HPDI) SYSTEMS AND KITS

THE FUTURE OF MOBILE GAS

• Much lower fuel costs - up to 95% replacement of diesel with gas
• Maintain diesel power, transient response, and reliability
• Capable of meeting Tier 4 standards with less emissions technology
• Engine retrofit is fuel systems only – base engine retains robust diesel components
• Engine controls work like diesel
• Same or better fuel efficiency compared to diesel base engine
• Rail and Mining applications in production in 2017
• Tanks and tenders will be adapted to store and deliver LNG

HPDI injector replaces existing diesel injector

Accelerating Through Partnership
HPDI Partnerships

Caterpillar / EMD / Westport

• Agreement announced June 5, 2012
• Initially targets Cat high horsepower, off-road equipment including mining trucks and EMD locomotive engines
• Production launch in 2017 for factory and retrofit offerings

EMD / Westport / CN / Gaz Metro

• In-service demonstration of HPDI locomotive
• Funding support from Sustainable Development Technology Canada (SDTC)
Work is Well Underway at EMD: HPDI

Test cell upgrade

Test engine

Test engine
LEADING THE INDUSTRY IN GAS-POWERED EQUIPMENT

OIL AND GAS
A Dynamic Advantage

RAIL
Flexible Fuel Options

MARINE
Your Dual-Fuel Solution

MINING
Performance and Reliability

Electro-Motive Diesel is owned by Progress Rail Services, a Caterpillar Company

April 23, 2014

Copyright © 2014 ELECTRO-MOTIVE DIESEL, INC
Thank You