

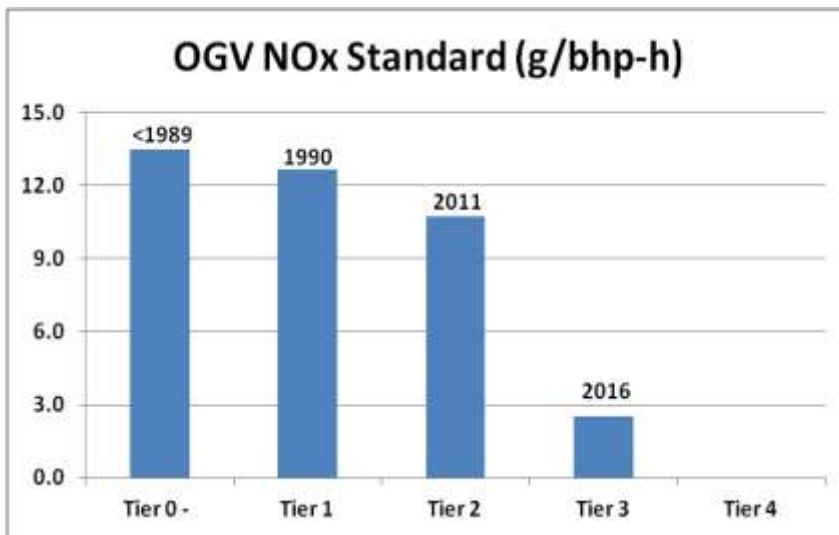
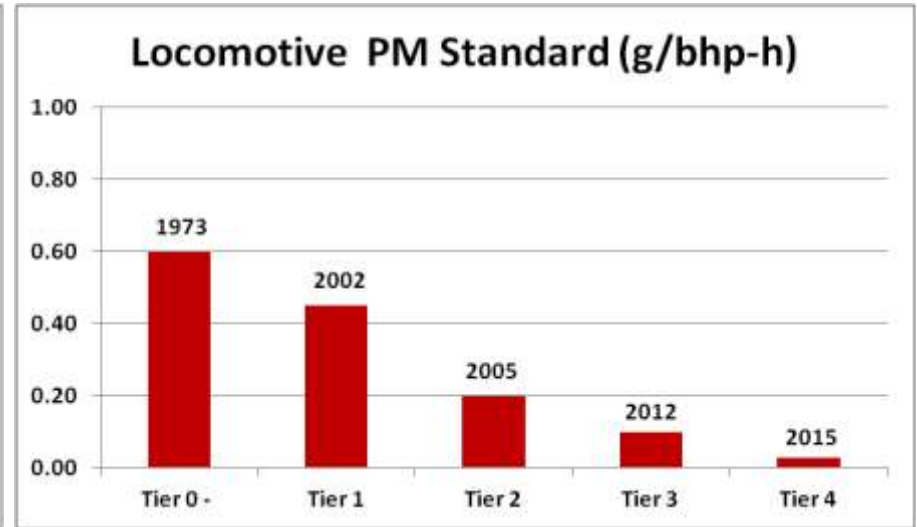
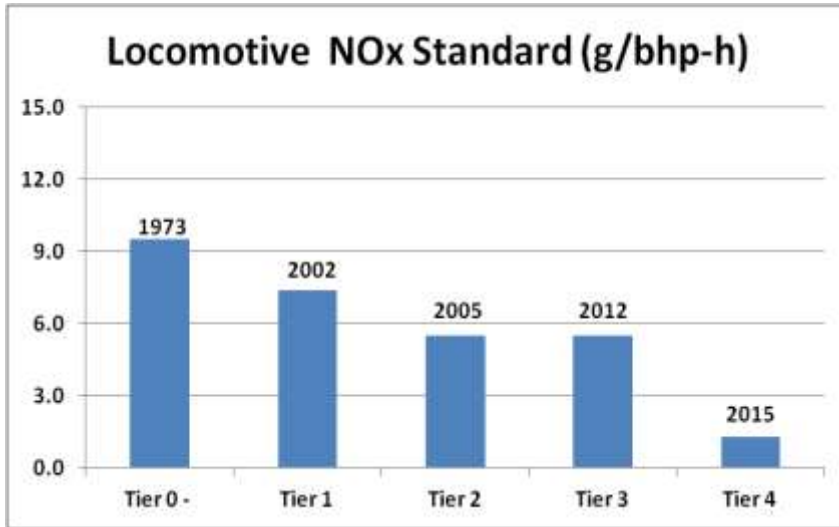
Locomotive and Marine Vessel Projects

August 29, 2012



Randall Pasek
Mobile Source Division

Locomotive/OGV Emission Standards



No OGV PM Emission Standard

By 2015, OGVs must use
<1,000 ppm sulfur content fuel

UP 9900 Tier 4 Prototype

- Meet Tier 4 PM levels and ~ 40% below Tier 3 NOx levels
- EMD 59MX
 - Two-stroke
 - 12 Cylinder
 - 3200 hp
 - Tier 2 (base)
- Aftertreatment
 - Heavy EGR
 - DOC/DPF



PM Aftertreatment

- DOC / DPF
 - Exhaust – 9 each
 - EGR – 2 each
- Weight
 - ~ 6 tons
- DPF Regeneration
 - Both Active and Passive
- Control level
 - <0.01 g/bhp-hr

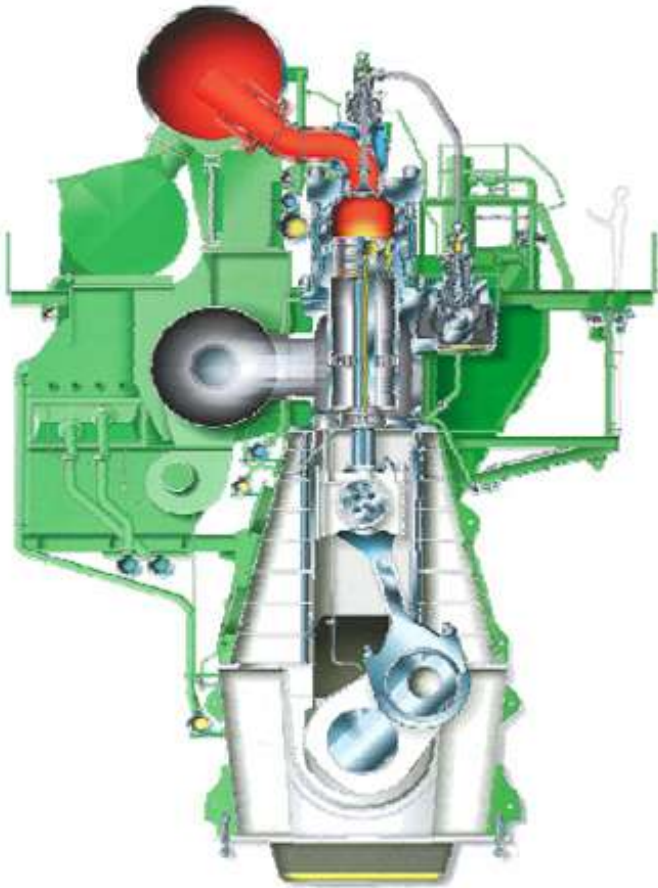


GE 2015 Tier 4 Prototype

- >4,000 hp GE Evolution[®] 4 stroke engine
- NOx Control
 - Heavy EGR
- PM control
 - DOC and DPF?



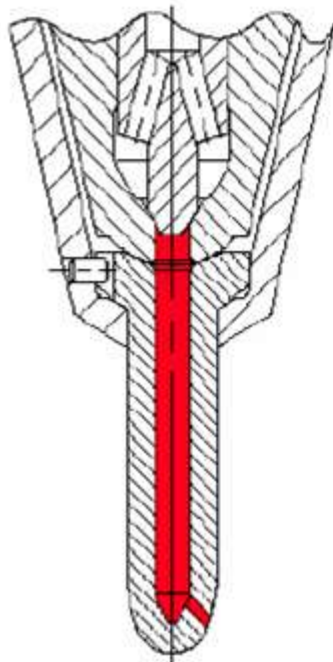
Ocean Going Vessel Main Engines



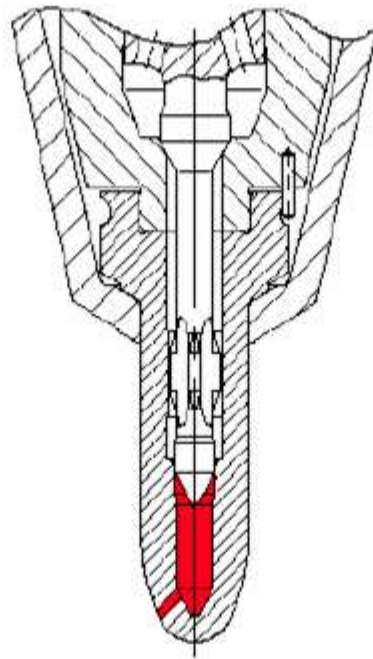
- Large Slow Speed Engines
- 20k to 75k+ HP
- 100 rpm
- Two-Stroke

Slide Valve Injector Project

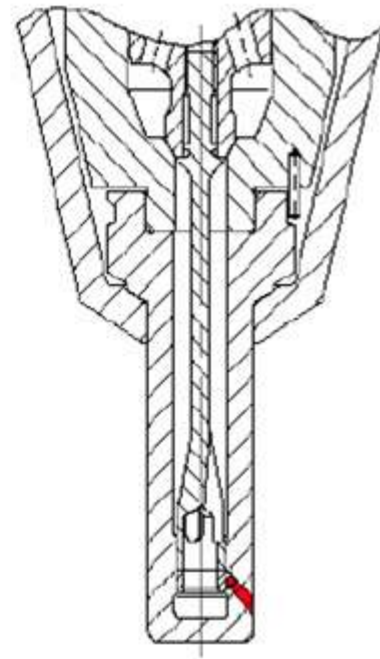
- Slide Valve Reduces “Sac Volume” in injector
- Achieve up to 30% NO_x and 25% PM emission reductions



Standard



Mini Sac



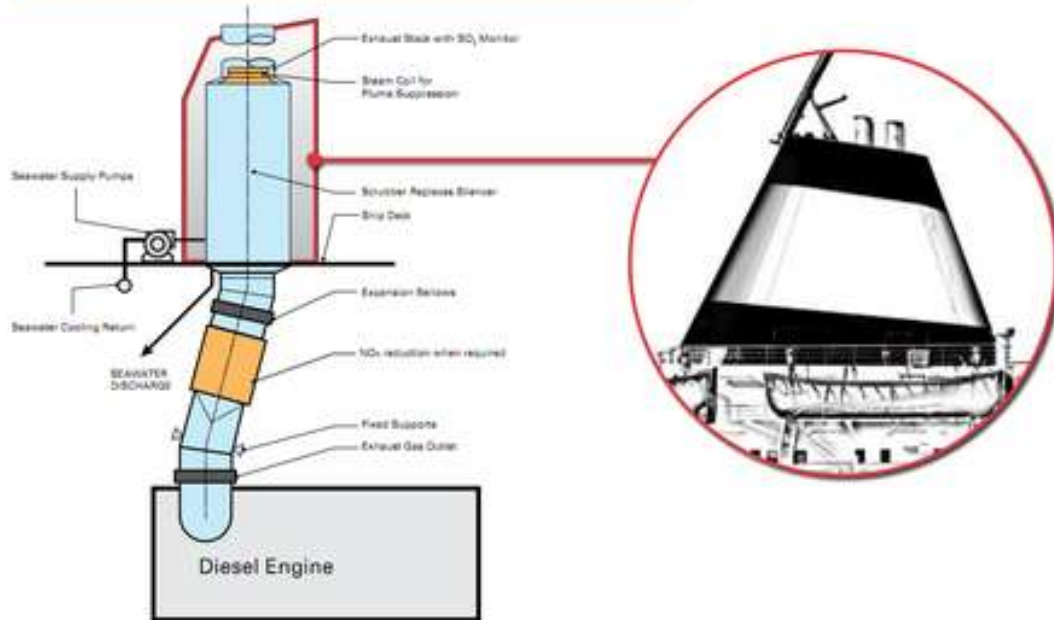
Slide

Slide Valve Retrofit Project

- MAN B&W S70MC-C (15k to 35k HP)
- Low Load Conditions
 - 2008 Retrofit Study Showed Less than Expected Reductions.
- Three Nozzle Configurations
 - Conventional
 - Low NOx
 - Slide Valve
- Tests in September 2012

Seawater Scrubber

The BELCO® Ship Pollution Control Scrubbing System Design



- SO_x and PM Control
 - SO_x - >90%
 - PM - >50%



Seawater Scrubber Projects

- Bluefield Holdings and Krystallon
 - Auxiliary Engine Scrubber
 - Krystallon SC500 7 MW size
- Installed and Operating on APL C11 Cargo Ship (4300 TEU)
- Testing Completed
- Results
 - SO_x, HFO: 98-99%; MGO: 95-98% control
 - PM, HFO: 56-70% MGO: 68-75% control



Seawater Scrubber Projects

- CSU Long Beach / Belco Technologies
- Partnered with CMA CGM Norma (10,000 TEU) Container Vessel
- Project Should be Completed in Two Years
- Goal is 85% PM and 50% SOx reductions



Tugboat Retrofit Technology



- **Vessel 1**
 - Original twin 600 hp DDC engines
 - Rebuilt with DDC Clean Cam Tier 2 kit
 - SCR with actively regenerated DPF
- **Vessel 2**
 - Repowered with twin 800 hp MTU-DDC Tier 2 engines
 - SCR – DOC – passively regenerated DPF