PEMS Testing – Applications and Lessons Learned

2012 PEMS Conference and Workshop
March 29th, 2012
CE-CERT, Riverside, California

Michael Block
Saeed Abolhasani
Filippo Toscano
Eric Persson
Outline

- About Emisstar
- Four PEMS Testing Applications
- What Have We Learned?
Emisstar LLC

“Energy and Emissions Technology, Policy, and Implementation”

• Formed in April 2005
• Dual focus
  • Fossil-fuel emissions remediation
  • Alternative energy sources
• Over 90 years collective experience
  • Testing Services – PEMS, laboratory, CFR Parts 86, 89, 1065, etc.
  • Air quality science & engineering
  • Engineering & project management
  • Strategic planning for sustainability, goods movement and renewables
  • Diesel engine, vehicles and emissions control technology assessment and implementation
• Three US facilities – New York, Texas, California

www.emisstar.com
<table>
<thead>
<tr>
<th>Client</th>
<th>Application</th>
<th>Location</th>
<th>Why Unique?</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKRF/Columbia University</td>
<td>Cement Trucks</td>
<td>NYC</td>
<td></td>
</tr>
<tr>
<td>Capacity of Texas</td>
<td>Advanced Hybrid Yard Tractor</td>
<td>Longview, TX &amp; POHA</td>
<td>Unique Test Cycle Development</td>
</tr>
<tr>
<td>Cerion Energy</td>
<td>Mississippi River Ferry Boats</td>
<td>New Orleans</td>
<td>Ferry -- side push embankment</td>
</tr>
<tr>
<td>Croton Water Treatment Project</td>
<td>Nonroad Construction Equipment</td>
<td>Bronx, NY</td>
<td></td>
</tr>
<tr>
<td>Cummins Power Systems</td>
<td>Natural Gas Gen Set for EPA NSPS</td>
<td>Allentown &amp; Northumberland, PA</td>
<td></td>
</tr>
<tr>
<td>EcoPower Hybrid Systems</td>
<td>Advanced Hybrid Gantry Crane</td>
<td>POLA</td>
<td>Unique Test Cycle Development</td>
</tr>
<tr>
<td>EnerTeck LLC</td>
<td>Advanced Aftertreatment, Marine Vessels</td>
<td>Paducah, KY</td>
<td></td>
</tr>
<tr>
<td>Enviromagnetics Corporation</td>
<td>Fuel Additive (J1321)</td>
<td>New Jersey</td>
<td>On-Highway Truck -- J1321</td>
</tr>
<tr>
<td>Evans Cooling Systems</td>
<td>On-Highway Vehicles</td>
<td>North Carolina</td>
<td></td>
</tr>
<tr>
<td>Generator Services/D2G</td>
<td>Multi-fuelled Gen Sets</td>
<td>Rancho Cucamonga, CA</td>
<td></td>
</tr>
<tr>
<td>Hyundai Heavy Industries Ltd.</td>
<td>Large Marine Gen Set Engines</td>
<td>Ulsan, South Korea</td>
<td>Exhaust Flow; Engine Load</td>
</tr>
<tr>
<td>MRCT/Ingram Marine Group</td>
<td>Loco Engine Powered Push Boats</td>
<td>Paducah, KY</td>
<td></td>
</tr>
<tr>
<td>Komatsu America Corporation</td>
<td>Advanced Nonroad Hybrid Excavator</td>
<td>Cartersville, GA</td>
<td>Test Cycle Development</td>
</tr>
<tr>
<td>Navistar Corporation</td>
<td>EPA SCR HDIU Performance Testing</td>
<td>Sacramento, CA</td>
<td></td>
</tr>
<tr>
<td>Nett Technologies</td>
<td>Gantry Crane Aftertreatment</td>
<td>POHA</td>
<td></td>
</tr>
<tr>
<td>Schlumberger</td>
<td>Fracturing Trailers Petroleum Industry</td>
<td>Denton, TX</td>
<td>Strain gauge for load</td>
</tr>
<tr>
<td>Smith Electric Vehicles US Corp</td>
<td>On-Highway Elec Vehicle Range Testing</td>
<td>Milford, UK</td>
<td></td>
</tr>
<tr>
<td>University of Rochester</td>
<td>Alt-Fuelled School Buses</td>
<td>Rochester, NY</td>
<td></td>
</tr>
</tbody>
</table>
Applications-2

• Capacity
• EcoPower Hybrid Systems
• MRCT/Ingram Marine Group
• Komatsu America
Capacity – Terminal Tractor

- TCEQ NTRD
- Conventional vs. series hybrid
- POHA (and CA) operation
- Criteria emissions and fuel consumption
- Dry run at Capacity facility
- Then POHA
Capacity – PEMS Instrumentation

• SEMTECH DS – Gaseous
• SEMTECH EFM – 4” and 2.5”
• MAHA MPM4 – PM
• J1939 for both
Capacity – Terminal Tractor

- Exhaust Flow Meter
- MAHA MPM-4 Particulate Matter Measuring System
- Zero Calibration Gas
- Weather Station Probe
- Probe
- Zero Calibration
- Gas
- SEMTECH generator to power the SEMTECH-DS unit
- EFM pressure sensor box
- Fabricated shelving to support the PEMS equipment
- SEMTECH’s heated line
- SEMTECH unit
- Exhaust flow meter
- MAHA MPM-4 Particulate Matter measuring system
- SEMTECH unit
- Portable generator to power the SEMTECH unit
- High temperature resistant silicon hose
- SEMTECH heated line
- Fabricated shelving to support SEMTECH unit
- Fabricated shelving to support SEMTECH unit
Capacity – Test Cycle

Duty Cycle (1) – unloading containers from a vessel (via gantry)

Duty Cycle (2) – loading containers onto a vessel (via gantry)

4 “sub-cycles”
EcoPower - RTG Testing

Conventional Power for RTG

![Diagram of existing diesel power plant for RTG]

Hybrid Power for RTG

EcoPower Patented Technology

![Diagram of hybrid power plant for RTG]

Replace the old GenSet by the newest GenSet technology, battery pack and energy management system.
EcoPower – PEMS Instrumentation

• SEMTECH DS

• AVL 494 PM PEMS

• Kral fuel flow meter – onboard fuel flow measurement, temperature compensated (*)

* 40 CFR §86.345-79
EcoPower – Test Cycles - 1

- **7.5 lifts per hour** followed by 20 min idle
- **15 lifts per hour** followed by 20 min idle

Study “Rubber tired Gantry (RTG) crane load factor study”, Starcrest, POLA & POLB, November 2009:
- Two RTG cranes were monitored in for a total of 751.5 hours.
- During this time 7376 moves are reported for an average of 10 container moves per hour or 20 lifts if you count empty hoisting.
EcoPower – Test Cycles - 2
EcoPower – Test Cycles - 3

Step 1: Spreader parked/trolley to position for pick-up

Step 2: Hoist down the spreader towards the target container

Step 3: Hoist up container.

Step 4: Trolley the container to end position

Step 1a: Spreader parked/trolley positioned for pick-up

Step 2a: Hoist down the spreader towards the target container

Step 3a: Hoist up container.

Step 4a: Trolley container to end position
EcoPower – Test Cycles cont’d

Step 5: Lower the target container to the ground.

Step 6: Lift the spreader to the default position.

Step 7: No move as average trolley travel is half distance. All trolley contribution to be covered by move 6a.

Step 8: To wait for cycle corresponding idling time and go to step 1a for second half of the cycle.

Step 5a: Lower the target container onto the trailer of the truck.

Step 6a: Lift the spreader to the default position.

Step 7a: Lift the spreader to the default position.

Step 8a: To wait for cycle corresponding idling time and return to step 1.
Step 9: every 720 seconds the crane will gantry for 45 seconds moving from the container and coming back over the test container.
MRCT/Ingram – Objectives

Quantify the performance of a retrofitted DOC/CVS Kit
MRCT/Ingram – Application

Test Vessel and Engine

- James F. Neal
- Newly overhauled push-boat
- Two EMD 12V-710 engines
- Rated at 3000 hp per engine
- 710 in³/cylinder
- Turbocharged
For testing configurations without XtrmCat™, DOC bricks were taken out.
Model 12-710 Engine
Injector Rack Position/Brake HP at Various Engine Speeds

Rack Length (inches)

Engine Out (Brake Horsepower)
Injector Rack Position
Testing location and embankment

Back and front view of test vessel during the test
## ISO 8178 E3 – Ideal vs. Actual

<table>
<thead>
<tr>
<th>Test Sequence/Mode</th>
<th>ISO 8178 E3</th>
<th>MRCT E3 Test Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RPM  Load</td>
<td>Actual RPM  Actual Load</td>
</tr>
<tr>
<td>1</td>
<td>100% 100%</td>
<td>94% 86%</td>
</tr>
<tr>
<td>2</td>
<td>91% 75%</td>
<td>84% 59%</td>
</tr>
<tr>
<td>3</td>
<td>80% 50%</td>
<td>74% 36%</td>
</tr>
<tr>
<td>4</td>
<td>63% 25%</td>
<td>66% 21%</td>
</tr>
</tbody>
</table>
Komatsu – Hybrid Excavator
Komatsu – PEMS Technique

• SEMTECH DS – gaseous
• Sensors PM
• SEMTECH (EFM)
• No load – cycle based data
Komatsu – Test Cycle

1. Dig using 90° swings (10 times)
2. One minute to reposition for next segment
3. Dig using 180° swings (10 times)
4. One minute to reposition for next segment
5. Dirt leveling (10 complete swings)
6. One minute to reposition for next segment
7. Trenching using 45° swings (10 times)
8. One minute to reposition for next segment
9. Over the side ditching using 90° swings (10 times)
10. One minute to reposition for next segment
11. Traveling at full speed for 1 minute 15 seconds
12. Idling for 5 minutes immediately after travelling segment
Challenges – 1

“Axiomatic” (i.e. self-evident truths)
• When the engine or vehicle/equipment fails it is ALWAYS the fault of the PEMS
• When delays are caused by human error it is ALWAYS the fault of the PEMS testing team
• Corollary – blame those who are not immediately around (potty or pizza break)
Challenges – 2

• Three entities
  • Application owner
  • Device owner
  • Testing outfit
• Testing entity is typically not the same as the “vehicle” application entity (Cap & Kom exceptions but Cap had to coord w/POHA)
• Different goals
• Different expectations
• Different schedule!
• May create issues
Lessons Learned - 1

• Roles and responsibilities across all three (or more) entities

• Need a champion (application)!
  • The clearer the defined role of a committed champion the easier it all is....
Lessons Learned – 2

• Instrument installation – plan!
• Plan for instrument failures – “when” not “if
• PM component tends to be more challenging and/or complex
  • Filter media chain of custody
  • Time align w/gaseous
  • Counterpoint: cal gases
• Logistics
  • Ship, not truck requires tight logistics
  • Bi-coastal
  • Duplication where possible – ancillaries
Contact Information – Emisstar LLC

Michael C. Block, Principal
(949) 218-8229
michael.block@emisstar.com
www.emisstar.com