Fall 2010 Composite Data Products
ARRA Material Handling Equipment
Quarter 3 of 2010

Composite Data Products
Final Version September 30, 2010

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Fall 2010 Composite Data Products
ARRA Material Handling Equipment

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September 30th, 2010
Fuel Cell MHE Systems Deployed

Cumulative Units Deployed

Fuel Cell Units Deployed - ARRA

Class III
Class II
Class I

2010 Q1
2010 Q2

136
122
14

206
122
49
35
Cumulative Fuel Cell Operation Hours - ARRA

65.9% FC Stacks > 1000 Hours
Min Fleet Average = 599 fuel cell hours
Max Fleet Average = 1338 fuel cell hours
Fueling Events by Quarter - ARRA

Cumulative Fuelings = 13,329

Number of Fills

2009Q1 2009Q2 2009Q3 2009Q4 2010Q1 2010Q2
Hydrogen Dispensed to Material Handling Equipment By Quarter - ARRA

Cumulative Hydrogen Dispensed = 6,198 kg

2009Q1  2009Q2  2009Q3  2009Q4  2010Q1  2010Q2

Hydrogen Dispensed [kg]
Refueling Time of Day - ARRA

Time of Day [hours]

Number of Refuelings

Refueling Time of Day - ARRA

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Histogram of Fueling Times

- 13,329 Events
- Average = 1.93 min

Fill data for class 1, 2, and 3 trucks
1. Some refueling events not recorded/detected due to data noise or incompleteness.
2. The outer arc is set at 40% total refuelings.
3. Full Pressure is either 3600 psi or 5000 psi.
Operating Time Between Fuelings - ARRA

Average of 4.1 op hours between fills

1) Some fueling events not recorded/detected due to data noise or incompleteness.
2) Data indicative of actual use and does not represent the max capability of the systems.
Histogram of Fueling Rates

Histogram of Fueling Rates
ARRA

13,329 Events
Average = 0.27 kg/min

Fill data for class 1, 2, and 3 trucks
Histogram of Fueling Amounts

Average = 0.47 kg

Fill data for class 1, 2, and 3 trucks
Fuel Cell Operation Hours by Quarter - ARRA

Total Hours = 149,046

2010 Q1: 52,613 hours
2010 Q2: 96,433 hours

Total Operation Hours = 149,046
Forklift Maintenance By Category - ARRA

Number of Events
Total Events = 789
73% were unscheduled

Labor Hours
Total Hours = 1165
69% were unscheduled

- Controls, Electronics, Sensors: 24%
- Preventative maintenance: 10%
- Thermal management: 13%
- Energy Storage System: 23%
- Fuel System: 24%
- Other: 14%
- Electrical: 13%
- Operator Error: 28%
- Air System: 17%
- FC Stack: 13%
- Scheduled equip upgrade: 20%
- Air system: 9%
Fuel Cell System Scheduled and Unscheduled Maintenance by Category

Number of Maintenance Events by Category

- Total Events = 789
- 71% were unscheduled

Number of Labor Hours by Category

- Total Hours = 1165
- 68% were unscheduled
Average Fuel Cell System Maintenance by Quarter

Average Fuel Cell System Quarterly Maintenance - ARRA

Average Fuel Cell Maintenance Events

Average # of Events per System

10Q1 10Q2

Average Fuel Cell Maintenance Hours

Operator Error (Unscheduled)

Unscheduled

Scheduled

10Q1 10Q2

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Operating Time at Fuel Cell Voltage Levels - ARRA

1) 100% max fuel cell voltage is approximately open-circuit voltage
Operating Time at Fuel Cell Current Levels
Operating Time at Fuel Cell Power Levels - ARRA

- X-axis: % Rated Max Fuel Cell Power
- Y-axis: % Fuel Cell Operating Time
- The graph shows the distribution of operating time at various fuel cell power levels.

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Innovation for Our Energy Future
Shaded areas represent the min and max site average hydrogen use and fill frequency.
Average Daily Fuel Cell Operation Hours per Fleet - ARRA

25th and 75th Percentile

Median
Average Daily Fuel Cell Operation Hours per System - ARRA

50.4% Fuel Cell Systems Average 5-7 Hours Daily
1) Near Miss is an event that under slightly different circumstances could have become an incident:
   - unplanned H2 release insufficient to sustain a flame

2) Incident is an event that results in:
   - a lost time accident and/or injury to personnel
   - damage/unplanned downtime for project equipment, facilities or property
   - impact to the public or environment
   - any hydrogen release that unintentionally ignites or is sufficient to sustain a flame if ignited
   - release of any volatile, hydrogen containing compound (other than the hydrocarbons uses as common fuels)