



Fuel Cell-Powered Lift Truck Sysco Houston Fleet Deployment

Project ID: H2RA010
Scott Kliever, Program Manager
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Project Overview

■ Timeline

- Start: October 1, 2009
- Finish: September 30, 2013
- 60% complete (Feb 29, 2012)

■ Budget

Total Project Funding

- DOE: \$1,201,918
- Sysco: \$2,046,710

■ Barriers

- Safe hydrogen use in high-throughput distribution center
- Full fleet conversion of greenfield center
- Operator productivity improvements
- Fuel cell use in freezer setting
- GenDrive[®] fuel cell lifetime and reliability

■ Partners

- Plug Power – GenDrive[®] system and service provider
- Air Products – Hydrogen and hydrogen infrastructure provider
- Big-D Construction – Site preparation provider for hydrogen infrastructure

Relevance

OBJECTIVES

- Support American Recovery and Reinvestment Act goals of long-term economic growth by successfully demonstrating a new technology
- Establish a proving ground for expanded use of hydrogen fueling technology at Sysco, thereby promoting future adoption of fuel cells in other applications to help drive their use in the U.S.
- Promote the economic and environmental benefits of hydrogen fuel cell technology

TACTICS

- Convert the entire class-2 and class-3 lift truck fleet at Sysco Houston's greenfield distribution center to fuel cell use
- Demonstrate the economic benefits of large fleet conversions of lift trucks from lead-acid batteries to fuel cell power units by measuring, analyzing and reporting on the performance, operability and safety of the systems
- Demonstrate freezer operation
- Obtain affordable and reliable hydrogen



Plan and Approach

■ **Fueling Station Installation**

- Install hydrogen handling and dispensing equipment consistent with merchant liquid hydrogen supply

■ **GenDrive Power Unit Construction**

- Complete build of 26 class-2 and 79 class-3 GenDrive power units (including 7 temporary rental units)

■ **Startup, Training and Safety**

- Commission and start up of the fueling station and power units and train Sysco Houston personnel in their use and maintenance
- Complete NEPA environmental forms

■ **Lift Truck Operation and Evaluation**

- Receive operational and maintenance support for the power units and the hydrogen handling and dispensing equipment and evaluate their performance over the duration of the project

■ **Program Management and Reporting**

- Provide overall project management and reporting to the DOE over the course of the project, including quarterly reports, annual assessments and the submission of data to NREL

Milestones

Milestones	Progress	% Complete
Fueling Station Installation	Big-D completed preparatory work for hydrogen infrastructure installation Air Products completed installation of hydrogen fueling system	100%
GenDrive Build	Plug Power completed build of 26 class-2 and 79 class-3 power units (including 7 temporary rental units)	100%
► Go/No Go	<ol style="list-style-type: none"> 1. Fuel station was fully tested and deemed operational 2. Fuel cells passed factory acceptance testing 	100%
Annual Assessments Month 18, 30 and 48	<p>Assess reliability of the fuel cells by measuring the time between failures and examining the cause of failure</p> <p>Assess cost to maintain and operate the fuel cells, as well as overall operator experience</p>	60%

Progress and Technical Accomplishments

PROGRESS

- Sysco Houston is successfully using hydrogen fuel cell technology for the first time in a total fleet environment
- Facility has proper safety, backup and operational procedures in place
- Close monitoring and return on investment calculations have increased Sysco's involvement in fuel cell powered lift truck operations
- Fully implemented hydrogen safety plan

ACCOMPLISHMENTS

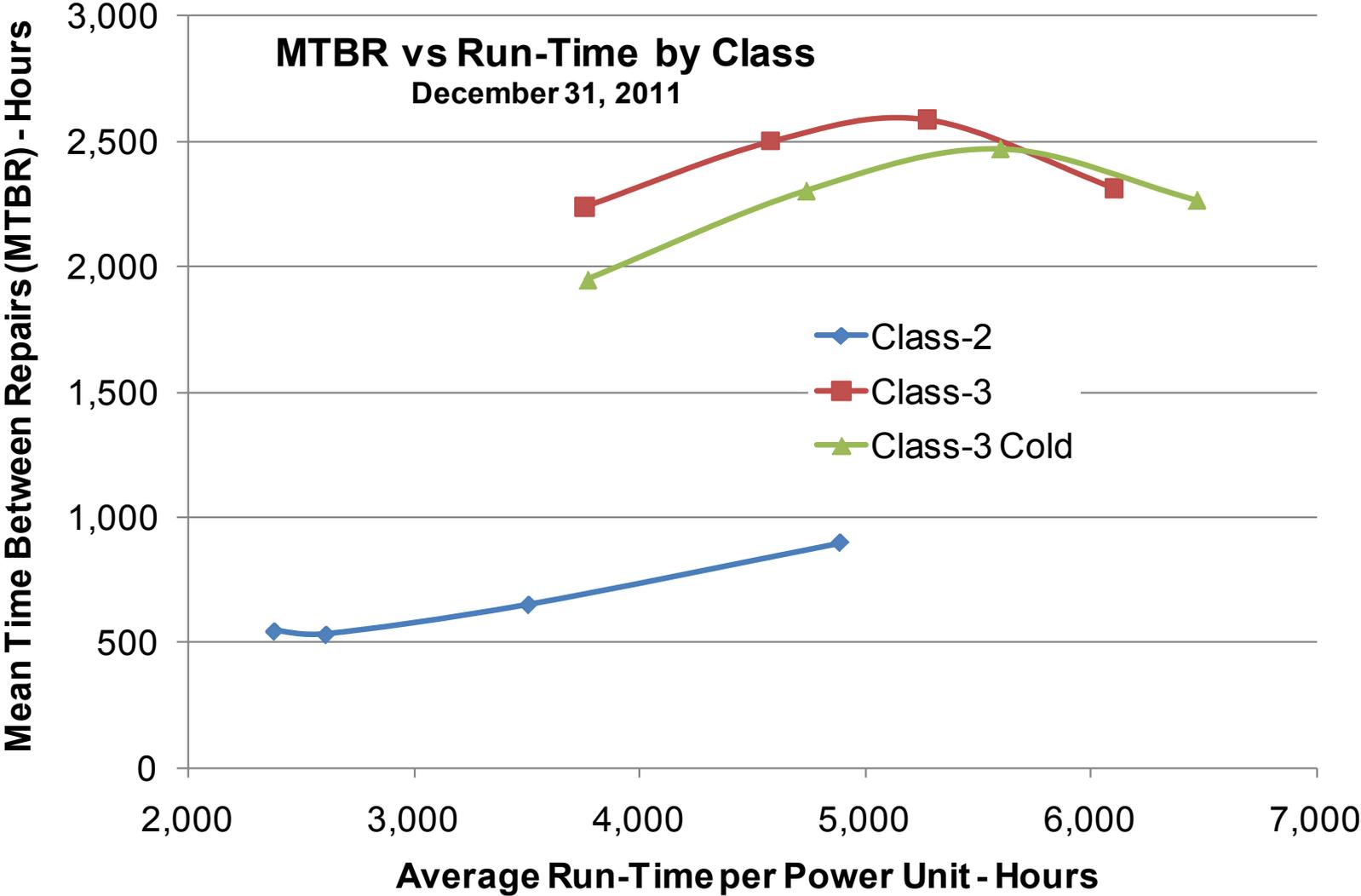
- Converted the entire class-2 and class-3 lift truck fleet in a greenfield distribution center to fuel cell use
- Built permanent hydrogen fueling infrastructure
- Trained over 100 employees on operation and safety of hydrogen use
- Improved operator productivity due to elimination of battery degradation and charging time
- Through life of project 5.5 jobs have been created



Technical Accomplishments and Progress: Fuel Cells

- Over 22 months and 570,000 hours of continuous fuel cell operation to December 31, 2011
- All class-2 power units were converted from 250-bar to 350-bar pressure to reduce fueling frequency
- Successfully demonstrated the operation of 25 class-3 power units in sub-zero temperatures
- We are saving nearly \$100,000 per year in man-hours spent on refueling fuel cells versus swapping batteries
- Performance of fuel cells is much better than lead-acid batteries
- The current cost of hydrogen fuel is approximately the same as the cost of electricity to charge lead-acid batteries
- The cost of fuel cells is coming down as production increases
- We have changed the way we maintain our pallet jack and forklift power source from reactive maintenance with lead-acid batteries to preventative maintenance with the hydrogen fuel cells

Fuel Cell Repair Frequency

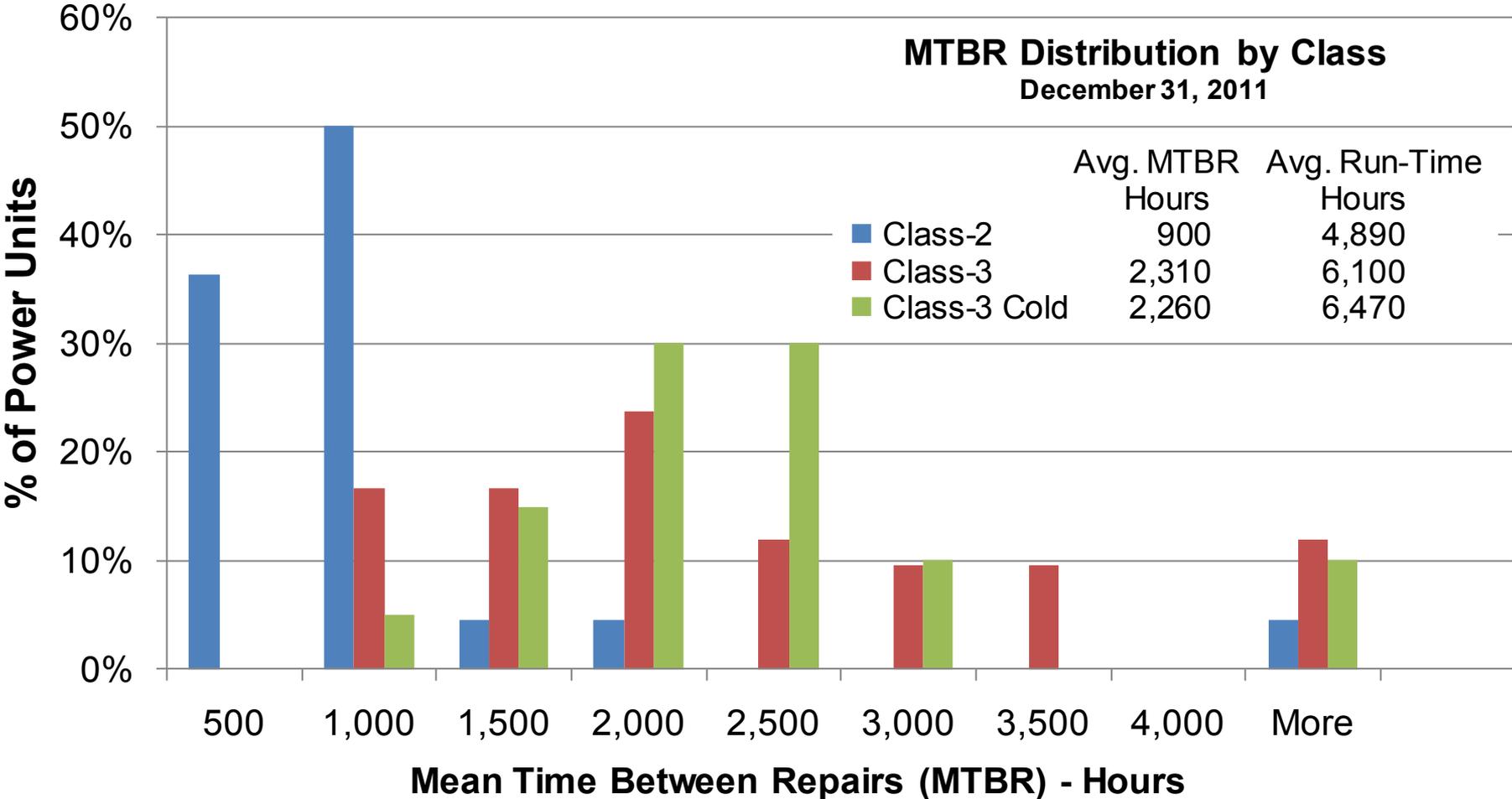


Fuel Cell Repair Frequency – Take Away

You can see that the cyclical repairs are coming due on the Class 3 fuel cells. Being just 2 years into the maintenance program we should see a rolling trend as required maintenance comes due for both the Class 2 & 3 fuel cells.

The Class 2 fuel cells are on a very nice trend as some of the early start up issues were addressed and performance is on the increase.

Fuel Cell Repair Distribution

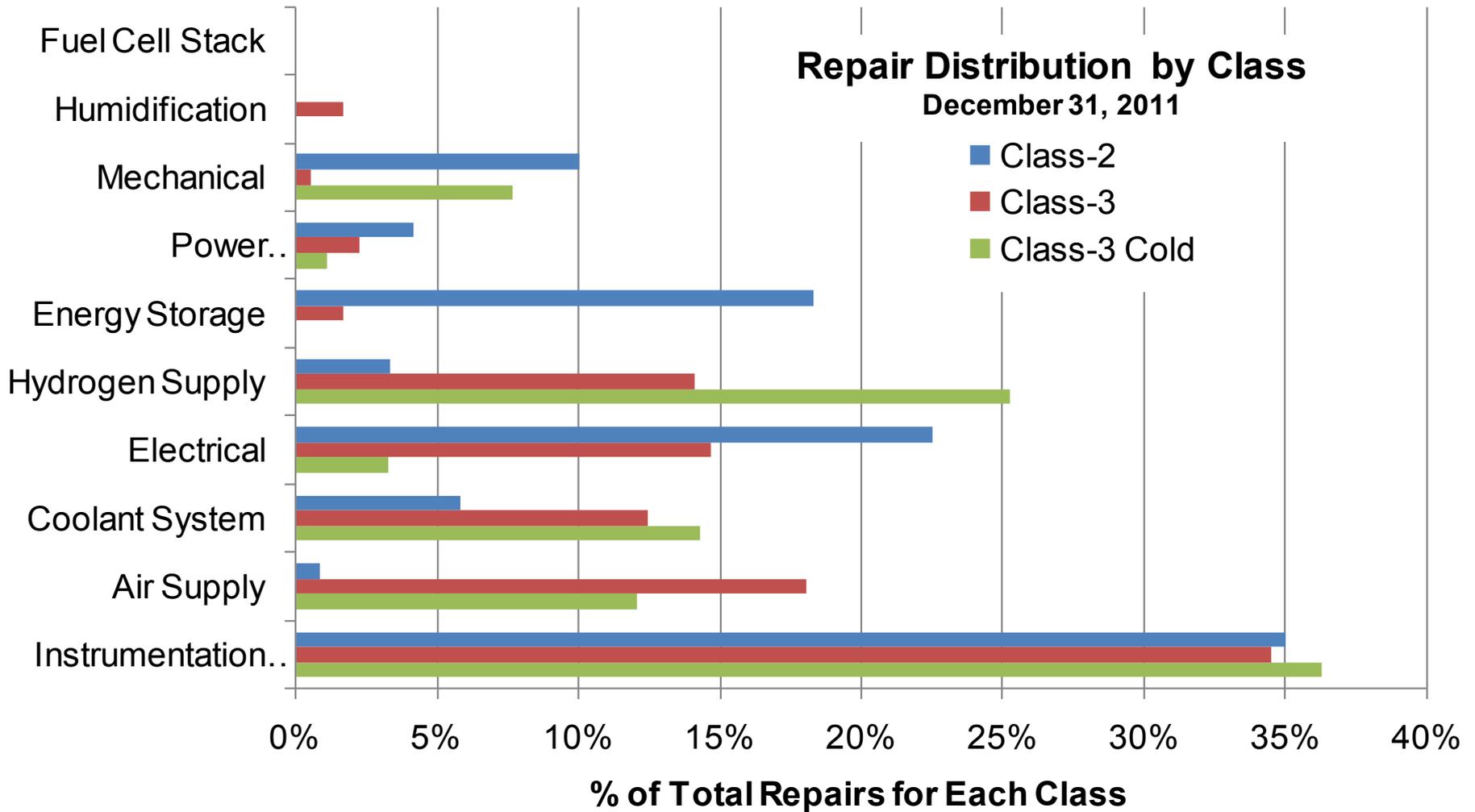


Fuel Cell Repair Distribution – Take Away

The Class 2 fuel cell units became more reliable after the original installation and the first 1,000 hours of service.

Much of the distribution of repairs came after the first year (2,000) hours of run time. We implemented the Class 2 fuel cells into our operation approximately 6 months after the initial start up of operations using the Class 3 units.

Types of Fuel Cell Repairs



Types of Fuel Cell Repairs – Take Away

The instrumentation and electrical components seemed to be the main area that needed some attention in looking at the way Sysco uses these units across our 680,000 square foot facility.

Corrections were made early in the project which helped in the future design of fuel cells received at our other Sysco locations.

The hydrogen supply for the Class 2 units were converted from 250 bar psi to 350 bar psi. This helped us reduce the frequency of stops at the refueling islands.

One of the most reliable components of the hydrogen fuel cell is the fuel cell stack.

Technical Accomplishments and Progress: Hydrogen

- Air Products commissioned the fueling station in December 2009
- Liquid tank operates with a MAWP of 150 psig, bulk high-pressure storage tanks operate at 6,000 psig
- Indoor dispensers are 250 and 350-bar pressure and capable of 700 kg/day
- Operator dispenser recognition requires pin code and badge scan
- 45,820 kg of hydrogen consumed to December 31, 2011
- Developed a hydrogen safety plan in 2011
- Helped DOE develop a process for reviewing future hydrogen safety plans



Collaborations

■ Partners:

- Plug Power – GenDrive system and service provider
- Air Products – Hydrogen and hydrogen infrastructure provider
- Big-D Construction – Site preparation provider for hydrogen infrastructure

Proposed Future Work - 1

- Sysco's hydrogen fuel cell program currently includes replacing approximately 1,444 lead-acid batteries with 722 fuel cells at seven (7) broadline distribution centers
- Sysco has finished implementing fuel cell fleet conversions at Philadelphia, San Antonio, Northeast RDC and Houston facilities ≈ 422 fuel cells
- Sysco has committed to additional fuel cell fleet conversions at Boston, Long Island and Riverside facilities ≈ 300 fuel cells
- Expansion plans are based on proven reliability and safety of current operations at Sysco Houston
- Sysco is supporting the conversion to fuel cells to help reduce the overall costs of fuel cell power units and hydrogen fuel
- Sysco Houston will help other Sysco facilities develop hydrogen safety plans

Proposed Future Work - 2



Continue Operation And Evaluation

- Monitor GenDrive power units project performance, operability and safety
- Monitor liquid and gaseous hydrogen fueling equipment project performance, operability and safety
- Monitor and provide project performance, operability and safety reports to the DOE, including any safety and performance data and issues identified during operation of the power units
- Support DOE communication efforts

Summary

- Relevance:** Demonstrate the economic benefits of large fleet conversions of lift trucks from lead-acid batteries to fuel cell power units
- Approach:** Install an Air Products hydrogen fueling station, build Plug Power GenDrive power units and evaluate program to ensure success
- Technical Accomplishments:** Plug Power built and commissioned GenDrive units; Air Products installed the hydrogen fueling system
- Technology Transfer/Collaborations:** Plug Power, Air Products and Big-D Construction
- Future Work:** Continue operation and evaluation at Sysco distribution centers; replace approximately 600 lead-acid batteries with 300 fuel cells at three (3) additional sites

Supplemental Slides

Fuel Cell Performance Results

Unit Type	# of Units	Average Hours/Unit	Total Hours	Average MTBR
Class-2	26	4,900	127,400	900
Class-3	47	6,100	286,700	2,310
Class-3 Cold Temperature	25	6,500	162,500	2,260
Total	98		576,600	

MTBR = Mean Time Between Repairs (all data to December 31, 2011)

Questions?

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