



Fuel Cells and Electric Forklift Trucks

Steve Medwin

The Raymond Corporation

June 14, 2011

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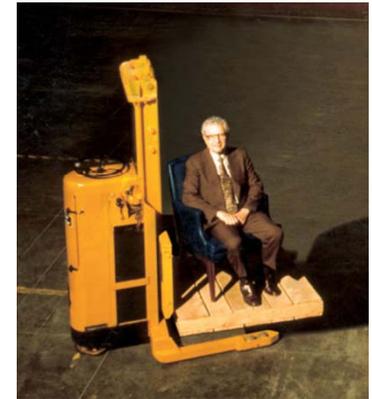
Agenda

- › The Raymond Corporation
- › Fuel Cells for Forklifts
- › Truck Compatibility
- › Pros and Cons
- › Usage in North America
- › Conclusions



The Raymond Corporation

- › Founded in 1922
 - Design, manufacture, sell & service electric forklift trucks
- › Purchased by Toyota Industries in 2000
 - Now part of Toyota Material Handling Group (TMHG)
- › Started investigating fuel cells in 2004
- › Fuel cells operational in factory since 2007
 - First indoor refueling in New York State
- › Became independent distributor and service provider of Plug Power fuel cells in 2010
 - Raymond customers actively using fuel cells
- › Evaluating new fuel cell models and exploring other energy storage systems



Greene, NY – Raymond Headquarters



Class I & II

- VNA / Orderpicker
- Reach Trucks
- Counterbalance
- Custom Solutions



400,000 sq.ft. (factory)
1000 employees



Class III

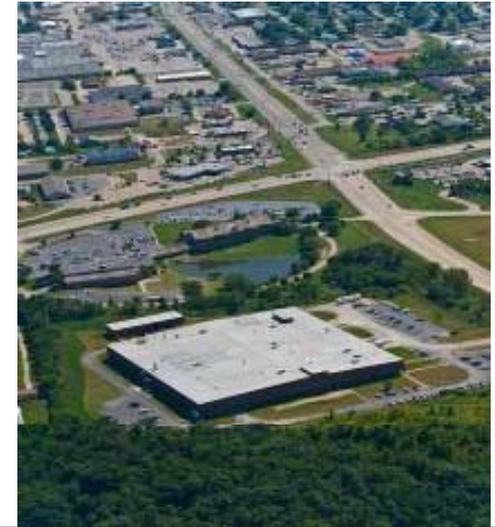
- Pallet Trucks
- Walkie Stackers



180,000 sq.ft. (factory)
173 employees



Muscatine, IA



Syracuse, NY



190,000 sq.ft.
139 employees

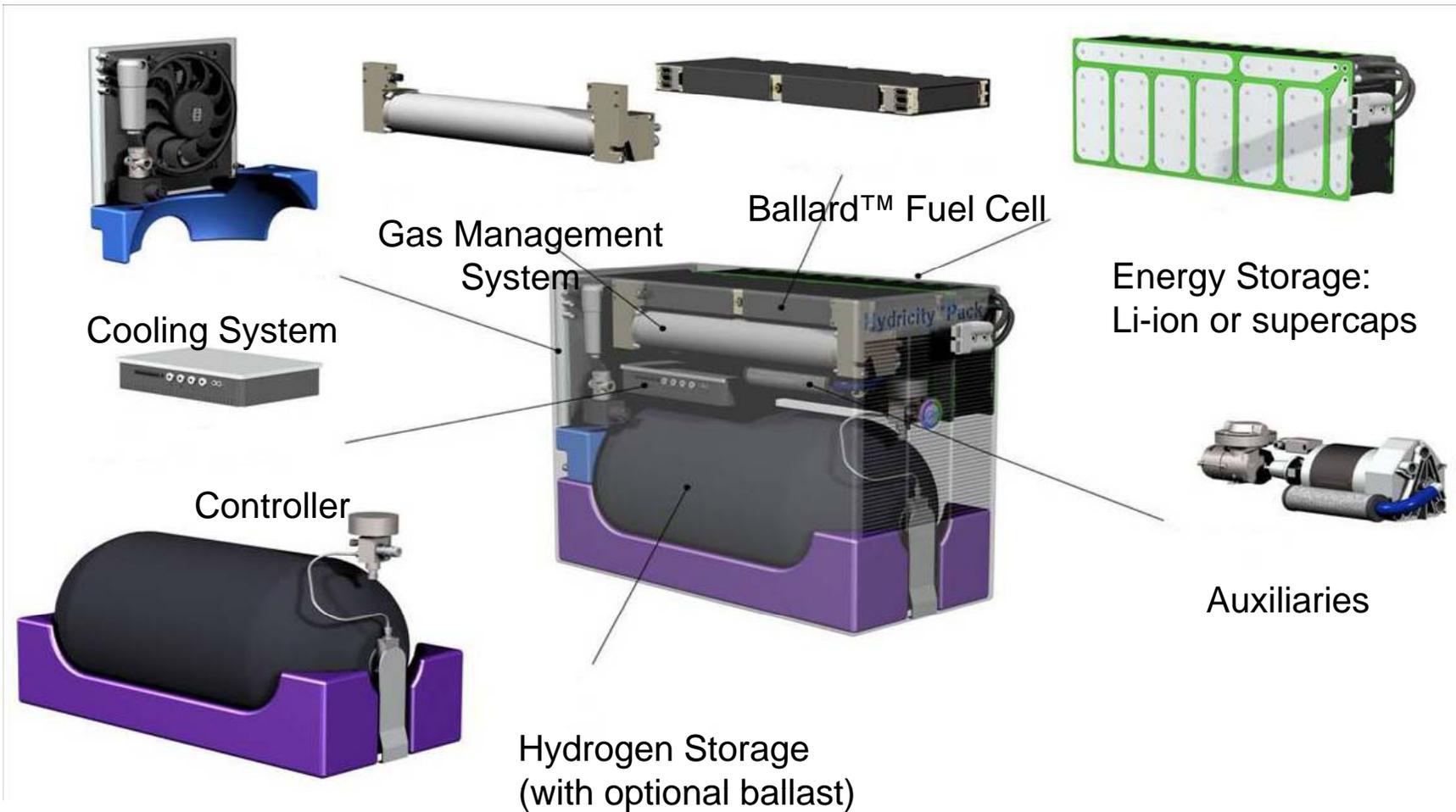
Over 2 million parts available



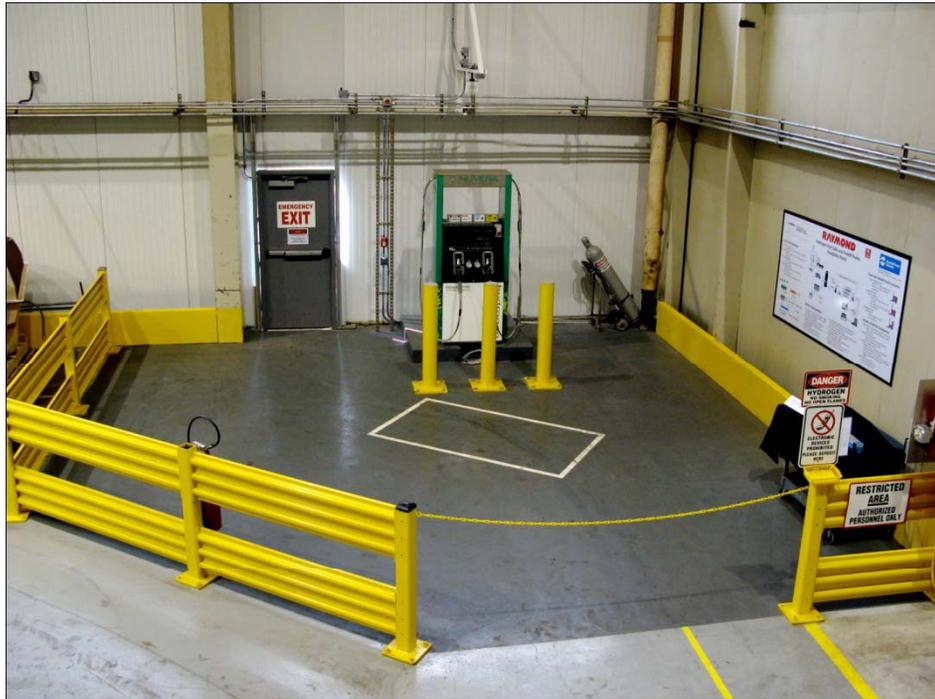
30 Dealers and 108 Branches
3,779 employees

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Fuel Cell Battery Replacement Systems

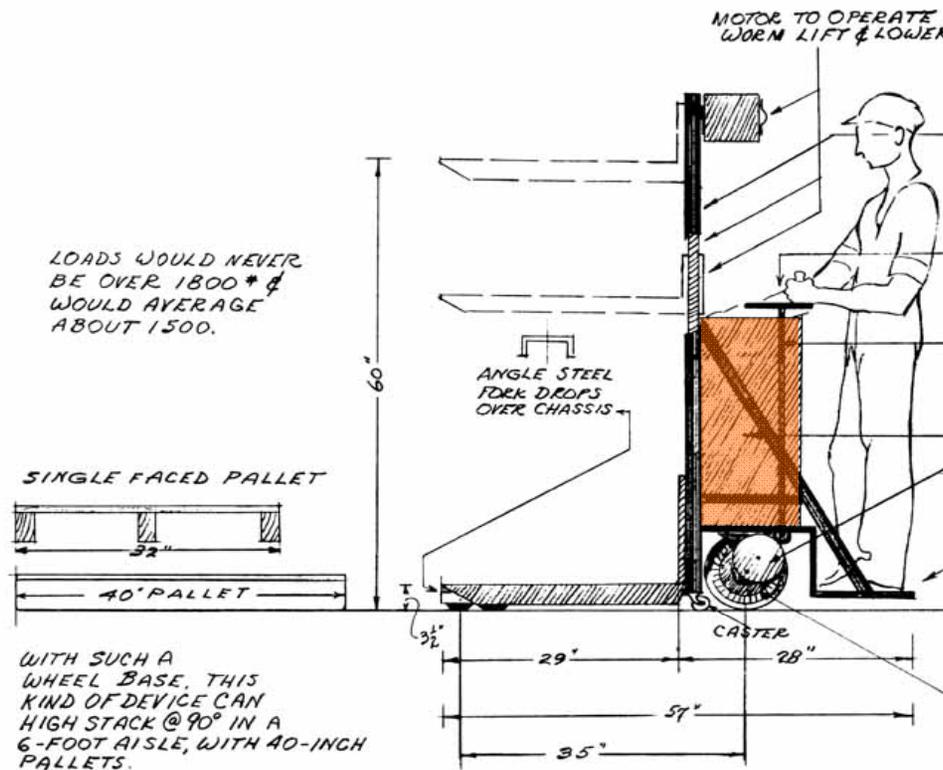


Refueling at Indoor Dispenser



Energy Source and Design of Forklift Truck

PRELIMINARY SKETCH FOR FORK-TYPE DEVICE FOR OPERAT.



Lead-acid battery has always been **critical** part of design

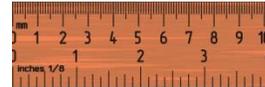
Ensuring Compatibility Between ESS and Forklift Truck



- Industrial Truck Association (ITA) established **Energy Storage System (ESS)** committee to work on this issue
 - Includes fuel cells and new battery technologies
- Created Recommended Practice (RP) to **facilitate the communication** between truck manufacturers and ESS manufacturers
- RP describes the **minimum requirements and key characteristics** of the ESS as they relate to the lift truck originally designed for use with a lead acid battery

Five Critical Requirements for Energy Storage Systems

1. Size



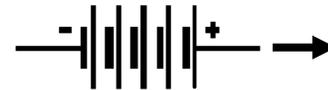
2. Weight



3. Center of gravity



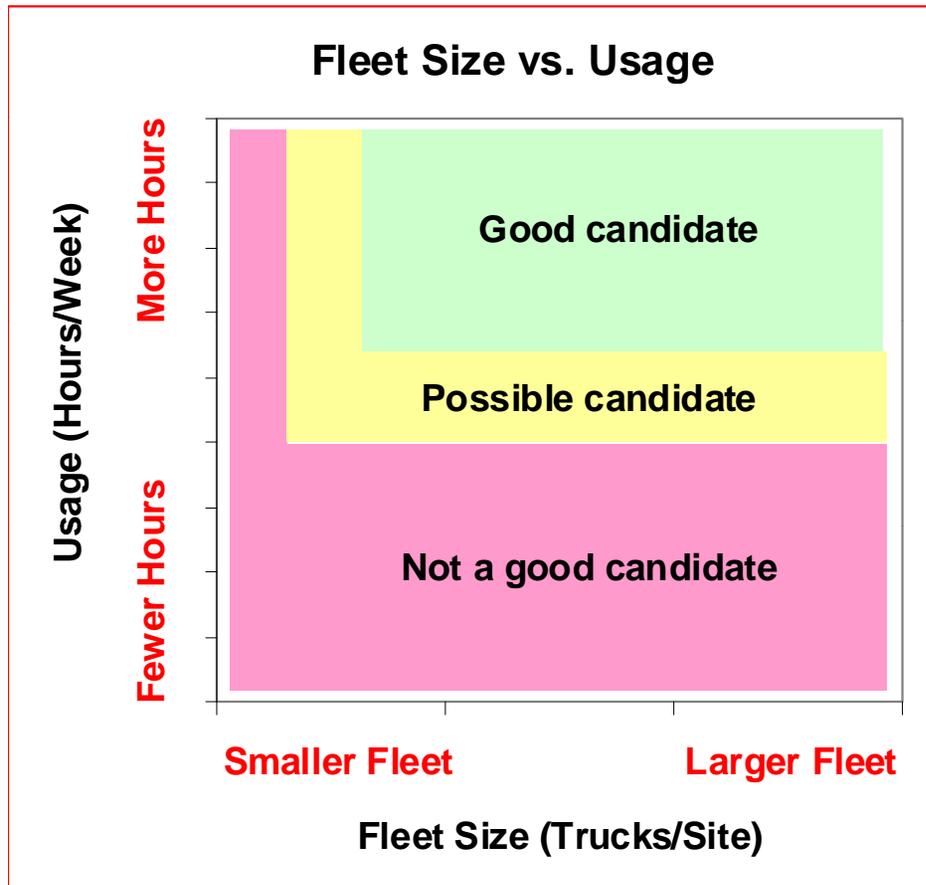
4. Power delivered



5. Power absorbed



Ideal H2 FC Customer Profile



- Larger fleet sizes (50+ trucks)
- High productivity or throughput requirements
- Multiple shifts
- Many battery changes
- High electric costs
- Local cost of hydrogen is low
- Greenfield projects provide better ROI than fleet conversions

FC Value Proposition for End Users

- Productivity increases from
 - No battery changes
 - No voltage drop as seen in batteries
- Reduced electric usage
 - No battery charging
 - Reduced peak loading
- No need for expensive battery infrastructure
 - Battery rooms, chargers, maintenance, power to building, dedicated personnel, etc.
- Environmental benefits



Factors Working Against FC Systems

- Expensive systems
- Need for “in-plant” hydrogen infrastructure
- Multiple vendors
- New technology in material handling
- Battery technology is well established
- Strong competitive technologies



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Fuel Cell Forklift Truck Projects

Raymond customers using fuel cells

- Sysco Houston: 90+ trucks
- Sysco San Antonio: 116 trucks, late 2011
- UNFI Sarasota, FL: 65 trucks
 - First fuel cell powered orderpickers
- BMW, Spartanburg, SC: 86 trucks
- Wegmans, Pottsville, PA: 90+ trucks

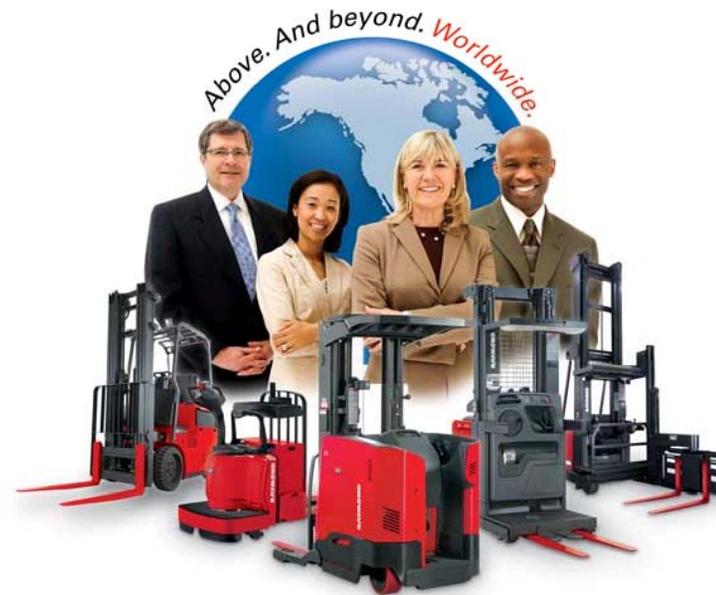
Plug Power customers in North America

- 1000 – 1100 units deployed in forklifts

Conclusion

- FCs commercially available for range of truck models
- Currently deployed all over North America
- System cost and hydrogen infrastructure limiting growth

- Suppliers need to drive costs down
- Truck manufacturers need to continue to test systems
- Customers need to partner with a company that will **commit to delivering the best solution to fit their individual needs**



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Raymond Fuel Cell Approval Matrix

					Plug Power					
					Ambient		Cold Storage			
					21"	18"	21"	18"		
Class I										
4100					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
4150					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
4200					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
4250					GD-12M36-241	GD-10M36-230	GD-12M36-240	GD-10M36-230		
Class II										
EASi Rch					GD-12M36-240		GD-12M36-240			
EASi DR					GD-12M36-240		GD-12M36-240			
7400					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
7400 DR					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
7420					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
7420 DR					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
7600					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
7600 DR					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
7620					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
7620 DR					GD-12M36-240	GD-10M36-230	GD-12M36-240	GD-10M36-230		
5200										
5400					GD-8M24-240		GD-8M24-240			
5500					GD-8M24-240		GD-8M24-240			
5600					GD-12M36-240		GD-8M36-240			
8900										
Class III					Ambient		Cold Storage			
8300					GD-3M24-312		GD-3M24-312F			
8400					GD-3M24-312		GD-3M24-312F			
8500					GD-3M24-312		GD-3M24-312F			

➤ We have tested and approved all these truck/fuel cell configurations

➤ Additional fuel cell units will be tested as they become available to us

Fuel Cell and Hydrogen Costs - US

	FC battery replacement system cost*	Estimated hydrogen usage/shift (hydrogen \approx \$6 to \$15/kg)
Class 1 SDCB	\$32,000 to \$35,000	2.5 to 3.5 kg/shift
Class 2 and SUCB	Reach & SUCB: \$33,000 OPR: \$22,000	2.5 to 3.5 kg/shift
Class 3	\$18,000	1 to 1.5 kg/shift

*Estimated list pricing

30% federal tax credit is available

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Raymond and Plug Power

- The Raymond Corporation is now an independent distributor for the sale, rental and lease of Plug Power GenDrive™ fuel cell units in North America, Hawaii, Mexico
- Raymond also will provide warranty and maintenance service on GenDrive products through our Dealer network.
- Raymond is a GenDrive Authorized Distributor of service parts through the PDC

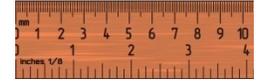
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+

plug power

1. Size

“The maximum dimensions of the ESS are defined as the size of the battery designed to fit into a given truck as defined by the truck manufacture.”



Fuel cell unit in pallet truck

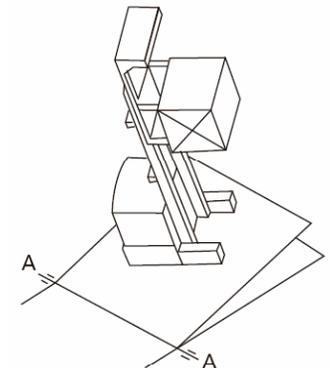
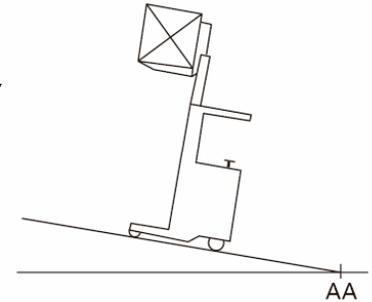
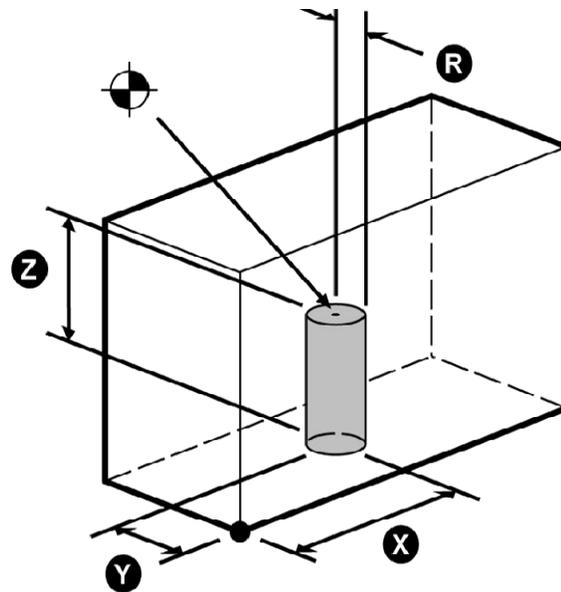


Fuel cell unit in reach truck

3. Center of Gravity



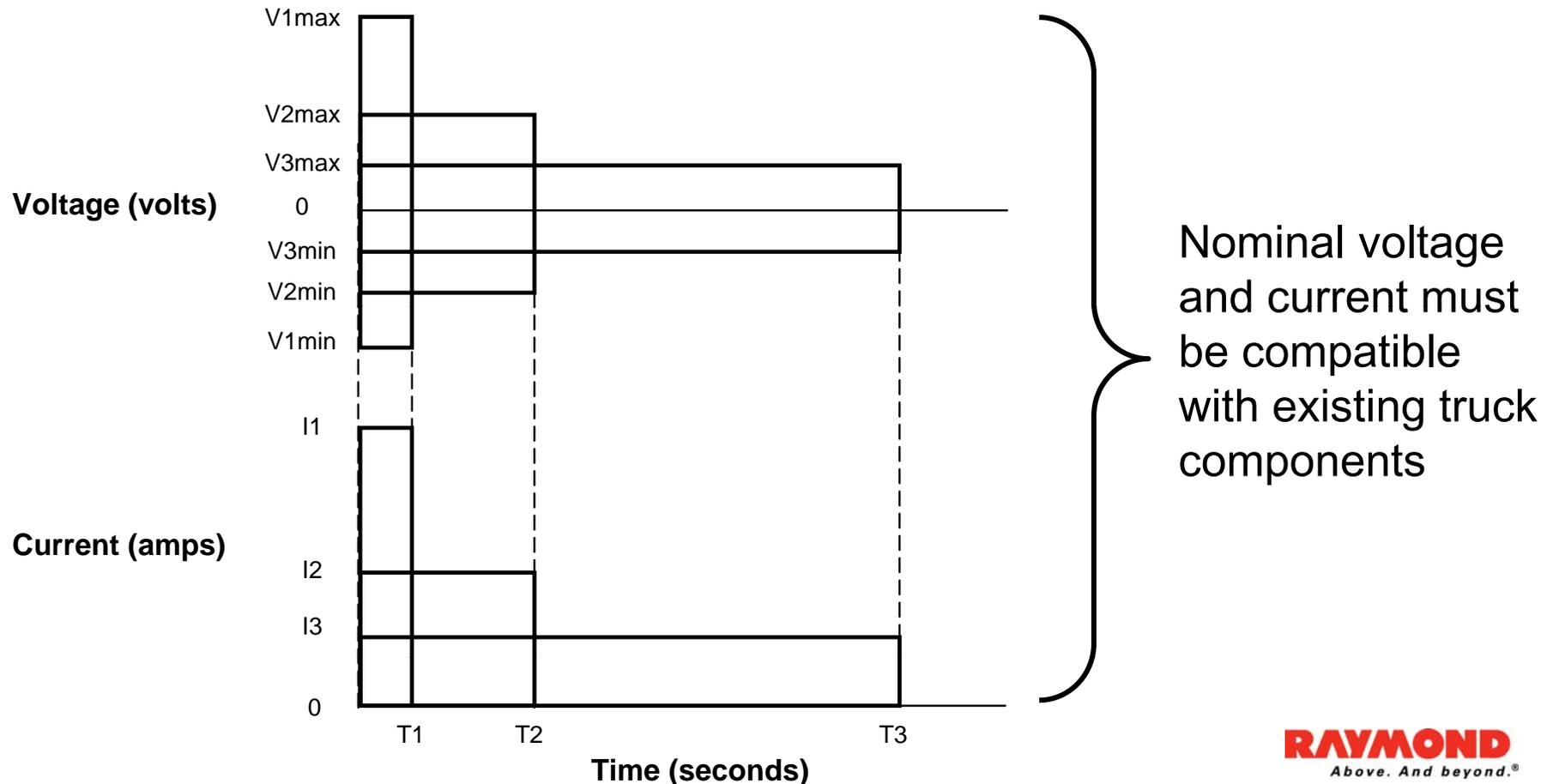
“The location of the ESS center of gravity (CG) should be located within a cylindrical shape of radius r as defined by the truck manufacturer and shaded in the figure below, with the top of the cylinder located at the volumetric center (X, Y, Z) of the battery being replaced.”



4. Power Delivered



“The truck manufacturer shall specify the current and voltage delivery requirements of the industrial truck at various time durations necessary to maintain acceptable performance.”



5. Power Absorbed



“The truck manufacturer shall specify the current and voltage absorption requirements of the industrial truck at various time durations necessary to maintain acceptable performance.”

