EPRI ELECTRIC POWER RESEARCH INSTITUTE

Class I Electric Industrial Forklifts

Over the last 25 years, sales of electric lift trucks have grown from less than one-third of annual lift truck sales to more than half of annual sales. Since 1982 U.S. sales of electric lift trucks have consistently hovered around 55% of total. In Western Europe, approximately 70% of forklifts are electric.

Forklifts are divided into seven classes. Class I, II and III trucks are electric-powered. Class IV through VII trucks are internal combustion (IC) vehicles.

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Product Description

Class I forklifts operate in a wide range of manufacturing, warehouse and retail applications.

As defined by the Industrial Truck Association, Class I forklifts have the following attributes:

- Battery-powered
- Counterbalanced
- Sit-down or stand-up rider trucks
- Solid "cushion tires" for use on hard, flat surfaces
- Some air-filled "pneumatic" tires for use on rougher surfaces, generally outdoors
- Lift capacity typically ranges from 3,000 lbs. to 11,000 lbs. but can be as high as 20,000 lbs.
- Depending on tires, Class I trucks can compete with Class IV and Class V internal combustion trucks in some lift capacities.

Drivetrain Systems

Until recently, most lift trucks used brushless DC motors. Since 2000 most manufacturers have shifted toward AC power. Some experts predict DC drive systems will be discontinued within three years. In AC power systems a controller converts DC current from a standard DC battery to 3-Phase AC current. AC power benefits include:

- Precise motor control and more power
- Improved energy efficiency
- More consistent performance levels throughout shift
- No motor brushes
- No motor commutators or contactors
- Essentially maintenance-free system

In the United States, 36-volt and 48-volt dual capacity configurations are most common, with one motor for the hydraulic and power steering systems and another for the trucks' drivetrain. Larger 80-volt systems are gaining popularity in the U.S., and prevail in Europe.

New Directions

Several manufacturers are adding features such as pneumatic tires, waterproofing and AC drives that enable the use of electric forklifts in more demanding and outdoor applications; traditionally, most Class I electric lift trucks have been limited to indoor use.

Utilities are testing 11,000-lb. to 20,000-lb. capacity outdoor forklifts in applications previously limited to IC trucks, such as on loading docks and at ports, as well as in distribution centers, industrial warehouses, manufacturing and processing facilities.

Major manufacturers are testing fuel cells as an alternative to battery packs. Additionally, hybrid systems using both a battery and a fuel cell are being developed as an alternative to fast charging or battery swapping. There are ongoing developments by Ballard Power Systems with Exide Technologies and Nuvera Fuel Cells with East Penn Mfg.

Technology Enhancements

The industry is incorporating a number of performance and usability technology enhancements that provide a competitive edge for electric lift truck manufacturers and lower operating costs for their customers:

- Wireless Technology – Integration of forklift operating data with wireless data acquisition systems, including Radio Frequency Identification (RFID)
- Ergonomics – For enhanced operator comfort
- Digital Displays – Instant operational information, built-in fault analyzers, easier matching of performance with operator skill
- Multi-Function Controls – Adoption of mini-levers and joysticks for improved operator comfort and productivity
- Safety Systems – Sensors and controllers to reduce tip-overs and dropped loads

New, low-maintenance gel cell and sealed batteries are reducing maintenance demands

Batteries and Charging

Many high-production operations keep two battery packs for each truck. One pack charges while the other is in use. This process typically requires a separate battery charging and maintenance room. The need for battery rooms coupled with battery watering and maintenance requirements have created barriers for growth in the electric lift truck industry. New, low-maintenance gel cell and sealed batteries are reducing maintenance demands.

- Average battery size is 938 Ah; lead-acid
- Most run an 8-hour shift on one charge

EPRI has conducted numerous studies of the long-term impacts of fast charging on battery life. Results to date have shown no adverse effect on battery life, and in some cases, extended battery life.

Fast charging of batteries offers several advantages:

- Eliminates time needed for battery swapping
- Frees floor space by eliminating battery room
- One battery pack per truck, instead of two
- Reduces staff time devoted to battery maintenance
- Eliminates accidents involving battery changing
- Increases truck operating time
- Potential for lower lifecycle costs, ability to monitor charging history, truck usage, water level, etc.

Battery System Ratings – Class I			Recharge Energy[1]	
V	Ah	kWh	kWh/Day	kWh/Year
36	1,210–1,540	43.5–55.4	49.7	12,922
48	880–1,100	40.8–50.9	48.3	12,558

[1] Crown Equipment ratings based on 260 days/year, 1 charge-cycle/day
kWh/Day = V x Ah x DOD / Recharge Efficiency / 1,000 x 1 charge-cycle/day
kWh/Year= kWh/Day x # of Days per Year OR:
kWh/Year= kWh/Cycle x # of Cycles per Year
(DOD = Depth of Discharge)
Annual Revenue ($) = kWh/Year x $/kWh utility average rate

Electric industrial lift trucks provide a quiet, zero-emission, efficient alternative to internal combustion equipment in warehouses, factories and any enclosed areas where forklifts are used.

OSHA suggests employers consider switching from fossil fuel-powered equipment to battery-powered machinery when possible

Benefits of Electric Forklifts

- Quiet
- Emission-free
- Cost-effective
- Enhanced workplace health and safety. OSHA suggests employers consider switching from fossil fuel-powered equipment to battery-powered machinery when possible to reduce potential for carbon monoxide (CO) poisoning in the workplace. Current OSHA standards limit CO to 50 parts per million per 8-hour exposure period.
- Eliminate hazards associated with fluid leaks
- No heat generation—important in industrial settings
- Smoother, vibration-free operation

Challenges and Opportunities

- Higher first costs than IC trucks, generally due to the need for a charger and, often, an extra battery pack
- Lower maintenance and much lower fuel costs substantially reduce lifecycle costs of electric trucks

Lifecycle cost comparison of electric and ICE lift trucks[1]

		Internal Combustion		
	Electric	**Propane (LPG)**	**Gasoline**	**Diesel**
Life Expectancy	9 years	6.5 years	6.5 years	7 years
Initial Cost [2,3]	$29,739[4]	$21,200	$20,107	$22,263
Annual Fuel Cost[3]	$585	$2,917	$3,463	$2,115
Annual Maintenance Cost[3]	$1,655	$2,800	$2,800	$2,800
Total Life Cost	$49,512	$58,364	$60,814	$56,671
Annual Average Costs	$5,750	$8,979	$9,357	$8,096

[1] Analysis based on 4,000 lb. load capacity forklift truck, data from Lead Industries Association.
[2] Mfg. suggested list price.
[3] National averaged values are used for fuel, maintenance, labor and capital costs.
[4] Includes battery and charging equipment.

Manufacturers

- Clark Material Handling, Lexington, KY
  859.422.6400; www.clarkmhc.com
- Crown Equipment, New Bremen, OH
  419.629.2311; www.crown.com
- Doosan Infracore America, Warrensville Heights, OH
  216.595.1212; www.dhiac.com
- Hyster Co., (NACCO Industries) Greenville, NC
  800.497.8371; www.hysterusa.com
- Jungheinrich Lift Truck Corp., Richmond, VA
  804.737.6084; www.jungheinrich.com
- Kalmar RT Center, Cibolo, TX
  210.599.6541; www.kalmarrt.com
- Komatsu Forklift, Covington, GA
  770.787.5100; www.kflusa.com
- Linde Material Handling, Summerville, SC
  803.875.8000; www.lmh-na.com
- Mitsubishi /Caterpillar, Houston, TX
  713.365.1000; www.cat-lift.com, www.mit-lift.com
- Nissan/Barret Forklift Corp., Marengo, IL
  815.568.0061; www.nissanforklift.com
- Raymond Corp., Greene, NY
  607.656.2311; www.raymondcorp.com
- Toyota USA, Irvine, CA
  949.474.1135; www.toyotaforklift.com
- Yale Material Handling, Greenville, NC
  252.931.5100; www.yale.com

Industry Trade Associations

- Industrial Truck Association (ITA), Washington, DC
  202.296.9880; www.indtrk.org
- Material Handling Equipment Distributors Assoc. (MHEDA), Vernon Hills, IL
  847.680.3500; www.mheda.org
- Material Handling Institute of America (MHIA), Charlotte, NC
  707.676.1190; www.mhia.org

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