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Electric Retrofit for Airport Container Pallet Loader

This document describes the demonstration of an aircraft cargo loader that was retrofitted from internal combustion (IC) to electric-drive operation.

Background

Electrification of airport ground support equipment (GSE) is one way for airports and airlines to reduce operating costs and emissions. An electric-drive option exists for many GSE models, and more options are being introduced every year. However, replacing IC units with new electric-drive equivalents may not make economic sense when existing units have not yet reached end-of-life, usually about 20 years. One solution is to use a retrofit kit to convert existing IC equipment to electric drive.

Benefits include significant savings and reduced emissions: Retrofitting existing equipment costs about one-fifth the cost of replacing old equipment, and electrification results in operating cost savings of approximately 80%. Additionally, electric-drive equipment aids compliance with emissions regulations.

Project Overview

In 2007, Delta Air Lines, JBT AeroTech, KLS Company LLC, Southern Company and Electric Power Research Institute, launched the study to retrofit a diesel-powered aircraft cargo loader, the Commander 15 (C15), from JBT AeroTech (formerly FMC Airport Systems). The C15 is used in airports worldwide to move luggage containers and other palletized cargo between ground level and cargo bins on wide-body aircraft. The duty cycle of the C15—typically short duration under heavy load, limited distance traveled, and a significant amount of downtime between servicing aircraft—made it an ideal candidate for electric conversion.

For the study, JBT AeroTech developed a prototype electrification kit and installed it into a C15 diesel cargo loader that was originally manufactured in 1996. Data was collected during a four-month period from February 20 to June 23, 2009, while the loader was in service at Atlanta Hartsfield International Airport.

The company applied lessons learned in the study to develop a commercial version of the retrofit kit for 1995–2003 model-year C15s; it is now available as a field-installable retrofit kit. The proven feasibility of the retrofit may induce other airlines to convert existing GSE to electric drive before equipment reaches end-of-life. JBT AeroTech also has since introduced a factory-built electric: the C15i.

Table of Contents

Retrofit Procedure

To retrofit a C15, the diesel engine and fuel tank are removed and replaced with an electric motor, battery pack, and motor controller. In addition to replacing the diesel engine components, the retrofit required reinforcement of the swing-out engine carriage and alterations to the hydraulic

system and control panel. The modified loader operates on 160VAC, using a battery pack consisting of two separate 80V, 300 Ah industrial batteries wired in series, but charged individually at a nominal 80VDC.

For this project, which created the prototype conversion kit, the C15 was removed from service in Atlanta and sent to the JBT AeroTech Orlando, FL facility for modification. There, engineers developed and tested the necessary conversion steps along with the detailed retrofit manual. Once the retrofitted C15 was ready for the field test, it was returned to service in Atlanta and placed in operation at Concourse E, from where many international flights which use wide-body aircraft arrive and depart.

Battery Chargers and Management

The loader's batteries were charged using existing Delta-owned fast-charging equipment. Delta has other electric GSE in its fleet and fast-charging infrastructure in place in multiple locations in Atlanta.

For this demonstration, Delta used PosiCharge model GSE 800 multi-port industrial rapid chargers. The charging system communicates with the batteries through a Battery Monitor and Identification Device (BMID), which relays the battery temperature and parameters to the charger to allow maximum charge rate without battery damage. The BMID also records cumulative charge history and initiates scheduled equalization charges at regular intervals based on need.

Operating Environment

Equipment used to service aircraft at Concourse E is typically staged between the aircraft gates while awaiting use. Two dedicated C15 loaders are assigned per gate for deployment to a parked aircraft's fore and aft cargo bins. To unload an aircraft's cargo, the pallet loader, in "operate mode," extends up to the cargo bin, containerized pallets are rolled from the cargo hold onto the loader, the loader retracts to the ground, and the pallets are rolled from the loader to a waiting trailer connected to a tow-tractor. Similarly, palletized cargo waiting to be loaded onto the aircraft is towed by a tractor to the waiting pallet loader, rolled onto the loader, then lifted up and rolled into place in the craft's cargo hold. The weight of each container varies based on cargo; the loader is designed to handle 7.5 tons. After a flight departs, the loaders, in "drive mode," back away approximately 80 feet to their staging positions to await the next flight. They pull forward again when a new flight arrives, and the process repeats itself.

Fast Charging Benefits and Opportunities

As the name implies, fast charging returns energy to industrial batteries faster than conventional charging—typically three to six times faster. Fast charging can return a battery to 80% state-of-charge in about one hour. Several factors affect the exact recharge time, including the battery's size, age, type, and condition, its state of charge, and the charger's power rating. Two factors distinguish fast charging from conventional charging:

- High current. Fast charging charges a battery at the highest current rate it can accept while retaining the maximum life capability of the battery.
- Battery management. Fast charging preserves battery life by monitoring battery temperature and/or internal resistance and adjusting charging current as necessary.

Fast charging can save time, floor space, labor costs and energy. Multi-port fast charging units are growing in popularity because they reduce infrastructure installation costs; one unit can service multiple pieces of GSE at once. Other creative options exist for reducing infrastructure installation costs. For example, Delta demonstrated a system at a different Atlanta terminal gate where the fast charger shared the electric power source with the passenger loading bridge.

1996 C15 cargo loader converted from diesel to electric, in operation at Atlanta-Hartsfield International Airport

On a typical 24-hour day at Concourse E, a C15 loader services two aircraft and is working about four hours. An IC container loader idles continuously during those four hours. Because the electric equipment shuts down when not in use—for instance, while an operator moves a container onto the loader platform—the actual run time for the electric pallet loader during those four hours in service is estimated to be 1.7 hours. Loaders rarely leave the staging area. They drive to and from the maintenance shop for maintenance, and occasionally drive to nearby gates if equipment shortages dictate, but in general, the equipment is in drive mode for only short time periods and short distances.

Study Results

Study partners tested the converted C15 on a variety of different aircraft over the four-month demonstration. The loader was placed into normal operations, and data was collected and downloaded weekly. Sixteen data sets that clearly matched flight activity from this time period were selected for analysis. The study showed that the electric-powered demonstration pallet loader performed identically to the diesel IC version. The only difference was the need for routine charging.

Average battery capacity consumption was calculated at 41.4 Ah per hour of continuous run time, using a weighted average of operate and drive modes. Configured as delivered with two 80V, 300 Ah batteries, the loader could operate continuously for a period of 5.8 hours before the batteries reached 20% state-of-charge, necessitating a recharge. This is more than sufficient for a normal shift, considering the average run time was 1.7 hours per day. The use of opportunity charging in this and similar operations easily permits multi-shift operation.

An IC container loader consumes about 1.3 gallons of diesel per hour. Average electricity consumption of the converted pallet loader, using a weighted average of operate and drive modes, was calculated at 6.2 kWh per hour of operation. Based on costs of $2.50 per gallon of diesel fuel and $0.10 per kWh of electricity, the electric loader can reduce total operating costs by 80%.

Estimated emissions reductions were calculated to be 7.8 grams/hour of hydrocarbons, 140.3 g/hr of nitrogen oxide, 13.0 g/hr of carbon monoxide, and 1.6 g/hr of particulate matter for each hour of operation that the electric loader replaced the IC loader.

During the study, the loader experienced two failures, which put it out of service for approximately four weeks. Failures were attributed to prototype shortcomings that could be corrected by design adjustments. Other than maintenance required to repair a failure in the motor controller, the loader

New C15i electric loader power module

required only routine servicing, which included servicing the battery on a weekly basis. Because of its simplicity, maintenance costs of the electric loader were predicted to be equal to or less than the IC loader.

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