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ABSTRACT

In late 1999, the United States Postal Service (USPS) which operates the largest and most visible civilian vehicle fleet in the world, awarded possibly the largest contract for electric vehicles in history to the Ford Motor Company. Five hundred vehicles were procured with the option of an additional 5,500 vehicles over a period of several years. With a fleet of 208,000 vehicles burning more than 110 million gallons of fuel each year, the USPS constantly pursue methods to reduce operating costs and air pollution. As the owner of the nation's largest fleet of alternative fuel vehicles (AFVs), the USPS is committed to the continuing expansion of its AFV fleet and has assumed a strong leadership role in the development and deployment of AFV technologies. Electric vehicles, such as the recently purchased 500 vehicles, are a key part of the deployment of AFV technologies.

This paper describes a collaborative effort between the USPS, Department of Energy (DOE), Ford Motor Co., Baker Electromotive Co., etc. in the preparation, testing and deployment of the 500 Electric Carrier Route Vehicles (ECRVs). Included, as part of this purchase was the design and installation of recharging facility infrastructure at 24 sites. Following first article testing, durability and operator use testing were conducted to assure defined performance specifications were met before acceptance of the vehicles.

INTRODUCTION

For much of its 200-year history, the USPS has been involved with the evolution of the AFV technology. In 1899, the USPS experimentally used an electric vehicle for mail transport in Buffalo, New York. The USPS continued its evaluation of electric vehicle technologies by testing vehicles in 1901, 1903, 1914, 1959, 1960, 1970, 1973, 1975 (350 vehicles), 1980 (30 vehicles), 1993 (6 Ford Ecostars), and in 1996 (10 electric Long Life Vehicles (LLVs). Today, the USPS is evaluating for mail delivery the performance of 500 ECRVs deployed primarily in California.

In the last decade, the USPS AFV fleet has grown to include over 27,000 vehicles, the largest AFV fleet in the U.S. However, due to technological constraint, lack of infrastructure as well as industry support, the majority of the AFV fleet continues to operate on gasoline. Our initial major commitments in the 1990s were directed to the compressed natural gas (CNG) and ethanol vehicles due to the then state of electric vehicle technology, availability and cost.

BACKGROUND

As a government agency, the USPS must comply with the Energy Policy Act of 1992 and Clean Air Act of 1990. These Acts require a percentage of new vehicle acquisition to be AFVs. In particular, from 1999 and beyond, they require 75% of vehicle acquisitions to be AFV. The USPS has taken advantage of the opportunity to play a leadership role in alternative fuel use and to continue their pattern of environmental responsibility, while aspiring towards reductions in the cost of operation and maintenance of its fleet by using cleaner fuels.

PROGRAM PLAN

In December 1999 a contract was awarded to Ford Motor Co. to provide the USPS with 500 ECRVs and the associated infrastructure (recharging stations). Baker Electromotive assembled the vehicles for Ford Motor Co. using a Ford supplied chassis and a Grumman Olson supplied body at their Rome, New York facility.

Support funding for the contract came from various sources such as the US Department of Energy (DOE), the California Air Quality Management Districts (AQMDs), the State of New York, the California Energy Commission (CEC), etc.

The 500 ECRVs were to be deployed mainly in 24 post offices in California. Each site was visited by a special team from the USPS and Ford to provide a comprehensive plan for the design and installation of the recharging infrastructure. This team evaluated existing power systems, new charge system requirements, applicable building and electric codes, wire runs and changes to the parking lot configuration to accommodate

the charging infrastructure for the new ECRVs. In addition to the recharging infrastructure located at the post office locations two charger systems were installed at each of the 11 vehicle maintenance facilities (VMFs) supporting these 500 vehicles.

Deployment began in March 2001 and was not completed until March 2002. Once delivery began, a comprehensive study was undertaken to compare the operations and economics of these ECRVs to other types of carrier route vehicles to assist in the decision to exercise the option to purchase the remaining 5,500 vehicles.

Unfortunately, the September 11 terrorist attack and subsequent bio-terrorist attacks on the mail system required the USPS to redirect its priorities resulting in a suspension of all vehicle purchases for the fiscal 2002 year. Therefore, the USPS will not be able to purchase any vehicles this year, including the ECRV option quantities. As a result, the USPS will not acquire new ECRVs until the financial situation improves. However, the USPS remains very interested in AFVs and continues to work with Ford and the industry to advance the technology.

THE ELECTRIC VEHICLES

The ECRVs provided (see Figure 1) incorporate advanced control and battery technology. The traction batteries are mounted between the chassis frame rails to supply power. The battery provides 312-volt direct current (DC) which is converted to three-phase alternating current (AC) for driving the motor.

Figure 1. The USPS Electric Vehicle

The vehicle powertrain consists of a 90 horsepower high efficiency induction motor driving a single-speed constant ratio transaxle. The vehicle has a payload of 1250 lbs. with standard equipment including power steering, regenerative braking, four wheel ABS and low rolling resistance tires. For cold weather areas, an optional fuel fired heater is provided.

The ECRVs are based on the Ford's EV Ranger chassis, which has been in production for the last several years.

An extensive on board Data Acquisition and Interface Systems (DAIS) has been also installed in 25 vehicles based on the Ford Global Test Module (GTM) to collect and store vehicle performance and battery charging data. The DAIS units installed in the ECRVs include a data logger assembled by the Ford personnel and proprietary software developed by Ford.

Using the data supplied by the DAIS, the USPS will be able to evaluate vehicle electricity usage and charging pattern, conduct detailed analyses of individual vehicle performance, diagnose component failures, and analyze parasitic loads and system component efficiencies. In addition, other parameters are also collected such as vehicle speed, miles driven, and number of starts and stops.

Lead acid batteries provided with the vehicles will be warranted for 36 months or 36,000 miles, whichever occurs first. An agreement between Ford and its contractors has been reached to provide full battery module recycling and battery pack remanufacturing. Therefore, the program has a closed-loop, zero waste product system to eliminate any potential battery waste issues.

VEHICLE INSPECTION AND TESTING

For this program, with its new technology and risk involved, an extensive vehicle testing program was necessary. The supplier was required to provide six electric first article vehicles for pilot model testing. The testing was conducted in three parts. Part 1 included the USPS pilot model vehicle inspection and Customer Acceptance Testing (CAT). Parts 2 and 3 consist of baseline vehicle characterization and accelerated reliability testing based on a modified version of the Department of Energy EV America Test. Parts 2 and 3 were conducted by Southern California Edison in Pomona California with USPS Engineering oversight. All three parts must be completed and passed for approval. The vehicle was also required to have zero emission vehicle (ZEV) certification.

1A. USPS VEHICLE INSPECTION AND TEST - This test required two of the pilot model vehicles for testing. Also required was the charging unit (power control station (PCS) in this case). The test was conducted at the Baker facility in Rome, NY, in June 2000. The vehicles were tested to the engineering specification for the procurement.

The vehicle inspection and test was divided into two categories, vehicle conformance to design and feature specifications (length, width, cargo area, materials, component locations) and performance testing.

The first part or vehicle inspection included an overall examination and inspection of the vehicle. An inspection checklist was developed based on the procurement specifications. The checklist addressed all major items on the vehicle such as vehicle design, materials, charge power, energy storage, battery enclosure, safety appliances, and sound levels. The USPS conducted the test using the inspection checklist evaluating each item line by line for compliance.

The second part of the vehicle inspection consisted of performance testing. During this section of the test speed, acceleration, gradeability, braking and clearance circle were evaluated. Following vehicle inspection and testing, the vehicles were sent to California for part B of the testing.

The vehicles were conditionally approved based on vehicle inspection and test results with Ford agreeing to make corrective actions on noted faults. Because the faults noted were deemed minor and easily correctable, there was no need to conduct another formal vehicle inspection and delay acceptance. Items identified as requiring attention included the front bumper (damage to driver side fender and passenger side diamond plate), pinched hood (making it difficult to open), water leaks into the cab and cargo area, electrical system (change so the turn signals override the emergency flasher), and elimination of the noise generator. Ford revised their build specifications and developed a plan for incorporating the changes into production.

1B. USPS CUSTOMER ACCEPTANCE TESTING - The Customer Acceptance Testing (CAT) was held at the Fountain Valley California Post Office, July 11 through August 16, 2000. The purpose of the CAT was to collect data from actual USPS operators at a field site using the vehicles on a daily basis. Two pilot model vehicles were used for this test. Each of the two vehicles was driven by a number of carriers over a three-week period. Drivers and routes were selected on a random basis, with each selected driver assigned to drive a vehicle for a minimum of two days. Before testing started, each carrier received Ford provided training on driving and charging the vehicles. The drivers completed a vehicle survey daily, which requested user input on operation characteristics, route information, weather conditions, and vehicle performance. Over a three-week period, working six days per week, two vehicles and a two-day drive interval per driver, the survey sample size was 18.

During the test, several failures occurred requiring the manufacturer support. One vehicle went into reverse several times when placed in drive and one vehicle could not be started after the wheels had been curbed. A charger required adjustment so that it could charge the vehicle during off peak hours. In all cases the manufacturer made the necessary repairs and the equipment was quickly returned to service.

Route miles for this testing ranged from 4 to 34 miles with 13 being the average. This average route length closely reflects the national route average of 15 miles. The average recorded temperature during testing was 80 degrees F with mostly clear weather conditions throughout the test period. The vehicles were tested on park and loop, mounted, and express mail routes.

The questionnaire the drivers completed requested the operators rate the vehicle in the areas of overall handling, cornering stability, braking ability, steering response, ease of use of controls, acceleration, all around visibility, ease of ingress and egress, seat comfort, heater and defroster, and effectiveness of the state-of-charge meter and charger station. The ratings were on a scale of 1-5 with 5 being most satisfactory. The overall rating for the vehicle was 4.26.

The survey also solicited operator comments. Some of the comments listed are as follows:

1. The step down from the cab to the ground is too far - The operators enter and exit the vehicle many times on their route; so the step down height is an important item for them.

2. The back bumper is too long - This is also important to the operators because they have to reach in the cargo area to retrieve the mail trays for delivery.

3. The window sill height too high for access to mailboxes

4. The back door pull down strap was too high to reach

5. The parking brake was difficult to pick up

6. Auxiliary fan not turning off automatically

7. Door locks difficult to engage

2. BASELINE VEHICLE CHARACTERIZATION - Two vehicles were tested for eight weeks to perform vehicle characterization. The EVAmerica Baseline test procedures were reviewed and modified to be more consistent with the USPS ECRVs duty cycles. These tests were conducted on closed tracks and dynamometers, and the results are highly repeatable. The test included acceleration, braking, maximum speed, gradeability, electrical power consumption and range in different modes, road handling, battery charging and PCS performance. The test was conducted from September through November 2000 by Southern California Edison with input from the South Coast AQMD, and DOE Field Operations Program, Idaho National Engineering and Environmental Laboratory (INEEL) under USPS Engineering oversight.

Test	Requirements	
	Met	Exceeded
Acceleration		✓
Maximum Speed		✓
Braking	✓	
Gradeability	✓	
Road Handling	✓	
Water Test	✓	
Dynamometer Range	*	*
Road Range	*	*
Battery Charging	✓	
Sound Levels		✓
EMF Levels	N/A	N/A
Compatibility with Elect. Devices	✓	

Table 1. Testing Results from Southern California Edison (SCE).

The results obtained from the testing show the vehicles meet the requirements set by the specifications except for range (see table 1). The average range test resulted in slightly lower mileage than the specification requirement of 50 miles.

3. ACCELERATED RELIABILITY - The purpose of this test was to obtain several years of traditional fleet-use operations data within a single year. Two vehicles underwent Accelerated Reliability Testing with the goal of accumulating 20,000 miles, the equivalent of 4 years of regular mail delivery service. This goal was based on the average delivery route of 15 miles driven six days per week. The information gathered included energy use, maintenance requirements, and the effects of accumulated mileage on vehicle ranges. Energy use was collected using kilowatt-hour (kWh) meters mounted onboard the vehicles conductively charged on dedicated chargers to avoid impacting charge for vehicle range and performance. Several other parameters are calculated, including miles per Kwh and charging profiles, not only for entire fleets, but also for single model types and individual vehicles.

Testing began in August 2000. The USPS decided to accept the vehicles after only one month of testing, however testing continued for the full one-year period.

During testing, the vehicles were constantly driven and then recharged. The average availability of both vehicles during testing was 97.6%. Periodically specific testing was done to determine the effect of battery life, due to charge/discharge cycling and use, on vehicle range. Over the one-year test period, no reduction in vehicle range due to batteries was noted. Ford performed routine maintenance on the vehicles during this test as necessary. At the completion of accelerated testing both vehicles had been driven over 19,000 miles. The average power consumption for the vehicles over the duration of the test was .62 kilowatts per mile.

ERGONOMICS TEST - The USPS conducted ergonomics testing of the ECRVs at the White Plains New York Facility February 2000. Using a sample of five vehicles, the ergonomic evaluation covered vehicle measurements, operator interviews and video taping of the operators loading and unloading the vehicles. The evaluation identified a number of areas for improvement including bumper length, cargo door strap, turn and hazard signal enunciator volume, seat belt, letter tray position, driver seat adjustment, reverse warning signal, and heating and fan system operation.

Based on the ergonomic evaluation, changes were made to make future vehicles more operator friendly. Examples of improvements include relocation of the parking brake, changes to the ventilation electric system, reduced signal enunciator volume, improved seat adjustment capability, and changes to the letter tray.

INFRASTRUCTURE

The ECRV project required the installation of significantly more support infrastructure than would have been necessary to support a similar deployment of gasoline powered vehicles. Each vehicle required a power control system (PCS) for recharging. Because all the vehicles were used for delivery at the same approximate times, recharging also occurred at the same approximate times. This required a PCS be available for each vehicle. To reduce equipment requirements dual PCS units (see figure 2.) were used.

Figure 2. Two Electric Vehicles being charged.

The PCS is a conductive vehicle charging station housed in a weatherproof plastic housing. The PCS monitors and enables the flow of electricity to the vehicle battery during charging. A separate meter was installed at each site to monitor electricity used by the vehicles separately from the normal operational site usage. Included in the construction were new transformers and pads, main disconnects, new main panels, timers,

trenching for conduit, PCSs and provisions made for future PCS stations.

SITE SELECTION

Site by vehicle delivery date	No. of vehicles
Huntington Beach VMF	
Fountain Valley	28
Los Angeles Central VMF	
Dockweiler	40
Ida Jean Haxton	25
Irvine Harvest	24
Costa Mesa Main	20
San Diego Midway VMF	
Bostonia	20
Linda Vista	22
Long Beach VMF	
La Mirada	15
Torrance VMF	
Harbor City	5
Los Angeles North VMF	
Los Feliz	32
Pico Rivera	16
Norwalk	26
La Puente VMF	
El Monte Main	30
San Gabriel Main	20
Glendora Main	20
Covina Main	20
USPS Engineering Merrifield	1
Brightwood VMF	
Lamond Riggs	14
Oakland VMF	
Alameda Main	20
Sacramento VMF	
Royal Oaks	20
San Jose VMF	
Blossom Hill	20
Bicentennial	33
Alameda Station	24
White Plains	5
Total	500

Table 2. Deployment List

Much preparation and planning was required to identify the sites to which the ECRVs would be deployed. Initially, over 800 sites and VMFs were reviewed. Based on developed decision criterion, 36 sites were selected with deployment made to 24 of the 36 post offices. The site selection process included site personnel interviews, site surveys, current electric utility service, route surveys and current refueling practices. The plan was to deploy electric vehicles to sites so that no more than half the site vehicles were electric for the initial 500 vehicle purchase (phase 1). The next step, or phase 2, was to add additional ECRVs to existing ECRV sites to standardize on vehicles for use and maintenance benefits. ECRV charging units were installed at 24 post offices and 11 Vehicle Maintenance Facilities. Of the 500 vehicles purchased, 480 were located in California (Table 2. Deployment List).

PROGRAM EVALUATION

It is important to the USPS to attain information on the ECRVs for comparison to other alternative fuel vehicles in the areas of performance and life cycle to make decisions regarding the future acquisition of vehicles. Vehicles were studied from information from three months worth of data from the first three deployment sites, Fountain Valley, Dockweiler and Ida Jean Haxton stations. Figure 3 shows the electric vehicle fleet at Fountain Valley post office. Data was also gathered from the USPS vehicle maintenance system and ECRV first article testing information. These vehicles were compared to the Grumman gasoline Long Life Vehicles (LLVs), Ford ethanol-gasoline flex fuel vehicles (FFVs) and the Chrysler EPIC electric vehicles. Included in the life cycle costs are capital, repair and maintenance, fuel, infrastructure, subsidies and other costs. Vehicle operation, reliability, projected vehicle life and infrastructure requirements are included in technical performance. Factors such as regulatory compliance, driver satisfaction, and environmental effects are also reviewed.

After reviewing the data the findings were as follows:

1. The ECRV life cycle cost is several thousands of dollars higher than a comparable equipped ethanol-gasoline FFV.

2. The charging system infrastructure comprises a large percentage of the life cycle cost difference between the ECRV and the FFV.

3. The frequency and cost of battery pack replacement have a significant impact on the life cycle cost.

4. It is difficult to reliably predict repair and maintenance costs for the ECRVs based on a short term evaluation and accelerated durability testing.

5. Reductions in electricity costs can be achieved by reducing the amount of charging during the high cost peak hours, installing electrical load management equipment, ensuring the time clocks are adjusted properly, and using the best available electricity rate structures.

Figure 3. Electric Vehicle Fleet at Fountain Valley post office.

CONCLUSIONS

For the most part, the deployment for the 500 ECRVs requires tremendous effort for coordinating and installing infrastructure. The ECRVs are very well received by the drivers with little training involved. To a certain extent, there are few minor ergonomics issues that are being resolved. For the first 9 months of the deployment, the ECRVs are generally trouble free.

Even though the USPS has stopped acquiring new ECRVs due to the September 11 event, we are still very much active in pursuing new technologies for shaping our future as the owner of the largest delivery vehicle fleet in the world. With comprehensive experience in compressed natural gas vehicles, alcohol vehicles, electric vehicles and great demands for new vehicle acquisition every year, the USPS is in a great position to influence the transportation industry in general and in alternative fuel in particular and can make a tremendous impact for the environment.

As the USPS continues exploring new technologies such as the hybrid-electric and fuel cell vehicles, the major challenge remains to be battery technology. The current lead acid battery still has significant issues with energy density, power density and life cycle cost. Another major issue is that with the ever-changing nature of new technology, the existing vehicles and/or their components will be obsolete so quickly that the end users would have problems in repair/replacement.

As major developments continue to evolve in many areas of alternative fuel, the USPS will continue its research and development effort to search for an optimal solution for powering its fleet. The answer may not come in one shape or form but may take many forms. However, the USPS will continue to modify its strategy to accommodate real world and fiscal situations.

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