220408

ETX400-24-TSO

Manual with Instructions for Continued Airworthiness

Revision Log

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Airworthiness Limitations

The Airworthiness Limitations section is FAA approved and specifies maintenance required under Secs. 43.16 and 91.403 of Title 14 of the Code of Federal Regulations unless an alternative program has been FAA approved.

There are no new (or additional) airworthiness limitations associated with this equipment and/or installation.

FAA APPROVAL:

Introduction

This manual covers the inspection, maintenance (charging) and replacement aspects for the ETX900-TSO battery installed on 14 CFR Part 23 aircraft. Installation of the rechargeable lithium battery defined herein meets the guidance of AC 20-184. In accordance with Federal Aviation Administration (FAA) Advisory Circular (AC) 23.1309-1E and FAA Technical Standard Order (TSO) TSO-C179b, the Failure Condition Classification (FCC) for this TSO Battery is "Major" - unless other installations deem the analysis lessor or greater, dependent on the function(s) in the installation.

Although many internal and external safety features have been designed per TSO-C179b and AC 20-184, failure to follow all application use, installation, charging, and storage instructions may result in battery damage and could lead to fire!

Abbreviations

The following table describes the terminology used in this document.

AC	Advisory Circular / Alternating Current
Ah	Amp-Hour is a unit of measure of charge that can be stored in a battery.
AFMS	Airplane Flight Manual Supplement
AML	Approved Model List
BMS	The Battery Management System refers to the collection of electronics responsible for monitoring and protecting the battery cells.
Cell	A single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across two terminals.
DC	Direct Current
GPU	Ground Power Unit
HMR	Hazardous Materials Regulations
IAW	In Accordance With
ICA	Instructions for Continued Airworthiness
LED	Light Emitting Diode
LRU	Line Replaceable Unit
OEM	Original Equipment Manufacturer
OVPD	Over-Voltage Protection Device
RTCA	Radio Technical Commission for Aeronautics
SDS	Safety Data Sheet
STC	Supplemental Type Certificate
TSO	Technical Standards Order

ICA Revisions

When a revision to the Instruction for Continued Airworthiness (ICA) is necessary, the STC holder will coordinate its approval with the FAA. Approved revisions to the ICA will be available from the documentation section of the EarthX Website: https://earthxbatteries.com/.

Description

EarthX Lithium batteries are a maintenance free replacement for lead-acid or lithium batteries. The battery operation is automatic (no operator control). The battery is part of the main aircraft electrical system with the alternator (charging system) being the primary power source and the battery being the secondary power source; the battery function in the aircraft is unchanged. This battery includes a thermal run-away containment system. The containment system includes a vent tube designed to carry vapor or smoke to the exterior of the aircraft in the extremely improbable event of a thermal run-away condition. There are no emissions during normal operation. The battery can be operated at high G loads (see specification section).

Specification

Voltage	13.2 V
Capacity (1C, 1hour rate at 23 °C)	15.6Ah @ 1C rate
Peak Power (Ipp), 23/-18 °C	800 / 390 amps
Rated Power (Ipr), 23/-18 °C	600 / 365 amps
Weight	5.4lb
Maximum Altitude	25,000 Ft
Dimensions	6.5in (L) x 3.0in (W) x 6.6in (H) 166mm(L)x77mm(W)x168mm(H)
Operational and Crash Safety G Load	20G

Removal and Reinstallation

"This article meets the minimum requirements of technical standard order (TSO) C179b. Installation of this article requires separate approval." The article may be installed only according to 14 CFR part 43 on aircraft eligible IAW the Approved Model List for STC SA01005DE. Below are the installation specific in-service requirement(s):

- An automatic Over-voltage Protection Device (OVPD), as part of the aircraft's charging system, is required. Do not install battery if the aircraft does NOT have an OVPD.

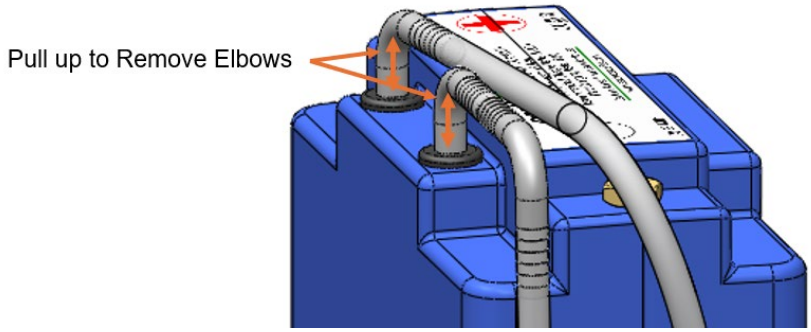
Remove all metal objects from your person before handling the battery and use insulated tools for installation.

The power terminals are ALWAYS live. Do not short across the terminals. Use caution when handling the battery inside the aircraft around metallic structures.

Battery Removal

1. Remove the battery box cover or battery hold down bracket.
2. Note the routing and placement of wires, cables, vent tube and foam insert (if installed).

3. Remove the battery positive (red) cable first.
4. Remove the battery negative (black) cable.
5. Disconnect the battery fault/status monitoring plug.
6. Remove the vent tube, by removing the vent tube "barbed" elbows from the old battery. Pull up on the elbows while making a circular motion.



Vent Tube Removal

7. Remove the battery from the battery box or battery tray.
8. Check the battery cables, battery connectors and vent tube fittings for corrosion or damage. Pay special attention to the positive battery cable (red cable), check for cuts or wear marks in the insulation. Clean and or replace as required.

Battery Reinstallation

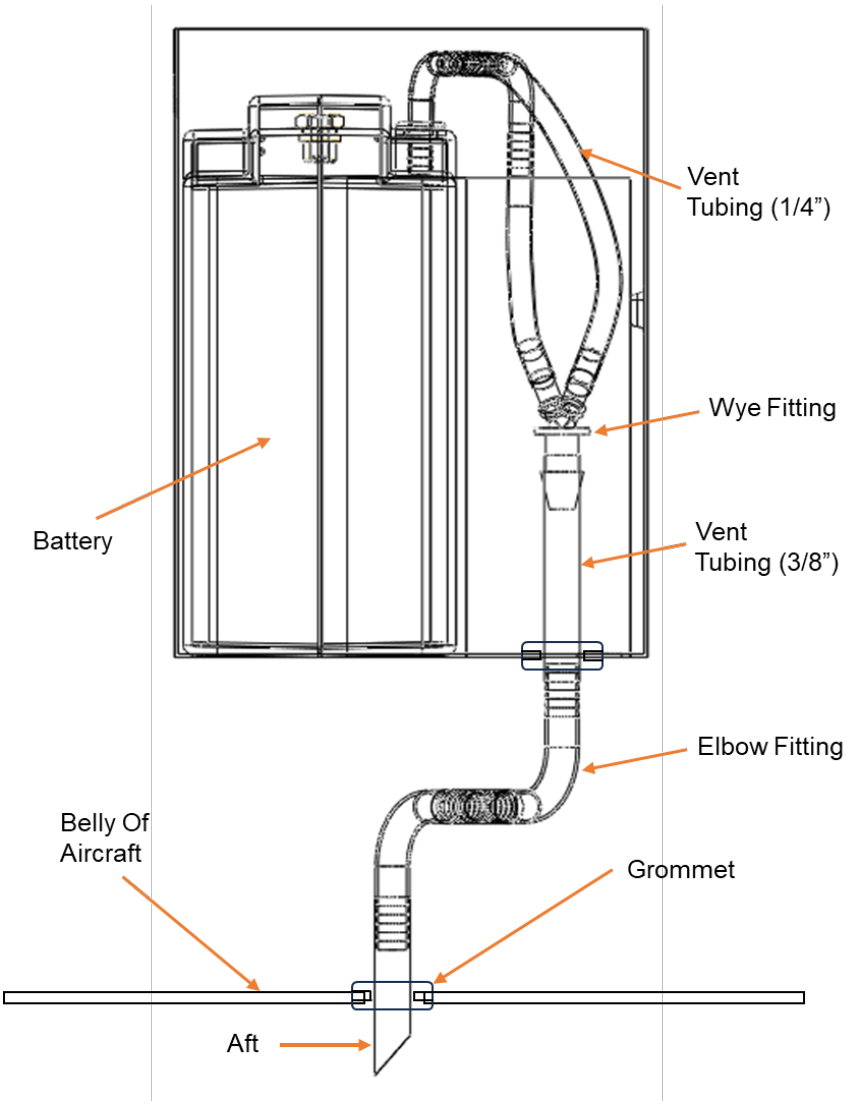
It is recommended you check the voltage before installing. If the voltage is below 26.4V, charge the battery before installing. Follow these steps to install your new battery.

1. Reinstall the battery in the battery box or battery tray.
2. Connect the positive (red) cable first. Make sure the Phillips screw is securely fastened (45in-lbs), but do not over-tighten. Next, connect the negative (black) cable. Do not connect the battery in reverse polarity (positive to negative or negative to positive).
3. Connect the existing vent tube and barbed fitting to the new battery's vent tube stubs (remove the protective caps that are installed at the factory over the vent tube stubs).
4. Reconnect the battery fault/status monitoring plug.
5. Re-install the battery hold down bracket or battery box cover and tighten securely.

Battery Vent Replacement

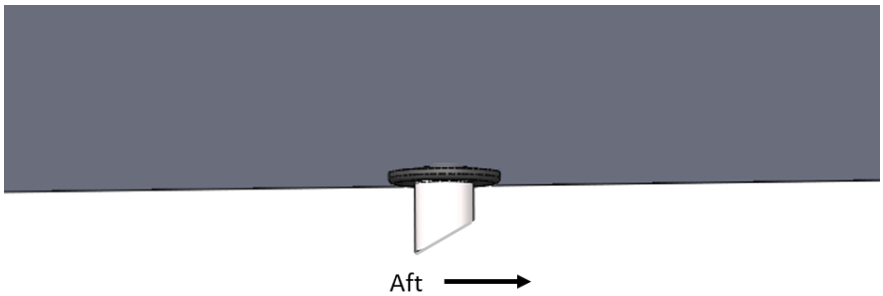
The vent system is made up of tubing, fittings, fasteners and grommets. Worn or kinked tubing should be replaced. The tubing should also be replaced if a tube connection to a fitting is loose. See Table 1 below for replacement parts. Follow these steps to replace all or part of the battery vent as required.

1. To remove a section of tubing, cut the tube (longitudinally) at each end, at the tube fittings. Remove the section of tubing noting the route. If the tube is held by an Adel clamp, loosen the clamp and pull the tube through the clamp.
2. Cut a new piece of tubing the same exact same length as piece removed.
3. Re-install the new tubing in the same manner as the tube that was removed. The vent tube should include downward sloping and or vertical section, so condensate drains to the outside of the aircraft. The tubing minimum bend radius is 3", so elbows are required to make small radius bends. See the installation example below.



Firewall Forward Battery Vent Installation Example

4. If replacing the tube that exits the belly of the aircraft, leave at least 1" exposed on the outside of the aircraft and secure in place with RTV silicon. Cut the tube at an angle towards the aft of the aircraft.



Fuselage Installed Battery Vent Tube Example

Part Number	Part Description
5239K13	1/4" Teflon Tubing
5239K15	3/8" Teflon Tubing
5670K17	90 Degree ¼" SS Elbows
5670K18	90 Degree 3/8" SS Elbows
5463K722	3/8" Wye Tube Fitting
L6-AL	90 Degree ¼" Close Elbows
9600K313	1/4"ID 3/8" OD, 1/16" Panel Grommet
9600K316	3/8"ID 9/16" OD, 1/16" Panel Grommet
9600K86	3/8"ID 9/16" OD, 1/8" Panel Grommet

Table 1 – Vent System Parts

Be careful not to crush or restrict flow through the tubing.

Only EarthX supplied tubing and tube fittings should be used.

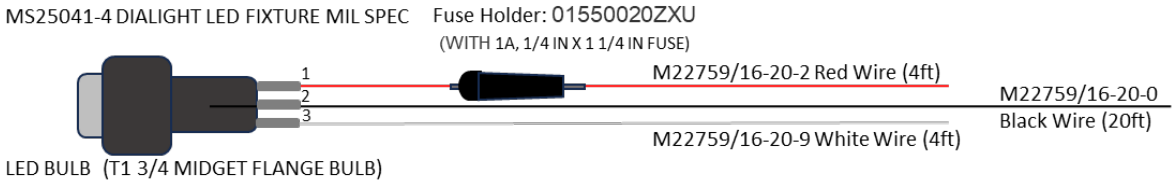
Fault/Status Indicator LED Bulb or Fuse Replacement

To replace the LED bulb, remove the LED lens bezel by turning it counterclockwise, slide the bulb out of the housing, then replace with a new bulb (24 volt, T1 3/4 Midget Flange type LED bulb).

To replace the fuse, push the ends of the fuse holder together and ¼ turn counterclockwise to open the fuse housing, then replace with a new fuse (¼ x 1 ¼", 1-amp, fast blow fuse).

Fault/Status Indicator Replacement

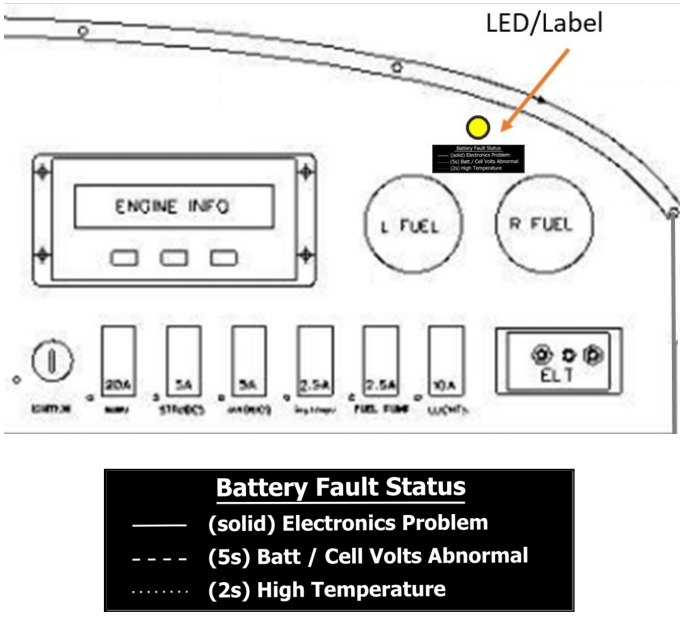
The installation or replacement of the EarthX Fault/Status LED Indicator (part# 11MM24) is detailed below.



Fault / Status Indicator

1. Power OFF the aircraft to remove power.
2. Removed trim panel if required.
3. Remove the LED lens bezel by turning it counterclockwise.

4. Remove the panel nut from the front of the LED housing and feed the LED housing through the hole.
5. At the LED housing, cut off the black wire.
6. Behind the instrument panel, disconnect the red wire (with inline fuse) from the circuit breaker.
7. Behind the instrument panel, disconnect the white wire from aircraft ground.
8. Secure the new Fault/Status Indicator in place on the panel in the same location as the old Fault/Status Indicator.
9. Unsolder the black wire from the new LED housing and solder the existing black to terminal 2 of the LED housing.
10. Behind the instrument panel, route the red wire (with inline fuse) to an instrument circuit breaker; crimp on (supplied) #6 ring lug to wire and secure to breaker.
11. Route the white wire to an available ground stud, crimp on (supplied) #6 ring lug and secure in place.



LED/Label Installation Example

Return to Service Checks (Tests)

Follow these steps to check the battery operation prior to returning to service:

1. Verify the vent tube protruding from the aircraft can NOT be pushed up and into the interior of the aircraft with the force of an index finger.
2. Apply power to the aircraft via master switch, observe proper voltage, greater than 25.6V.
3. Verify the battery Fault/Status LED is off (no faults).
4. Press the LED "push-to-test lens" and observe the LED illuminates (if equiped).
5. At the battery, jumper the fault/status discrete output to battery negative terminal using a test clip and verify panel LED indicator is "On".
6. Verify engine starts as normal.

Inspection

The supplemental Instructions for Continued Airworthiness (ICA) are required by 14 CFR part 23 for this Article (Part) installed on Aircraft (14 CFR 23.1529 for this application and TSO).

Battery Inspection Intervals

Battery:

Upon installation, record the next battery inspection due date based on the battery age as follows:

- 0-24 months: The battery and its mounting hardware must be inspected on or before 24 months from the installation date. Like aircraft annual maintenance, the period of 12 calendar months extends from any day of any month to the last day of the same month in the following year.
- 24+ Months: If the battery was inspected at Annual Inspection, the due date for the next inspection is at the next annual inspection. If the battery was inspected at a time other than annual inspection, inspect the battery no later than 12 months after the last inspection date.

Charging Systems:

Annually: An annual inspection (check and/or test) is required for the voltage regulator and OVPD of the aircraft charging system for safe operation of the battery and aircraft electrical system.

Battery Inspection Instructions

The following inspections/tests shall be performed:

1) Visually inspect the battery for signs of damage; plastic case cracks, warped plastic or long side of the battery is swollen. Visually inspect the box, connections, and venting provisions in accordance with AC 43.13-1B Section 2. STORAGE BATTERIES (refer to paragraph 11-19). Confirm that the battery is secure in its mounting location. Replace it if damaged.
2) Verify the battery fault/status monitoring LED is operational (not required for digital communications). To do this, use a wire jumper to connect the fault/status discrete output (which connects to the remote LED) to battery ground, and verify the LED is lit.
3) Fully charge the battery (see Battery Charging section below).
4) After fully charging the battery in the previous step, allow the battery to rest over-night (minimum of 12 hours) without any load applied to the battery. Verify the battery is "holding a charge" by confirming the voltage is greater than 26.4 volts.
5) Verify the battery capacity. A battery's current capacity as compared to its original capacity is an indication of the battery's remaining service life. A battery with greater than 80% of its original "rated" capacity is considered fit for continued service. If the battery capacity is less than 80%, then it must be replaced. Alternately, if the batteries tested capacity is capable of supporting the aircraft's emergency load for the required amount of time it is consider fit for continued service. It is recommended that the battery be replaced after 6 years of service. To test the battery capacity:

a. Fully charge the battery (see Battery Charging section below).
b. Turn on all electrical loads for flight operation and start a timer.
c. Measure and record the battery's discharge amps using a DC clamp-on current meter at the positive terminal of the battery.
d. Using the measured amps in the previous step and the battery's nameplate rated capacity (in Ah), calculate the time to discharge the battery 80%.

Time to discharge 80% (Hours) = $\frac{Rated\ Capacity\ in\ Ah * .8}{Measured\ Discharge\ Amps}$
For Example, (8 Ah Rated Capacity, 8 amp measured discharge rate)
Time to discharge 80% = $\frac{8 * 0.8}{8}$= 0.8 hours

e. Terminate the test after the number of hours calculated in the previous step has expired or if the battery is over-discharged (shuts off discharge current). If the battery is still supplying power at the termination of the test, then the battery's capacity is greater than 80%. If the battery's capacity is greater than 80%, then the battery has passed the test.
f. Fully charge the battery.
6) Verify battery terminals are clean, and terminal screws are properly secured (torque to 45in-lbs).
7) Visually inspect the vent tubes to ensure they are not blocked (plugged, pinched, or kinked). Replace it if damaged.
8) Verify the battery box and or battery restraint system is in good working order.
9) Test complete, record in Aircraft Logbook with inspection info or storage log.

Aircraft Charging System Inspection Instructions

The regulator and OVPD may physically be separate devices or in a single housing. Follow the regulator and/or OVPD manufacturer's ICA or maintenance instructions for periodic checks.

Maintenance

This is a maintenance free battery with no internal replaceable components. Charging is only required as needed (see Battery Charging section of this manual).

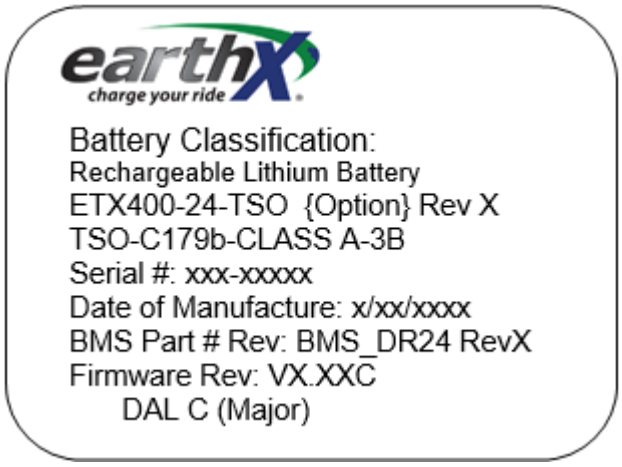
The following conditions indicate battery end-of-life, and the battery shall be replaced:

- Insufficient capacity per inspection requirements above
- Insufficient power to crank engine.
- On-going battery fault indication (refer to the "Troubleshooting" section)
- Will not hold a charge (<26.4 volts a week after charging the battery to full charge)

At battery end-of-life contact EarthX. The only approved replacement lithium battery is an EarthX battery of the same model number. The model number is displayed on the top label of the battery.

Configuration Control

The battery "Configuration Control" information is on the back side battery label (revision, TSO number, manufacturing date and serial number).



Battery TSO Configuration Label

Battery Charging

If at any time the aircraft will not start, or the battery seems low, or the voltage is less than 26.4 volts, charge it. To charge the battery, connect the battery charger to the battery and leave the charger "On" until the charge light is extinguished. The recommended and maximum charge rate is specified on the top label of the battery. Never exceed the maximum charging amps for your battery.

This table shows typical charging times using the Optimate series of chargers. Refer to the manufacturer's instructions if compatible (LiFePO4) chargers are used:

Charging Amps	Charging Time
5 amp	4 hours

Lithium batteries have a very low self-discharge rate which means the battery, if disconnected from the aircraft, could "hold its charge" for over a year. However, some aircraft may have systems that use a small amount of power with the "Master switch" off. In those cases, we recommend disconnecting a battery cable from the battery during long term storage (greater than 6 months).

Only an approved battery charger shall be used, see EarthX website for compatible chargers.

If the battery has been over-discharged and "disconnected" (meaning automatic electronic disconnect commanded by the Battery Management System), the voltage at the battery terminal should be near zero volts if the battery still has a load on it. If the battery is disconnected from the load, it will automatically reconnect, and the terminal voltage should return to > 20 volts (remove the load by removing the positive or negative cables from the battery). In this case, simply connect

the battery to a charger to restore charge (charge with 1-20 amps for 20-30 minutes). If the battery is holding a charge (voltage not decreasing over 10-minute period), the battery is ok to fully charge. If the battery voltage does not return to >20 volt after removing all loads, then (step 1) connect the Optimate charger cables to the battery (red clamp to positive and black clamp to negative), next (step 2) plug the charger power cord into AC outlet (or press the reset button on the charger). The charger should startup and go into the "Save" charging mode. If not contact EarthX technical support.

If using a Ground Power Unit (GPU), the current rating or current setting SHALL NOT be more than the max charge rate stated on the battery label or in this manual. It is recommended that a warning label is placed next to the GPU plug stating the max current allowed.

 **Never charge a faulty battery (a battery that will not accept a charge or hold a charge).**

 **Never use the de-sulfate setting on your charger.**

 **If the battery gets hot while charging, discontinue charging and use.**

 **Do not charge battery in temperatures above 140 degrees F (60C), or in direct sunlight.**

 **When charging a battery outside the aircraft, place it on a non-flammable surface, and remove any flammable items nearby.**

Troubleshooting

The battery is an integral part of the aircraft electrical system and as such to is useful to know the aircraft electrical system voltage and or current at the time of the battery fault.

The Voltage/Current column in the table below lists the voltage/current level or condition that could correspond with the battery fault. For example, over-voltage is an electrical system problem and may be reported and addressed with other aircraft equipment.

The table below is a summary of the battery's fault/status codes indicating a battery issue.

LED Light	Voltage	Possible Cause	Recommended Action
Slow Flashing (5s on/5s off)	Less than 25.5V	Battery over-discharged due to faulty charging system (alternator) not charging the battery.	Charge the battery. Verify aircraft charging system is functioning.

Slow Flashing (5s on/5s off) (> 1 hour)	25.5-29V	Weak or failing cell	Charge the battery with an approved charger and observe fault LED. If LED persists, charge the battery a second time. If the LED fault persists, the battery should be replaced.
Slow Flashing (5s on/5s off)	Greater than 31V	Over-charging (due to faulty charging system regulator)	Verify aircraft charging system is functioning properly; could be faulty voltage regulator and or over-voltage protection device.
Solid Light	Any voltage	BMS electronics issue	Isolate the battery from the aircraft (disconnect positive or negative cable). If the fault is not extinguished, the battery should be replaced.
Solid Light that turns off after 3 minutes	Any voltage	Short Circuit protection was activated	Verify normal voltage (25.5-29V) at the battery terminals. Battery can be returned to service.
Short Flashing (2s on/2s off)	Any voltage	Battery temperature very high (> 85°C / 185°F) due to environment or excessive discharge.	If due to excessive discharge amperage, let the battery cool down prior to cranking or charging. If the environmental temperature is too high, engineer means to cool battery when in service.

The table below is a summary of the battery's fault/status codes indicating a possible charging system issue.

LED Light	Airplane Voltage/Current	Charging System - Possible Cause	Recommended Action
Slow Flashing (5s on/5s off)	Less than 25.6V	Battery over-discharged due to faulty charging system (alternator) not charging the battery.	Charge the battery. Verify aircraft charging system is functioning.
Slow Flashing (5s on/5s off)	Greater than 30V	Battery over-charged due to faulty charging system (regulator), high voltage.	Verify battery fault LED extinguishes. Verify aircraft charging system is functioning.

For additional information go to https://earthxbatteries.com/ and review the FAQs.

Battery Storage and Handling

If the aircraft is to be put in storage for an extended period (> 6 months), disconnect the battery cable to eliminate drain from the Aircraft's electrical system. A fully charged battery can be put in storage for up to a year without charging but should be charged and inspected annually.

Our batteries can be stored at temperatures between -40°C to +70°C. Our batteries have no liquid inside and will not freeze.

Special care must be taken in the handling, shipping, and storage of rechargeable lithium batteries. As a result, installers, end users, and personnel involved in the maintenance and disposal of rechargeable lithium batteries require training in the special characteristics related to rechargeable lithium battery safety. Leaving battery output terminals or leads exposed may result in external short-circuiting of the battery during shipping, handling, testing and installation. Terminals of batteries shall be covered with non-conductive protective devices to avoid any possibility of shorting during handling, shipping, and storage.

Batteries can be recycled at any location accepting lithium-ion type batteries. Drain battery and or cover terminals with electrical insulating tape prior to recycling. For recycling information and where to recycle check this website (https://www.call2recycle.org/).

 **Do not incinerate or expose to open flames!**

 **The Safety Data Sheet (SDS) is available on EarthX's website.**

 **Always follow the manufacturers' recommended safety precautions and procedures.**

Weight and Balance

The installation of the battery is considered a permanent installation. The basic aircraft weight and balance should be updated inclusive of the added equipment when the installation is completed and documented on the aircraft Weight and Balance Record (WBR). See the "Specifications section of this manual for the battery weight.

Reference Documents

- ETX400-24-TSO FAA Approved Airplane Flight Manual Supplement (AFMS)

Regulations / Standards

This battery is designed and tested to the following safety regulations as outlined in:

- FAA Technical Standard Order TSO-C179b
- FAA AC 20-184, Guidance on Testing and Installation of Rechargeable Lithium Battery and Battery Systems on Aircraft
- FAA AC 23.1309-1E, System Safety Analysis and Assessment for Part 23 Airplanes
- RTCA DO-160G, Environmental and Test Procedures for Airborne

Equipment

- RTCA DO-254, Design Assurance Guidance for Airborne Electronic Hardware
- RTCA DO-311A, Minimum Operational Performance Standards for Rechargeable Lithium Batteries and Battery Systems
- UN 38.3, – United Nations ST/SG/AC.10/11/Rev.6, Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, Section 38.3, Lithium Metal and Lithium-Ion Batteries.