

eGSE America:  
Electric Aircraft PushBack  
Tractor (EAPT)  
Technical Specifications

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## 1 SCOPE

This document outlines the specific design and performance requirements for the propulsion and energy management systems of a battery-powered, electric aircraft pushback tractor (hereafter “tractor”). This document shall apply to both a “towbar” and “towbarless” type of pushback tractor. The use of “shall” in this document indicates a mandatory requirement. The use of “should” indicates a recommendation or that which is advised but not required.

## 2 APPLICABLE DOCUMENTS

Portions of the following documents, to the extent specified herein, are a part of this Recommended Practice.

ASME/ANSI B56.9-1992 (Reaffirmed 2000)	Safety Standard for Operator Controlled Industrial Tow Tractors
ANSI/NEMA No. 250-1997 (AUG01)	Enclosures for Electrical Equipment (1000 Volts Maximum)
BCI Technical Manual 2 <sup>nd</sup> Edition	Battery Technical Manual, Second Edition, Pages 39 - 41
CiA Draft Standard (OCT02)	CANOpen: Device Profile for Battery Modules Proposal 418
CiA Draft Standard (JAN03)	CANOpen: Device Profile for Battery Charger Proposal 419
IWC Report Final Draft (APR02)	National Infrastructure Working Council (IWC) Non-road Fast Charging & Connectors  <u>Sub-Committee Report: <a href="#">Electric Ground Equipment Conductive Fast Charge Specification</a></u>
MIL-STD-461E (AUG99)	Electromagnetic Interference Characteristic Requirements for Equipment
NFPA No. 505 (AUG02)	Standard for Use, Maintenance and Operation of Industrial Trucks. Fire Safety for Powered Industrial Trucks
SAE ARP1247 Rev. C (DEC98)	General Requirements for Aerospace Powered Mobile Ground Support Equipment
SAE AIR 1375 (JUN00)	Minimum Safety Requirements for Special Purpose Airline Ground Support Equipment

SAE ARP1817 Rev. A (MAR98)	Batteries for Battery Powered Ground Support Equipment
SAE AS4828 (JUN02)	Technical Manual Development for Ground Support Equipment
SAE ARP4852 REV.B (NOV00)	Design Specifications for Towbarless Push-Back Tow Vehicles
SAE J163 (JAN01)	Low Tension Wiring and Cable Terminals and Splice Clips
SAE J377 (FEB87)	Performance of Vehicles Traffic Horns
SAE J551-1 (JUN96)	Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles and Devices (60 HZ to 18 GHZ)
SAE J551-12 (SEP96)	Vehicle Electromagnetic Immunity – On-board Transmitter Simulation
SAE J561 (JUN93)	Electrical Terminals – Eyelet and Spade Type
SAE J858a (AUG69)	Electrical Terminals Blade Type
SAE J1127 (MAY00)	Battery Cable
SAE J1128 (MAY00)	Low Tension Cable
SAE J1654 (MAY00)	High Voltage Cable
SAE J1673 (JUL96)	High Voltage Automotive Wiring Assembly Design
SAE J1690 (AUG96)	Flashers
SAE J1742 (MAR98)	Connections for High Voltage On-Board Road Vehicle Electrical Wiring Harnesses Test Methods and General Performance Requirements
UL 583	Electric-Battery-Powered Industrial Trucks (9 <sup>th</sup> Edition, JUN96, including revisions through JUL99)

### 3 DESIGN REQUIREMENTS

#### 3.1 General Requirements

- 3.1.1 The tractor shall comply with all performance requirements of this technical specification over the full range of environmental factors specified in SAE ARP1247, Paragraph 3.6.
- 3.1.2 The tractor should comply with the requirements of NFPA 505 and UL 583 for Type E, ES, EE, or EX vehicles. Manufacturer shall specify whether the tractor meets the requirements of Type E, ES, EE, or EX.
- 3.1.3 The manufacturer shall list and describe, in detail specifically, which aircraft the tractor will adequately service while meeting the requirements found herein.
- 3.1.4 Towbarless tractors should comply with SAE ARP4852. The manufacturer shall specify all areas of non-compliance with SAE ARP4852.

#### 3.2 Electrical System

The electrical system shall consist of an appropriate size and type of traction battery pack that powers a compatible electric motor(s) through an electronic controller(s) to produce smooth acceleration and operation. Traction battery voltage should reflect the best design for duty cycle, vehicle speed, tractive effort, and minimum current losses. The traction battery charger shall be appropriately selected to properly charge the traction battery and meet the requirements of the particular application.

##### 3.2.1 Traction Battery

- 3.2.1.1 The traction battery should comply with the requirements of SAE ARP1817. The vehicle manufacturer shall specify all areas of noncompliance with SAE ARP1817. Battery rating and testing by the manufacturer shall follow the requirements of the BCI Battery Technical Manual. The battery provided shall be of size and capacity to satisfy performance and accessory requirements. Operational characteristics, such as the average amp-hour draw, any non-gassing requirements, available maintenance, and personnel and facilities, should also be considered when selecting the proper battery. The vehicle manufacturer shall provide the battery manufacturer's specifications, including the 1-hour, 3-hour, and 5-hour discharge rating of the traction battery (in ampere-hours), and shall specify the battery discharge rate (in amperes) when operating under a load as defined by the following:

$$\text{Load} = 0.8 * \frac{(\text{Maximum Dynamic Draw Bar}_{(100\% \text{ SOC})} + \text{Maximum Dynamic Draw Bar}_{(50\% \text{ SOC})})}{2}$$

- 3.2.1.2 Means of restraining the traction battery in the lateral and longitudinal directions shall be provided.
  - 3.2.1.3 Vehicle manufacturer should supply the battery manufacturer's recommended traction battery charging algorithm.
  - 3.2.1.4 Vehicle manufacturer should supply traction battery maintenance requirements.
  - 3.2.1.5 Vehicle manufacturer shall indicate the depth of discharge below which the traction battery should not be discharged.
  - 3.2.1.6 The traction battery shall be protected by a cover, which shall support at least 12 lbs/ft<sup>2</sup>.
  - 3.2.1.7 The traction battery and traction battery compartment shall be designed so electrolyte from the battery is captured in an auxiliary tray or the battery tray and is not allowed to drain onto the ground, corrode parts of the tractor, or create acid paths for current to flow to the chassis. This requirement does not apply when sealed batteries are used.
  - 3.2.1.8 Battery cable connectors shall be located so they create no danger of igniting gases expelled during battery charging. The location also should be convenient for charging while not being subject to damage during battery removal or installation.
  - 3.2.1.9 Manufacturer shall supply an MSDS for the battery and any materials used in the tractor that would not typically be found in an automotive shop.
  - 3.2.1.10 Manufacturer shall specify recommended and maximum allowable battery weight (full-rated load).
  - 3.2.1.11 Beginning at full charge, vehicles should be capable of operating and charging after being out of service in an ambient temperature between 40°F and 120°F and off charge for 16 days. No operator action should be required during this period.
- 3.2.2 Propulsion System
- 3.2.2.1 The electronic controller(s) and motor(s) shall be sized for the application and shall limit maximum battery discharge as specified in Section 3.2.1.5 to prevent degradation of battery life and abrupt loss of tractor operability. This limit shall be adjustable, repeatable, and accurate within 10% battery state of charge (SOC.)

- 3.2.2.2 All wiring and components used in the high-voltage propulsion system shall be of a “two-wire” design, using an insulated return wire rather than the vehicle chassis as ground, and sized in compliance with SAE J1673.
- 3.2.2.3 Vehicles shall not contain exposed conductors, terminals, contact blocks, or devices of any type that create the potential for personnel to be exposed to 60 volts (nominal battery voltage) or greater (the distinction between LOW VOLTAGE and HIGH VOLTAGE, as specified in SAE J1127). Access to any HIGH VOLTAGE components shall require the removal of at least one bolt, screw, cover, or latch. Devices that contain HIGH VOLTAGE components shall be clearly marked as “HIGH VOLTAGE.” These markings should be installed at any point that voltage can be accessed by the end user. HIGH VOLTAGE cable and wire marking shall consist of orange insulation and/or orange sleeves or spiral wrapping as required by SAE J1673, Paragraph 3.5.3.
- 3.2.2.4 All HIGH VOLTAGE cable shall comply with the requirements of SAE J1654. All LOW VOLTAGE battery cable shall comply with the requirements of SAE J1127.
- 3.2.2.5 HIGH VOLTAGE connectors (except charger power supply to vehicle) should utilize latching devices to prevent inadvertent disconnection, shall be keyed to prevent misconnection, and should be moisture proof. HIGH VOLTAGE connectors should comply with the requirements of SAE J1742.
- 3.2.2.6 The tractor should use a single speed, multi-speed automatic, hydrostatic, or continuously variable transmission.
- 3.2.2.7 A propulsion power system operating at greater than 60 volts shall be isolated from the vehicle chassis so leakage current does not exceed 20 mA with the battery connected.
- 3.2.2.8 An arrangement for the controller to provide regenerative braking should be offered. Maximum regenerative braking settings shall be adjustable so maximum current returning to the traction battery pack can be set to avoid potential damage to traction battery pack or electrical components.
- 3.2.2.9 Regenerative braking shall not adversely impact the tractor’s braking stability, particularly on varying road surfaces.
- 3.2.2.10 If a traction motor with armature brushes is used, the motor should be easily accessible for brush inspection.

### 3.2.3 Accessory Power System

3.2.3.1 The accessory power system shall be used to power the following:

- Two sealed beam headlights on front of tractor (one each side)
- Two tail lights on rear of tractor (one each side)
- Two brake lights on rear of tractor (one each side)
- Two back-up lights on rear of tractor
- Emergency flashers
- Floodlight for front and rear hitches or pickup device.

A combination assembly may be used to accommodate the brake and tail lights. A horn shall be supplied and should comply with the requirements of SAE J377.

3.2.3.2 The accessory power system should incorporate a “2-wire” design, using an insulated return wire rather than the vehicle chassis as ground for isolation purposes. If chassis ground is used for the accessory power negative, it shall be isolated from the traction system by at least 500,000 ohms resistance. The accessory power system shall be supplied from the main traction battery by an electronic DC-to-DC converter.

3.2.3.3 Low-voltage connectors should comply with the applicable requirements of SAE J163, J561, and J858a. The vehicle manufacturer shall specify all areas of noncompliance with SAE J163, J561, and J858a.

3.2.3.4 Low-voltage wire shall meet the requirements of SAE J1128.

3.2.3.5 All electronic components shall be protected by an enclosure meeting the requirements of ANSI/NEMA 250-1997, Type 4 Enclosure.

3.2.3.6 The electrical/electronic systems shall incorporate proper shielding and filtering to ensure electromagnetic compatibility of the vehicle with any and all communication and navigation frequencies in and around the airport ramp areas in accordance with MIL-STD-461E. The tractor shall not be susceptible to externally generated electromagnetic fields and shall comply with the applicable sections of SAE J551-1. Additionally, vehicles shall not be susceptible to electric magnetic fields from an on-board radio transmitter and shall comply with the requirements of SAE J551-12.

### 3.2.4 Battery Charging

3.2.4.1 It shall not be possible to drive the tractor when the tractor is connected to the charger.

3.2.4.2 Charging circuits shall be isolated from the vehicle chassis so ground current from the grounded chassis does not exceed 20 mA at any time the vehicle is connected to an off-board charger.

3.2.4.3 The charge connector shall be prevented from being inadvertently connected to the controller or motor rather than the battery.

### 3.2.5 Electrical Systems

3.2.5.1 Electric Systems shall comply with the requirements of SAE ARP1247, Paragraphs 3.13.1.2.5, 3.13.1.2.6, 3.13.1.2.9, 3.13.1.2.10, 3.13.1.2.12, 3.13.1.2.20, and 3.13.1.2.23.

## 4 PERFORMANCE REQUIREMENTS

4.1 The following performance requirements apply to dry level concrete (co-efficient of friction of 0.7 or better), with an outdoor ambient and traction battery temperature of 77°F (25°C), unless otherwise specified.

4.1.1 The manufacturer shall report the maximum static drawbar pull, with the traction battery at 100% and at 50% (+/- 10%) SOC.

4.1.2 The maximum tractor speed with no towed load shall be a minimum of 5 miles per hour and the maximum tractor speed shall be settable by a controlled method.

4.1.3 The manufacturer shall report the maximum draw bar of the tractor at a speed of 4.0 miles per hour (6.0 kilometers per hour) with the traction battery at 100% and at 50% (+/- 10%) SOC.

4.1.4 At the maximum drawbar stated in 4.1.3, the controller, motor, and battery shall be capable of continuous operation at 4.0 mph (6.0 kilometers per hour) for at least 3 minutes without overheating or damage to the propulsion system.

## 5 OPERATOR CONSIDERATIONS

### 5.1 Instruments

5.1.1 Dash instrumentation should include a SOC indicator for the propulsion battery. Indications should be repeatable and accurate to +/- 10% of full scale.

5.1.2 Dash instrumentation shall include an hour meter and an indicator light to warn the operator of a brake failure.

### 5.2 Safety Requirements

5.2.1 The tractor requirements shall comply with the requirements of SAE ARP 1247, Paragraphs 3.8, 3.9, and 3.10; SAE AIR 1375, and ANSI B56.9-1992.



- 5.2.2 The tractor shall be equipped with a deadman type seat switch interlock that deactivates the traction circuit whenever the operator is not on the seat. The switch and its installation shall be designed to prevent false tripping due to driving over bumps or the operator leaning in any direction on the seat.
- 5.2.3 The traction system controller shall incorporate a “static return to off” feature. This requires the operator to set the directional control to neutral before tractor movement is possible once the seat switch has been opened.
- 5.2.4 A handbrake interlock shall be provided to prevent traction system operation unless the handbrake is disengaged.
- 5.2.5 Vehicles using HIGH VOLTAGE traction systems shall be equipped with a “master” switch that shall interlock controller propulsion functions and battery contactor(s), if any, to render the propulsion system inoperative. Contactors(s) used in conjunction with the master switch shall be capable of interrupting maximum rated controller/inverter current.

A manual service disconnect for vehicles using a HIGH VOLTAGE traction system also shall be required. It shall have the following characteristics:

- Manual action is required to break the connection
- The disconnection is physically verifiable
- The disconnection does not create exposed conductors capable of becoming energized while exposed
- The service disconnect is clearly marked and is accessible without the use of tools.

The tractor should be designed for easy access to those areas that require frequent checks and/or servicing.

- 5.2.6 Information regarding maximum towing speed shall be properly placarded on the dash and at the tow points if potential damage exists to the traction motor during maintenance towing at higher than recommended speeds.

## 6 MAINTENANCE REQUIREMENTS

- 6.1 Requirements of SAE ARP1247, Paragraph 3.12.5, shall be followed where applicable. Systems and components requiring expertise not normally found with ground equipment mechanics shall have adequate troubleshooting charts and procedures. Simplified and/or automatic test equipment is encouraged.
- 6.2 The tractor shall be supplied with a service manual that includes the traction system and which complies with the requirements of SAE AS4828.
  - 6.2.1 The manual shall include a complete electrical schematic, wiring diagram, and component location chart.
  - 6.2.2 Instructions for removing the battery pack shall be adequately illustrated in the manual.
  - 6.2.3 Any special tools or test equipment shall be identified in the manual and drawings or the source of procurement documented.

## 7 OPTIONS

The vehicle manufacturer shall specify options available.

- 7.1 Optional cab accessories should include a windshield wiper, window heater/defroster, dome light, turn signals, and provisions for a ramp two-way radio.
- 7.2 An indicator light on the dash to caution the operator of motor brush wear should be offered where applicable.
- 7.3 Cold weather option for the battery should be offered.
- 7.4 Hazard lights that are capable of at least 1 hour of continuous operation in the event of shutdown or isolation of the propulsion battery pack or failure of the DC/DC converter system should be offered, as required by SAE J1690.
- 7.5 Universal chargers which communicate with the vehicle battery pack and are capable of automatically charging a wide range of battery packs should be offered.
  - 7.5.1 A vehicle charge receptacle meeting the requirements of the IWC Electric Ground Equipment Conductive Fast Charge Specification should be offered.
  - 7.5.2 The inlet should incorporate a method to ensure that accessible receptacle high-voltage pins are not energized when exposed to human contact and during normal vehicle operation, and the vehicle shall be immobilized to prevent a “drive-off” scenario when the charge plug is engaged in the vehicle receptacle.

- 7.5.3 The charge receptacle should be located on the vehicle in way that minimizes incidental connector “snags” after the operator removes the charge connector from the vehicle charge receptacle.
- 7.5.4 The battery to charger communications module should comply with the requirements of “CiA Draft Standard Proposal 418.”
- 7.5.5 The vehicle-charger communication protocol should meet the requirements of “CiA Work Draft Proposal 419.”
- 7.5.6 The charger should be capable of returning the battery from the maximum depth of discharge specified in Section 3.2.1.5 to 80% SOC in less than 2 hours.