AIRCRAFT STARTER OWNERS MANUAL

P/N ES1033

STARTER MODELS

E-Drive Series
X-Drive Series

Table of Contents

Table of Contents (cont'd)

Thank you for purchasing a Sky-Tec starter. We encourage you to read this manual thoroughly. It contains a wealth of information about how to properly install and maintain your starter so that it may give you many years of safe and reliable service.

Should you have a question regarding your starter that is not covered in the manual, Hartzell Engine Technologies Product Support is ready to assist you. We may be reached at the following contact information:

Phone: +1.334.386.5400, option 2
E-mail: techsupport@HartzellEngineTech.com
Fax: +1.334.386.5400
Web: www.Skytec.aero/contact/

WARNING:

PEOPLE WHO FLY SHOULD RECOGNIZE THAT THERE ARE VARIOUS TYPES OF RISKS INVOLVED IN THIS ACTIVITY, AND THEY SHOULD TAKE ALL PRECAUTIONS TO MINIMIZE THEM SINCE THEY CANNOT BE ELIMINATED ENTIRELY. THE STARTER IS AN IMPORTANT COMPONENT OF THE AIRCRAFT. A STARTER FAILURE COULD RESULT IN THE INABILITY TO RESTART AN ENGINE IN FLIGHT RESULTING IN AN UNPLANNED LANDING OR EVEN MORE SEVERE CONSEQUENCES. THIS MAY CREATE AN UNSAFE CONDITION THAT MAY RESULT IN DEATH, SERIOUS BODILY INJURY, AND/OR SUBSTANTIAL PROPERTY DAMAGE. IT IS, THEREFORE, ESSENTIAL THAT THE STARTER IS PROPERLY MAINTAINED ACCORDING TO THE RECOMMENDED SERVICE PROCEDURES AND MONITORED TO DETECT IMPENDING PROBLEMS BEFORE THEY BECOME SERIOUS. ANY UNUSUAL OPERATION SHOULD BE INVESTIGATED AND CORRECTED, AS IT MAY BE A WARNING OF IMPENDING FAILURE.

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Record of Revisions

Revision Letter	Issue Date	Page Revised	Description	Inserted Date	Inserted By
New	04/23/2019	N/A	Original Release		

Record of Revisions

Revision Letter	Issue Date	Page Revised	Description	Inserted Date	Inserted By

Record of Temporary Revisions

Temporary Rev. Letter	Page Number	Issue Date	By	Date Removed	By

Service Publication List

Publication Number	Description	Starter Affected

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AIRWORTHINESS LIMITATIONS

A.0 General Information

CAUTION:

THE AIRWORTHINESS LIMITATIONS HEREIN ARE THOSE MANDATED BY HARTZELL ENGINE TECHNOLOGIES. THESE LIMITATIONS ARE THE MINIMUM REQUIRED TO MEET CONTINUED AIRWORTHINESS BUT MAY BE SUPERSEDED BY MORE STRINGENT REQUIREMENTS AS PUBLISHED BY THE FAA, AIRCRAFT, ROTORCRAFT OR OTHER MANUFACTURERS THAT USE THESE COMPONENTS IN THEIR APPLICATIONS. FAILURE TO OBSERVE THESE LIMITATIONS MAY COMPROMISE THE COMPONENT OR THE APPLICATION IT IS USED IN.

A.1 Airworthiness Limitation Statement

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

Airworthiness Limitation Revisions Log

Revision Number	Description of Revision

AIRWORTHINESS LIMITATIONS (cont'd)

A.2 Life Limits

A. The FAA establishes specific life limits for certain component parts as well as the complete starter. Such limits require replacement of the identified parts after a specified number of cycles or hours of use.

B. Additions of, or changes to, any life limit for the starter or its components, will be noted in the Airworthiness Limitation Revision Log.

C. Life Limits

(1) Starter models and their component parts affected by this manual currently do not have any life limited parts.

(2) There are no new (or additional) Airworthiness Limitations associated with this equipment.

1.0 General Information

WARNING:

IMPROPER OR UNAUTHORIZED APPLICATIONS OF THE INFORMATION CONTAINED IN THIS MANUAL MAY RENDER THE AIRCRAFT OR THE COMPONENT UNAIRWORTHY AND RESULT IN LOSSES, DAMAGES, OR INJURY TO THE USER.

DO NOT USE OBSOLETE OR OUTDATED INFORMATION. PERFORM ALL INSPECTIONS OR WORK IN ACCORDANCE WITH THE MOST RECENT REVISION OF THIS MANUAL. INFORMATION CONTAINED IN THIS MANUAL MAY BE SIGNIFICANTLY CHANGED FROM EARLIER REVISIONS. USE OF OBSOLETE INFORMATION MAY CREATE AN UNSAFE CONDITION THAT MAY RESULT IN DEATH, SERIOUS BODILY INJURY, AND/OR SUBSTANTIAL PROPERTY DAMAGE. REFER TO THE MANUAL INDEX FOR THE MOST RECENT REVISION LEVEL.

The accuracy and applicability of this manual has not been verified for any assembly, component or part not manufactured by Hartzell Engine Technologies LLC (HET). Any use of the manual for other than its intended or implied purpose is prohibited. The use of the manual for the purpose of performing any installation, maintenance, replacement, adjustment, or inspection of any assembly, component or part not manufactured by HET is not approved, endorsed, or sanctioned by HET.

This manual has been reviewed and accepted by the FAA. Additionally, the Airworthiness Limitations Section of this manual has been approved by the FAA.

This manual has been approved by Hartzell Engine Technologies LLC as the proper methods and procedures that FAA or other airworthiness authority Certificated Repair Stations and A/P Mechanics should use in the inspection and maintenance of the subject Hartzell Engine Technologies LLC starter.

No liability will be assumed by Hartzell Engine Technologies LLC for actual, consequential, incidental or other types of damages directly or indirectly resulting from the unauthorized use of this manual for other than its stated purposes.

The liability for use of the authorized data in this manual for the maintenance, or return to service is limited to the specific terms and conditions stated under the applicable Limited Warranty in effect for each piece part, component, assembly or whole unit sold by HET.

Because of the numerous modifications, Supplemental Type Certificates (STC), Parts Manufacturing Approvals (PMA), or Form 337 Field Approvals that may apply, it is the responsibility of the repairman, mechanic, or maintenance facility to determine the proper engine or aircraft application of this starter assembly. Please refer to the appropriate aircraft Type Certificate (TC), Supplemental Type Certificate(STC), aircraft equipment list, maintenance manuals, and/or Log Book entries for determination.

When performing installation, maintenance, replacement, adjustment, or inspection of any HET assembly, component or part, it is imperative that the latest revision of this HET manual or other product support document be referenced. Reference the HET website to be sure you have the latest revision before performing any work. (http://www.skytec.aero)

All reasonable attempts were made to make this manual as complete and accurate as possible. If you have any questions, comments, corrections or require clarification of any information contained in this manual, please write to Hartzell Engine Technologies LLC, 2900 Selma Highway, Montgomery, Alabama, 36108 USA. TEL +1.334.386.5400, FAX +1.334.386.5410.

1.1 General Specification (manual)

A. This manual follows unique HET formatting using ATA 100 and iSpec 2200 standards as required. Principle units of measure in the manual are U.S. units with International System of Units (SI) in parentheses.

B. The E-Drive and X-Drive series (12v & 24v) starter models are considered in this manual. Variations of these starters may be noted as applicable.

C. All aircraft, rotorcraft, or engine applications are limited to the holder of the TC, STC, PMA or TSO and only at the date of that document publication or revision.

D. Only approved, competent persons with the necessary skills may do maintenance tasks described in the manual.

E. The manual describes maintenance on components as they are installed on aircraft and tasks that should be accomplished in a properly equipped service facility.

F. Maintenance tasks and subtasks are referenced in the manual but will have no specific identification numbers.

G. The manual contains: Description and operation, Troubleshooting, Instruction for Continued Airworthiness (ICA) and Maintenance information along with part numbers required for basic maintenance tasks.

1.2 How to use the manual:

A. Make sure the manual contains information applicable to your aircraft, engine, or replacement starter. Look for the model number on the Title Page and if applicable, the part number of the replacement or superseded component.

B. Refer to the troubleshooting section prior to assure that the observed or reported condition lies with the starter.

C. Use only the sections needed, use the check section to determine what actions may be needed periodically and the maintenance sections for servicing the starter.

D. If you need to identify a part or find a part number, refer to illustrations herein or the applicable aircraft or engine service or overhaul manual.

E. It is imperative that you read, understand, and observe all the applicable WARNINGS and CAUTIONS before you do any work on this component.

F. Fully test the starter per the instructions in this manual when running the aircraft. Utilize the aircraft and/or engine manufacturers service manuals and publications before returning the aircraft to service. Use the AFM or POH for aircraft operations.

G. Some sections in this manual apply to all starters considered herein. Other sections will contain information specific to a particular starter model or variation of the model.

1.3 Measurements

A. The measurements given in the manual are taken from original manufacturing drawings.

B. Measurements are given in U.S. Units followed by SI Units in parentheses.

1.4 Units of Measure

A. SI Units

A	Ampere
Ah	Ampere hours
g	Gram
min	Minute
N	Newton
Nm	Newton meter
VDC	Volt direct current
°C	Degree Celsius
%	Percent
Ω	Ohm
W	watt
Hz	Hertz

B. U.S. Units (SI units)

ft (m)	Foot (meter)
in (c)	Inch (centimeter)
lb (kg)	Pound (kilogram)
lb-in (Nm)	Pound inch (Newton meter) torque
lb-ft (Nm)	Pound foot (Newton meter) torque
°F (°C)	Degree Fahrenheit (Celsius)

C. Multiplying Prefixes

µ	Micro
m	Milli
k	Kilo
M	Mega
p	pico

1.5 Abbreviations

A. The abbreviations given below are used in the manual: (upper or lower case)

ATA	Air Transport Association of America
BBA	Brush Block Assembly
CE.	Commutator End
DE.	Drive End
DIA	Diameter
FAA	Federal Aviation Administration
FIG.	Figure
GAMA	General Aviation Manufacturers Association
HET	Hartzell Engine Technologies LLC
ID	Inside Diameter
IPC	Illustrated Parts Catalog
MAX.	Maximum
MFR	Manufacturer
MIN.	Minimum
N/A	Not Applicable
NO.	Number
OD	Outside Diameter
PARA.	Paragraph
PG.	Planetary Gears
P/N	Part Number
REF.	Refer To
S/A	Subassembly
STR	Starter
TOL	Tolerance

1.6 Definitions

A. This paragraph defines the warnings and notifications used in this manual. Warnings place critical attention to use of tools, materials, procedures, or limitations, which must be followed without deviation to avoid injury to the technician or other persons. Cautions place immediate attention to use of tools and procedures which must be followed to avoid injury, damage to equipment and/or facilities. Notes call attention to procedures which make the job easier.

B. The following are basic definitions of the terms used herein: (as related to this manual)

AMMETER: The device for measuring electrical current in variations of amperes.

ARBOR PRESS: Tool used to press in or press out bearings and other close tolerance parts.

ARMATURE: A stationary set of conductors wound in coils on an iron core.

BRUSH: Device for transmitting current through the commutator to the armature. It is a composite carbon block which includes a spring, lead and contact.

CARBON PILE: Device used in testing. The carbon pile is basically a large adjustable resistor. It is formed of carbon granules, and its resistance is dependent on the pressure applied across the granules. Mechanical adjustment controls the pressure across the granules in such a way as to increase or decrease resistance.

COM END: End plate that retains multiple brush assemblies and is comprised of commutator cover, brushes, brush holder and leads.

CONTINUITY: The continuous path for the flow of current in an electrical circuit.

DRIVE END HOUSING: The external housing which contains the starter drive pack and retains the motor shaft. It may also be referred to as the Pinion Housing or D.E.

GAUSS STRENGTH: A unit measure of the magnetic flux density produced by a magnetizing force. Measured in cgs (centimeter-gram-second) or Teslas.

GEAR REDUCTION ASSEMBLY: Assembly of gears used for converting motor speed to motor torque. The gear reduction is generally 3 to 1. Includes gears, gear track, and gear housing.

GEAR TRACK: The ring gear on which the planet gears ride.

GROWL: Noise made when an armature growler device is employed. This unit applies an AC magnetic field to the armature being tested. This induces voltages in the windings and if any windings are shorted, there will be currents flowing and the corresponding forces make the armature vibrate or "growl".

INSULATOR: Component that resists the flow of electricity.

LEAKAGE: Dissipation of voltage or current from a component or connection.

MAGNET HOUSING: The portion of the starter which contains the rare earth permanent magnets used to create the flux field necessary for starter operation.

OPEN: Electrical term for a complete disruption in electrical current. Infinite resistance.

ECB: Term used for electronic circuit board. Used in early starters as an electronic control ass'y.

REAR HOUSING: The external housing which contains the components of the starter. It may also be referred to as the Com End Housing (C.E.).

RFI: Radio Frequency Interference. Electrical interference created from commutator/brush connection, the coil controller, or other poor connections.

RPM: Revolutions per minute.

COMMUTATOR: Smooth segmented copper structure on the armature that provides a contact surface for the brush to run on. Provides for the current reversal through the armature that allows for continuous rotary motion.

SHORTED: Common term for a connection which has zero or very little resistance as seen on an Ohmmeter in an electrical circuit.

STARTER: The complete unit which transforms electrical energy from the battery or external source into rotational energy to turn the powerplant over for starting.

STARTER DRIVE PACK: Assembly which supplies rotational force to the starter ring gear to allow engine starting. Includes the pinion gear, torque limiting clutch, drive solenoid coil, and return spring.

STARTER MOTOR: Device that supplies rotational force from the starter to the starter shaft.

TACHOMETER: Device used to indicate RPM. (as used in testing)

TEST BENCH: Device so constructed as to allow testing of the starter or component parts.

TERMINALS: Studs, screws or other connections provide access for electrical power.

THROUGH BOLT: Special bolts which connect front and rear starter housings.

VOLT/OHM METER: Instrument used to measure voltage, current, or resistance. (DVM)

1.7 Disposal

A. Disposal of parts and assemblies should be as follows:

(a) Rejected parts should be tagged and scrapped per FAA requirements and parts must be rendered unusable prior to discard.

(b) Filter capacitors and PCB components may be considered hazardous waste and should be discarded whole through your local hazardous waste management system.

1.8. Model Identification

A. E-DRIVE Series

ERB-8011 (24 Volt - 12/14 pitch gear)	ERB-8012 (24 Volt - 10/12 pitch gear)
ERB-8051 (24 Volt - 12/14 pitch gear)	ELB-8021 (24 Volt - 12/14 pitch gear)
ERZ-8011 (12 Volt - 12/14 pitch gear)	ERZ-8012 (12 Volt - 10/12 pitch gear)
ELZ-8011 (12 Volt - 12/14 pitch gear)	ERZ-8041 (12 Volt - 12/14 pitch gear)
ELB-8011 (24 Volt - 12/14 pitch gear)	ELZ-8021 (12 Volt - 12/14 pitch gear)

(ELB & ELZ are Left hand rotation starters. Limited applications for ELZ starters.)

B. X-DRIVE Series

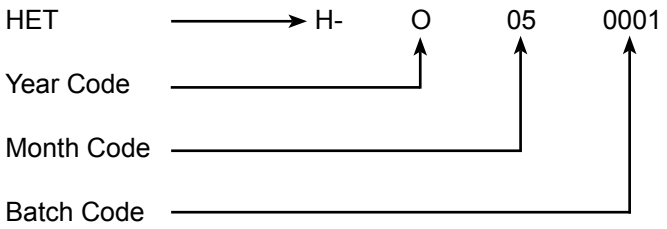
(Solenoid to the Left:)

SRB-9021 (24 Volt - 12/14 pitch gear)	SRB-9022 (24 Volt - 10/12 pitch gear)
SRZ-9021 (12 Volt - 12/14 pitch gear)	SRZ-9022 (14 Volt - 10/12 pitch gear)

(Solenoid to the Right.)

SRB-9031 (24 Volt - 12/14 pitch gear)	SRB-9032 (24 Volt - 10/12 pitch gear)
SRZ-9031 (12 Volt - 12/14 pitch gear)	SRZ-9032 (14 Volt - 10/12 pitch gear)

1.9. Serial number Identification



Example above: HET, 2014, May, first unit of the month (batch)
Year Code: O = 2014, P = 2015, Q = 2016, etc.

1.10 Warranties

For warranty information, visit our website at https://skytec.aero/aircraft-starter-support/warranty/

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DESCRIPTION OF OPERATION

2.0 GENERAL

A. The starting circuit is designed to carry high current with a minimum loss of voltage. This circuit includes the battery, solenoid starting switch, manual starting switch, starter, the aircraft/ rotorcraft connecting wiring and structure. The starter cranks the engine for starting while the battery supplies the power. The manual switch and solenoid starting switch control the operation.

B. Two types of Sky-Tec starter are discussed in Description of Operation contained within this manual, the E-DRIVE and the X-DRIVE. Each starter has a unique method of accomplishing engine start. The different starters are developed based on the requirements established by the engine or aircraft manufacturer for design and available space.

2.1 BASIC STARTER DESCRIPTION

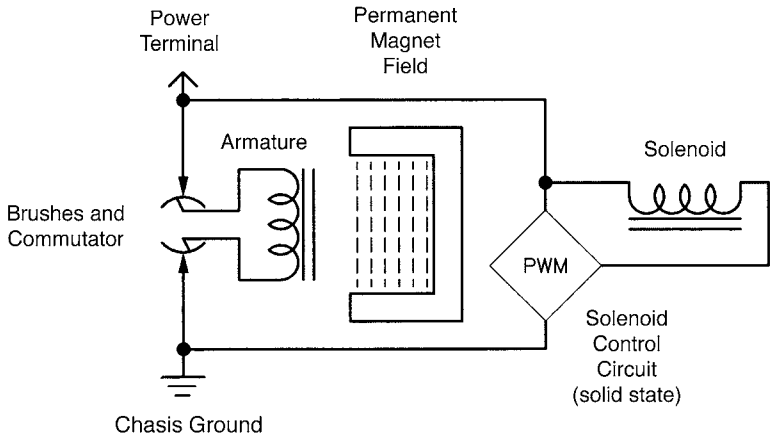

Fig. 2.1 - Typical E-Drive (Simplified Diagram)

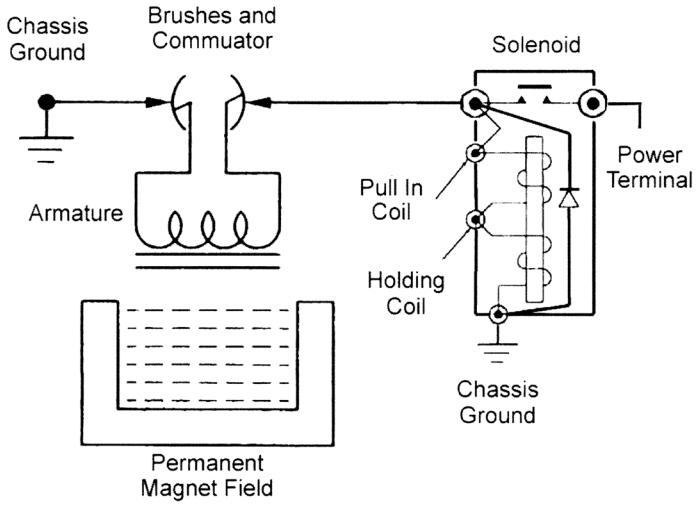

Fig. 2.2 - Typical X-Drive (Simplified Diagram)

2.2 TECHNICAL PURPOSE

A. The starter's purpose is to provide the aircraft engine rotational force allowing ignition and sustained engine running speed. The starter motor must develop a high cranking torque during the period of time when the starting switch is closed. The starter motor is designed to engage its pinion with the engine starter ring gear at the beginning of the start cycle, and then disengage when the ignition switch is released.

(1) The BATTERY is the source of electrical power whenever the BAT Master Switch is ON and is the source of power for starting the aircraft.

(2) The E-Drive and the X-Drive starters accomplish aircraft engine start through starter ring gear to crankshaft rotation, however, this is done using different methods.

2.3 PHYSICAL DETAIL

A. E-DRIVE

(1) The starter motor must develop a high cranking torque during the period of time when the starting switch is closed. The starter motor is designed to engage its pinion with the engine starter ring gear at the beginning of the start cycle, and then disengage when the ignition switch is released. This is accomplished through the use of the starter drive pack which contains a control circuit, solenoid coil, torque limiting clutch assembly, and a return spring.

(2) The gear reduction starter motor consists of six major components: (a) The Starter Drive Pack, (b) The Gear Reduction Assembly, (c) The Drive Housing, (d) The Armature, (e) The Magnet Housing Assembly, and (f) The Commutator Assembly. *The Drive Pack consists of the pinion gear, torque limiting clutch, solenoid coil, and return spring.*

(3) When the starting circuit is energized, battery current is applied to the starter terminal. Current flows through the brushes to the commutator through the armature windings to ground. Permanent magnets are used to create a strong magnetic field. The magnetic force created begins to turn the armature. Current is then supplied to the Drive Pack (engage and hold coil). Refer to Fig. 2.1.

(4) As the armature turns, the Drive Pack pinion extends and meshes with the engine starter ring gear via the electromagnetic coil. The ball clutch torque limiter holds the pinion for start loads but will allow slippage should an engine "kick-back" occur, preventing damage to the ring gear or starter.

(5) When the engine achieves a start and the starter switch is released, the pinion gear will de-mesh from the starter ring gear via a return spring in the Drive Pack.

(6) Both left and right hand rotation units operate the same except for direction of rotation and respective part numbers.

(7) The following details operation of the primary components: (Refer to Fig. 2.5b)

(a) **The Drive Pack Assembly** consists of the torque limiting clutch assembly, solenoid assembly and the pinion gear. The Drive Assembly mounts within the drive housing. The drive shaft passes through the drive assembly and engages via helical splines.

(b) **The Gear Reduction Assembly** consists of the drive shaft, planetary gears, metal gear track, and retaining cover. It provides a reduction from the high speed low torque motor to the low speed high torque drive shaft. The drive shaft transmits torque to the drive assembly via helical splines.

2.3 PHYSICAL DETAIL

A. E-DRIVE (Cont'd)

(7) The following details operation of the primary components: (cont'd)

(c) **The Drive End Housing** encloses the drive mechanism and contains the needle bearing in which the drive shaft rotates. *(The drive end housing assembly includes the intermediate housing.)*

(d) **The Armature** consists of a laminated soft iron core assembled on the armature shaft, a commutator and the windings, which are wound in slots in the core and connected to the commutator. The commutator is made up of a number of copper segments insulated from each other and from the armature shaft. The armature shaft extends into the reduction gear assembly and is supported on each end by bushings.

(e) **The Magnet Housing Assembly** includes the frame which physically supports the other components of the motor and the permanent magnets. The permanent magnets supply the magnetic field required for producing rotary motion.

(f) **The Commutator Assembly** contains one of the armature shaft bushings and the brush holder assembly, which contains the brushes. Each brush is a one piece composite matrix with integral shunts. They are spring loaded and ride on the armature commutator as it rotates.

B. X-DRIVE

(1) The starter motor must develop a high cranking torque during the period of time when the starting switch is closed. The starter motor is designed to engage its pinion with the engine starter ring gear at the beginning of the start cycle, and then disengage when the ignition switch is released. This is accomplished through the use of an external solenoid and lever arm assembly.

(2) The gear reduction starter motor consists of eight major components: (a) the Externally mounted solenoid and lever arm assembly, (b) the Discreet Clutch, (c) the Drive End Housing, (d) the Permanent Magnet Housing (e) the Gear Reduction Drive Assembly, (f) the High Performance Armature, (g) the Long Life Brush Block and (h) Commutator End Housing.

(3) Current is supplied to the coil of the externally mounted solenoid, which compresses the solenoid plunger, pivots the lever, and extends the pinion along the shaft to engage the engine starter ring gear. Refer to Fig. 2.2.

(4) Once the solenoid plunger is fully compressed, the motor contact is closed and cranking current is supplied to the motor.

(5) When the starting circuit is energized, battery current is applied to the starter terminal. Current flows through the brushes to the commutator through the armature windings to ground. Permanent magnets are used to create a strong magnetic field. The magnetic force created begins to turn the armature.

(6) When the engine achieves a start and the starter switch is released, the pinion gear is retracted from the engine starter ring gear by the solenoid return spring.

(7) The following details operation of the primary components: (Refer to Fig. 2.6b)

(a) **The Externally Mounted Solenoid** actuates the pivot lever and slides the pinion along the drive shaft. It also provides cranking current to the starter motor once the plunger is fully retracted and the starter motor contacts are closed.

2.3 PHYSICAL DETAIL

B. X-DRIVE (Cont'd)

(7) The following details operation of the primary components: (cont'd)

(b) **The Discreet Clutch Assembly** is a one way torque transmission mechanism. It allows torque to be transmitted from the starter motor to the engine starter ring gear, but allows the pinion to free spin once the aircraft engine starts and the engine starter ring gear RPM exceeds that of the pinion.

(c) **The Drive End Housing** contains the solenoid, lever, drive shaft end bushing and provides tapped holes for securing the through bolts.

(d) **The Permanent Magnet Housing Assembly** is a precision manufactured tube that contains rare earth permanent magnets. These magnets supply the magnetic field required for producing rotary motion.

(e) **The Planetary Gear Reduction Assembly** consists of the planetary gears, ring gear, ring gear housing, housing bushing, and drive shaft. It provides a reduction from the high speed low torque motor to low speed high torque. The helix of the drive shaft transmits torque to the discreet clutch mechanism.

(f) **The High Performance Armature** consists of a lamination of soft iron pressed onto the armature shaft. Copper wire windings run through the laminated core to the copper commutator bars. These bars are insulated from each other and the armature shaft with a phenolic form. The geared end of the armature extends into and becomes the sun (drive) gear of the planetary gear reduction assembly.

(g) **The Long Life Brush Block Assembly** has two pair of brushes. The brushes are one piece composite matrix with integral shunts. These brushes contact the commutator bars and energize the windings of the armature, causing it to become magnetized. They are spring loaded and ride firmly on the armature commutator as it rotates.

(h) **The Commutator End Housing** contains one of the armature shaft bushings, vent tube, the brush holder assembly with brushes, and provides mounting tabs for the through bolts. It works in conjunction with the drive end housing to hold all components in place.

2.4 Starter Duty Cycle Requirements

A. The starter cranks the engine for starting while the battery supplies the power. The engine does not always start on the first attempt, resulting in significant heat generated in starter components. This requires a limitation to the number of start cycles which can be made before a cool down period must be applied, refered to as the "Duty Cycle". The information below indicates the duty cycle requirements for the E-DRIVE and X-DRIVE starters.

B. E-DRIVE & X-DRIVE Starters:

(1) Engine must be grounded to the aircraft.

(2) Engage starter for 10 seconds of power (start), 20 seconds cool down (rest) for up to 20 starts then 10 minutes cool down before next start attempt.

(3) Do not apply power to starter unless installed on engine. Do not free run as this may cause internal damage to the starter.

2.5 OPERATIONAL DATA

A. Starter Models E-DRIVE Series

Weight: 9.25 lbs (4.20 kg)
Light weight, 4 pole permanent magnet drive motor.
Gear Reduction at 3.6 to 1
Max Duty Cycle - 10% continuous
30 sec. on 270 sec. rest (continuous)
10 sec on 20 sec. rest for 20 starts (intermittent)
Operating temperature range
-45˚ F to +155˚ F (-44˚ C to +68˚ C)
Operating Speed (Max motor output under load)
3100 RPM
Max drive Amperage (70 amps under load)
80 - 125 Amps @ 150 RPM during start (12.0v- 24.0v)
Operating Input (Min. & Max. under load)
(12.0v) - 9.0v to 14.5v, (24.0v).18.0v to 29.0v

B. Starter Models X-DRIVE Series

Weight: 7.75 lbs (3.52 kg)
Light weight, 4 pole permanent magnet drive motor.
Gear Reduction at 5 to 1
Max Duty Cycle - 10% continuous
30 sec. on 270 sec. rest (continuous)
10 sec on 20 sec. rest for 20 starts (intermittent)
Operating temperature range
-45˚ F to +155˚ F (-44˚ C to +68˚ C)
Operating Speed (Max motor output under load)
3100 RPM
Max drive Amperage (70 amps under load)
80 - 125 Amps @ 150 RPM during start (12.0v- 24.0v)
Operating Input (Min. & Max.under load)
(12.0v) - 9.0v to 14.5v, (24.0v).18.0v to 29.0v

2.6 APPEARANCE

A. Features - E-DRIVE Series

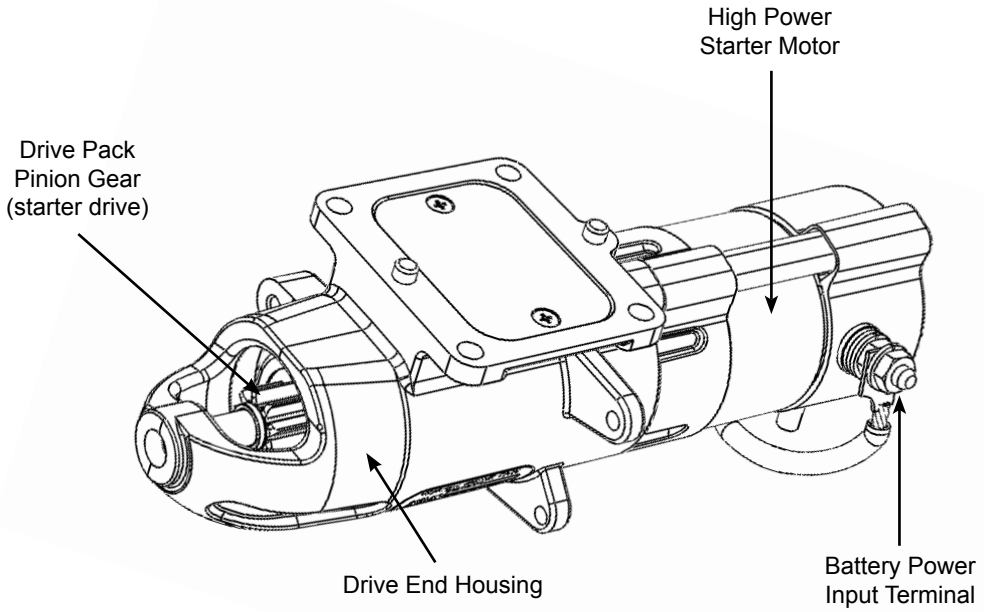

Figure 2.3a - E-Drive Front View
(Sample Configuration)

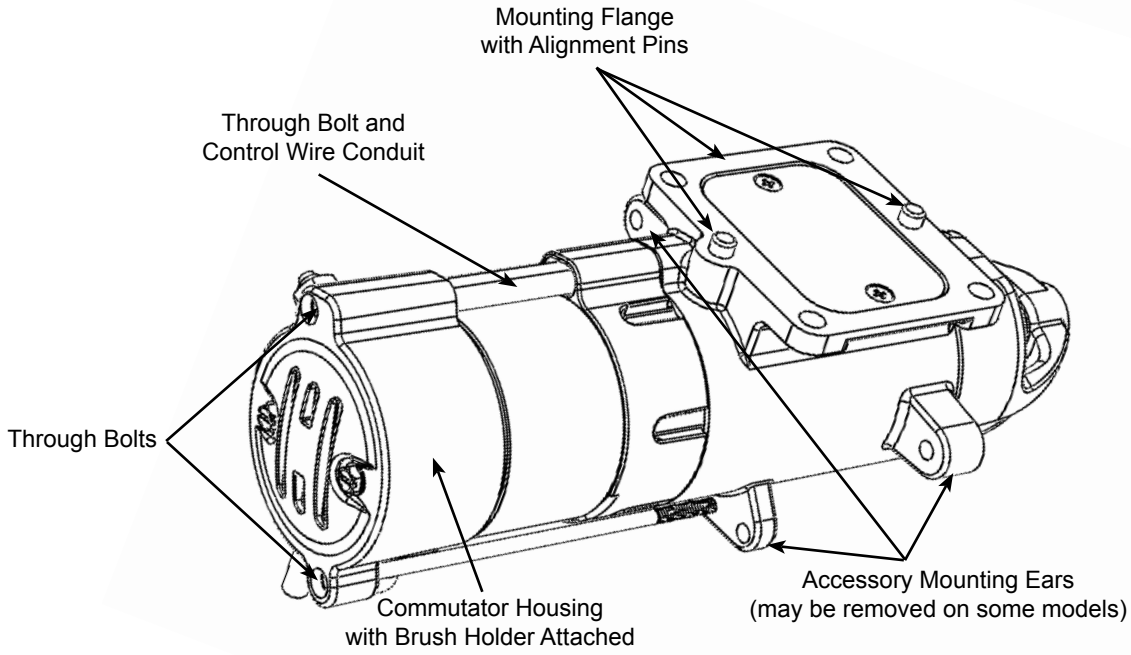

Figure 2.3b - E-Drive Rear View
(Sample Configuration)

2.6 APPEARANCE

B. Features - X-DRIVE Series (Right Solenoid Shown, Left Opposite)

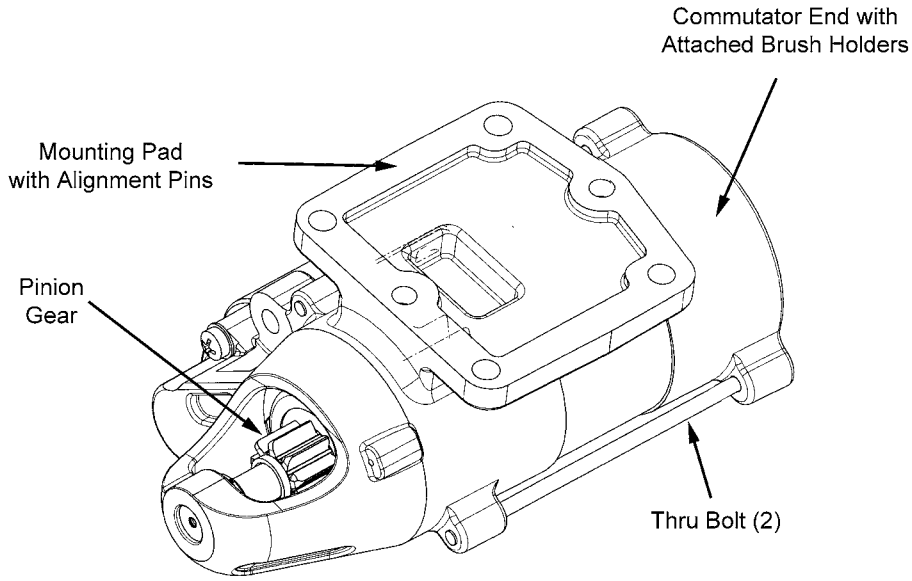

Figure 2.4a - X-Drive Front View (Sample Configuration)

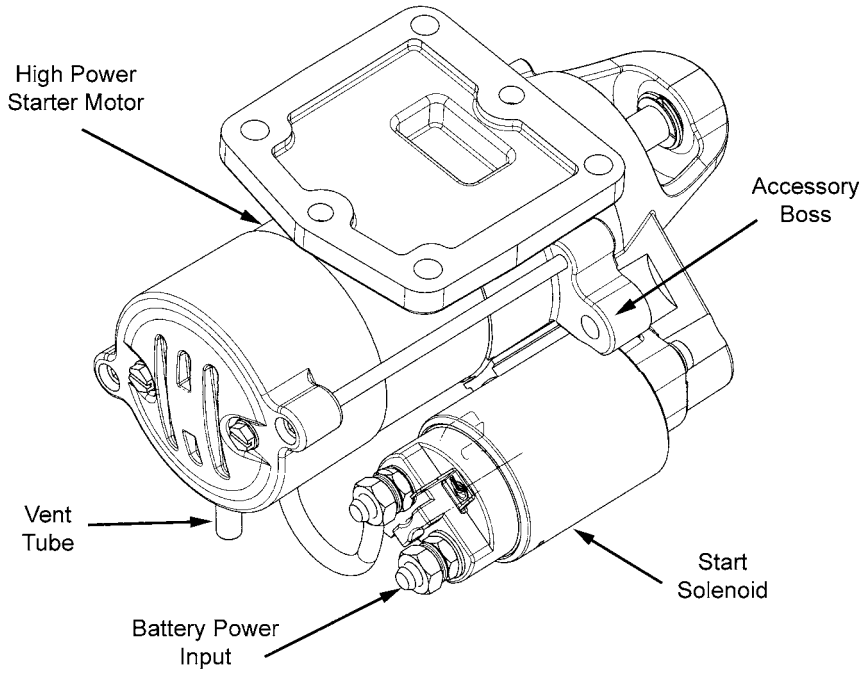

Figure 2.4b - X-Drive Rear View (Sample Configuration)

2.6 APPEARANCE

C. Features - E-DRIVE Series (Cutaway)

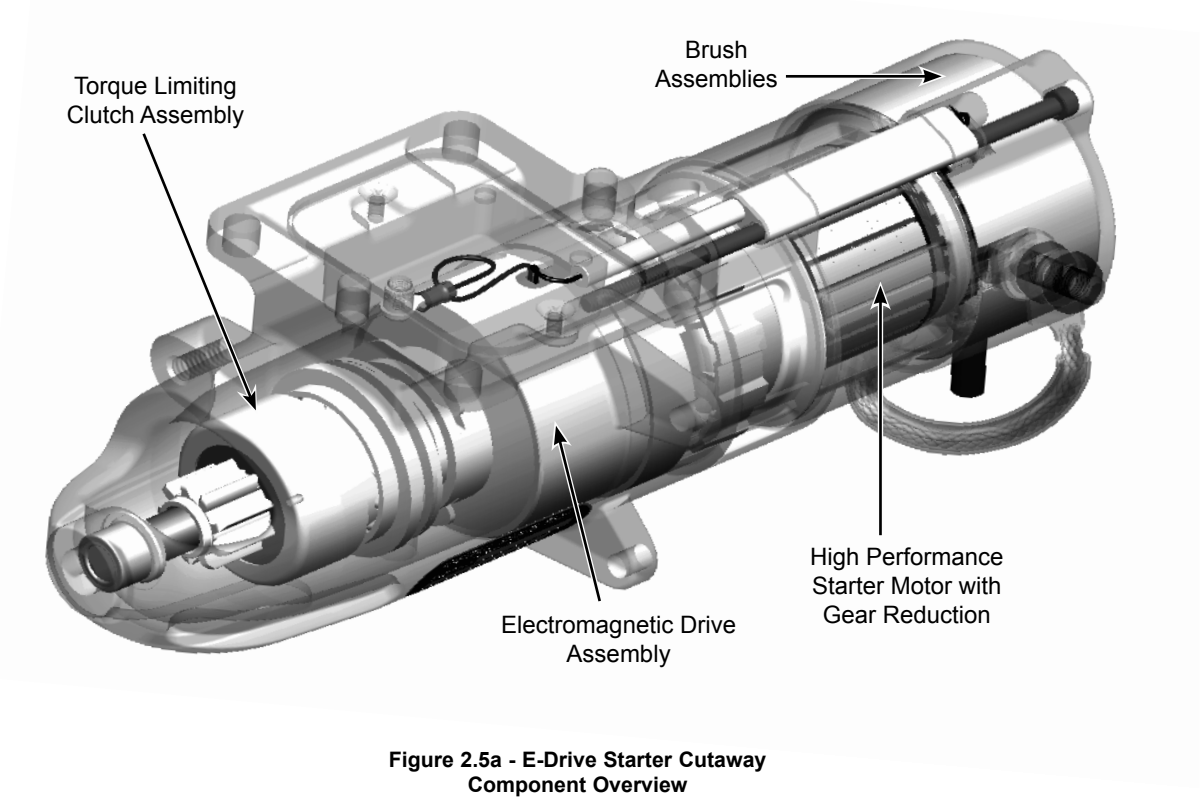

Figure 2.5a - E-Drive Starter Cutaway
Component Overview

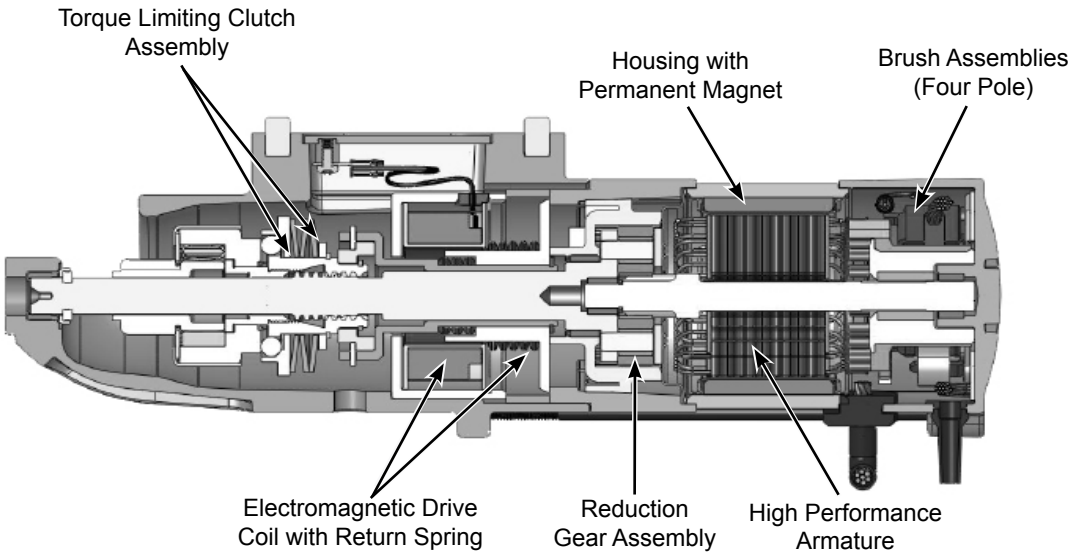

Figure 2.5b - E-Drive Starter Cutaway
Component Detail

2.6 APPEARANCE

D. Features - X-DRIVE Series (Cutaway)

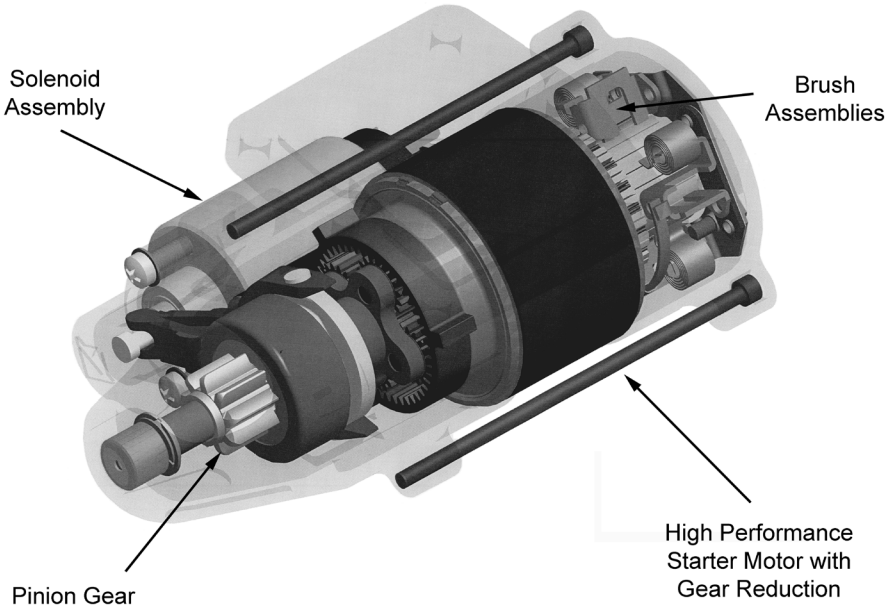

Figure 2.6a - X-Drive Starter
Cutaway
Component Overview

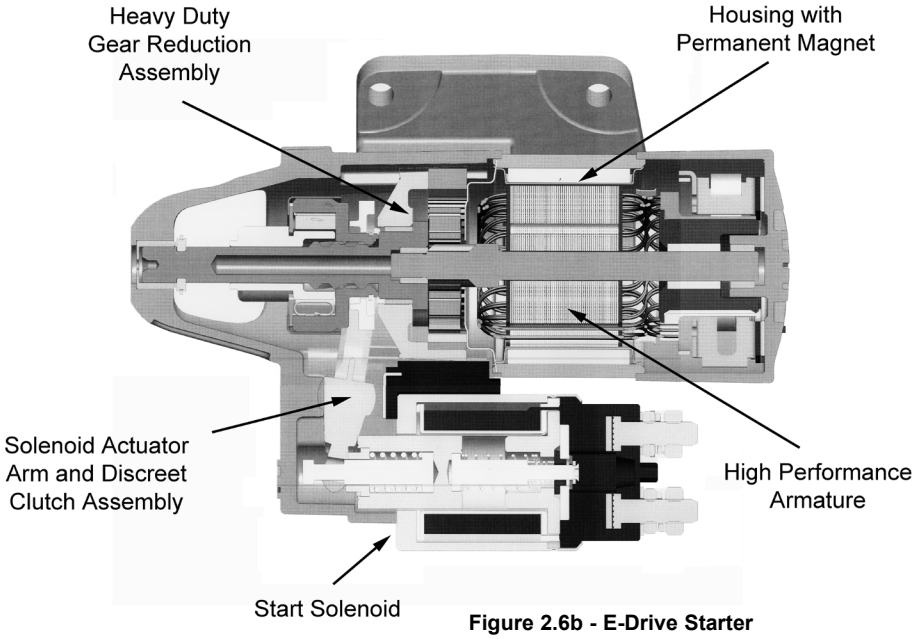

Figure 2.6b - E-Drive Starter
Cutaway
Component Detail

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TROUBLESHOOTING

3.0 General

A. In the event that a start is not achieved either by slow cranking or no reaction to engaging the start switch, it should not be assumed a starter fault exists prior to employing proper troubleshooting procedures. The overall objective of troubleshooting is to find the root cause of trouble and take corrective action to prevent a recurrence. Even a healthy starter will perform poorly when installed on an aircraft engine with a poorly maintained electrical starting system.

B. This section provides general troubleshooting procedures for the starter assembly for unscheduled maintenance and for possible fault detection prior to maintenance activity. It gives procedures to follow to determine the best course of action. Block type troubleshooting charts are also provided. Upon determination of fault(s), refer to TESTING (section 5) for applicable test procedure(s).

3.1 Procedure

WARNING:

WHEN SERVICING OR REPAIRING THE STARTER, CAUTION MUST BE TAKEN TO AVOID HAZARDOUS SITUATIONS. WHEN MOUNTED AND USED ON AN AIRCRAFT, THE STARTER WILL PRESENT A PHYSICAL HAZARD FROM PROPELLERS, ROTORS AND OTHER ROTATING DEVICES. WHEN TESTED OFF THE AIRCRAFT, THE STARTER PRODUCES A HIGH TORQUE AND USES HIGH ELECTRICAL CURRENT WHICH PRESENTS BOTH PHYSICAL AND ELECTRICAL SHOCK HAZARDS, THAT CAN RESULT IN SERIOUS INJURY IF PROCEDURES IN THIS MANUAL OR IN THE AIRCRAFT/ENGINE SERVICE MANUALS ARE NOT FOLLOWED.

Note:

It is required to reference the aircraft or rotorcraft AFM or POH as well as the applicable service or maintenance manual as required.

A. The block charts represent main areas of potential trouble in the starter. The charts cover standard troubleshooting for E-DRIVE and X-DRIVE starters.

Refer to Table 3.6 for troubleshooting possible causes found in Table 3.1 thru 3.5.

E-DRIVE and X-DRIVE Troubleshooting Tables:

Table 3.1	No response or intermittent starter operation
Table 3.2	Noisy operation (acoustic)
Table 3.3	Slow starter operation
Table 3.4	Starter engages with no propeller movement
Table 3.5	Odor during or after start

E-DRIVE and X-DRIVE Troubleshooting Figures:

Figure 3.1	Starter electric system troubleshooting

3.2 Troubleshooting Charts

A. No response or intermittent starter operation

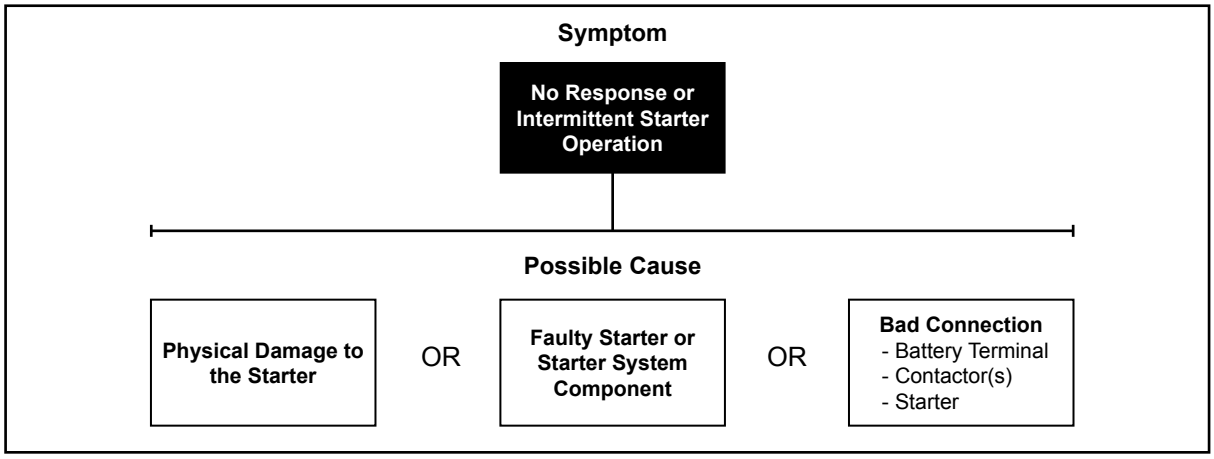

Table 3.1

B. Noisy operation (acoustic)

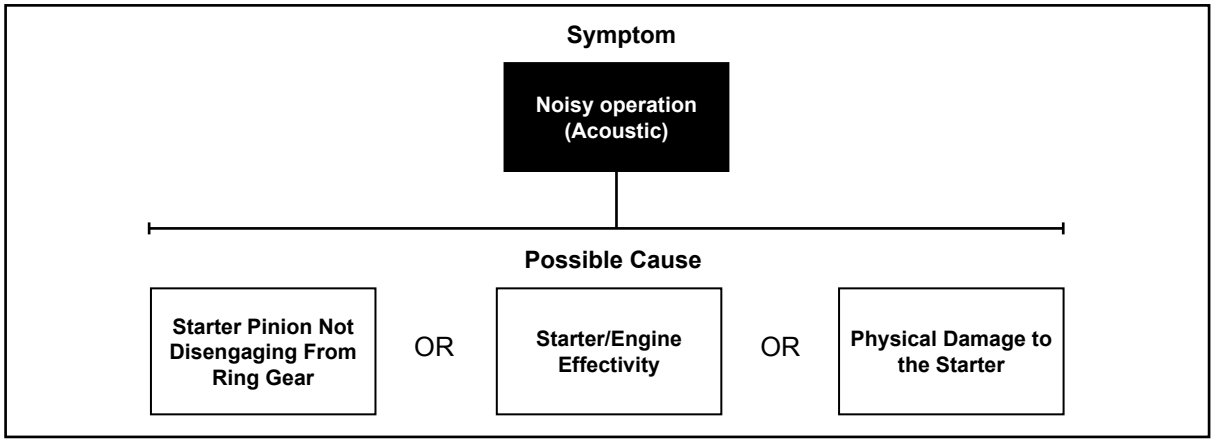

Table 3.2

C. Slow starter operation

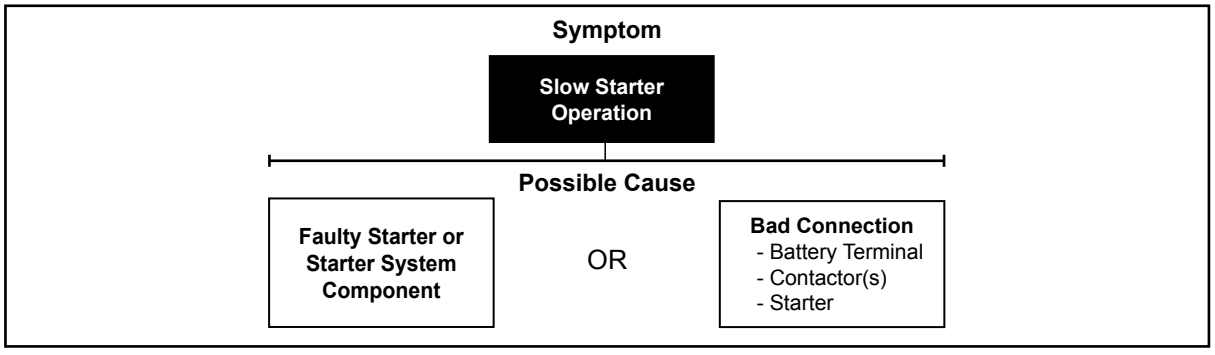

Table 3.3

3.2 Troubleshooting Charts (cont'd)

D. Starter engages with no propeller movement

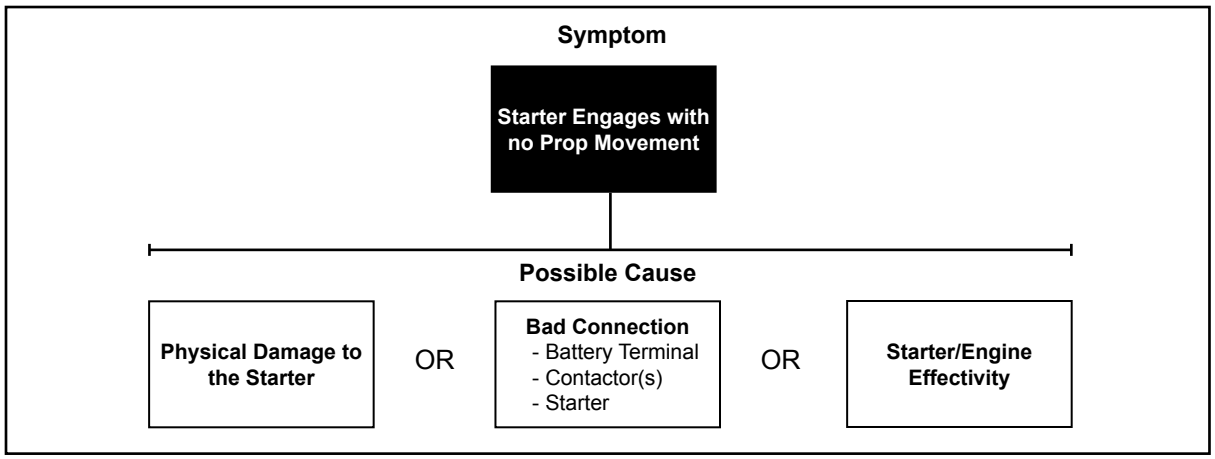

Table 3.4

E. Odor during or after start

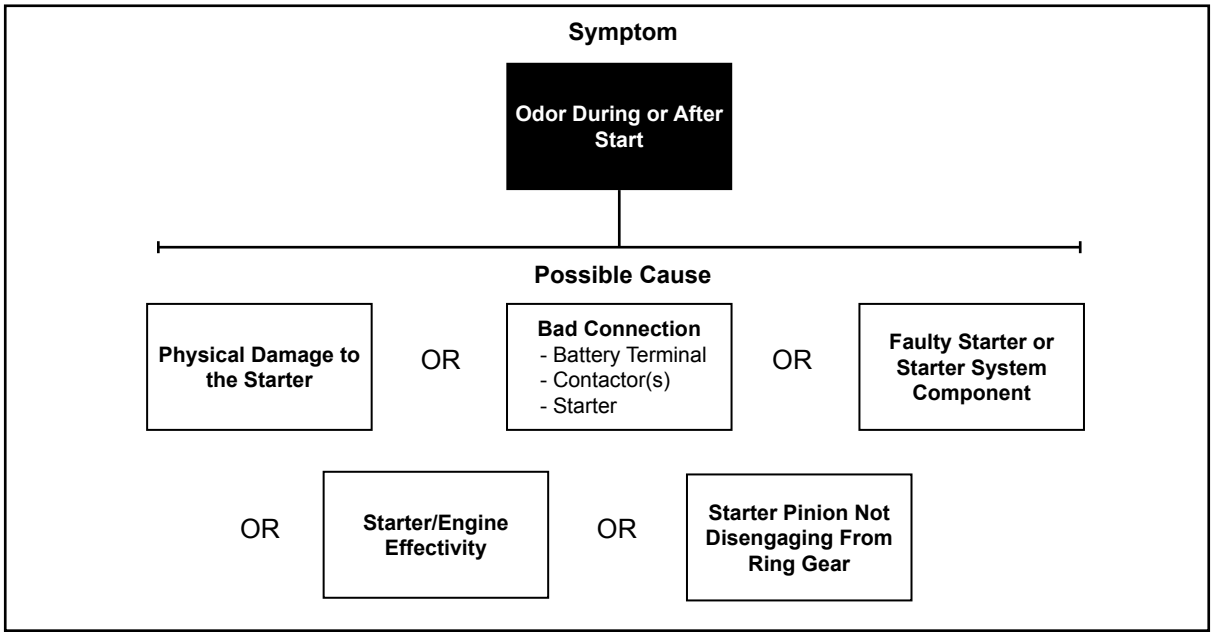

Table 3.5

3.2 Troubleshooting Charts (cont'd)

E. Troubleshooting Steps to Possible Causes (see Tables 3.1 thru 3.5)

Possible Cause	Troubleshooting Steps
Physical Damage to the Starter	Perform a visual inspection of the starter. If physical damage is discovered, replace the starter.
Starter/Engine Effectivity	Ensure the starter is compatible with the engine model-number that is installed.
Starter Pinion Not Disengaging From Ring Gear	Inspect starter pinion after engine shutdown to ensure it has retracted from the ring gear. If not retracted from the ring gear, ensure the correct starter for the ring gear is installed. **NOTE:** E & X starter models are available that support either 122 or 149 tooth ring gears. Ensure the correct model starter is installed as it relates to installed ring gear tooth count.
Bad Connection	Check terminals at the battery, contactors, and starter. Ensure terminal nuts and wire connections are secure. Inspect aircraft wiring for breaks and frays.
Faulty Starter or Starter System Component **Refer to Figure 3.1**	Record voltage at the battery with engine crank switch engaged **(step 1, figure 3.1)**. A shorted starter will pull a significant amount of power from the battery. If test voltage drops below 11V / 22V, the cause of the power drain may be the battery or a shorted starter.
	Record voltage at the starter with the engine crank switch engaged **(step 2, Figure 3.1)**. The starter needs 10V / 20V to operate properly. If the test voltage is below 10V / 20V, replace the starter. If test voltage is equal to or above 10V / 20V, record the voltages between each cable terminal and across contactors with the engine crank switch engaged **(step 3, Figure 3.1)**. Correct any deficiency noted.
	Test resistance between the battery and ground and starter and ground **(step 4, Figure 3.1)**. If resistance is greater than 0.2 Ohm, clean or repair ground connections. If resistance reads less then 0.2 Ohm, replace the starter or contact Sky-Tec Product Support.

Table 3.6

3.3 Starter Electric System Troubleshooting

A. Refer to Table 3.6

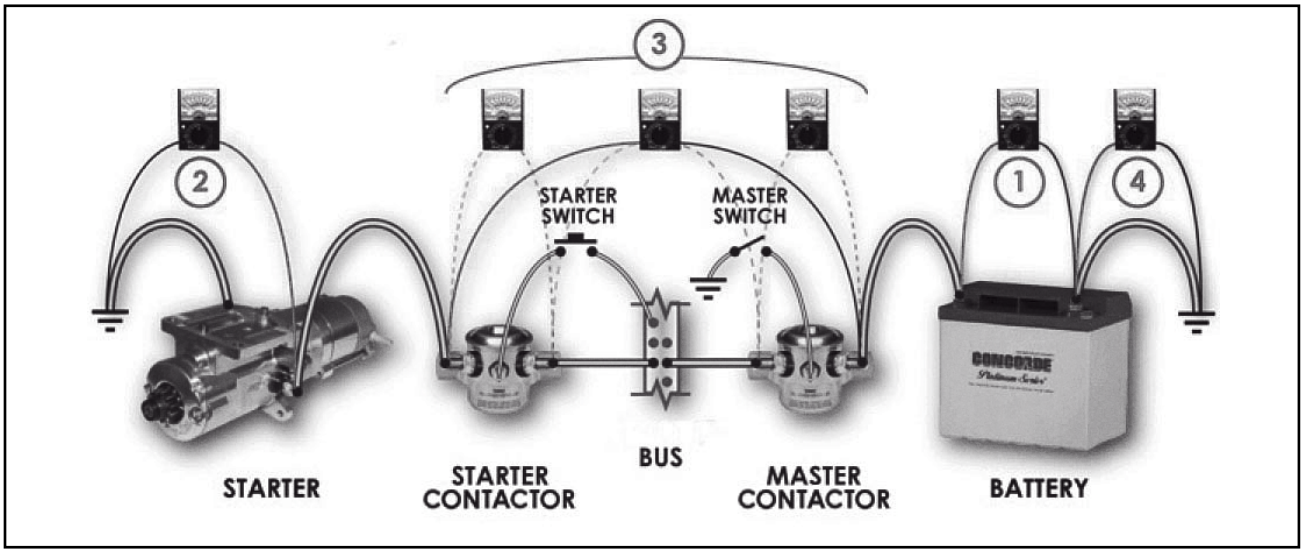

Figure 3.1

CHECK

4.0 General

A. This section calls out the various checks and inspections needed to assure reliable and safe operation of the E-DRIVE and X-DRIVE series starters in service. The checks are listed in hours time in service (TIS) or in calendar time whichever is applicable. Refer to Chapter 6, Maintenance, in this manual as required by the specific check.

4.1 Inspection Checks (E-DRIVE)

(*Use the engine or aircraft manufacturers service manual as required.)*

A. 10 Hours TIS. (One time)

(1) Perform an initial check of the starter assembly. Check if through-bolt torque seal is broken. If torque seal is broken, do not re-torque the bolts, replace the starter.

(2) Check starter assembly mounted on the engine for security. Re-torque the attach bolts per the per the engine/aircraft maintenance or service manual.

(3) Check for signs of overheating or electrical arcing, if noted, determine cause. (Refer to Chapter 3 "Troubleshooting")

(4) Make sure the starter assembly is clear of interference with airframe structure.

(5) Check all terminal hardware for tightness and insulators for condition. Hold bottom nut and re-torque top terminal nut. (Ref. Table 6.1)

B. 50 Hours TIS and each 50 hours thereafter. (or at any engine oil change)

(1) Examine general condition of the starter, replace if required.

(2) Perform operational check of the starter assembly.

C. 100 Hours TIS and each 100 hours thereafter. (or each annual inspection)

(1) Check if through-bolt torque seal is broken. If torque seal is broken, do not re-torque the bolts, replace the starter.

(2) Check for corrosion at power terminal. If present clean and coat terminal with Dow Corning® DC-4 or equivalent.

(3) Check all terminal hardware for tightness and insulators for condition. Hold bottom nut and re-torque top terminal nut. (Ref. Table 6.1)

D. 500 Hours TIS and each 500 hours thereafter*. (or each four years, the first to occur)

(1) Remove starter from aircraft and examine general condition of the starter.

(2) Inspect the housings for cracks or damage at the pinion gear opening, accessory boss, and at the flange mount. If present, replace the starter**.**

(3) Inspect power terminal stud and insulator for cracks, arc marks or burns.

(4) Inspect flexible vent tube on comm end for obstruction, clean as required.

E. 2000 Hours TIS (or any time the engine reaches engine manufacturers TBO)

(1) Recommend replacement of starter assembly. *(The OEM TBO shall supersede this TBO if otherwise stated in the engine/airframe service manual.)*

4.2 Inspection Checks (X-DRIVE)

(*Use the engine or aircraft manufacturers service manual as required.)*

A. 10 Hours TIS. (one time)

(1) Perform an initial check of the starter assembly. Check if through bolt torque seal is broken. If torque seal is broken, do not re-torque through-bolts, replace the starter.

(2) Check solenoid for looseness. Re-torque the screws if found loose. (Ref. Table 6.1)

(3) Check starter assembly mounted on the engine for security. Re-torque the attach bolts per the per the engine/aircraft maintenance or service manual.

(4) Check for signs of overheating or electrical arcing, if noted, determine cause. (Refer to Chapter 3 "Troubleshooting")

(5) Make sure the starter assembly is clear of interference with airframe structure.

(6) Check all terminal hardware for tightness and insulators for condition. Hold bottom nut and re-torque top terminal nuts. (Ref. Table 6.1)

B. 50 Hours TIS and each 50 hours thereafter. (or at any engine oil change)

(1) Clean pinion gear and exposed drive shaft at pinion gear with mineral spirits or isopropyl alcohol.

(2) Lubricate exposed drive shaft at pinion gear with dry spray silicon.

(3) Examine general condition of the starter, replace if required.

(4) Perform operational check of the starter assembly.

C. 100 Hours TIS and each 100 hours thereafter. (or each annual inspection)

(1) Check if through bolt torque seal is broken. If torque seal is broken, do not re-torque through-bolts, replace the starter.

(2) Check for corrosion at power terminal. If corrosion is present, clean and coat terminal with Dow Corning® DC-4 or equivalent.

(3) Check solenoid for looseness. Re-torque the screws if found loose. (Ref. Table 6.1)

(4) Check all terminal hardware for tightness and insulators for condition. Hold bottom nut and re-torque top terminal nut. (Ref. Table 6.1)

D. 500 Hours TIS and each 500 hours thereafter. (or each four years, the first to occur)

(1) Remove starter from aircraft and examine general condition of the starter.

(2) Inspect the housings for cracks or damage at the solenoid mounting arm, pinion gear opening, accessory boss, and at the flange mount. If present, replace the starter**.**

(3) Inspect power terminal stud and insulator for cracks, arc marks or burns.

(4) Inspect flexible vent tube on comm end for obstruction, clean as required.

E. 2000 Hours TIS (or any time the engine reaches engine manufacturers TBO)

(1) Recommend replacement of starter assembly. *(The OEM TBO shall supersede this TBO if otherwise stated in the engine/airframe service manual.)*

INSPECTION AND TESTING

5.0 General

A. This chapter gives the tests and inspections required to help determine the condition of the E-DRIVE and X-DRIVE series starter removed for maintenance. Refer to the procedures given in section 3, TROUBLESHOOTING before applying tests in this section.

B. Where applicable, Sky-Tec components called out this section will correspond to the item(s) listed in section 6, MAINTENANCE.

5.1 Testing

A. Equipment

(1) Standard tools

- Standard mechanic's hand tools.
- Arbor Press
- Torque wrench pound/inch (newton/centimeter)
- Torque wrench pound/foot (newton/meter)
- Safety gloves
- Protective goggles (eye protection).
- Ear Plugs (hearing protection)
- Safety shoes
- Protective cotton apron
- Air compressor (shop air)

(2) Special tools

Special tools used in this chapter are limited. Additional special tools are identified by part number and/or description as listed in SPECIAL TOOLS, EQUIPMENT, AND FIXTURES contained in the applicable starter overhaul manual.

- Starter test bench (12/24 volt, 0 - 220 Amp) (may be assembled per Fig. 5-2)
- Common Armature Growler

(3) Instruments

- A multimeter, (Simpson 260 or Triplett 630) or equivalent (accuracy 1%).
- A Baker ST106A surge/hi-pot tester (or equivalent).
- An Oscilloscope x100, x1000 range. (optional).
- Starter test meter, Amtest Model 648 (or equivalent).
- Optical tachometer.

B. Test conditions

(1) Ambient temperature: 70 to 80 ^{o} F (21 to 27 ^{o} C).

5.1 Testing (cont'd)

C. Precautions (All starters)

(1) Regular maintenance must be accomplished per this manual and per the applicable aircraft and/or engine service manuals and publications. In addition, observe the following precautions:

a. DISCONNECT THE BATTERY before connecting or disconnecting test instruments (except voltmeter), or before removing or replacing any unit. Accidental grounding or shorting of power from the battery may cause severe damage to the unit, airframe, and/or wiring.

b. If the starter is tested on an aircraft/rotorcraft to observe starter performance, make sure that the area in and around the aircraft/rotorcraft is secure and all staff and personnel are warned that testing is in progress. **Contact with propeller or rotor blades may cause injury or death.**

c. If the starter is being tested on the bench without a starter test machine, be sure that the starter is retained and secure before power is applied. High torque can cause the starter to move with force. Starter testing uses high current while testing the motor, make sure that the power connection is secure and insulated and do not touch during operation. **Keep fingers away from the drive end.**

5.2 Testing & Inspection Prior to Removal

A. E-DRIVE and X-DRIVE Starter Testing & Inspection

(1) The E-DRIVE or X-DRIVE starter should be operated for a few seconds (not to exceed 6 seconds) with the magneto switch off to make sure that the pinion engages properly and that it turns freely without binding or excessive noise.

(2) The power wire connection and terminal stud should be checked for security and signs of arcing or burnt wire insulation.

(3) The solenoid jumper wire and connections should be checked for security and signs of arcing or burnt wire insulation. (**X-DRIVE** starter only.)

(4) The engine should be started two or three times to see that the pinion disengages properly when the engine is turned off.

B. **E-DRIVE and X-DRIVE** Starter Inspection for Arcing

(1) Inspect and record the condition of the starter as installed on the engine for troubleshooting purposes.

(2) Before removing the starter, the threads of each terminal stud should be inspected for signs of arcing.

(3) Arc marks are usually caused by a loose wire terminal connection resulting from failure to tighten the attaching nut.

(4) Arc marks can also be caused by improper service techniques that permit wires to be connected and disconnected while current is flowing. Failure to disconnect battery NEG terminal prior to removing the starter power wire.

(5) If there is only carbon, it may be cleaned off. However, if examination of the stud shows damage, the starter should be replaced. If damaged, replace starter hardware, power terminal, and wiring as required.

5.2 Testing & Inspection Prior to Removal (Cont'd)

C. Removing E-DRIVE and X-DRIVE starter.

(1) Remove oil and dirt from the housing, insulators, and pinion area.

(2) Refer to the applicable aircraft/engine maintenance manual or service instruction and to section 6, MAINTENANCE of this manual for removing the applicable starter from the engine/aircraft.

5.3 Pinion Gear Inspection

A. With E-DRIVE or X-DRIVE starter removed: Refer to Figure 5.1.

(1) Refer to the applicable aircraft/engine maintenance manual or service instruction and to section 6, MAINTENANCE of this manual for removing the applicable starter from the engine/aircraft.

(2) Inspect the pinion gear appearing in the opening of the front starter housing.

(3) It is not necessary to extend the pinion gear to inspect. Rotate the pinion gear using your finger or thumb and inspect the teeth and valley with a 3x or 5x magnifying glass.

(4) The following are cause to replace the starter:

a. The valley of the pinion gear may have no cracks or splitting.

b. The pinion gear cannot have broken or chipped teeth.

c. The pinion gear should not have teeth worn sharp or uneven.

(5) Should any condition in 5.3.A.(4) be observed, inspect the aircraft engine starter ring gear for damage prior to replacing the starter. Use the applicable inspection information from the aircraft/engine maintenance manual or service instructions and replace aircraft engine starter ring gear if required.

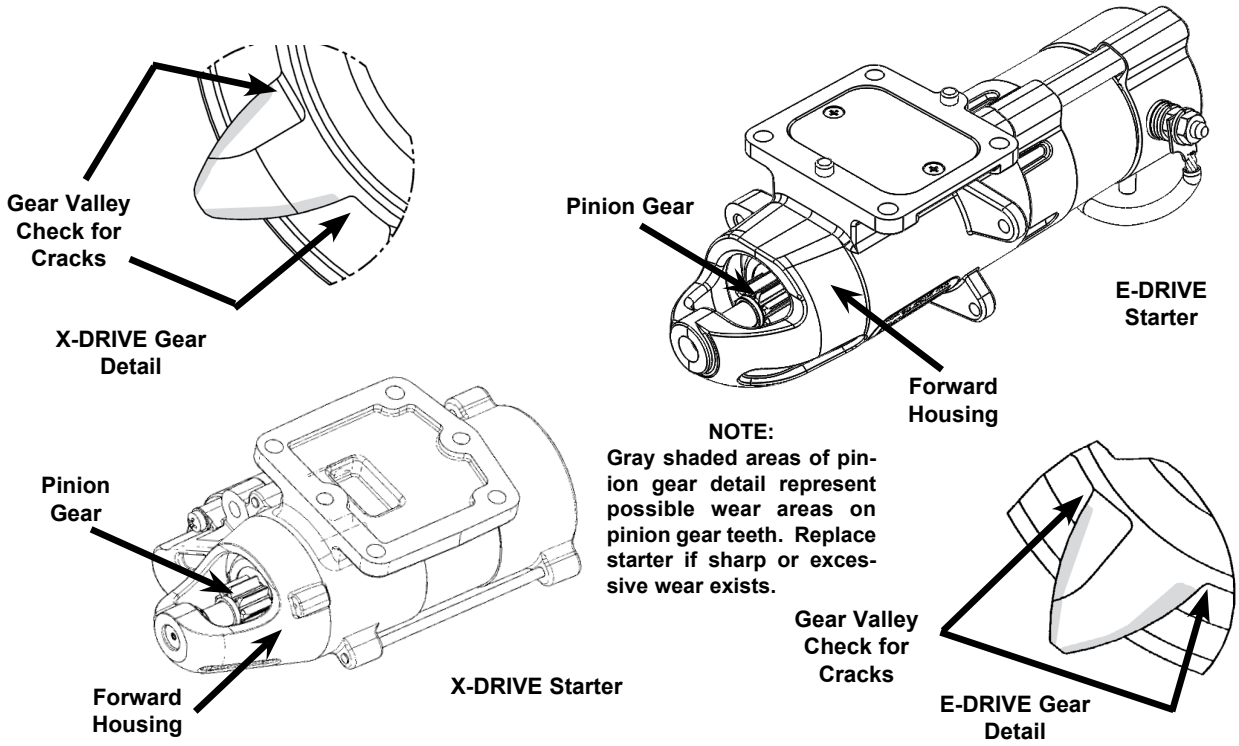

Figure 5.1 - Pinion Gear Inspection

5.4 Starter Bench Testing
(E-DRIVE)

NOTE:
The test bench physical hook-up is the same for both the E-DRIVE and X-DRIVE starters except for the connection of the power wire. However the test number between the two starters are different.

A. Connect the starter as illustrated in the Figure 5-2, "Bench Test Diagram".

(1) Use locally procured components to assemble the test rig.

(2) Use "16" gauge copper wire for power connections.

(3) The test battery, voltage should match the starter voltage. (12v or 24v)

NOTE:
Some carbon pile resistors designed for battery testing have built in voltmeters and ammeters. The built in ammeter can be used in place of the external shunt and ammeter. However, the built in voltmeter will not work for this application so an external voltmeter must be connected as illustrated.

B. Adjust the carbon pile for maximum impedance (no load, full off position).

(1) Most carbon pile resistors are operated with a hand wheel that applies tension to the carbon plates.

(2) Normally, turning the hand wheel fully counterclockwise releases tension and places the carbon pile resistor in the maximum impedance state.

C. Operate the "Momentary Push Button" and slowly adjust the carbon pile resistor while observing the voltmeter.

(1) When the voltmeter reads 22 ± 1 volt (24 volt) or 11± 1 (12 volt), the carbon pile resistor is properly adjusted for testing.

(2) This setting should be accomplished within l0 seconds. If the proper adjustment is not achieved in 10 seconds, stop and allow the starter and carbon pile resistor to cool before attempting another adjustment.

5.4 Starter Bench Testing (Cont'd)

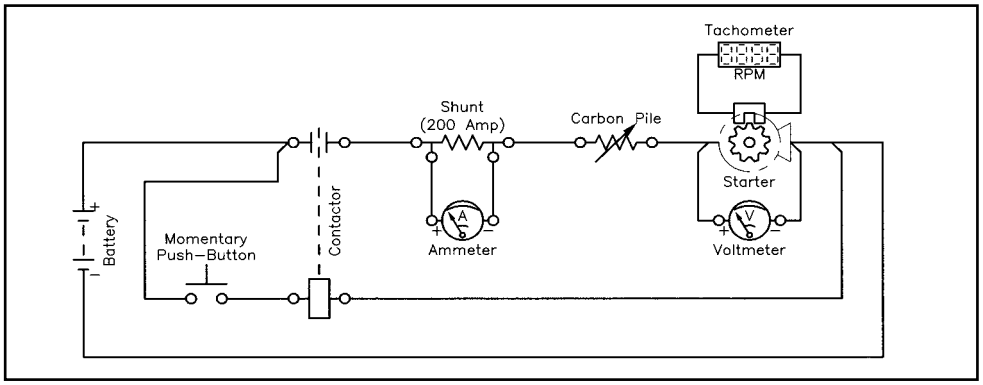

Figure 5.2 - Bench Test Diagram

5.4 Starter Bench Testing (Cont'd)
(E-DRIVE)

D. Once the carbon pile is properly adjusted and allowed to cool, depress the momentary push button while observing the ammeter.

(1) Do not hold the push button for more than 6 seconds.

(2) For 24 volt, the in rush current will cause the ammeter to rapidly move up scale to more than 100 amp and rapidly drop to a value between 40 amp and 80 amp for one second duration before dropping to a value between 20 amp and 30 amp.

(3) For the 12 volt starter, the current will cause the ammeter to rapidly move up scale to more than 150 amp and rapidly drop to a value between 60 amp and 100 amp for one second duration before dropping to a value between 30 amp and 50 amp.

E. Usually, a changing audible tone is heard that corresponds to the decrease in current at about one second after depressing the push button.

(1) For 24 volt, after two seconds, current should fall to 20 amp to 30 amp and remain at that level for the remainder of the test.

(2) For the 12 volt starter, after two seconds, current should fall to 30 amp to 50 amp and remain at that level for the remainder of the test.

F. Once the pinion accelerates to a steady speed, it should be turning 2700 ±300 rpm. Great care must be taken with speed measurements, as the pinion gear extends and rotates with considerable force.

G. The greatest current and speed changes are observed after the in rush event when the carbon pile resistor is set for lower voltage readings at the starter.

(1) Setting the voltage lower than specified in the carbon pile resistor adjustment procedure may result in the starter not operating properly.

(2) Setting the voltage higher than recommended may result in catastrophic failure of the armature due to excessive

5.5 Starter Bench Testing

(X-DRIVE)

NOTE:
The test bench physical hook-up is the same for both the X-DRIVE and E-DRIVE starters except for the connection of the power wire. However the test number between the two starters are different.

A. Connect the starter as illustrated in the Figure 5-2, "Bench Test Diagram".

(1) Use locally procured components to assemble the test rig.

(2) Use "16" gauge copper wire for power connections.

(3) The test battery, voltage should match the starter voltage. (12v or 24v)

5.5 Starter Bench Testing (Cont'd)

(X-DRIVE)

NOTE:

Some carbon pile resistors designed for battery testing have built in voltmeters and ammeters. The built in ammeter can be used in place of the external shunt and ammeter. However, the built in voltmeter will not work for this application so an external voltmeter must be connected as illustrated.

B. Adjust the carbon pile for maximum impedance (no load, full off position).

(1) Most carbon pile resistors are operated with a hand wheel that applies tension to the carbon plates.

(2) Normally, turning the hand wheel fully counterclockwise releases tension and places the carbon pile resistor in the maximum impedance state.

C. Operate the "Momentary Push Button" and slowly adjust the carbon pile resistor while observing the voltmeter.

(1) When the voltmeter reads 22 ± 1 volt (24 volt) or 11± 1 (12 volt), the carbon pile resistor is properly adjusted for testing.

(2) This setting should be accomplished within 10 seconds. If the proper adjustment is not achieved in 10 seconds, stop and allow the starter and carbon pile resistor to cool before attempting another adjustment.

D. Once the carbon pile is properly adjusted and allowed to cool, depress the momentary push button while observing the ammeter.

(1) Do not hold the push button for more than 6 seconds.

(2) For 24 volt starters, the steady current draw should be between 50 and 60 amps.

(3) For the 12 volt starter, the steady current draw should be between 60 and 80 amps.

MAINTENANCE

6.0 General

A. This section contains information regarding recommended maintenance for the E-DRIVE and X-DRIVE series starters in this manual. These recommendations assure reliable and safe operation of the starter while in service. Maintenance is listed in hours time in service (TIS) or calendar time, whichever is applicable, but each are the first to occur. Some maintenance is one time initial and others are recurring. Refer to Chapter 4, CHECKS for required inspections.

B. HET recommended maintenance: Checks and TIS may be superseded by the aircraft or engine manufacturers established time limits and schedules based on experience and/or unique requirements under its Type Certificate or other certifications.

6.1 Periodic Maintenance

NOTE: The aircraft and/or engine manufacturer's periodic or event checks are contained in the respective maintenance manual or service information.

A. The starter system should be inspected at regular intervals, the frequency of which should be determined by the type of service and the conditions the aircraft is operated. Since many airframe related maintenance tasks directly or indirectly affect starter function, it is recommended that the aircraft manufacturers periodic inspection/maintenance be followed prior to or in conjunction with any Sky-Tec prescribed starter maintenance. These include:

(1) **Battery** - A battery condition and capacitance check.

(2) **Wiring** - A starter circuit wiring and terminal condition check.

(3) **Lubrication** - Lubrication is recommended on the exposed pinion shaft of the starter using dry silicon lubricant at 50 hours TIS and at each oil change.

(4) **Operation** - Perform an operational check of the starter after maintenance is performed on the aircraft or engine electrical systems. Use the appropriate AFM, POH, service information or maintenance manual as applicable.

6.2 Torque Information

CAUTION: APPLYING TORQUE BEYOND THE VALUES SET IN TABLE 6.1 WILL SEVERELY DAMAGE THE STARTER. EXCEEDING THESE VALUES MAY REQUIRE REPLACEMENT OF THE STARTER.

Table 6.1 - Torque Specifications

Description	Torque Value (US)	Torque Value (SI)
Nut, Power* top (E-Drive)	75-80 in-lbs	8.47-9.04 Nm
Nuts, Solenoid* top (X-Drive)	75-80 in-lbs	8.47-9.04 Nm
Screws, Solenoid (X-Drive)	40-45 in-lbs	4.52-6.48 Nm
Bolt, Flange** (5/16)	204 in-lbs	23.05 Nm
Nut, Flange** (5/16)	204 in-lbs	23.05 Nm

* Torque top nut while holding bottom nut or damage to starter will occur. Attachment of battery power wire from the engine or airframe may use HET torque unless value differs from engine/airframe OEM torque. OEM torque shall supersede Sky-Tec value.

** Attachment of flange bolts or nuts on the engine or airframe may use Sky-Tec torque unless value differs from engine/airframe OEM torque. OEM torque shall supersede Sky-Tec value.

6.3 Through Bolts

A. The starter through bolts are designed to retain proper torque for the life of the starter and require no maintenance.

B. Inspect through bolt while installed. The through bolt must not be damaged, cracked, or bent.

C. If any through bolt is bent, cracked, damaged or housings are loose, the starter should be replaced. (Damaged through bolts may indicate serious internal damage in the starter.)

D. If the through-bolt(s) are found loose, do not re-torque through-bolts, replace the starter.

6.4 Brush Maintenance

A. The starter brushes are designed to last for the life of the starter and require no maintenance.

6.5 Removal from the Aircraft

A. To remove the starter from a specific engine, refer to the aircraft and/or engine service instructions or maintenance manuals for detailed information.

B. General starter removal:

(1) Make sure all external power has been disconnected.

(2) Unless otherwise advised, gain access and disconnect the ground (-) cable from the battery post. Isolate and secure the ground (-) terminal.

(3) Disconnect the cable from the starter power terminal stud and isolate the terminal.

(4) Remove the starter from the engine by removing the 5/16 inch hardware (4 places). (OEM applications may use bolts or nuts with some using both.)

(5) Remove the starter from the aircraft engine.

6.6 Materials

A. This section presents the current materials available for maintenance. All items presented herein are available through a Sky-Tec authorized distributor and are the only parts available. Some parts such as the starter attachment hardware are available from aircraft/engine (OEM).

B. Hardware

(1) As required, Nut, Input terminal, HET P/N 8X-1376. (E-DRIVE)

(2) As required, Lockwasher, Input terminal, HET P/N 50028. (E-DRIVE)

(3) As required, Nut, Solenoid Input terminal, HET P/N 20739. (X-DRIVE)

(4) As required, Lockwasher, Solenoid, Input terminal, HET P/N 20740. (X-DRIVE)

6.7 Installation on the Aircraft

A. To install the starter on the engine, refer to the applicable engine and/or aircraft service and maintenance manuals. Always follow the OEM instructions.

B. **General Installation**

(1) Make sure the aircraft battery and any external power has been disconnected.

(2) Position the starter on the crankcase flange and check to make sure there is no interference with the pinion housing and ring gear.

(3) Install the retaining hardware through the starter flange and brackets as required. Torque the crankcase bolts to 204 in-lbs (23.05 Nm) unless stated different in the appropriate engine or aircraft maintenance manuals. OEM torque shall supersede HET value.

(4) Connect the power wire and torque nut in accordance with Table 6.1.

(5) For starters with accessory boss fittings, reconnect items as removed in accordance with the appropriate engine or aircraft maintenance manuals.

(6) Unless otherwise advised by the OEM, connect the positive battery cable to the positive (POS) battery terminal, then connect the aircraft ground cable to the negative (NEG) battery terminal.

(7) Check the starter for security and make a running performance test per the AFM or POH and the engine/aircraft service and maintenance manuals.

6.8 Special Conditions:

NOTE: For engine OEM's Special Condition "Sudden Stoppage", refer to the latest revision of Lycoming Engines, Inc. SB 533B or Continental Motors, Inc. SB96-11B.

A. SUDDEN ENGINE STOPPAGE:

(1) If the engine has experienced "sudden stoppage" as defined by the engine manufacturer, the starter may be impacted critically by this event. For the starter, "sudden stoppage" generally applies to damage occurring during the start cycle. However, even if the starter was not engaged, a sudden stop of the propeller and drive train may damage the starter by cracking the mounting flange, damaging the pinion housing, or damage to the power terminal stud or wire.

(2) If "sudden stoppage" as defined by the engine manufacturer has occurred, the starter must be removed and thoroughly inspected for any damage and if found, the starter should be replaced. Refer to the appropriate engine or airframe manuals to remove the starter.

B. LIGHTNING STRIKE:

NOTE: For engine OEM's Special Condition "Lightning Strike", refer to the latest revision of Lycoming Engines, Inc. SB 401 or Continental Motors, Inc. SB88-9.

(1) Lightning strike is a very unpredictable event both in occurrence and in resultant damage. A lightning bolt entry point may have many exit points or only one. The path of the electrical current cannot easily be determined in most cases because while the current may surge through well bonded areas without damage, a gap in any metal contact point will result in an arc or flash burn. This is especially true of rotating parts such as gears or shaft.

(2) On a well bonded composite aircraft, the lightning bolt will stay on the outer surface throughout the aircraft with little damage to components. However the path of the electrical current may be more difficult to determine because while the current may surge through well bonded areas without damage, a gap in any metal contact point or structure above or below the composite will result in an arc, burn, or shattered composite.

(3) If a report of a potential or actual lightning strike is made, inspect the aircraft for entry and exit points for the lightning bolt. The purpose is to assure that there was indeed a strike. The points of entry or exit are generally on the aircraft extremities such as the wing tip, propeller tips, spinner tip or the tips of tail surfaces. Commonly, the entry point is a single burn mark and the exit several burn marks or burnt static wicks. This discussion is important because if there was a strike it may have coursed through the engine.

(4) Cowlings, especially fiberglass or other non-metallic types may not have as good a bond. Many cowlings will not be well bonded due to frequent removal. This may force the electric charge to take a route through the engine components. Lightning will arc at any gap where the path of resistance is less than the surrounding air.

(5) If a strike has occurred, remove the starter and inspect for arc marks. The most likely damage will occur within the starter or at attachments or mounting brackets. Observe the mounting flange to crankcase and accessory boss bracketry for arc marks at joints and attach points.

(6) If evidence of a strike is observed and the starter is being replaced, it is advised that the starter terminal and wire be inspected for burns or melting. If found, the entire aircraft electrical system should be inspected. Use the appropriate engine and/or aircraft manufacturer's maintenance manuals or service instructions to accomplish this task.

(7) If there is no indication of arcing or other damage and a lightning strike cannot be confirmed, reinstall the starter and check per the applicable airframe and engine manufacturers maintenance or service instructions.

(8) Upon completion, perform several test starts of the engine per the POH or AFM prior to returning the aircraft or rotorcraft to service. Make an appropriate logbook entry concerning the lightning strike.

6.9 Storage and Shelf Life:

A. STORAGE:

This section addresses the storing of new or repaired starters.

(1) Short term storage is up to but not exceeding twenty-four (24) calendar months.

(a) Short term on the shelf: requires only that the unit be kept inside in the original packaging.

(b) Short term on the aircraft (or unmounted engine): No additional action other than that required for the engine or aircraft is needed.

(2) Long term storage is storage up to but not exceeding twelve (12) calendar years.

(a) Long term on the shelf: Requires that the starter be removed from the box and from the plastic bag as originally packaged:

1 Discard the original bag.

2 Wipe or lightly spray outside with an electrically friendly preservative oil.

3 Place in a new bag that is specifically formulated for corrosion resistance in the storage of metal products. (Ref. Armor Poly VCI, Armor Protective Packaging, Howell, MI USA, www.armorvci.com or an equivalent.)

4 Place back into original shipping container and store in a cool dry environment.

(b) Long term on the aircraft (or unmounted engine): If it is anticipated that the aircraft (or unmounted engine) will be in a long term storage situation:

1 As soon as practicable, lightly spray or wipe outside surfaces with an electrically friendly preservative oil.

2 No additional action other than that required for the engine or aircraft is needed.

B. SHELF LIFE:

(1) This starter manufactured by HET has a shelf life of up to, but not to exceed, twelve (12) calendar years, regardless of storage or usage. *Shelf life time applies only if storage requirements are observed.*