

Application Notes and Service and Support Manual¹ ***TransWarp Motors***TM



WarpTM ***Motors***



ImPulseTM ***Motors***



**Application Notes and
Service and Support Manual
for
*WarpTM Motors***

To get the best results from the motor, please read this document carefully.

Before carrying out any maintenance or repair, read the SAFETY section of this publication. Motors can cause serious injury or damage if operated, dismantled or reassembled incorrectly.

Credits

Special thanks to:

Warfield Electric Company Inc.
175 Industry Avenue
Frankfort, Illinois 60423

And especially: Jerry Warfield, Jim Scrivens, Jack Wayne, Nancy Monahan, Chuck Minderman, Steve Cancialosi, Myron Boyajian, and the rest of the folks at Warfield Electric Company Inc. We would never have gotten this far without you! You guys make it happen! Professionals all!

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Safety Information

This is not an all inclusive list. Use common sense and act responsibly, electric motors are extremely powerful and could cause death, dismemberment or other serious injury if misused or not safely handled!

Use caution when operating any motor. If you're not sure what you're doing, find a knowledgeable person to advise you!

Remove all metal jewelry and metal objects from hands, wrist, fingers, etc. before working on any electric motor.

If working on an electric vehicle, make certain the vehicle is positioned securely with the drive wheels safely clear of the floor and blocked up so that the drive wheels cannot make contact with the floor under any circumstances. Block the non-drive wheels if they remain in contact with the floor so that the vehicle cannot roll in either direction.

Before troubleshooting or working on any electric vehicle, disconnect the battery and discharge all capacitors. Reconnect the battery only as needed for specific checks or tests.

Motors must only be connected to a power source by knowledgeable and experienced personnel.

Motors should NEVER be run at more than 12 Volts without a load. Running a motor without a load could result in harm to people or the motor. Absence of a load is considered misuse and could prove dangerous to anyone in the vicinity and void the motor warranty.

Portions of the motor may become **hot** and proper precautions must be taken.

Motors are heavy and are likely to become damaged if dropped, or cause damage to anything they fall upon (including people and body parts). Use extreme caution when working with motors!

Make certain the motor is disconnected from any power source before servicing.

Motors contain moving parts that could cause severe injury if the proper precautions are not taken. Never touch an operating motor.

Motors should never be operated beyond the limits established by the manufacturer.

Motors must not be modified in any manner; doing so will void the motor warranty and could prove extremely dangerous.

Wear protective or safety equipment such as safety shoes, safety glasses and gloves when working with motors.

Make sure you know where the closest functioning eye wash station is before working on or testing batteries.

Do not defeat any safety circuits or safety devices.

Under no circumstances should you push in any contactor of an electric vehicle while the drive wheels are in contact with the floor. Pushing in a contactor when the drive wheels are in contact with the floor can cause serious property damage, personal injury or death.



New Motor Warranty*

WARFIELD ELECTRIC COMPANY, INC. (Company), warrants that new motors sold by it are merchantable and free of defects in material and workmanship at the time that they are shipped from the company's factories.

The company makes no warranty with respect to the re-manufactured motors other than the warranty stated above. All implied warranties of merchantability and all express and implied warranties of any other kind are hereby excluded.

The company will repair or, at its option, replace any part of any re-manufactured motor sold by it that fails to conform to the warranty stated above, provided Warfield Electric Company, Inc. (factory) is contacted for a Repair Authorization Number (RA#) and such part is returned to the company's factory or to a factory authorized service station, transportation charges prepaid, within the warranty period specified below:

NEW MOTOR WARRANTY extends for a period of six months or 2000 hours of equipment operation, whichever first occurs, following the date of delivery of such equipment into which the motor has been installed, but warranty coverage will not exceed a period of two years from the date the motor was shipped from the company's factory. Proof of equipment installation date and equipment hour-meter reading must be provided on request.

LIMITATION OF LIABILITY

The company's liability, whether in contract or in tort or under any other legal theory, arising out of warranties, representations, instruction or warnings (or any lack or inadequacy thereof), deficiencies, failures or defects of any kind or from any cause shall be limited exclusively to repairing or replacing parts (during normal business hours) under the provisions stated above. All liability for damages, including, but not limited to, those expenses, or injury to business credit, reputation or financial standing is hereby excluded.

The warranties contained therein shall not apply to or include any of the following and the company shall have no liability with respect to:

1. Repair or replacement required as a result of: (A) accident; (B) misuse or neglect; (C) lack of reasonable and proper maintenance; (D) operation in excess of recommended capacities; (E) repairs improperly performed or replacements improperly installed; (F) use of replacement parts or accessories not conforming to Warfield Electric Company, Inc. specifications which adversely affect performance or durability; (G) alterations or modifications not recommended or approved in writing by Warfield Electric Co., Inc. and (H) wear and deterioration of motor appearance due to normal use or exposure.
2. Normal replacement of consumable service items, such as brushes and brush springs.
3. Motors in equipment whose ownership has been transferred from the first purchaser for use to another.

* No agent of Warfield Electric Company, Inc. is permitted or authorized to change, modify, or amend any term of this warranty.

General Information

NetGain Motors, Inc.'s **WarP™ Motors** are manufactured in Frankfort, Illinois, USA. We utilize NetGain's engineering and racing expertise to design motors that will perform under the unusual operational dynamics of electric vehicles.

All aspects of an electric motor have been considered - from the components to the methodology of assembly - to make a motor that would offer excellent performance in an electric vehicle.

Electric motor components are a critical aspect of an electric vehicle. The bearings, shaft sizing and material, commutator, brush rigging and brush composition, field and armature windings, armature laminations, and insulation quality are all critical aspects of an electric motor. Assembly steps critical to performance are clearances, brush “break-in”, the insulation, and overall quality of workmanship.

Many DC motors are made to meet class F temperature rating (155° C.), our **WarP™ Motors** all utilize class H insulation materials rated at 180°C. Our **WarP™ Motors** have been stress tested to 205°C. Whether using your DC motor for drag racing or for an everyday EV, temperatures should normally never approach 180°C. **WarP™ Motors** have internal fans and a temperature snap switch (normally open) as a standard item. Depending upon the motor model, this switch will close at 120°C or 150°C. in order to allow protection of the motor and all its components (assuming the proper circuitry has been implemented by the user). High volume fans not only help dissipate motor heat, but also help clear carbon dust from the motor, thus preventing a possible flash-over and would-be damage. If your motor is sealed, it is important that you periodically open the motor and use compressed air to blow out any carbon dust that may have accumulated. Compressed air should be directed at the brushes and armature and should exhaust through the fan end of the motor. If proper caution is taken, this can be accomplished with the motor spinning in order to help exhaust the carbon dust.

Motor ratings are given for the normal range of the motor's operation under various voltages and loads. Ratings with forced cooling have not been done since there are many variables that cannot be controlled to allow the data to be useful. Motors will perform closest to their initial HP output the cooler they are kept within normal operating temperatures!

Some larger DC motors have interpoles. Due to the compactness of most motors 9” or less in diameter, in these horsepower ratings, interpoles are difficult to fit inside. Our **WarP 11HV™** motor does have interpoles and is thus able to withstand higher armature voltages. By default all of our other motors are advance timed at the factory in order to handle voltages as high as 170 Volts to the armature. Though many users have exceeded this voltage, we do not condone it.

Lastly, please remember that **WarP™ Motors** offer distinctive standard features on every motor that we feel make it the best choice for an electric vehicle motor in the industry. Some of these features are:

Motor Features

- ✓ Specifically designed for street and racing EV's
- ✓ Top quality, sealed, steel bearings with high temperature grease
- ✓ Motor temperature snap switch
- ✓ Motor temperature thermistor / diode (some models, effective 2010)
- ✓ Brush Wear Indicators (some models, effective 4/2007)
- ✓ High efficiency fan
- ✓ Fully counter-sunk field pole bolts for a clean/smooth appearance and to provide reduced clearance requirements.
- ✓ Optimized brush timing
- ✓ Oversize brushes
- ✓ High quality brushes- not “quick-seat”
- ✓ Fully 90% plus brush wear-in²
- ✓ Heavy duty, vibration resistant, stainless steel brush springs
- ✓ Predrilled, advanced timing holes for higher performance
- ✓ Class “H” insulation temperature rating throughout the motor
- ✓ Best in class patented varnishing process, includes “flooding the cases to ensure no gaps!
- ✓ Voltage ranges starting at 48 Volts
- ✓ Interlocking commutator construction
- ✓ High peak motor efficiency
- ✓ Dynamically balanced armatures
- ✓ Hand made in the U.S.A. by experts

² The brush wear-in process is completed before the brushes are placed into the enclosure so that no carbon dust is allowed into the motor.

To ensure that we are on the right page when talking about the motors, we will provide some lingo, or “motor speak” terminology.

Motor Lingo

Motor Frame or Case

This is the rolled iron field ring that holds the motor field pole shoes. The holes around the field ring represent the field pole shoe bolt holes. There may be 4 sets of 3 holes each (WarP 9, WarP 11), 4 sets of 2 holes (ImPulse 9) or 8 sets of 2 holes (WarP 11HV). Additionally, there may be lift-eye holes around the field ring – usually between the field pole bolt holes. The field rings are lathe bored and the end surfaces are machined to provide mounting for the end brackets.



Illustration 1: Field Rings, Motor Frame or "Case"

Complete Motor Armature

These are completed armatures. The double bands around the armature stack allow these motors to handle higher RPM's more gracefully.

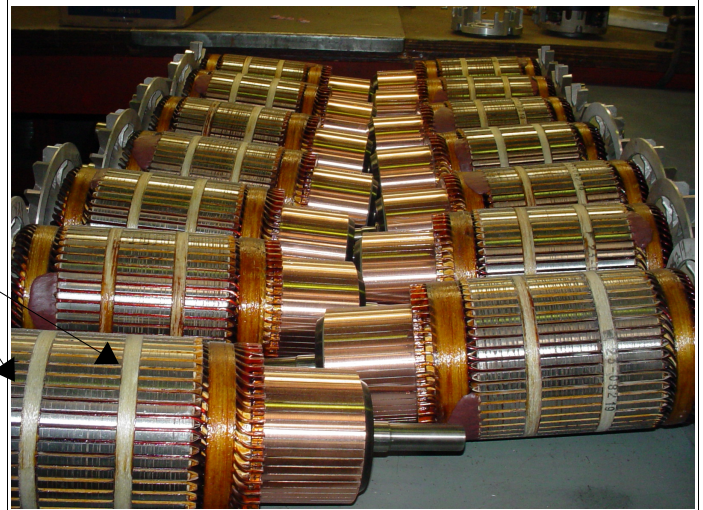


Illustration 2: Complete armatures

Brush Ring

This is the “ring” that the brush holder is attached to. The ring is then bolted to the aluminum commutator end bell



Illustration 3: Brush Rings

Motor Armature Shaft

These are armature shafts. They are machined to exacting tolerances to accommodate the application. Bearings will eventually be pressed onto both ends.



Illustration 4: Armature Shafts

Terminal Studs

These are the terminal studs, 3/8" on the left and the new style 1/2" size on the right.

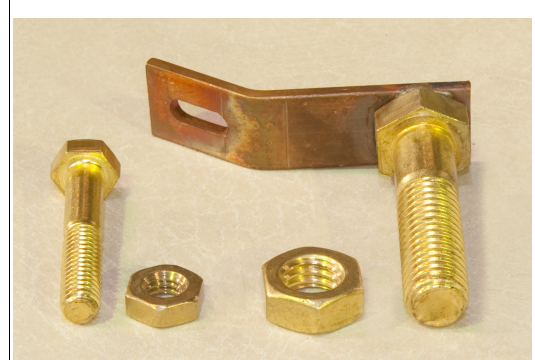


Illustration 5: Terminal Studs

Armature Stack

The armature stack consists of laminated discs made of a magnetic steel alloy pressed onto a keyed shaft. Every motor requires a specific number of discs that have been calculated to provide the desired performance curve. Discs are weighed to determine the proper amount and even a single disc discrepancy will be detected by the balancing process.

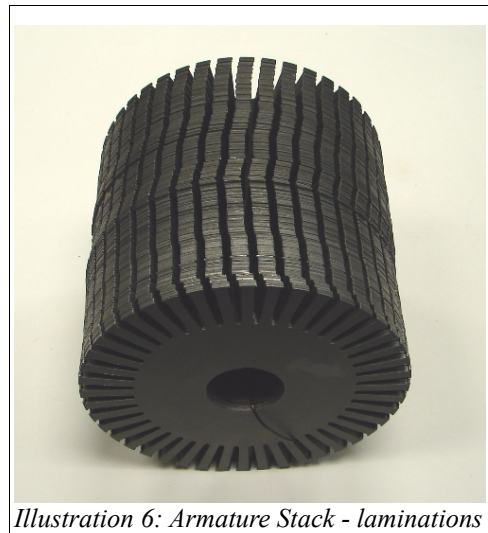


Illustration 6: Armature Stack - laminations

Armature Wire

The armature wires used in our WarP 9 Motors are .091" * .365". They start out as a long flat wire and then go through a process to bend them to the exact shapes needed for an armature. The ends have the insulation removed so they are suitable for welding.



Illustration 7: Armature Wire

Commutator End (CE) Bell

These aluminum housings are the commutator end bells. The new style with Helwig-Carbon brushes is on the top, while the lower one is representative of the earlier models. Notice the 1/2" terminal studs, 4-wires per brush pair, dual wafer, and red-top brushes. These brackets encase the armature bearings in precision machined cavities to support the armature in the magnetic field structure of the frame. The commutator end bell supports and precisely locates the brush rigging assembly and the armature shaft. The armature shaft may be used for RPM sensors, alternators, air conditioning, power steering or other appliances.

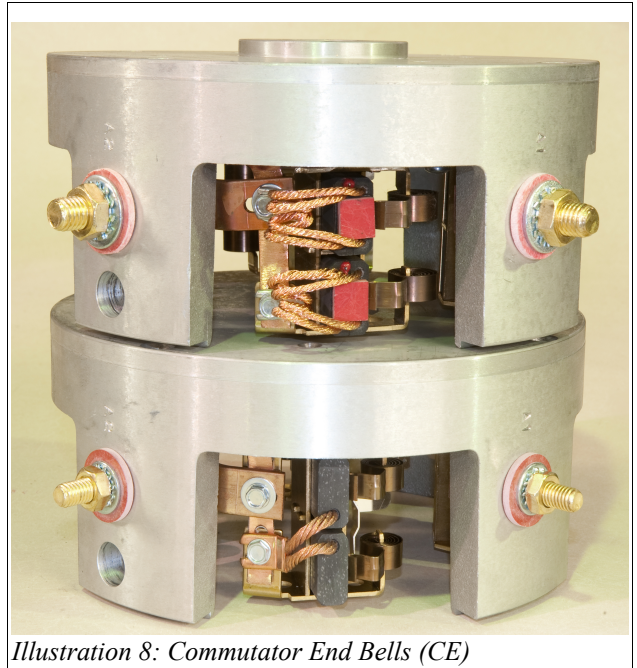


Illustration 8: Commutator End Bells (CE)

Drive End (DE) Bell (or Bracket)

Our brackets are made of aluminum to provide a lower overall weight essential in electric vehicles.



Illustration 9: Drive End Bells (DE)

Shunt Wires

These are the wires that come out of the brushes.

Brushes

The new style brushes from Helwig-Carbon with 4-wires per brush pair, dual wafer, and red-tops are on the left, while a more conventional brush is shown at right. Also notice the difference in color between the brushes which indicates a different formulation that is used in these high performance brushes.



Illustration 10: Shunt Wires and Brushes

Thermal Switch, Temperature Snap Switch/Nuisance Switch

This is a snap switch (Normally Open “NO”) and may be terminated to a plastic plug identical to the BWI (newer design), or may be 2 wires extending from the motor case (older design)



Illustration 11: Temperature Snap Switch

Connectors for Instrumentation

This is the connector that is used for connection to a BWI (Brush Wear Indicator) if the motor is so equipped. They accept 1/4” female spade connectors. If a motor is equipped with BWI this connector will be located in the aluminum end-bell. These same connectors are also used for connection of the temperature snap switch, and for the thermistor. These two connections will be in the motor frame, and the thermistor will have a “+” and “-” symbol stamped in the case to designate which is which.



Illustration 12: BWI and Temperature Snap Switch Connections

Brush Holder

Brush holders are generally made of bronze and are machined to allow the precision made brushes to slide easily up and down. A spring is used to apply pressure to the brush that holds it in contact with the commutator. In this photo a brush wear indicator connection is also shown.

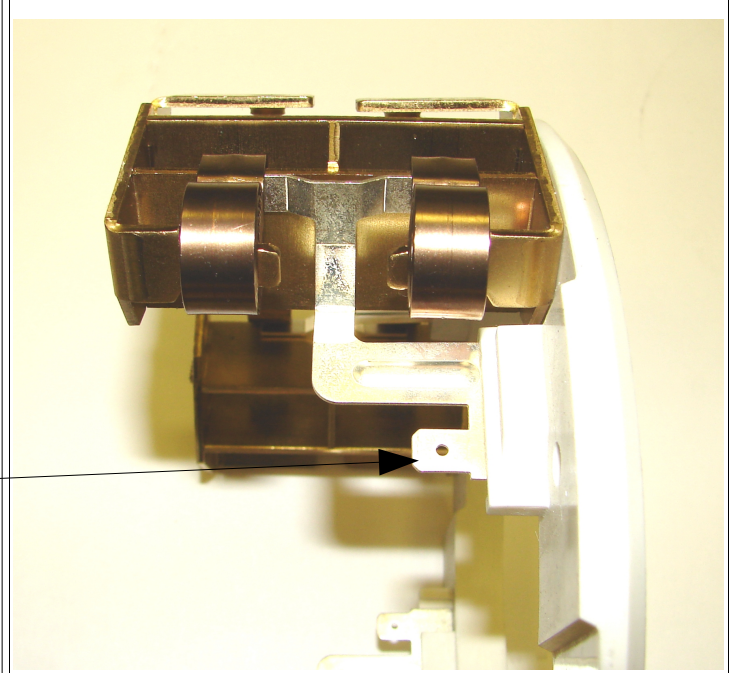


Illustration 13: Brush Holder

Brush Rigging

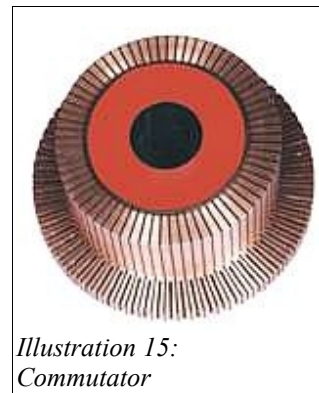
Electrical “switching” of the motor takes place between the commutator and the brushes. The brush ring may be made of a phenolic plastic ring that locates and supports steel studs or holes that support and precisely locate the brush holders at the proper angle in relation to the commutator. Brush springs



Illustration 14: Brush Rigging Assembly

Commutator

The commutator (collector) contains a number of copper bars that the brushes will contact. The number of bars must match the number of “slots” in the armature laminations. Varying the number of bars and slots allows motor performance to be modified.



*Illustration 15:
Commutator*

Bearings

Our motors use very high quality sealed bearings that are rated to 14,000 RPM's.



Illustration 16: Bearings

Brush Springs

The brush springs provide pressure on the top of the brushes to ensure the brushes maintain proper contact pressure with the commutator.

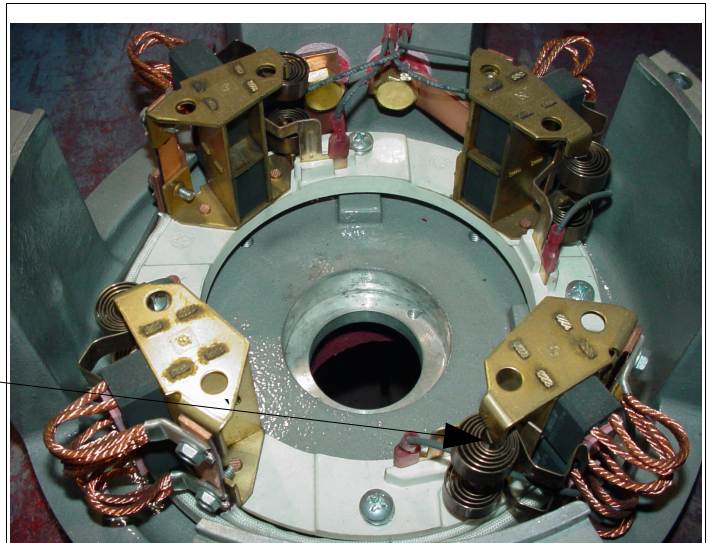


Illustration 17: Brush Springs

Field Pole Shoes

The field pole shoe consists of laminations which are riveted together to form a single structure. Laminations are critical because they allow magnetic flux to pass along the length of the lamination, but do not allow electrical eddy currents to pass from one lamination to another.



Illustration 18: Field Pole Shoes

Field Coils

The field coils consist of an exact length of carefully wound flat copper ribbon insulated with NOMEX between turns and then covered in insulating varnish. Each coil is shaped to the contour of the inside dimension of the frame assembly. After insertion into the frame, the entire frame will be flooded with insulation varnish.



Illustration 19: Field Coil Assembly

Interpoles

Most of our motors do not use interpoles. If so equipped, the interpoles are constructed similar to these, and they will be placed between the field coils.

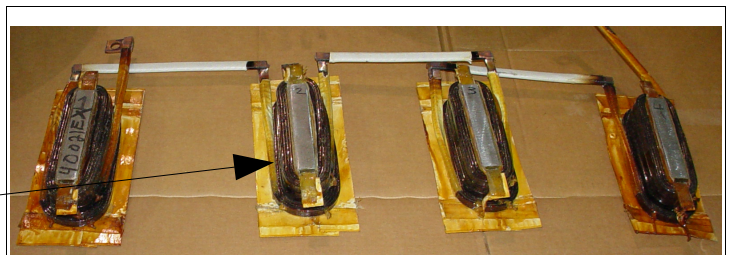


Illustration 20: Interpoles

Motor Characteristics

Timing Marks

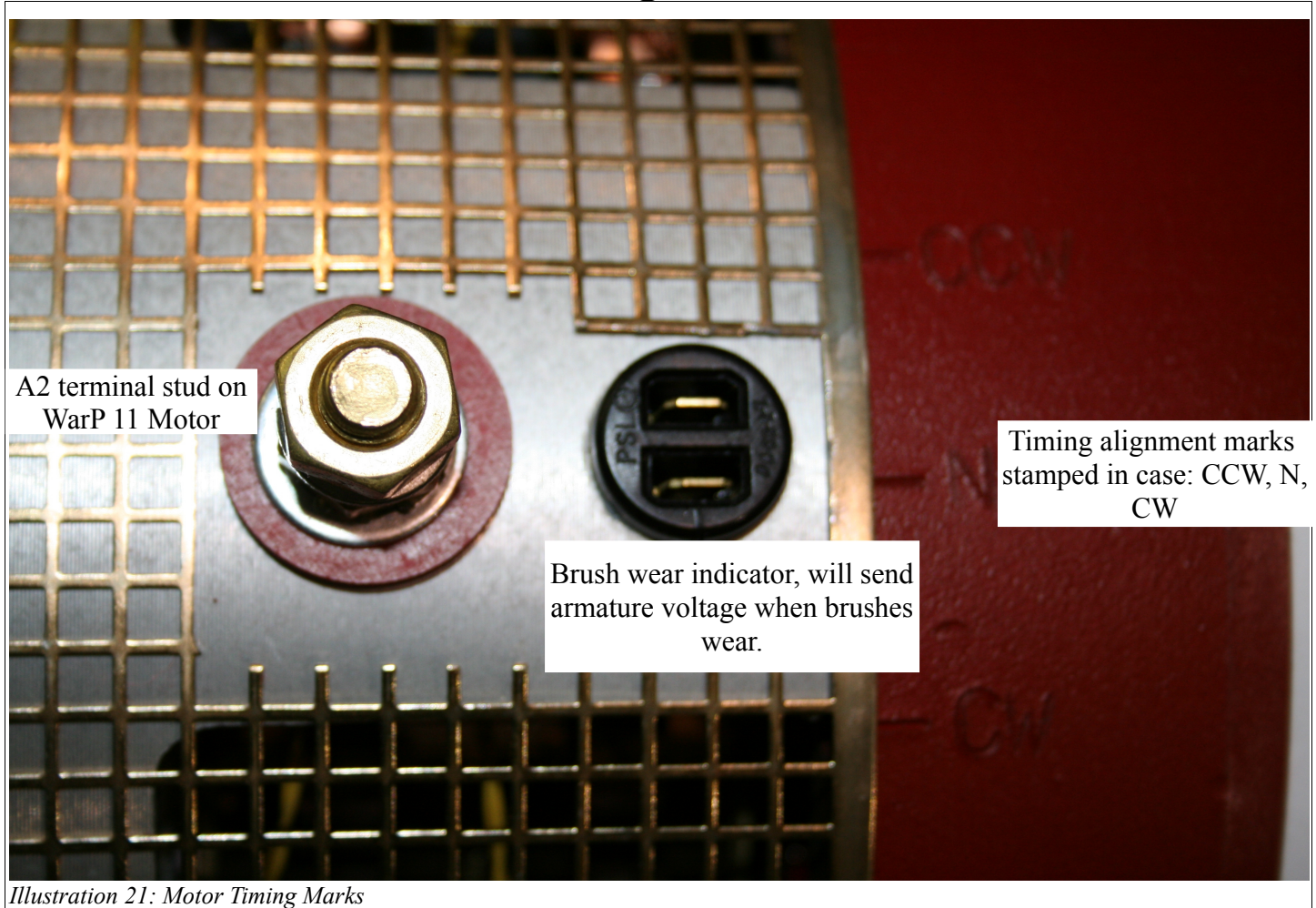


Illustration 21: Motor Timing Marks

The timing marks will align with a bolt in the CE end-bell. There are twelve holes pre-drilled and tapped into the case that allow the end-bell to be rotated to a Neutral position (**N**), a Clock-Wise (**CW**) when viewed from the Drive End of the motor, or Counter-Clock-Wise (**CCW**). The A2 terminal stud happens to align with the “**N**” Neutral timing mark when the motor is actually advanced **CCW**. It is not the terminal location that determines the timing, but rather the BOLT that holds the end bell to the steel case.

In the neutral timing position the motor will perform the same regardless of rotation and will provide equal power in both rotations (**CW** and **CCW**). If the motor is to be rotated primarily in a single rotational direction, performance of the motor in that rotational direction may be increased (higher RPM's, less arcing, lower amp draw) by having the timing set for the normal rotational direction. Performance will be decreased when the motor is then rotated in the opposite direction of the favored timing. Full power should be avoided when the motor is operated in the the rotational direction opposite the favored timing, or damage to the motor may occur.

Motor Characteristics (CONT.)

Motor Rotation

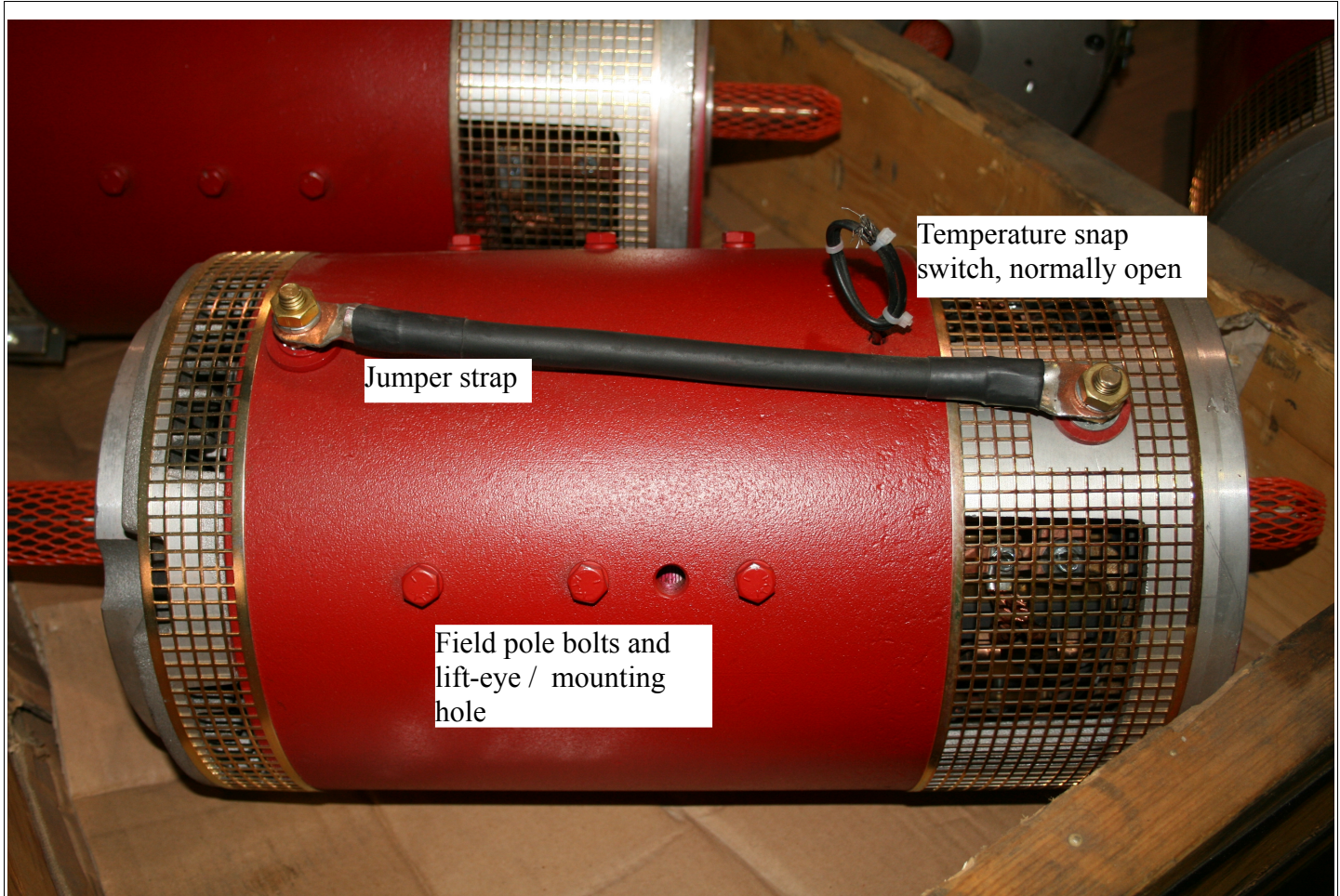


Illustration 22: Motor Rotation

The direction of series wound DC motor rotation is not affected by the polarity of the input power source. The direction of rotation is determined by the sequence in which fields are energized. The cable jumper strap shown above may be positioned either between the A1 (Armature) terminal, and the S1 (Stator) terminal, or the A2 and S2 terminals in order to effect a counter-clockwise rotation when viewed from the Drive End (DE) of the motor.

If the jumper strap is placed between A1 and S2, or A2 and S1 the rotation of the motor will be in the Clock-Wise (**CW**) rotation when viewed from the DE of the motor – regardless of input polarity from the power source.

Though it does not matter to the motor whether it is wired (A1-S1, A2-S2, A1-S2, A2-S1) some controllers do require a specific connection arrangement. Precedence should always be given to the controller manufacturers recommendation or possible damage to the controller may result.

Total allowable indicator run out on shafts is .002". Shafts are continually checked to ensure tolerance compliance through the entire manufacturing process. The raw stock used on 9" diameter motors is 1 5/8", while the raw stock for 11" motors is 2.25".

Motor Mounting

The bearing can accept axial loads (thrust) (See attached Special Update), so if the motor is coupled directly to the propeller shaft of a boat (or aircraft) it is not necessary to use a separate thrust bearing. In such an installation the shafts should be connected by a universal joint or the motor should be on flexible mounts symmetrically positioned around it. The motor can withstand occasional splashes of fresh water when it is running, but it should be protected against falling rain, sea water, oil (and other liquids that are corrosive or that do not evaporate without leaving a deposit) or direct impingement of water thrown off the wheels of a vehicle. It should not be in a small unventilated space, except in low current or intermittent applications. Note that when the motor is used with an electronic controller the current in the motor can be several times the current being taken from the battery when the motor is running slowly. The motor should not be mounted where a flammable or explosive atmosphere could be present. The motor should be connected using cables suitable for the current at which the motor will be run.

When attaching driven components to the shaft, lock the shaft against rotation by holding the driven component with a suitable tool. Do not try to lock the motor by pushing anything through the ventilation holes or into the motor to jam the armature as this could cause serious damage. Components which are a tight fit on the shaft should be pressed using suitable distance pieces, and removed using a puller whose pressure screw presses on the end of the shaft. The use of a hammer or levers is likely to damage the bearings, making them noisy and shortening their life. Taper locks may be used to fit components to the shaft; they avoid the need for force fits and also prevent fretting.

Total allowable indicator run out on shafts is .002". Shafts are continually checked to ensure tolerance compliance through the entire manufacturing process. The raw stock used on 9" diameter motors is 1 5/8", while the raw stock for 11" motors is 2.25". Care must be exercised that the correct key-way is used on shafts. Using a key-way with a taper-lock adapter can cause some minor distortions or even cracking of the armature shaft if tightened too hard.

The motor should be protected from road debris, liquids, dust, etc. as much as possible. We highly encourage the use of an air filter and blower motor, such as the one pictured below.



Illustration 23: Forced Air Cover-band and Blower example

Motor Timing

Most motors are assembled at the factory with the brush timing set in the ‘advanced’ **CCW** (Counter Clock-Wise) position when viewed from the **DE** (Drive End) of the motor. This provides maximum efficiency for most vehicular applications with the exception of some Honda vehicles. Most Honda vehicles will require a **CW** advancement of the brushes. You should ALWAYS know the desired rotation for the particular application of a motor. Incorrect timing may cause significant performance degradation, motor damage, and safety issues. Advanced timing may also be referred to as “favored timing”.

If the motor will be run in only one direction, or in one direction most of the time, but with occasional reversing at low power, then the efficiency at high power can be increased by ‘advancing’ the brushes. All **WarP** Motors ship in an advanced CCWDE rotation unless otherwise specified.

To change the brush advance, remove the four bolts that hold the Commutator End (CE) bell in position (see photo) and turn the CE end bell until the CE end bell bolt holes align with the stamped marking in the case for the desired timing. For an application in which the current will always be high (150A or more) or where the voltage will exceed 72 Volts, advance timing should be considered.

The A2 terminal stud **SHOULD NOT** be used to set motor timing. Notice that in this example the timing is set to advanced CCWDE, while the A2 terminal stud aligns with the “N” Neutral timing mark! This motor is correctly timed advanced CCWDE.

The 4 end bell bolts should be tightened to 35 ft. lbs.

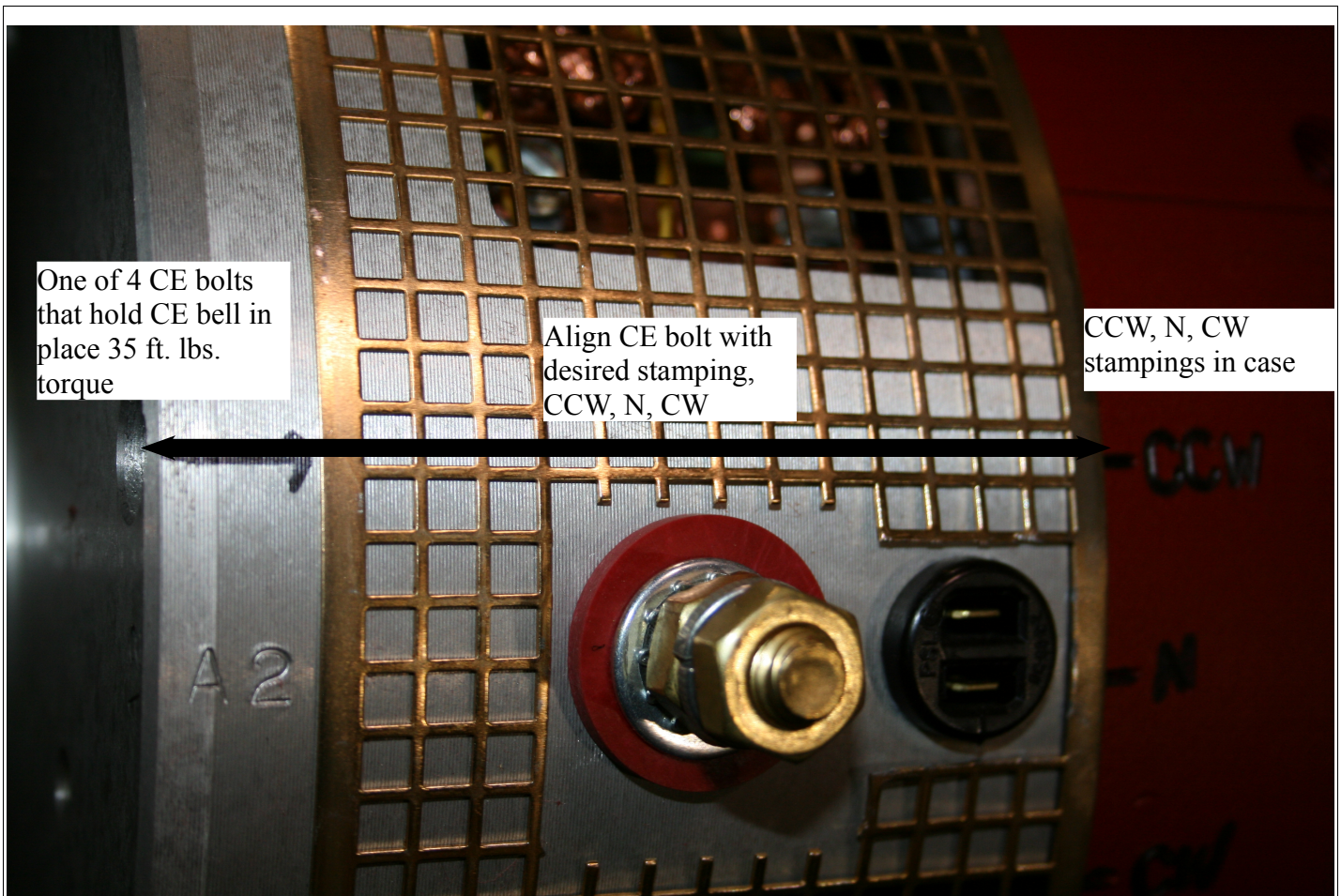
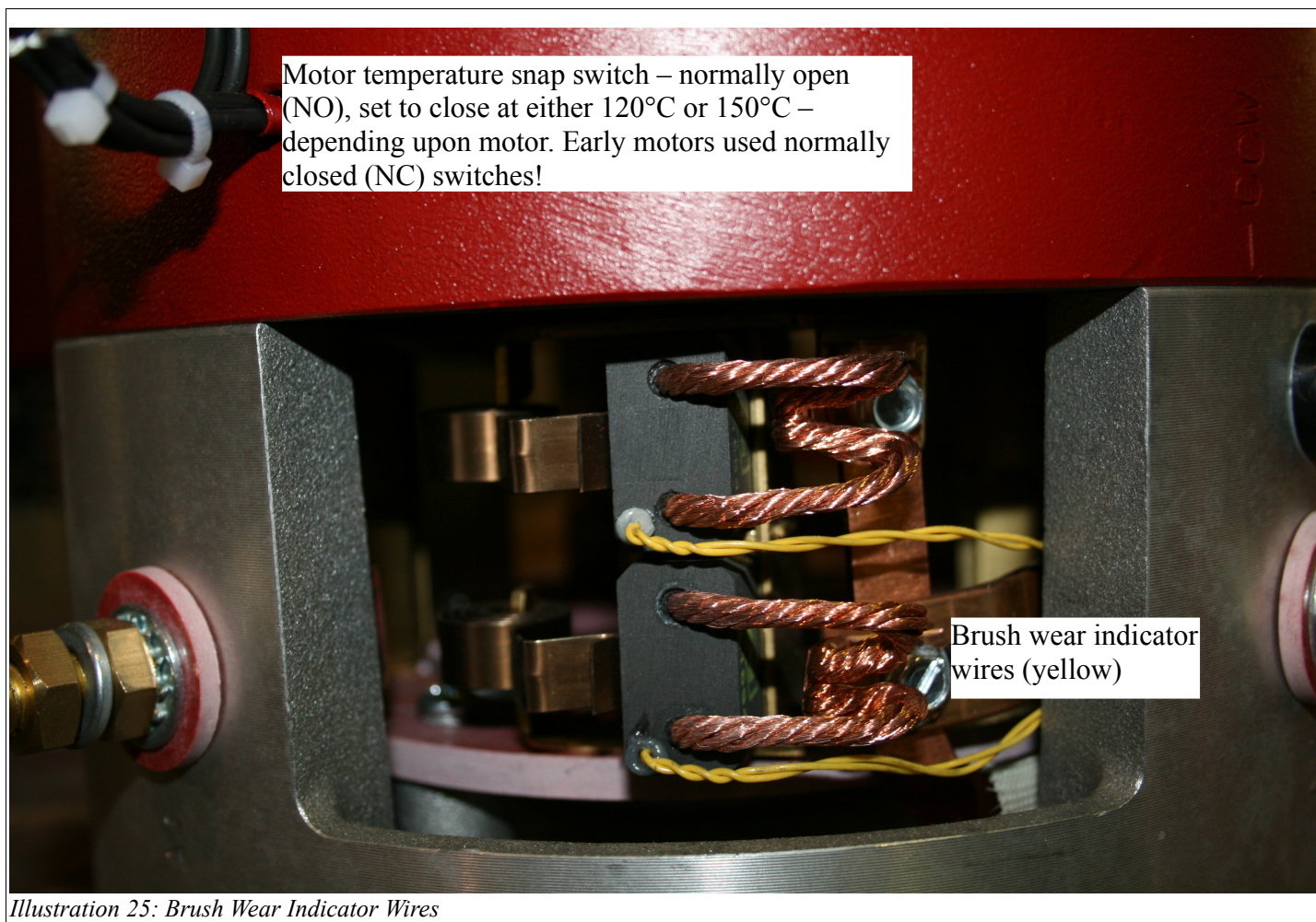


Illustration 24: Motor Timing - Bolt Alignment

Brush Wear Indicator (cont)

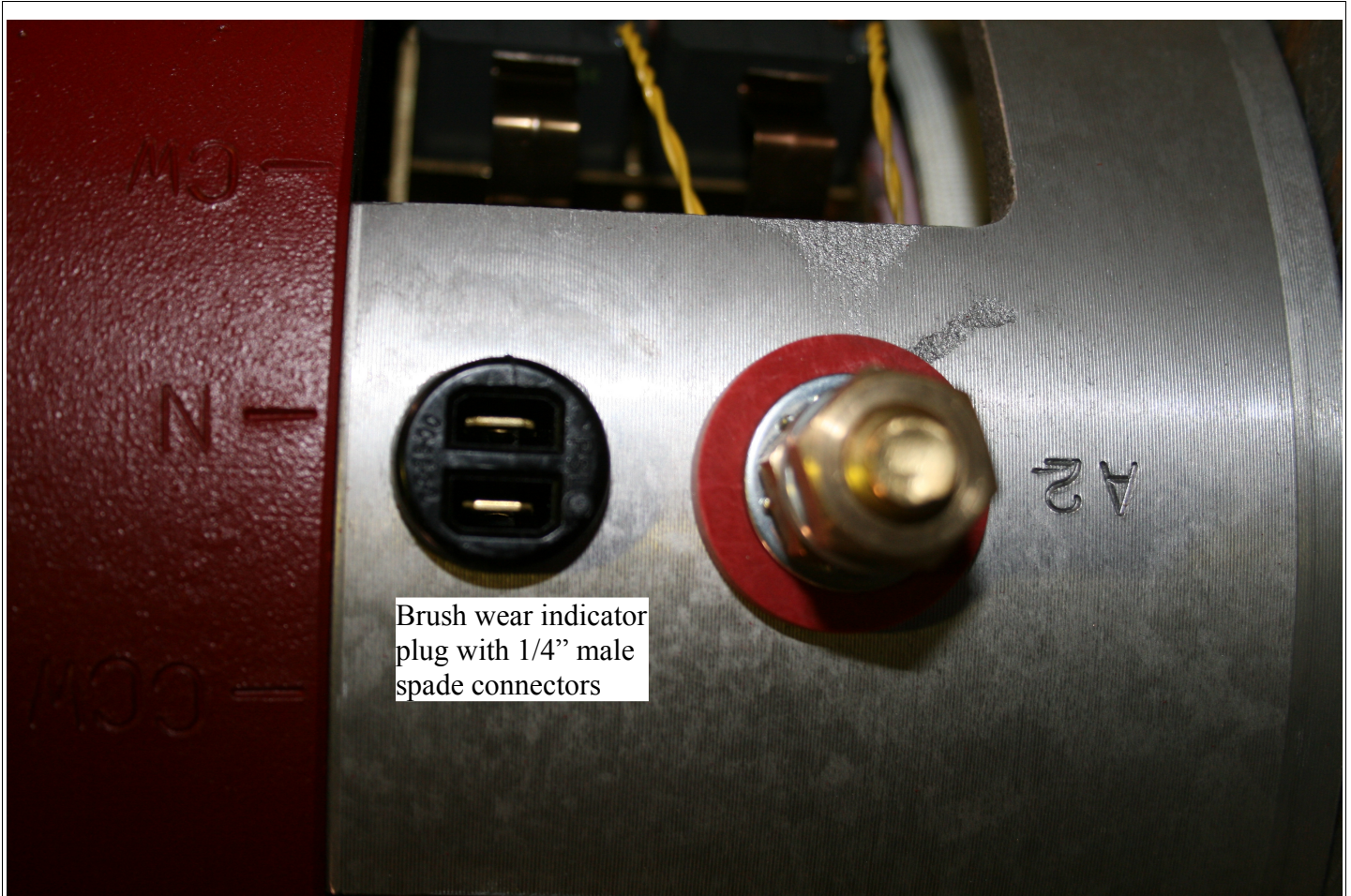


The thin yellow wires in this image are the “brush wear indicator wires”. There is one going to every brush if your motor is so equipped. Not all models have this feature.

The brush wear indicator normally has no voltage on it. When brushes wear to the point where two brush sets at 90 degrees to one another both contact the armature, the armature voltage will be seen at the indicator plug (see next image). The indicator plug uses female 1/4” spade connectors.

NOTE: Motors produced prior to 1/1/2011 **MAY** use “NC” (Normally Closed) snap switches. You must check to determine what your motor has.

Brush Wear Indicator



Brush wear indicator plug with 1/4" male spade connectors

Illustration 26: Brush Wear Indicator Plug

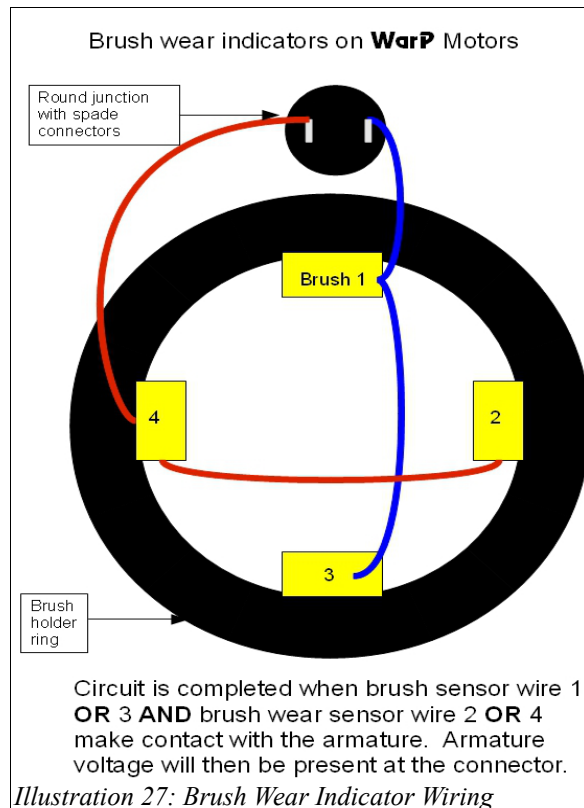


Illustration 27: Brush Wear Indicator Wiring

Brushes

General Brush Information

DC motor brush wear is the result of mechanical friction between the brushes and the commutator, as well as electrical erosion of the brush material. A brush compound that is well suited to an application will result in an electrical erosion of the brush material with very little physical residue. Brushes should typically last 2,000 hours. This time is very dependent upon various factors, including temperature, spring pressure, atmospheric conditions (humidity, ambient temperature), current loading, RPMs, and other factors. High humidity is generally better for brushes than low humidity.

There is a relatively high coefficient of friction between the brush carbon and the bare copper bars of a commutator. Over time, a patina or “film” will develop on the commutator. This “film” can reduce the coefficient of friction to 10% of the original bare copper bar value. A good patina is important and the use of commutator stones used to seat the brushes and shine the commutator should be discouraged.

Silicone sealer and any and all silicone products should be avoided in or around brushed motors! This includes silicone vapors! The use of uncured silicone products will result in extremely rapid degradation of the brush compound and may cause severe motor damage. Completely cured silicone products may be used.

The faster a motor spins, and the higher the amps fed to the motor, the more likely you are to see arcing and sparking. This arcing and sparking will greatly reduce the brush life. Arcing and sparking may also be the result of brushes that are not seated properly. The best method of seating brushes that have not been properly radius-ed to match a particular commutator is to cover the commutator with very fine emery paper and then spin the armature. Ideally, this would be done externally to the motor (i.e. a bench arrangement) so as to minimize the amount of carbon dust that can enter the motor.

Proper operation of a motor requires a good patina film be present. A good patina film requires:

- Proper brush size to carry the current being applied
- Proper brush pressure
- Humidity at proper level
- Commutator RPM within limits designed for motor operation
- Lack of abrasives and other contaminants
- Proper brush material and grade
- Mechanical integrity of brush rigging and commutator.

There is no single brush composition that will give good brush life in all applications. The application must be understood to arrive at a brush composition that will work well, and allow for proper patina filming to occur.

RPM's also affect brush life rather dramatically. A motor running at 3,600 RPM's will wear brushes approximately twice as fast compared to the same motor running at 1,800 RPM's.

To achieve the longest brush life, the brushes must be designed properly for the application and the environment. Brushes should never be used that will handle the maximum, but rather the normal load the motor will be faced with. If the motor is sealed, it should be periodically inspected and compressed air should be used to blow dust from the motor. It is best to start at the fan end of the motor and blow compressed air towards the brush area. Then blow compressed air into the commutator end of the motor and ensure that all dust is removed from around the brushes (they should travel freely), as well as around the commutator.

Brushes (cont.)

Brush Grades

This is a brief description of the various brush grades commonly used in **WarP** Motors:

- **K254**: This grade was originally developed for use in low voltage fork lift truck applications. It should be used in motors that will see a max operating voltage of 80 Volts. In some specialized cases this could be increased to 120 Volts. This grade has a low contact drop and will take some overload but should be limited to roughly 350 Amps for 30 seconds or less. The amount and duration of current it can handle depends upon how well the motor is ventilated. This grade does not have the ability to clean the commutator after a current overload.
- **H60**: This grade was originally developed for use in traction applications. Traction applications generally consist of high overloads with periods of coasting and some low load operation. This grade has a high contact drop (good for high voltage motors) and good filming capability (better dry lubricant and wear life of the brush and commutator) and will work best in most “daily driver” EV applications. This grade can handle the occasional high current overloads from any size controller, as long as the ventilation is good and the overload amount and duration are not so extreme as to allow the brush to overheat. This grade has some cleaning ability and is very hard and strong and therefore will take some time to seat in. The long seat in time (typically as long as 48 hours) is an indication that it will provide a long wear life. A variation of this brush is suitable for cold weather applications (H60C) where the motor is being operated for extended periods in temperatures below 40° F.
- **H49**: This grade was also developed for use in traction applications. But, this grade is a little different from others in that it is designed for medium contact drop and low filming. This grade will work well in high voltage high power applications where there is very little operation at low loads or coasting. For proper life the motor will have to be maintained at or above 200 Amps per sq. in. of brush surface area. This grade would be best suited for racing and high performance applications. This grade can handle occasional high overloads from any controller, as long as the ventilation is good and the overload amount and duration are not so extreme as to allow the brush to overheat. This grade has more cleaning ability than other grades and is a bit softer than the others, so it may bounce slightly less. This brush seats very quickly, but it may also require the regular use of compressed air to expel carbon dust from the motor. Seating time will typically be as little as 6 hours.
- **H100**: The original brush used **In WarP** Motors. The brushes originally used served well in applications where PbA (lead acid) batteries were used. The shunt wire diameters were increased over the original fork-lift design and the shunt wires were insulated in some models for better reliability and performance. In the proper application these brushes are a low-cost alternative to the higher performance compounds and still offer extremely long life, durability and performance when used with controllers under 1,000 Amps, or when used with PbA batteries.

Brush Sizes & Grades Table

Brush Part or #	Motor Model	Brush Grade	Brush Size T * W * L	Brush Sq. In.	Manufacturer
10327002		?T300?	.625" * 1.250" * 1.75	.781"	NGM
10345068		H82C	.5 * 1.125 * 1.75	.5625	ADC
10399300		H100	.9375 * .625	.5859	NGM
Prior NetGain		H100	.625 * 1.00 * 1.75	.70312	GE
Standard ¹	WarP 9 ImPulse 9 TransWarP 11	H60	.625 * 1.125 * 1.5	.70312	Dual wafer with red-top by Helwig-Carbon
Race ²		H49	.625 * 1.125 * 1.5	.70312	
Cold ³		H60C	.625 * 1.125 * 1.5	.70312	
Long-Life ⁴		H38	.625 * 1.125 * 1.5	.70312	
Standard ¹	WarP 11 TransWarP 11	H60	.625 * 1.125 * 1.5	.70312	Dual wafer with red-top by Helwig-Carbon
Race ²		H49	.625 * 1.125 * 1.5	.70312	
Cold ³		H60C	.625 * 1.125 * 1.5	.70312	
Long-Life ⁴		H38	.625 * 1.125 * 1.5	.70312	
10499500					
10427001					
10440300					
OEM ⁵		K254	.625 * 1.125 * 1.5	.70312	Dual wafer with red-top by Helwig-Carbon
FULL RACE ⁶					Custom designs for each motor model.

1 Standard brush used for this motor – this will take effect after 7/1/2012 – prior standard was H49 Grade

2 Race grade brushes assume a minimum of 200 Amps/sq. in., and no coasting. These brushes will dust and wear quicker than H60

3 Should be used if vehicle is used exclusively in this environment – suggested for occasional usage in warmer environment

4 Requires extensive brush seating

5 Special OEM grade that handles high humidity and cool environments under 96 Volts!

6 This option requires special brush rigging, brush holders, brushes, and motor modifications performed by Helwig-Carbon

Brush Change Procedure

Brush Change Procedure:

1. Be sure all power is disconnected and no voltage is present at the motor.
2. Remove commutator end cover shroud.
3. Ensure the face of the new brushes closely matches the contour of the commutator.
4. Remove the screw that holds the brushes to the brush rigging.
5. Lift the spring off of each brush, and then carefully lift the brush till it is out of the brush holder far enough that the brush spring can rest on the side of the brush.

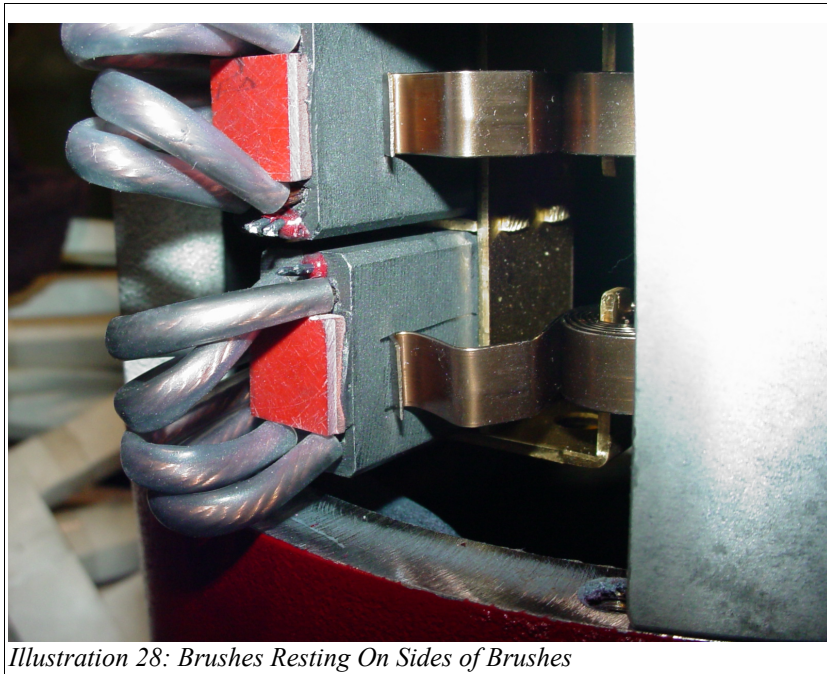


Illustration 28: Brushes Resting On Sides of Brushes

6. While holding the brush spring away from the brush, remove the old brushes.
7. Making certain that the brushes are being inserted correctly for the normal rotation of your motor, insert a new brush in the position from which the old brush was removed. The brush should slide easily, NEVER force a brush into a holder.
8. Install the screw that connects the brush pigtail to the brush rigging.
9. Replace brush spring and ensure it does not touch the shunt wires.
10. If shunt wires are not insulated, ensure they do not contact anything. Shunt wires may be bent away from any contacts.

Frame Ground Issues

One of the most common issues with brushed motors is a grounding issue that is normally due to accumulated brush dust. It is normal for the brushes to wear and therefore to create some dust. This dust is conductive and may, over time, form a path from the brush holder to ground. Any brush grade will demonstrate higher wear rate initially as the brush becomes seated. As the brush becomes perfectly worn to the comm in respect to the bottom bevel and the concave radius it will generate an abnormal amount of dust when compared to the wear rate after the seating has been completed. The time to properly seat the brushes varies from brush grade to brush grade.

The brush compound, humidity, voltage, amperage and numerous other mechanical, electrical and environmental factors can all affect how quickly brushes wear. If the proper brushes for an application are used, the minimum run-time hours should be greater than 1,000 hours. Under ideal conditions the run-time hours can be 3, 000 to 4,000 hours (or more) on a set of brushes.

The dust that accumulates must be cleaned periodically from the inside of the motor. High velocity ventilation of the motor will help prevent the accumulation of this dust. It may be possible for a tube extension added to the compressed air blow gun will allow access to the inside of the motor.

If a frame ground condition is detected, the solution may be as simple as using compressed air to blow the accumulated dust from the motor. Ideally this would be done with the motor running so that the internal fans can assist with the expulsion of the brush dust. Compressed air will need to be blown from both ends of the motor, and, ideally, in 360 degrees around the motor. We highly encourage and recommend that appropriate masks and goggles be used for protection from the brush dust that is expelled during this operation.

If the frame ground is not cleared in the prior operation, a more aggressive method could be used that uses Acetone. A squirt bottle filled with Acetone will help to clean the inside of the motor and wash away the dust. The use of Acetone is acceptable and will not damage the brushes or the comm, but the brushes will absorb the Acetone and running of the motor prior to the complete vaporization of the Acetone will cause this absorbed Acetone to ignite. Compressed air may be used after the use of the Acetone to help speed the vaporization of the Acetone, but care should be taken as it could take some time to completely vaporize any residual Acetone.

The most aggressive method of clearing a frame ground is to remove the motor from the vehicle, and to then remove the end-bells and armature. The above techniques can then be applied with greater access to internal components.

In many cases this will clear the problem without a complete rebuild of the motor. But, this is only appropriate for frame leaks caused by accumulated brush dust, and may not work in ALL instances, though the success rate is quite high.

Commutator and Brush Rigging



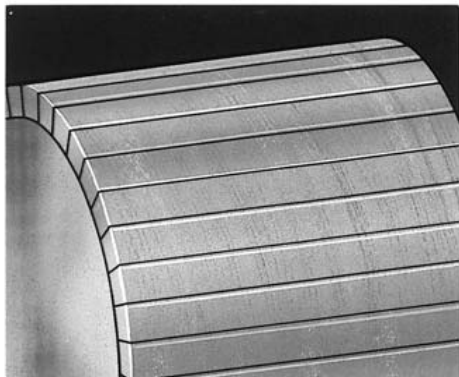
*Illustration 29:
Commutator*

The brass bars of the commutator conduct the electricity fed to them from the brushes to the armature wires to create a magnetic field.

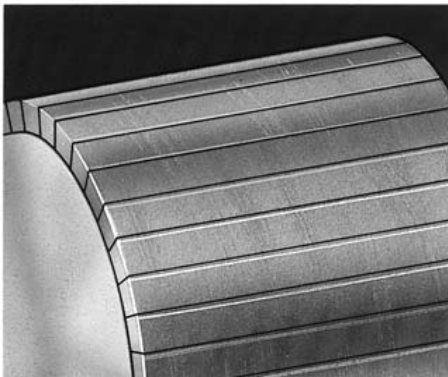
- A commutator is in good condition when it is clean and smooth with a medium polish and a light brown color.
- Keep clean by occasionally wiping with a canvas pad.
- Do not use lubricants or emery abrasive.
- If a commutator becomes rough, it needs to be resurfaced.
- If the commutator does not show any unusual wear, the brushes should NOT be removed. Removing the brushes and checking them may shorten the brush life by 50% or more!

Guide To Commutator Appearance

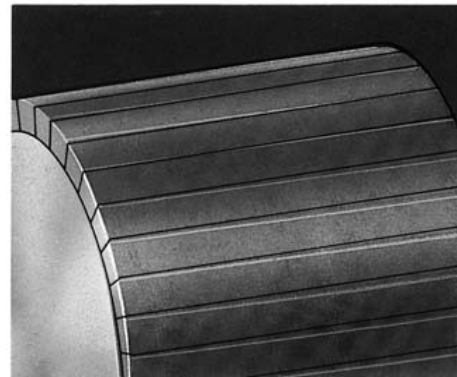
7



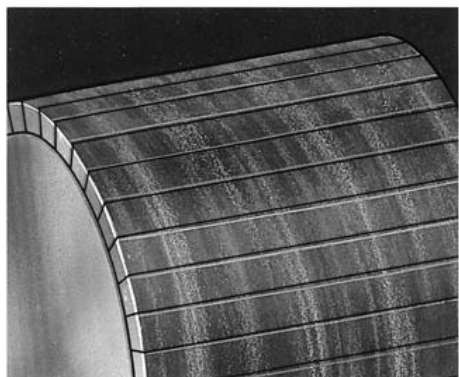
Light Film: Indicates good brush performance. Light load, low humidity, brush grades with low filming rates, or film reducing contamination can cause lighter color



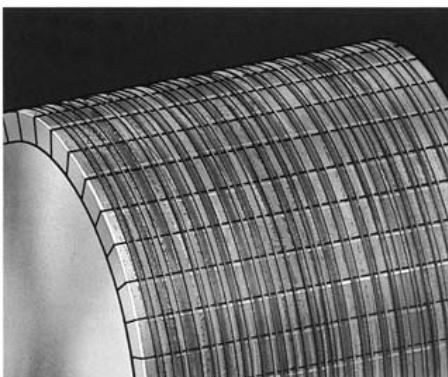
Medium Film: Is the ideal commutator condition for maximum brush and commutator life.



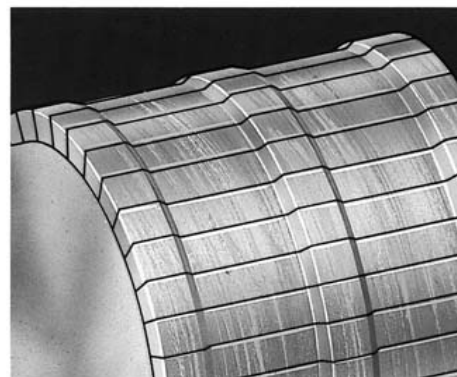
Heavy Film: Results from high load, high humidity or heavy filming rate grades. Colors not in the brown tones indicate contamination resulting in high friction and high resistance.



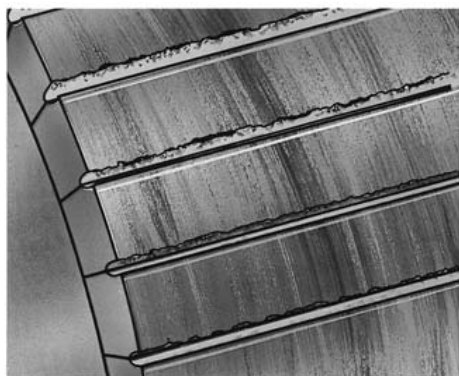
Streaking: Results from metal transfer to the brush face. Light loads and/or light spring pressure are most common causes. Contamination can also be a contributing factor.



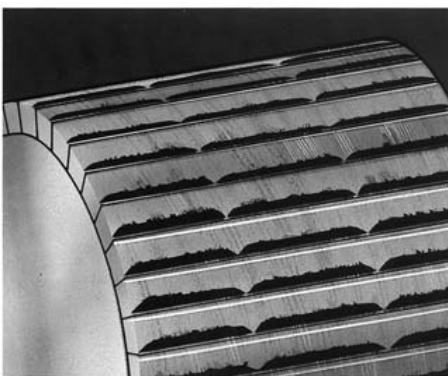
Threading: Is a further development of the streaking condition as the metal transferred becomes work hardened and machines into the commutator surface. With increased loads and increased spring pressure this condition can be avoided.



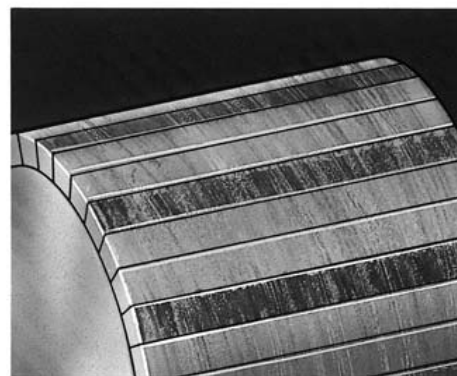
Grooving: May result from an overly abrasive brush grade. The more common cause is poor electrical contact resulting in arcing and the electrical machining of the commutator surface. Increased spring pressure reduces this electrical wear.



Copper Drag: Develops as the commutator surface becomes overheated and softened. Vibration or an abrasive grade causes the copper to be pulled across the slots. Increased spring pressure will reduce commutator temperature.



Bar Edge Burning: Results from poor commutation. Check that brush grade has adequate voltage drop, that the brushes are properly set on neutral and that the interpole strength is correct.



Slot Bar Marking: Results from a fault in the armature windings. The pattern relates to the number of conductors per slot.

Current and Voltage

When the motor is being ventilated by its own rotation (i.e. there is no separate fan or forced air cooling) the current (measured at the motor; we suggest that an ammeter should be installed between the motor and controller) in continuous running should not be over the figures given in the following table for the relevant voltage, also measured at the motor:

Motor Operating Voltages and Amperage							
Motor Model	Minimum Armature Voltage	Maximum Armature Voltage	5 Minute Amperage Rating	1 Hour Amperage Rating	Continuous Amperage Rating	Maximum RPM	Maximum Continuous RPM
WarP 7 / TransWarP 7	48	170	400	200	185	7800	5500
403-06-4001 / WarP 8 / ImPulse 8	48	170	400	200	180	5500	4000
ImPulse 9	48	170	450	225	190	5500	4000
WarP 9 / TransWarP 9	48	170	450	225	190	5500	4000
WarP 11 / TransWarP 11	48	170	500	250	200	5000	3000
WarP 11HV	48	240	450	225	190	5500	4000
WarP 13	48	170	550	275	225	4500	3000

Short-term current (~10 seconds) may be up to 2000A. (For racing or similar applications these figures may be briefly exceeded). RPM's should generally not exceed a speed of 5,500 RPM. The maximum RPM speed should not be exceeded even briefly; doing so can cause immediate damage, and there is a risk that the armature could suddenly burst apart with heavy pieces being ejected through the motor casing, liable to cause serious injury.

We highly encourage the use of a “scatter shield” around the commutator of the motors! The standard brush guard is not sufficient to handle an exploding commutator!

The bearings used in our motors are rated to 14,000 RPM's, and the commutator manufacturer claims all commutators are spun tested to 10,000 RPM's. Testing these claims is strongly discouraged!

Motor Cleaning

The outside of the motor may be cleaned with a damp or oily rag, or with a brush. Any cleaning products that are used should be sprayed on the rag or brush, but not directly on the motor. Do not clean the motor with a pressure-washer.

If the motor is subjected to salt water or road salt it should be rinsed with fresh water to remove the contaminants.

We highly encourage the use of a compressor to periodically blow carbon dust out of the inside of the motor case. Normally the air should be injected from the commutator end and blown towards the exhaust fan end of the motor. It is advisable to first blow the dust from the drive (fan) end of the motor, then from the commutator end. Ideally this would be done with the motor spinning so that the fan may help eject the carbon dust. It is suggested that eye protection and a mask be used to protect yourself from the carbon dust.

You can prolong the life of the motor brushes and commutator by ensuring that filtered air is blown into the motor through the commutator end of the motor. Kits are available to accomplish this. This is particularly important in dusty environments or any environment where an abrasive may enter the motor (i.e. road salt).

In cases where the vehicle is driven on salted roads, the motor should be shrouded in order to keep road salt and debris from accumulating on or in the motor.

In cold weather the owner should consider either cold weather style brushes, or a commutator stone for cleaning the buildup on the commutator. The normal brush grade suggested for use in cold weather conditions is the H60C. It is important to blow the commutator with compressed air to remove any abrasives if a commutator stone is used.

Motor Cooling

Motors come standard with high volume fans, however, these fans are only rotating when the motor is running. Consequently, we strongly encourage the use of a forced air cooling kit to help cool the motor when stopped at a stoplight, or when traveling at low speeds. Additionally, all 9" WarP Motors are equipped with a thermal snap switch that is **Normally Open (NO)** and closes at 120° C (248° F). All 11" and larger motors have a **NO** temperature snap switch that closes at 150° C (302° F).⁸

Additionally, all motors produced after 12/1/2011 are now being equipped with temperature thermistors. These thermistors may be used to monitor the motor temperature with a motor temperature gauge. The thermistor used on our motors is:

Digi-Key

[568-3254-1-ND](#) (KTY84/130,113)

IC Temperature Sensor DO34

Lead Free ROHS COMPLIANT

Resistance in Ohms @ 25° C (77° F) = 603

Operating temperature range = -40° C (-40° F) - 300° C (572° F)

Contact NetGain Motors, Inc. for further information on Authorized Dealers who can supply temperature gauges.

Cooling shrouds (Part Number: 10808219EE) are available directly from NetGain Motors, Inc. that allow you to connect your own 2" diameter (ID) hose and blower unit.

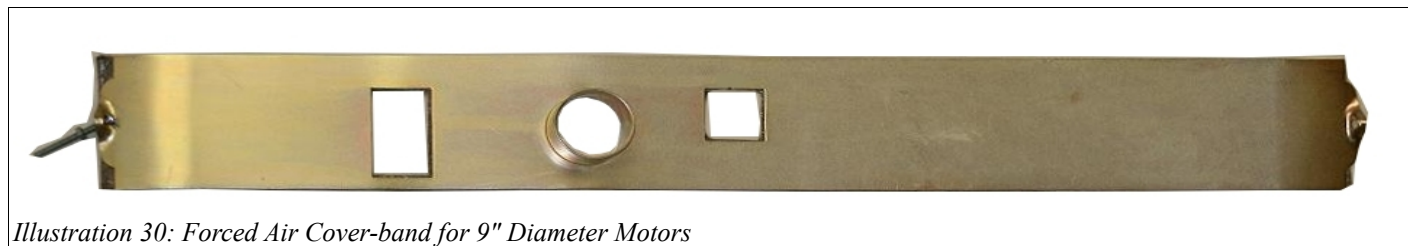


Illustration 30: Forced Air Cover-band for 9" Diameter Motors

Some Authorized Dealers also sell entire kits, such as the one shown below:



Illustration 31: Forced Air Blower Kit for 11.45" Diameter Motors

Additional information may be found in the attached Special Update entitled: **WarP™ Motors** Heat and RPM Protection Bulletin

⁸ Motors produced prior to 12/1/2011 may contain snap switches that are **Normally Closed (NC)** and open at the specified temperatures

Routine Maintenance

The frequency with which maintenance is required depends on the severity of the application and the environment in which the motor is being utilized. In an application that does not involve high currents, dust or other contamination it could be every few thousand hours. In a vehicle used for racing, it is advisable to check the motor after each race, and, at a minimum, blow carbon dust from the motor. In racing applications it is essential to inspect the commutator often, but do not remove brushes unless a problem is suspected.

Turn the motor slowly in its normal direction of rotation at least one full revolution. There should be a faint, smooth rubbing sound from the brushes. Rasping or clicking sounds indicate a possible problem.

Take off the brush cover shroud and check that the flexible leads leading to the brushes have plenty of slack in them and are not close to being pulled tight between the terminals and where they pass into the individual brush channels. Gently pull each flexible lead to check that the brushes are free to move in their channels. In case of any doubt, see the section below on “Removing the brushes”. If the motor has accumulated many hours of running, you should blow dust out of the armature with compressed air. Take care to avoid breathing the dust.

Try to shake the shaft. If there is significant play or if there have been unusual noises with the motor running, see the section below “Dismantling and reassembly of the motor”. You should ALWAYS replace the bearings whenever the armature is removed from the end-bell.

Bearing grease will lose its lubricating ability over time, not suddenly. The lubricating ability of a grease (over time) depends primarily on the type of grease, the size of the bearing, the speed at which the bearing operates and the severity of the operating conditions.

WARNING: Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of these motors.

WARNING: Controllers may apply hazardous voltages to the motor leads after power to the controller has been turned off. Verify that the controller is incapable of delivering hazardous voltages and that the voltage at the motor leads is zero before proceeding. Failure to observe this precaution may result in severe bodily injury or death.

WARNING: Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. Protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.

Brushes: Brush pressure is correctly established at the factory and maintained at the correct value throughout the life of the brush by means of a constant pressure spring design. Brushes and brush-holders should be clean so that the brushes are free to move in the holders.

Brushes should not be removed unless a problem is suspected, usually by an abnormal commutator wear pattern (See: **Guide To Commutator Appearance**), or brush chipping. If for any reason a brush must be removed, it should always be placed back into the exact spot from which it was removed. Brushes should never be “swapped around” with one another.

Replace brushes with new brushes of the same grade before wear permits any damage to the commutator. It is highly recommended to change out the complete set, and in high power EV applications, new springs should also be considered.

The brush holders in all motors are of constant pressure design and are not adjustable.

Bench Test Procedure

(Test at 12 volts ONLY)

CAUTION! Read completely!

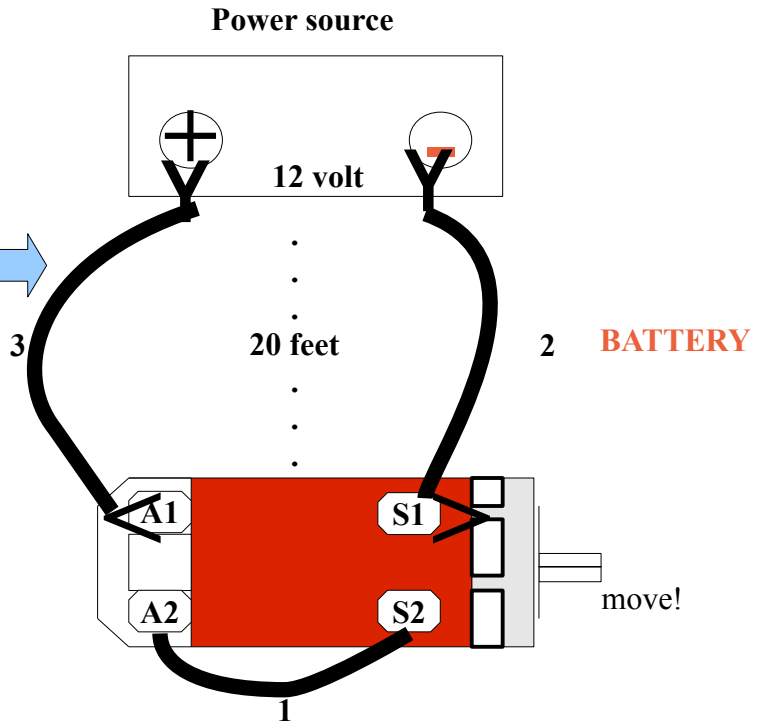
Caution!!!!

Sparks can ignite gases emitted from batteries!

Use quick-connect cables for battery and motor! →

DO NOT HARDWIRE MOTOR AND CONNECTIONS!

Make certain that the motor is securely strapped or bolted in position. The motor must **not** be allowed to



If a battery is used instead of a charger, the battery must be at least 20 feet away from the motor in a well ventilated area or preferably outside of the building!

The cables **MUST** be connected and disconnected in the order shown!

Connecting sequence:

1. Connect cable #1 and cable #2 first.
2. **Connect cable #3, to power source positive terminal (+) at the power source first, NOT at the motor.**
3. Connect the other end of cable #3 to terminal (A1) at the motor which is 20 feet away from the power source.

Disconnecting sequence:

1. Disconnect cable #1 first. (This deactivates the motor)
2. Disconnect cable #2 and then #3 from the power source.

Motor Short - Test Procedure

In order to test a motor and determine whether there are any shorts the following points should be probed and the results should be as shown:

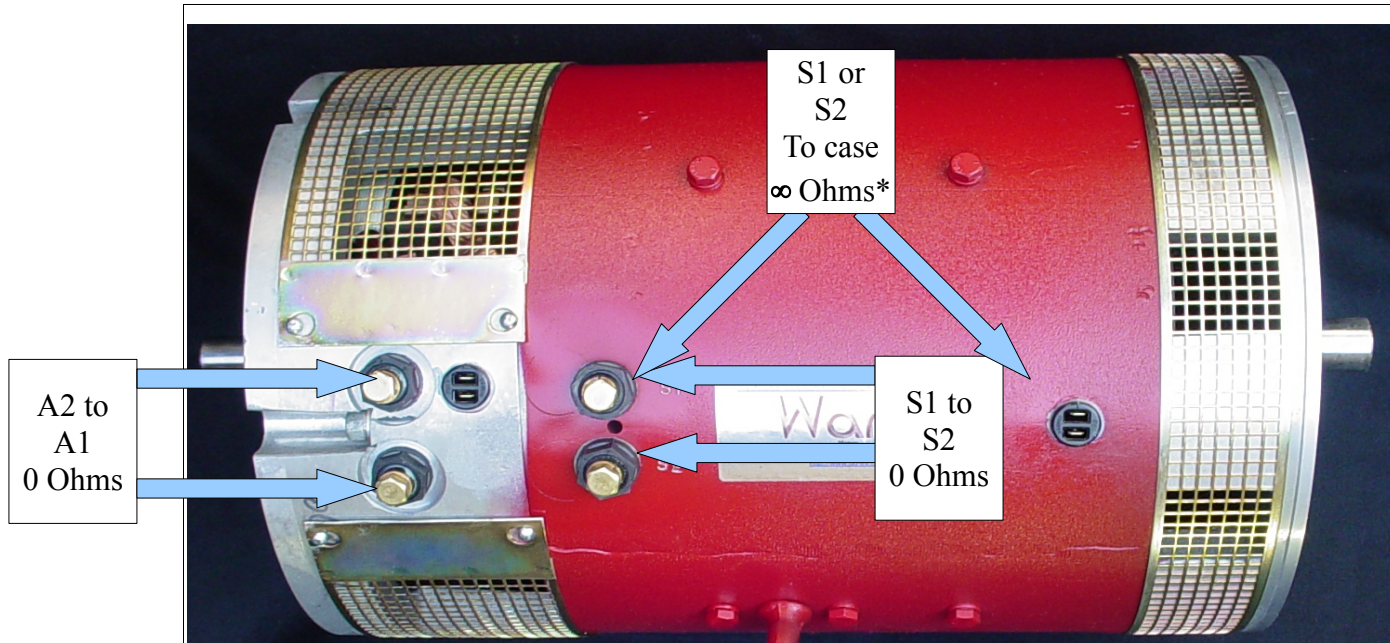


Illustration 32: Motor Short - Test Procedure

* Infinity ohms in theory, but may be > 50,000 Ohms on GE Motors, and > 100,000 on CAT and Raymond Motors, If the amount is lower than 100,000 Ohms on a NetGain motor, you may wish to use compressed air to blow dust from the motor and then continue to check.

Dismantling and Reassembly

Tools required: [THIS SECTION TO BE ENHANCED AND EXPANDED...]

- A bench vice with soft jaws (alternatively slip a piece of copper pipe over the motor shaft to protect it from damage by the vice jaws)
- A large spanner
- A large regular screwdriver and a Phillips screwdriver
- A strong Allen key (long-arm type, or of the socket type that can be used with a torque wrench or T-handle)
- Three long lengths of heavy threaded rod (studding) each with two nuts locked against each other at one end so they can be turned with a spanner (not to be used with reinforced armature versions of the motor; see page x for description of a tool to be used instead)
- Internal cir-clip (snap ring) pliers (only for some models)
- A small hammer
- A length of steel rod about 1.5 inches diameter
- A drift suitable for pressing on the outer race of the bearing,
- A short [SIZE] screw and some thick washers that fit it
- A [SIZE] length of [SIZE] threaded rod (studding) and a nut
- A piece of steel tube with (1 inch) inside diameter and length of [SIZE] to [SIZE]
- Anaerobic adhesive
- Anti-seize assembly compound (245 Blue recommended!)
- Commutator surfacing stone
- Here are some videos from Mathieu in Germany who did a good job of showing how to disassemble and re-assemble a WarP motor.

<http://www.youtube.com/watch?v=BxRYY6s67fY>

<http://www.youtube.com/watch?v=FXmelRFPLtQ&feature=g-upl&context=G2a1a4a6AUAAAAAAAAAAAA>

Dual Motor Wiring

There are multiple methods of wiring dual motor combinations. Normally, the armatures and fields are wired in series in order to provide maximum torque. When wired in series, both motors see full amperage, but only receive $\frac{1}{2}$ the available voltage. This will limit the RPM's to about $\frac{1}{2}$ of what they would receive if the armatures and fields were wired in parallel. People racing electric vehicles have used this technique for years, but few people have explored the other wiring options and their resultant behavior.

The attached table briefly describes the effect of the 4 methods of wiring multiple motors. None of these methods should be seen as an endorsement or recommendation from NetGain Motors, Inc. Our motors are series wound and the normal methods of wiring the motors is as described in the first paragraph and in options 1 and 2 below. It should be noted that options 3 and 4 can do serious damage to the motors if the user is not familiar with how the voltage and current are applied across the fields and armature.

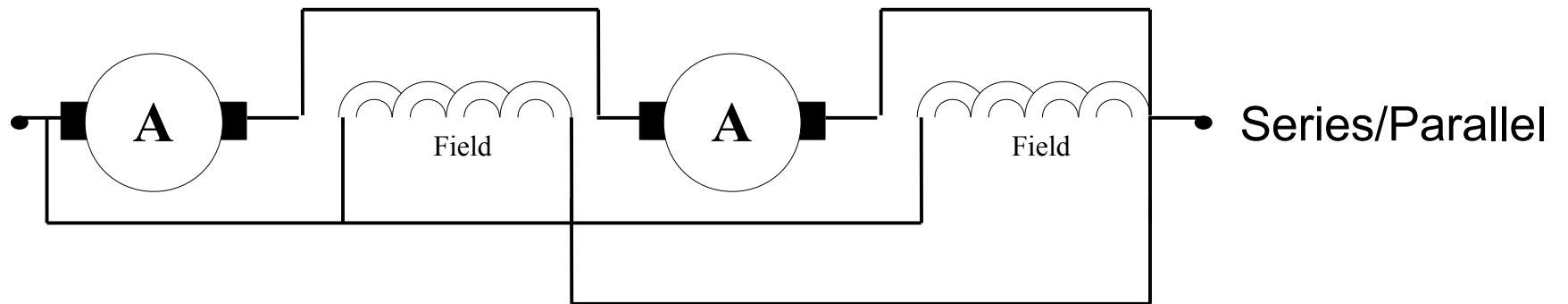
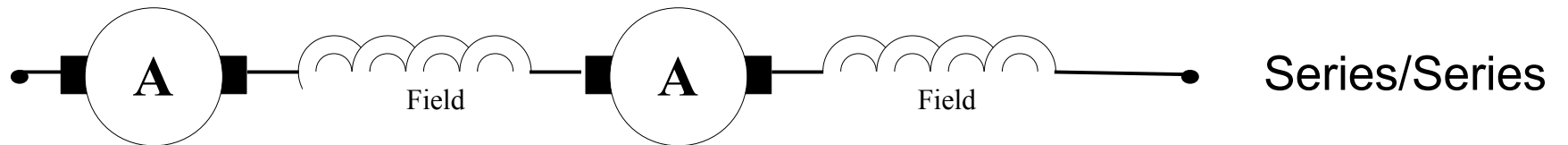
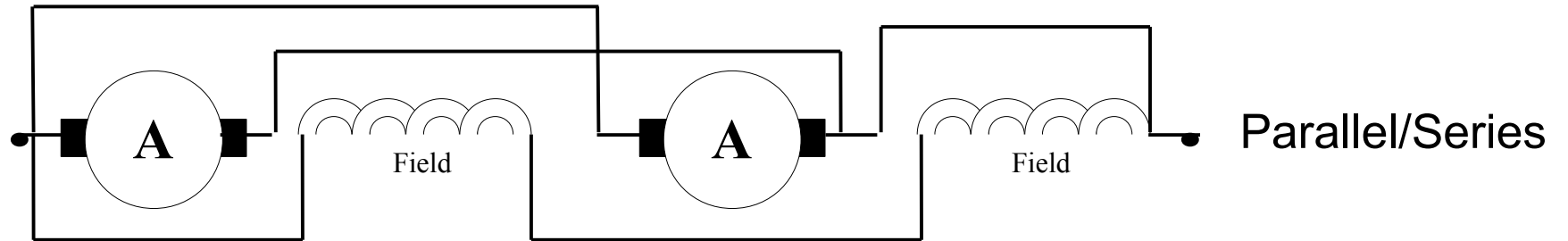
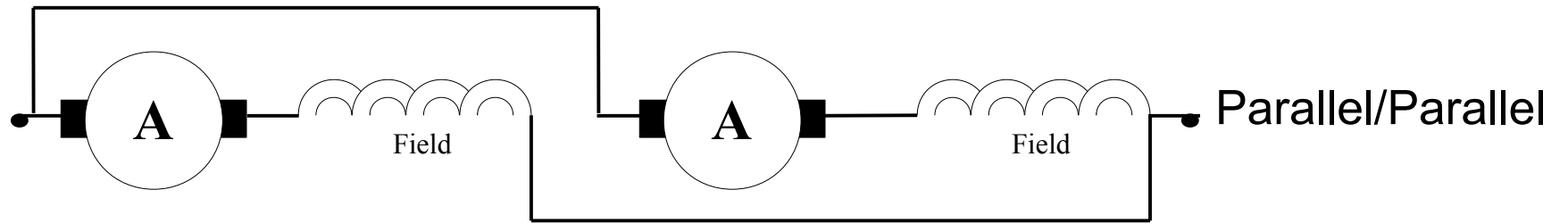
Wiring Method	Armatures Wired as:	Fields wired as:	Result (as compared to a single series wound DC motor)
1	Parallel	Parallel	Alternate wiring, both motors see full voltage and $\frac{1}{2}$ amperage. Torque is much lower, but RPM's are much higher resulting in higher HP – (100% field)
2	Parallel	Series	Very low RPM/volt, but 4X the torque as the field is at 200%
3	Series	Series	Normal wiring, both motors see full amperage and $\frac{1}{2}$ voltage, RPM's limited to $\frac{1}{2}$ of parallel/parallel wiring – (100% field weakening)
4	Series	Parallel	Higher RPM than parallel/parallel as field is weakened 50%. Torque is also $\frac{1}{2}$ of series/series – (50% field weakening)

For some of these wiring configurations you will need to know the field impedance – which varies by motor. This table is provided for your information.

Field Coil Resistance		
Model	Part #	Resistance
WarP 7 TransWarP 7	00-08207 00-08217	9.29 Milliohms (mΩ)
ImPulse 9	00-08259 00-08269 00-08249	3.29 Milliohms (mΩ)
WarP 9 TransWarP 9	00-08219 00-08309	3.92 Milliohms (mΩ)
WarP 11 TransWarP 11	00-08311 00-08711	7.80 Milliohms (mΩ)
WarP 11HV	00-08911	7.56 Milliohms (mΩ) 6.18 Milliohms (mΩ) (interpoles)

The normal air-gap is .060. The next page contains rough electrical diagrams for these wiring methods.

Dual Series Wound DC Motor Wiring



Selecting EV Components

The Vehicle

There are numerous factors to consider in trying to select the appropriate components for a particular conversion product, and they go hand-in-hand. The intended user of the vehicle should first define their intended application. Some people define “performance” as being able to achieve the greatest range with their vehicle. Others may define performance as achieving a particular speed in a specific time. It is important to determine what the performance goals are for a vehicle before choosing the vehicle. If someone is looking for range and chooses a vehicle for conversion that does not have room for batteries, they will likely be disappointed in the end result. Similarly, if someone is looking for the quickest 0-60 miles per hour time and selects a heavy vehicle they might also be disappointed. Knowing the performance expectations can help determine an appropriate vehicle for conversion.

An ideal vehicle is one that has the existing braking capacity, as well as the suspension capacity to handle the weight of the batteries and other components installed during the conversion.

It is advisable to measure the height to the top of each wheel opening on the vehicle before any conversion is undertaken. Ideally, this should be the height after the conversion is completed. Obtaining the proper ride height and suspension travel is crucial to the vehicles handling and safety. It may be necessary to have a company that specializes in suspension suggest alternatives after the vehicle has been converted.

In some cases a vehicle that is already owned is chosen for conversion simply because the customer already owns it. It may not be an appropriate vehicle, but the decision has already been made.

The Batteries

The rule-of-thumb when using lead-acid batteries for a conversion is that the vehicle will end up weighing about 1,000 lbs more than it did before the conversion and usually have a range of 20-30 miles. Certainly, some people have converted vehicles with 50+ mile ranges, but the extra range comes at the expense of carrying capacity. It is best to know and consider the effect of adding 1,000 lbs of weight will have on the vehicles handling and braking capacity.

Besides the weight of the lead-acid batteries, the voltage is known to sag severely during heavy amperage draw. Lead-acid (PbA) battery range may be cut in $\frac{1}{2}$ during cold weather. The typical life of PbA batteries is normally around 2-3 years in an EV application. The normal “starting” batteries used in ICE vehicles are generally not considered a good candidate for EV's as they usually cannot handle the heavy charge and discharge cycles. The most commonly used PbA battery are the gold-cart style batteries. But, these “flooded” batteries will require constant checking of the water levels, and they generally cannot deliver the amperage required in modern EV's. They will provide the best range of PbA batteries, their life can be 4+ years if properly maintained, but they are heavy.

Lighter and more powerful PbA batteries known as “absorbed glass mat”, and even better “spiral wound” batteries will provide higher amperage draws, but the range will typically be around $\frac{1}{2}$ of what the large flooded batteries will deliver, but these types of batteries can generally deliver higher amperage over a longer period than flooded type batteries.

Whenever economically feasible, Lithium Iron Phosphate (LiFe, or similar) battery chemistry should be considered. Besides the improvement in the amperage that can be delivered, the LiFe batteries are not nearly as sensitive to cold weather or high temperature, and the voltage does not sag as deeply under heavy amperage draw.

It is not unusual for someone to have a Li powered vehicle that has a 70-90+ mile range, and perform very well. In part the improved performance is due to the much lower weight of the Li batteries, but also due to their ability to supply high amperage.

The Controller

In most vehicles being converted a 1,000 Amp or higher controller should be considered. Certainly, 500 Amp controllers have worked well for many years, and since the older style PbA batteries may have only been capable of 300 Amps discharge, a 500 Amp controller was sufficient. Indeed, if a vehicle only requires 150 Amps to travel at its average speed, the use of a 1,000 Amp controller will not offer any advantages – EXCEPT at start-up! And, the difference between 500 Amps and 1,000 Amps at start-up can be quite significant with most motors capable of 4 times the torque at 1,000 Amps that they produce at 500 Amps. LiFe batteries exist today that can discharge 4,500 Amps, and the potential of these batteries is improving rapidly.

If you have a heavy vehicle, you need the higher amperage controllers. Often times, people think it is easier on a motor to only provide it 500 Amps rather than 1,000 Amps. Though 500 Amps will produce less heat than 1,000 Amps, you must take into consideration whether the amperage will provide the necessary torque the motor needs to start rotating. If the amperage isn't high enough to start the armature spinning, all of the 500 Amps will be split between just a couple of commutator bars. If the armature doesn't turn it is considered a stall condition, and the heat build-up can quickly cause a commutator bar to raise. A stall condition is not covered under warranty, and the condition is quite easily determined by the scorch marks 90 or 180 degrees apart on the commutator.

The speed that the vehicle will be able to obtain is determined (in part) by the voltage that is delivered to the motor – not necessarily by the voltage that is delivered to the controller. When a new off-shore manufacturer of controllers entered the market a few years back, we were swamped by calls from users of this new 120 Volt 1,000 Amp controller who could not get their vehicles over 30 MPH. Users naturally accused the motor of not being able to power their vehicle, when the actual cause of the problem was that the controller was only able to deliver 36 Volts to the motor. Volts = RPMs in a nearly linear manner with series wound motors. If the voltage to the motor doubles, the motor RPMs will double.

EV racers found it necessary to build 336 Volt + battery packs due to the fact that 12 Volt PbA batteries would sag to 5.5 Volts when 1,400 Amps were drawn from them. If the motors are capable of handling 168 Volts, and the PbA battery pack is 168 Volts nominal, then the motor would only see about 77 Volts when 1,400 was drawn from the battery pack. In order to deliver the maximum voltage to the motor, it became necessary increase the PbA battery pack voltage. As LiFe battery voltage typically sags far less under heavy amperage draws, the battery pack voltage need not be as high as a comparable PbA battery pack voltage.

The Motor

Matching all the components of an EV is a critical aspect of any conversion. Choosing batteries that can't discharge high enough current may mean that the controller won't be able to supply the motor with the amperage it may need for a particular job. Choosing a controller that can't supply the motor with the current it needs to perform will likely result in a conversion that doesn't meet expectations. Choosing a battery pack that is too low a voltage may limit the speed the vehicle is able to attain. Choosing a motor that is too small for a vehicle will lead to the motor heating up and being overworked and possibly leading to motor failure. Choosing a motor that is too big for an application may lead to the motor “lugging” which will normally result in commutation problems over time, and eventually to other motor problems.. For the best electric vehicle experience, it is essential that the electric motor be carefully sized to the vehicle for which it is intended. Simply using a “bigger motor” for a larger or heavier vehicle is not necessarily the best way to match components. Likewise, choosing a motor that is simply too small for an intended application is also likely to end up with an undesired result.

Many factors are used to determine which motor is suitable for the weight (and aerodynamics) of the vehicle to be

propelled and the speed which is to be maintained. There are some online tools which can tell you how a vehicle might perform under varying conditions, such as: <http://www.evconvert.com/tools/evcalc/> But, even excellent tools such as this cannot take all the various battery, controller, and motor options into account.

NetGain Motors, Inc. is will assist Authorized Dealers or their customers in trying to size the right motor for their particular application, however we prefer to provide the Authorized Dealer with the information so that they remain the primary point of contact with the customer. In order to assist Authorized Dealers in motor selection, we need to be provided with as much of the following pieces of information as possible:

- Battery Pack Information
 - Voltage
 - Internal resistance
 - Discharge capabilities
- Motor Controller
 - Voltage capabilities
 - Amperage capabilities
- Vehicle Characteristics
 - Vehicle weight (after conversion)
 - Top speed to be maintained on level terrain
 - Top speed to be maintained on grade
 - % grade
 - Gear ratios of transmission
 - Gear efficiency
 - Rear differential gear ratio
 - tire diameter
 - Type of tire/surface (i.e. rubber on concrete)
 - Coefficient of drag
 - Frontal area

It is possible that the customer will have unrealistic goals, objectives, or understanding of a technology they are unfamiliar with. It is unlikely that you could suggest a motor combination that would provide a 0-60 MPH of 2.9 seconds and a top speed of 250 MPH with direct drive in a 4,000 lbs vehicle at 48 Volts.

Direct driving a vehicle with an electric motor sounds simple, and it is the first thing that many people believe they want. However, to properly direct drive a vehicle considerations must be given to the safety of the vehicle and the workmanship of the conversion. A mistake in wiring a direct drive conversion leaves little room for mistakes. It is unlikely that the brakes of the vehicle would be sufficient to stop an electric motor receiving full-power. Without a manual disconnect (such as a clutch, or neutral transmission gear), it could prove extremely dangerous or fatal for the driver and occupants of the vehicle or even bystanders. There are benefits to direct drive, in that the normal transmission losses may be eliminated. This is useful when racing, but offers little benefit to a “daily driver” type of vehicle. Although direct drive works well for racing, it is not advisable for around town driving as the motors should normally spin 2000 - 4000 RPMs in order to properly cool. Forced air cooling is highly encouraged to help cool direct drive motors, as well as vehicles that are used in stop and go (around town) driving.

There are also significant drawbacks to the use of direct drive vehicles, beyond just the safety issue. Direct drive will normally require twice the motor and twice the controller of a vehicle with a transmission (a 2000 Amp controller rather than a 1000 Amp controller) Either a larger motor will be needed for direct drive, or a second motor which will add additional weight and consume additional space will be needed. This will normally offset the customer's expected savings of a direct drive configuration. Additionally, dual motors will require a more complicated wiring scheme in order to allow for reverse direction movement of the vehicle. Dual motor direct drive also decreases the overall electrical efficiency of the system slightly.

The motors enjoy spinning at 2,000 - 4,000 RPMs. You should always design your conversion so that the normal operating RPMs of the motor are within this range. You may accomplish this by modifying the gear ratios (transmission and rear differential) and tire diameters. In general, the electric motors prefer spinning about 1,000 RPMs higher per gear than the original internal combustion engine did. Dual motors do, however, allow for alternative wiring schemes (series/parallel) that allow greater flexibility and performance.

If you have a transmission, you can usually double the weights normally associated with a single motor direct drive. The following table may be used as a general reference, but may not be applicable to all situations. The frontal area, and coefficient of drag greatly effect power requirements with speeds greater than 45 MPH. The gradient, gear ratios and surface of the road will have a significant effect on the vehicles ability to perform as expected.

Direct Drive Motor Selection⁹			
Motor	Vehicle Weight	Dual Coupling Motor	Vehicle Weight
TransWarP 7	1,400 lbs	WarP 7	2,800 lbs
TransWarP 9	1,750 lbs	WarP 9	3,500 lbs
TransWarP 11	2,100 lbs	WarP 11	4,200 lbs
TransWarP 11HV	1,900 lbs	WarP 11HV	3,800 lbs

The use a transmission allows you to double the figures of the first table:

Transmission-ed Vehicle Motor Selection	
Motor	Vehicle Weight
WarP 7	2,800 lbs
WarP 9	3,500 lbs
WarP 11	4,200 lbs
WarP 11HV	3,800 lbs

Though figures from both tables are considered conservative, you must consider the additional load placed on the vehicle by the weight of the vehicle operator and passengers. Pulling or carrying an additional load is not considered in these figures.

The motors enjoy 120-156 volts, no higher than 170 to the armature – though people utilizing the motors for racing are, in some cases, providing the motors with 192+ Volts. The battery pack should be as stout as the controller can handle as the voltage will sag to 6-7 volts a battery when drawing 1000 amps at start-up (from lead-acid batteries, Lithium will also sag, but not as significantly, generally around 20-25%). With series wound DC motors, **Volts = RPMs** in a linear manner - double the volts and you double the RPMs (hence the need for a stout battery pack). **Amps = Torque**. The motors will draw all the amps they can to start spinning (max torque at stall). Amps and Torque are a non-linear relationship – doubling the amperage will quadruple the torque until saturation of the motor occurs.

⁹ Direct Drive assumes that a differential with additional gearing is being utilized.

Motors may be stacked, or combined inline with one another in order to handle additional loads.

Driving an EV

People who are new to driving EV's should understand a few of the basic differences between the ICE vehicles they are used to driving and EV's. Whereas the typical ICE develops horsepower and torque as the RPMs increase, the typical series wound DC motor produces maximum torque at stall. Thus it is possible to start a vehicle from a dead-stop in 2nd or 3rd (sometimes 4th) gear! Of course it is easier on the electric motor to start in a lower gear, and the motors enjoy being run in the 2,000-4,000 RPM range, so choose your gear appropriately.

Never try to “hold position” on an incline with your electric motor. If someone is stopped at a stoplight on a hill and tries to hold position using the electric motor, it is possible that a “stall condition” could occur and damage the electric motor. It is highly encouraged to use the brakes to hold position rather than the electric motor.

Don't try to move the vehicle forward if the motor is spinning in the reverse direction. In other words, if you are rolling backwards, make certain the motor is stopped before applying power to move forward. This only pertains to direct drive vehicles. In vehicles with a transmission the electric motors are not affected by the direction or movement of the vehicle. But, even if you have a transmission, it is far easier on the motor if the vehicle isn't rolling backwards.

You may be able to pass a vehicle quicker by up-shifting with an electric motor powered vehicle, rather than down-shifting as is normal in ICE vehicles. When an increased load is placed on the electric motor (such as by up-shifting), it will draw greater amperage and produce greater torque and allow quicker acceleration.

It is not necessary to “rev” the electric motor when moving from a standstill. The electric motors torque curve actually decreases as the RPMs increase, so you may have better performance by not revving the electric motor. Of course, if a clutch is used, the electric motor can certainly be revved to allow easy acceleration as was normal with the ICE. But, it is not required – may be useful on hill starts, but normally not required.

Choosing the right gear for a given speed can take some time to determine. Though not necessarily the optimum, it is “generally” best to run the electric motor at about 1,000 RPMs higher per gear than when the ICE was used. The motors prefer to spin 2,000 to 4,000 RPMs to properly cool themselves. If running below 2,000 RPMs for extended periods, or in stop and go traffic, a forced air blower can be utilized to cool the motor, and can make a significant difference in motor temperature. To determine whether you are in the correct gear, you may need to up-shift and down-shift for awhile till you find the gear where the motor is spinning in the 2,000 to 4,000 RPM range, AND, the amperage draw is the lowest.

EV Routine Maintenance

In addition to the “normal” maintenance that may be required on any vehicle you own or operate, some special considerations must be given to electric conversion vehicles. It is critical that some routine maintenance be performed on your electric vehicle. Whether your vehicle is a daily driver, a race vehicle, a boat, or any type of electric vehicle, you must perform some routine maintenance to ensure long life of your components and continued operational safety.

The exact routine will vary by the type of vehicle, the components utilized, and the use of the vehicle. For instance, if you have a vehicle that utilizes flooded lead-acid batteries, you will need to check the water in the batteries on at least a monthly basis. Regardless of the type of batteries you are using, you should plan on checking the tightness of all electrical connections on some regular basis. A loose or corroded connection can cause loss of power, or arcing and sparking that could prove hazardous! Arcing and sparking can lead to a fire, so it is strongly encouraged that an appropriate fire extinguisher be readily accessible in your electric vehicle.

We highly encourage the use of Nord-Lock (<http://www.nord-lock.com/>) lock washers wherever suitable! This includes all motor terminals, as well as all battery connections. This is even more critical when the EV is used near salt water. The Nord-Lock washers are corrosion resistant. Their standard steel washers are zinc flake coated with Delta Protekt® and endure a minimum of 600 hours of salt spray test in accordance with ISO 9227.

If you have a racing vehicle, it is important to use compressed air after EVERY race event in order to help expel carbon dust that accumulates. This is important with all brushed DC motor vehicles. Blowing out the carbon dust is required and reduces the possibility of a ground to the frame through the electric motor or an internal shorting or arcing situation.

You should protect the electrical connections and the motor from environmental contamination, such as salt spray, that could corrode components and/or damage the motor. Contaminants, such as dust, will act as an abrasive on the brushes and commutator. Dust can even be sucked through the motor and wear the internal insulation and even cause internal arcing to occur. We highly encourage the use of forced air blowers and air filters on most motors. If you do not use a filter and blower to protect your motor, you should consider a shroud of some sort to help avoid road debris from entering the motor. It is safe to use an oiled rag to wipe down and remove dirt from the motor case.

Remember, NEVER use silicone around brushed DC motors. This includes silicone fumes. Silicone can cause the rapid degradation of the brushes used in brushed DC motors and also lead to damage of the commutator and other motor components.

Special Updates and FAQs

Special Update

Date: April 13, 2005

To: All **WarP™ Motors** Dealers
Motor Wiring

Several sources have recently inquired as to what the proper method was for wiring the terminal lugs on the cases of **WarP™ Motors**. This **Special Update** clarifies the proper wiring method.

All **WarP™ Motors** cases have four terminals, **A1, A2, S1, S2** stamped on the case at the factory. Motors are designed to normally operate in **C**ounter **C**lock **W**ise rotation at the **D**rive **E**nd (**CCWDE**) for forward vehicle operation. When a motor is specified as “advanced timing”, it is assumed to be relative to the normal **CCWDE** rotation. Motors that do not have advanced **CCWDE** timing may be wired for **C**lock **W**ise rotation at the **D**rive **E**nd (**CWDE**). These instructions should help clarify the proper wiring method for both rotations.

WarP™ Motors (except the **WarP 13™**) should ALL be jumpered according to these instructions (battery polarity does not matter):

For **CCWDE** rotation wire as follows:*

CCWDE preferred connection method:

Connect **A1** to **S1**

Connect **A2** to one input power terminal and **S2** to the other input power terminal

CCWDE alternative connection method:

Connect **A2** to **S2**

Connect **A1** to one input power terminal and **S1** to the other input power terminal

For **CWDE** rotation wire as follows:

CWDE connection method:

Connect **A1** to **S2**

Connect **A2** to one input power terminal and **S1** to the other input power terminal

CWDE alternative connection method:

Connect **A2** to **S1**

Connect **A1** to one input power terminal and **S2** to the other input power terminal

Motors that have “advanced timing” for **CCWDE** rotation should not be run in **CWDE** mode. Doing so may damage the motor and void the warranty.

Dealers may request a motor be timed advanced for **CWDE operation by specifying this on their Purchase Order. This will be considered a “Special Order” and may involve an additional cost.*

Special Update

Date: October 24, 2006

To: All **WarP™ Motors** Dealers

TransWarP 11™ Motor Wiring

Normal wiring for Counter Clockwise Rotation when viewed from the Drive End (CCWDE) of a **WarP™**, **Impulse™** or **TransWarP 9™** Motor is: A1-S1 or A2-S2.

However, on the **TransWarP 11™** the wiring for CCWDE is: A1-S2 or A2-S1. For CWDE the wiring on these motors is A1-S1 or A2-S2.

Additionally, all of the NetGain Motors, Inc.. 11-inch and 13-inch motors incorporate a 150° C snap switch. Other motors utilize a 120° C snap switch.

Wiring information for other **WarP Motors™** may be found in the **Special Updates** dated 04/13/2005 and 03/01/2006.

You may locate copies of these and all other **Special Updates** on our Web Site at:

http://www.go-ev.com/dealers-only/Dealer_Manual

All motors produced in 2007 will incorporate 2 lifting holes to aid installation. These holes will be positioned 90 degrees apart in order to allow better positioning of the terminal studs.

Broken fins, which occasionally occurred on **Impulse 9** and **WarP 9** motors due to the placement of advanced timing holes, will now be machined during assembly.

Dealer input is always welcomed, if you have any suggestions on how we might improve our motors, please contact us!

You may locate copies of these and all other **Special Updates** on our Web Site at:

http://www.go-ev.com/dealers-only/Dealer_Manual

Special Update

Date: February 13, 2006

To: All **WarP™ Motors** Dealers

Heat and RPM Protection Bulletin

Throughout the year we have had inquiries about the effects of heat and RPM's on **WarP™ Motors**. This **Special Update** summarizes many of our conversations with individual dealers and shares the same knowledge across our entire dealership network. As in our other **Special Updates**, this information does not cover every aspect of the motor's usage. If you have a situation that you are unsure about, please call someone that has the expertise or seek more detailed information. Please act responsibly and protect yourself and your customer from personal harm or damage to the motor.

Motor Heat

1. All **WarP™ Motors** are rated over Class H, which is 180 degrees C, but one still needs to protect the motor from overheating
2. If you are using your motor for drag racing, with 10-20 seconds of high load, the brushes and comm will heat up faster than the other parts of the motor. To protect your motor in this case, measure temperature in the brushes and the comm surface area using an infrared device that can react quickly. Heat can build very fast, as you would expect and may already know!
3. If your motor is used for normal vehicle travel, the ends of the pole shoes and the motor case by the shoe bolts will generally be the area of greatest heat build up. To protect your motor in this area, the normal temperature snap switch is installed. Connect it to give the driver a warning light or to automatically open the circuit if it indicates overheating. Heating will build slower here, but fast action needs to be taken to protect the system.
4. Consider setting a temperature of 110-120 degrees C for your action starting point as a safe way to manage a potential overheating situation.
5. Lastly, always ensure that sufficient and proper air circulation through the motor is not impaired!

Motor RPM

1. All **WarP™ Motors** have commutators that were tested to over 8,000 RPM, but that does not mean they can be run at that speed indefinitely!
2. Most motor commutators built now are composite. Steel commutators were used in the past, but are now made for custom orders and very expensive. Steel core commutators are generally able to withstand higher RPM speeds.
3. We like to encourage safe speed ranges from 2000- 3500 RPM, even though we know some of our **WarP™ Motors** are peaked around 5,500 RPM for small intervals of time. When working with a customer, please be sure to design gearing so that the customer gets the speed he wants, but the motor will not be at a high RPM band for long periods of time.
4. Lastly, utilize one of the many ways available to protect the motor from exceeding 8,000 RPM and make sure it is installed and working properly. It just needs to work once to pay for itself, save the motor and protect all the people around the vehicle!

Special Update

Date: February 15, 2006

To: All **WarP™ Motors** Dealers
Care and Maintenance

This **Special Update** summarizes many responses we have given to dealers and customers alike about motor care and maintenance. As the sphere of users continues to grow for electric motors used in vehicles, knowledge about motors needs to be communicated to all those users across our entire dealership network. As in our other **Special Updates**, this information does not cover every aspect of the subject.

Here are a few simple steps one should take to make the **WarP™ Motors** give years of great performance.

1. Protection from the elements is important. Utilize good design concepts and materials to protect the motor from rain, snow and ice.
2. Design the motor mounting area to allow for good air flow. The motor needs a continuous supply of clean fresh air to cool properly.
3. Protect the motor from “dirty air” that may be used to cool it. Most airborne grit will act as an abrasive, which will eventually cause harm to the internal parts of your motor.
4. Clean the brushes and comm area regularly from the dust/dirt that occurs during normal operation.
5. Regularly check connections, voltages, tolerances and alignment to assure they are within normal specifications.
6. If you suspect or question the motor's operation, immediately shut it down. Record any visual signs, audio sounds or scents at the time and ask an expert for an opinion prior to operating the motor again.
7. Always operate the motor within the normal safety ranges for voltage, amperage, temperature, and RPM
8. Follow all the safety rules available to you.
9. Remember your motor will take care of you, if you take care of it.

Special Update

Date: January 1, 2009

To: All **WarP™** Motor Dealers
Motor Troubleshooting

The Dealer's Manual, and the Owner's Manual that is included with all new motors, includes a bench test and safety procedure for motors. A copy of the Owner's Manual may be found under the Dealers Only area of our web page (<http://www.go-ev.com/dealers-only>) Look under Section V – End User Supplements -> Owner's Manual.

We occasionally receive end user questions asking whether their motor is operating correctly. Seldom is the problem in the motor. Usually, the problem is somewhere else in the wiring, the controller or operation of the vehicle.

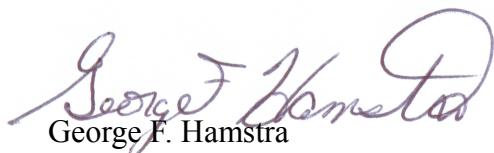
For example, we receive calls from people who indicate that at full throttle the vehicle will only accelerate to 30 MPH. The first thing to check, if the customer is using the typical 0-5K potentiometer is whether the potentiometer is actually functioning properly. A potentiometer that only puts out 2K ohms when fully depressed will limit the speed of the vehicle.

We also receive numerous questions from customers who are interested in the motor's performance at higher voltages – other than the 72 Volts found in our graphs. Voltage affects the motor's RPM's in an almost linear manner. Doubling the voltage will double the RPM's of the motor. Usually, the increase is slightly more than double since most losses occur at start up or are fixed. Amperage affects the torque of the motor – but in a non-linear manner. If the amperage is kept constant, and the voltage is doubled, the motor will produce the same torque, but at twice the RPM's.

The following information may be of interest to you or your customers in troubleshooting electric vehicles. The Owner's Manual will also be updated in order to include this information for your customers.

Feel free to contact us with any suggestions, additions or recommendations you may have concerning our motors.

Sincerely,



George F. Hamstra

Series Wound DC Motor Troubleshooting

Safety Considerations

Caution!!! Before working on the control, control circuits, motor, motor circuits, battery and any circuit or circuits of an electric vehicle, be aware of all applicable safety considerations.

The following is a list of some typical safety guidelines for working on electric vehicles – the list does not consider every possible safety aspect. If you are unsure about something you should contact someone knowledgeable. And, as always – use good judgment and common sense!

Caution!!! This list may not be complete for the electric vehicle you're servicing.

Typical Safety Checklist

- Remove all metal jewelry and metal objects from hands, wrist, fingers, etc. before working on any electric vehicle.
- Use only an industry approved battery lifting device for removing and installing electric vehicle batteries.
Do not use a chain!!!
- Make sure the vehicle is positioned securely with the drive wheels safely clear of the floor and blocked up so that the drive wheels cannot make contact with the floor under any circumstances. Block the non-drive wheels that remain in contact with floor so that the vehicle cannot roll in either direction. Guard the drive wheels to protect personnel.
- Before troubleshooting or working on an electric vehicle, disconnect the battery pack and discharge all capacitors. Reconnect the battery only as needed for specific checks or tests.
- Make sure you know where the closest functioning eye wash station is before working on or testing the battery pack.
- Do not defeat any safety circuits or safety devices.
- Pushing in any contactor while the battery pack is connected can cause injury, property damage, and/or death.

Caution!!! Under no circumstances should you push in any contactor of the electric vehicle while the drive wheels are in contact with the floor. Pushing in a contactor when the drive wheels are in contact with the floor can cause property damage, personal injury, or death.

Voltage Measurement

These readings must be taken with the throttle at full-speed – make certain all safety precautions are in place before beginning.

1. Record voltage reading at battery pack half of the battery connector. _____ V_b
2. Record voltage reading at motor from terminals S1 & S2. _____ V_s
3. Record voltage reading at motor from terminals A1 & A2. _____ V_a
4. Add readings from steps 2 & 3 to get motor voltage. _____ V_m
5. Subtract motor voltage V_m from battery voltage V_b , and record the value. _____ V_d

The voltage difference V_d should be about 0.5 volts with the drive wheels off the floor running at full speed. (Approximately 100 amps of motor current)

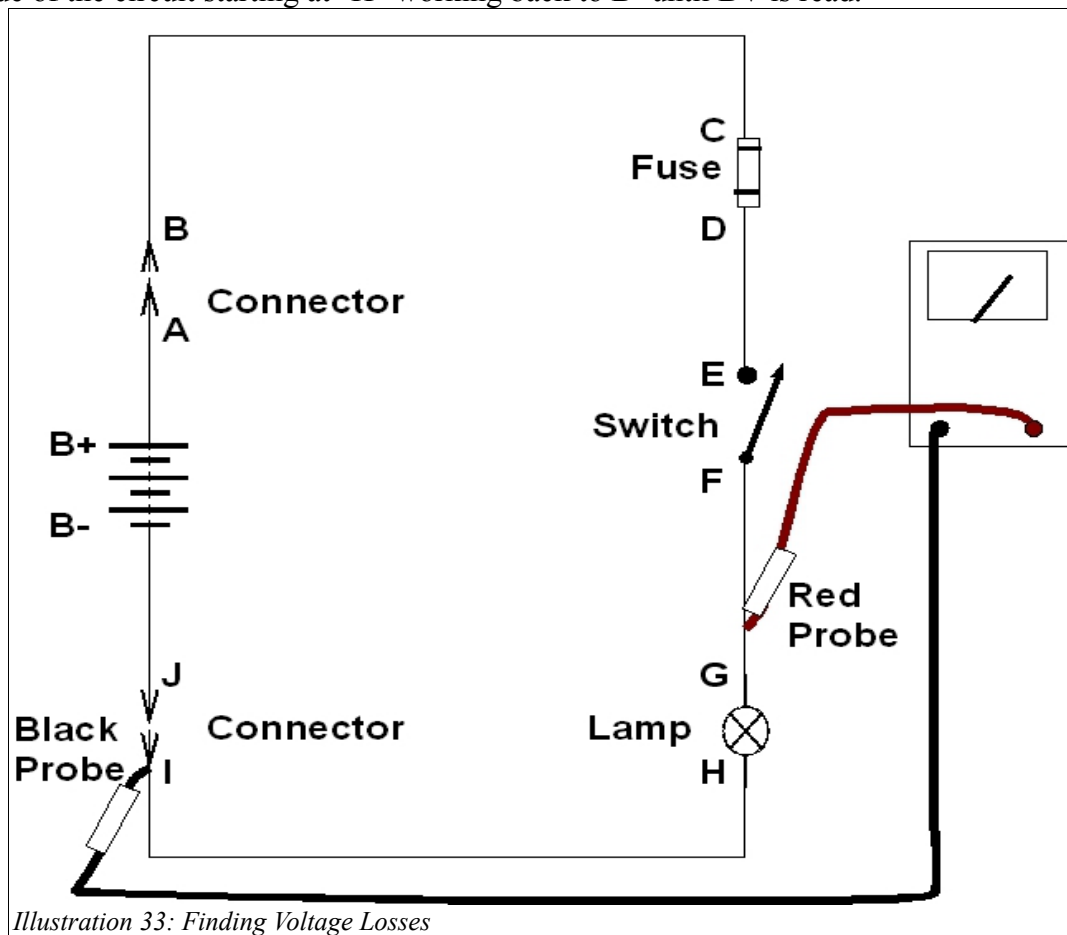
Finding Voltage Losses

A voltage loss is a voltage drop that appears across a wire, cable, connector, contactor tips, or other electrical item that normally has virtually no losses. These losses can prevent a contactor from working properly, a motor from running at full speed, a lamp from shining at full brilliance, or improper operation of other electrical components.

Note: An unwanted voltage drop can occur on either the positive or negative side of the circuit. Therefore both sides of the circuit may have to be checked to locate the voltage drop.

One way to find a voltage drop is to use a schematic and a voltmeter to trace around the "live" circuit, first on the positive and then if necessary on the negative side. See example below.

1. Start by connecting the Black lead of the meter to B- at the battery.
2. Then touch the Red lead to point "G", the positive side of the load.
3. The reading at "G" should = battery voltage BV. If it does, go step (6). If it does not go to step (4).
4. If the voltage at "G" is less then BV probe back to "F", then "E" and so on until BV is read.
5. In this example if the voltage at "F" is less than BV but the voltage at "E" is BV, then the switch is defective.
6. If the voltage at "G" in step (3) equaled BV then C, then connect the Red lead to B+ and probe the negative side of the circuit starting at "H" working back to B- until BV is read.



FAQ's

Last updated: October 25, 2011

Welcome to the **NetGain Motors, Inc.** Frequently Asked Questions (FAQ). This document will attempt to answer many of the questions that we are asked related to our products. It is not intended to provide answers to all your questions. We suggest you contact one of our Authorized Dealers for further assistance and guidance.

1. Where did the **WarP** name come from?

We are not “trekkies”, but we do enjoy *Star Trek*. However, that had very little to do with the original name selection for our motors. The name was a natural way of differentiating our motor series, and also showed that we intended on incorporating new and advanced thinking in the enhanced designs of the motors we planned on building. The “**War**” portion of the name comes from **Warfield Electric**. Jerry Warfield was instrumental in our original designs (and subsequent designs, as were John Wayland and numerous others...). The capital “**P**” at the end of the name is also significant. It stands for “**Phil Brown**”, a close friend and supporter of our original electric dragster concept vehicle. Unfortunately, Phil was taken by cancer prior to the project gaining momentum. We intend to maintain this method of honoring **Phil** in the naming of our **ImPulse**, and **TransWarP** motors as well. As the **ImPulse** motors are the least powerful of our motors and the **TransWarP** motors utilized a transmission style armature shaft, the TV series names were a natural fit and also allowed us to use the capital “**P**”.

2. Which **WarP** , **ImPulse** , **HyPerDrive** or **TransWarP Motor** should I use?

The answer to this question depends upon MANY factors! We would be happy to discuss which motor we feel meets your needs the best, and to run your requirements through our motor selection software. The first question you should ask is: What is the intended purpose of the vehicle? Will it be used as a “daily driver”? Will it be used strictly for racing? Will it be a performance vehicle, or will it be designed for greatest range between charges? In addition to knowing the answers to these questions, you should have some realistic thoughts relating to:

- | | |
|---|-------|
| 1. Top speed to be maintained on level terrain | _____ |
| 2. Top speed to be maintained on grade | _____ |
| 3. Percent grade the vehicle will travel on | _____ |
| 4. Wind resistance (frontal area) of the vehicle | _____ |
| 5. Total vehicle weight (with driver/passengers/load) | _____ |
| 6. Final gear ratio | _____ |
| 7. Tire Diameter | _____ |
| 8. Voltage to be supplied to the motor | _____ |
| 9. Coefficient of drag | _____ |
| 10. Battery internal resistance | _____ |

3. What is the difference between **WarP**, **ImPulse** , **TransWarP**, and **HyPerDrive** motors?

The **ImPulse** line of motors were designed to be lower power and/or shorter motors than our traditional **WarP** series motors. The **ImPulse 9** is shorter than a **WarP 9**, and is less powerful. However, it is more powerful than the 8” diameter motor it was designed to replace. In addition to being more powerful than an 8” motor, it shares many of the beefy components of the **WarP 9** motors (commutator, bearings, brushes, etc.). The **ImPulse 9** also has the same bolt pattern and mounting characteristics of an 8” motor. The **WarP** motors are

our most common motors. The **WarP 9** and **WarP 11** were designed to be interchangeable with one another. The **WarP** motors are the most common motors we make for EV conversions. The **TransWarP** motors were designed to meet the needs of direct drive, racing applications, as well as being used by **EMIS**. The “rule of thumb” when dealing with direct drive is that #1 it is not good for use as a daily drive #2 it will require twice the motor and twice the controller of a vehicle with a transmission.

Our latest offering is the **HyPerDrive 9** motor. This is actually two specially race prepped **WarP 9** motors with different shafts, bearings, brushes, brush rigging, etc. than our normal **WarP 9** motors. The **HyPerDrive 9** is two motors that are designed to be fitted together and work as a single motor. The “**Pe**” portion of the name is my thanks to Mike **Pethel** who helped push for the development of this radical design. A dual commutator version of our popular **WarP 11HV** named the **HyPerDrive 11** will soon join the product line.

4. How do I become a dealer of **WarP Motors** ?

You should visit our Web Page (<http://www.go-ev.com>) and print a copy of the **Dealer Application**. Fill out the form completely and FAX or Email it back to us. You must have a valid existing business with a state resale sales tax number in order to even begin the process. We also consider proximity to other Dealers, experience converting vehicles to electric, and other factors, web only Dealers will no longer be considered.

5. What is an ICE, what is an EV, Hybrid?

ICE stands for Internal Combustion Engine. EV stands for Electric Vehicle. A hybrid vehicle is one that uses a mixture or combination of technologies to propel the vehicle. Hybrids are generally one of two types: series or parallel. A parallel hybrid uses multiple, possibly combined, means of powering the vehicle, while a series hybrid generally uses a source to produce electricity in order to power an electric motor that actually drives the vehicle.

6. What do the abbreviations "**DE**" and "**CE**" stand for?

"**DE**" stands for "**Drive End**". This is the end of the motor that usually contains the fan and usually has a larger diameter shaft. "**CE**" stands for "**Commutator End**". This is the end of the motor where the brushes and commutator are. Motors that are specified as "no **CE** shaft" do not have a shaft extending from this end. "**CE**" is also the abbreviation used by Dennis Berube for his world record holding electric dragster: Current Eliminator.

7. What do the abbreviations "**CCW**" and "**CW**" mean?

"**CW**" stands for "**ClockWise**" rotation and "**CCW**" stands for "**Counter-ClockWise**" rotation. These abbreviations are normally used in conjunction with "**DE**" and "**CE**" to indicate the perspective of the armature rotation. For instance: "**CCWDE**" would indicate Counter-ClockWise rotation when viewed from the **Drive End** – this is the default for all **WarP Motors** with the exception of the TransWarP 7 which is neutrally timed from the factory (but may be ordered with advanced timing. **CWDE** would indicate "ClockWise rotation when viewed from the **Drive End**. Most vehicles require **CCWDE**, however, some vehicles (i.e. Honda transmissions) may require **CWDE**. You should verify the rotation prior to ordering as the timing can be requested to be advanced timed for the rotation of the motor.

8. What is "**Timing**" on an an electric motor?

Timing an electric motor refers to the area of the commutator that is being energized has been moved from a normally centered position. Normally, brushes are fixed into a position on the commutator during the manufacturing process. The position they are normally set at from a manufacturer is a "neutral" position. A

"neutral" position allows the motor to operate and perform almost identically in **CCWDE** and **CWDE** rotations at normal voltages. A normal voltage for most series wound motors in a neutral timed arrangement is generally less than 96 volts. Above this voltage motors should almost always be advanced in the direction of their normal rotation in order to reduce arcing, improve RPM's, and to provide increased performance at higher voltages. **CAUTION: If a motor is advance timed and then powered to run in the opposite direction of the advancement, significant arcing and damage could result if high power is applied! Regen should not be attempted with motors that have been advance timed!**

9. How do I know how much to advance the timing on a motor?

All new **WarP Motors** have pre-drilled holes that allow the commutator end-bell to be removed and the brushes repositioned in a neutral, or an advanced position, either **CWDE** or **CCWDE**. The **WarP Impulse** and **TransWarP Motors** are each advanced ~12 degrees. The **WarP 8** motor is advanced ~10 degrees. The amount of advancement is based upon the width of the brushes, the number of commutator bars, the diameter of the commutator and various other factors that are monitored when the motor is run on a dynamometer. The proper terminology used to describe an advanced timed motor would be "advanced timed, **CCWDE**" or "advanced timed **CWDE**". The term "retarded" that is often used to describe the timing of **ICE** (Internal Combustion Engine) vehicles is not applicable to electric motors. In order to change the timing, you may simply loosen 4 bolts and rotate the bell housing in the direction you desire to advance the timing from the neutral position. All of our motor cases are stamped with "CW" "N" and "CCW" - you can determine the advance state by seeing which commutator **end bell bolt (NOT the terminal studs!)** is aligned with the letters stamped in the case.

10. How can I order **WarP Motors**?

WarP Motors may only be ordered through an Authorized Dealer. A list of Dealers is available on our web page at <http://www.go-ev.com>

11. What if I need something other than the "standard" motor?

NetGain Motors, Inc. will work with our motor manufacturer – Warfield Electric in order to ascertain your specific needs and develop a motor to meet your needs. Custom motor options, such as special materials, components, shaft splining, special composition brushes, or other variances from standard configurations are available at an additional cost. Contact **NetGain Motors, Inc.** with your needs and we will provide a quote.

12. Where can I get replacement parts for my motor.

Replacement parts and components can be ordered through any Authorized Dealer.

13. Can I put an alternator or generator or windmill or solar panels on my vehicle to keep the battery charged?

In brief: "NO"! We receive this question on almost a daily basis! If you figure out a method of actually getting more energy out of something than you put into it – please let us know immediately! To date, no one has figured out how to accomplish this feat – and though you aren't going to receive a ticket for trying, there are certain laws that you would be in violation of. Though windmills and solar cells may certainly be used to help charge batteries, most of the motors we sell are for use in vehicles that can draw between 340,000 watts (for a short time), and 15,000+ watts at highway speeds. If you have the time and plenty of sunlight and wind, these resources could certainly replace at least some of the energy consumed – just not as fast as people generally use it, or as quickly as you may want.

14. Can I use your motors in marine applications?

Certainly, but don't submerge them, and protect them from saltwater. Also, pay particular attention to the previous question. It is extremely difficult to create a watercraft with 10-12 hours worth of wide-open power with generally available battery technology. Fresh water should be used to spray off any saltwater that may get on the motor.

15. What are the two wires that come out of the motor case and how do I use them?

These wires are connected to a normally closed 120C thermal switch. On 11" and 13" diameter motors a 150C thermal switch is used. This switch is used to determine whether a motor is nearing a temperature that could cause internal damage to the motor. Some people refer to this switch as a "nuisance switch". We do not suggest that this switch be used to automatically disable the motor if a heat condition arises as circumstances may require driving the vehicle to a safe area before shutting down. Some people use this switch to keep a contactor open by applying 12-volts to the switch. If the voltage is dropped (by the switch opening), then a light could be lit, or a buzzer sounded to indicate a potential problem exists. The two wires were changed to a recessed plastic connector that has two 1/4" mail spades. This makes it extremely easy to connect with. Additionally, the Normally Closed (NC) switch has been replaced with a Normally Open (NO) switch. This also makes it simpler to wire a warning indicator. We have also changed from two wires to black plastic spade connector terminal to make it easier to make your connections.

16. What is the round black connector on the commutator end bell used for?

Some motors may have been made with a brush wear indicator. If you look carefully into the connector you will see that the round black connector actually accepts flat, female, tab connectors. When the brushes wear to a point where the brush wear indicator wire touches the commutator, **a voltage equal to the commutator voltage will be fed through the brush wear indicator connector**. As this could be a high voltage, appropriate care should be given if this connector is used. Once the brushes wear to the point where the wire touches the commutator surface it is necessary to replace the brushes quickly or damage to the commutator could occur from the indicator wire. This feature has been removed from most motors as it was difficult to use the pack voltage for an indicator.

17. What are **TransWarP Motors**?

The **TransWarP Motors** are not a motor with a transmission. Rather the Drive End (DE) of the **TransWarP Motors** have a 1.375", 32-tooth, involute splined shaft that matches a Chevrolet Turbo 400 transmission output shaft. The drive end bell has been pre-drilled to accept an optional "shorty" tail-shaft housing. The output shaft accepts an optional industry standard 1350 series slip-yoke for easy connection to almost any manufacturers drive-shaft (with matching 1350 series yoke. The commutator end shaft has also been increased in size to 1.125" with a 1/4" key-way. This allows easy coupling of **WarP Motors** to **TransWarP Motors**. These motors were designed to be part of the **EMIS System** also available from **NetGain Motors, Inc.** You can couple a **WarP Motor** to a **TransWarP Motor** of the same size for direct drive applications.

18. Can I direct drive my vehicle using your **TransWarP Motors**?

Our motors like to spin 2000-4000 RPM's. Running the motors at very low RPM's will generally draw significant amperage and not allow the fan to cool the motor. Direct drive works well in racing applications, however it is not the best choice for a daily street driven vehicle. The generally accepted rule of thumb is this: Direct drive will require twice the motor and twice the controller of vehicle with a transmission. This means you would have to use a **WarP 9** coupled to a **TransWarP 9** in an application where a single **WarP 9** would normally suffice if a transmission was used. Additionally, if a single **Zilla 1K** controller could have been used, you will need a **Zilla 2K** for a direct drive application. Additionally, you must force cool air into direct drive motors if the normal RPM's of the driven vehicle are below 2000 RPM's.

19. How do Volts and Amps affect a motors performance?

VOLTS=RPM's in an almost linear manner. If you double the voltage you will double the RPM's of the motor. Usually, RPM's increase just slightly more than double as most losses are fixed. You will notice that the performance graphs for our motors are all at 72 Volts. If you plan on running at 144 volts you can simply multiply the RPM's by 2. AMPS=Torque. Torque will remain constant if the amperage does not change and only the voltage is varied. If you look at our 72 Volt graphs and find a ft. lbs. of torque and the amps required to produce that torque, you can simply double the RPM's if you are planning to run at 144 volts, - the torque will be produced at twice the RPM's if the amperage doesn't change. If you increase the AMPS, the torque will increase, but in a non-linear manner that is difficult to extrapolate. If you increase the voltage you will basically extend the torque curve of the motor.

20. What voltage and amperage should I run at?

Your budget and performance expectations will normally be the deciding factor, but generally speaking you should consider a voltage between 120 and 156 volts to the motor armature. Motors should never see more than 170 volts to the armature. However, the battery pack voltage should be as high as the controller will allow if using lead-acid batteries. You should generally have a higher pack voltage (ideally) than the motor voltage due to a condition referred to as "voltage sag". When most lead-acid batteries are required to deliver 1000-2000 Amps the battery voltage can easily sag to 5-5.5 volts per battery. Lead-acid batteries have been known to explode during racing applications from heavy discharges – a credit to the **Zilla** controllers! However, if the voltage of a 12 volt battery sags to 6 volts, the motor will only see ½ the voltage you intended, and consequently only spin at ½ the RPM's you thought it should!

21. What motor controller should I use with these motors?

Prior to the advent of the **WarP-Drive** and **Soliton** controllers, the only controller that was **ever** suggested in a pure electric vehicle application by **NetGain Motors, Inc** was the **Zilla** Controller from <http://www.cafeelectric.com>! The two most popular controllers as of the date of this FAQ are now the **WarP-Drive** by ngcontrols.com, and the **Soliton 1** by evnetics.com. Both of these controllers are highly regarded and we suggest they be considered in new EV conversions, or as replacements for older style controllers. You may certainly use other controllers, such as the ever popular **Curtis 1231C**, **Raptors**, **T-Rex's** and **Logitech Systems** – just to name a few of the more popular and highly regarded EV controllers. Due to the communications necessary in the **EMIS System**, **Alltrax** brand motor controllers are required in this application, no other controller will currently work.

22. How much power can these motors produce?

Series wound motors, such as these, are renowned for the massive torque they produce from 0 RPM. These motors will suck every AMP they can in order to try and start the armature spinning. Though our motors are regularly abused by **Zilla** controllers delivering 1000-2000 Amps for brief periods, the 9" motors are actually rated at 450 Amps for 5 minutes, 225 Amps for 1 hour, and 190 Amps continuous duty. The 11" motors are rated at 500 Amps for 5 minutes, 250 Amps for 1 hour, and 200 Amps continuous. We believe these are conservative ratings. The difference in the variously sized motors is the amount of torque and RPM at which the torque will be delivered. If the ratings of a single motor are exceeded, you can divide the figures in ~½ and use multiple motors. There are additional losses of around 8-10% when using dual motors.

23. Where can I obtain an adapter plate made for my vehicles transmission?

Many **WarP Motor** dealers specialize in making transmission adapter plates, as well as providing the other components used in EV conversions. Our **Authorized Dealers** are listed on our web-site at <http://www.go->

ev.com/dealers.html. You can check the annotations in each Dealers listing to locate the best match for your specific needs.

24. Can I run the motors at 10,000 RPM's?

No load and high voltage causes these motors to spin to excessive RPM's **EXTREMELY** quickly! The motors should ONLY be spun at no load with a maximum of 12 volts. The bearings are rated to ~14,000 RPM's. We do not suggest running these motors beyond 5500 RPM's (7800 RPM for the 7" motors). For short durations (i.e. drag racing) the motors have been known to approach 10,000 RPM's, but this is strongly discouraged! If high RPM's are an essential requirement of your application you should consider requesting Kevlar banding and other optional modifications that can be performed at the factory or by a few of the Authorized Dealers.

25. Where can I get additional assistance with my conversion?

An excellent resource is your local chapter of the Electric Auto Association. These groups have been doing conversions to pure electric for 30+ years and have extensive knowledge. Some of the Members of the EAA are world renown for their abilities. There are numerous books available, (i.e. ***Build Your Own Electric Vehicle*** by Seth Leitman and Bob Brandt) and most of our Dealers are willing to discuss your project with you and offer guidance advice. There is also a very active discussion group on the internet called the EVDL (<http://www.evdl.org/index.html>) and the DIY forums (<http://www.diyelectriccar.com/forums/>). Our Authorized Dealers are the best resources in the world. They have generally completed numerous conversions and will work with you to supply parts and insight into a vehicle conversion, as well as supplying you with the various components you'll need.

26. What is the EVDL and how do I subscribe?

The EVDL is the Electric Vehicle Discussion List. You can find all the details needed to subscribe and view the archives at: <http://www.evdl.org/>

27. What components do I need to make an electric vehicle?

You will obviously need an electric motor. You'll also need a motor controller, and a device to act as the throttle and signal the motor controller as to the power needed - a 5K potentiometer is by far the most typical method, but the Hall Effect is a safer alternative. You'll also need batteries, a battery charger(s), possibly a battery equalization system, possibly a transmission adapter plate, battery boxes/enclosures, a DC-to-DC converter, a transmission adapter plate, lots of cable, lugs, contactor[s], connectors, gauges and wiring.

28. What makes a good conversion vehicle?

First pick a vehicle you like that is in good condition. It is not uncommon for people to keep EV's for many years. As the weight of the vehicle will probably increase (I've never seen one that decreased if lead-acid was being used), consider the gross vehicle weight constraints. Choose a lightweight vehicle with strong suspension and brakes - sports cars and small pick-up trucks make ideal candidates. Do not change the ride height of the vehicle, or the ride characteristics. The heavier the vehicle, the more likely you are to be dissatisfied with the range and performance. Pickup trucks make very good candidates, as the batteries can be placed under the bed along the frame rails, and they are designed for carrying additional weight (i.e. Batteries). They also have brakes designed to stop the vehicle with the extra weight you may add.

29. I want to go 300 miles on a charge at 75 miles per hour in my Suburban – okay?

NO! The typical range of a lead-acid EV is 25-50 miles on level terrain – depending upon the batteries and weight of the vehicle. Even with the most advanced battery chemistry currently available this is beyond current technology. Conversions using the various Lithium batteries available are claiming 75-150 mile

ranges, so we are headed in the right direction, just not there yet... And the same goes for recharging the batteries in 5 minutes – it won't happen for quite awhile.

30. I want to use a small generator to run the electric motor while I am driving on the highway.

At first this sounds plausible, but using \$5.00/gallon fuel (gasoline) to derive \$1.00 per gallon fuel (electricity) is only the beginning of the issues surrounding this. Generators are noisy. Most generators are not designed to operate in a moving vehicles and can spill fuel and cause an unsafe driving condition. If you try to quiet them you will reduce their ability to produce electricity. When generators are running they typically produce more pollutants in one hour that 250 hours of driving an ICE. Even in a lightweight vehicle you will require around 150 amps at 144 volts to maintain 60 MPH – that's more than a 21Kw generator! So the question is “Trains do it why can't a car?”. The simple answer is that trains run level, and straight as much as possible, with few stops, and cost millions of dollars. Trains are not concerned about their 0-60MPH time, or merging with traffic. It only takes a small fraction of the power needed to obtain a speed to maintain the speed. Additionally, steel wheels on steel tracks offer 1/50th of the rolling resistance of rubber on concrete. A typical EV will use 144 Volts and 500 to 1000 Amps to get started from a dead stop. This is 144Kw of power – a VERY big generator.

31. Can I use capacitors to power the vehicle?

Probably not entirely. Though capacitors offer very high power density, their energy densities are very low (the opposite of fuel cells). Super-capacitors (aqueous based) and ultra-capacitors (organic based) usually become a slave to the batteries. There is potential for the use of capacitors in EV's, particularly when used with regen braking, but regen braking should not be done with series wound DC motors. The use of capacitors might be beneficial in obtaining a speed, but probably doesn't make much sense to use them to maintain speed.

NOTES

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.