NEW GENERATION MOTORS CORPORATION

Washington, DC U.S.A.

SC-M150-00X Axial Flux, Permanent Magnet, DC Brushless Electric Motor Operating Manual Version 1.00

TABLE OF CONTENTS

1. SC-M150 MOTOR SERIES

The SC-M150-00X series of motors from New Generation Motors Corporation, represents the leading drivesystem technology of Axial Flux, DC Brushless, Permanent Magnet motors for light vehicles. The SC-M150 motor incorporates active mechanical flux weakening with its air gap adjustment mechanism to provide the most optimal motor characteristics during varied driving conditions.

Motor Model:	SC-M150-04	SC-M150-08
Bus Voltage Range (Volts)	48-53	84-108
Min./Max Air Gap Setting (mm)	1.8/6.0	1.8/6.0
Motor Diameter (mm)	315	315
Motor Width (Stator to Rotor only) (mm)	70	70
Weight (Kg)	20	20

2. ELECTRICAL CONNECTIONS

The electrical connections for the motor include the phase lead connections to the controller and the sensor cable lead connection to the controller. These wires and cables are housed in a protective conduit and should not be removed from this covering. This harness should be properly strain relieved at all times, be sure to note the range of motion required between the controller and the motor due to suspension travel of the vehicle. The following sections give instructions for these connections.

2.1 Phase Lead Connections

The phase leads are permanently attached at the motor end. Any attempt to remove or modify the connections at the motor end may void the warranty. The phase leads have not been terminated to allow the user to customize the cable length and method of connection to the EV-C200-XX2 series controller. It is recommended that no less than 6AWG be utilized in the connections of the phase leads to the controller and that any connectors used be sufficiently rated to handle the current and voltage.

The phases are marked during final assembly for identification:

RED	Phase A
GREEN	Phase B
BLACK	Phase C

2.2 Sensor Cable Connection

The sensor cable is permanently attached at the motor end. Any attempt to remove or modify this cable may void the warranty. The sensor cable has a DB-15M that connects directly to the EV-C200-XX2 controller. This connection should be properly secured at the controller face and appropriately strain relieved between the motor and the controller.

3. STRUCTURAL INTERFACES

There are two different structural interfaces on the motor: The mounting interface of the motor to the vehicle's suspension members and the wheel mounting interface. Each of these will be discussed in the following sections.

3.1 Mounting of the Motor

Proper design, analysis, and testing of the vehicle suspension should be done prior to integration of the motor. The motor has been designed with specific mounting provisions. Failure to properly mount the motor and/or a failure in the vehicle suspension to which the motor is integrated may void the warranty.

Drawing 010-000093 (Sheet 2), found in the Appendix, shows the back and side views of the motor. Note the five(5) bolt pattern of ¼-20UNC holes and the mounting axle protruding out from the backplate, these are the primary attachment points for the motor. There are three (3) steps to correctly mounting the motor to the vehicle (i.e. suspension upright or trailing arm).

Step 1: The motor should be integrated to the structural member of the vehicle with a light press fit on the 1.181" diameter section of the axle. The unthreaded length of the axle protruding from the backplate is approximately 0.5 inches. This unthreaded portion should be fully recessed into the mounting member of the vehicle so that only threads are showing. The backplate of the motor should be tight up against the mounting member of the vehicle.

Step 2: The motor must be securely fastened to the mounting member at the five(5) bolt locations. The threaded inserts in the backplate are approximately 0.4 inches in length. High quality hardware (minimum of SAE Grade 8) should be used and the length properly selected such that full engagement of the bolts into the inserts is achieved. Provisions should be made to prevent the bolts from loosening under vibration and load (i.e. threadlocker and/or safety wire).

Step 3: The axle nut provided with the motor should be used as a final clamping device to pull the motor securely to the vehicle's suspension member. The axle nut should also have provisions to prevent it from loosening under vibration and load.

3.2 Mounting of the Wheel

The SC-M150-00X motors have been designed to interface with the NGM Aluminum Wheel (PN: 010-000200) built for the Bridgestone Ecopia tire. Contact NGM for guidelines on interfacing the motor with other wheels.

Drawing 020-000105, found in the Appendix, shows a side view of the wheel correctly assembled on the spindle. To mount the NGM wheel, remove the lock ring. Slide the wheel onto the spindle with the pocketed side of the wheel towards the motor. The six(6) drive pins protruding from the spindle should engage with their respective holes on the wheel. The wheel should not rotate relative to the spindle if it is properly engaged. If the wheel does rotate, remove it from the spindle and put it back on checking for proper drive pin alignment. Run the lock ring down on the wheel and tighten appropriately. The lock ring has been machined with holes to fit a standard ¼ inch open face adjustable spanner wrench. Use proper methods to ensure the lock ring remains tight under the shock and vibration loads of the road.

4. AIR GAP MECHANISM

The Air Gap Adjustment Mechanism is a lead screw based mechanism that allows the gap between the rotor and stator of the motor to be adjusted externally while the motor is in operation. The purpose of adjusting the air gap is to vary the flux density in the air gap to achieve the desired operating characteristics of the motor. As the gap is made larger (opening the gap) the top speed capability of the motor is increased with a reduction in available torque. Closing the gap will give the motor the ability to produce more torque while limiting its top speed. The following paragraphs will discuss the mechanical attributes of the mechanism. Section Five will discuss in more detail the theory of operation of an axial flux system.

4.1 Mechanism Operation

The actuation of the mechanism is based on a right hand threaded lead screw with a pitch of 16 threads per inch. Attached to the lead screw, protruding from the axle on the backplate side, is either a spur gear (24pitch, 24tooth) or belt pulley (5mm pitch, 18 groove, HTD type). Turning this counterclockwise (facing the backplate) opens the gap, while turning is clockwise closes the gap. At each end of the rotational travel of the system there is a physical stop to prevent further rotation of the mechanism. Applying excessive torque in attempting to turn the mechanism beyond these points will cause damage to the system.

4.2 Load Required

The primary load that the mechanism deals with is the axial force of the permanent magnets being attracted to the stator. This load decreases as the gap is increased, therefore, the torque required to move the mechanism is greatest when trying to open it from the minimum gap position. The running torque required at the pulley or gear to open the gap from minimum position is approximately 35-40 in-lb. Due to stiction in the system, the “breaking” torque required to start moving the gap from any position of rest is more than the running torque required to keep it moving. This may account for as much as a 50% or more increase in initial required torque.

4.3 Dangers of Gap Adjustment

The most important concept to understand concerning the adjustment of the gap during vehicle operation is that rapid decrease of the gap can result in forcing excess power into the vehicle power bus causing damage to both motor and controller. The system should not be used as a primary means to decelerate a vehicle. A simple analogy is that of a regular manual transmission in a car. If one attempts to downshift into a gear too low for the speed of travel, it is likely that some drive-line component will fail to be able to take the loads.

5. THEORY OF OPERATION

This section is intended to provide the user with some basic information to help better select and operate an NGM motor system for maximum performance.

5.1 Understanding Losses and Efficiency

Losses in a motor system are of two basic types, rotating losses and power related losses. In order to understand how to best operate an NGM drive system, the causes of both should be understood at the basic level.

The rotating losses are those caused by the magnetic field interacting with the stator iron, the friction in the bearings, and the windage (aerodynamics) of the rotating parts. The magnetic field losses are of two types, those caused by eddy currents in the conductive parts which are in the magnetic field and those caused by the hysteresis of the stator core. Your wheel motor is designed to greatly reduce both of these types through very careful design, choice of materials, and manufacturing methods. Additionally, because of the elimination of transmission bearings common in most systems, the rotating friction is greatly reduced. Removing any parts that rotate faster than the wheel itself also reduces the windage losses. Nevertheless, the rotating losses are significant. In fact, in a properly sized motor system they are approximately half of the total losses, the other half being the power related losses.

The rotating losses increase both with speed and with increase in magnetic flux. It is worth noting that there is both a linear and a squared term in the speed dependency. The dependency on magnetic flux is less familiar than with speed dependence, but is important because in the NGM system the flux can be varied by adjusting the air gap.

The power related losses are of two main types. The first type is the purely resistive losses. The motor winding current is proportional to the torque output of the motor, rather than the input power, and losses are proportional to the square of the winding current. It is for this reason that the ability to adjust the motor coupling is important. In order to minimize the resistive losses, the gap should be adjusted to the minimum point that gives the required top speed at the given voltage.

The second type of power related losses are switching losses of the power devices used to control the current through the motor windings. Each time the controller switches current through the motor windings a small amount of energy is lost. Although the amount is very small with each pulse, with a high switching frequency these losses can be significant. The current modulation techniques used in the NGM motor system greatly reduce the switching losses over other systems. Regardless of the type of system, however, in general the losses are higher at higher input voltages and are lower at the high end of the speed range for a given gap.

5.2 Air Gap Effects on Drive System:

The effects of changing the air gap are quite simple, the smaller the air gap the higher the coupling between the rotor and the stator (i.e. the greater the torque capability); however, this is accompanied by a lower top speed of the motor. Therefore, the larger the air gap the lower the coupling (i.e. lower the torque capability) and the higher the top speed. Also, the smaller the air gap, the higher the attractive force between the rotor and the stator. This translates to a higher loading on the thrust bearing in the motor and results in an increase of the spinning losses. As a result, it is most efficient to run the motor at its top speed for a given gap. The gap settings will be different for each vehicle depending on bus voltage, tire diameter, power required (weight, aerodynamic drag, rolling resistance, road terrain) and desired speed.

5.3 Bus Voltage Effects on Drive System:

NGM is producing two SC-150 motor versions, one low voltage and one mid-range voltage configuration. The low voltage system is optimized around 48 volts, and the mid-range system is optimized around 96 volts. For either of these systems, the top speed of the motor for a given air gap varies with the bus voltage. For instance, in the 48-volt system, as the voltage of the battery pack decreases (i.e. the battery state of charge decreases) the top speed of the system will also decrease.

5.4 Tire Size Effects on Drive System:

As tire diameter is increased, there are two effects on the drive system. First, for a given air gap, as the diameter of the tire is increased, the amount of traction force produced at the tire contact patch is reduced. Second, it may be the case that the minimum air gap (i.e. smaller air gap for the larger tire diameter) of the system is such that the top speed is above the required speed. This scenario would, in general, be less efficient than if the system could be operated at a gap providing a top speed comparable to the desired speed (i.e. a smaller tire diameter). As stated above, the smaller the air gap, the higher the spinning losses. Therefore, in general, a smaller tire diameter allowing for the desired top vehicle speed is relatively better with respect to torque and unpowered spinning losses of the motor.

6. NGM WARRANTY AND LIABILITY

6.1 NGM Warranty

New Generation Motors Corporation warrants that its SC-M150 series motor will be free from defects in title, materials, and manufacturing workmanship for one (1) year. If a SC-M150 series motor is found to be defective, then, as your sole remedy and as the manufacturer's only obligation, New Generation Motors Corporation will repair or replace the product. This warranty is exclusive and is limited to the SC-M150 motor.

This warranty *shall not apply* to SC-M150 series motors that have been subjected to abuse, misuse, abnormal electrical, mechanical or environmental conditions, or any condition other than what can be considered normal use (including, and not limited to, opening of the motor for any purpose).

6.2 Warranty Disclaimers

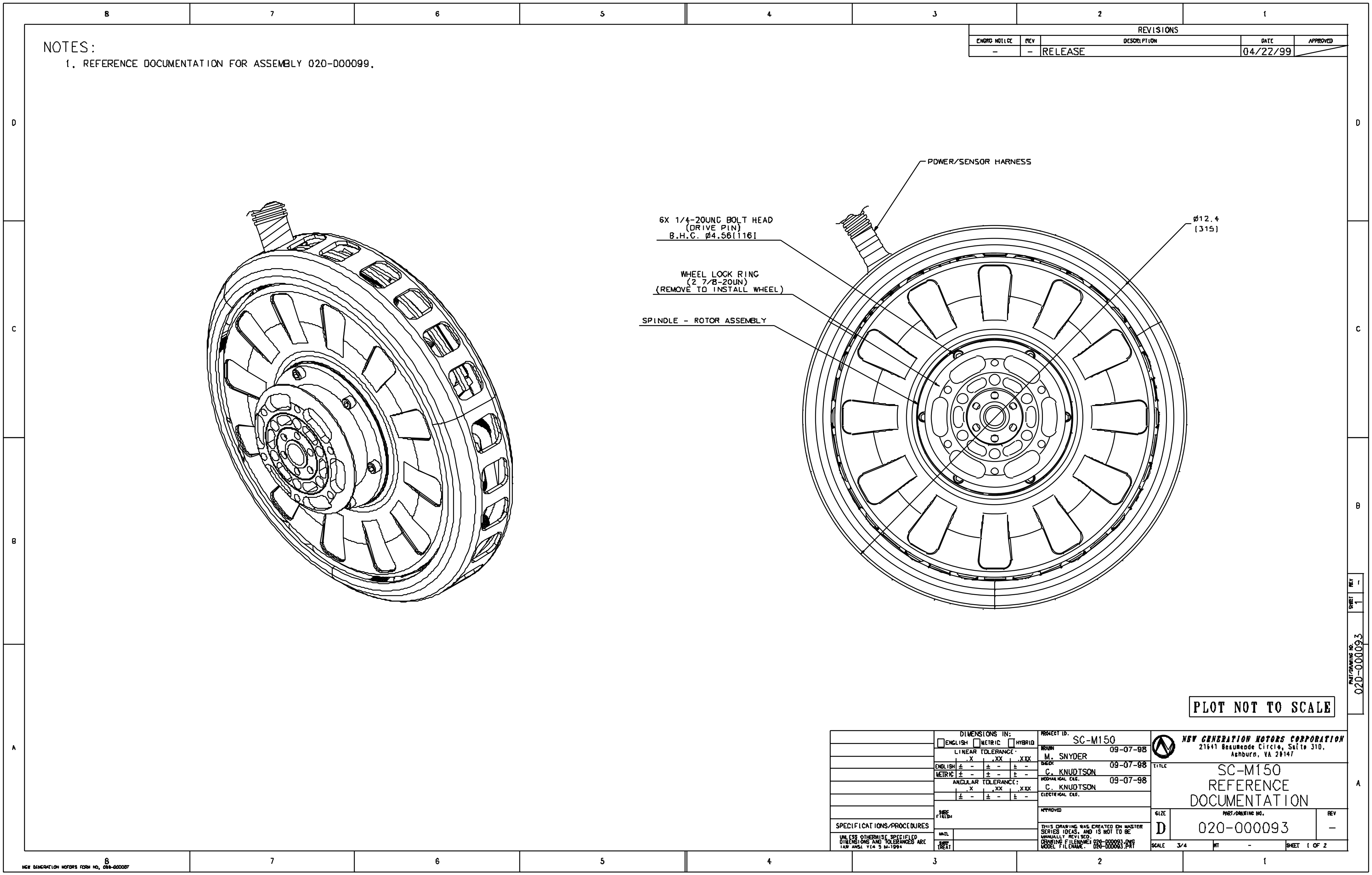
New Generation Motors Corporation makes no other warranties, express, implied, or otherwise, regarding SC-M150 series motors, and specifically disclaims any warranty for merchantability or fitness for a particular purpose.

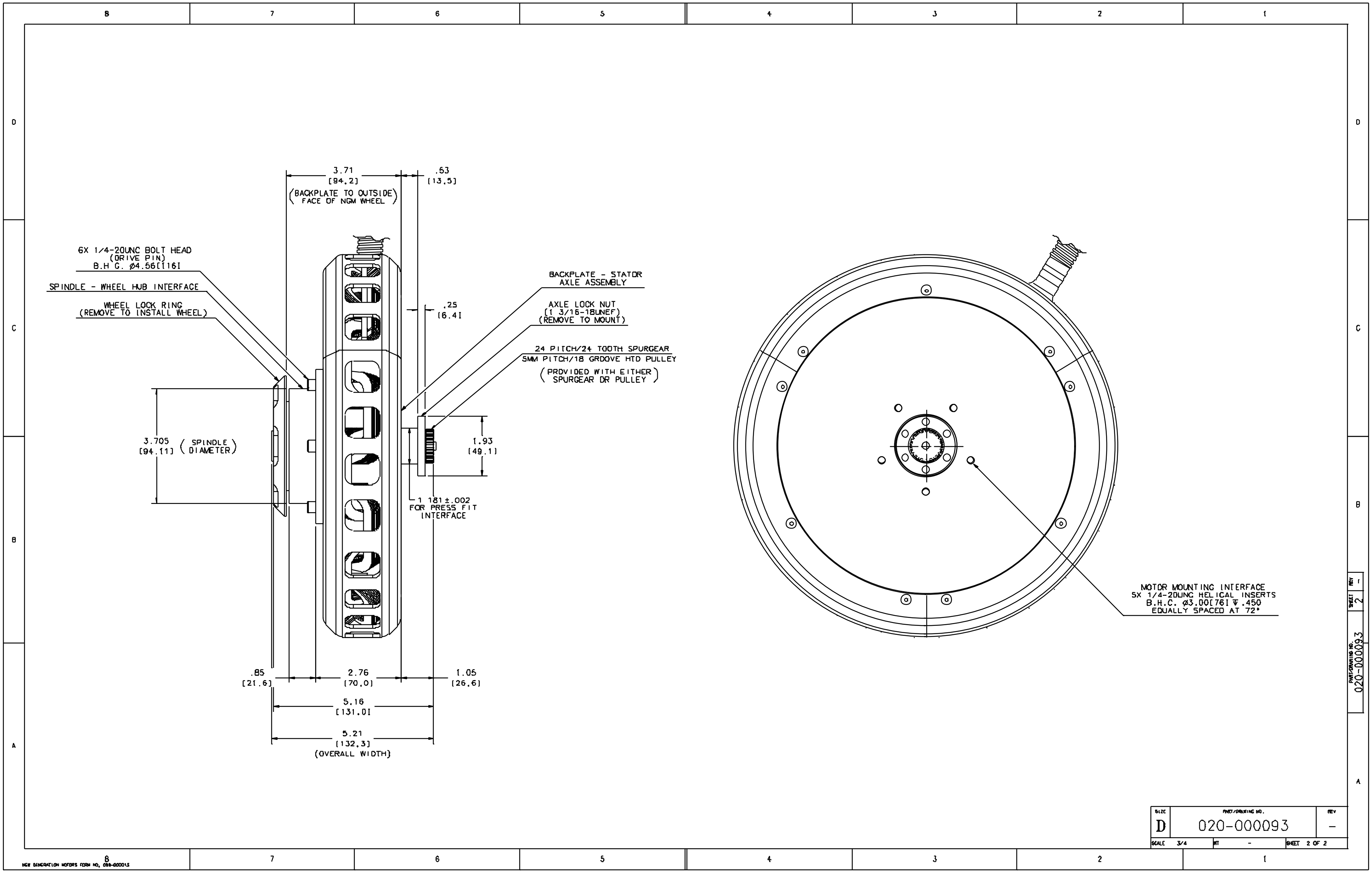
The exclusion of implied warranties is not permitted in some States and countries thus exclusions specified herein may not apply to you. This warranty provides you with specific legal rights. There may be other rights that you have which vary from State to State.

6.3 Limitation of Liability

The liability of New Generation Motors Corporation arising from this warranty and sale shall be limited to the replacement of defective parts. In no event shall New Generation Motors Corporation be liable for costs of procurement of substitute products or services, or for any lost profits, or for any consequential, incidental, direct or indirect damages, however caused and on any theory of liability, arising from this warranty and sale. These limitations shall apply not withstanding any failure of essential purpose of any limited remedy.

APPENDIX: DRAWINGS




3.71
[94.2]
(BACKPLATE TO OUTSIDE FACE OF NGM WHEEL)
.53
[13.5]
6X 1/4-20UNC BOLT HEAD
(DRIVE PIN)
B.H.C. ø4.56[116]
SPINDLE - WHEEL HUB INTERFACE
WHEEL LOCK RING
(REMOVE TO INSTALL WHEEL)
.25
[6.4]
BACKPLATE - STATOR AXLE ASSEMBLY
AXLE LOCK NUT
(1 3/16-18UNEF)
(REMOVE TO MOUNT)
24 PITCH/24 TOOTH SPURGEAR
5MM PITCH/18 GROOVE HTD PULLEY
(PROVIDED WITH EITHER SPURGEAR OR PULLEY)
3.705
[94.11]
(SPINDLE DIAMETER)
1.93
[49.1]
1.181±.002
FOR PRESS FIT INTERFACE
.85
[21.6]
2.76
[70.0]
1.05
[26.6]
5.16
[131.0]
5.21
[132.3]
(OVERALL WIDTH)
MOTOR MOUNTING INTERFACE
5X 1/4-20UNC HELICAL INSERTS
B.H.C. ø3.00[76] ⊽.450
EQUALLY SPACED AT 72°
SIZE
D
PART/DRAWING NO.
020-000093
REV
-
SCALE 3/4
WT -
SHEET 2 OF 2
NEW GENERATION MOTORS FORM NO. 050-000015

REVISIONS				
ENGRG NOTICE	REV	DESCRIPTION	DATE	APPROVED
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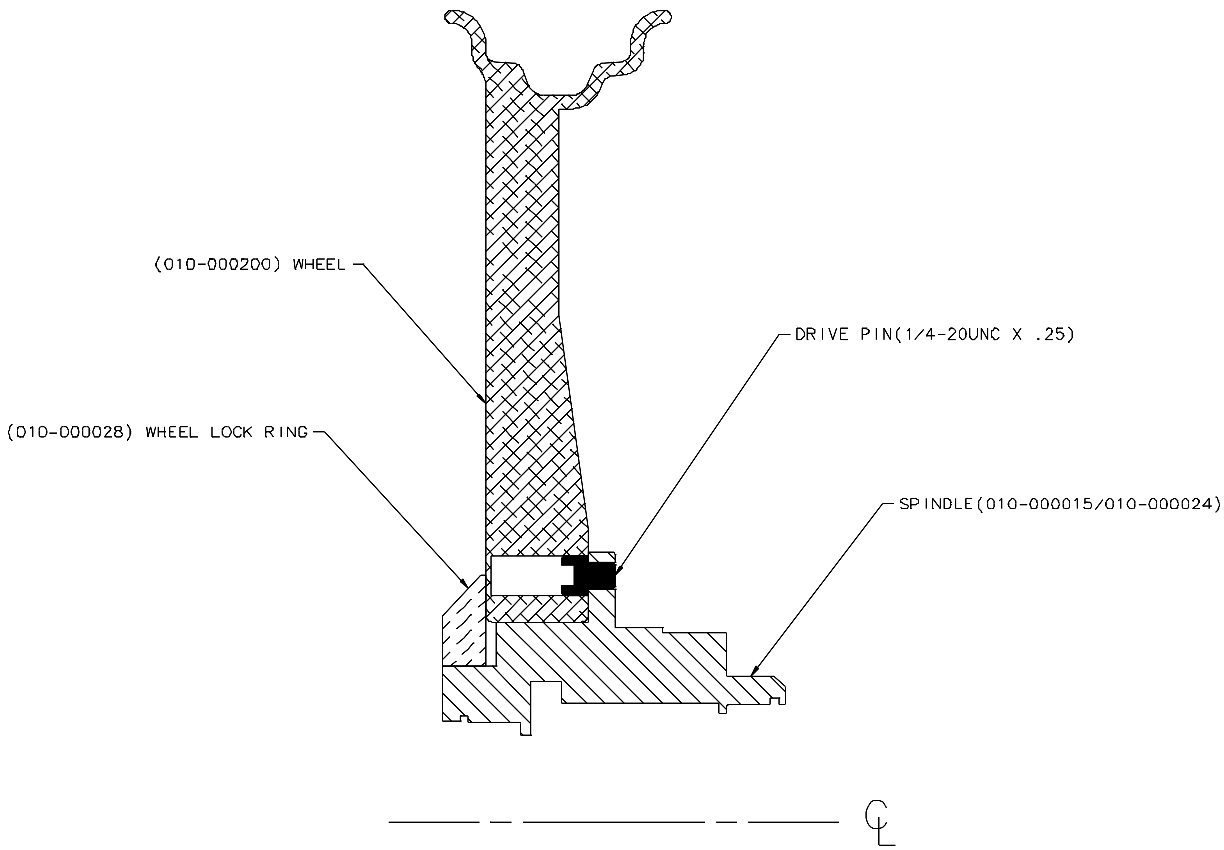

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