MATE TECHNICAL BULLETIN 3/22/16

Sealing Brushless Motors – MTB-001

Background: In underwater robotics there are a number of motors available for use with ROVs. To meet MATE safety specifications all of these must be sealed. Because they are brushless, there is a temptation to place the motor directly into the water and apply power. The connections from the manufacturer for these motors are not designed to be submerged. Typically, the magnet wires are brought together and then soldered to a larger power lead. That soldered connection is then covered with heat shrink tubing. When these motors are placed in water, initially they may function fine and do not exhibit any malfunctions. This can be misleading and will lead to problems in later operation.

Once water has a chance to seep under the heat shrink tubing, there is now a direct path to ground for electrons. Also a path becomes established from phase to phase of the motor leads. Problems with this include the following:

1. Electrolysis of motor leads. With the motor leads submerged and in water, electrolysis can take place between your motor leads and other items of lower electrical potential. Over a period of time (usually few hours of operation) the copper in your wires is etched away to the point of no longer being in existence. At this point one of two things happen. The reduced size results in the wire acting like a fuse and it burns open under current or the wires just fall off from the connection point.

2. Exposed electrical connections presenting a safety hazard. This is especially dangerous in ROVs where the motor voltage can be as high as 48V

In some instances in water with very high conductivity (salt water) streams of bubbles coming from the ROV can be observed at connection points that are not properly sealed.

Many teams want to jump on the brushless bandwagon because "they are easy and we don't have to waterproof them". These motors are not waterproofed to MATE specifications and while they are used in a commercial product, they do not meet MATE safety standards and should not be used as is.

Solution: For brushless motors and stepper motors, the solution is to seal the motors with epoxy. The electrical portion of the motor can be placed in a mold or other holder to allow all the wires to be sealed. Epoxy can be poured into the mold and seal the connections at the same time.

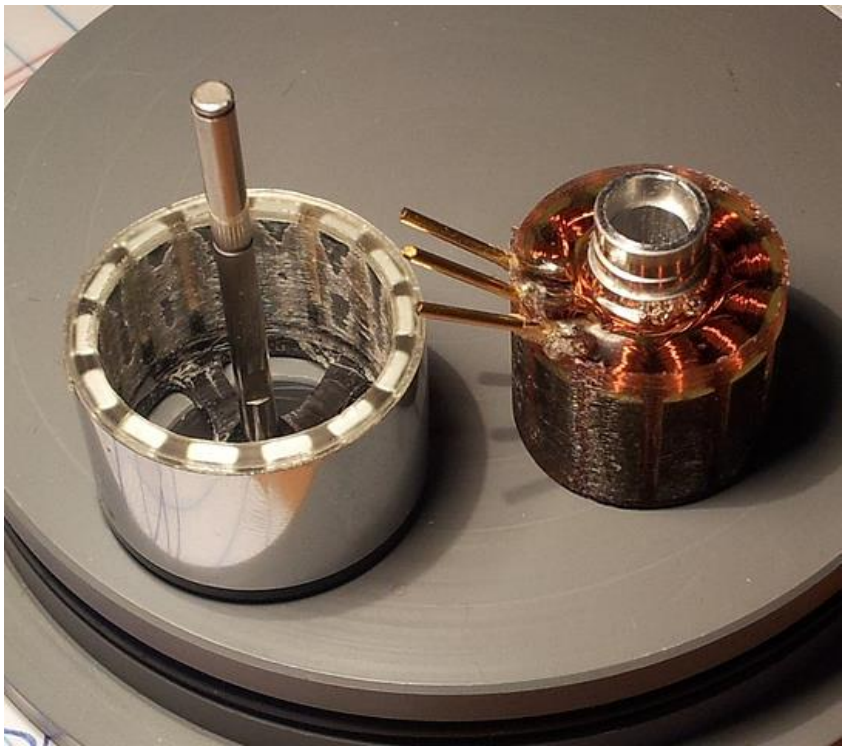
Design Notes:

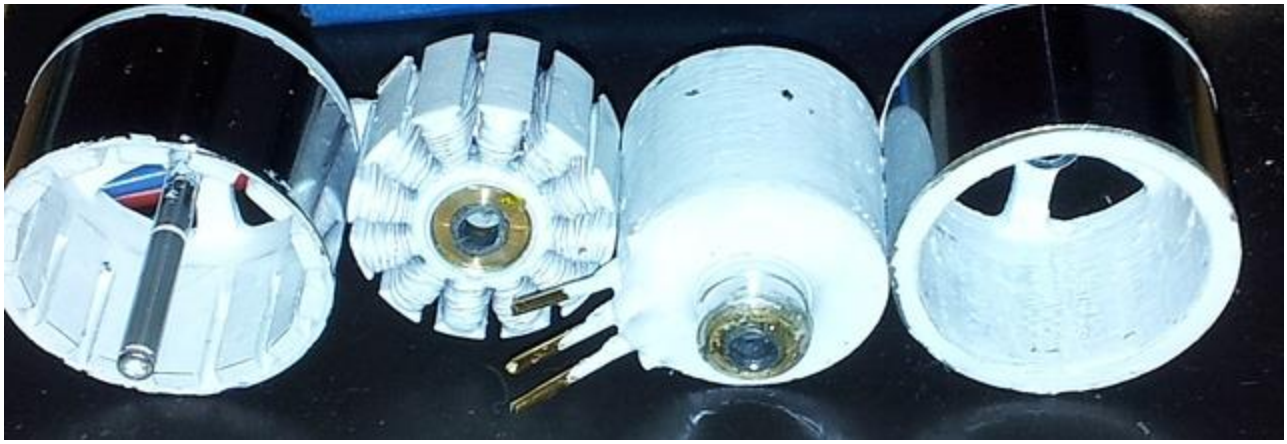
- The mold for the electrical portion of the motor should be as close fitting as possible.
- It is possible to make molds out of 3D Printer material, if water soluble material is used, water can be used to aid in removing the mold.
- For Stepper motors or motors where the electrical portion is on the outside of the motor, an armature replacement can be turned on a lathe to replace the rotating component during the sealing process.
- The lower the viscosity of the epoxy used the easier it is to flow into all the tight spaces in the area being sealed.

- Placing the motor into a vacuum chamber while the epoxy is being sealed will help pull the epoxy into all the crevices providing a better seal. A simple vacuum chamber can be made using a canning jar and a brake bleeding hand vacuum pump. It will take a while to evacuate the air but it will measurably increase the sealing.
- Epoxy selection: Any epoxy can be used, but for best chances at long motor life, an electrical insulating and thermally conductive epoxy should be used. Non-thermally conductive epoxies can cause a buildup of motor heat. This shouldn't be a problem operating underwater, but if operating in high ambient temperatures, it could cause a problem.

Examples:

The following three figures show examples of the motor sealing process found on the OpenROV forum.





MATE TECHNICAL BULLETIN 3/22/16

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Testing: When sealing a motor, it is not enough to say "we sealed it, it's good to go". You need to test your results before putting the motor into operation. The best way to test by immersing the motor into a solution of conductive water and measuring the resistance between the water and the motor leads.

It is possible to seal the leads of a brushless motor stator (not rotor) in epoxy. The connection points between the motor leads (thick flexible and plastic insulated wires) and the motor windings (magnet wire) must be fully enclosed in the epoxy. To verify compliance, it is recommended that you photo document your process and include testing results.

One way to test this is to put the motor in a tub of typical water with the leads outside of the water. "Typical" meaning pool water, ocean water, etc. Typical conductive water that the ROV will be operating in, not distilled water.

Bring the leads out of the water while the motor is in the water. Make sure that the leads, don't touch the water. Let the motor sit in the water over night to get "acclimated".

When you return the next day, attach one lead of a meg-ohm meter (megger) to a copper plate and put into the water.

Attach the other lead of the megger to a motor lead and test. If you have more than 10Meg ohms of resistance you are good and sealed. Repeat the test for all three motor leads.

I'm sure that you will find that a stock brushless motor is not sealed and that this megger test will fail for those. Also, one thing that the overnight soak is performing is to allow water time to seep into the connection, this is sped up by placing the motor into a pressure vessel such as a paint pressure pot and subjecting it to pressures up to 40psi.

SAFETY WARNING: ***If the motor is placed under pressure, the pressure vessel should be certified for the pressures used and equipped with a functioning high pressure relief valve. In cases for MATE related testing, pressures should be kept in the 25 to 40 psi range. Safety glasses should be worn at all times by anyone in the area and the system should never be left unattended..***

A megger is not a voltohm meter that reads into the megohms. It is a high voltage testing device used to locate faulty insulation and connections and unfortunately they are fairly expensive ($500+ USD) Here is a link to one that tests at 500VDC and is under $100.

http://www.amazon.com/s/ref=nb_sb_noss_1?url=search-alias%3Dindustrial&field-keywords=vc60b

MATE TECHNICAL BULLETIN 3/22/16

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insert diagram showing testing procedure.

MegOhm Testing: A megohm meter is a special type of high resistance tester that subjects the device under test to much higher voltages than a multimeter utilizes. A typical multimeter might have a voltage as low as 1.5VDC while measuring ohms. This is not adequate for electrical sealing testing.

A MegOhm meter or "megger" typically has multiple voltage settings. 250VDC, 500VDC and 1000VDC and common test voltages.

SAFETY WARNING: ***Due to the high voltages present during megger testing, care must be taken to ensure that no person becomes part of the electrical circuit. Safety glasses should be worn during all testing.***

Below is an example testing data sheet

Test conducted by: Johnny Student

Megger Model: Samyo VC60B+

Time	Measured Ohms	PSI	Comments
1/1/16 12:00pm	>100 Mohms	Atmosphere	Testing Started
1/2/16 12:00pm	>100 Mohms	Atmosphere	End of 24 hour soak
1/2/16 12:01pm	>100 Mohms	40 psi	Started Pressure test at 12:00pm
1/2/16 12:30pm	>100 Mohms	40 psi	
1/2/16 1:00pm	>100 Mohms	40 psi	End of 1 hour pressure test