Insulation testing using guard on motors

Introduction

Insulation testing is indispensable to the proper care and maintenance of motors. Efforts made by engineers and technicians to keep a motor running smoothly are wasted if the motor insulation is weak or broken. According to IEEE publications (see Figure 1), electrical problems are the cause of about 47 % of motor failures, and the main culprit is insulation failure in the motor stator and rotor. Therefore, the testing of a motor's electrical insulation should be done properly and according to the latest testing standards and practices.

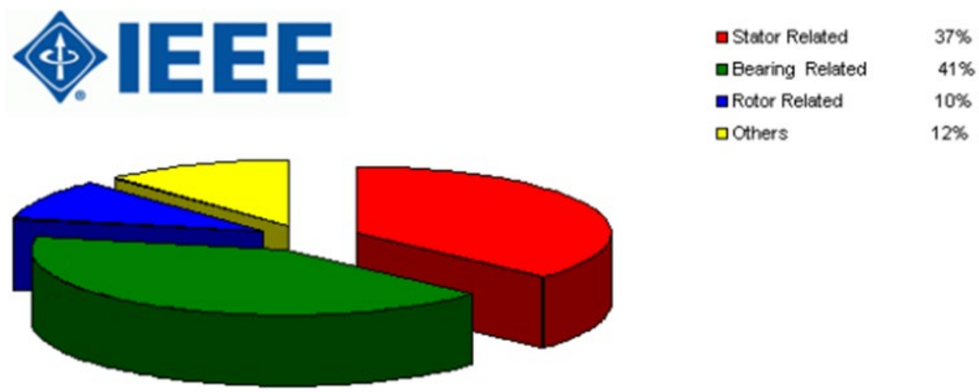

Figure 1: A 1995 IEEE Study on causes of motor failure show stator and rotor issues account for 47 %

Different types of tests are required to provide a full bill of health of motors, but insulation resistance testing is the first and most important test to do on all motors. This test ensures that the motor's insulation has appropriate electrical resistance when measured with respect to ground/earth. The insulation in motors play a vital role in their smooth and faultless operation because it keeps the flow of electrical energy confined to where it is required.

Trending insulation resistance values over time help reveal insulation weakness before it results in a failure. As shown in Figure 2, two motors can have different insulation resistance values, but the motor with results that demonstrate vast degradation over time, as evidenced by trending the data, is the motor to worry about.

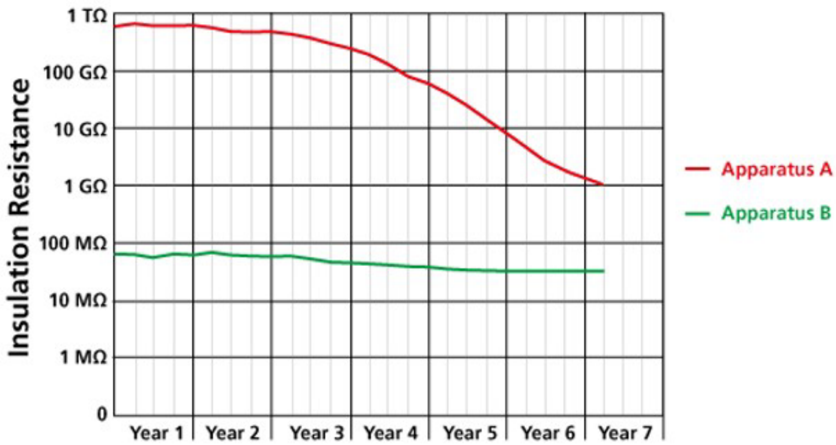

Figure 2: Motor A is a concern as it has insulation degradation over time, while Motor B is good because of minimal degradation even though it has a lower insulation resistance value

A high insulation resistance value is necessary to ensure that the motor can be safely used. However, if a low resistance value is measured, then further investigation is needed before concluding that the motor insulation is unacceptable. It is possible that external contamination is the cause of a low insulation resistance value, and the insulation is perfectly fine.

An innovative testing method, from Megger, provides a way to identify and quantify the presence of contamination. This testing method employs the guard terminal (blue connection). The guard terminal connection measures surface leakage on insulation and automatically removes it from the final insulation resistance value. Surface leakage is caused by contamination in the form of moisture, oils, dust, and other compounds. When measuring an insulation with and without the guard terminal connected, it is possible to quantify the amount of contamination on that insulation material.
The case study summarised next shows the effective use of the guard terminal on a motor.

Insulation Testing of a Motor

Figure 3: Running 500 V insulation resistance tests on a three-phase AC motor

The test subject is a relatively small three-phase AC motor from the manufacturer Brook Crompton. This motor had been in service for many years and was recently put in storage. However, the storage facility did not have environmental controls. It is suspected that moisture had built up within the motor while it was in storage. The insulation of each phase will be tested with respect to ground/earth using 500 V, as seen in Figure 3.

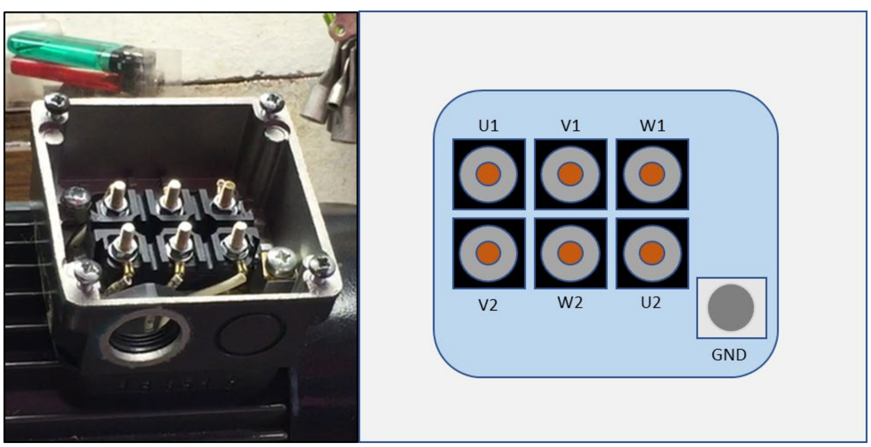

Figure 4: Standard terminal junction with access to both ends of each winding phase (U, V, and W) as well as the ground/earth connection

The motor's windings are accessible from the terminal box (see Figure 4), where all three phases are clearly labelled U, V, and W. Both ends of each phase are accessible from the terminal box, as well as the ground/earth connection. At this stage of testing all phases are floating.

Figure 5: Testing phase U by connecting between U1 and Ground; all other connections left disconnected. Resistance reading of 537 MΩ

The first test done is a simple insulation resistance measurement between phase U and the motor ground/earth. The Megger insulation tester is connected using the red and black test leads to U1 and ground/earth, as shown in Figure 5.

The result of this test is an insulation resistance value of 537 MΩ. It is not possible to determine if this is a good value without context or a reference value. However, more insight can be gathered by running the test again while using the guard terminal connection that is found as the blue connection on the Megger insulation tester.

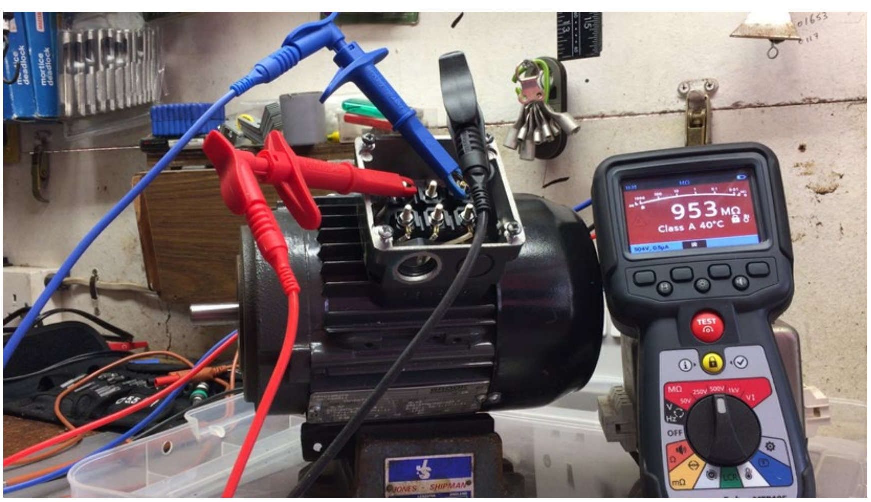

Figure 6: Repeating the test on phase U with guard applied to phase W results in higher resistance measurement (953 MΩ)

As seen in Figure 6, the insulation of phase U was tested to ground/earth again but this time it was done while using the guard on phase W. The resultant measurement was 953 MΩ, which is much higher than when tested without the guard connection (537 MΩ).

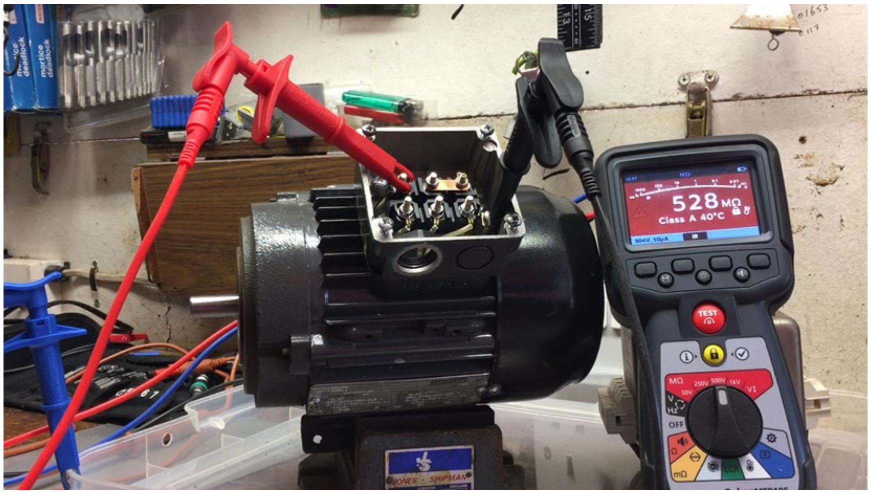

Figure 7: Repeating testing on phase U to ground; phases V and W are connected. Resistance reading of 528 MΩ

In order to eliminate all contamination causing leakage current, it is necessary to connect and guard the other two phases. As seen in Figure 7, phases V and W were connected using a small copper strip across V1 and W1. The initial insulation test between phase U and ground/earth was repeated, which provided a similar result of 528 MΩ.

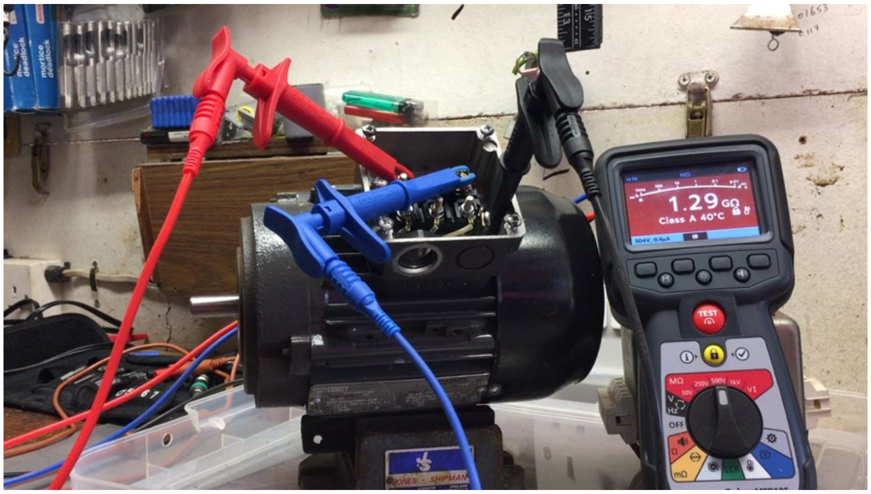

Figure 8: Testing phase U while applying guard to both phase V and W provides the true resistance of phase U to ground, which is 1.29 GΩ

In Figure 8, the guard terminal is connected to phases V and W while the insulation test on phase U to ground/earth is repeated. This time, the insulation resistance value of phase U was 1.29 GΩ. The amount of contamination build-up in the motor during its time in storage was very significant, as seen by these test results.

Conclusions

If an insulation resistance value is the same when using the guard terminal as it is when not using it, then it means that there is no significant contamination on the motor's insulation. However, in the case given herein, there was significant contamination that caused low insulation resistance values. As summarised in Table 1, using the guard terminal prevents incorrect readings and shows how much contamination is present.

Brook Crompton motor details:		**3 Phase, 0.5 hp (370 W), 230/460 V**	
Test #	**Tester Connections**	**Result**	**Comment**
1a	Black – GND Red – U phase Blue – not connected Phases – V and W not linked	537 MΩ	Testing the good insulation of phase U provides a low reading, but it is improved when using the guard connection.
1b	Black – GND Red – U phase Blue – W phase Phases – V and W not linked	953 MΩ	
2a	Black – GND Red – U phase Blue – not connected Phases – V and W linked	528 MΩ	Testing phase U again, but with both the other phases connected to the guard terminal provides the most accurate and true measurement.
2b	Black – GND Red – U phase Blue – V and W phases Phases – V and W linked	1.29 GΩ	

Table 1: Summary of insulation tests done

It is highly recommended to test motor insulation while using the guard terminal. This is a great technique for identifying the true insulation resistance of each phase in a motor.