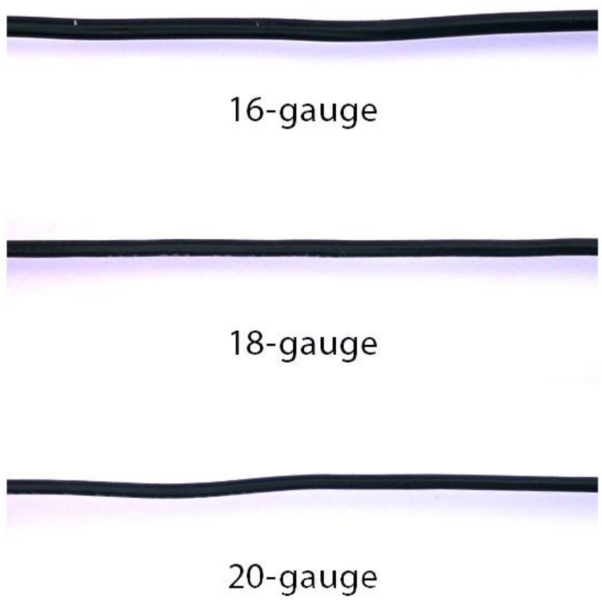
NANOVEA®
A Better Measure.

# Fatigue Testing of Wire
## with Electrical Conductance Apparatus




Prepared by
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## INTRO

Electrical wires are the most common form of interconnects between electrical devices. Wires are usually made of copper (and sometimes aluminum) due to copper's ability to conduct electricity very well, ability to bend, and its cheap cost. Outside of material, wires can also be assembled in different ways. Wires can come be obtained in different sizes, usually denoted by gauges. As the wire diameter increases, the wire gauge decreases. Longevity of the wire will change with wire gauge. The difference in longevity can be compared by conducting a reciprocating linear test with the Nanovea Tribometer to simulate fatigue.

### IMPORTANCE OF FATIGUE TESTING OF WIRE

For reliability of electrical devices, the wires must have high durability. A single wire can be the reason the whole device becomes non-functional. As a result, finding critical conditions when wires begin to fail is important to prevent device failure. Fatigue testing is done to simulate real life conditions to better understand how failure occurs. To identify failure for an electrical component, a multimeter was augmented to the Nanovea Tribometer. The addition of the multimeter helps precisely identify the point of failure compared other methods, such as visual inspection.

## MEASUREMENT OBJECTIVE

Three different wire gauges were tested with the Nanovea Tribometer with a reciprocating linear test module. The resistance of the wire was continuously measured during the test to identify the point of critical failure. To avoid electrical contact, an insulating aluminum oxide ball bearing was used. Each test was conducted in the same manner to compare the durability between wires.

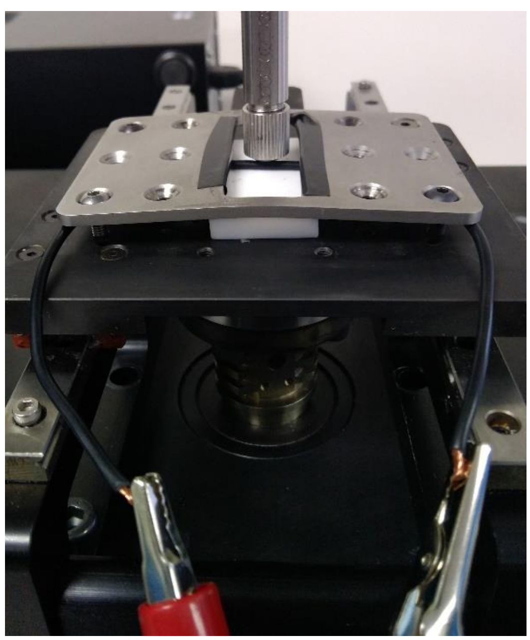

**Figure 1: Fatigue test setup with Nanovea Tribometer for electrical wires**

## TEST PROCEDURE

| Test Parameters | Value |
|---|---|
| | |
| Test Module | Linear Reciprocating |
| Normal force (N) | 15 |
| Rotational speed (rpm) | 50 |
| Wear track amplitude (mm) | 20 |
| Ball Material | $Al_2O_3$ |
| Ball Diameter (mm) | 6 |
| | |

**Table 1: Test parameters for fatigue testing on wire**

## RESULTS AND DISCUSSION

The three wire gauges all failed at different times. The higher gauge (smaller wire diameter) showed failure much faster than the lower gauge.

The selection of the point of failure was found when the resistance began reading infinity (no electrical current flowing through the wire). This meant the metal in the wire became discontinuous due to the fatigue testing. Continuity may be briefly restored from the internal wires brushing each other. To combat this inconsistency, the point of failure was selected from the first occurrence of discontinuity.

| Sample | Revolutions | Minutes | Distance (m) |
|---|---|---|---|
| 16 Gauge<br>18 Gauge<br>20 Gauge | 1404<br>308<br>130 | 28.08<br>6.16<br>2.60 | 56.16<br>12.32<br>5.20 |

**Table 2: Point of failure for wires in revolutions, minutes, and distance**

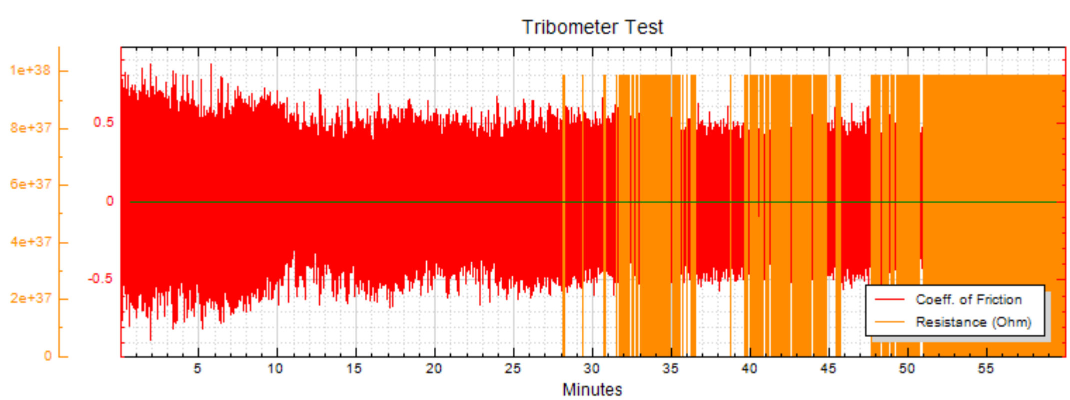


**Figure 2: Friction and electrical conductance graph for 16 Gauge**

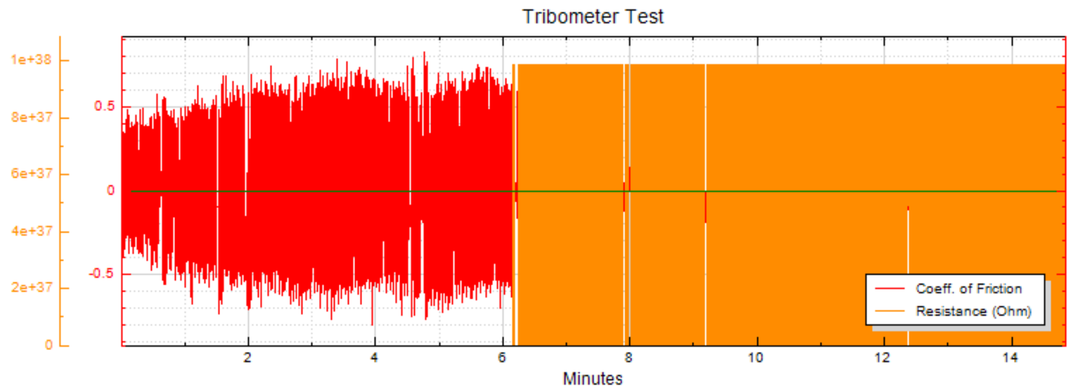


**Figure 3: Friction and electrical conductance graph for 18 Gauge**

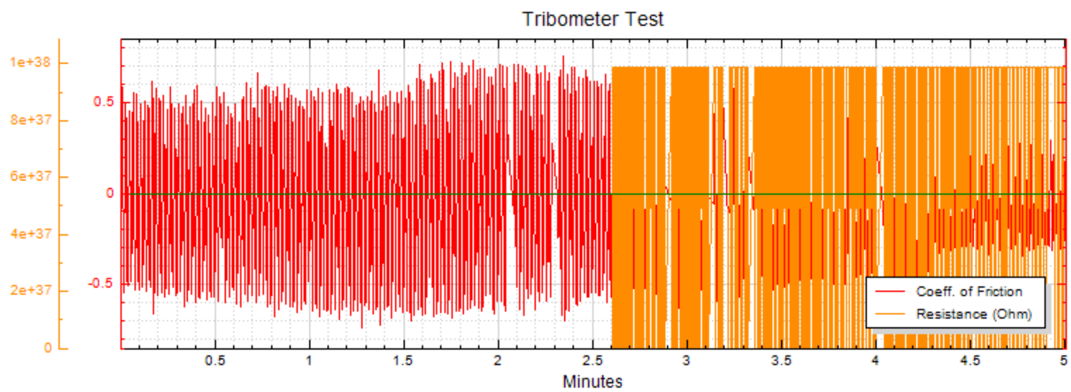


**Figure 4: Friction and electrical conductance graph for 20 Gauge**

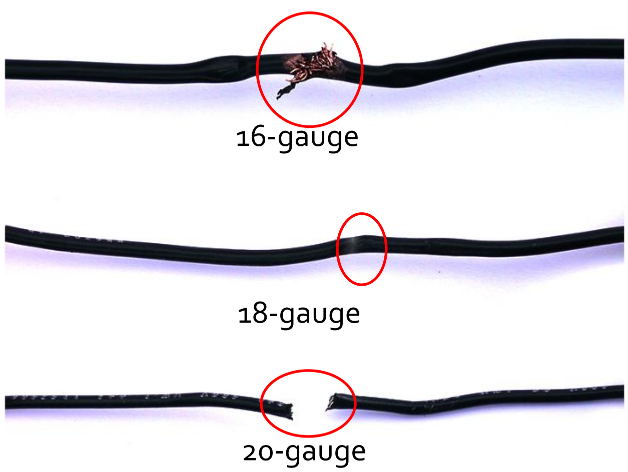


**Figure 5: Post-test visual inspection of wires.**

Figure 5 shows the results from the fatigue testing. Each wire failed in different ways. The 16-gauge wire failed when the metallic wires was worn through. The 18-gauge wire had its sheath remain intact, but the metallic wires were still damaged. The use of the multimeter allowed detection of failure, even when internal. The 20-gauge wire was torn through and completely separated into two pieces under similar testing conditions.

## CONCLUSION

Three different wire gauges underwent fatigue testing under the same conditions. The 16-, 18-, 20-gauge wires lasted 28.08, 6.16, and 2.60 minutes respectively. Lower gauge wires have shown to last much longer than higher gauge wires under these testing conditions. Each wire has shown different failures under similar test conditions. The use of the multimeter to record electrical conductance allowed for a consistent way to identify failure. This proved especially useful for the 18-gauge wire since it failed before visual damage can be seen.

Nanovea Tribometer offers precise and repeatable wear and friction testing using ISO and ASTM compliant rotative and linear modes, with optional high temperature wear, lubrication and tribo-corrosion modules available in one pre-integrated system. An optional 3D non-contact profiler is available for simple in-situ depth measurements or high-resolution 3D imaging of wear tracks in addition to other surface measurements such as roughness.

Learn More about the Nanovea Tribometer

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## MEASUREMENT PRINCIPLE

### TRIBOMETER PRINCIPLE

The sample is mounted on a rotating stage, while a known force is applied on a pin, or ball, in contact with the sample surface to create the wear. The pin-on-disk test is generally used as a comparative test to study the tribological properties of the materials. The COF is recorded in situ. The volume lost allows calculating the wear rate of the material. Since the action performed on all samples is identical, the wear rate can be used as a quantitative comparative value for wear resistance.

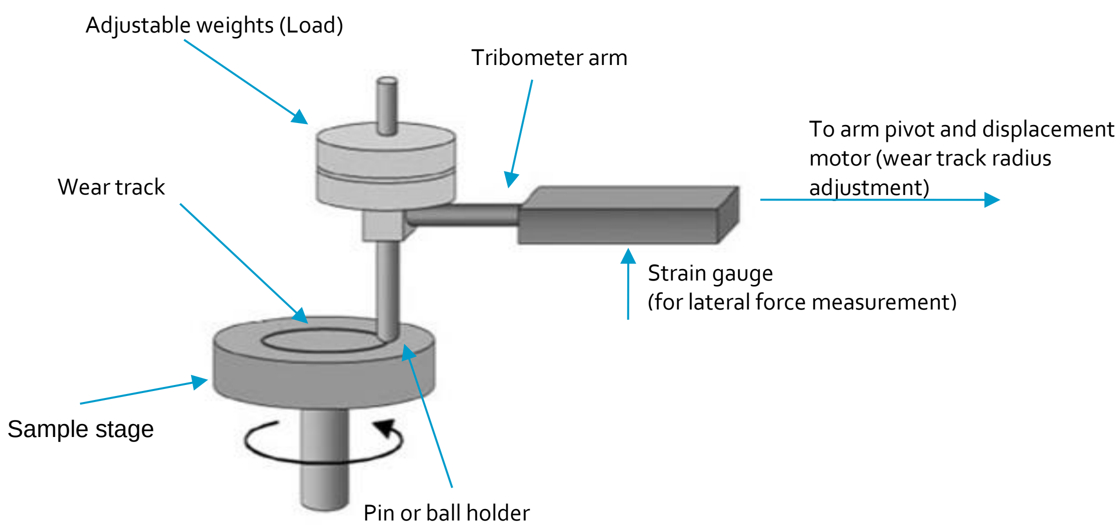


**Fig. 1: Schematic of the pin-on-disk test.**