Scratch Testing of Paint Coatings on Conductive Substrates for Automotive Applications

Automotive paint goes through wear and tear on a daily basis and is often used in harsh environments. A complete paint coating on a car not only helps the vehicle look great but can also protect against corrosion of the substrate beneath it. Whether the vehicle gets hit by a rock or banged by the car parked next to it, paint coatings can go through a beating. Scratch resistance determined through scratch testing is a great way to examine the physical properties of the paint and to know how the coatings may perform in the field.

The scratch testing reported here was performed according to ISO 1518: Paints and Varnishes – Determination of Scratch Resistance. This method regulates a constant load scratch and is carried out either (1) by a "pass/fail" test at a given load or (2) by testing at progressively increasing loads to determine the minimum load of failure. Failure can be determined in two different ways, depending on the conductive properties of the substrate. For a conductive substrate, failure is determined by the lowest force at which a voltage reading is measured. A voltage reading occurs when the coating is completely removed allowing for a closed-loop circuit to be established between the scratch probe and the instrument stage. For a nonconductive substrate, failure is determined visually by examining the scratches. For this application note, progressively increasing load tests were employed to determine the scratch properties of automotive paints on conductive substrates.

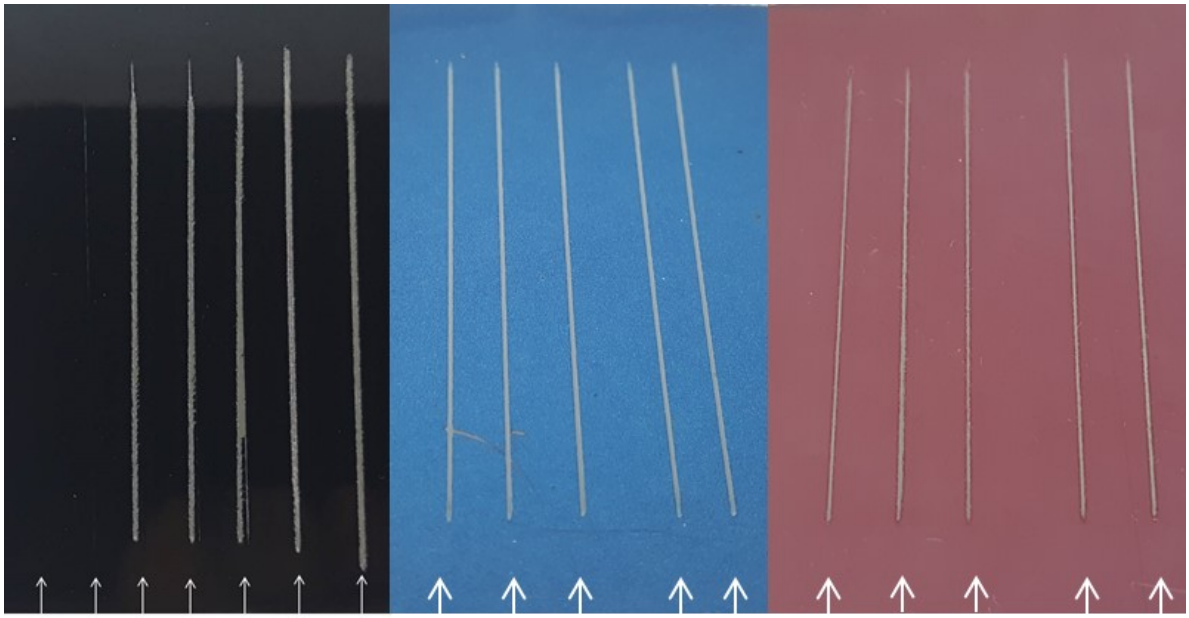

Figure 1. Images of the scratched car panels: from left to right, black panel with loads of 1 kg, 2 kg, 3 kg, 3.5 kg, 4 kg, 4.1 kg, and 4.05 kg; blue panel with loads of 4.1 kg, 4.1 kg, 4.1 kg, 4.5 kg, and 5 kg; and red panel with loads of 4.1 kg, 4.1 kg, 4.1 kg, 4.5 kg, and 5 kg.

Three painted automotive panels were tested using the Elcometer 3000 Motorised Clemen Unit for scratch resistance following ISO 1518 recommended procedures. A black panel is tested against one blue and one red car panel for scratch resistance. Each scratch test involves both a forward and backward stroke of the scratch tip across the sample. The voltage reading was observed on the initial forward stroke but the image below shows the result of the entire scratch after the backward stroke has been completed. A 1 mm diameter hemispherical Tungsten-Carbide scratch tip was used for testing. Loads of 1 kg, 2 kg, 3 kg, 3.5 kg, 4 kg, 4.1 kg, and 4.05 kg were used on the black panel in order to find the minimum force of failure. As seen in Figure 1, the 1 kg force is not observable in the image and the 2 kg force scratch is barely visible. Once the load reached 3 kg, the scratch became much more obvious, but no voltage reading was observed until the 4.1 kg and 4.05 kg scratches. A voltage reading of over 10 volts was observed for the 4.1 kg scratch and a smaller reading of about 2 volts was observed for the 4.05 kg scratch. Although hard to see in Figure 1, the 4.1 kg scratch is more reflective than the others and visually it is clear the coating has been completely removed. For this test it can be determined that the minimum force of paint coating removal for this sample is 4.05 kg and complete coating removal occurs at 4.1 kg.

To compare the blue and red panels with the black panel, each panel was tested three times at the complete coating removal load of the black panel, 4.1 kg. There was no voltage reading for any of these scratches on either panel indicating no failure occurred. Additional scratches at 4.5 kg and 5 kg were performed to determine if failure would occur. Even at the instrument maximum allowed load of 5 kg, no voltage reading occurred for the blue and red panels. Observing the scratches of the blue and red panels in Figure 1, it can be determined that the coating was not completely removed, as the base metal could not be seen. It is clear that the blue and red panels have much more scratch resistance than the black panel.

As demonstrated through these scratch tests, the automotive paint coatings can be easily evaluated through scratch testing to determine their scratch resistances and their abilities to cope with other utility and environmental impacts such as lubrication, wetting, car-washing, exposure to UV, or varying temperatures. Many other coating applications involving harsh or abrasive environments could be benefited from scratch testing as well.