NANOVEA

NANO SCRATCH & MAR TESTING

OF PAINT ON METAL SUBSTRATE

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INTRODUCTION

Paint with or without hard coat is one of the most commonly used coatings. We see it on cars, on walls, on appliances and virtually anything that needs some protective coatings or simply for aesthetic purposes. The paints that are meant for the protection of the underlying substrate often have chemicals that prevent the paint from catching on fire or simply that prevent it from losing its color or cracking. Often the paint used for aesthetic purposes comes in various colors, but may not be necessarily meant for the protection of its substrate or for a long lifetime.

Nevertheless, all paint suffers some weathering over time. Weathering on paint can often change the properties from what the makers intended it to have. It can chip quicker, peel off with heat, loose color or crack. The different property changes of paint over time is why makers offer such a wide selection. Paints are tailored to meet different requirements for individual clients.

IMPORTANCE OF NANO SCRATCH TESTING FOR QUALITY CONTROL

A major concern for paint makers is the ability for their product to withstand cracking. Once paint begins to crack, it fails to protect the substrate that it was applied on; therefore, failing to satisfy their client. For example, if a branch happens to stroke the side of a car and immediately after the paint begins to chip off the makers of the paint would lose business due to their poor quality of paint. The quality of the paint is very important because if the metal under the paint becomes exposed it may begin to rust or corrode due to its new exposure.

Reasons like this apply to several other spectrums such as household and office supplies and electronics, toys, research tools and more. Although the paint may be resistant to cracking when they first apply it to metal coatings, the properties may change over time when some weathering has occurred on the sample. This is why it's very important to have the paint samples tested at their weathered stage. Although cracking under a high load of stress may be inevitable, the maker must predict how weakening the changes may be over time and how deep the affecting scratch must be in order to provide their consumers with the best possible products.

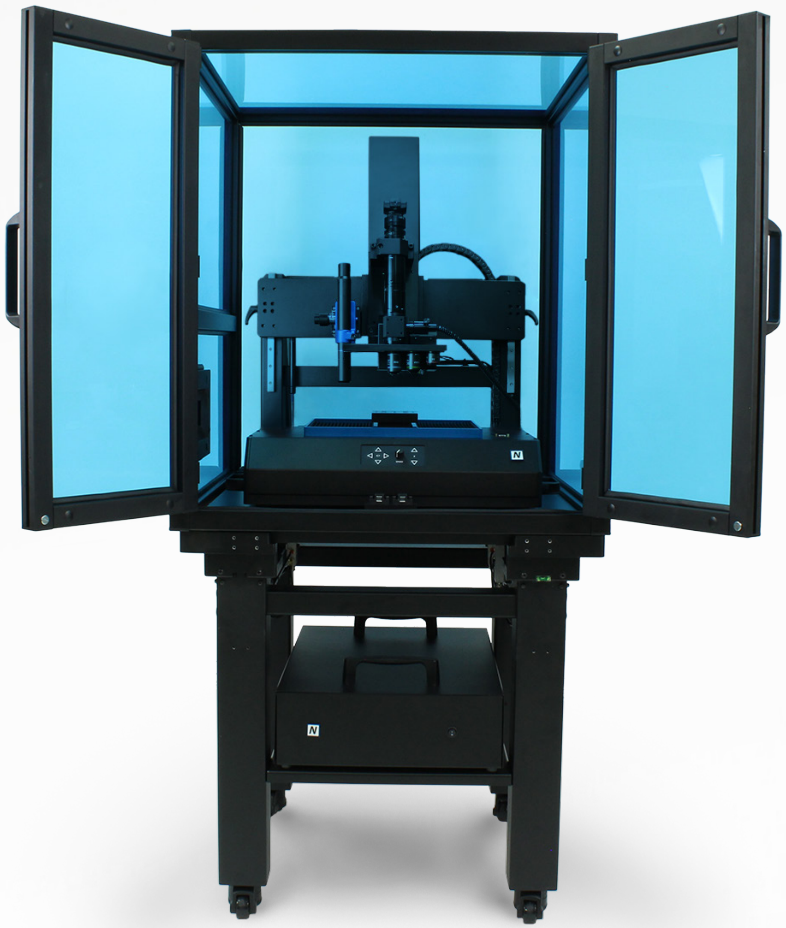
MEASUREMENT OBJECTIVE

*We must simulate the process of scratching in a controlled and monitored manner to observe sample behavior effects. In this application, the **NANOVEA** PB1000 Mechanical Tester in Nano Scratch Testing mode is used to measure the load required to cause failure to an approximately 7 year old 30-50 µm thick paint sample on a metal substrate.*

A 2 µm diamond tipped stylus is used at a progressive load ranging from 0.015 mN to 20.00 mN to scratch the coating. We performed a pre and post scan of the paint with 0.2 mN load in order to determine the value for the true depth of the scratch. The true depth analyzes the plastic and elastic deformation of the sample during testing; whereas, the post-scan only analyzes the plastic deformation of the scratch. The point where the coating fails by cracking is taken as the point of failure. We used the ASTMD7187 as a guide to determine our testing parameters.

We can conclude that having used a weathered sample; therefore, testing a paint sample at its weaker stage, presented us with lower points of failure.

Five tests were performed on this sample in order to determine the exact failure critical loads.



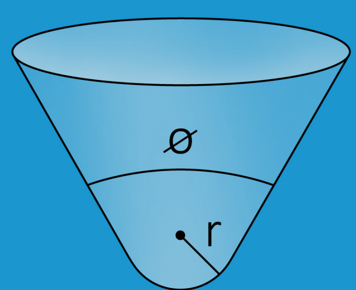
NANOVEA PB1000

Large Platform Mechanical Tester

TEST PARAMETERS

following ASTM D7027

LOAD TYPE	Progressive
INITIAL LOAD	0.015 mN
FINAL LOAD	20 mN
LOADING RATE	20 mN/min
SCRATCH LENGTH	1.6 mm
SCRATCH SPEED, dx/dt	1.601 mm/min
PRE-SCAN LOAD	0.2 mN
POST-SCAN LOAD	0.2 mN

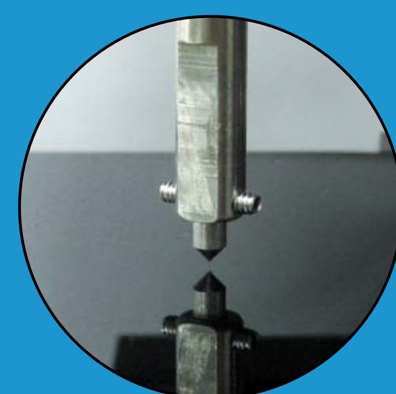


INDENTER TYPE

Conical

Diamond 90º Cone

2 µm tip radius



RESULTS

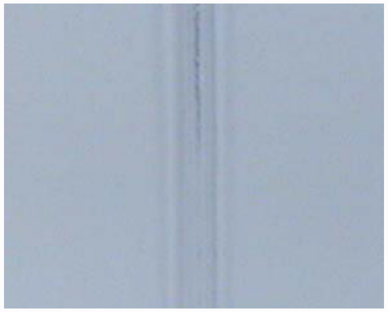
This section presents the data collected on the failures during the scratch test. The first section describes the failures observed in the scratch and defines the critical loads that were reported. The next part contains a summary table of the critical loads for all samples, and a graphical representation. The last part presents detailed results for each sample: the critical loads for each scratch, micrographs of each failure, and the graph of the test.

FAILURES OBSERVED AND DEFINITION OF CRITICAL LOADS

CRITICAL FAILURE:

INITIAL DAMAGE

This is the first point at which the damage is observed along the scratch track.



CRITICAL FAILURE:

COMPLETE DAMAGE

At this point, the damage is more significant where the paint is chipping and cracking along the scratch track.

DETAILED RESULTS

*** Failure values taken at point of substrate cracking.**

CRITICAL LOADS		
SCRATCH	INITIAL DAMAGE [mN]	COMPLETE DAMAGE [µm]
1	14.513	4.932
2	3.895	4.838
3	3.917	4.930
AVERAGE	3.988	4.900
STD DEV	0.143	0.054

FIGURE 2: Micrograph of Full Scratch (1000x magnification).

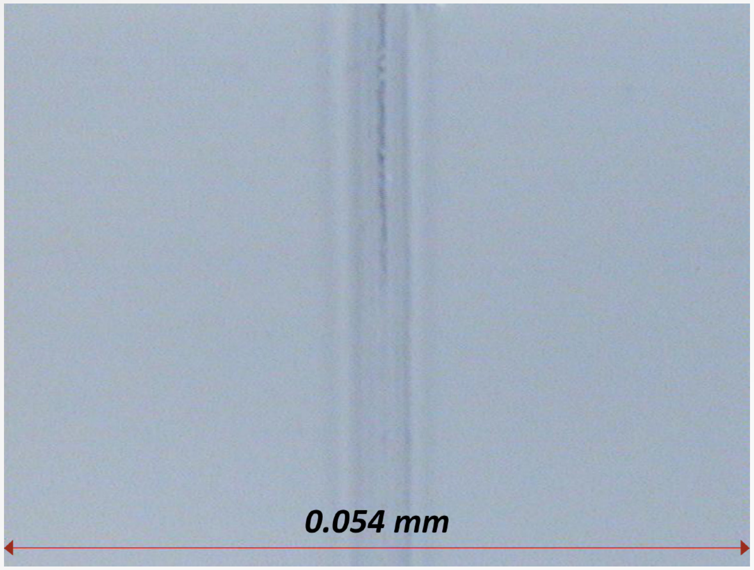


***FIGURE 3:* Micrograph of Initial Damage (1000x magnification).**

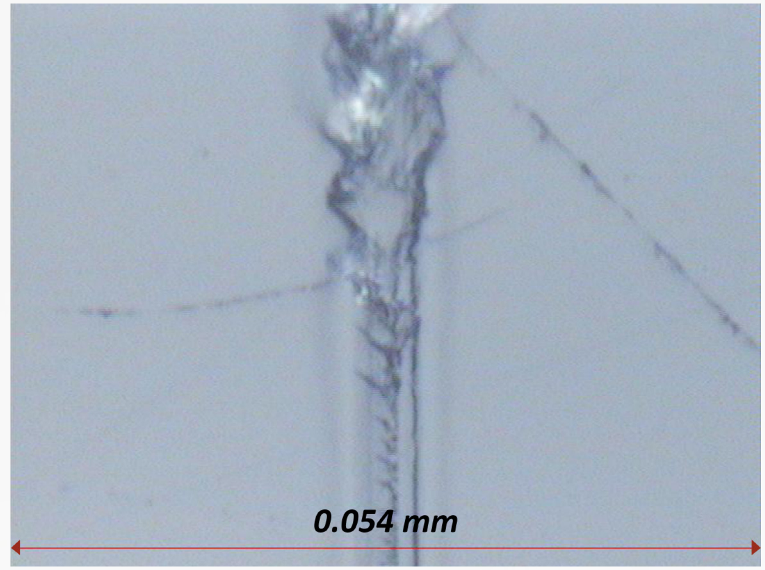


***FIGURE 4:* Micrograph of Complete Damage (1000x magnification).**

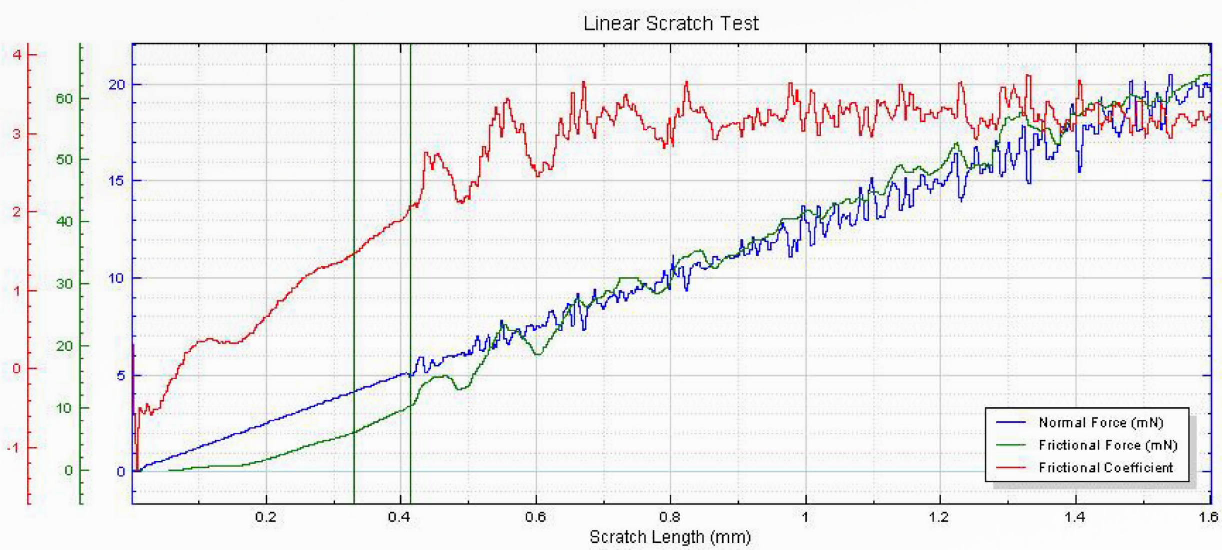


***FIGURE 5:* Friction Force and Coefficient of Friction.**

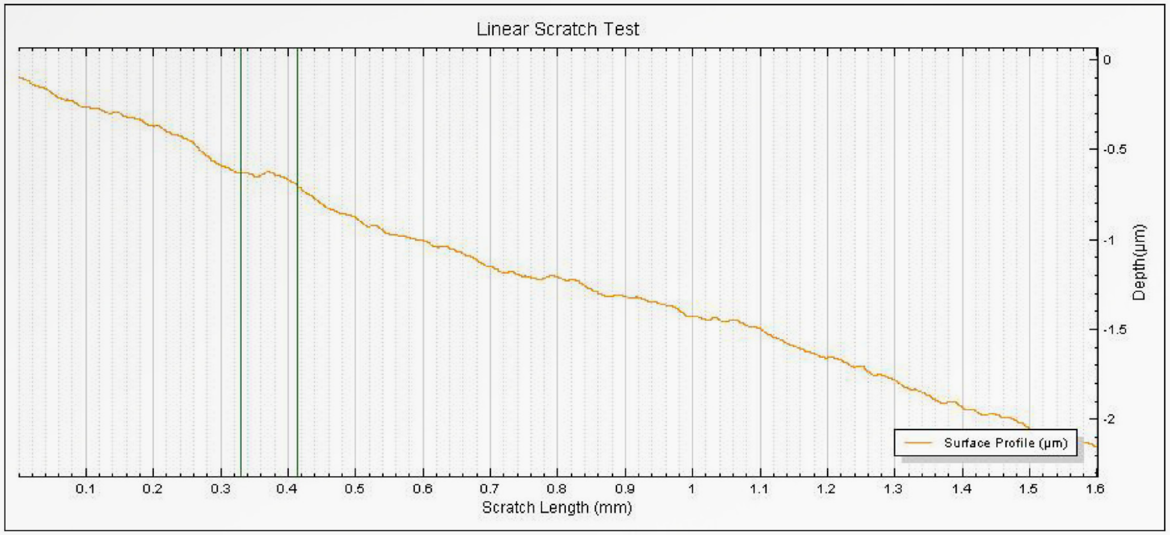


FIGURE 6: ***Surface Profile.***

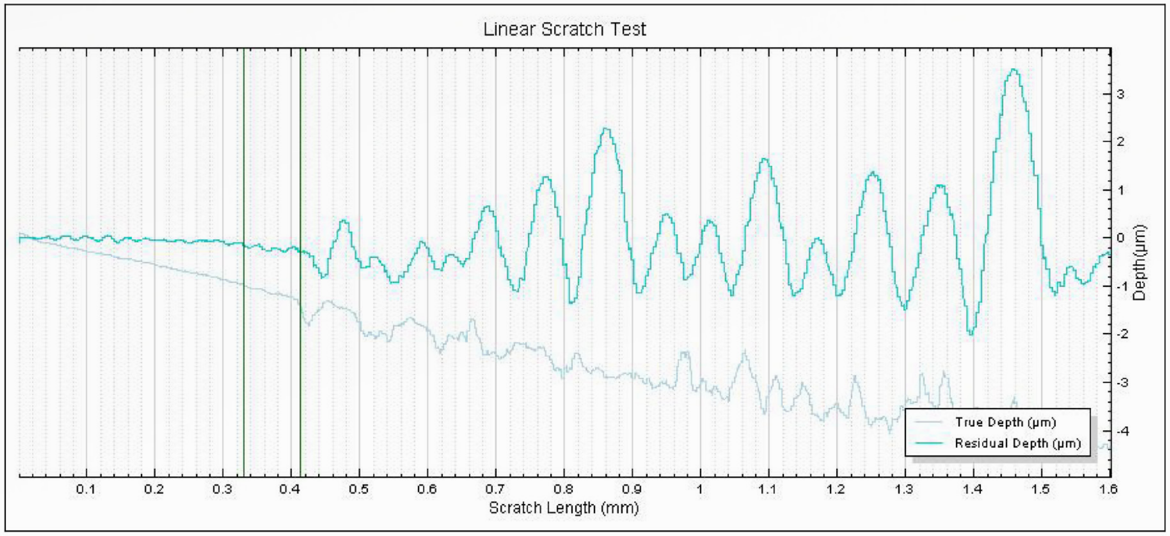


FIGURE 7: ***True Depth and Residual Depth.***

CONCLUSION

The ***NANOVEA*** Mechanical Tester in the Nano Scratch Tester mode allows simulation of many real-life failures of paint coatings and hard coats. By applying increasing loads in a controlled and closely monitored manner, the instrument allows to identify at what load failures occur. This can then be used as a way to determine quantitative values for scratch resistance. The coating tested, with no weathering, is known to have a first crack at about 22 mN. With values closer to 5 mN, it is clear that the 7 year lap has degraded the paint.

Compensating for the original profile allows to obtain corrected depth during the scratch and also to measure the residual depth after the scratch. This gives extra information on the plastic versus elastic behavior of the coating under increasing load. Both cracking and the information on deformation can be of great use for improving the hard coat. The very small standard deviations also show the reproducibility of the technique of the instrument which can help manufacturers improved the quality of their hard coat/paint and study weathering effects.