Finish Forensics

Original paint, re-spray, restoration? How much and where?

Bruce Smith explains the tools of the paint detective's trade.

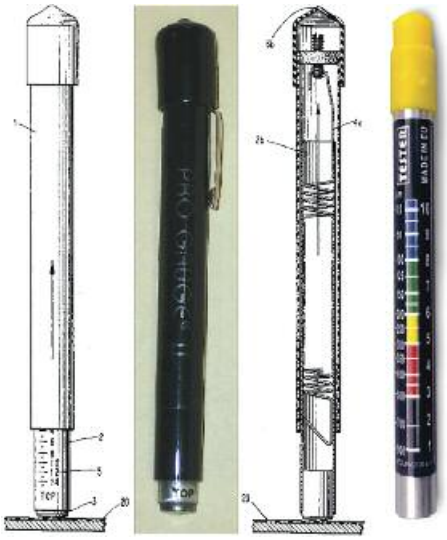
For all but the exceptionally blessed, owners of old Porsches have cars with some non-factory paintwork. Whether piecemeal, re-spray, or full down-to-the-metal restoration, it's more likely than not that some paint repair exists. The extent is often a mystery, especially for those who weren't the caretaker when the body work was carried out. Whether for purchase, sale, or curiosity, who doesn't want a detailed map of their car's finish? The downside is that you risk discovering things you hadn't imagined.

Over the years, several approaches to non-destructive measurement of surface coatings have been developed with various levels of reliability, complexity, and cost. Instruments using methods based on ultrasonic, optical, or magnetic properties are available for various applications. Those best suited for non-conductive coatings over ferromagnetic substrates (painted steel for instance) usually make use of magnetic or electromagnetic effects. Expiring patents and the availability of smaller, cheaper microelectronics have reduced the cost of compact measurement gauges to levels affordable for even casual use.

Thickness measurement gauges based on magnetic or electromagnetic properties generally fall into two categories. The first uses magnetic attraction to a ferromagnetic surface, which will decrease as the gap distance to the surface increases. The second method uses a change in the inductance in the windings of a transformer, which is correlated to separation distance. Both are based on a non-conductive layer in the gap, i.e. an insulative coating. The most common coating type is a paint film but since the densities of most polymeric, plastic or organic films are similar, these methods work with a variety of layers.

Magnetic Pull-Off Gauges

Gauges based on magnetic attraction are usually the pull-off type using either a permanent magnet or an electromagnet surrounding an iron core. The concept is simple where the attractive magnetic force across the paint gap is mechanically countered with a spring or a weight. The pull-off force needed to separate the magnet from a surface is read off of a dial in some models or a plunger attached to a helical spring in pencil type versions.

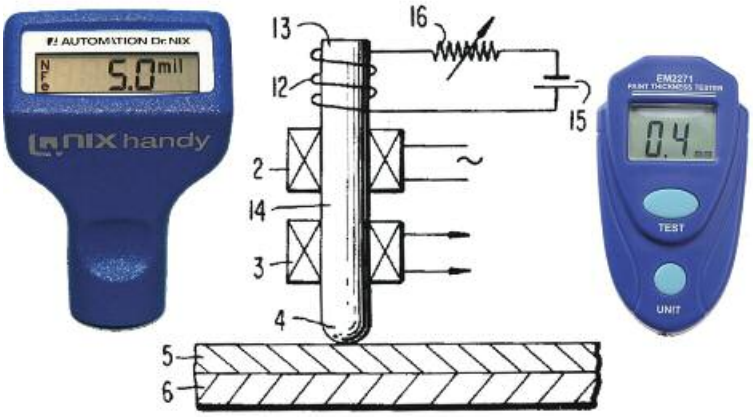


Pencil type magnetic pull-off gauges using an internal countering spring.

BSA Tinsley first made compact magnetic pull-off gauges in the 1940s with an accuracy of about +/- 15% for coatings in the 0.1-10 mil range. Examples of modern pencil-type gauges are shown at left, together with a cutaway showing the inner workings. A bit more about their range and accuracy later.

Electromagnetic Induction

Non-magnetic layers coated over steel can be also measured by correlating magnetic induction to gap thickness. Variations have been around for decades and the diagram below shows a design used in many hand-held gauges. The approach uses a small iron core probe (14) with a magnetizing coil (12) and a source of DC current (15) at its end. A second excitation coil (2) is connected to alternating current to generate an alternating magnetic field. A third coil (3) measures changes in the magnetic flux density in the core caused as the pole end (4) is brought close to a substrate (6) coated with a non-magnetic film (5). Calibration correlates the field change to film thickness.



Electromagnetic induction gauges and a schematic of the operation principle.

Measuring over Aluminum

Although the techniques above necessitate a ferromagnetic substrate, those with aluminum or alloy body panels aren't out of luck. For non-ferrous metals, electromagnetic induction can be employed by passing a high frequency alternating current through a coil near a substrates surface to set up an eddy current field, which in turn induces a magnetic field. The induced magnetic field is dependent on the underlying layers, which can be detected by a second sensing coil. Since the geometry and circuitry can be similar to electromagnetic induction gauges, most gauges also incorporate the capability to make eddy current-based measurements for non-ferrous substrates.

Comparison and Calibration

The calibration of measurement gauges requires a series of known coating thicknesses to test against. Since most plastics have densities between about 1.2 and 1.4 g/cm^3 (including cured acrylics, epoxies, polyesters, and polyurethanes) a simple measurement standard can be made from polyester packaging tape in increments that corresponds to the range

A calibration thickness standard using 3 mil polyester tape on steel.

of available gauges and coated layers on our cars. Pictured above is a calibration standard made by overlapping layers of 3 mil packaging tape on bare steel sheet metal. The tape thickness was confirmed using a micrometer to measure folded-over tape, which indeed checked out to be 6.0 mils. A total of 25 overlapping layers were created using progressively smaller tape lengths to leave a ½" measurement surface for each interval. Four gauges were tested - two pull-off type and two induction type. The results are tabulated below. The pull-off gauges are simple and quick but there is a knack to using them. It takes a bit of practice regarding positioning, pull-off speed, and noting the final thickness before the plunger disappears into its housing. This can affect both accuracy and repeatability. Repeatability is generally better with the induction gauges. The most expensive induction gauge also proves to be the most accurate, though its range is limited to 20 mil. Knowing the measurement offsets of each by running this sort of test can allow for straightforward recalibration.

	Qnix Handy	**EM2271**	**ProGauge II**	**AutoLakTest**
Method	Induction	Induction	Pull-Off	Pull-Off
Cost	$400	$40	$60	$24
Fe/Al	Both	Both	Fe only	Fe only
Thickness (mil) actual at left.				
3	2.5	3	2	2
6	5.5	7	4	5
9	9.0	10	8	8
12	12.0	13	11	12
15	15.0	16	14	14
18	18.0	19		18
21		22		22
24		26		25
27		30		
30		33		
45		48		
60		63		
75		79		

Calibration and cost data for four compact gauges. Fe indicates ferromagnetic induction and Al indicates non-ferromagnetic (eddy current) capability. EM2271 is also called AGPtek or MiNi Digital Paint Tester.

Is Beauty only Skin Deep?

After measurement, the challenge is to interpret the data taken from our cars. The internet is abundant with collections of perspective drawings of 356s and most other Porches. Recording values directly onto such printouts allows for a mapping of measurements, giving a good sense of what lies beneath the surface. Interpretations of coating thicknesses can be argued, but the summary above is an attempt at providing some useful ranges.

Thickness (mils)	Indication
2-3	Paint is thin and has been polished nearly to the primer coat.
3-7	A normal range for a factory paint job or restoration. A variation of 1 mil or a bit more is not uncommon, especially for older paint. Repainting may have occurred.
7- 11	Car has been painted over. If the condition is good, this is a proper range for repaint over an original finish.
11-15	Multiple repainting is likely. A skim filler coat may also be present in some areas, which should be no thicker overall than multiple primer coats.
>15	Multiple repaints and and/or a filler coat are present. Variations across body panels may give an indication of the extent of body work. Thicknesses approach a paperclip at about 30 mils, a dime at 50 mils, a penny at 60 mils, a quarter at 70 mils, and a nickel at about 80 mils. A gauge with a range up to 80 mils is useful to evaluate the extent of filler. Abrupt changes may indicate underlying sheet metal repair.

A summary of coating thicknesses and correlations to what may lie beneath.

On a final note, opinions regarding skim coating vary and the practice has been frowned upon by some aficionados. But it's a fact of life that many good body shops have used thin skim layers to ensure a high level of fit-and-finish. Whatever the outcome, it's best to evaluate all measurements in context of the entire car or, better yet, together with data across several cars.

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