E. Springer,[1] B.Sc. and P. Bergman,[1] M.Sc., LL.B.

Applications of Non-Destructive Testing (NDT) in Vehicle Forgery Examinations

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ABSTRACT: Some non-destructive testing methods (NDT) used in industry and adapted for forensic use were reviewed. These methods were X-ray radiography, eddy current thickness measuring, and magnetic thickness measuring. Examples of applications of these methods in vehicle forgery examinations are illustrated.

KEYWORDS: criminalistics, non-destructive testing methods, vehicle forgery

Forensic science is an applied science. There is generally a lag between scientific developments and their application in forensic laboratories. This may be attributed to a wide variety of reasons such as excessive case loads, lack of research establishments in the forensic area, or the fact that people are expected to gain expertise in many areas. Forensic laboratories, unlike industry, apply scientific tests in order to aid in settling cases that are litigated in court. Because of this, it is preferable to test materials without destroying them so that they can be brought before the court or re-tested by other parties. In addition, forensic examinations often have to be carried out when only small quantities of evidence are available so that it is preferable to use as little as possible in the examination. Another reason for the use of non-destructive testing wherever possible is to avoid unnecessary damage to the citizen's property.

This work intends to increase the awareness of our colleagues of a field that has been developing rapidly over the years, mainly in industry. This field is that of non-destructive testing (NDT).

Non-destructive testing methods are widespread in forensic examinations and include techniques such as microscopy and spectroscopy. Here, however, it should be noted that the term NDT refers to a well defined family of examinations that is used in industry for quality control and failure detection. Several methods that have been adapted by us for use in examination of vehicle forgeries will be discussed.

Vehicle forgery is a widespread phenomenon occurring in many countries [*1*]. For one of any number of reasons, various methods are employed to give a new identity to a vehicle. There are three main methods used in vehicle forgery [*1,2*]. One method involves only document alteration. The other methods involve physically altering the vehicle being

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[1]Head, Fingerprint Development Laboratory; and Assistant to the Director, respectively, Division of Identification and Forensic Science (D.I.F.S.), Israel National Police H.Q., Jerusalem, Israel.

forged. In one of these methods, the engine and chasis number (Vehicle Identification Number-VIN) can be obliterated and re-stamped. Another method involves the transfer of key parts from a wrecked vehicle to a stolen vehicle. Here, the part upon which the VIN is stamped is cut out of the wrecked vehicle and welded onto the stolen vehicle. In many cases, the stamping appears to be legitimate when in fact, the vehicle being examined may actually be made up of two halves of different vehicles that have been welded together. Especially in this last type of case, the examination must include removal of paint from the vehicle in order to reveal the forgery. This, of course, damages the suspect vehicle, which does not always prove to be forged. For this reason, we searched for compatible non-destructive tests that would be of assistance in such instances.

Methods

Among the various methods described in the literature, [3] we examined three methods that were readily available to us. These methods were X-ray imaging (radiography) and coating thickness measurement by use of eddy current and magnetic testing instruments. Some of the other existing methods not described here include ultrasound, beta backscatter, etc. [3].

X-Ray Method

This method is a straight-forward means of examination and is often employed for contriband screening, bomb mechanism examination, etc. However, factors such as radiation hazards and safety precautions as well as large exhibit size make this method cumbersome and expensive. Having access to a suitable industrial facility enabled us to overcome these limitations.

A suspect vehicle was driven into a special examination room (Fig. 1). Here, a remote-controlled X-ray tube can be positioned over the desired suspect area. Photographic film is placed on the underside of the part being examined (floor, doorpost, etc.) aligned with the X-ray tube. After positioning, the examiner vacates the room and exposes the film to the radiation.

Eddy Current Thickness Measurement Method

An eddy current is an electric current induced within the body of a conductor when that body either moves through a non-uniform magnetic field or is in a region where there is a change in magnetic flux [4].

In thickness measuring, a test probe generates a high frequency electric field in a coil which sits in a ferrite pot core [5]. When the probe is placed on or near the substrate, electrical energy in the form of eddy current is transferred to the base material. The magnitude of the eddy current depends among other things, on the amplitude and frequency of the inducing current, and electrical conductivity of the material being tested (coating and substrate). In the case of a non-conductive coating on a conducting substrate, the change of the impedance of the probe is proportional to the distance between the probe and the substrate. This distance is simply the thickness of the coating.

There is a wide variety of commercial instruments available for coating thickness measurements using the eddy current principle. These instruments measure the thickness of non-conductive coatings on conductive substrates. Since vehicles have non-conductive materials such as paint on metal surfaces, they are suitable for evaluation by this method.

FIG. 1—*Suspected vehicle in X-ray examination room; note X-ray tube positioned in upper-right hand corner.*

Magnetic Thickness Measuring Method

In this method, a probe is used to measure either the attraction between a magnet and the base metal, which is influenced by the thickness of the coating, or the reluctance of the magnetic flux passing through the coated base [5]. An induced probe output voltage is measured as a function of the flux density. This flux density is a function of the coating thickness.

This principle is useful for measuring the thickness of non-magnetic coatings on ferromagnetic substrates such as iron or steel. This coating/substrate combination is of course found on vehicles. Compact, simple to use instruments based on this method are also available. Figure 2 depicts the unit used in this study. The equipment includes standards for calibration of the zero point, a three millimeter coating, and a ten millimeter coating. Operation is straight-forward. Calibration of the zero point is made using the zero standard. The relevant thickness standard is used to calibrate the point in the range of interest (in our case, 3 mm). Before placing the probe, the area that is to be measured is cleaned of dust or other heavy contaminations.

It should be noted that both in the eddy current and the magnetic methods, when high accuracy and precision are required (as in industry, where one is usually interested in absolute values), careful steps must be taken to calibrate the instrument and factors such as geometrical shapes must be taken into account. However, these requirements are less important in vehicle forgery examinations, where large deviations in coating thickness are of interest. These deviations point to areas where body filler and non-original painting had been applied.

Results and Discussion

In order to examine the feasibility of the suggested methods, contact was made with several industrial-related companies. The X-ray facility was found in an aircraft main-

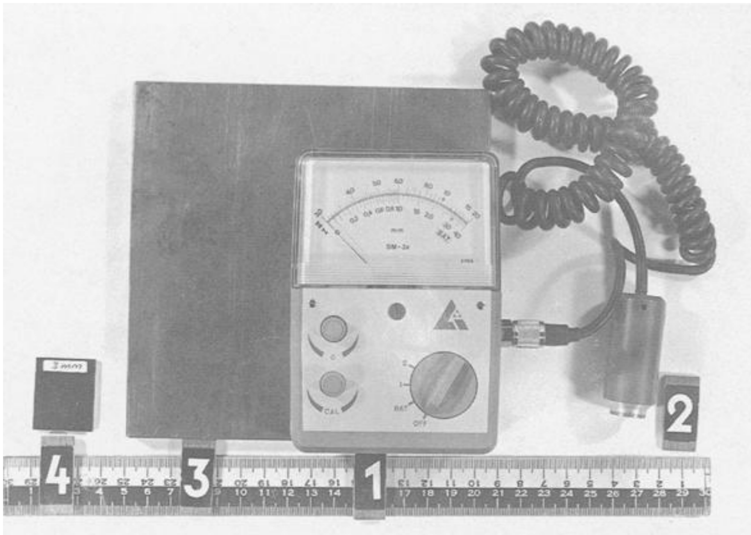

FIG. 2—*Magnetic coating thickness measurement unit used in the study. 1- unit; 2- probe; 3- zero standard; 4- 3-mm standard.*

tenance company and the other methods were tested at a company that provides quality control services. Suspect vehicles were brought to both facilities and were examined using the previously mentioned methods.

Coating thickness measurements using the eddy current and magnetic principle gave basically the same relative results. In our laboratory, we use an instrument based on the magnetic principle. Sample results of the X-ray method and the magnetic method are described as follows.

X-Ray Method

Figure 3 is a photograph of the front/right doorpost where the radiograph was taken. Figure 4 is a positive of the radiograph. One can distinguish a non-original welding seam near the center of the figure. A welding seam in this specific area is not present in a new vehicle. In addition, original welding in this vicinity is of the spot welding type. The presence of the type of welding found indicates either a repair after an accident or a forgery.

Figure 5 reveals a non-original welding seam along the floor of the same vehicle. Note the large nail that was placed as filler into the welding seam.

The areas of the vehicle chosen for initial x-ray photography are those prone to be severed during the forging process.

After the seams were partially revealed in the photographs, paint and filler were removed along the entire length of the seams. This is done in order to prove that the vehicle is composed of two sections and that the welding is not part of a local repair.

Magnetic Method

Five different vehicles were examined using this method. Table 1 lists the results of thickness measurements taken of various parts of these vehicles.

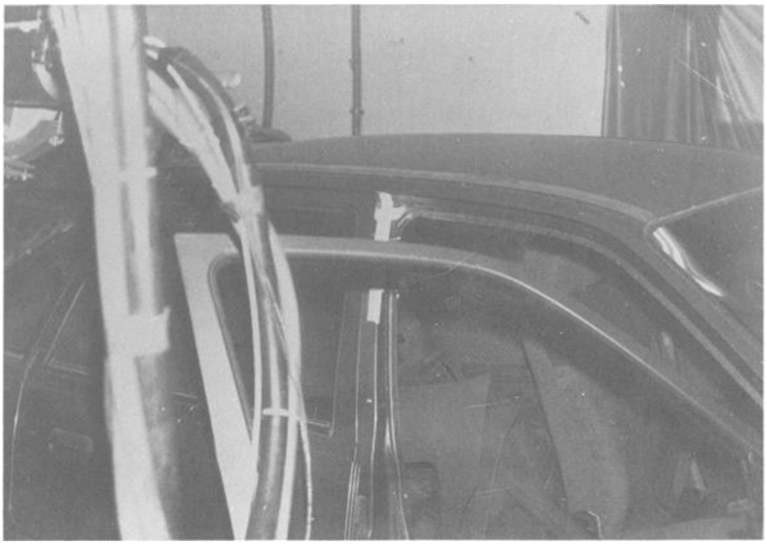

FIG. 3—*Front-right door of the vehicle in Fig. 1.*

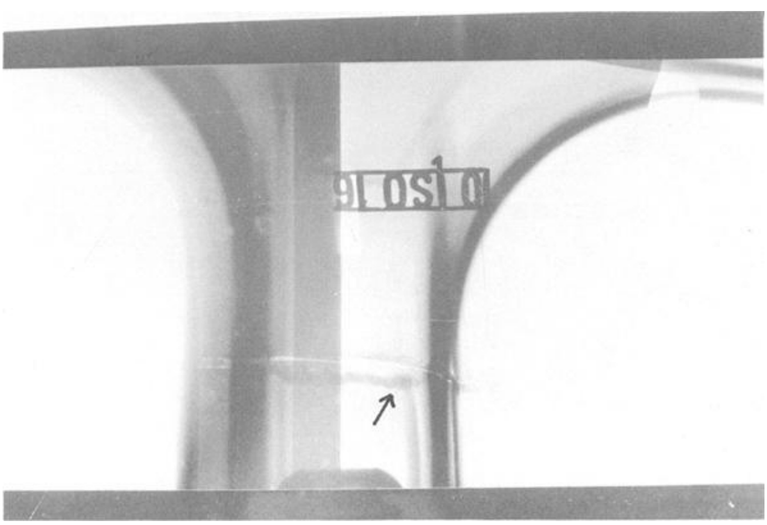

FIG. 4—*Positive of radiograph of front-right doorpost; arrow points to dark line, which is a non-original welding seam.*

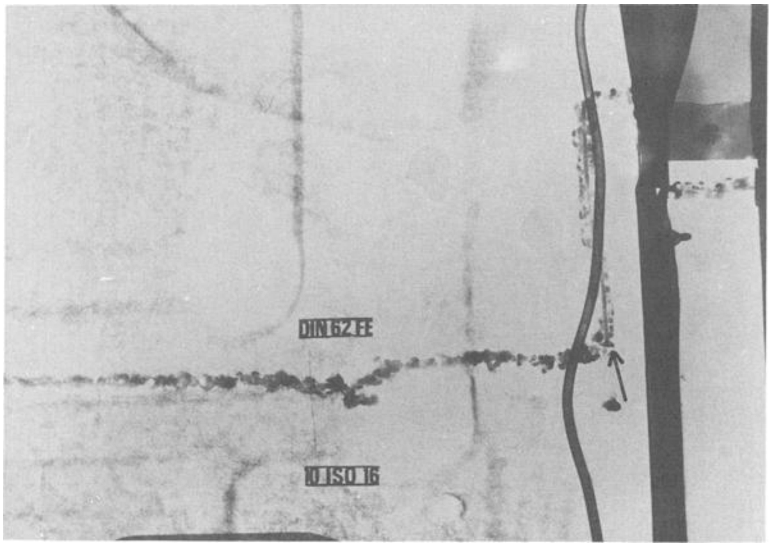

FIG. 5—*Positive of radiograph of vehicle's front floor; irregular line is a nonoriginal welding seam. Arrow points to a large nail that was placed as filler in the welding seam.*

From the data recorded, one sees that the coating thickness of most of the parts in all the vehicles examined are between 0.2 to 0.4 millimeters. Even an old, refurbished vehicle (VW "Beetle" convertible), after being stripped and re-painted, still has a similar coating thickness. Large fluctuations in certain areas indicate the existence of body filler used in repairs. The examiner can then focus on these areas and decide whether or not a legitimate body repair was done or a forgery is being attempted. Having located specific suspect areas, the examination is continued by conventional methods after coating removal. Damage to the vehicle is thereby limited.

TABLE 1—*Thickness measurements results—magnetic method.*

	Part's Coating Thickness (mm)				
Vehicle Type	Roof	Door	Fender	Trunk Lid	Hood
Fiat Fiorino	.25 .25	.25 .25	.25 .25	.25 .25	.25 .25
(new)	.25	.24	.25	.25	.24
VW "Beetle"	.20 .25	.35 .35	.30 .70	.30 .35 .70	.30 .55
	.25	.35	.65	1.00 1.50	.60
VW "Beetle"					
convertible	.25 .25	.30 .30	.45 .40	.20 .20	.20 .25
(refurbished)	.25	.30	.44	.40	.30
Mercedes 240	.20 .20	.40 .20	.40 1.00	.20 .20	.20 .20
	.20 .20	.20 .50	1.00		1.00
Ford Van	.20	.70 .80	.20 2.2		1.25
		1.00 2.20	.40 1.00		1.40

Conclusions

Non-destructive tests are widely used in industry. Many of them can be adapted for use in forensic examinations of vehicle forgeries. Implementation of such methods saves time and diminishes damage to the exhibits examined. Awareness of these methods can enable adaptations to other areas of forensic science.

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Address requests for reprints or additional information to
E. Springer
Fingerprint Development Lab
DIFS
Israel National Police HQ
Jerusalem, Israel 91906