CASE REPORT

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Abrasive Cutting of a Safe: A Case Study

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ABSTRACT: A case study of an abrasive safe cutting is presented. The suspects were linked to the offense by the characteristics of two abrasive discs in their possession and debris collected from their clothes. Experiments of abrasive and oxygen cutting of steel were carried out. It was found that some characteristics may distinguish between debris of the two processes.

KEYWORDS: criminalistics, safe cutting

The usual method of safe breaking in Israel is to cut through the safe by abrasive disc or oxygen cutting. A study concerning identification of debris from both processes has been described [*1*]. It was reported that in both processes spherical particles were formed due to burning of steel particles.

This paper reports on an interesting case of the linkage of abrasive discs possessed by one suspect to an attempted cutting of a safe. In this case the suspect and two others were linked to the offense by spherical and irregular particles found on their shirts.

Experiments were carried out to assess the influence of the rotating speed of abrasive discs on the percentage of spherical and irregular particles that are formed. The populations of formed particles were compared with population of formed particles in oxygen cutting.

The Case

A safe was stolen from a factory. During the attempt to cut the safe door by abrasive discs, the suspects were surprised by police, and they fled the scene. Three suspects were arrested and their shirts as well as a grinder with two mounted abrasive discs possessed

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by one of the suspects were seized. These exhibits, the safe door, and debris from the scene were brought to the laboratory for examination.

Case Examination—Experimental Procedure

The shirts were shaken out and the collected material and the material from the scene of cutting were examined under a stereomicroscope. Magnetically separated particles were mounted on aluminum stubs coated with 3M double-sided adhesive. Scanning electron microscope/energy dispersive X-ray (SEM/EDX) analysis of the particles as well as samples from the safe door was carried out using a CamScan 4 SEM combined with a Tracor-Northern TN 5500 EDX system.

All experimental cuttings of the safe were carried out using a 9 inch diameter abrasive disc (for cutting steel) at three different rotating speeds: 6500 rpm, 5200 rpm and 2800 rpm in order to examine the effect of the rotational speed on the percentage of spherical particles formed. The Bosh GWS-20-30 grinder possessed by one of the suspects having a single rotational speed of 6500 rpm was used to obtain a sample of particles for cutting at this speed. For particle samples at 5200 rpm and 2800 rpm a Peugeot grinder with five different rotational speeds (5200 rpm being the highest) was used. Oxygen cutting was also carried out to compare the obtained population of particles with populations obtained by abrasive cuttings. From each experiment, after magnetic separation samples were prepared for SEM/EDX examination. A hundred randomly selected particles in every sample were examined in order to calculate the percentage of spherical particles.

Results and Discussion

Figure 1 shows the general view of the cuts in the safe door. Figure 2 shows a close view of two close parallel cuts in the door: one 270 mm length with a maximal depth

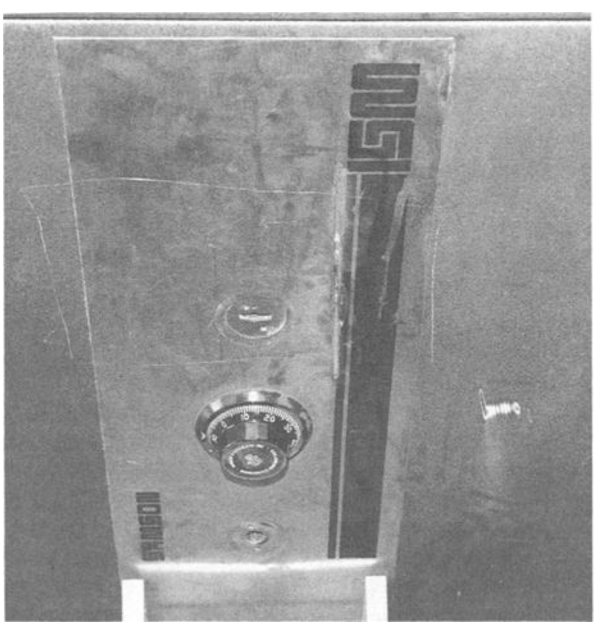

FIG. 1—A general view of the cuts in the safe door.

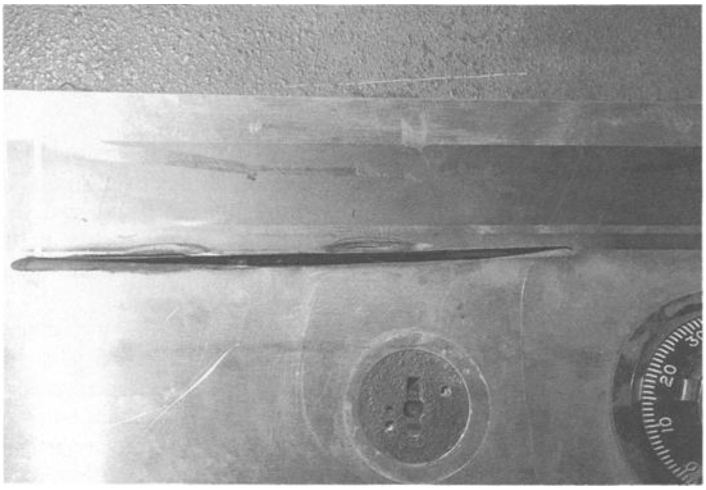

FIG. 2—*A close view of two close parallel cuts in the safe door.*

of 24 mm, and the second, 60 mm length with a maximal depth of 2 mm. The diameter of one of the discs apprehended from the suspect was 197 mm and the diameter of the second disc was 153 mm. The original diameter of the both discs before wearing was 229 mm (9 inch). As mentioned above, both discs were mounted on the grinder (Fig. 3), which is a rather unusual method of applying abrasive discs for cutting. Figure 4 shows the match between the combination of the two discs and the two parallel cuts in the safe door, namely when the two discs are placed in the appropriate cuts a match is found between the centers of the two discs. This match is shown schematically in Fig. 5. Because the discs were worn down to different diameters before the offense, such a match provides a linkage of high probability between the discs and the cuts in the safe door.

FIG. 3—*The grinder with two mounted abrasive discs apprehended with the suspect.*

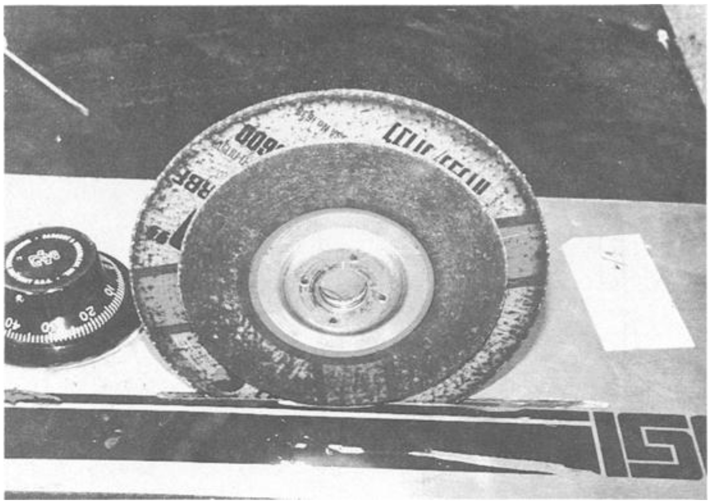

FIG. 4—*The match between the combination of the two discs and the cuts in the safe door.*

As may be seen from Fig. 1 a steel plate is covering the central part of the safe door. The thickness of the plate is 1 mm and its composition is 16% Cr in addition to Fe (stainless and heat resistant steel [2]) (Fig. 6). The door itself is made of plain carbon steel and is painted with two layers of paint: black-grey (top coat) and white (under coat). After magnetic separation, the debris from the scene of the crime consisted of many irregular and spherical particles. The fact that high percentage of nonspherical particles is formed in abrasive cutting was not stated by Collins and Powell [*1*]. The possibility of finding irregular particles was suggested only by one of the reviewers in the section of the manuscript: "Discussion with Reviewers." In any case, the difference in the percentage of spherical particles produced by oxygen and abrasive cutting was not reported by Collins and Powell and was not proposed as means to distinguish between the two processes. In fact, the percentage of spherical particles may be very significant in assessing which cutting process was used (see subsequent discussion).

All examined spherical particles from the debris at the crime scene resembled the composition of plain steel (steel of the safe door), sometimes with addition of very small concentrations of elements: Al, Si, K, Ca, Cr, Ti, or Mg. Large concentrations of the last two elements were found in the two paint layers. This result may distinguish between particles formed by abrasive or oxygen cutting of steel painted with paints having high concentrations of Ti and particles formed by fluxed arc welding, where high percentage of particles with large concentrations of Ti is usually found [*1*]. Most of the irregular particles in the debris resembled spherical particles in composition. A minority of the irregular particles resembled in composition the stainless steel plate covering the safe door. It should be emphasized that no spherical particles were found with the composition of the stainless steel plate. It is probable that the temperatures developed during the cutting were not high enough to ignite or to melt the stainless steel particles.

In the debris collected from the shirts of the three suspects a similar population of particles was found. Due to the presence of the irregular stainless steel particles in addition to spherical and irregular plain steel particles in debris from the suspects, they could be linked to the offense with higher probability.

It is reasonable to assume that the percentage of spherical particles formed in abrasive cutting will depend on the tangential velocity of the cutting area of the disc, since a

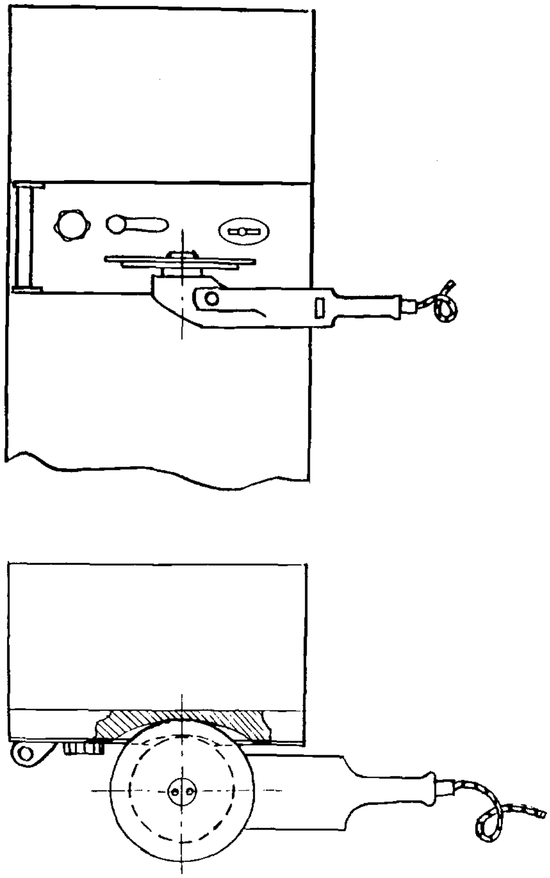

FIG. 5—*Schematic drawing of the match shown in Fig. 4.*

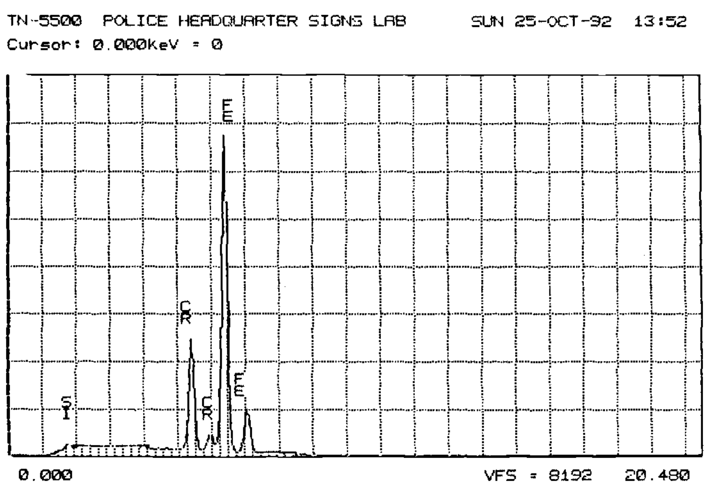

FIG. 6—*SEM/EDX spectrum of the steel plate covering the safe door.*

TABLE 1—*Experiments of abrasive and oxygen cutting.*

	Abrasive cutting (9 inch disc)			
	2800 rpm	5200 rpm	6500 rpm	Oxygen cutting
% of spherical particles in the ferromagnetic debris	3	19	42	80

larger tangential velocity will cause a greater heat build-up, which may ignite the steel particles. This assumption is confirmed by the results shown in Table 1. Obviously, it may be concluded that a disc with a smaller diameter (for example, worn disc) will produce a smaller percentage of spherical particles than the disc of the same type with a larger diameter and the same rotating speed.

The results in Table 1 show, as might be expected that a much higher percentage of spherical particles is formed in oxygen cutting as compared to abrasive cutting. Figure 7 shows the appearance of the debris (after magnetic separation) produced by abrasive

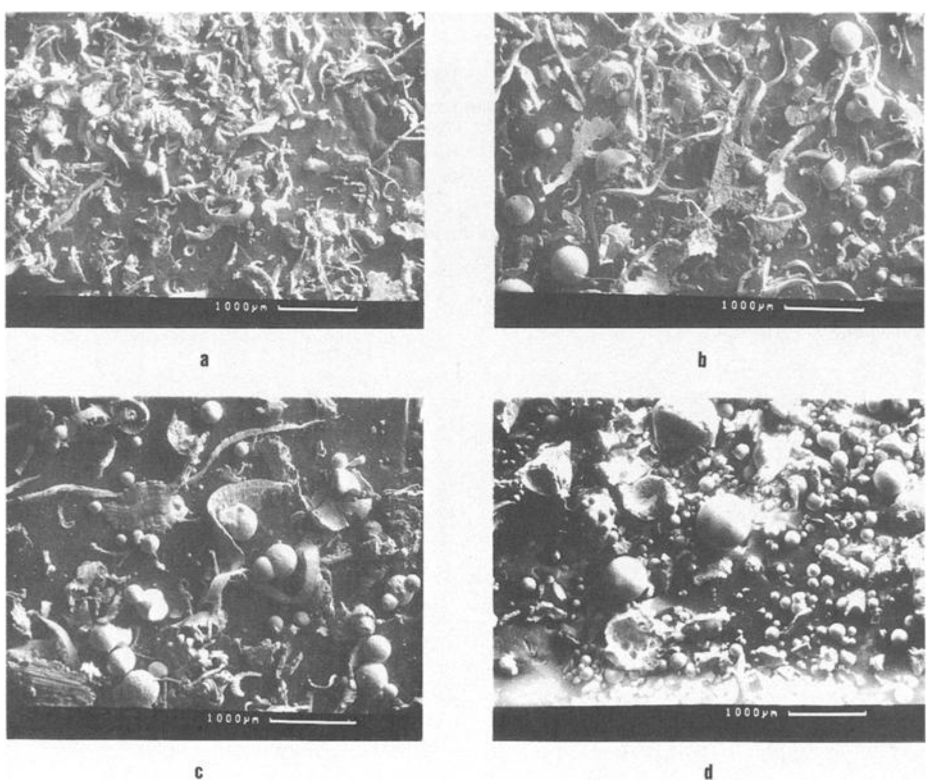

FIG. 7—*SEM micrographs of magnetically separated particles formed by abrasive and oxygen cutting:* (a) *abrasive cutting: 2800 rpm.* (b) *abrasive cutting: 5200 rpm.* (c) *abrasive cutting: 6500 rpm.* (d) *oxygen cutting.*

and oxygen cutting. It may be seen that in addition to a much lower percentage of spherical particles, a considerable percentage of irregular particles formed in the abrasive cutting had the form of filings. On the other hand, none of the irregular particles formed in oxygen cutting had the form of filings. This result may serve as additional means for distinguishing between debris from abrasive and oxygen cutting.

Conclusion

A case study was presented in which abrasive discs possessed by one suspect were linked with high probability to the cutting attempt of a safe. A match was also found between the debris collected from the shirts of the suspects and the debris found in the scene.

In cutting experiments it was found that much higher percentage of spherical particles is formed in oxygen than in abrasive cutting. It was also observed that rotating speed of a disc may affect considerably the percentage of spherical particles. These characteristics may provide evidential value for linking suspects to an offense of cutting safes.

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