The forensic examination of plastic cable ties.

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ABSTRACT

This paper presents the results of a study on the forensic examination of plastic cable ties. The study involved the visual and microscopic examination of more than 2000 cable ties of known origin, which were obtained from various retail outlets and tradesmen's workshops, and included both sealed and opened packages. These reference samples encompassed 18 different types of ties.

In addition, 92 randomly collected samples obtained mainly from building sites, were examined. Another 30 different types of plastic cable ties could be differentiated among these samples.

INTRODUCTION

Cable ties are commonly used as tying and fastening devices in many industries, professional workshops and also households. The forensic examination of cable ties is often required when they are used as improvised handcuffs to tie up victims.

Manufacturing process

Plastic cable ties are manufactured by an injection moulding process, in which several individual moulds are grouped together side by side to produce a batch of ties in a single stroke of moulding. They are produced in the form of 'fish-bone' batches of varying numbers depending on size - the smaller the size, the greater is the number of ties in one 'fish-bone' [1]. For example, in the production cycle of ties sized 200 x 4.8 millimetres, 10 moulds (channels) are present, side by side in each quarter of the 'fish-bone', thereby producing 40 ties per injection of plastic (Figure 1).

Figure 1. A 'fish-bone' batch of 40 cable ties, size 200 x 4.8 millimetres, courtesy of Cable-Loc Systems Richmond, South Australia.

Commonly, each mould bears some identification mark, either a number, a letter or a combination of both and in some cases together with a company logo. These marks are used by manufacturers for quality control so defects or blocking of any 'fish-bone' channels can be identified. In the production cycle of longer ties, such as those sized 370 x 4.8 millimetres, only 5 moulds may be present in each quarter of the 'fish-bone', thereby producing 20 ties per injection of plastic.

If moulds consecutively numbered 1-20 are used, a batch of ties consecutively numbered 1-20 is produced. The ties are then added to bags, so in this case if 100 ties are needed per bag then five sets of ties consecutively numbered 1-20 may be present in each bag. Normally, a manufacturer would have additional moulds so that if there is a problem during quality control, the faulty mould can be replaced. This would result in the next batch of bags containing sets of ties numbered differently from the original sequence 1-20.

The appearance of a cable tie is determined by the size and the shape of the mould used in the manufacturing process. Cable ties, which are produced in a variety of colours and sizes, are plastic strap fasteners that consist of a clasp at one end, adjacent to a longer thin rectangular strap with a pointed and usually ribbed end (Figures 2, 3).

Figure 2. Photograph of clasp, M1- mould number, M 3- circular pin detail, magnification approximately 4x

Figure 3. Photograph of strap, M2-mould detail on the ribbed end, a linear indent, running diagonally across two ridges, magnification approximately 5x

Physical features of cable ties (e.g. shape of the clasp, shape of the strap, colour, width and length), together with macroscopic markings (e.g. mould number) can be compared visually. Cable ties also possess microscopic features that are impressed onto the plastic during manufacturing. Microscopic markings in the form of striations, indents or protrusions can be caused by fine irregularities in the mould (mould detail) and the pins that are used to push the cable ties from the mould (pin detail). These microscopic features can be used for comparison of cable ties, which have the same macroscopic markings [1,2].

CASE SCENARIO

This study was conducted in conjunction with a case, which involved two black plastic cable ties that had been used to bind a victim during an armed robbery. During a search of a suspect's car, an opened bag of ties similar in appearance to those used to bind the victim was found. The authors

were asked to examine the ties removed from the victim to establish if they could have come from the suspect's bag of cable ties.

MATERIALS AND METHODS

The study involved visual and microscopic examination of suspect’s cable ties, the ties used to bind the victim and more than 2000 cable ties of known origin, which were obtained from various retail outlets and tradesmen’s workshops, and included both sealed and opened bags.

In addition, 92 randomly collected samples obtained mainly from building sites, were examined. Physical features and macroscopic markings of these ties and the shape of the strap end of the cable ties were used to classify the ties into groups. Further microscopic comparison of roughly parallel ridges present on the strap was conducted on cable ties within each group.

RESULTS

Results of visual examination of case cable ties

The suspect's bag contained 76 black cable ties, which were all found to be similar in appearance, width and length to the victim's ties. All ties from a similar sealed bag of 101 black cable ties were found to be similar in appearance and width to, but slightly different in length from the suspect's ties. The suspect's bag contained ties with consecutive numbers ranging from 37 to 47, and numbers 49 and 545. The reference bag contained ties with consecutive numbers ranging from 27 to 37, 39 to 47 and numbers 49 and 545. The distribution of mould numbers within the opened suspect's bag was found to be different from that found within the sealed bag of reference ties.

At this stage no further investigation into the distribution of mould numbers could be done, since another similar bag of cable ties obtained from the same retail outlet as the examined reference sample was found to contain cable ties which had different physical features (shape) and macroscopic markings (manufacturer information) from the reference cable ties.

This finding was the first reason to conduct the study.

Results of microscopic examination of case cable ties

Five ties with number 45 present in the suspect's bag and four ties with number 45 present in the reference bag were examined microscopically and compared with the two ties numbered 45 recovered from the scene. The mould features, marked M1 and M2 in Figures 2 and 3, respectively, were compared between these ties using a low magnification microscope.

All examined ties bore indistinguishable mould details, the most significant of which was considered a linear indent, running diagonally across two ridges at the ribbed strap of the ties, as indicated by the white circle in Figure 3, since this mould detail was observed only on cable ties with the mould number 45. This finding is consistent with these ties being manufactured using the same mould [2].

The examination also included microscopic comparison of impressed detail from a circular pin, marked M3, in Figure 2. The M3 pin detail on both victim's ties and all five suspect's ties consisted of striations, together with two distinct indents (Figures 4,5).

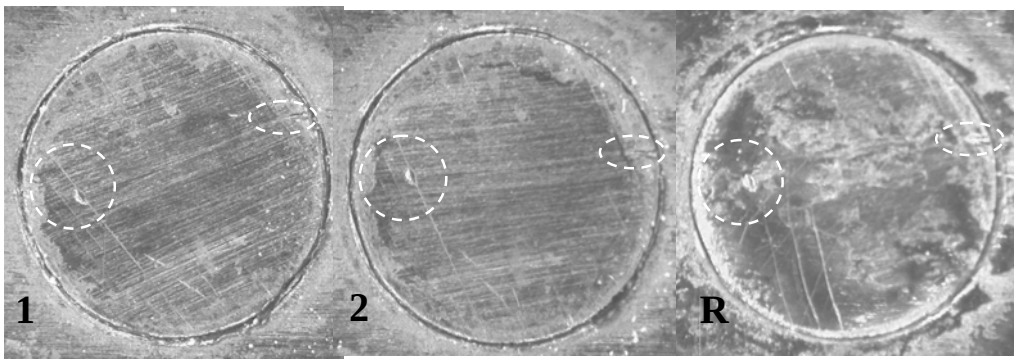


Figure 4. Comparison of M3 pin detail (diameter approximately 3 millimetres) in the same orientation between two victim's ties (1, 2) and the reference ties(R).

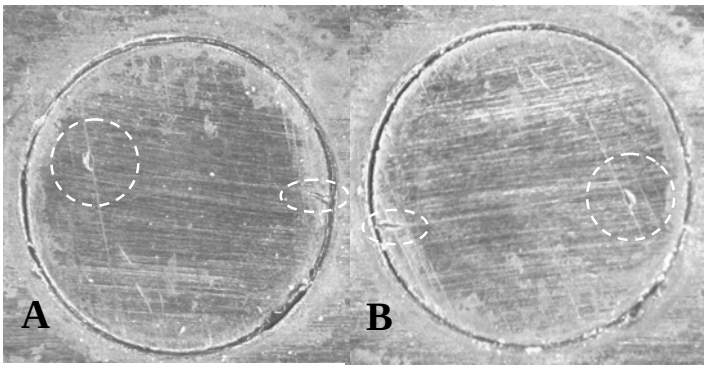


Figure 5.Comparison of M3 pin detail (diameter approximately 3 millimetres) in the same orientation between two types of suspect's ties (A, B).

When viewed as depicted in Figure 2, the orientation of this pin detail was found to be similar on the victim's ties, marked 1 and 2 in Figure 4, and generally similar to one of the five suspect ties, marked A in Figure 5, but different from the remaining four suspect ties, marked B in Figure 5.

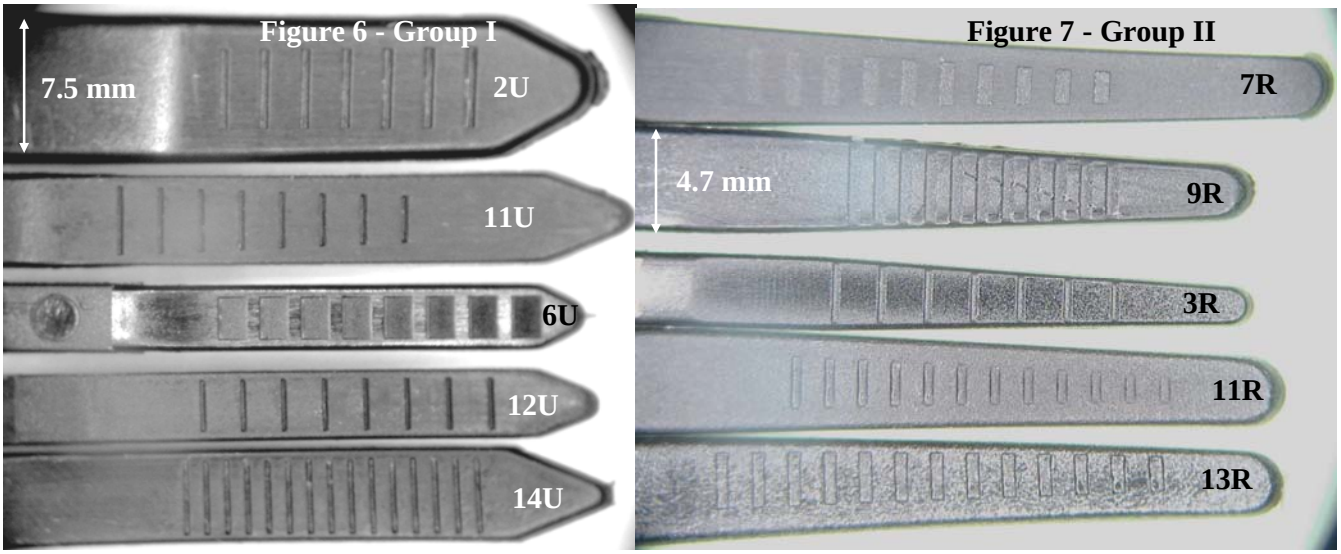
The orientation of two indents of this pin detail on all four reference ties, marked R in Figure 4, was found to be similar to the victim's ties, but there were no well defined striations present.

At this stage there were no data available to evaluate the significance of these findings, which was the second reason for conducting the study.

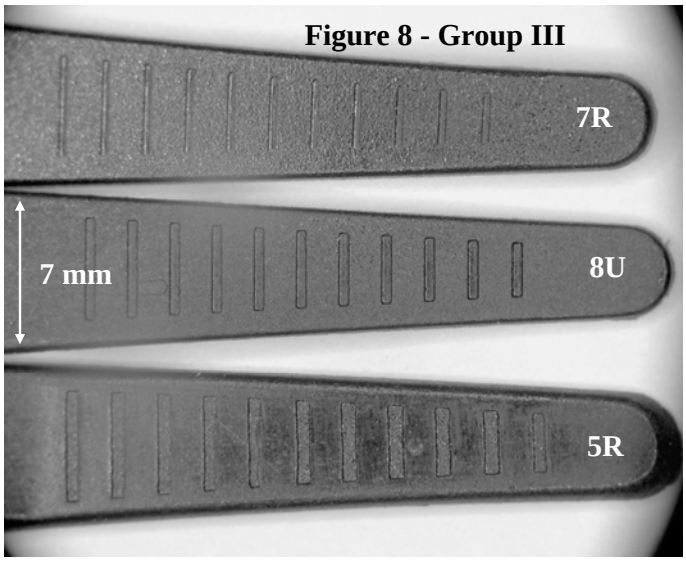
Results of the study

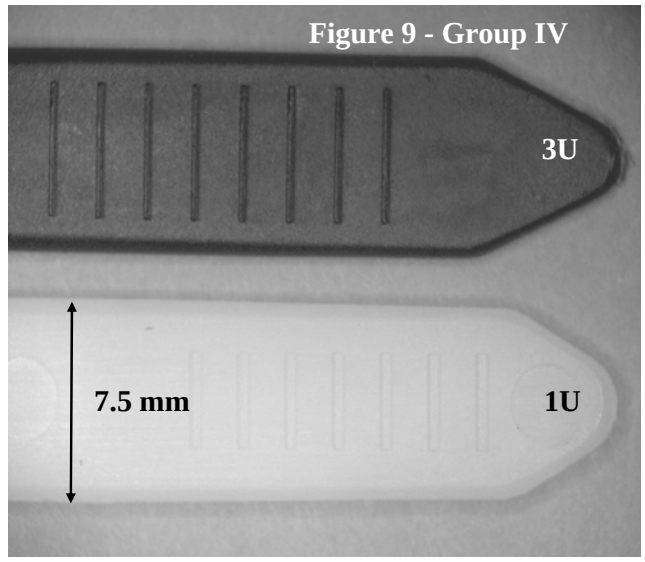
The examined cable ties were classified into four groups based on the shape of the strap end. Further microscopic comparison of roughly parallel ridges present on the strap within each group (Figures 6,7,8,9) resulted in 48 different types of cable ties being discriminated.

The summaries of results for each group are listed in Tables I– IV.



Figures 6-7. Photographs of strap end details- Group I - triangular bent down end, samples 2U, 11U, 6U, 12U and 14U as listed in Table I, Group II - tapering bent down end, samples 7R, 9R, 3R, 11R and 13R as listed in Table II





Figures 8-9. Photographs of strap end details -Group III-straight tapering end, samples 7R, 8U and 5R as listed in Table III, Group IV - triangular straight end, samples 3U and 1U as listed in Table IV

TABLE I. Physical characteristics and macroscopic markings - GROUP I

Type	Sample	Length x width millimetres	Number of ridges on strap	Manufacturer's marking	Number of ties examined
1	U	350 x 6.5	7	e BURNDY	1
2	U	380 x 7.5	7	50 A TCA	4
3	U	150 x 3.6	8	50 A TCA	1
4	R	370 x 4.7	8	193 - 216 PANDUIT	83
5	U	290 x 4.7	8	221 PANDUIT	1
6	U	200 x 3.6	8	F 12 PANDUIT	1
7	R	200 x 4.7	8	X 93 PANDUIT	102
8	U	120 x 4.8	8	M 13 PANDUIT	1
9	R	100 x 2.5	8	O 111 PANDUIT	102
10	R	140 x 3.8	8	G 1 - G 100	126
11	U	350 x 4.8	8	G78 ; G75	2
12	U	300 x 3.7	8	G 444 ; G 45	2
13	U	>300 x 4.9	10	01 AVC	1
14	U	300 x 4.8	15	2 ... 17	4
				Total number of ties examined	431

All reference samples (R) of Group I were collected from tradesmen's workshops and five of ten types of unknown random samples (U) could be linked to the same manufacturer as the reference samples.

TABLE II. Physical characteristics and macroscopic markings - GROUP II

Type	Sample	Length x width millimetres	Number of ridges on strap	Manufacturer's marking	Number of ties examined
1	U	300 x 4.5	7	HT - 300 26	1
2	R	200 x 4.5	7 * 4	1 - 100 yy	120
3	R	150 x 3.6	7 * 4	1 - 50 yy	102
4	U	285 x 4.7	8	33	1
5	U	200 x 4.5	8	84 ... 77	7
6	U	380 x 4.8	9	@ K 61	1
7	R	300 x 4.7	10	none	26
8	R	75 x 2.5	11	12-17, 51-99	180
9	R	200 x 4.7	11	yy2 - 1 - yy2 - 50	206
10	R	150 x 3.6	12	K 1 L - K 200 L	625
11	R	190 x 4.5	12	K 51-75 G	25
12	U	150 x 3.6	12	14	1
13	R	190 x 4.5	13	9 - 35	25
14	U	305 x 4.7	14	TCA 33 ...44	7
			Total number of ties examined		1327

Some of the reference samples (R) of Group II were purchased from hardware stores and some collected from tradesmen's workshops. None of the six types of unknown random samples (U) could be linked to any manufacturer of the reference cable ties.

The reference samples 2 and 3 of this group had four additional ridges (7*4 Table II.) on the underside of the strap, a mould feature, which was present only on these two samples. It was concluded that they are both products of the same manufacturer, although different manufacturers were indicated on their packaging. An inquiry to one of the manufacturers revealed that if the type of cable ties ordered by a distributor are not in stock, similar ties from another manufacturer would be supplied instead. It was also confirmed that the manufacturer identified on one of these samples using the group classification was correct. This finding explained why the second reference sample for the case contained cable ties, which had different mould characteristics from the first reference sample. Similarly, the reference samples 11 and 13 of this group, purchased from the same hardware store on the same day, which had identical labels on the packaging, were found to contain different types of cable ties.

TABLE III. Physical characteristics and macroscopic markings - GROUP III

Type	Sample	Length x width millimetres	Number of ridges on strap	Manufacturer's marking	Number of ties examined
1	U	120 x 2.4	0	none	1
2	R	100 x 2.2	9	none	6
3	U	370 x 3.6	9	14 ... 24	5
4	R	200 x 2.5	10	B ... V	12
5	R	450 x 7.8	11	27-49 , 545	101
		CASE CABLE TIES		37-49 , 545	78
6	R	450 x 7.8	11	K 1 E - K 20 E	100
7	R	380 x 7.6	11	K 44 K – K 52 K	10
8	U	380 x 7.4	11	28	1
9	U	>300 x 7.4	11	46	1
10	R	370 x 4.8	11	76 - 100	99
11	U	370 x 4.8	11	73	1
12	U	310 x 4.7	11	70 ... 97	10
13	U	300 x 4.8	11	66 ... 75	4
14	U	300 x 4.7	11	31 ... 35	2
				Total number of ties examined	431

All reference samples (R) of Group III were purchased from various retail outlets, which included a major hardware store where the two case reference samples, 5 and 6, were obtained.

None of the unknown random samples was found to be similar to the case cable ties, which was an important result used to evaluate the significance of findings related to the case.

TABLE IV. Physical characteristics and macroscopic markings - GROUP IV

Type	Sample	Length x width millimetres	Number of ridges on strap	Manufacturer's marking	Number of ties examined
1	U	455 x 7.5	7	10 E TCA	4
2	U	450 x 4.7	0	8H; 19H; 15E TCA	3
3	U	370 x 7.5	8	G5 ... G17	6
4	U	140 x 3.4	0	25 ... 43	5
5	U	> 130 x 4.8	na	*7 yy ; 15 yy*	2
6	U	> 370 x 7.8	na	20 ; 22	2
				Total number of ties examined	22

All cable ties of Group IV were unknown random samples (U), two of which, 1 and 3, had the characteristics consistent with the classification system. The remaining four samples were included in this group, since they represented unique types, although two of them, 5 and 6, were not intact.

In addition, a part of this study was evaluation of the same-numbered ties distribution within sealed bags, some of which are listed in Table V, and microscopic comparison of the mould and M3 pin details on the same-numbered cable ties originating from similar sealed and opened bags.

TABLE V. Distribution of the same-numbered ties within sealed bags of 100 ties

Group	Sample	Range of manufacturer's numbers	Different numbers	Frequency
I	9 R	B , J , O , T	4	16 - 35 x
I	7 R	X93 X95 X97 X99	4	25 x
II	8 R	2 - 22, 26 - 50	28	1 - 8 x
II	9 R	yy2 1 - yy2 50	28	3 - 4 x
II	3 R	1 yy - 50 yy	50	2 x
II	10 R	K 1 L - K 50 L	50	2 x
II	10 R	K 1 L - K 50 L	50	2 x
II	10 R	K 51 L - K 100 L	50	2 x
II	10 R	K 151 L - K 200 L	49	2 x
II	10 R	K 151 L - K 200 L	50	2 x
II	10 R	K 151 L - K 200 L	48	2 x
III	6 R	K 1 E - K 20 E	20	5 x
III	5 R	27 - 49 , 545	24	4 - 5 x
III	CASE TIES	37 - 49 , 545	13	4 - 7 x
III	10 R	76 - 100	25	3 - 4 x

The distribution of the same-numbered ties within sealed bags of different manufacturers varies, but it can also vary between packs of the same manufacturer, as demonstrated on sample 10R (Group II), which represents six similar bags purchased from the same retail outlet on the same day.

Apart from the sample 8R (Group II) and the case cable ties, the same-numbered ties from the same pack were found to bear indistinguishable mould and pin details.

The orientation of the M3 pin detail between the same-numbered ties from the bag 8R varied and the same was observed on another similar bag of ties.

The same-numbered ties originating from bags of different batches could be differentiated by microscopic examination of the M3 pin detail.

CONCLUSION

The results of this study confirmed that the conclusions of a recently published UK study [2], outlining the manufacturing process and microscopic examination of ties from one cable tie company, can be applied to cable ties of different manufacturers.

This includes comparison of mould and pin details between the same-numbered ties, which can be used to determine if the ties were manufactured in the same mould and at the same time, within the same batch, before any adjustments to the mould or the pins used for production were made.

The study showed that in order to determine whether the victim's ties could have come from the suspect's bag of ties, a minimum of six similar packages of ties need to be examined rather than relying on inquiries to a manufacturer or a distributor.

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REFERENCES

[1] N. S. W. Shum, B. K. K. Cheung, Class characteristics on plastic cable ties, oral presentation at the 17th International Symposium on the Forensic Sciences, Wellington NZ, 28 March - 2 April 2004.

[2] M.E.Gorn, P.S.Hamer, The Forensic Examination of Cable Ties, Journal of Forensic Identification, 56 (5), 2006, 744-755.