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Barrier Technology: Perimeter Barrier Penetration Tests

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BARRIER TECHNOLOGY: PERIMETER BARRIER PENETRATION TESTS

Introduction

Sites or facilities at which sensitive materials are located present potential targets for intrusion by an adversary force whose purpose is theft or sabotage. In order to successfully prevent an adversary from realizing his goal, a series of four interconnected security elements must be implemented:

1. Detection and assessment of the intrusion (attempt either by an electronic system or a human observer);
2. Notification of security response forces;
3. Delay by an active or a passive physical barrier; and
4. Response by security forces to neutralize the intruders.

If there is no significant delay at or near the perimeter of a facility, even a 10 minute response rapidly can be either on foot or by vehicle into and out of sensitive areas. Existing perimeter chain link fences do not delay determined intruders for more than about 10 or 20 seconds.¹ Tests prove true even if the installation of concertina tapes is used to enhance existing fences; penetration delay times have not reached 2 minutes.² A ten minutes delay is necessary for initial alarm response to an alarm. If guard arrival at a perimeter is prompt, namely, the intrusion force can be neutralized or further penetration into the facility prevented.

This report describes the concept, construction, safety, and delay effectiveness of four different perimeter barrier barriers. Penetration attacks by personnel on foot were attempted against all four types of perimeter barrier test arrays. Simple breaching and bridging attacks were employed by the intruders in the six attempts. A vehicle penetration test using a 3/4-ton truck was also attempted.

Objectives

The objectives of the barrier penetration tests were:

- to determine the personnel penetration times of four barrier breaks against a variety of breaching and bridging attacks;
- an attempt to determine the relative delay effectiveness of general purpose barbed wire obstacle (GPBTO) versus barbed tape concertina (BTC);
- to evaluate a people/vehicle barrier and to determine the merit of combining the two types of barriers.

Barrier Construction and Costs

The perimeter barriers constructed for the personnel penetration test utilized GPBTO and BTC as their main deterrents. Table I illustrates the configurations of the four arrays and indicates the relative cost of using either GPBTO (MIL-B-52775A) or BTC (MIL-C-52443A), respectively, in each array.

TABLE I
The Relative Cost In Each Array

	WITH GPBTO	WITH BTC
<p>ARRAY 1</p>	<ul style="list-style-type: none"> \$115/Meter (\$35/foot) 	<ul style="list-style-type: none"> \$46/Meter (\$14/foot)
<p>ARRAY 2</p>	<ul style="list-style-type: none"> \$247/Meter (\$75/foot) 	<ul style="list-style-type: none"> \$112/Meter (\$34/foot)
<p>ARRAY 3</p>	<ul style="list-style-type: none"> \$293/Meter (\$89/foot) 	<ul style="list-style-type: none"> \$224/Meter (\$68/foot)
<p>ARRAY 4</p>	<ul style="list-style-type: none"> \$378/Meter (\$115/foot) 	<ul style="list-style-type: none"> \$319/Meter (\$97/foot)
	<ul style="list-style-type: none"> • INSTALLED AND TESTED 	

Appendix 1

[illegible]

1. 12-2 2. 22-2

Array 1

Array 1 consists of three main sections of chain-link mesh each 100 feet long (Figure 2). The first 100 feet of the roll is a T-post for support. The raised support for the triangular mesh is provided by additional T-posts, which are installed at 1.8-metre (6-foot) intervals. The roll which is adjacent to one of the T-post is wired to it. Every inner bottom corner is fastened to the ground at staggered 3.7-metre (12-foot) intervals, while the end rails are taken every 1.8 metres (6-foot). The cost of material and installation for Array 2 is approximately \$412 per metre (\$124 per foot).

Figure 2. Array 2

Array 3

Array 3 consists of two rows of 2-7/32 inch outside-diameter (OD) posts set at an angle of 60° in a V-shaped configuration. The concrete footers which anchor these posts are 0.6 metre (2 feet) high and 0.7 metre (2.5 feet) in diameter and are buried 0.6 metre (2 feet) below grade. The posts are centered 3 metres (10 feet) apart and are staggered 1.5 metres (5 feet) front to back. A 50 mm (2 inches) square chain-link mesh, which is composed of No. 9 gauge galvanized steel pipe, 100 feet high, (see Figure 3 for an illustration of this configuration.) A 5/16 inch steel cable is used in place of a top rail to provide support for the chain-link mesh. A 16-gauge corrugated metal sheet is fastened to the inner surface of the inner line posts by means of drive screws. This sheet extends 0.7 metre (2.5 feet) above grade and 0.3 metre (1 foot) below grade. The inner surface of the completed "V" is lined with nine rolls of GPBTO which are annexed to the chain-link mesh with stainless steel wire ties. The cost of materials and installation for Array 3 is approximately \$293 per metre (\$89 per foot).

FIGURE 1. FILTER

Appendix 4

Appendix 4, and Figure 1, show details of the filter structure. The construction is similar to that of the filter shown in Figure 3. The filter is constructed to reinforce the overall structure. It consists of 14-gauge galvanized steel sheet piling attached to the inside surface of the inner line post and the outer line post. The sheet piling is attached to the post by a corrugated steel trough. Additional bracing is provided by a 1/2-inch x 1/2-inch x 1/4-inch angle brace on the outer surface of the filter. The angle brace is bolted into the groove and bolted together at the end of the line post. The filter is supported by a 1/2-inch x 1/2-inch x 1/4-inch angle brace. The corrugated steel sheet piling is attached to the rock and a telephone pole is mounted to the corner of the filter. The filter is then filled up with rock. Finally, a roll of 1/2-inch x 1/2-inch x 1/4-inch angle brace is attached to the filter mesh with stainless steel wire ties. The filter is then installed. The cost of materials and installation for Appendix 4 is \$400 per cubic foot of rock.

Figure 1.1.1

 

Penetration Tests

The order in which the perimeter barrier arrays were attacked by test personnel was Array 2, Array 3, Array 1, and Array 4. Penetration tests on Arrays 1 through 4 consisted of a total of 16 different penetration attempts. A total of 27 individual attacks were attempted. Twenty-six attacks were completed; one attack was aborted due to breaching equipment failure. In all of the successful attempts, at least one person crossed over the array. In some tests, two or three people crossed the array. The times shown in Table II indicate the test completion time of the first person to successfully penetrate the array.

TABLE II
Perimeter Barrier Penetration Tests

Barrier Array	Test Description	Time to Penetrate (min)	Number of Personnel
Array 1	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
Array 2	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
Array 3	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
Array 4	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1
	Personnel crossed over the barrier by using the gap between the barrier and the ground.	1	1

Appendix D

The method of construction of Appendix D is similar to the method of construction of Appendix C. The method of construction of this type is as follows:

Method 1 consists of a change that is made to the tape using a roll of tape. Figure 60. Each attachment is made either at the end of the tape roll or at the start of a new roll. The tape is cut and crushed that roll to the ground. The tape is then rolled forward to the next roll. A total of 10 to 15 repetitions is required to cross the 7.6 metre (25-foot) area. Each roll will be crossed in approximately 1 to 4 seconds.

Figure 60. The construction of Method 1.

Method 2 consists of a change that is made to the tape using a roll of tape. Figure 60. Each attachment is made either at the end of the tape roll or at the start of a new roll. The tape is cut and crushed that roll to the ground. The tape is then rolled forward to the next roll. A total of 10 to 15 repetitions is required to cross the 7.6 metre (25-foot) area. Each roll will be crossed in approximately 1 to 4 seconds.

Method 3 consists of the attachment of a roll of tape to the end of the tape. The tape is cut and crushed that roll to the ground. The tape is then rolled forward to the next roll. A total of 10 to 15 repetitions is required to cross the 7.6 metre (25-foot) area. Each roll will be crossed in approximately 1 to 4 seconds.

Method 3 consisted of crawling under the concertina wire, aided by a 5-foot-long, 2-inch pipe, used as a lever arm and a laminated wooden tripod used as a lifting aid (see Figure 12). Three men ran the pipe under the concertina wire and began lifting the wire with it. A fourth man, equipped with the full ram, began to crawl into the opening between the pipe and the ground. As the three-man lifting team raised the pipe to an overhead position, the pipe broke at its coupling sheared and the pipe rebounded onto the head of the fourth man. The man in question retreated from under the BTG; the attack was aborted. A second pipe, constructed in a similar manner to the broken pipe, was tested by the attack team before another attack was attempted. It, too, began to fail at the threaded coupling. Consequently, the third method of attack was deemed to be a result of mechanical failure of the breaching aid. It is probable that a sleeve welded over the threaded joint would strengthen the pipe sufficiently to allow it to withstand the moment of penetration were made with pipe utilized as a lever arm. This method of attack would probably be effective only if the metal tent pins used for staking the concertina to the ground were either loose or improperly positioned.

Figure 12. Penetration of Array 2 Method 3

Other factors that may affect the results of the field studies are the size of the area being tested. In the case of the 1000 ft² area, the area was relatively small and the animals were getting into one method of escape. They were escaping into the brush and the rather large rolls for penetration were not made to be as tight as they could be. When the area was increased to 1600 ft², the animals began to escape into the brush and into almost half of the maze after about one hour of time. But, again, the animals were not forced out one path. However, since the animals were rather comfortable in the maze, it was not an individual path. One method to improve the maze would be to make the maze more difficult. It was found that more animals were in the IDC than were in the maze. This was due to the fact that the maze interior was not as tight as the IDC. Consequently, small sections of the IDC were taken down to allow for the animals to pass through a portion of the IDC. The difficulty of this was that the animals were not as comfortable in the IDC because of the number of rolls (120 per square ft) of the maze interior and the rolling process.

Figure 13. Penetration of Array 2 Method 4

Although it is a method of scaling fences, the pathway is not a direct climb. It is a series of steps, with the first step being the most difficult. The second step is the most difficult, as it is the most difficult to get over the top of the fence. The third step is the most difficult, as it is the most difficult to get over the top of the fence. The fourth step is the most difficult, as it is the most difficult to get over the top of the fence. The fifth step is the most difficult, as it is the most difficult to get over the top of the fence. The sixth step is the most difficult, as it is the most difficult to get over the top of the fence. The seventh step is the most difficult, as it is the most difficult to get over the top of the fence. The eighth step is the most difficult, as it is the most difficult to get over the top of the fence. The ninth step is the most difficult, as it is the most difficult to get over the top of the fence. The tenth step is the most difficult, as it is the most difficult to get over the top of the fence.

Figure 14. Construction of Array 2 Method 3.

Array 3 (Over climb)

The methods of all three arrays are used so that the most difficult method is always the last.

Method 1 consists of jumping over the Array 1 fence using a 4.5-metre (16-foot) ladder, a 2.4-metre (8-foot) stepladder and extension books (1.2-metre (4-foot) long extension books) (see Figure 15). Two men support the Array 1 fence, the 4.5-metre ladder and extension over the top of the array until the far end of the ladder is on the top ladder on the opposite side. The ladder was released and fell to rest, crossing the top rolls of the GPSTO. The third man carrying the 2.4-metre stepladder and the extension books immediately set the stepladder up to one

Figure 1. A large, open, rectangular structure.

The structure is a large, open, rectangular container, possibly a tent or a large container, made of a light-colored material, possibly canvas or plastic, with a dark frame. It is shown in a black and white photograph. The structure is open at the top, and a person is standing inside, looking towards the camera. The structure is situated on a plain, light-colored surface, possibly a field or a large open area. The structure is made of a light-colored material, possibly canvas or plastic, and has a dark frame. The person is standing in the center of the structure, looking towards the camera. The background is a plain, light-colored surface.

Method 4 consisted of a vehicle penetration attempt made through the array by means of a rocket-powered 3/4-ton truck (see Figure 21). The truck was used as a breaching and, in the unimpeded run, in an attempt to open a hole in the array so personnel penetration either on foot or in another vehicle could be accomplished in a very short period of time. The vehicle impacted at 33.7 kph (52 mph) and, after initial contact with the vehicle barrier was made, penetrated approximately 1.8 metres (6 feet), as shown in Figure 22. No vehicle size hole was opened in the array, and it is doubtful that another vehicle could easily be driven through the damaged section of the array if the breaching vehicle were removed. Removing the damaged vehicle from the array could be both difficult and time consuming. Unaided personnel would probably be able to penetrate the damaged array, however, by leaping from the cab roof to the ground inside of the array. It is doubtful that the RTC that enveloped the front end of the vehicle from ground level to 0.5 metres (1.5 feet) above the roof of the truck would prevent personnel penetration (see Figure 22).

Vehicle penetration tests against other perimeter and vehicle barriers resulted in either complete vehicle penetration or a hole large enough to allow crawling and unaided personnel penetration.

Figure 21. Penetration of Array 4 McPhed 4 (at impact)

Array 2

Penetration time for Array 2 ranged from 13 seconds when the intruder was able to cut through the ladder, via 100 to 140 minutes for a second, when the intruder cut through the ladder and then cut through. One attack was aborted due to the reason for the failure of the attack was a lack of visibility of a climbing aid and not the lack of complexity or deterrent nature of the array. The RIFC cut through the intruder on both the cut-through and go-through attempt, but no injury or damage to the intruder were incurred, although delay caused by the cut-through increased the penetration time for the walk-through attempt. Intruder cut through which are comparable to the cut through 2, and the 65-foot high, concrete fence, were the same as the cut through for Array 1 (see Table 1). However, definite improvement in delay was achieved by Array 2. This can be attributed to the increased height and quantity of the bar tape utilized in this array. In addition, Array 2 was probably the more effective in the placement of the plants, and the small number of cut-throughs made the 90-degree 65-foot height of the bottom rolls.

Array 3

Penetration time for Array 3 ranged from 20 seconds when the intruder was able to cut through the 100 minutes when 12-inch hole in the ladder and the ladder tape were cut through. The worst result was an unexpected problem where the intruder was able to cut through the ladder tape and cut through the ladder tape. The intruder time was 20 seconds. The intruder was able to cut through the ladder tape and cut through the ladder tape, but this method of breaching could be obtained from a concealed position. Although the intruder was judged that no strategy time was attributable to the GPRTO or the RIFC, even though two locations were identified, and therefore RIFC could not be used to cut through the GPRTO to reach the array coils. In fact, however, the gain in time for RIFC was not a factor in the expected time. The installation of roll of GPRTO in an environment made it possible in Array 3 to cut through in any way by intruder. The ladder tape was cut through by the intruder on both sides of the fence, and the intruder was able to cut through the ladder tape and cut through the ladder tape. A maximum of five rolls of either GPRTO or RIFC could be cut through the ladder tape and cut through. Without the placement of GPRTO or RIFC, the intruder time could be as low as 1 minute.

Array 4

Penetration time for Array 4 was 10 minutes for the cut through Array 4. The improvement was expected except that the cut through of the vehicle barrier. No cut-through on this array was attempted because the possibility of increasing the structural integrity of the section for the planned cut through penetration. If it were attempted, cut-through would have been at a height of 6.7 metre (22 foot) above ground level, at the top of the corrugated steel sheet, since in this array the void between the fence, a tilted concrete rock and a telephone pole. Whether attempted personnel penetration through the vehicle barrier cross section could be achieved in less than one hour is doubtful, even though the intruder would be in a concealed position.

See Array 2, Method 3 on page 20 for details

Vehicle penetration of Army 4 by a 6.4-ton truck resulted in extensive front-end damage to the vehicle and no personnel were injured. Personnel vehicle barriers, such as the one used to penetrate the storage facility, jumping from the ground to the ground, are not effective.

Conclusions

The results of the personnel penetration attacks, after independent trials, indicated that the personnel vehicle barriers were not effective in preventing intruders from penetrating the perimeter. Although the use of a vehicle barrier, being an early warning device, could be used to detect intruders, the training method requires a highly visible vehicle to be introduced into the perimeter, and the intruder must find the barrier. Highly visible vehicles, such as maintenance vehicles, are not in the area of a facility, and personnel are not trained to respond to such a vehicle.

Vehicle barriers, particularly Army 3 and 4, spaced several meters apart, would clearly indicate the training failure, since the intruders would be forced to carry the vehicle through the perimeter over the personnel barriers. Also, if the intruders' scenario included a jump over the perimeter, the personnel barrier position could be changed, since the intruders would have to transfer the vehicle from one side to the inside of the barrier. It should be noted that a standing, erect, or crouching intruder could be used to expose electronic perimeter alarm sensors. When Army 3 vehicle barriers and portable hand tools were used against Armys 2, 3, and 4, the penetrations were made in less than 10 seconds, longer than those for initial security forces.

When GPBTO or BTC were used on Armys 1 through 4, no significant advantage was demonstrated after the GPBTO or BTC, although the BTC seemed to cause the intruders to increase the time taken to improve upon their penetration times. The GPBTO is actually a 1000-psi hydraulic rammer, which is the only known type to inflict serious damage on a perimeter barrier.

One of the types of these tests was the separation of a vehicle barrier into Armys 4 to test its own penetration capabilities. The fact that the 44-ton truck impacting the barrier at 40 mph did not result in a full success fully was attributed to the distribution of the energy of the impact over a wider area. Similar vehicle tests performed on standard perimeter barriers allowed the vehicle to pass through the barrier because no load-distributing member was present.

Installing positive vehicle barriers around a site perimeter should be considered. This would force the intruder to abandon his vehicle or consume significant time in penetrating the barrier with his vehicle. Further, by separating the vehicle barrier from the personnel barrier so that the vehicle barrier is encountered first, the intruder is (1) forced to carry on foot any

penetration tools or bridging aids he may need to accomplish his mission and (2) denote the use of a vehicle for breaching the personnel barrier.

There are some potential aesthetic and functional problems associated with these (perhaps all) perimeter barriers. Snow, wind-blown trash, and plant growth may detract from the effectiveness of personnel barriers enhanced with barbed tape. Video or visual assessment of a zone that includes personnel or vehicle barriers is complicated and requires careful design and placement of sensors,⁸ lighting, assessment aids, and barriers.

In addition, a perimeter barrier can be detrimental to the security of an area if it is used by an intruder for the purpose of concealment from guard patrol reconnaissance or as a point from which to initiate forcible penetration or attack firing positions. For these reasons, the personnel and vehicle barriers should be located toward the inside of a detection/assessment system not only to prevent easy access to buildings or igloos but also to allow prolonged assessment of any detected intrusions.

Arrays 2, 3, and 4 offer some penetration delay improvement over standard and enhanced security fences. Cut-through penetration times on these arrays have been extended and short crawl-under penetration times on Arrays 3 and 4 are impractical. However, for almost all known perimeter barriers under 3.1 metres (39-foot) wide and 3 metres (49-foot) high, short-circuit penetration times are possible if complex or bulky bridging aids are used by prepared intruders.

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