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WARNING SHOT TARGET BALLISTIC TEST EVALUATION.

Prepared for:

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A Report on:

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TABLE OF CONTENTS

| | | |
|---|--|----|
| 1. | INTRODUCTION | 1 |
| 2. | RESEARCH OF WARNING SHOT TARGET ALTERNATIVES..... | 1 |
| 3. | FABRICATION OF SAMPLE TARGETS | 3 |
| 4. | TEST PROGRAM..... | 4 |
| 4.1 | Ballistic Testing of Fabricated Warning Shot Target (WST)..... | 4 |
| 4.2 | Ballistic Testing of Possible Alternative Warning Shot Targets | 8 |
| 4.3 | Discussion of Test Results | 12 |
| 5. | COST COMPARISON OF SUCCESSFUL DIFFERENT WST..... | 12 |
| 6. | CONCLUSION AND RECOMMENDATIONS | 13 |
| Appendix A: V _{proof} Ballistic Test Results | | 14 |

LIST OF FIGURES

| | | |
|--------------|--|----|
| Figure 2.1: | Alternative Target Type 1: Recycled Rubber with ¼” AR500 Steel backing (requires modifications) | 1 |
| Figure 2.2: | Alternative Target Type 2: M-T36 Ballistic Polymer Unit (requires modifications) | 2 |
| Figure 2.3: | Alternative Target Type 3: Portable Tactical Trap (requires modifications) ... | 2 |
| Figure 3.1: | Typical Set-up (Ceiling mount) WST Sample: 2 ft x 2 ft Plywood/Lexan, Pre Impact Front View | 3 |
| Figure 4.1: | Bullet Types used for Ballistic Evaluation (9mm, 5.56mm & #4 Buck round) | 4 |
| Figure 4.2: | Post Impact Front View | 5 |
| Figure 4.3: | Typical failure of Original Warning Shot Target, Post Impact Side view..... | 5 |
| Figure 4.4: | Target Type F - 5.56mm bullet, Post Impact Front View | 7 |
| Figure 4.5: | Target Type F - 5.56mm bullet, Post Impact Rear View..... | 7 |
| Figure 4.6: | 5.56mm Ballistic Impact Failure of Target type N (1 Layer Neoprene Rubber) with ¼” Steel Backing | 9 |
| Figure 4.7: | 5.56mm Ballistic Impact Failure on Target Type N (1 layer Neoprene) | 9 |
| Figure 4.8: | Target Type J - 5.56mm, 9mm and #4 Buck round, no penetration, Post Impact Front View | 10 |
| Figure 4.9: | Target Type J - 5.56mm, 9mm and #4 Buck round, no penetration, Post Impact Rear View | 10 |
| Figure 4.10: | Target Type M - 5.56mm, 9mm and #4 Buck round, no complete penetration, Post Impact Front View..... | 11 |
| Figure 4.11: | Target Type M - 5.56mm, 9mm and #4 Buck round, no complete penetration, Post Impact Rear View..... | 11 |

LIST OF TABLES

Table 4.1: Ballistic Testing of Fabricated WST as per Specification Provided by CPRC
and Modifications Implemented by Bosik..... 6
Table 4.2: Ballistic Evaluation of Alternate Targets and Results 8
Table 5.1: Summary of Successful Warning Shot Targets 12

1. INTRODUCTION

This report is for a program undertaken by Bosik Technologies Limited (Bosik) for the Canadian Police Research Centre (CPRC) of the National Research Council of Canada under CPRC contract 558498. This program for the CPRC was to provide assistance to Correctional Services in the evaluation of alternate warning shot targets. The objectives of the program were three folds: 1) conducting literature research of alternative targets, 2) fabrication of sample targets as per specifications provided by the CPRC, and 3) set up and ballistic test the various targets. The objectives of the evaluations were to determine which targets would prevent penetration and ricochet of the selected weapons, and have the desirable features of low cost, low weight and ability to absorb multiple shots.

The evaluations were conducted using three cartridge types: Black Hills 9mm FMJ RN with 147 grain round, Federal 5.56mm with a 55 grain hollow point round and a 12 gauge shotgun Remington 2 $\frac{3}{4}$ " #4 Buck round. The result of the literature search of alternative targets, fabrication of an original design provided by CPRC and ballistic evaluations and test results as well as costs for successful targets are presented in the following sections.

2. RESEARCH OF WARNING SHOT TARGET ALTERNATIVES

Bosik has conducted a literature search on possible warning shot target alternatives to the two solutions provided by CPRC WST project: (1) Lexan/Plywood layers, and (2) Recycled rubber with steel backing, as detailed in **Section 3 Table 2.1** summarizes possible warning shot targets, manufacturers and projected costs for 2 ft x 2 ft size target as modified to suit the WST project specifications. Bosik also has examined internally possible alternatives and performed initial preliminary evaluations of alternative targets that offer cost savings. Photographs of the alternative targets are shown in **Figures 2.1 to 2.3**.

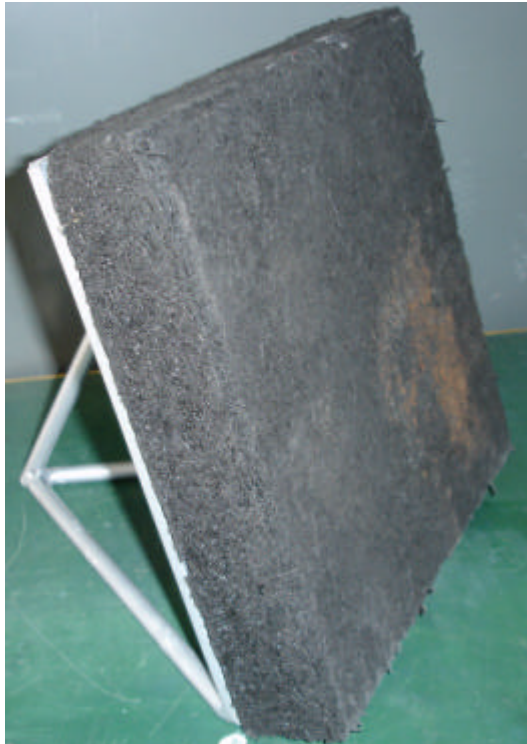


Figure 2.1: Alternative Target Type 1: Recycled Rubber with $\frac{1}{4}$ " AR500 Steel backing



Figure 2.2: Alternative Target Type 2: M-T36 Ballistic Polymer Unit



Figure 2.3: Alternative Target Type 3: Portable Tactical Trap

2.1: Literature Search Result of Alternative Possible Targets

| Target Type | Alternate Target Description | Manufacturer / Supplier | Target Projected Cost (2ft x 2ft WST) |
|-------------|---|--------------------------------------|---------------------------------------|
| 1 | 2" x 24" x 24" Recycled Rubber with ¼" steel backing, (to be modified) up to 2000 rounds capacity | Range Systems / Renew Resources Inc. | \$ 568 |
| 2 | M-T36 Ballistic Polymer Target Unit (13" x 18"), (to be modified) | Ballistic Technology | \$ 1070 |
| 3 | Portable Tactical Trap (Trap Facing 24" x 36") (to be modified) up to 3500 rounds capacity | Range Systems / Renew Resources Inc. | \$ 1418 |

Note: All the alternative possible targets will require small modifications to conform to the WST specifications (i.e. 2 ft x 2 ft and/or 4 ft x 4 ft size and provision of ceiling and/or concrete wall mounting methods).

3. FABRICATION OF SAMPLE TARGETS

Two sizes of Warning Shot Targets were fabricated according to Warning Shot Target (WST) specifications provided by CPRC. The first target, was 2 ft x 2 ft, with backing material of 2 layers of ¾" plywood glued together and painted bright red on the front. The front of the target was made up of ¼" Lexan, the same size as the plywood backing. The second target was identical to the first target, except its size was 4 ft x 4 ft. The target had two methods of attaching to the structure: suspending from the ceiling and/or attaching to concrete wall. In this test program only the 2 ft x 2 ft Warning Shot Target (ceiling mount) was tested.

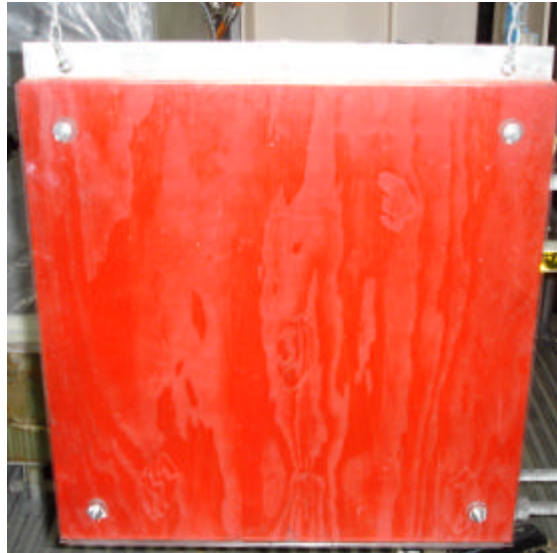


Figure 3.1: Typical Set-up (Ceiling mount) WST Sample: 2 ft x 2 ft Plywood/Lexan, Pre Impact Front View

4. TEST PROGRAM

A ballistics test program was carried out to determine the safety of the targets in terms of ricochets, safety and life expectancy. A V_{proof} test was conducted in accordance with the National Institute of Justice (NIJ) standard 0101.04, with special requirement of factory loaded ammunition. To eliminate the risks of ricochet, the warning shot targets were installed flat and perpendicular (0°) to firing point. Both the specified (by CPRC) target and possible alternative warning shot targets were evaluated. A sheet of Bristol board and cardboard box were used to determine penetration and/or possible spalling of the projectile.

Three factory loaded bullet types were used in the evaluation of the targets: Black Hills 9mm FMJ RN with 147 grain round, Federal 5.56mm with a 55 grain hollow point round and a 12 gauge shotgun Remington 2 $\frac{3}{4}$ " #4 Buck round. Details were supplied by CPRC. The 9mm and 5.56mm rounds were fired using a ransom rest and test barrels supplied by Bosik. The V_{proof} ballistic test reports for this test program are found in **Appendix A**.



Figure 4.1: Bullet Types used for Ballistic Evaluation (9mm, 5.56mm & #4 Buck round)

4.1 Ballistic Testing of Fabricated Warning Shot Target (WST)

The fabricated warning shot target (2 ft x 2 ft Lexan/Plywood) was evaluated to determine the safety in terms of ricochet, safety and life expectancy. The original design WST failed the ballistic test. **Table 4.1** summarizes the target description, ammunition used, test results and pass/fail criteria of the specified Warning Shot Target (WST). After the first ballistic test (using all three bullet types), it was found that the WST had ricocheted, spalled and was penetrated. Therefore, the WST was modified by putting 1 layer of $\frac{1}{8}$ " Lexan on the front to eliminate ricochets and by adding $\frac{1}{8}$ " mild steel plate on the back to eliminate penetration. Eventually, 2 layers of $\frac{1}{8}$ " Lexan and $\frac{3}{8}$ " ($3 \times \frac{1}{8}$ " steel backing were used to meet requirements. **Figures 4.2** and **4.3** show the ballistic impact result for target type A (Lexan/Plywood). As can be seen in **Figure 4.3**, there was a large penetration on the plywood.



Figure 4.2: Post Impact Front View



Figure 4.3: Typical failure of Original Warning Shot Target, Post Impact Side view

Table 4.1: Ballistic Testing of Fabricated WST as per Specification Provided by CPRC and Modifications Implemented by Bosik.

| Target Type | Description | Test Results | Cartridge | Overall Pass/Fail |
|--------------------------------|---|---|---------------|-------------------|
| A: Original WST | 2' x 2' Warning Shot Target (WST), ¼" Lexan with 2 layers ¾" Plywood backing | - 9mm complete penetration | Fail | Fail |
| | | - 5.56mm complete penetration | Fail | |
| | | - #4 Buck round complete penetration | Fail | |
| | | - Ricochets and spalling | | |
| B: Modified WST | 2' x 2' Warning Shot Target, ¼" Lexan with 2 layers ¾" Plywood and 1/8" mild steel plate backing | - 5.56mm complete penetration | Fail | Fail |
| | | - 9mm no complete penetration | Fail | |
| C: Modified WST | 2' x 2' Warning Shot Target, ¼" Lexan with 2 layers ¾" Plywood and 1/4" (2 x 1/8") mild steel plate backing | - 5.56mm no complete penetration with large deformation | Pass | Fail |
| | | - #4 Buck round complete penetration | Fail | |
| | | - Ricochets and spalling | | |
| D: Modified WST | 2' x 2' Warning Shot Target, 1 layer of 1/8" Lexan with 2 layers ¾" Plywood and 1/4" (2 x 1/8") mild steel plate backing | - 5.56mm complete penetration | Fail | Fail |
| | | - #4 Buck round no complete penetration | Pass | |
| | | - No spalling, no ricochets | Pass | |
| E: Modified WST | 2' x 2' Warning Shot Target, 2 layers of 1/8" Lexan with 2 layers ¾" Plywood and 1/4" (2 x 1/8") mild steel plate backing | - 5.56mm no complete penetration with large deformation in steel backing | Marginal/Pass | Fail |
| | | - 9mm no complete penetration | Pass | |
| | | - #4 Buck round no complete penetration | Pass | |
| | | - No spalling, no ricochets | Pass | |
| F: Modified WST | 2' x 2' Warning Shot Target, 2 layers of 1/8" Lexan with 2 layers ¾" Plywood and 3/8" (3 x 1/8") mild steel plate backing | - 5.56mm no complete penetration with very small deformation in steel backing | Pass | Pass |
| | | - 9mm no complete penetration | Pass | |
| | | - #4 Buck no complete penetration | Pass | |
| | | - No spalling, no ricochets | Pass | |

Note: Target type A is an original design provided by CPRC specifications. Target types B to F are modified designs of the original. After extensive ballistic evaluations of the warning shot target, (utilizing Lexan layers and adding steel plate on the back), it was found that target type F (2 layers of Lexan with 3/8" steel plate backing) had the best combination of good safety (no complete penetration), life expectancy and resistance to ricochets. **Figures 4.4** and **4.5** show the successful ballistic impact results for target type F. As can be seen in **Figure 4.5**, there was no complete penetration on the 3/8" backing plate.

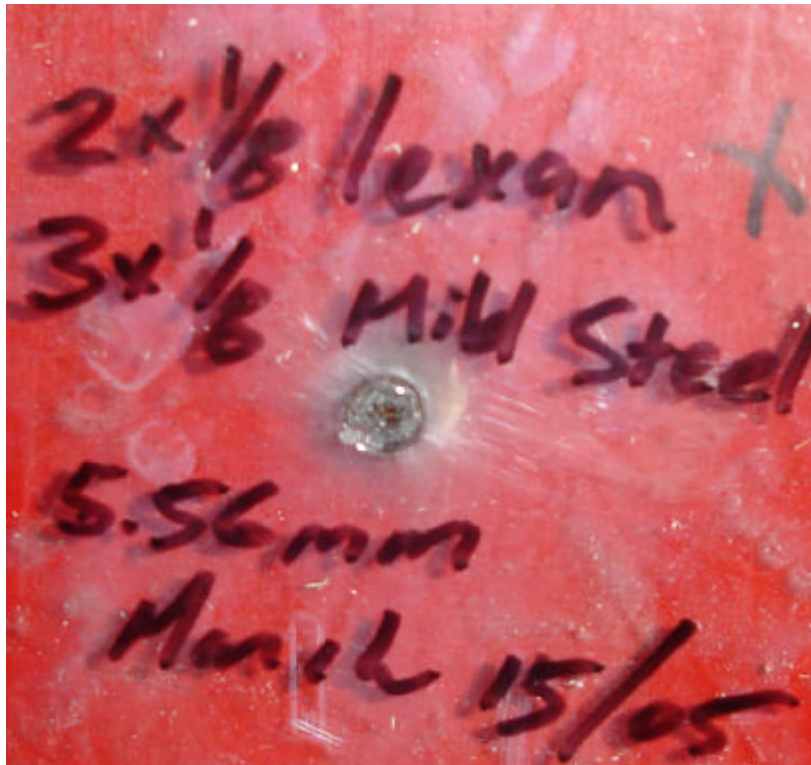


Figure 4.4: Target Type F - 5.56mm bullet, Post Impact Front View

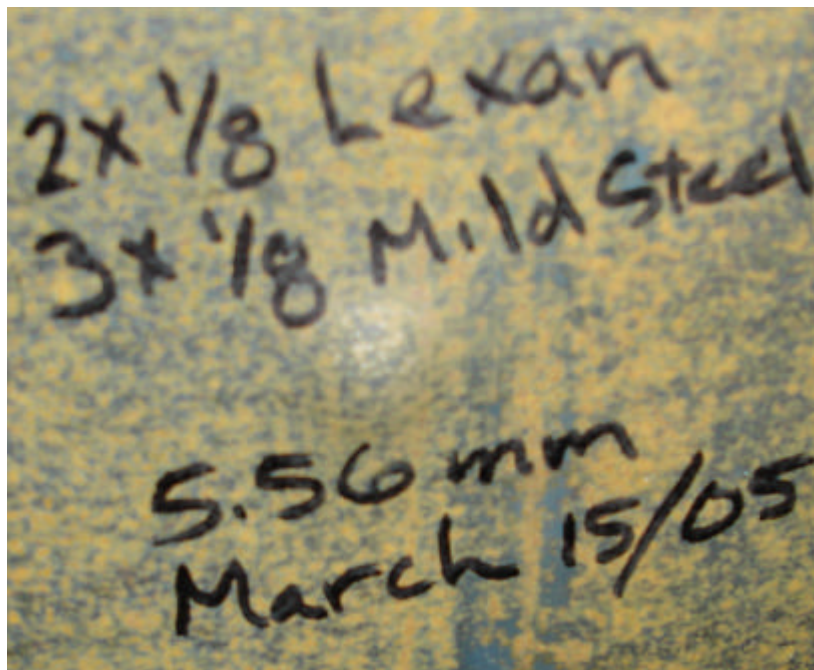


Figure 4.5: Target Type F - 5.56mm bullet, Post Impact Rear View

4.2 Ballistic Testing of Possible Alternative Warning Shot Targets

In this section, various alternative warning shot targets were evaluated. In **Table 4.2** below, the results of the ballistic evaluation of alternative warning shot targets are presented. These include off-the-shelf targets (will require modifications to conform to WST specifications) and internally (by Bosik) fabricated warning shot targets.

Table 4.2: Ballistic Evaluation of Alternate Targets and Results

| Target Type | Alternate Target Description | Test Results | Pass/Fail |
|-------------------------|---|---|-----------|
| G: Range Systems | 2" x 12" x 12" recycled rubber with ¼" steel backing | <ul style="list-style-type: none"> 9mm no complete penetration 5.56mm no complete penetration #4 Buck round no complete penetration No deformation on backing plate | Pass |
| H: Range Systems | 2" x 12" x 12" recycled rubber with no backing | <ul style="list-style-type: none"> 5.56mm complete penetration 9mm complete penetration #4 Buck round complete penetration | Fail |
| I: Bosik | 2" x 12" x 12" recycled rubber with 1/8" mild steel backing | <ul style="list-style-type: none"> 9mm no complete penetration #4 Buck round no complete penetration 5.56mm no complete penetration with large deformation | Fail |
| J: Bosik | 2" x 12" x 12" recycled rubber with ¼" mild steel backing | <ul style="list-style-type: none"> 9mm no complete penetration #4 Buck round no complete penetration 5.56mm no complete penetration with very small deformation | Pass |
| K: Bosik | ¾" Neoprene rubber 4 layers with ¼" mild steel backing | <ul style="list-style-type: none"> 5.56mm no complete penetration 9mm no complete penetration (4 layers of rubber were penetrated) and no damage to steel backing. #4 Buck round no complete penetration (penetrated 3 layers of rubber) | Pass |
| L: Bosik | ¾" Neoprene rubber 3 layers with ¼" mild steel backing | <ul style="list-style-type: none"> 5.56mm no complete penetration 9mm no complete penetration #4 Buck round no complete penetration | Pass |
| M: Bosik | ¾". Neoprene rubber 2 layers with ¼" mild steel backing | <ul style="list-style-type: none"> 5.56mm no complete penetration 9mm no complete penetration #4 Buck round no complete penetration | Pass |
| N: Bosik | ¾". Neoprene rubber 1 layer with ¼" mild steel backing | <ul style="list-style-type: none"> 5.56mm complete penetration | Fail |

Target types G, H, I and J, are the same sample (Range Systems) which is a recycled rubber with ¼" AR500 steel backing. The sample was tested with and without steel backing. Target types K, L, M and N are the same sample (Bosik) of Neoprene rubber that was tested with ¼" mild steel backing and varying the number of rubber layers to obtain the optimal number of layers.

Photographs of the targets that failed the ballistic test are presented in **Figures 4.6** and **4.7** below.

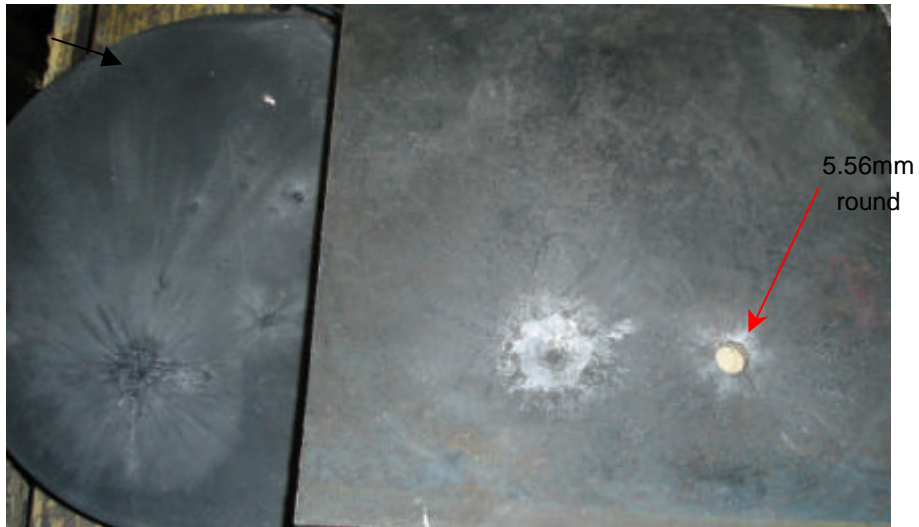


Figure 4.6: 5.56mm Ballistic Impact Failure of Target type N (1 Layer Neoprene Rubber) with ¼” Steel Backing

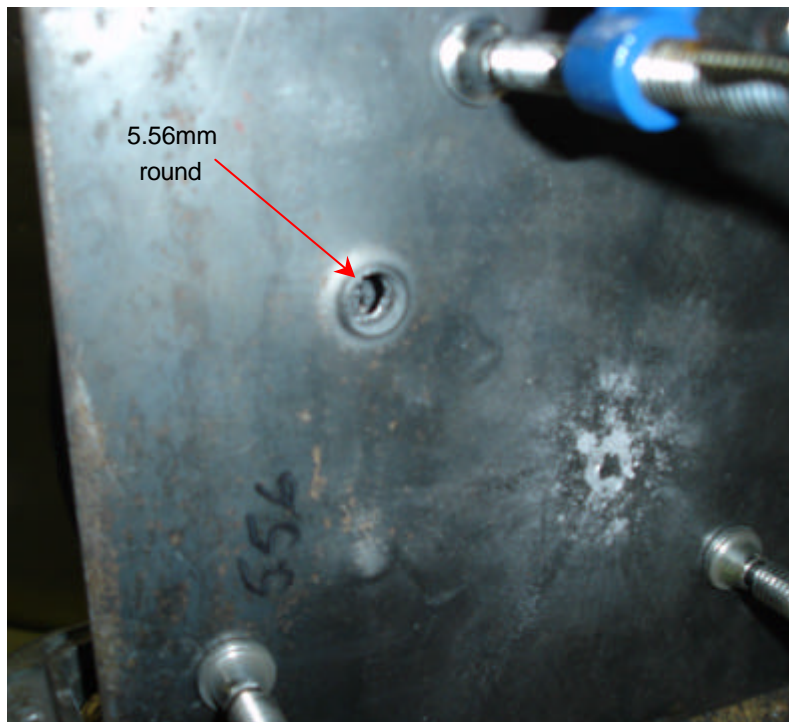


Figure 4.7: 5.56mm Ballistic Impact Failure on Target Type N (1 layer Neoprene)

Photographs of the targets that passed (successful) the ballistic test are shown below in **Figures 4.8 to 4.11**.

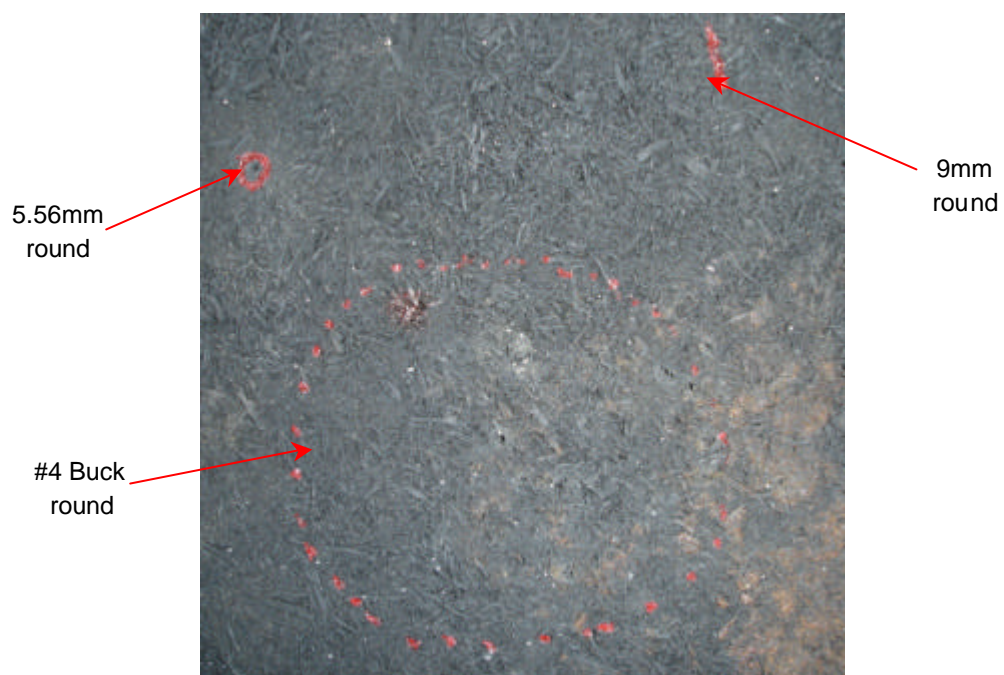


Figure 4.8: Target Type J - 5.56mm, 9mm and #4 Buck round, no penetration, Post Impact Front View



Figure 4.9: Target Type J - 5.56mm, 9mm and #4 Buck round, no penetration, Post Impact Rear View

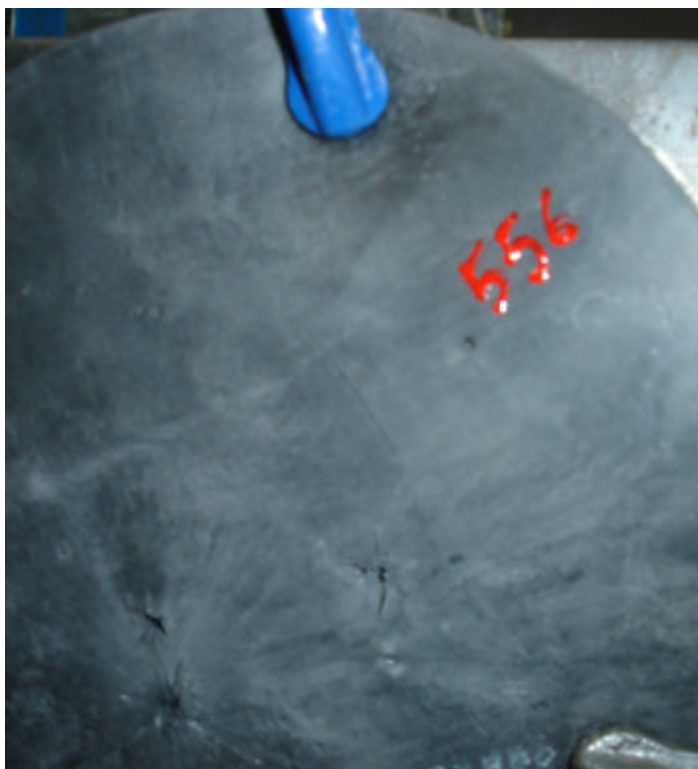


Figure 4.10: Target Type M - 5.56mm, 9mm and #4 Buck round, no complete penetration, Post Impact Front View

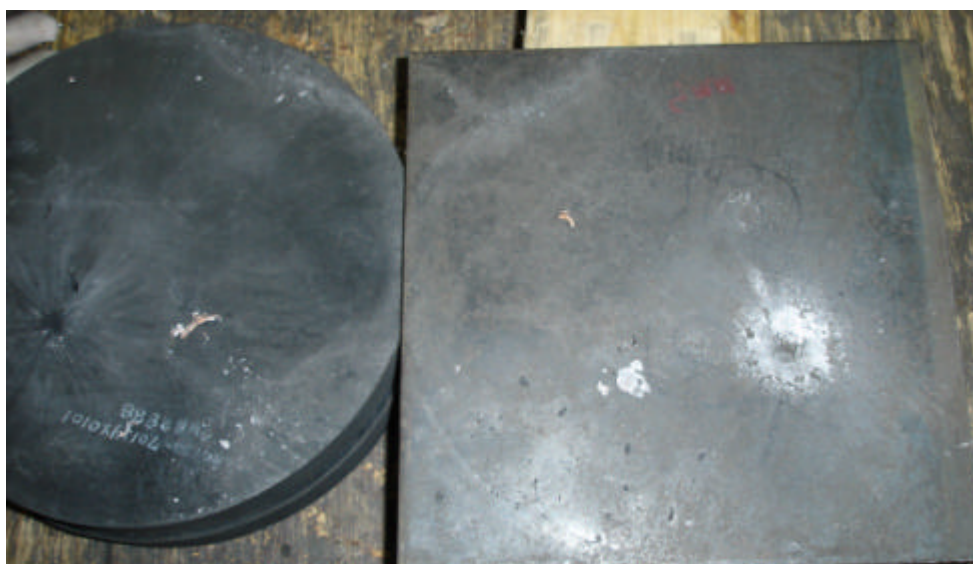


Figure 4.11: Target Type M - 5.56mm, 9mm and #4 Buck round, no complete penetration, Post Impact Rear View

4.3 Discussion of Test Results

The original design specified in the project by CPRC failed the ballistic test (due to penetration by all three types of bullets, ricochets and spalling). It was modified by Bosik using 2 layers of Lexan and by adding 3/8" steel plate backing. This design passed the test; it eliminated ricochets and exhibited good safety, but life expectancy is limited due to the plywood chipping as more shots are fired. The recycled rubber with 1/4" AR500 steel backing (Range Systems) passed the ballistic test and eliminated ricochets and there was no deformation on the plate backing. Also the recycled rubber target modified by Bosik by adding 1/4" mild steel plate backing passed the test with similar results to that exhibited by Range Systems, except that there was a small deformation of the backing plate. The alternative target (2 layers Neoprene rubber with 1/4" steel plate backing) fabricated by Bosik internally passed the test and exhibited good safety, long life expectancy and eliminated ricochets.

The cost and weight comparisons of the four successful targets are presented in the following section.

5. COST COMPARISON OF SUCCESSFUL DIFFERENT WARNING SHOT TARGETS

The following table summarizes different types of warning shot targets (that passed the evaluation test), possible suppliers and fabricated costs.

Table 5.1: Summary of Successful Warning Shot Targets

| Target Type | Target Description | Manufacturer/ Supplier | Weight (2 ft. x 2 ft.) | Cost (2 ft. x 2 ft.) | Weight (4 ft. x 4 ft.) | Cost (4 ft. x 4 ft.) |
|-------------|--|------------------------|------------------------|----------------------|------------------------|----------------------|
| F | 24" x 24" WST: 2 layers of 1/8" Lexan with 2 layers 3/4" Plywood and 3/8" mild steel plate backing | Bosik | 82 lbs | \$ 285 | 328 lbs | \$870 |
| G | 2" x 24" x 24" Recycled Rubber with AR500 1/4" steel backing (2000 rounds capacity) | Range Systems | 96 lbs | \$ 568 | 384 lbs | \$2272 |
| J | 24" x 24" x 2" Recycled Rubber with 1/4" mild steel backing | Bosik | 96 lbs | \$ 330 | 384 lbs | \$1096 |
| M | 24" x 24" WST: 2 layers of 3/4" Neoprene Rubber with 1/4" steel backing | Bosik | 102 lbs | \$ 532 | 408 lbs | \$1915 |

The ballistic evaluation of this test program has resulted in four successful Warning Shot Targets. Target type F, composed of layers of Lexan, Plywood and backed by mild steel is the lightest and cheapest. This is based on the original 2 ft x 2 ft WST specified by CPRC, using 2 layers of 1/8" Lexan instead of one layer of 1/4" Lexan and adding 3/8" steel backing. The life expectancy is somewhat limited because the plywood chips off as more shots are taken. Target type G, is a recycled rubber glued to a steel backing. It had no ricochets and contained all three types of bullets without deformation on the steel backing plate. The rubber separated on the corners as more shots were taken. Target type J (recycled rubber) is a modified version of target type G. It exhibited the same characteristics with small deformation

on the backing plate. It is also significantly cheaper than Target type G (Recycled rubber). Finally, Target type M (Neoprene rubber) showed good ballistic results. It had no ricochets and exhibited longer life expectancy as more shots were taken. The cost is higher than Target types F (Lexan/Plywood) and J (Recycled rubber), due to the Neoprene rubber costs.

6. CONCLUSION AND RECOMMENDATIONS

Based on good safety and life expectancy, and the lack of ricochets, as well as weight and cost comparisons, we recommend target type J (recycled rubber with steel backing plate). If the targets are to receive a relatively small number of shots, then target type F (lexan/plywood/steel combination) offers the lowest price and weight.

Appendix A: V_{proof} Ballistic Test Results