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Evaluation of Police Protective Equipment

Biokinetics and Associates Limited

TECHNICAL REPORT
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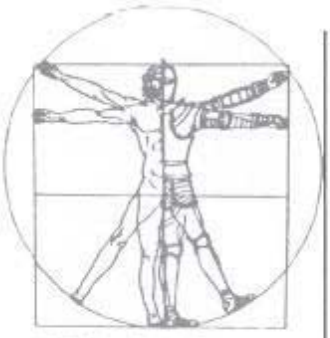

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EVALUATION OF POLICE PROTECTIVE EQUIPMENT

Prepared for

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Preface

This report summarizes the results of an evaluation of protective equipment supplied by Valiquette Sports for police use in crowd control situations. The work was conducted by Biokinetics and Associates Limited for the Canadian Police Research Centre in Ottawa under National Research Council Contract No. 91-1555/4505.

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1. Introduction

The following protective equipment was supplied for evaluation:

1. Protective vest (custom made)
2. Athletic neck guard or Nectech^{R} (I-Tech^{R} Sport Products Distribution Inc.)
3. Forearm protector (Bike Athletic Company)
4. Groin protector (Easton^{R} Donzis Air Management)
5. Girdle including pelvic, thigh and tailbone pad inserts (Bike Athletic Company)
6. Knee/shin pad (Cooper "RLG pad", "Bruce Hood")
7. Broom ball gloves ("DR 1150")

The equipment was evaluated subjectively and then tested to assess the impact attenuation and penetration resistance of the protective features. The results of this work are summarized herein.

2. Subjective Evaluation

2.1 Description

The subjective evaluation was conducted with the assistance of a Royal Canadian Mounted Police RCMP officer. The following equipment features were assessed subjectively with the officer's assistance.

- range of motion
- protective coverage
- ease of movement
- fit and adjustment
- donning and doffing
- comfort

The officer was observed donning and doffing the equipment and whilst demonstrating routine riot drill movements. The equipment was worn over a T-shirt with standard issue police riot boots, patrol trousers and riot helmet.

2.2 Protective Vest

The protective vest is a custom-made unit which covers the upper torso and outer arms. It comprises soft foam padding reinforced by plastic panels over the arms, the shoulders (in epaulettes) and in panels in the front and back of the jacket. It is fastened at the front via "Velcro" . The vest is easy to don and doff. The velcro straps in the upper arms allow for pre-adjustment for good individual fit. The vest was a comfortable snug fit on the assisting officer. Full and unhampered range of motion was possible with the vest worn over the officer's ballistic vest. The coverage of the vest is shown in Figures 2-l to 2-5. The vest is compatible with the police riot helmet, see Figure 2-6.

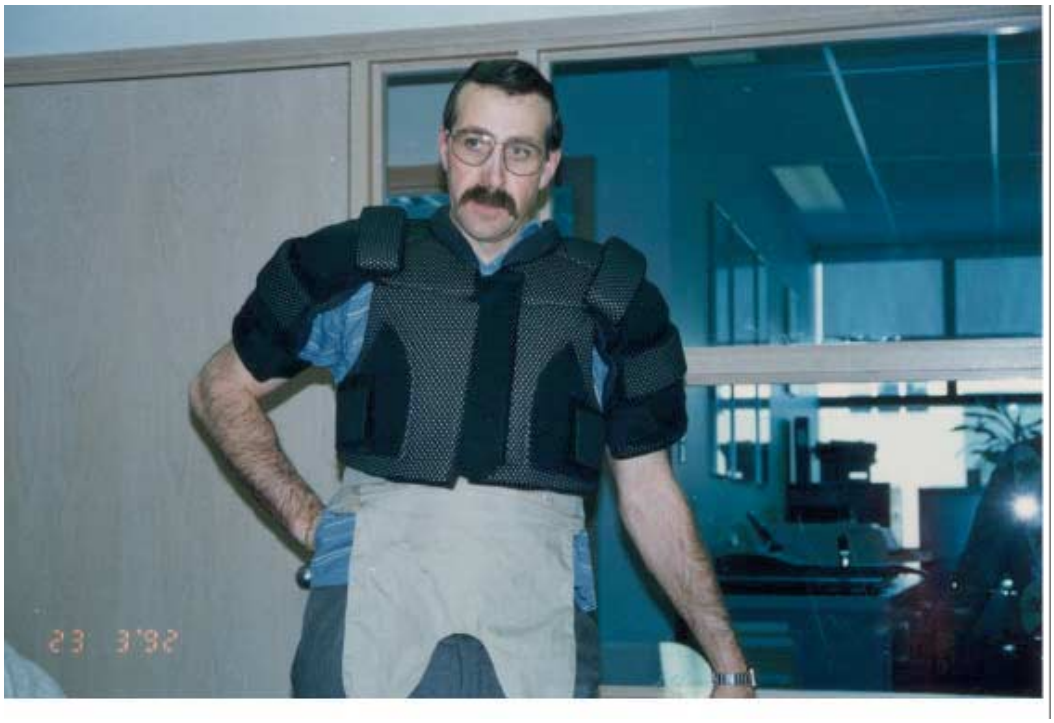

Figure 2-1: Assisting Officer Wearing Custom Made Protective Vest with Ballistic Vest

Figure 2-2: Custom Made Vest Showing Area of Coverage with Shield in Position

Figure 2-3: Showing of Protective Vest Coverage Relative to Lower Ribs

Figure 2-4: Protective Vest Coverage on Back (with Neck Guard)

Figure 2-5: Protective Vest Coverage when Arm Raised

Figure 2-6: Police Riot Helmet Worn with Protective Vest

2.3 Neck Guard

The neck guard is easy to don and provides coverage to the side and front of the throat not covered by the vest and helmet, see Figures 2-7 and 2-8. When the officer moved his head, the neck guard tended to ride-up and then stay out of position when the officer moved his head. It was considered comfortable to wear, but the failure of the neck guard to stay in position was a problem.

Figure 2-7: Neck Guard in Normal Wearing Position

Figure 2-8: Neck Guard Worn with Police Riot Helmet and Vest

2.4 Forearm Protector

The forearm protector (size large) was too large for the assisting RCMP officer. The forearm protector is not adjustable. The coverage and comfort of this protector on a larger male was good, allowing full range of motion and the use of the police shield.

2.5 Groin Protector

The groin protector sample (size large) was too large to fit under the regulation patrol trousers The comfort of this unit was considered good. It has an adjustable elasticized hip band.

2.6 Girdle Protector

The girdle provided for evaluation is the same as that currently used by the assisting officer. The officer reported that the girdle is comfortable to wear, the tail-bone padding unit remains comfortable over 3-4 hours of sitting. The girdle does however, cause uncomfortable heat build-up. The protective padding covers the sides of the pelvis, the lower spine and the tops of the thighs. The pelvic padding extends up into the soft tissue of the lower torso and causes discomfort and pressure points in this area, see Figure 2-8.

Figure 2-9: Position of Top Edge of Pelvic Padding in Girdle

2.7 Knee/Shin Pad

The knee/shin pad comprises a padded shaped plastic shin protector held onto the leg with two elasticised straps secured via "Velcro" and a padded knee protector held in position by a fixed elasticised strap, Figure 2-10. The elasticised straps may become uncomfortable during long wearing periods. This unit provided good coverage and did not restrict the range of motion and movement of the assisting officer. It can be worn under the patrol trousers. The shin pad is compatible with the police riot boots and can be worn on the inside or outside of the boots, see Figure 2-l1. The unit is easy to put on and remove and provides good individual fit.

Figure 2-10: Knee/Shin Pad in Normal Wearing Position

Figure 2-11: Knee/Shin Pad Worn with Police Riot Boot Showing Bottom Edge of Shin Pad

2.8 Broom Ball Gloves

The broom ball gloves provide hand and wrist coverage with padding over the back of the fingers, hand and wrist. The back of the thumb is further protected by a plastic insert. The gloves can be used with the batons and police shields and provide a good grip. The elasticised sides of the gloves allow for a comfortable and snug fitting glove.

3. Laboratory Tests

The protective equipment was evaluated under two different impact test conditions representative of riot impact hazards. The first test condition was a high mass, low velocity impact. This type of impact occurs when an officer is struck by a very heavy object which is travelling at a very low velocity, eg. ricochetting pieces of asphalt. The second impact tests simulated low mass, high velocity impacts. This type of impact occurs when the officer is struck with fast-moving low mass projectiles, such as small rocks.

4. High Mass - Low Velocity Impact Tests

4.1 Test Apparatus

The apparatus used for the high mass, low velocity impacts is shown in Figure 4-l and consists of a weighted free-fall drop frame which is guided between two rods. The impactor was instrumented with a uniaxial accelerometer in order to monitor the acceleration of the impactor during each impact. A data acquisition system was used to collect the accelerometer data at a set rate of 10,000 Hz. Acceleration data was calibrated and filtered using an SAE Class 1,000 filter. The data acquisition computer's hard disk was used to store the acceleration data.

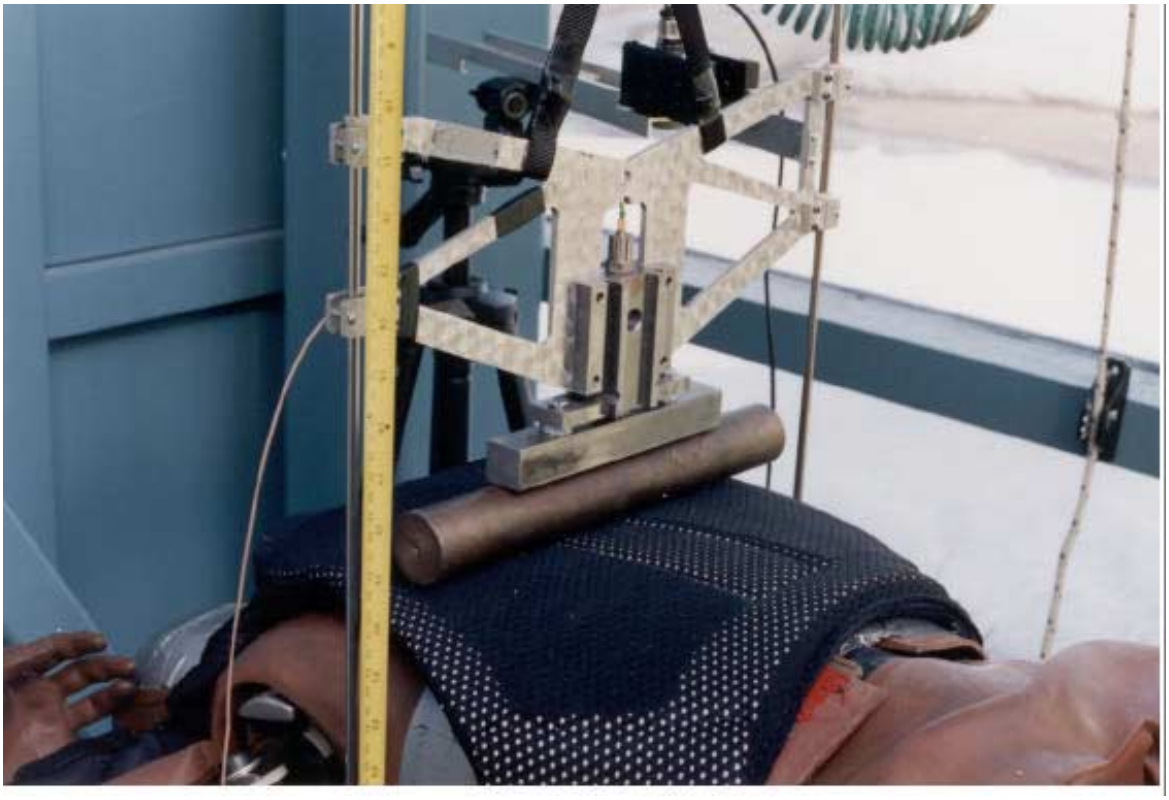

Figure 4-1: Test Set-up for Impact to Shoulder Epaulette

There were two types of impactors used for this test series. The first impactor was a 25 mm radius cylindrically faced bar, 125 mm in length. The second impactor was a 19 mm radius cylinder, 305 mm in length. In each test, the impactor was firmly secured to the bottom of the drop frame. The total mass of the impact system was 4.0 kg with the 25 mm radius impactor and 5.50 kg with the 19 mm radius impactor. A Hybrid III anthropomorphic crash test dummy was used as an impact surrogate in all tests.

The ability of the protective equipment to distribute the impact was assessed using pressure-sensitive film. This film is manufactured by Fuji Film Corporation and consists of two photosensitive emulsions which are sandwiched together. Upon impact the photo emulsions react to produce a "picture" of the loaded area. The higher the concentration of the load, the more the emulsions react and the darker the image in the loaded area.

4.2 Test Method

The Hybrid III was placed and secured on the test apparatus such that the selected impact site on the test dummy was positioned directly under the impactor. The selected impact test sites and the protective equipment employed are given in Table 4-1. The Fuji film was fixed on the surface of the test dummy at the impact site. The protective gear was then secured to the Hybrid III. The impactor was raised to the selected drop height and then released in guided free fall onto the test site. The impact energy for each test was calculated based on the measured impact velocity obtained from a GHI Systems Velocimeter.

4.3 Test Results

Data obtained from the direct impact testing using the cylindrical anvils is presented in Tables 4-l and 4-2.

Table 4-1: Results of Impact Tests on Protective Vest[1]

Protective Equipment	Impact Site on Test Dummy	Drop Height (m)	Velocity (s)	Energy (Joules)	Peak Acceleration (g)
Shoulder Cap	Shoulder	2.0	5.98	71.4	75.6
	"	3.0	7.20	103.7	102.4
	"	4.0	8.17	133.4	105.5
Off Shoulder Cap	Shoulder	2.0	5.95	70.8	241.0
Shoulder Pad & Epaulette	Shoulder	2.0	5.73	65.7	189.0
	"	3.0	7.15	102.4	264.6
	"	4.0	8.25	136.0	324.0
Front of Vest	Back plate on back of test dummy	2.0	5.89	95.5	370.1
	"	3.0	7.00	22.5	540.3

All tests conducted with 25 mm radius cylindrical bar impactor.

Table 4-2: Results of Impact Tests on Other Protective Equipment[1]

Protective Equipment	Impact Site on Test Dummy	Drop Height (m)	Velocity (s)	Energy (Joules)	Peak Acceleration (g)
Forearm Protector	Top of forearm	2.0	5.93	70.5	146.5
	"	3.0	7.20	103.5	239.4
	"	4.0	8.20	134.3	400.9
Thigh Pad of Girdle	Top of upper leg	2.0	5.98	98.2	64.6
	"	3.0	7.24	144.0	99.2
		4.0	8.33	190.7	157.5
Groin Protector	Tested on flat steel plate (not on test dummy)	1.0	4.21	48.8	42.5
		2.0	6.00	99.2	611.2

[1] All tests conducted with 19 mm radius cylindrical impactor.

5 Low Mass High Velocity Impact Tests

5.1 Test Apparatus

The apparatus used in the low mass, high velocity tests consisted of a high powered hunting slingshot and a standard golf ball. A Hybrid III anthropomorphic crash test dummy was used as an impact surrogate in all tests.

5.2 Test Method

Prior to testing the protective equipment five sites were selected for direct unprotected impact. These sites included the chest in the pectoral region, the shoulder, the back in . the region of the scapula, the forearm and the knee. Fuji film was placed directly over the area of impact at each site. Each site was then impacted by the golf ball using the slingshot at a draw of 75 N from a distance of 150 mm.

Fresh Fuji film was then replaced over the five impact sites and the appropriate protective equipment was fitted to the dummy. Each location was again impacted at the same severity as the unprotected impacts.

5.3 Test Results

Figures 5-1 and 5-2 show the knee impact Fuji film impressions (scanned using an HP Scanjet Plus) to illustrate the typical difference in impact severity between a protected and unprotected test site. The Fuji film impressions from the other impact were similar, the unprotected impact caused a deep-coloured impression in the Fuji film and the protected impact caused a broader, less intense impression.

The test sites which had protective covering of foam and stiff plastic, those being the back, chest and knee, showed a better load dispersion than the test sites with only foam protection, those being the forearm and shoulder. This indicates that a softer foam is acceptable when covered by a stiff load-bearing plate, but a stiffer foam would be better suited to protect from low mass, high velocity projectiles if no armour plate is used.

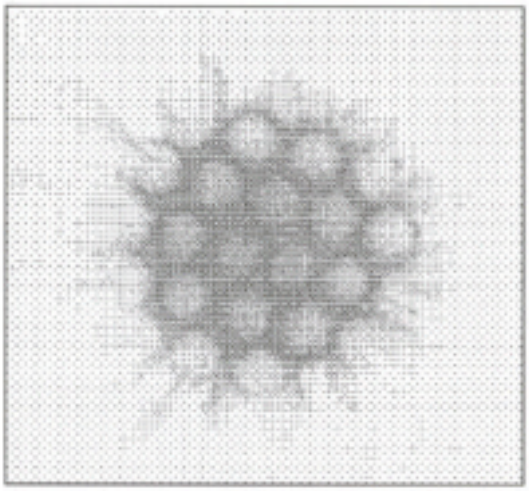

Figure 5-1
Close Range Knee Impact Without Protection