Personal Protection Systems

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National Security Equipment Committee
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Body Armour Performance

- INJURY
  - Prevent risk of death
  - Reduce severity of injuries
- THREAT
  - projectile, stab and blunt trauma
- PERFORMANCE ASSESSMENT
  - realistic and repeatable test methods
- FEATURES
  - comfortable, light, flexible, full coverage, durable and cheap

Body Armour Risk Management

INJURY Potential
- *injury type, severity (fatal/dis), incidence*

THREAT Environment
- *bullet type, weapon, exposure, distance*

PRIORITIES
- *exposure vs. severity*
- *trade-offs & consequences*

Risk Mgmt

PROTECTION REQUIREMENTS

Performance Realities

- No body armour is 100% effective!

balance = trade-offs

What performance limits and assessment?

Test Standards

- provide a consistent means to evaluate performance
- performance assessed on a relative or absolute basis, *i.e.*
  - better vs. worse
  - prevents a certain injury
- performance may not duplicate real-world conditions

Test Standards - Ballistics

- Civilian: National Institute of Justice (NIJ)
  - NIJ 0101.05 body armor
  - NIJ 0106.01 helmets
  - NIJ 0108.01 materials
- Military
  - DRDC, MIL, STANAG, US Army, MoD

Agency	Standard No.	Title	Scope
DND	/D-87-001-455/SF-001	Performance specification helmet, ground troops and parachutists for the CF	Specification
DRDC-V	DREV-FRAG-01	Ballistic test method for personal amrours and lightweight materials	V_{50}, V_{eff}, V_{proof}
MIL	MIL-P-46593A (ORD)	Projectile, calibers .22, .30, .50 & 20mm	Specification
MoD	UK/SC/5449	Ballistic test method for personal amrours and lightweight materials	Specification
NIJ	NIJ 0101.04	Ballistic resistance of personal body armor	V_{proof}, V_{50}
NIJ	NIJ 0106.01	Ballistic helmets	V_{proof}, impact
NIJ	NIJ 0108.01	Ballistic resistant protective materials	Vproof
STANAG	2920 DRAFT	Ballistic test method for personal amrour materials and combat clothing	Method
STANAG	XXXX	Ballistic test procedures for evaluating the protection levels of logistic and light armoured vehicles	Method
U.S. Army	TOP 1-2-710	Ballistic testing of personnel armor materials	V_s/V_r
U.S. Army	TOP 2-2-710	Ballistic tests of armor materials	V_{50}

Test Methods – Ballistics

- Penetration
  - risk of death

V Proof
V 50

- Blunt trauma
  - risk of injury

BFS
(Back Face Signature)

Threats - Ballistics

- Street threats
- Service weapons
- Severity
  - mass
  - speed (at target)
  - shape, construction
  - hardness

15

Threats – NIJ Definitions

Handgun threat levels

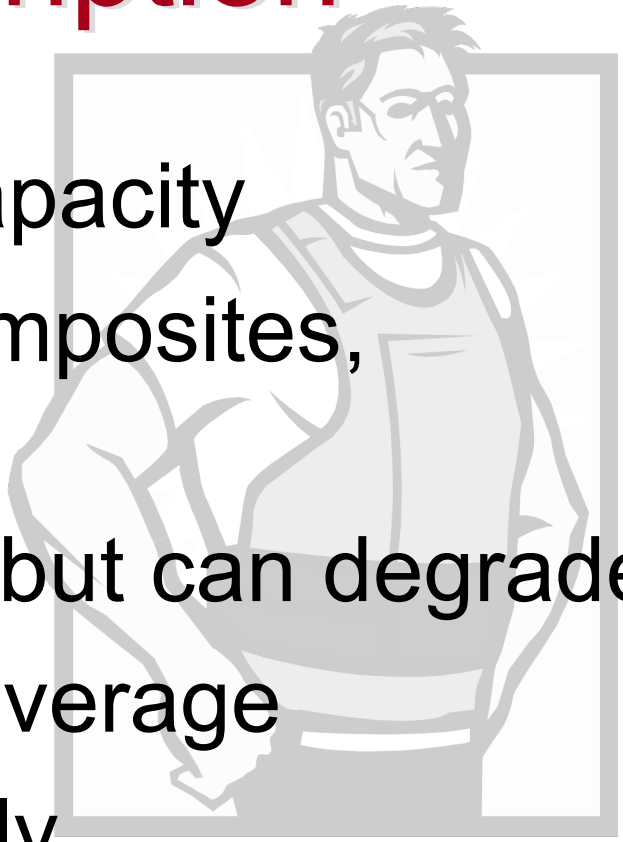
Level I	minimum full-time wear	0.22” LRN 0.38” FMJ RN	329 m/s 322
Level IIa	greater protection full-time wear	9 mm FMJ RN 40 S&W FMJ	341 322
Level II	bulkier ~ full-time wear	9 mm FMJ RN 0.357” JSP	367 436
Level IIIa	highest level intermittent use	9 mm FMJ RN 44 Mag SJHP	436 436

Threats – NIJ Definitions

Rifle threat levels

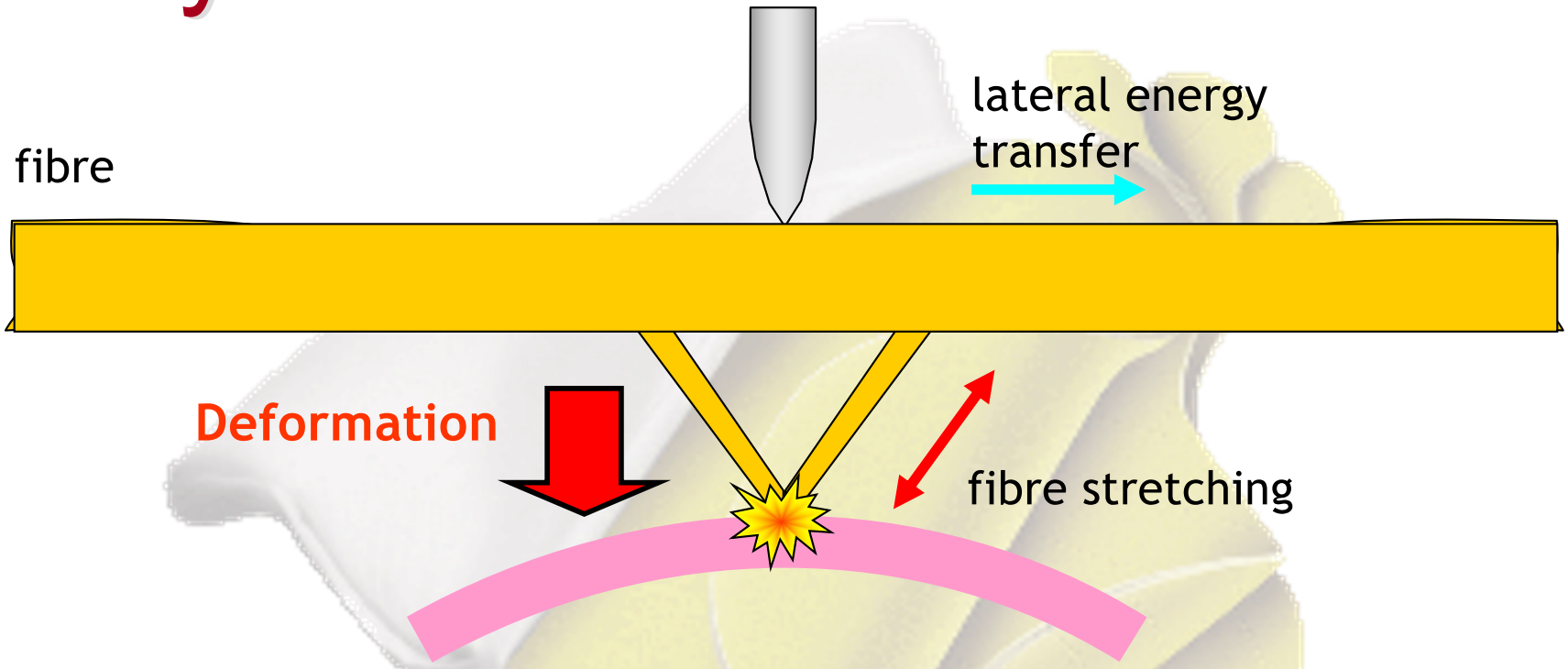
Level III	tactical situation terrorists	7.62 mm NATO Ball FMJ	838 m/s
Level IV	tactical situation terrorists	30-06 M2 AP FMJ	869

Body Armour - Description



- has a limited protective capacity
- can be made of fibres, composites, ceramics, polymers
- most materials are stable but can degrade
- must provide adequate coverage
- must fit the wearer properly
- must be worn

Body Armour - Ballistics

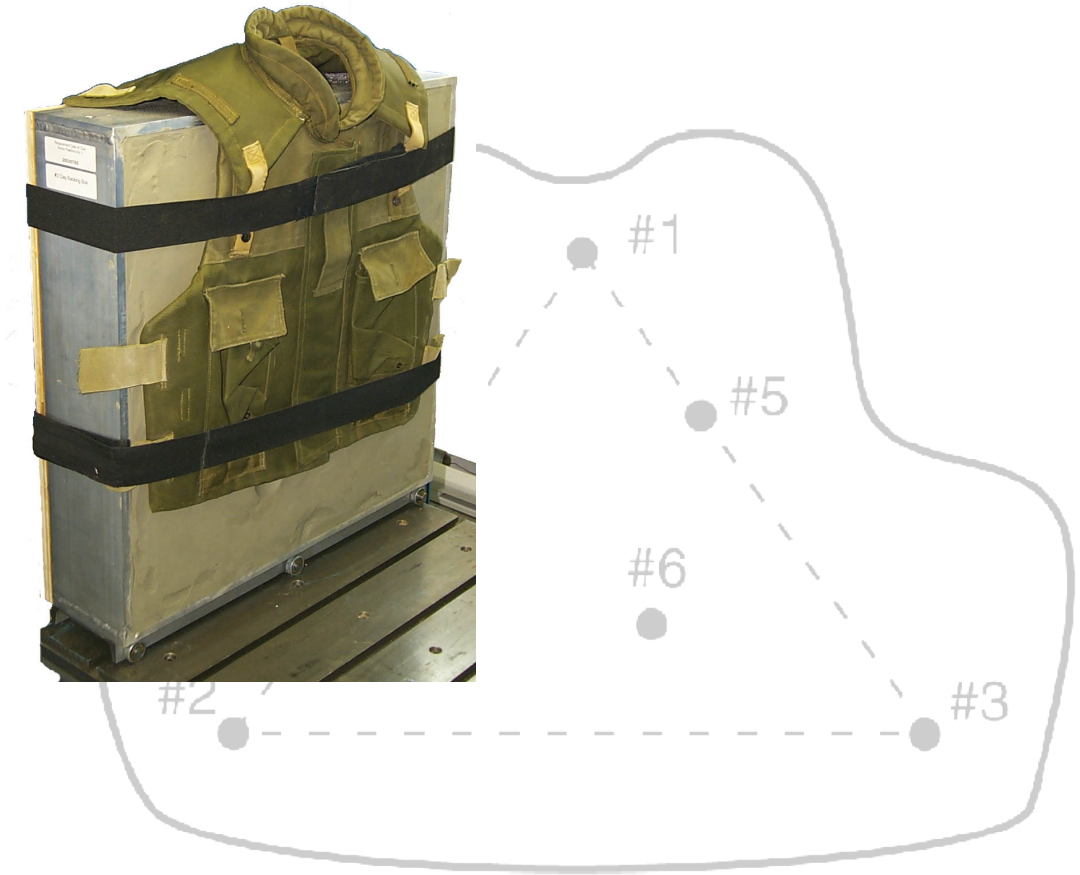


Bullet defeated in two ways for fabrics:

- stretching of the fibre
- lateral transfer of energy

Body Armour – Ballistic Tests

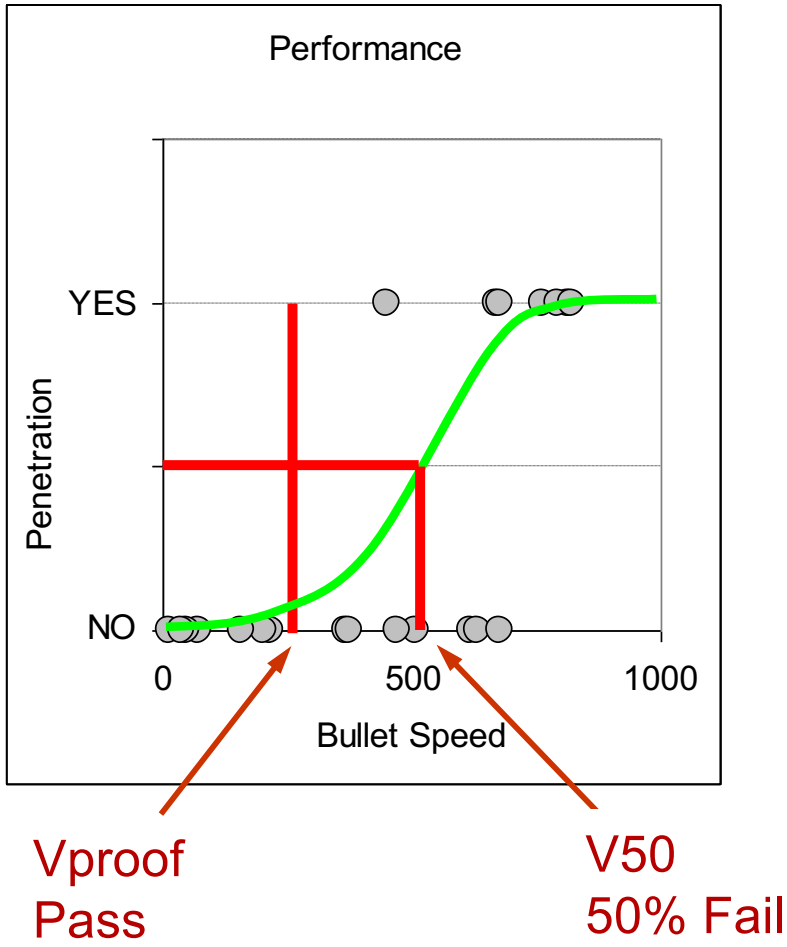
- shot pattern defined to ensure fair tests



44 Mag impact onto ballistic fabric

Body Armour - Performance

- Penetration
  - V proof, V 50
- Blunt trauma
  - limit on deformation into clay block



Injuries - Stab

- Fatal
  - stabbings to the chest and abdomen
  - deep penetrative wounds
  - multiple stab wounds
- Solution: Protect torso from weapon penetration

- Non-fatal
  - mostly to the extremities
  - severity not dependent on depth but on length of wound
- Solution: Protect extremities from slashing

Threats – Stab

- Puncturing, cutting, slashing
- Level of threat
  - style of weapon
  - sharpness
  - energy (speed, mass)
  - delivery

Test Standards - Stab/Slash

- Civilian:
  - NIJ 0115.00 body armor
  - PSDB Body Armour Standards for UK Police, Part 3 Knife and Spike Resistance
  - HOSDB Slash Resistance Standard for UK Police (2006)
  - California Ice Pick Test

Agency	Standard No.	Title	Scope
DND	/D-87-001-455/SF-001	Performance specification helmet, ground troops and parachutists for the CF	Specification
[illegible]	MIL-STD-662F	Test method standard V50 ballistic test for armor	V_{50}
DRDC-V	DREV-FRAG-01	Ballistic test method for personal amrours and lightweight materials	V_{50}, V_{eff}, V_{proof}
[illegible]	MIL-H-44099A	Helmet, specification, ground troops and parachutists	Specification
MIL	MIL-P-46593A (ORD)	Projectile, calibers .22, .30, .50 & 20mm	Specification
[illegible]	MIL-P-46135A	Projectile, calibers .50 [illegible]	Specification
MoD	UK/SC/5449	Ballistic test method for personal amrours and lightweight materials	Specification
[illegible]	NIJ 0108.01	Ballistic resistance of personal armor	V_{proof}, V_{50}
NIJ	NIJ 0106.01	Ballistic helmets	V_{proof}, impact
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STANAG	2920 DRAFT	Ballistic test method for personal amrour materials and combat clothing	Method
[illegible]	XXX	Ballistic test procedures for evaluating the protection levels of logistic and light armoured vehicles	Method
U.S. Army	TOP 10-2-506	Ballistic testing of personnel armor materials	V_s/V_r
[illegible]	[illegible]	Ballistic tests of [illegible] materials	V_{50}

Test Methods – Stab (NIJ / PSDB)

- Minor Penetration
  - risk of minor injury
  - 7 mm penetration
  - perpendicular / oblique

E1

- Major Penetration
  - risk of major organ injury
  - 20 mm penetration
  - perpendicular / oblique

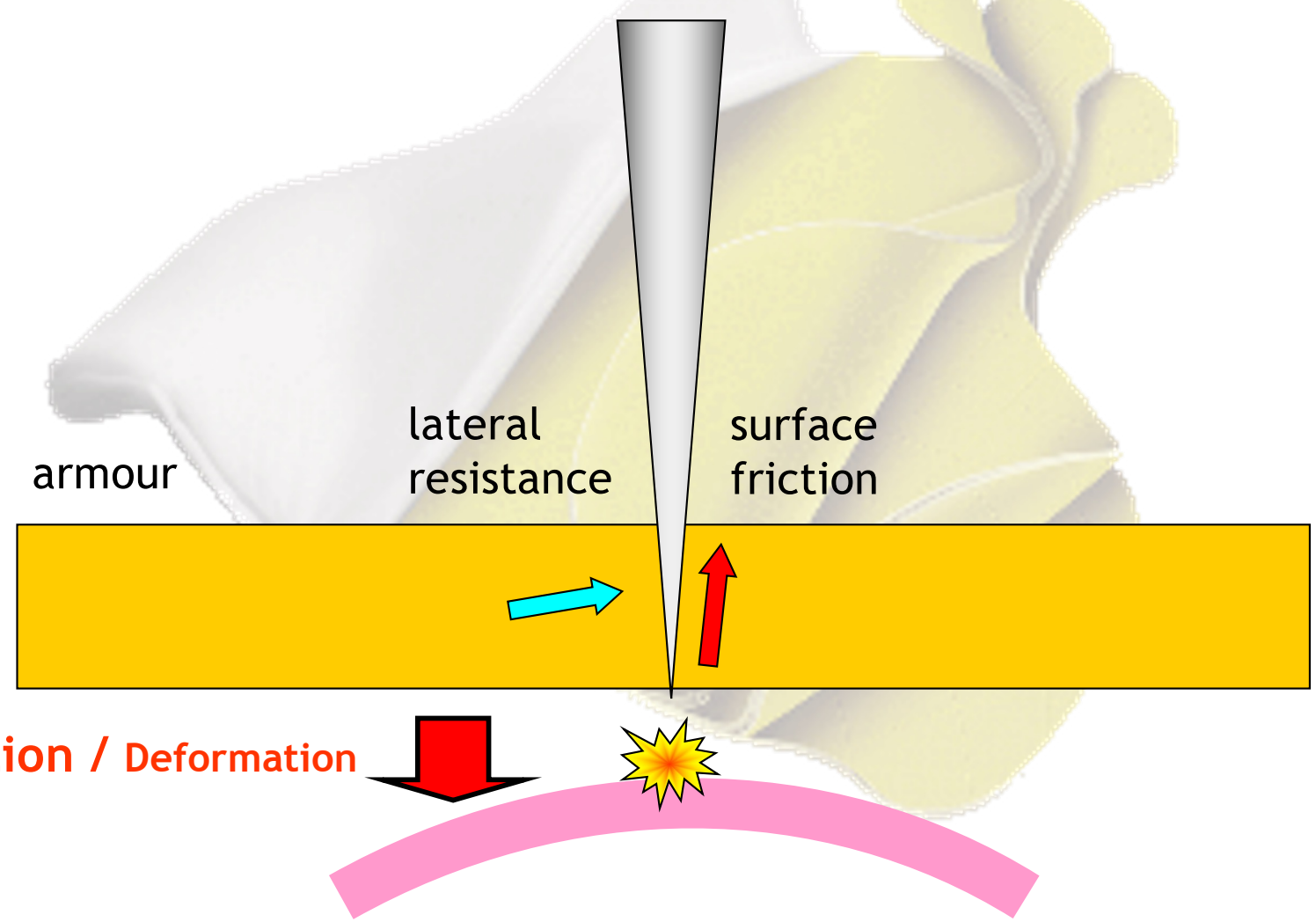
E2

Threats – NIJ Definitions

Stab threat levels

Level I	minimum full-time wear covert	edged blades spike	E1=24 J E2=36 J
Level II	greater protection full-time wear overt/covert	edged blades spike	E1=33 J E2=50 J
Level III	highest level intermittent use overt	edged blades spike	E1=43 J E2=65 J

Body Armour - Stab

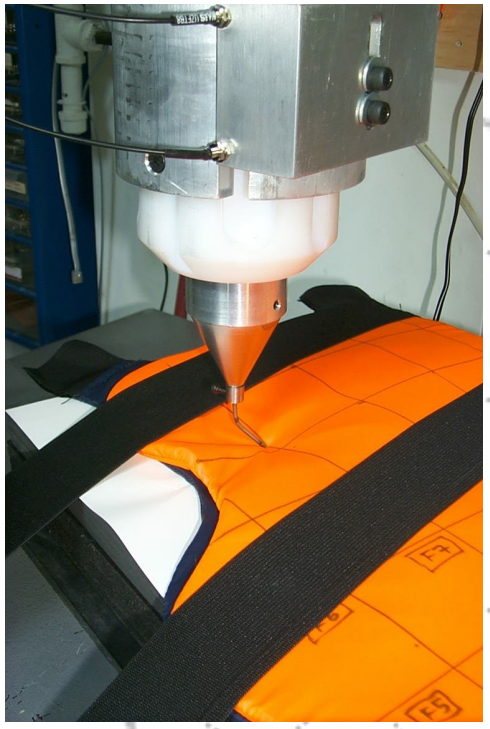


Body Armour - Description

- can be made of fibres, metals, polymers, composites and ceramics
- fabrics, rigid plates, multiple plates
- must provide adequate coverage
- must fit the wearer properly
- must be worn

Body Armour – Stab Tests

- stab pattern defined to ensure fair tests



Knife and spike threats

Product Conformance

- Compliance
  - meets the intent of the standard
  - can be conducted by competent labs
- Certification
  - meets requirements of std., recognized by NIJ
  - conducted by NIJ approved labs

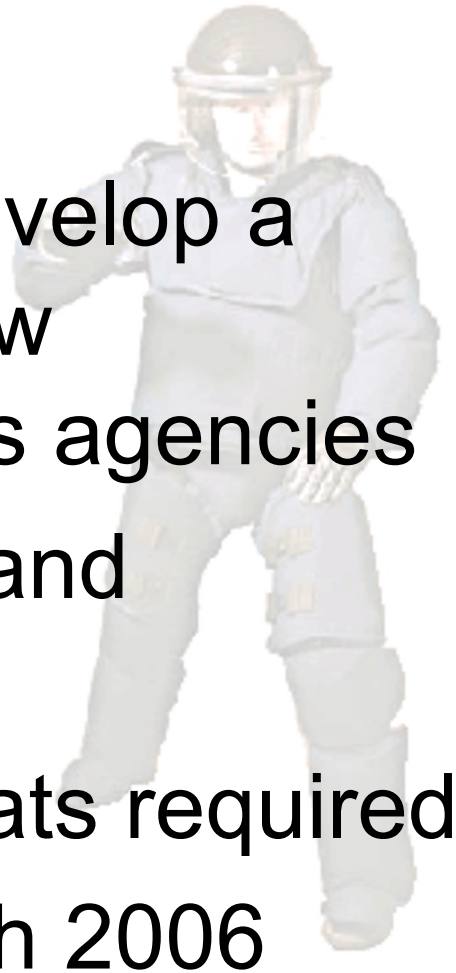
US { HP White
   { US Testing

Other None

Standards - Limitations

- minimum requirements
- do not address all threats and conditions
- quality controls not stipulated
- possible concerns with degradation of performance
- both procurement and suppliers required to exercise diligence

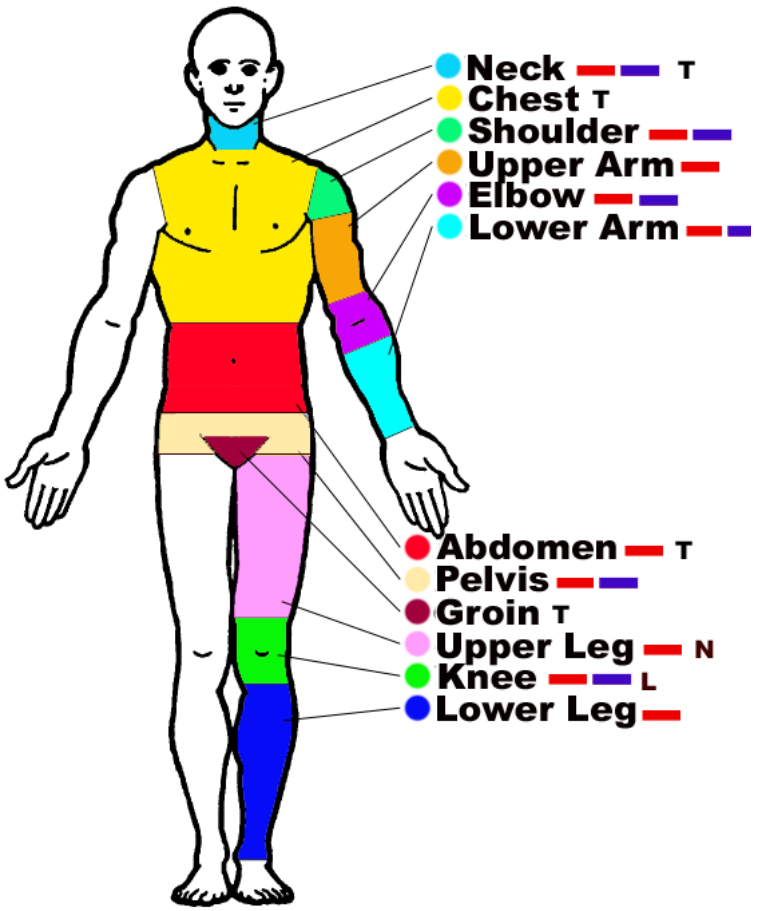
Blunt Trauma



- CSA committee set up to develop a blunt trauma standard for law enforcement and corrections agencies
- protection to the core body and extremities
- analysis of injuries and threats required
- CSA Z617 released in March 2006

Blunt Trauma – Injuries

No. Officers 2300



Body Region	No. Injuries
Arms	2
Torso	4
Legs	7
Head	8
Foot	3
Hands	3

Body Region	Date	Impact Location	Low injury	Moderate (days lost)	Serious injury (days lost)
Arms	21-Apr	Arm Hit with a wood stick or lumber			89
Arms	22-Apr	Brick on the arm		1	
Torso	20-Apr	Rock on the back	0		
Torso	20-Apr	Rock on the back			6
Torso	21-Apr	Rock on the shoulder	0		
Torso	21-Apr	Asphalt chunk on the chest- Thorax	0		
Legs	20-Apr	Pool ball on the	0		
Legs	20-Apr	Pavement on both legs			22
Legs	21-Apr	Projectile on the shield - injury on the knee			19
Legs	21-Apr	Pavement on leg	0		
Head	20-Apr	Pavement on helmet- Neck			89
Head	20-Apr	Corner of fence on the head - Neck			23
Head	21-Apr	Rock to the head - Neck	0		
Head	22-Apr	Pavement on helmet- Neck			6
Head	22-Apr	Pavement on helmet- Neck			50
Head	22-Apr	Pavement on helmet from third floor- Neck			88
Head	22-Apr	Pavement on helmet from a roof- Neck			46
Head	21-Apr	Projectile on the jaw	0		
Foot	20-Apr	Rock on the foot			4
Foot	21-Apr	Rock on the foot			81
Foot	21-Apr	Brick on the top of the foot			4
Hands	20-Apr	Projectile on the hand		0	
Hands	21-Apr	Hand hit with a stick		0	
Hands	22-Apr	Hustle and fall - cut on the hand		2	
Legs	20-Apr	Concrete block on the foot		1	
Legs	21-Apr	Rock on the ankle	0		
Legs	21-Apr	projectile on the ankle	0		

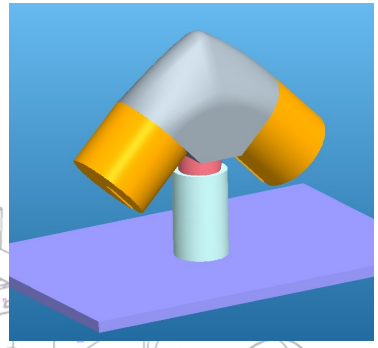
Injury ranking

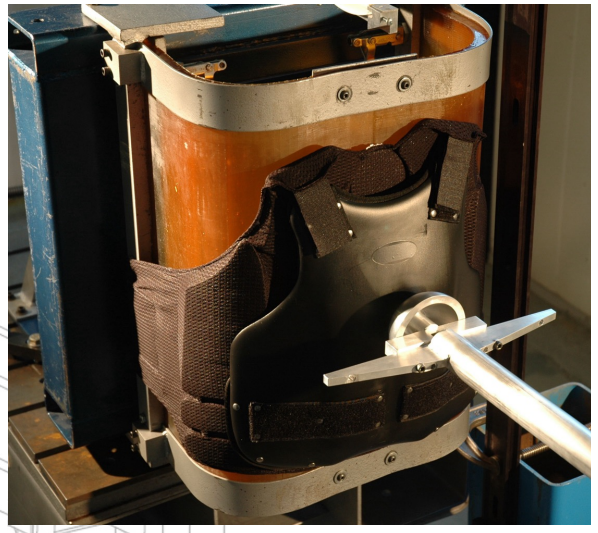
Injury data

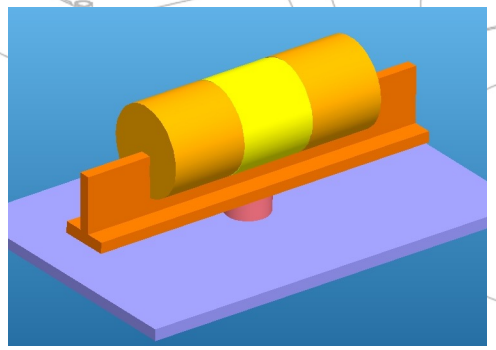
Blunt Trauma - Injuries

Applicability		Threat Category		Energy	Velocity	Mass	Drop Height	Body Region
L/E	C			(J)	(m/s)	(kg)	(m)	
✓		Thrown	Flat Edge Spherical	200 200 180	20 20 30	1.0 1.0 0.4	20.4 20.4 45.9	All
✓	✓	Hand Held	Pipe Edge	275 275	20 20	1.4 1.4	20.4 20.4	All
✓	✓	Personal Assault	Spherical	275	-	-	-	Cervical spine, thoracic spine, abdomen, groin, chest.
	✓	Struck	Flat Edge	240 240	5 5	17.0 17.0	1.4 1.4	Chest, spine, coccyx, joints.

Blunt Trauma – Test Methods



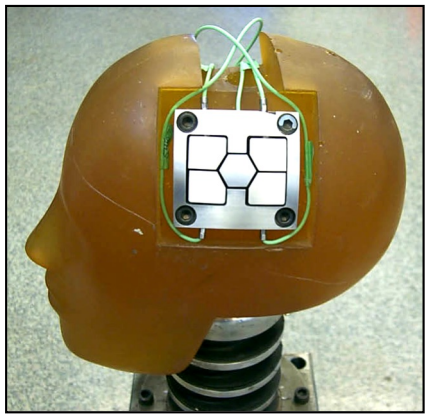




Future Developments

- Behind Armour Blunt Trauma – Torso
- Behind Armour Blunt Trauma – Head
- Threat Classification





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Questions?

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