Revisions to the NIJ Ballistic Resistant Body Armor Test Standard

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Outline

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Purpose of the NIJ Body Armor Standard

To provide the *test methods* and *minimum performance requirements* for law enforcement body armor.

Armor that meets this standard should provide reliable protection from the tested threats and similar rounds for the usable life of the armor.

Purpose of Changes to the Standard

Three primary intents of the changes in this revision:

1. Improve performance, so that all officers receive adequate protection.
2. Provide adequate protection for threats that are likely to be faced over the next decade.
3. Provide assurance that armors will provide protection through a lifetime of service.

Major Changes in a Nutshell

Updated armor types and threat rounds.

Testing of multiple sizes of concealable and soft armors to validate performance of all manufactured sizes.

Armor conditioning to validate long term durability.

Outline

2 New Threat Conditions

- Changes to Armor Types
- Tests on Multiple Armor Sizes
- Revised Sample Quantities

New Threat Conditions

Tests will be performed on *new* armor and armor that has been *conditioned* to validate it's long term durability.

New armors

There is an expectation that an armor's performance will degrade during the armor's life.
To account for this, *new* armors will be tested with elevated velocities, as in current tests.

Conditioned armors

Armors must still stop real threats at the end of their useful life.
Armors that have been through the new conditioning protocol will be tested with reduced velocities – less than the new armor test velocities, but still somewhat greater than the expected street velocities.

Revised Armor Types and Threats

Type I: .22 LR and .380 ACP

- Has been removed from the standard.

Type IIA: *Slow* 9mm and .40 S&W

- Both 9mm and .40 S&W test velocities increased.

Type II: *Fast* 9mm and .357 Magnum

- 9mm test velocity increased.

Type IIIA: .357 SIG and .44 Magnum

- 9mm threat replaced by .357 SIG.

Revised threats are intended to better reflect current street threats and law enforcement duty weapons.

Penetration-Backface Signature Tests

Revised Type IIA Velocities

NIST National Institute of Standards and Technology U.S. Department of Commerce

9 mm FMJ (124 gr) round.

- Estimated Street Velocity: 338 m/s (1109 ft/s)
- Conditioned Armor Test Velocity: 355 m/s (1165 ft/s)
- New Armor Test Velocity: 373 m/s (1225 ft/s)
  - NIJ 0101.04 was: 341 m/s (1120 ft/s)

.40 S&W FMJ (180 gr) round.

- Estimated Street Velocity: 312 m/s (1024 ft/s)
- Conditioned Armor Test Velocity: 325 m/s (1065 ft/s)
- New Armor Test Velocity: 352 m/s (1155 ft/s)
  - NIJ 0101.04 was: 322 m/s (1055 ft/s)

This armor should now be capable of stopping:

- Typical *standard* 9 mm cartridges from small handguns.
- Most .40 S&W rounds, including LE duty rounds.

Penetration-Backface Signature Tests

Revised Type II Velocities

NIST National Institute of Standards and Technology U.S. Department of Commerce

9 mm FMJ (124 gr) round.

- Estimated Street Velocity: 361 m/s (1185 ft/s)
- Conditioned Armor Test Velocity: 379 m/s (1245 ft/s)
- New Armor Test Velocity: 398 m/s (1305 ft/s)
  - NIJ 0101.04 was: 367 m/s (1205 ft/s)

.357 Magnum JSP (158 gr) round.

- Estimated Street Velocity: 378 m/s (1240 ft/s)
- Conditioned Armor Test Velocity: 408 m/s (1340 ft/s)
- New Armor Test Velocity: 436 m/s (1430 ft/s)
  - NIJ 0101.04 was: 436 m/s (1430 ft/s)

This armor should now be capable of stopping:

- Most ANSI/SAAMI +P rated 9 mm rounds from handguns.
- Most .357 and smaller, lead nosed revolver rounds.

Penetration-Backface Signature Tests

Revised Type IIIA Bullets and Velocities

NIST National Institute of Standards and Technology U.S. Department of Commerce

.357 SIG FMJ (125 gr) round.

- Estimated Street Velocity: 412 m/s (1350 ft/s)
- Conditioned Armor Test Velocity: 430 m/s (1410 ft/s)
- New Armor Test Velocity: 448 m/s (1470 ft/s)
  - NIJ 0101.04 (9 mm) was: 436 m/s (1430 ft/s)

.44 Magnum JHP (240 gr) round.

- Estimated Street Velocity: 396 m/s (1300 ft/s)
- Conditioned Armor Test Velocity: 408 m/s (1340 ft/s)
- New Armor Test Velocity: 436 m/s (1430 ft/s)
  - NIJ 0101.04 was: 436 m/s (1430 ft/s)

This armor should now be capable of stopping:

- Most .357 SIG and 9 mm rounds, including LE duty rounds.
- Most .44 and smaller, lead nosed revolver rounds.

P-BFS Test Summary

Test Rounds, Velocities, and Performance Requirements

	Test Variables					Performance Requirements		
Armor Type	**Test Round**	**Test Bullet**	**Bullet Mass**	**Conditioned Armor Test Velocity**	**New Armor Test Velocity**	**Hits Per Panel at 0° Angle**	**Maximum BFS Depth**	**Hits Per Panel at 30° or 45°**
IIA	1	9 mm FMJ RN	8.0 g (124 gr)	355 m/s (1165 ft/s)	373 m/s (1225 ft/s)	4	44 mm (1.73 in)	2
	2	.40 S&W FMJ	11.7 g (180 gr)	325 m/s (1065 ft/s)	352 m/s (1155 ft/s)	4	44 mm (1.73 in)	2
II	1	9 mm FMJ RN	8.0 g (124 gr)	379 m/s (1245 ft/s)	398 m/s (1305 ft/s)	4	44 mm (1.73 in)	2
	2	.357 Magnum JSP	10.2 g (158 gr)	408 m/s (1340 ft/s)	436 m/s (1430 ft/s)	4	44 mm (1.73 in)	2
IIIA	1	.357 SIG FMJ FN	8.1 g (125 gr)	430 m/s (1410 ft/s)	448 m/s (1470 ft/s)	4	44 mm (1.73 in)	2
	2	.44 Magnum SJHP	15.6 g (240 gr)	408 m/s (1340 ft/s)	436 m/s (1430 ft/s)	4	44 mm (1.73 in)	2
III	1	7.62 mm NATO FMJ	9.6 g (148 gr)	847 m/s (2780 ft/s)	– –	6	44 mm (1.73 in)	0
IV	1	.30 Caliber M2 AP	10.8 g (166 gr)	878 m/s (2880 ft/s)	– –	1 to 6	44 mm (1.73 in)	0
Special	1	Test threat to be specified by armor manufacturer or procuring organization.				Armor Performance and Shot requirements shall depend on armor type.		

Testing of Multiple Armor Sizes

NIJ–0101.04

All testing is performed on medium sized armor samples.

There is evidence that:

- Larger armors may be more easily perforated.
- Small armors tend to have larger BFS.

NIJ–0101.06

P-BFS tests shall be performed on samples that represent the largest and smallest armors that will be produced.

- Testing both large and small armor samples will provide an indication that all intermediate sizes will meet the performance requirements.

Testing of Multiple Armor Sizes

Implementation

New standard has multiple template sizes for soft armors:

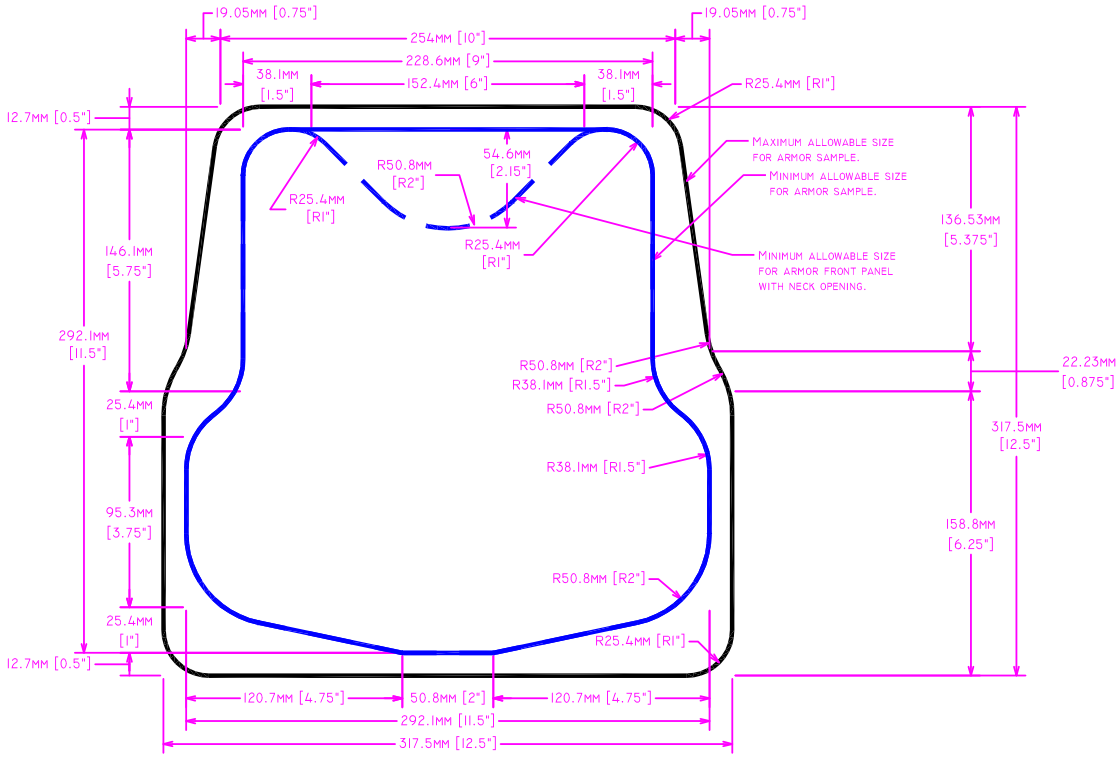
- Five template sizes ranging from very small to very large.
- Intended to cover the sizes worn by at least 95% of law enforcement officers.

Tests will be on samples fitting *two* of the templates.

- Sizes of samples will limit production sizes for that model.
- Exceptions, for models tested to:
  - Largest available template, no maximum production size.
  - Smallest available template, no minimum production size.

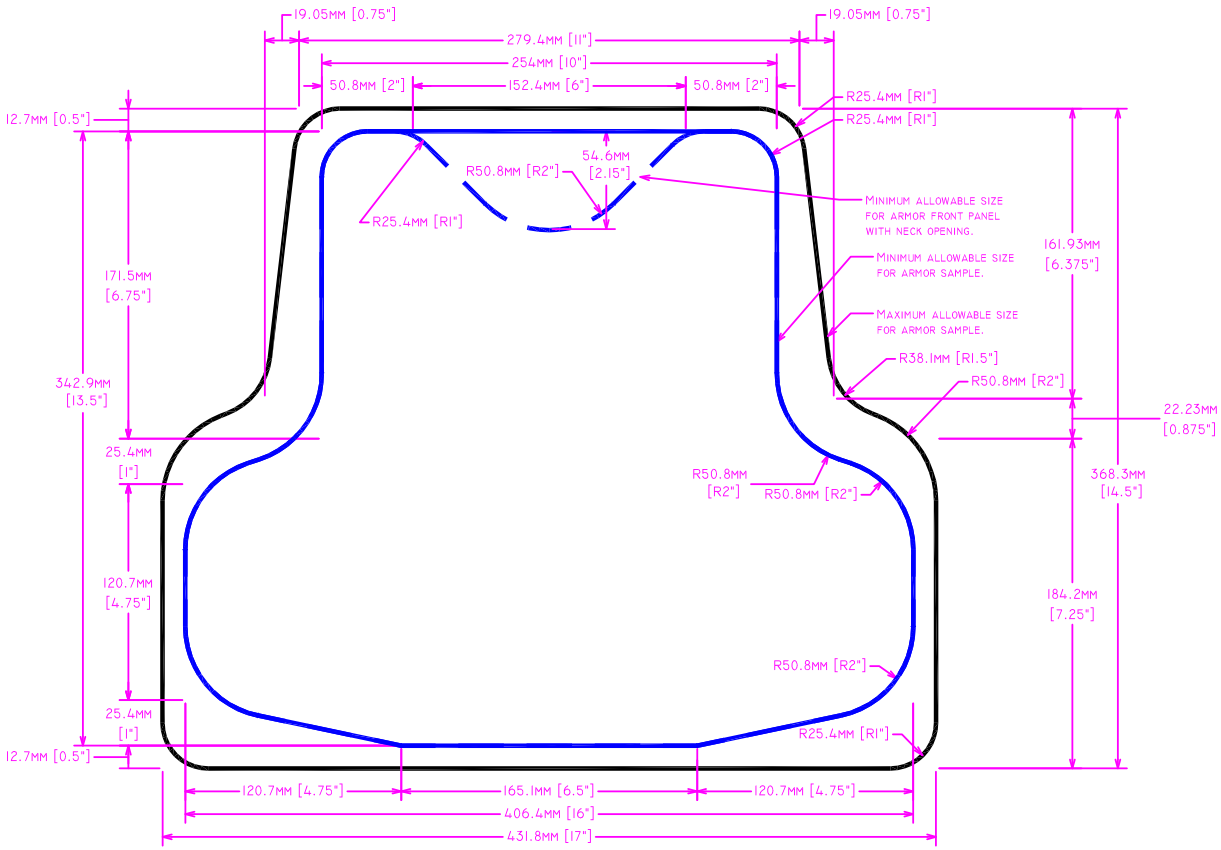
Concealable Template Size 1 – Smallest

12 inches Wide by 12 inches High



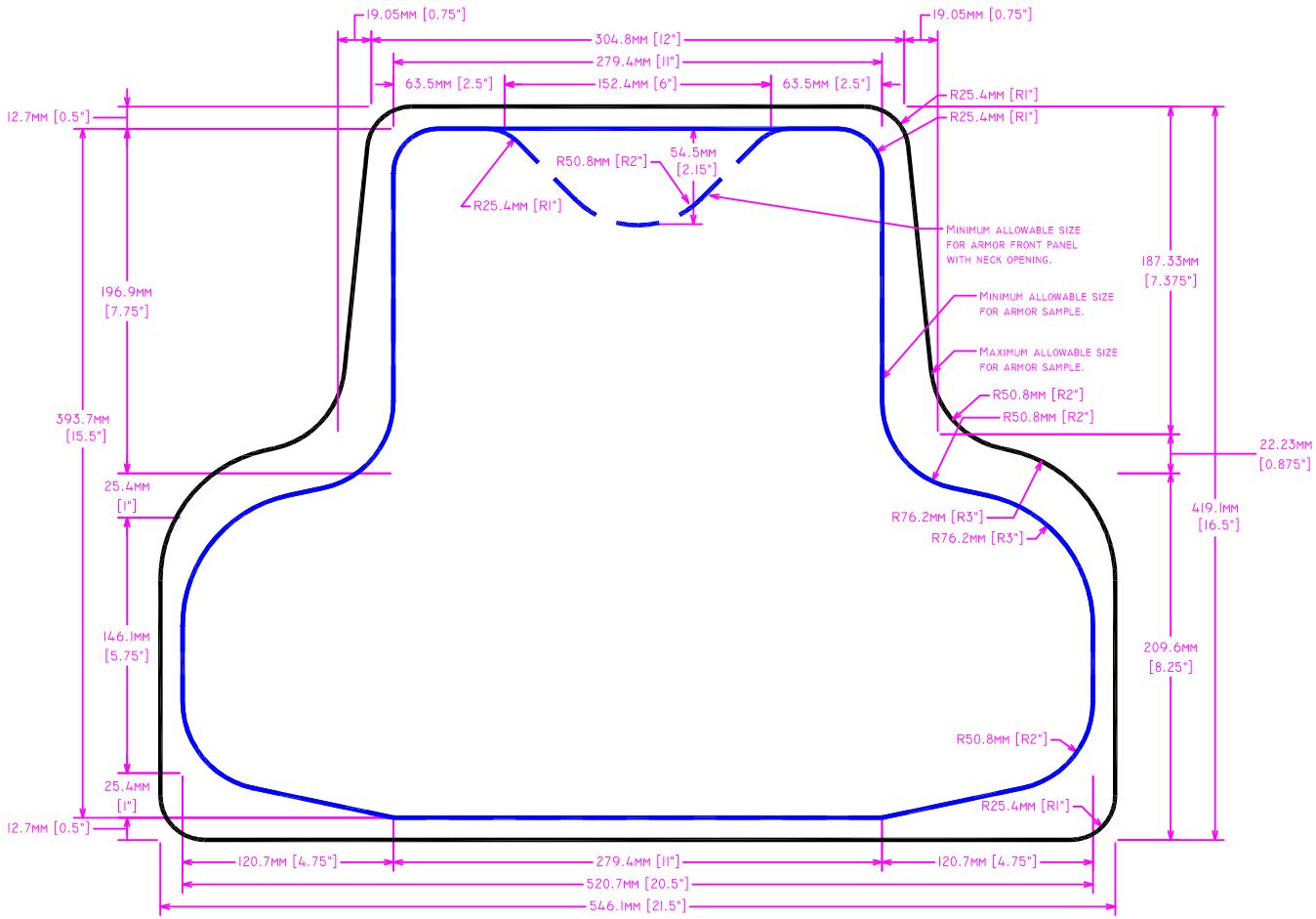
Concealable Template Size 2 – Small

16.5 inches Wide by 14 inches High



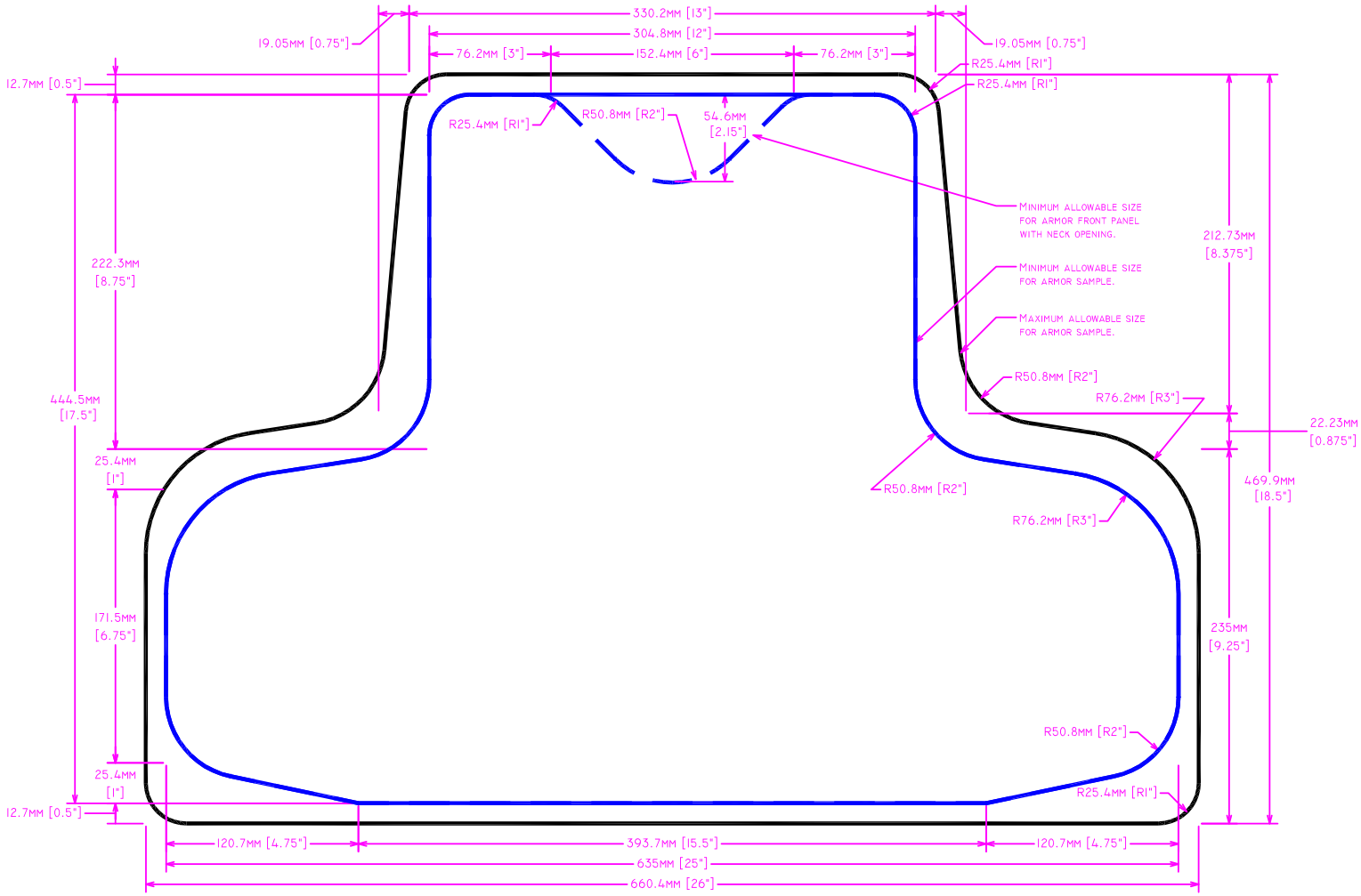
Concealable Template Size 3 – Medium

21 inches Wide by 16 inches High



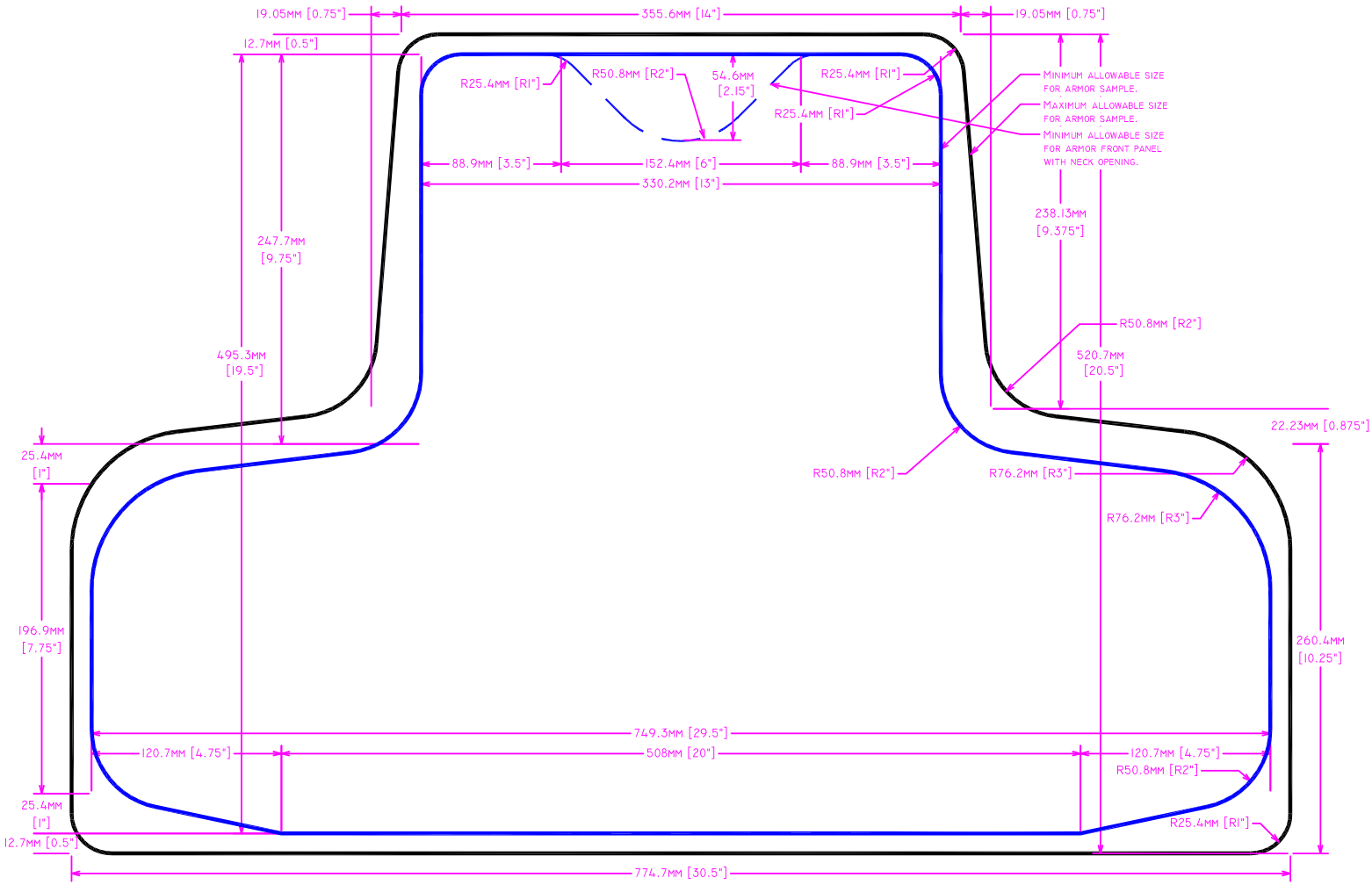
Concealable Template Size 4 – Large

25.5 inches Wide by 18 inches High



Concealable Template Size 5 – Largest

30 inches Wide by 20 inches High



Revised Sample Quantities

For Flexible Vests and Jackets

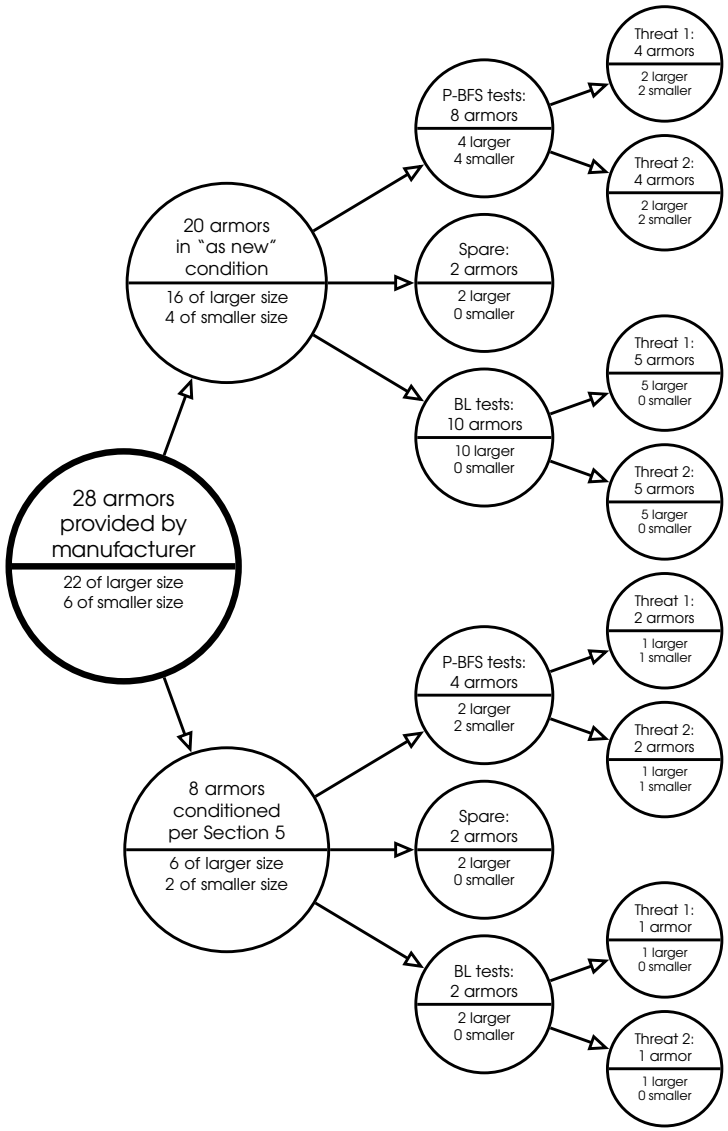


Figure 3, page 13 in pre-publication draft.

Revised Sample Quantities

For Flexible Vests and Jackets

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P-BFS Sample Requirements

- 8 new armors.
- 4 conditioned armors.
- 12 total sample armors.

Ballistic Limit Sample Requirements

- 10 new armors (5 per threat round).
- 2 conditioned armors (1 per threat round).
- 12 total sample armors.

Spare Armors

- 4 spare armors (2 per threat round).

Total

- 28 armors (14 per threat round).

Revised Sample Quantities
For Type III Hard Armors and Plates

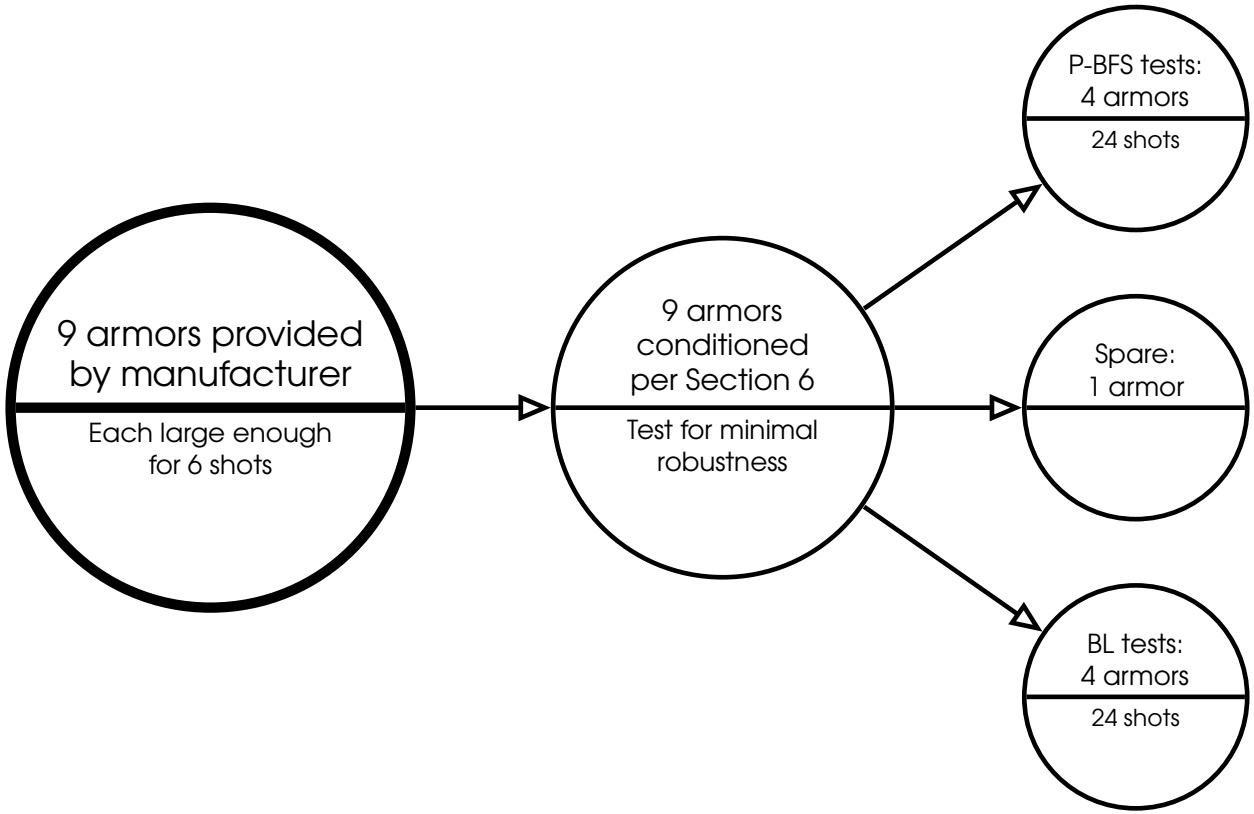

Figure 5, page 15 in pre-publication draft.

Revised Sample Quantities

Hard Armors and Plate Inserts

NIST National Institute of Standards and Technology U.S. Department of Commerce

Revisions to NIJ–0101

Type III P-BFS Sample Requirements

- 24 shots (1 threat round).
- 6 shots per plate.
- 4 sample plates.

Type III Ballistic Limit Sample Requirements

- 24 shots (1 threat round).
- 6 shots per plate.
- 4 sample plates.

Spare Armors

- 1 spare plate.

Total

- 9 plates.

Revised Sample Quantities
For Type IV Hard Armors and Plates

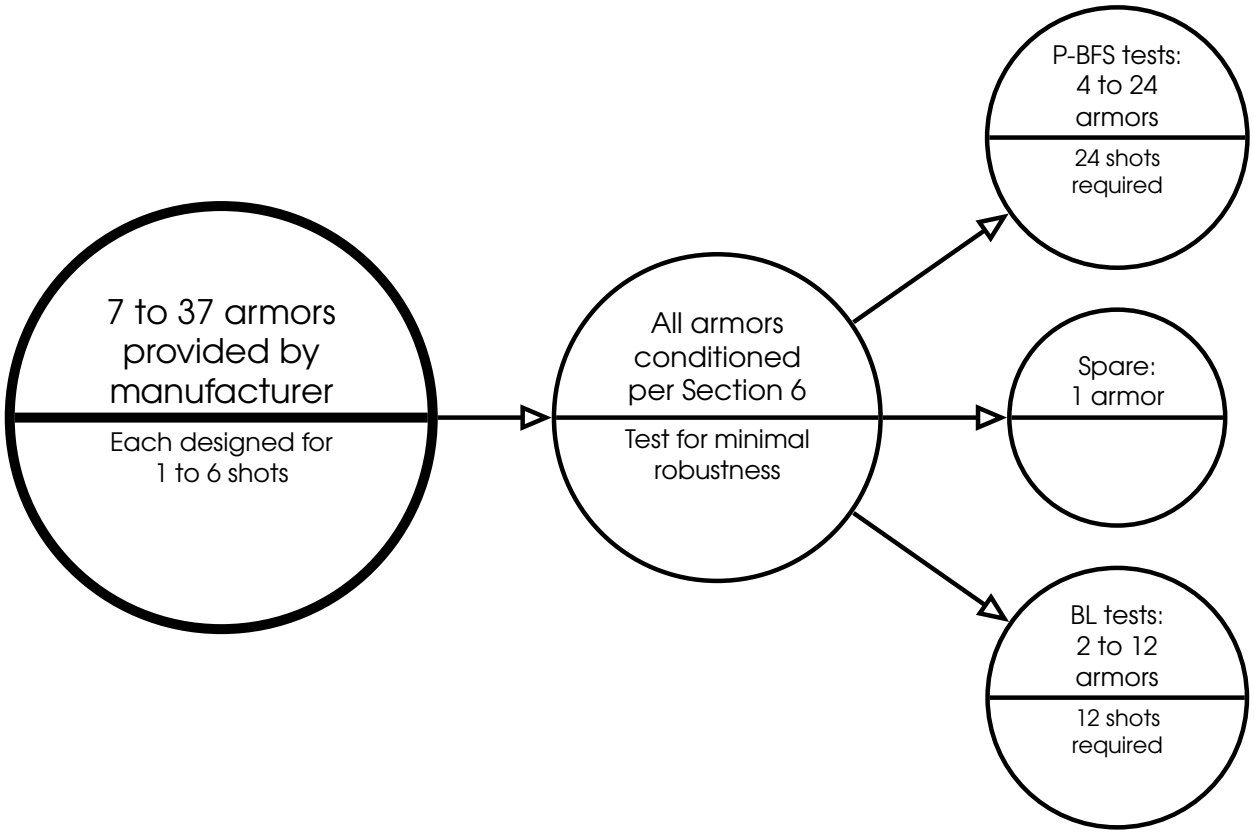

Figure 6, page 15 in pre-publication draft.

Revised Sample Quantities

Hard Armors and Plate Inserts

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Type IV P-BFS Sample Requirements

- 24 shots (1 threat round).
- 1 to 6 shots per plate.
- 4 to 24 sample plates.

Type IV Ballistic Limit Sample Requirements

- 12 shots (1 threat round).
- 1 to 6 shots per plate.
- 2 to 12 sample plates.

Spare Armors

- 1 spare plate.

Total

- 7 to 37 plates.

Outline

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3 Changes to Improve Confidence in the Test Results
- Reduced Shot–to–Edge Distance
- Revised P-BFS Shot Pattern
- P-BFS Testing and Performance Requirements
- Ballistic Limit Testing and Performance Requirements

Reduced Shot–to–Edge Distance

NIJ–0101.04

Test shots may not impact the armor less than 76 mm (3.0 in) from the edge.

Issues

- Reliability of armor close to the edge is unknown.
- Requirement was 51 mm (2.0 in) through 1985.
- Very small area of reliable coverage on smaller armors.

Reduced Shot–to–Edge Distance

NIJ–0101.06

Threat 1 minimum shot-to-edge distance: 51 mm (2.0 in).

- Penetrative threat.
- 9 mm Luger, .357 SIG, and rifle threats.

Threat 2 minimum shot-to-edge distance: 76 mm (3.0 in).

- Blunt trauma threat.
- .40 S&W, .357 Magnum, and .44 Magnum.

Expected Results

- Increased area of reliable coverage.
- Reduction in officer injuries and fatalities due shots impacting close to edges.

Revised P-BFS Shot Pattern

NIJ–0101.04

6 Shots per armor panel.

- Minimum shot-to-shot and shot-to edge distances specified.
- No maximum distances.

Issues

- Standard sample size allows shots to be widely spaced.
- Performance near edges is not validated.
- Performance when shots are close together is not validated.

Revised P-BFS Shot Pattern

NIJ–0101.06

Adjust P-BFS shot pattern to better validate armor performance.

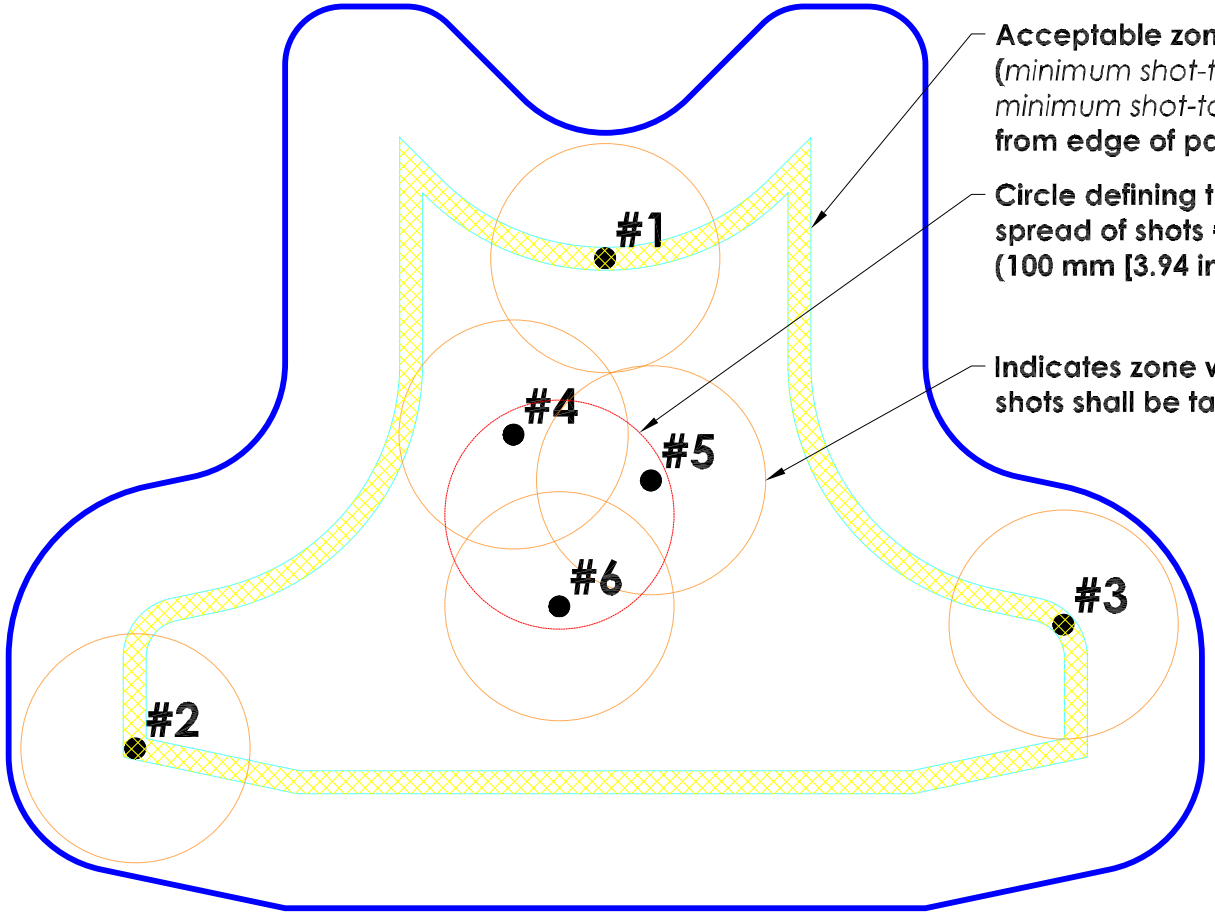
Shots 1, 2, & 3 shall be within 19 mm (0.75 in) of edge limit.

- For armors with minimum 51 mm (2.0 in) to edge spacing, all three shots between 51 mm (2.0 in) and 70 mm (2.75 in) from edge.

Shots 4, 5, and 6 all within a 100 mm (3.9 in) diameter circle.

- Generally located near center of armor.
- Will be randomly located when there is space.
- Will be positioned to exploit armor weaknesses.

Revised P-BFS Shot Pattern



Penetration-Backface Signature Tests

Changes to Test Requirements

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Revised backface signature requirements

Either:

- No BFS greater than 44 mm (1.73 in).

Or:

- Statistically, 95% of BFS must be 44 mm (1.73 in) or less.

$$Average\ BFS + 1.65\sigma \leq 44\ \text{mm}$$

Ballistic Limit Testing

NIJ–0101.04

Ballistic limit tests performed on two panels.

- 10 to 12 shots each test.
- No performance requirements.

Issues with NIJ–0101.04 Test Method

- Provides only a rough estimate of the ballistic limit, V_{50}.
- Does not provide any indication of the armor's performance at lower velocities.

Revised Ballistic Limit Testing

NIJ–0101.06

- Modified test procedure and increased sample quantity.
- New analysis and performance requirements.

Goal

To estimate the armor's full performance curve, including:

- An improved estimate of the V_{50}.
- Velocities where the probability of failure is low.

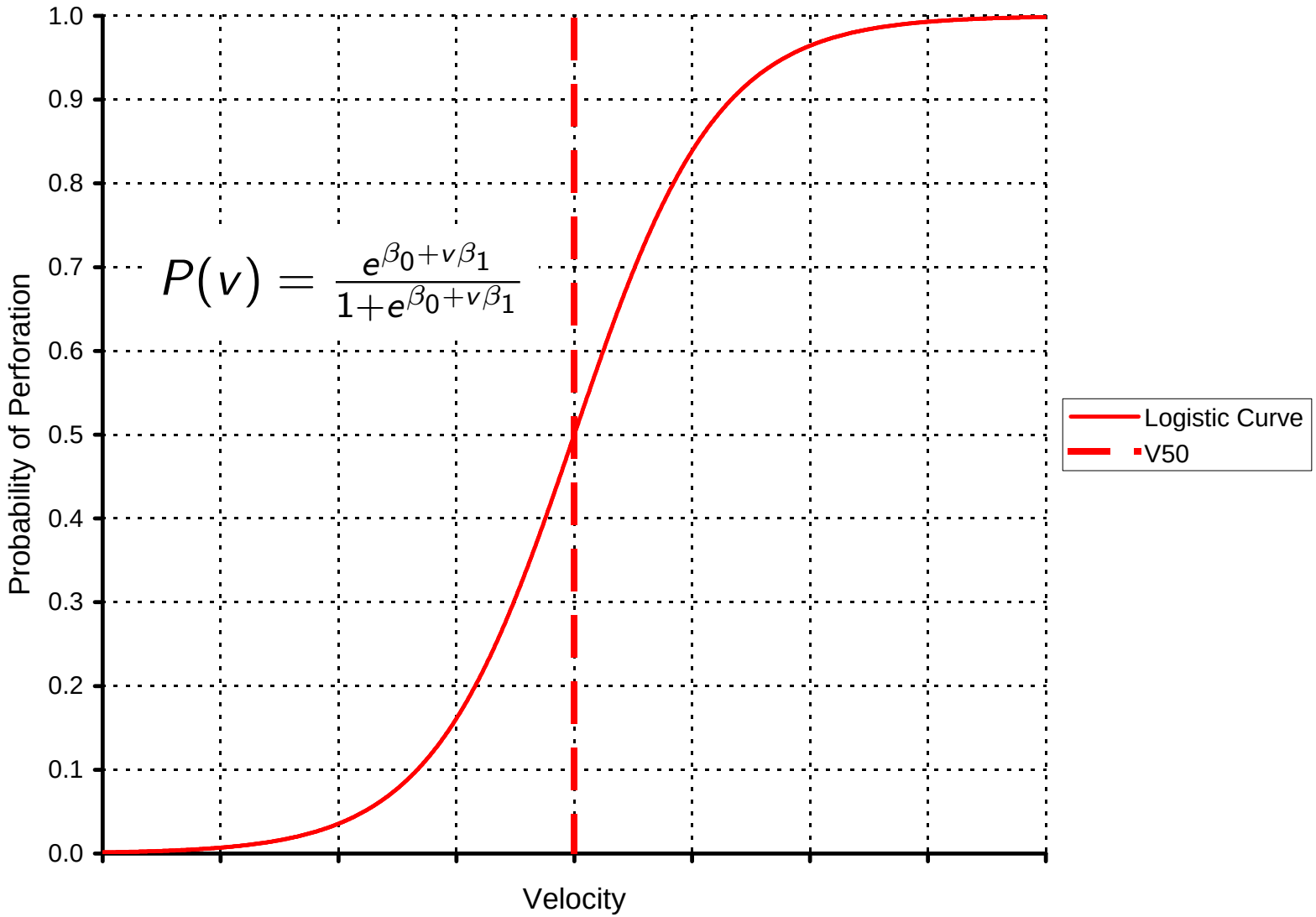
Implementation: For *new*, flexible vests and jackets

At least 120 shots of ballistic limit data for each caliber.

- Data from 10 panels, with at least 12 shots each.
- Tests will start at the reference velocity.

Example Model to Predict Velocity Response Curve

Logistic Response Model



Ballistic Limit Performance Requirements

For Flexible Vests and Jackets

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For all armors:

The lowest perforation velocity must be greater than the P-BFS test velocity plus 9.1 m/s (30 ft/s).

For new armors:

The estimated probability of perforation must be acceptably low at the P-BFS test velocity.

Only one environmental conditioned armor sample (24 shots) will be required for each caliber.

Outline

4 Changes to Improve Test Repeatability
- Revised Wetting Method
- Standardized Bullets

Revised Wetting Method

NIJ–0101.04

Armor is sprayed with a moderate mist for six minutes.

- Indicates whether wet armor will maintain performance.
- Does not verify integrity of panel covering seams.
- Can be significant variation in amount of water that samples are exposed to.

NIJ–0101.06

Samples will be submerged in a water bath for 30 min prior to P-BFS testing.

- Samples will be hung vertically in the bath.

Provides a better indication of armors' resistance to moisture.

Standardized Bullets

NIJ–0101.04

Standard specifies only bullet mass, geometry, and jacket type.

- Many different products meet these specifications.
- Bullets meeting these specifications have wide variations in hardness and deformability.

Bullet hardness can have a large impact on armor performance.

NIJ–0101.06

Manufacturer and model of all test bullets will be prescribed.

- Reducing the variability in the bullet properties should reduce the variability in the test results.

Outline

5 Closing Remarks

- Summary

Summary

Extensive changes have been made to the NIJ *Ballistic Resistant Body Armor Test Standard*.

Changes are intended to:

- Improve the reliability of law enforcement body armor.
- Validate the long term performance of the armor.
- Provide the law enforcement community with greater confidence that the armor will perform well when needed.
- Minimize variations between test laboratories.

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