BF Jacket

भारतीय मानक
Indian Standard

IS 17051 : 2018

वस्त्रादि — बुलेट प्रतिरोधक जैकेट — कार्यकारिता की अपेक्षाएं

Textiles — Bullet Resistant Jackets — Performance Requirements

ICS 13.310

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Textiles Protective Clothing Sectional Committee had been approved by the Textile Division Council.

The Indian military and security forces face a number of small arms threats. It is important to set minimum performance requirements of bullet resistant jackets and also screen their supply so that only acceptable quality reaches the user which eventually leads to reduction in fatal casualties to the security forces wearing such bullet resistant jackets.

Multiple test agencies in the country are involved in physical and ballistic testing of the bullet resistant jackets. However, at present there is no common procedure in place to ensure inter-laboratory correlation of test results.

Many ammunitions defined in international standards are not relevant in Indian context. The weapons and ammunitions handled (and faced) by the Indian forces need to be categorized into specific threat levels.

Operating and environmental protocols for the ballistic materials vary over the Indian sub-continent. These can affect shelf life as well as active life of bullet resistant jackets.

Statistical sampling plan for testing of bullet resistant jackets ensure that maximum data and population representation is obtained using minimum number of test articles. This helps in reducing the time and resources required to carry out ballistic evaluation for large supply of bullet resistant jackets.

In 2016, a committee under the chairmanship of Dr Manjit Singh, 'Distinguished Scientist and Director of Terminal Ballistics Research Laboratory (TBRL)' was constituted by 'NITI Aayog' to finalize performance and testing standards of body armour. This was a part of the roadmap for development of indigenous technology in body armour under 'Make in India' initiative by the Government of India. The team comprised of representatives from TBRL, Defence Materials and Stores Research and Development Establishment (DMSRDE), head quarter Defence Research and Development Organisation (HQ DRDO), Bureau of Police Research and Development (BPR&D), Directorate General of Quality Assurance (DGQA), Integrated Headquarters of Ministry of Defence (IHQ of MoD) (Army) and private manufacturers. Another committee headed by Dr N. E. Prasad, 'Director' of DMSRDE comprising of representatives of academia, Ministry of Home Affairs (MHA) and Infantry Directorate provided support in developing performance criteria for outer fabric and peripherals. The draft standard emanated from the deliberations at the above committees has been the basis for development of Indian Standard on the subject.

This Standard on the subject will facilitate following stakeholders:

a) *Manufacturer/supplier* — Design and develop bullet resistant jackets according to the requirements of the user.

b) *User* — Selection of bullet resistant jackets based on threat perception. Evaluating effect of operating conditions on performance and evaluation of service life, positioning samples for testing etc.

c) *Testing agency* — Evaluation of minimum performance and lot certification for bullet resistant jackets along with test methodologies and equipment to be used for evaluation.

In the formulation of this standard, considerable assistance has been derived from the following:

a) BPR&D QR (2015): Qualitative requirements and trial directives of bullet resistant jackets,

b) BPR&D QR (2015): Qualitative requirements and trial directives of bullet resistant vest,

c) IHQ of MoD (Army) GSQR 1438: Qualitative requirements for bullet proof jacket,

d) MIL – STD – 810 G: Environmental engineering considerations and laboratory tests,

e) MIL – STD – 662F : 1997: V_{50} Ballistic test for armor,

f) NIJ 0101.06: Ballistic resistance of body armor,

g) TBRL/BEM/TP-01/12: Standard operating procedures for ballistic evaluation of body armour, and

h) Bhattacharjee, D., Kumar, A. and Biswas, I. Verma, S and Islam, E, 2016, Thermo-Rheological and dynamic analysis of backing materials for measurement of behind armour blunt trauma, personal armour systems symposium, Amsterdam, The Netherlands.

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Indian Standard

TEXTILES — BULLET RESISTANT JACKETS — PERFORMANCE REQUIREMENTS

1 SCOPE

1.1 This standard prescribes the minimum performance requirements of bullet resistant jackets for protection against small arms and ammunition and provides procedures for their evaluation. The scope of the standard is limited to physical and ballistic evaluation of bullet resistant jackets against in-service small arms ammunition (*see* Table 7) used by the Indian armed forces, paramilitary, state police forces and other law enforcement agencies.

1.2 Physical and ballistic evaluation criteria and measurements are confined to the laboratory and test range conditions only. The data generated are strictly valid for comparison under same conditions of test.

1.3 This standard does not cover the threats from knives, sharply pointed instruments and shards, splinters and fragments from the hand grenades. These aspects may be dealt with in other standards.

1.4 This standard covers only the basic design of bullet resistant jackets and provides guidelines with respect to their evaluation. Specific requirements in terms of protection area of the body, accepted weight penalty of the jackets, threat perception, operating conditions, etc, are entirely dependent upon the user/purchaser. It is strongly recommended that the user works out the size, weight, threat, design factors, maneuverability, protection panels and other aspects before finalizing qualitative requirements.

NOTE — The tests described in the standard have inherent hazards, hence adequate safety norms for personnel and property shall be employed strictly while conducting the tests.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subjected to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY

For the purposes of this standard, the following definitions shall apply.

3.1 Acceptance Quality Limit (AQL) — Quality level that is worst tolerable process average when a continuing series of lots is submitted for acceptance sampling.

NOTES

1 This concept only applies when a sampling scheme with rules for switching, and for discontinuation, such as in IS 2500 (Part 1) or IS/ISO 3951 (Part 1) to (Part 5), is used.

2 Although individual lots with quality as bad as the acceptance quality limit may be accepted with fairly high probability, the designation of an acceptance quality limit does not suggest that this is a desirable quality level. Sampling schemes found in IS 2500 (Part 1), with their rules for switching and for discontinuation of sampling inspection, are designed to encourage suppliers to have process averages consistently better than the AQL. Otherwise, there is a high risk that the inspection severity will be switched to tightened inspection under which the criteria for lot acceptance become more demanding. Once on tightened inspection, unless action is taken to improve the process, it is very likely that the rule requiring discontinuation of sampling inspection pending such improvement will be invoked.

3.2 Angle of Impact — The angle between the bullet's line of flight and the perpendicular to the front surface of the backing material fixture (*see* Fig. 1).

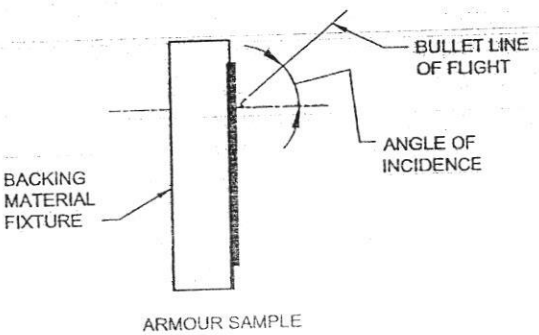


FIG. 1 ANGLE OF IMPACT

3.3 Areal Density — Weight of an object per unit area expressed in kg/m². Areal density is generally used to denote the weight of panels to normalize the effect of thickness.

3.4 Armour — Complete article providing required ballistic protection to specific coverage areas of the body. Armour comprises of panels which are individual ballistic components.

3.5 Back Face Signature (BFS) — The maximum indentation in the backing material caused by a non-perforating impact on the armour. This is also known as behind armour blunt trauma (BABT). BFS is the perpendicular distance between two planes, both of which are parallel to the front surface of the backing material fixture. One plane contains the reference point on the original backing material. The other plane contains the point that represents the deepest indentation in the backing material (*see* Fig. 2).

3.6 Backing Material — A homogeneous block of polymeric/mineral clay placed in contact with the back of the edge armour panel during ballistic testing and is used to measure BFS/depth of indentation.

3.7 Ballistic Limit — For a given projectile, the velocity at which the bullet is expected to perforate the armour panel 50 percent of the time. It is also denoted as V_{50}.

3.8 Ballistic Material/Panel — The protective component of any bullet resistant jacket sample, consisting of ballistic resistant materials. The material/panel may be covered with a protective/waterproof fabric, which is considered an integral part of the ballistic material/panel. The ballistic material/panel is usually kept inside a carrier fabric. The ballistic material/panel may consist of components specifically designed to protect specific body regions for example torso, back, groin, neck, etc.

3.9 Bullet Resistant Jacket (BRJ) — A wearable protective system which consist of ballistic material/panel and trauma mitigation pack (*see* 3.8 and 3.28) protecting parts of the body according to the threat level.

3.10 Bullet Resistant Vest (BRV) — A wearable protective system which consists of soft armour panel (SAP) and is usually constructed of pliable fabric based materials. Bullet resistant vests are designed to provide protection against low velocity handgun rounds only. Vest can also be used as covert/concealed armour and can cover the entire torso.

3.11 Conditioning Protocols — Special test protocols designed to subject ballistic materials under test to environmental and service conditions with the aim to provide an indication of the ballistic material's ability to retain ballistic performance after being exposed to severe environmental, in-transit or wear conditions over a period of time.

3.12 Depth of Indentation — The maximum depth of the crater formed in the backing material after an impact (drop test or firing) from the reference surface of the backing material fixture (*see* Fig. 2)

3.13 Fair Hit — The impact of a bullet on an armour panel that meets the shot spacing, angle of impact of bullet and velocity requirements specified in 9.2.4.

3.14 Flexible Armour Panel/Soft Armour Panel — Panel constructed of textile based materials (fabrics, laminates, etc) in such way that the complete armour can be bent/flexed at will. These armours, standalone

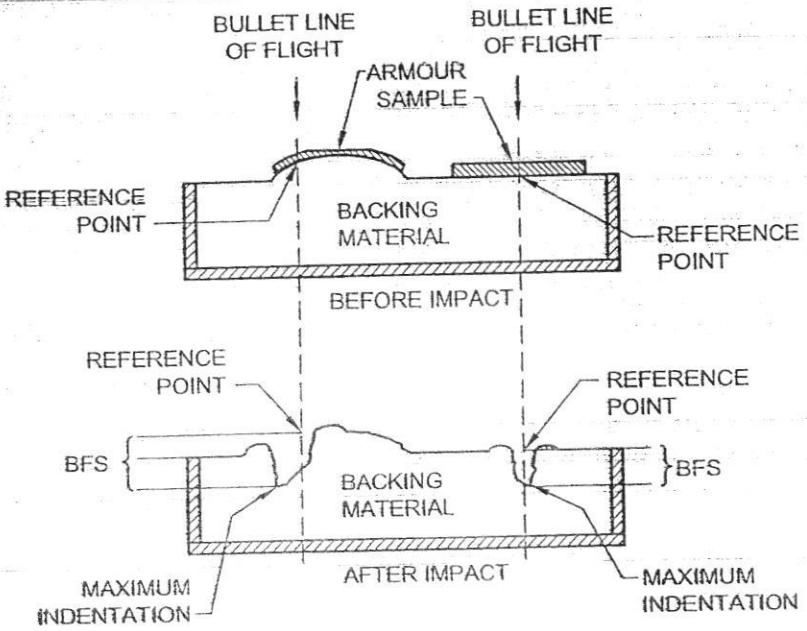


FIG. 2 MEASUREMENT OF BACK FACE SIGNATURE

provide protection against primarily hand gun threats only.

3.15 **Groin Protector (GP)** — Component of the body armour that protects the groin area. It is generally made of flexible armour panel/SAP, but in some cases hard armour panel/HAP as well.

3.16 **Hard Armour Panel (HAP)/Rigid Armour Panel** — Panel constructed of rigid plate (textile or ceramic reinforced composite, steel, etc) which provides protection against high velocity/rifle threats. These may be used as in-conjunction with (ICW) flexible armour panel/SAP or as standalone configuration (*see* **3.17** and **3.25**).

3.17 **In-conjunction With (ICW) Configuration** — Terminology used for hard armour panel configuration that is designed to withstand threats when worn along with a flexible armour panel/SAP as opposed to standalone.

3.18 **Lot Size** — Number of items in a lot.

3.19 **Model** — Designation given by the manufacturer to uniquely identify a specific configuration of bullet resistant jacket.

3.20 **Operating Conditions** — Environmental conditions which the bullet resistant jacket is likely to be subjected during its service life depending upon their location and usage.

3.21 **Perforation-Back Face Signature (P-BFS) Test** — Ballistic test procedure where the minimum performance requirement of bullet resistant jacket is evaluated in terms of perforation as well as back face signature.

3.22 **Sample** — One complete bullet resistant jacket.

3.23 **Sampling Plan** — Combination of sample size(s) to be used and associated lot acceptance criteria.

3.24 **Sample Size** — Number of items in the sample.

3.25 **Standalone Configuration** — Terminology used for hard armour panel configuration that is designed to withstand threats without the flexible armour panel/SAP.

3.26 **Strike Face** — The surface of the sample/armour panel, designated by the user/manufacturer as the one facing the incoming ballistic threat. The surface opposite to the strike face is the wear face.

3.27 **Thermo-mechanical Conditioning** — Accelerated ageing protocol in which the armour is subjected to temperature, humidity and mechanical loading simultaneously or sequentially.

3.28 **Trauma Mitigation Packs** — Part of the armour/ panel which is used to minimize the blunt trauma. Trauma packs are generally made of nonwoven fabrics, foams, polymer sheets. They may or may not be removable.

3.29 **Upper Prediction Limit** — Likely maximum back face signature that can occur over a number of hits.

4 MANUFACTURE

4.1 Bullet resistant jackets (without HAP) shall be in the form of jacket and shall not restrict overall movement of the neck of wearer.

4.2 The overall length of the bullet resistant jackets shall be such that there is no 'ride up' while sitting.

4.3 The overlapping degree of front and rear panels shall be such as to provide for maximum freedom of movement.

4.4 Bullet resistant jackets shall be adjustable at the shoulders, waist, and groin with hook and loop fastener as specified in **5.1.2**.

4.5 Bullet resistant jacket shall be provided with pocket with flaps, belt/kamarbandh and pouches as per the requirements specified in **5.1.3**, **5.1.4** and **5.1.5**, respectively.

4.6 Size Designations

The size of each bullet resistant jacket shall be designated by chest or bust girth as control dimensions, in cm. The currently applicable chest girth ranges for different size designations shall be as given in Table 1. If required by the user, any other size of bullet resistant jackets may also be supplied.

Table 1 Chest Girth Ranges of Body Measurements

(*Clause* 4.6)

Sl No.	Size Designations	Symbol	Chest Girth cm
(1)	(2)	(3)	(4)
i)	Extra Small	XS	72 – 80
ii)	Small	S	Above 80 – 88
iii)	Medium	M	Above 88 – 96
iv)	Large	L	Above 96 – 104
v)	Extra Large	XL	Above 104 – 112

NOTE — Chest girth shall be measured at a distance of 25 mm lower from the armpit of the wearer.

4.7 Restriction of Movement

The bullet resistant jackets shall be designed ergonomically to minimize restrictions of movement. Details for checking basic ergonomic features of bullet resistant jackets by conducting field tests by personnel are given in Annex B for guidance only.

5 REQUIREMENTS

5.1 Physical Requirements of Non-ballistic Components

Non-ballistic materials shall comprise of the outer carrier fabric, hook and loop fasteners, belt/kamarbandh, trauma pad, water repellent covers for SAP and HAP, webbings and buckles etc.

5.1.1 *Outer Carrier Fabric*

The outer carrier fabric shall be woven fabric and colour/print may be as per the requirement of purchaser. It shall meet the requirements given in Table 2.

5.1.2 *Hook and Loop Fastener*

All the clothing flaps of the jackets shall be provided with hook and loop fastener, so that it can be worn and taken off easily and quickly. The hook and loop tape fastener may be supplied in any colour as desired by the purchaser. The shade of the hook and loop fastener shall be uniform throughout on both hook and loop fastener. The hook and loop fastener shall conform to the requirements specified in Table 3. However, the width of hook and loop fastener at different locations of bullet resistant jacket shall be as per the agreement between buyer and seller.

5.1.3 *Pocket with Flaps*

The jacket shall be provided with minimum two external pockets in outer carrier fabric to house two magazines of self-carried assault rifle in each pocket. Two pockets shall also be provided to accommodate one grenade in each pocket. If required by the buyer, number and size of the pockets (suitable for any other ammunition) may also be provided other than as specified above.

NOTE — Generally the size of 5.56 LMG magazine is 19 cm × 7.6 cm × 3.5 cm and size of HE 36 grenade is 110 mm × 65 mm.

5.1.4 *Belt/Kamarbandh*

An additional belt of nylon material having minimum width of 10 cm shall be provided around the waist to properly secure the bullet resistant jacket with the body of the wearer around waist, so that weight of jacket is distributed on waist/shoulders. The belt/kamarbandh

Table 2 Requirement of Outer Carrier Fabric

(*Clause* 5.1.1)

Sl No.	Test Parameter	Requirement (s)	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Mass, g/m², *Max*	160	IS 7016 (Part 1)
ii)	Tensile strength, N, *Min*:		IS 7016 (Part 2)
	a) Warp wise	1150	
	b) Weft wise	900	
iii)	Tear strength, N, *Min*:		IS 7016 (Part 3), Method A2, Trouser shaped test piece, Single tear method
	a) Warp wise	160	
	b) Weft wise	140	
iv)	Flame resistance test:		IS 11871, Method A
	a) Duration of flame (After flame time), s, *Max*	5	
	b) Duration of afterglow, s, *Max*	5	
v)	Resistance to water penetration at hydrostatic pressure head of 30 cm water column height for 30 minutes	There shall be no water penetration	IS 7016 (Part 7)
vi)	Colour fastness rating to light (Change in colour on blue wool), *Min*	4	IS 2454

Table 3 Requirements of Hook and Loop Fasteners

(*Clause* 5.1.2)

Sl No.	Test Parameter	Requirement (s)	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Shear strength, Lengthwise, g/cm², *Min*	900	IS 8156
ii)	Peel strength, g/cm, *Min*	200	IS 8156
iii)	Endurance test of 5 000 cycles of closing and opening operations	The shear strength, lengthwise shall not be less than 675 g/cm²	IS 8156

shall be provided with double locking of jacket with hook and loop fastener.

5.1.5 *Pouches*

Two pouches (one each on front and rear of outer carrier) shall be provided to accommodate two HAPs as per sizes specified by the user. For 360° protection jacket, additional pouches shall be provided to accommodate the side plates, groin and throat HAPs as per sizes specified by the user.

5.1.6 *Water Repellent Covers*

SAP and HAPs shall be encased in water repellent cover. Water repellent cover shall meet the water resistance requirement as specified in Table 2, Sl No. (v).

5.1.7 Outer carrier shall be machine washable.

5.1.8 *Quick Release Mechanism (Optional)*

If required by the user, the bullet resistant jacket may have quick release mechanism which shall allow release of the jacket in single action by using one hand (left or right) from the torso within 5 s. The released jackets shall stay in one piece so as to reassemble for ready to wear within 30 s at night condition by trained users.

NOTE — The user organizations opting for quick release mechanism may decide various other parameters considering their functional/operational requirements. The additional weight of quick release mechanism shall not be included in the weight of bullet resistant jacket (*see* 5.2.5).

5.1.9 *Dynamic Weight Distribution System (Optional)*

If required by the user, the bullet resistant jacket may have dynamic weight distribution system. The weight distribution mechanism shall be based on external, flexible spine and hip belt that shall allow the user to change the ratio of weight load from hips to shoulders while on the move and without removing the bullet resistant jacket.

NOTE — The user organizations opting for dynamic weight distribution system may decide the various other parameters considering their functional/operational requirements. The additional weight of dynamic weight distribution system shall not be included in the weight of bullet resistant jacket (*see* 5.2.5).

5.1.10 *High Buoyancy Bullet Resistant Jacket (Optional)*

If required by the user, high buoyancy bullet resistant jacket may be provided.

NOTE — The user organizations opting for high buoyancy system may decide various other parameters considering their functional/operational requirements. The additional weight of high buoyancy materials shall not be included in the weight of bullet resistant jacket (*see* 5.2.5).

5.2 Physical Requirements of Ballistic Components

5.2.1 *General*

The major attributes of physical evaluation of ballistic components are dimensions, weight/areal density, number of layers, strike/protection area, surface area, labelling, etc. The components may comprise of multiple layers of different materials. However, each layer shall be of same material and of equal shape and size to maintain uniform thickness all over area up to edge of component.

5.2.2 *Protection Area of SAP*

The minimum coverage area of various components of SAP shall be as given in Table 4. The area shall be measured on bare ballistic SAP after removing the cover, trauma mitigation pack etc with the help of scaled drawing on graph paper and/or planimeter.

5.2.3 *Protection Area of HAP*

The minimum coverage area of various components of HAP shall be as given in Table 5. Corresponding design of front and side hard armour plates are given in Fig. 3 for information only. Area of HAP shall be

Table 4 Minimum Coverage Areas of Components of Soft Armour Panel

(*Clause* 5.2.2 and 5.2.5)

Sl No.	Size	Total Protection Area for SAP (including Torso, Neck, Shoulders and Groin)	Total Protection Area for Shoulder Only	Total Protection Area for Groin Only	Total Protection Area for Neck and Collar Only
		m^2	m^2	m^2	m^2
(1)	(2)	(3)	(4)	(5)	(6)
i)	XS	0.45	0.035	0.05	0.05
ii)	S	0.50	0.035	0.05	0.05
iii)	M	0.55	0.035	0.05	0.05
iv)	L	0.60	0.04	0.06	0.06
v)	XL	0.65	0.04	0.06	0.06

NOTE — If required, the user may change the protection areas as per operational requirements (*see* 1.4).

measured using 3-D scanning method. Bare HAP (such that ballistic material is exposed) shall be used for measuring area after removing the cover, trauma mitigation pack, etc.

5.2.4 *Areal Densities of Bullet Resistant Panels*

Maximum areal density of bullet resistant panels with respect to threat levels shall be as given in Table 6. Annex C gives maximum possible weights of bullet resistant jackets for different sizes and threat levels.

5.2.5 *Weight of Bullet Resistance Jacket*

Weight of different sizes of the jacket shall be calculated based on the protection areas of SAP and HAP specified in Tables 4 and 5 and areal density of the panel specified in Table 6 and total weight of outer fabric and other peripherals. Annex C gives maximum possible weights of bullet resistant jackets for different sizes and threat levels.

Table 5 Minimum Coverage Areas of Components of Hard Armour Panel (m^2)

(*Clauses* 5.2.3 and 5.2.5)

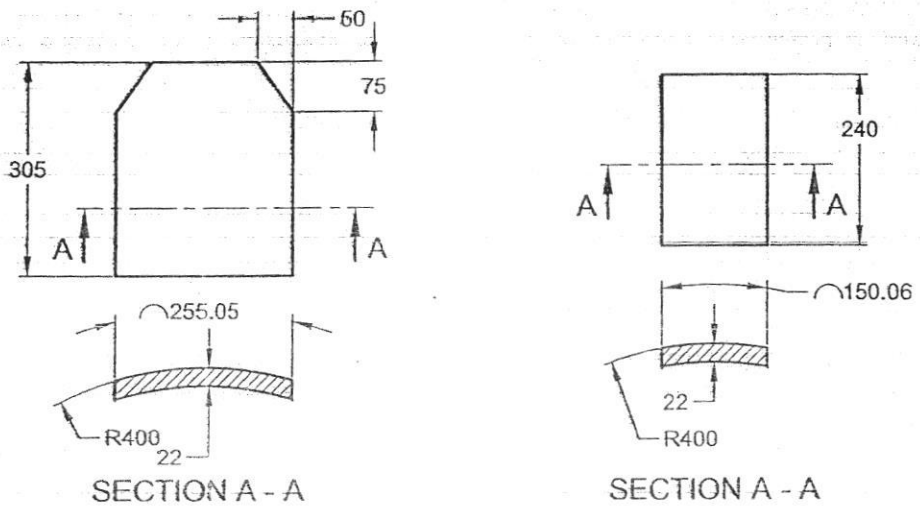
Panel / Size	XS	S	M	L	XL
Front/Back	0.066 7	0.070 0	0.073 5	0.077 2	0.081 0
Side (optional)	0.032 6	0.034 2	0.035 9	0.037 7	0.039 6
Groin (Optional)	0.037 0	0.037 0	0.037 0	0.037 0	0.037 0
Throat (Optional)	0.024 5	0.025 7	0.027 0	0.028 4	0.029 8
Total (considering front and back, two sides, throat and groin)	0.260	0.271	0.283	0.295	0.308
Total (considering only front and back)	0.133	0.140	0.147	0.154	0.162

NOTES

1 Throat width shall be 150 mm, *Min.*

2 Groin length shall be 200 mm, *Min.*

3 If required, the user may change the protection areas as per operational requirements (*see* 1.4).



All dimensions in millimetres

FIG. 3 DESIGN EXAMPLE OF FRONT AND SIDE PLATE (MEDIUM SIZE)

Table 6 Maximum Areal Density of Different Solutions (kg/m²)

(*Clause* 5.2.4)

Sl No.	Threat Level	Areal Density (25 mm BFS)			Areal Density (44 mm BFS)		
		SAP	HAP	Standalone	SAP	HAP	Standalone
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1	5	—	—	3.8	—	—
ii)	2	5	15	21	3.8	15	20
iii)	3	5	16	22	3.8	15	20
iv)	4	5	23	29	3.8	22	27
v)	5	5	27	33	3.8	25	30
vi)	6	5	40	46	3.8	38	44

NOTES

1 The above data is based on current technology. With each revision of the standard, these values may change with improvement in material/processing technology.

2 Areal density shall be calculated as weight of the panel (in kg) divided by the protection area (in m²).

5.2.6 *X- Ray of HAP*

Ballistic layer of HAP shall be provided evenly up to the edges and same shall be ensured by X ray examination of HAP.

5.2.7 *General Requirements for SAP and HAP*

The supplier shall declare the type of materials, number of layers, and their areal density in technical bid of tender and shall have to maintain the same in bulk supply. The information shall be kept in sealed condition and shall only be opened in case of failure of lot during bulk testing for comparison.

5.3 Labelling of Ballistic Components

All ballistic components of the bullet resistant jacket shall be properly labelled. The label shall be on the wear side of the component. The labelling shall be in bold legible letters and shall contain the following information:

a) Type of the material such as soft/hard armour panel;
b) Manufacturer name/logo/identification mark;
c) Threat level;
d) Name of product/model number;
e) Size;
f) Panel ID;
g) Lot/batch number;
h) Date of manufacturing in DD:MM:YYYY format; and
j) Date of expiry in DD:MM:YYYY format.

The strike face shall be clearly marked in large legible letters on the strike side. In conjunction panels shall have clear instructions on the panel that these shall not be separately used and shall only be used along with corresponding SAP. Washing and storage instructions shall also be provided in a flap within the component.

5.4 Sampling Plan and AQL for Outer Carrier, Accessories and Physical Requirements of Ballistic Component

Special inspection level S-1 and AQL of 4 percent as given in IS 2500 (Part 1) shall be used for manufacture, (*see* 4), outer carrier fabric, accessories and physical requirements of ballistic component during lot testing. Any of the items which do not meet the requirements specified in 4, 5.1, 5.2 and 5.3 shall be considered as defective. The lot shall be declared as conforming to the requirements of this standard, if the number of nonconformity does not exceed the acceptance number for special inspection level S-1 and AQL of 4 percent.

6 PERFORMANCE REQUIREMENTS

6.1 Threat Levels

6.1.1 Major threats faced by the Indian armed forces, paramilitary, state police forces and other law enforcement agencies shall be classified into 6 threat levels given in Table 7.

6.1.2 Launching systems shall preferably be test barrels, however weapons may also be used to achieve reference velocities.

6.1.3 Threat level 2 onwards may be ICW or standalone configuration. In case of former, the flexible armour panels shall be compliant to threat level 1 in all cases. In case of standalone configuration samples, they shall be compliant to the required threats. Threat levels 4 onwards shall also be compliant to threat level 3.

6.1.4 Service ammunition supplied by ordnance factories shall preferably be used for testing. In case of imported ammunition, the head stamp shall be mentioned in the data sheet/test report. Testing agency

may use re-loaded ammunition to meet the velocity requirements. However complete details of the propellants, cartridge cases, storage, and propellant charge versus mass details shall be made available to other test laboratories to ensure repeatability of test results. All relevant details shall be clearly mentioned in the test report.

6.2 Behind Armour Blunt Trauma

6.2.1 Behind armour blunt trauma (BABT) is measured in terms of back face signature (BFS) on backing material. Maximum permissible BFS limits shall be 25 mm or 44 mm.

6.2.2 The user may select maximum permissible BFS based on their requirement (*see* Annex D).

6.2.3 Conditioning and calibration procedures of backing material for both BFS measurements shall be the same.

6.2.4 Limiting value of BFS (25 mm or 44 mm) shall remain the same irrespective of the panel being subjected to any form of conditioning.

6.3 Performance Requirements of BFS

6.3.1 The panel shall be considered to have passed BFS requirements, if:

a) all BFS values are less than or equal to maximum permissible limit (25 mm or 44 mm).

OR

b) a single BFS value exceeds the maximum permissible value provided that the upper prediction limit (UPL) of all the values of that particular sample, operating condition and threat is less than or equal to the maximum permissible limit (25 mm or 44 mm).

6.3.2 For tender samples, only condition given in **6.3.1** (a) shall be applicable (*see* 7 for types of samples). For lot testing both the conditions given in **6.3.1** (a) and **6.3.1** (b) shall be considered in which case **6.3.1** (b) is a major defect.

6.3.3 UPL shall be calculated as per the details given in **6.4**.

6.4 Upper Prediction Limit (UPL) (X_U)

6.4.1 Upper prediction limit of BFS is applicable only in case of lot testing. All measured BFS shall be either less than or equal to the maximum permissible limit, or the probability of a single BFS exceeding maximum permissible limit shall be less than 10 percent with 95 percent confidence level in one sided tolerance level (*see* Annex E). The formula in such case is given by:

$$\bar{X} + \sigma K = X_U \text{ (25 mm/44 mm)}$$

Where, X_U is the upper prediction limit, $\bar{X}$ is the average of all back face signatures, σ is the standard deviation and K is a constant depending upon the number of shots.

6.4.2 UPL shall be considered for all the BFS values obtained in firing at 0° angle in one lot sample against single threat level.

NOTE — Angular shot shall not be considered for calculation of UPL. For example, shot fired at angle of 30° and 45° at SAP shall not be considered for calculation of UPL.

Table 7 Threat Levels

(*Clause* 6.1.1)

Sl No.	Threat Level	Ammunition	Bullet Weight (*see* Note) g	Bullet Type	Impact Velocity m/s	Distance of Impact m	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1	9 × 19 mm	7.4 - 8.2	FMJ/Pb	430 ± 15	5 ± 0.5	For all flexible panels
ii)	2	7.62 × 39 mm	7.45 - 8.05	FMJ/MSC	710 ± 15	10 ± 0.5	—
iii)	3	7.62 × 51 mm	9.4 - 9.6	FMJ/Pb	840 ± 15	10 ± 0.5	In addition, shall be compliance with threat level 2
iv)	4	5.56 × 45 mm	3.5 - 4.0	FMJ/(SI+Pb)	890 ± 15	10 ± 0.5	In addition, shall be compliance with threat level 3
v)	5	7.62 × 39 mm	7.45 - 8.05	HSC	700 ± 15	10 ± 0.5	
vi)	6	7.62 × 54R	10.3 - 10.5	API	830 ± 15	10 ± 0.5	
vii)	Special	Any other requirement by the user. Complete details of ammunition shall be stored for future upgradation of the standard.					

NOTE — Routine ballistic evaluation may use service ammunition where bullet weight is not considered. Bullet weight shall be considered for reloaded ammunitions.

FMJ:	Full Metal Jacket	Pb:	Lead Core
MSC:	Mild Steel Core	SI:	Steel Insert
HSC:	Hard Steel Core	API:	Armour Piercing Incendiary

6.5 Non-conformities

Non-conformity observed during ballistic evaluation is classified into two types as given in 6.5.1 and 6.5.2. Rejection based on non-conformities shall be considered only for lot testing of samples. For one particular lot of bullet resistant jackets, the acceptable quality limit testing shall be carried out on its constituent panels.

6.5.1 *Critical Defect*

a) Complete perforation (HAP and SAP).

OR

b) BFS of any shot exceeding 10 percent of maximum permissible limit.

OR

c) Ballistic limit — $V_{50,BL} < V_{50,\text{Manufacturer}}$ [permissible up to (–)10 m/s].

NOTE — Ballistic limit is an optional requirement and shall be tested only if required by the user. Test of ballistic limit is recommended for supply/lot size of more than 500 bullet resistant jacket.

6.5.1.1 *Decision on critical defect*

Complete lot shall be rejected in case of any critical defect.

6.5.2 *Major Defect*

a) Perforation of HAP but stopped by SAP.

OR

b) Any BFS > 25 mm or 44 mm (with UPL ≤ 25 mm or 44 mm).

6.5.2.1 *Decision on major defect*

Lot shall be rejected, if the non conformities are more than the rejection number corresponding to AQL of 2.5 percent (*see* Annex F).

NOTE — Constituent panels of a lot size shall be tested for non-conformities. For example, with a lot size of 100 bullet resistant jackets, 8 panels shall be tested for non-conformities (*see* Annex F).

6.6 Shelf life of SAP and HAP

The shelf life of SAP and HAP ballistic panels shall be minimum 5 years from the date of manufacture and shall be assessed as per the procedure given in 8.4.

7 SAMPLE DETAILS

7.1 Types of Samples

Samples of bullet resistant jacket submitted for ballistic evaluation are of three different types.

7.1.1 *R & D Sample*

Panels at developmental stage submitted by R & D agency/manufacturer are designated as R & D sample. These shall be tested as per the test procedures given in this standard. The user can select physical evaluation parameters, operating conditions and other requirements for stringent testing of their samples and testing carried out accordingly. However, decisions regarding conformity/non-conformity may not be given in test results.

7.1.2 *Tender Sample*

Samples invited by procuring agency from different manufacturers/suppliers for performance evaluation in the beginning of procurement are designated as tender sample. These shall be tested as per the test procedures given in this standard or any specific requirement of purchasing agency. No deviation shall be permitted during tender sample evaluation. In the event of failure, subsequent tests on the same model shall be decided by the user. The user shall specify all operating conditions as per their requirements. Upper prediction limit shall not be considered for tender samples. Optional ballistic limit tests may not be carried out on these samples.

7.1.3 *Lot Testing Sample*

Samples selected from lot offered by vendor during the course of supply are designated as lot samples. These shall be tested as per the test procedures given in this standard or any specific requirement of purchasing agency. Sampling plan and AQL standards shall be followed during lot testing. Only one size of bullet resistant jackets shall be offered in one lot. Non-conformities as per 6.5 shall be considered for lot samples. If required by the buyer, ballistic limit tests shall be carried out for order size/lot size of more than 500 bullet resistant jackets.

7.2 Sampling Plan and AQL

Special inspection level S-4 as given in IS 2500 (Part 1) shall be used for ballistic evaluation during lot testing. AQL of 2.5 percent shall be considered (*see* Annex F for sampling plans, AQL and example) for ballistic evaluation. Decision on critical and major defect during lot testing shall be taken based on the criteria specified in 6.5.

7.3 Quantity

Quantity of samples required for testing shall be as given in Table 8. For R & D samples, material details shall be provided as per Table 9.

8 OPERATING CONDITIONS

8.0 Operating conditions as given in 8.1 to 8.3 are optional and shall be considered before ballistic evaluation of the bullet resistant jackets. The user/manufacturer shall select their requirement according to application and usage of bullet resistant jackets as given in 8.1 to 8.3. Explanatory notes and guidelines for selection of operating conditions are given in Annex H for information only. Performance characteristics like limiting value of BFS (25 mm or 44 mm), etc, shall remain the same irrespective of the panel being subjected to any operating conditions. V_{50}

Table 8 Quantity of Samples

(*Clause* 7.3)

Sl No.	Sample Type	Physical	Ballistic	Remarks
(1)	(2)	(3)	(4)	(5)
i)	R & D	01/threat level/size	02/threat level/size/operating condition	Size 250 mm × 300 mm, Minimum
ii)	Tender	02/size	02/threat level/size/operating condition	As per user requirement
iii)	Lot testing	As per sampling plan or 02/size	a) P- BFS – As per sampling plan + 02 standby b) BL, if required – 02	As per contract
NOTE — Examples of number of samples required for ballistic evaluation are given in Annex G for information only.				

Table 9 Sample Detail Format

(*Clause* 7.3)

Sl No.	Details	Remarks
(1)	(2)	(3)
i)	Sample ID	ID of sample
ii)	Type	Soft / Hard armour panel/ Composite/ any other
iii)	Material	Raw materials used, in case of composites both reinforcement as well as resin/membrane
iv)	Layers	Total number of layers used
v)	Construction	Weave/Laminate/Hybrid
vi)	Dimensions	Length/Width/Thickness
vii)	Weight	Areal density, weight of sample
viii)	Type of test required	P-BFS, BL, etc
ix)	Threat Level	Define threat level and permissible BFS
x)	Number of shots	Total number of shots required per panel
xi)	Conditioning	Type of conditioning required
xii)	Any other requirement	—

values of panels subjected to operating conditions shall not be considered.

8.1 Extreme Temperatures

Separate samples shall be taken for high and low temperature tests. Both SAPs and HAPs shall be subjected to the tests specified in **8.1.1** and **8.1.2**.

8.1.1 *High Temperature*

Sample shall be heated in oven at 70 ± 5°C for 4 h ± 10 min. The material shall be examined for delamination, component separation, blistering or any other visual defects. The samples shall be kept in range conditions (*see* **8.4.3**) for minimum 12 h before conducting ballistic evaluation.

8.1.2 *Low Temperature*

Sample shall be cooled to minus 40 ± 5°C for 4 h ± 10 min. The material shall be examined for delamination, matrix cracking, component separation, or any other visual defects. The samples shall be kept in range conditions (*see* 8.4.3) for minimum 12 h before conducting ballistic evaluation.

8.2 Fluid Exposure

Both SAPs and HAPs shall be subjected to the tests specified in **8.2.1** and **8.2.2**.

8.2.1 *Water Resistance*

Sample shall be submerged vertically in water under a water column of 150 ± 10 mm (from topmost level of the panel) for minimum 30 min without any fold and bend with 50 mm clearance around the panel. The water in the bath shall be clean potable tap water at a temperature of 27 ± 5°C. After removing the samples from water, samples shall be placed vertically and allowed to dry for 10 min. Ballistic test shall be completed within 40 min after drying time.

8.2.2 *Sea Water Resistance*

Sea water shall comprise of 30 g/l aqueous solution of sodium chloride, prepared using grade 3 reagent grade water (*see* IS 1070) at a temperature of 27 ± 5°C. The sample shall be submerged in this solution for minimum of 30 min under a head of 145 ± 10 mm (*see* Note) from the topmost surface of the panel. After removing the samples from the solution, samples shall be placed

vertically and allowed to dry for 10 min. Ballistic test shall be completed within 40 min after drying time.

NOTE — The equivalent head of sea water is 0.975 times the head of fresh water for the same pressure difference.

8.3 In Transit Conditions

In transit conditions are applicable for hard armour panels only. Soft armour panels shall not be subjected to these tests. HAPs shall be subjected to the tests specified in **8.3.1** and **8.3.2**.

8.3.1 *Mechanical Drop Test*

8.3.1.1 Mechanical drop test is performed with specially designed fixture with a provision of free fall from a height of 1.2 m ± 10 mm (*see* Fig. 4). The system shall have a provision to strap hard armour panel along with soft armour panel (if applicable) on a box with a weighted object (preferably clay). The armour panel shall have free fall on a RCC surface. Total weight on the armour shall be 10 kg ± 100 g and total weight of clay shall be 4.5 kg ± 100 g. The armour shall be made to fall twice with the strike face down on the concrete surface. Impact shall occur at the centre of the face of HAP (not at an edge).

NOTE — Successive rebound shall be avoided during the drop test.

8.3.1.2 Radiographic/X-rays images shall be taken pre-drop and post-drop to inspect cracks, delamination or any other defects on the surface. The first shot shall be taken on the most severely damaged area on the sample as identified from the image, while keeping edge-to-shot distance within permissible limits. The shot pattern may be changed to exploit the weak areas identified post-drop. The deviation from set shot locations shall be recorded in the data sheet. There is no time limit on completion of ballistic evaluation after this test; however it is advisable to complete the evaluation on the same day.

8.3.2 *Vibration Test*

8.3.2.1 The hard armour panel (HAP) shall be positioned strike face down and bottom of the plate parallel to the y-axis. The sample shall be placed in a wooden box 25.4 mm larger than the HAP in all directions which is then mounted to the vibration table. Vibration test shall be conducted with the use of a package tester that imparts a 25.4 mm peak-to-peak, circular synchronous motion to the table at a frequency of 5 Hz for 1 h.

8.3.2.2 Pre-vibration and post vibration, radiographic/X-rays images of the sample shall be taken. The first shot shall be taken on the most severely damaged area on the sample as identified from the image, while keeping edge-to-shot distance within permissible limits. The shot pattern may be changed to exploit the weak areas identified post vibration. The deviation from set shot locations shall be recorded in the data sheet. There is no time limit on completion of ballistic evaluation after this test; however it is advisable to conduct the trials within the same day.

8.4 Service Life Assessment

Thermo-mechanical conditioning of soft and hard armour panels shall be conducted to simulate accelerated ageing. Following equipments are required for conducting the test:

a) Environmental chamber with tumbling apparatus,
b) Environmental chamber with controllable temperature and humidity values, and
c) Mechanical durability apparatus (as described in **8.3.1**).

NOTES

1 The procedures given simulates the service life of 5 years for bullet resistant jackets considering 8 h per day, 5 days per week, 50 weeks per year which is equivalent to 10 000 h.

2 This method may not reproduce all of the humidity effects associated with the natural environment, such as long-term effects of exposure to high humidity or to low humidity situations. This method does not attempt to duplicate the complex temperature/humidity environment but provides a generally stressful situation that is intended to reveal potential problem areas in the armour. It may induce problems that are indicative of long-term effects.

3 This method does not simulate an exact period of time in the field, nor it is intended as an absolute predictor of actual armour service life.

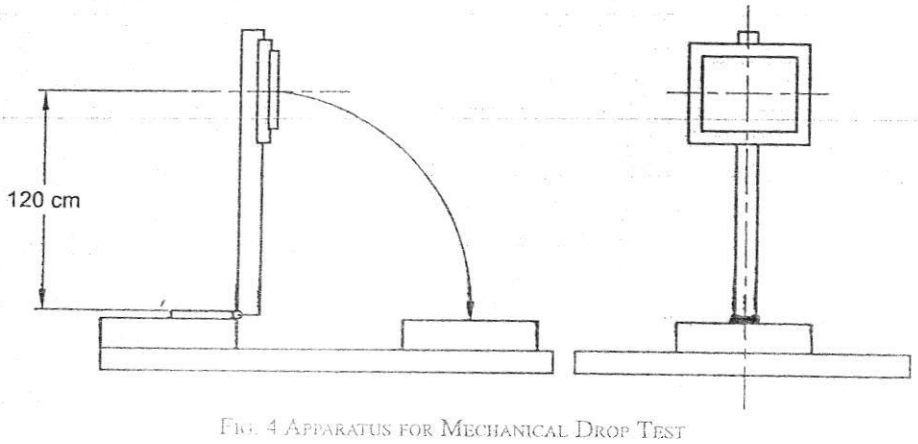


FIG. 4 APPARATUS FOR MECHANICAL DROP TEST

8.4.1 *Conditioning Requirements for Soft Armour Panel (SAP)*

8.4.1.1 *Pre-requisites*

8.4.1.1.1 In event of any internal folding in the sample, part of the waterproof fabric shall be cut and opened to manually flatten the ballistic material/trauma mitigation pack inside. The cut portion of water proof fabric shall be closed properly with adhesive tape.

8.4.1.1.2 Enclosing of sample shall be done in such a way that the sample maintains its structural integrity during tumbling.

8.4.1.1.3 The extra cover shall be removed after completion of conditioning. Ballistic evaluation shall be done without extra cover.

8.4.1.2 *Pre-conditioning*

The panels shall be stored in range conditions for minimum 24 h.

8.4.1.3 *Thermal-cum-mechanical test*

The samples shall be subjected to following conditions in an environmental chamber with tumbling apparatus:

a) Thermal:

Temperature	:	65 ± 5°C
Humidity	:	80 ± 5 percent
Time	:	10 days ± 1 h

b) Mechanical (Rotating and tumbling device):

Rotation rate	:	5 ± 1 rpm
Total rotations (10 days):		72 000 ± 1 500 (*see* Note)

NOTE — Total rotations include the variation in number of cycles to account for time tolerance of 1 h. To ensure that the required number of rotations is obtained, a totalizer shall be used to record the total number of rotations. The drum rotation rate may be varied within the given tolerance to achieve the necessary number of rotations.

8.4.1.4 *Details of rotating and tumbling drum*

8.4.1.4.1 *Dimensions*

a)	Diameter	:	832 mm ± 6 mm
b)	Depth	:	651 mm ± 6 mm

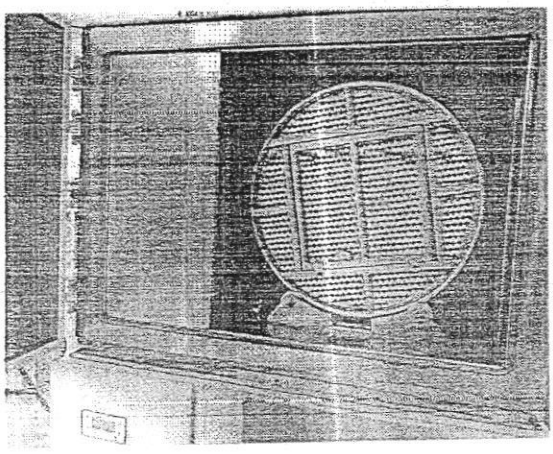
8.4.1.4.2 *Material of construction*

a) The material of construction shall be SS and shall confirm to chemical composition of any of the numerical symbol 304 S1 or 304 S2 or 304 H or 304 LN or 304 N as specified in IS 6911. Drum shall be perforated or meshed to allow free air flow within the drum (*see* Fig. 5A). The inner side of the drum shall be smooth, with no sharp edges to catch, abrade or tear the material.

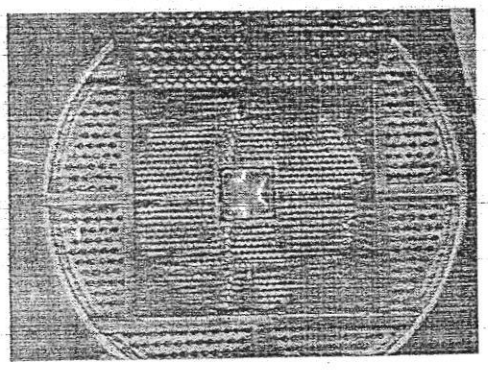
b) *Construction of fins* — 04 fins made of same material as drum running full depth of drum and spaced at 90° intervals about the circumference shall be provided. Each fin shall be 114 ± 3 mm high. The top edge of the fins shall be rounded with a diameter of 19 ± 3 mm, and the width of fin at the top shall be 20 ± 3 mm. The fins may be straight or tapered. The base of the fin shall not be thinner than 19 mm and shall not be thicker than 76 mm (*see* Fig. 5B).

8.4.1.5 *Post-conditioning*

The samples shall be kept in range conditions for minimum 12 h.



A) Position Inside Chamber



B) Internal Fins

FIG. 5 ROTATING AND TUMBLING DEVICE

8.4.1.6 *Ballistic trials*

Ballistic trials shall be conducted after post conditioning duration until all samples are tested (*see* 9).

8.4.2 *Conditioning Requirements for Hard Armour Panel (HAP)*

HAP shall be conditioned sequentially as per the procedure specified in **8.4.2.2** to **8.4.2.6**.

8.4.2.1 *Pre-requisites*

HAPs may be enclosed with the same material as that of SAP as given in **8.4.1.1.1**. Conditioned in-conjunction with (ICW) HAPs shall be tested with unconditioned SAPs.

8.4.2.2 *Pre-conditioning*

The panels shall be stored in range conditions for minimum 24 h.

8.4.2.3 *Uniform thermal exposure test*

The HAPs shall be subjected to following thermal conditions:

Temperature	:	65 ± 5°C
Humidity	:	80 ± 5 percent
Time	:	10 days ± 1 h

8.4.2.4 *Cyclic thermal exposure test*

Subsequent to the uniform thermal exposure test specified in **8.4.2.3**, the HAPs shall be subjected to cyclic thermal exposure test as per the details given in Table 10. The duration given in the table are dwell times and exclude the time required for the chamber to reach the temperature. Sample shall be kept in range conditions (*see* **8.4.3**) for 60 min before performing the test specified in **8.4.2.5**.

Table 10 Details of Atmospheric Conditions for Cyclic Thermal Exposure Test

(*Clause* 8.4.2.4)

Sl No.	Time	Temperature	Relative Humidity
	h	°C	Percent
(1)	(2)	(3)	(4)
i)	2	25 ± 2	50 ± 10
ii)	2	15 ± 2	N/A
iii)	2	5 ± 2	N/A
iv)	2	-5 ± 2	N/A
v)	2	-15 ± 2	N/A
vi)	2	0 ± 2	N/A
vii)	2	15 ± 2	N/A
viii)	2	30 ± 2	50 ± 10
ix)	2	45 ± 2	50 ± 10
x)	2	60 ± 2	50 ± 10
xi)	2	75 ± 2	50 ± 10
xii)	2	90 ± 2	50 ± 10

8.4.2.5 *Mechanical durability test*

Subsequent to cyclic thermal exposure test specified in 8.4.2.4, mechanical durability test shall be conducted as per **8.3.1**.

8.4.2.6 *Post-conditioning*

The samples shall be kept in range conditions for minimum 12 h.

8.4.2.7 *Ballistic trials*

Ballistic trials shall be conducted after post conditioning duration until all samples are tested (*see* 9). Ballistic evaluation shall be carried out in spite of appearance of any tear/crack or any other anomaly in HAP after conditioning (*see* **8.3.1.2**). Weak portions of HAP shall be targeted during ballistic evaluation.

8.4.3 *Test Interruption Protocols*

If the parameters of the conditioning chambers go out of range within specified limits, test interruption protocol shall be followed. The interruption flow charts for thermo-mechanical test (*see* **8.4.1.3**) and uniform thermal exposure test (*see* **8.4.2.3**) is given in Fig. 6 while for cyclic thermal exposure test (*see* **8.4.2.4**) is given in Fig. 7. Further decision on continuation of thermo-mechanical/uniform thermal exposure/cyclic thermal exposure tests shall be based upon the test interruption flowchart and joint decision between user, testing agency and manufacturer depending upon the type of sample (*see* **7.1**). The set values and range conditions shall be as follows:

a) Set values in chamber:
   1) Temperature: 65 ± 5°C, and
   2) Relative humidity: 80 ± 5 percent.
b) Range conditions:
   1) Temperature: 23 ± 3°C, and
   2) Relative humidity: 50 + 20 percent.

In event of any interruption, the test interruption format as given in Annex J shall be filled.

9 BALLISTIC EVALUATION

9.1 Range Setup

9.1.1 *Ambient Conditions*

Unless otherwise specified, the ambient/range conditions shall be as given below:

a) Temperature	:	23 ± 3°C; and
b) Relative Humidity	:	50 ± 20 percent.

Temperature and humidity values shall be recorded regularly at 2-3 h interval. The same shall be mentioned in the data sheets and reports.

9.1.2 *Test Layout*

The test range shall be setup as per Fig. 8. Threat levels 1 shall be tested from a distance of 5 m from the

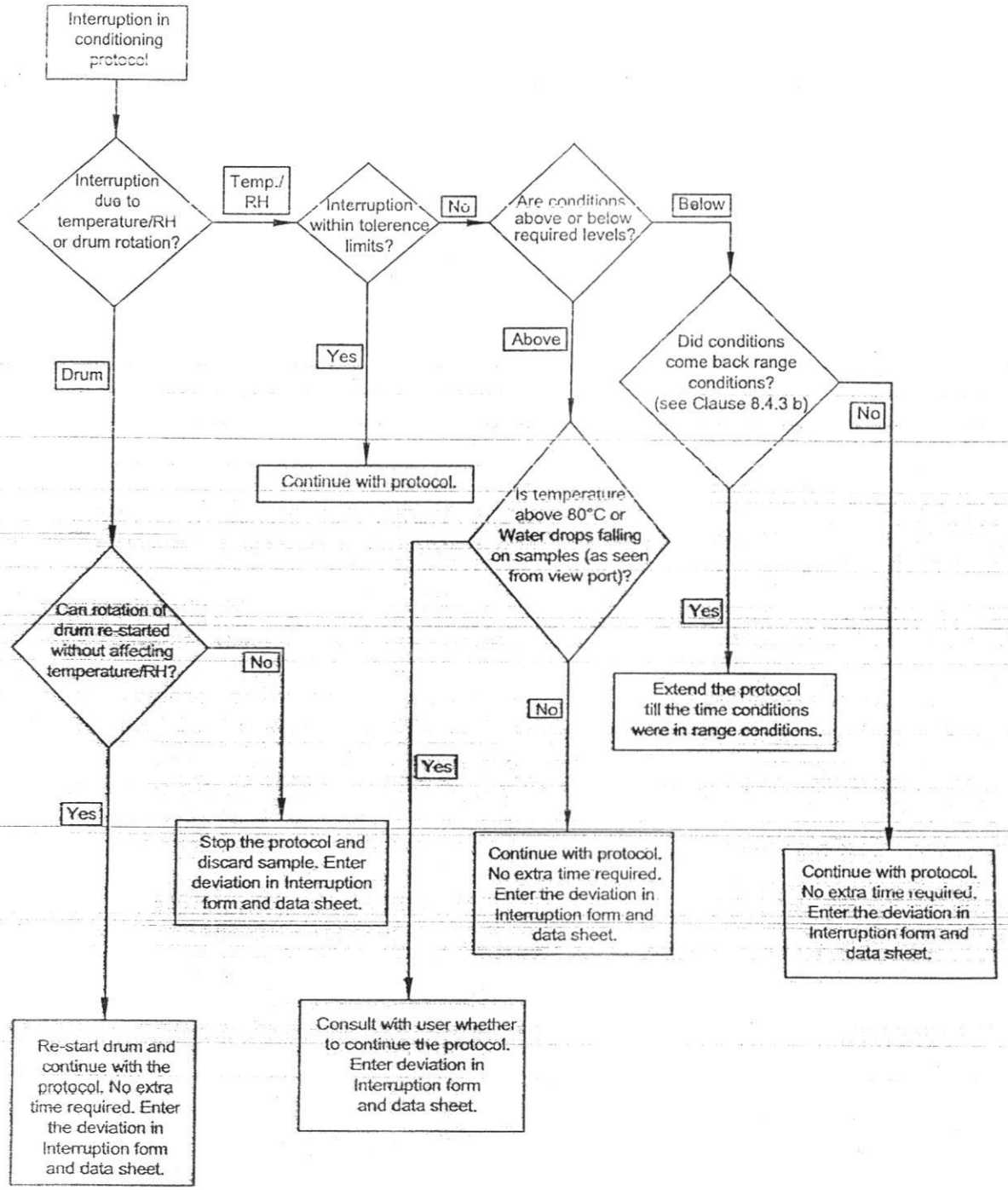


FIG. 6 INTERRUPTION FLOWCHART FOR THERMO-MECHANICAL AND UNIFORM THERMAL EXPOSURE

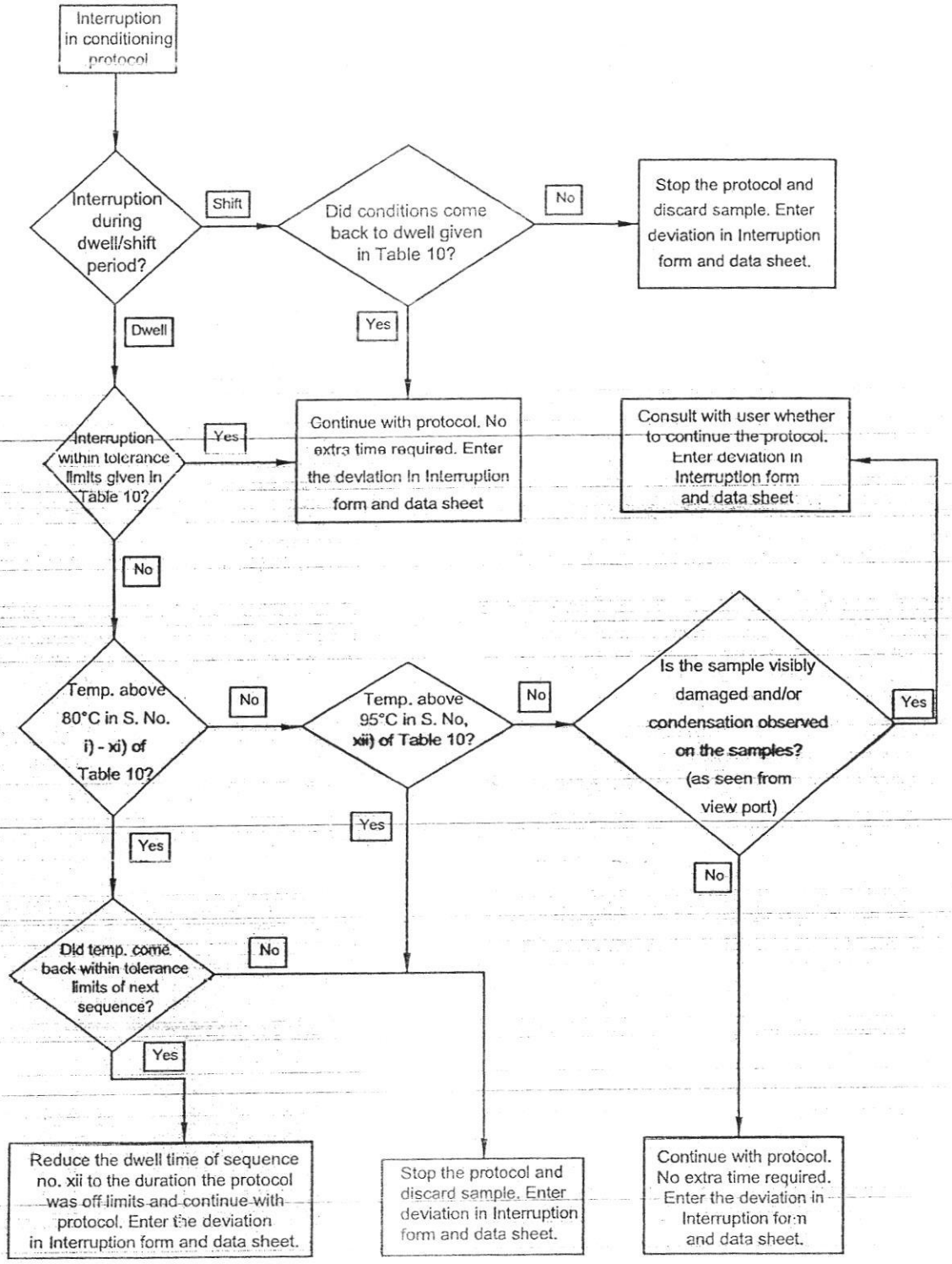
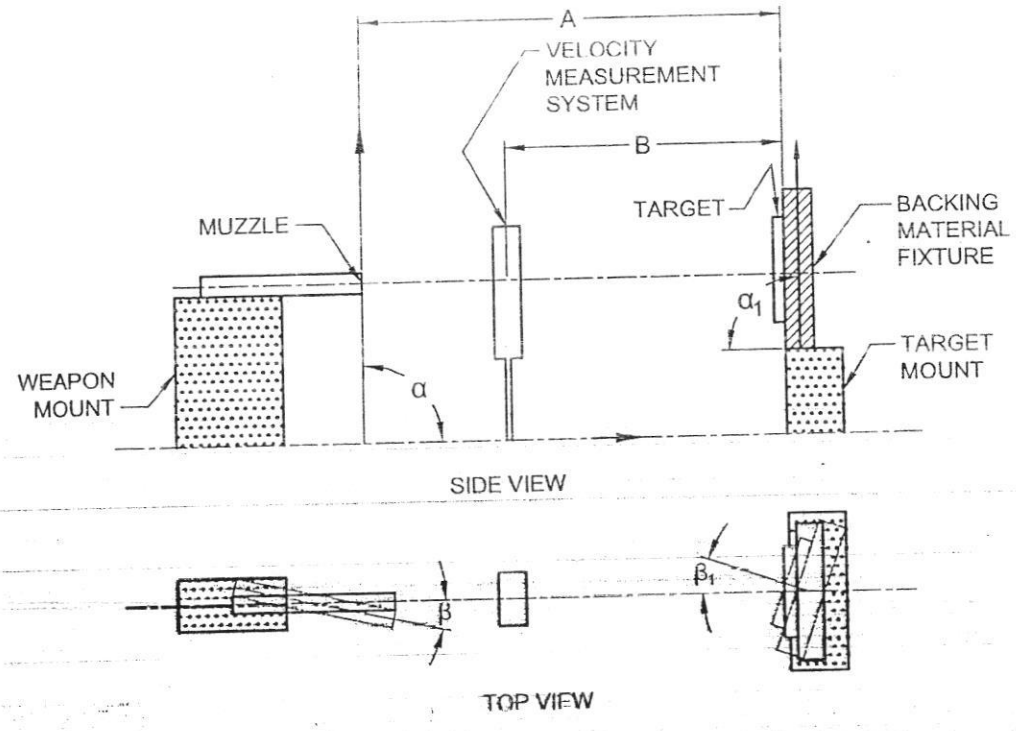


FIG. 7 INTERRUPTION FLOWCHART FOR CYCLIC THERMAL EXPOSURE



A: Distance between muzzle and target : a) 10.0 ± 0.1 m (Threat levels 2 to 6) and b) 5.0 ± 0.1 m (Threat level 1)
B: Distance between target and velocity measurement system, 2.5 ± 0.025 m (for discrete systems)
α: Elevation angle of muzzle, 90°
α_1: Elevation angle of target, 90°
β: Azimuth angle of muzzle, 0°
β_1: Angle of bullet impact on target, as per requirement

FIG. 8 TEST LAYOUT

front face of backing material fixture. Threat levels 2 and above shall be tested at a distance of 10 m from the front face of backing material fixture.

9.1.3 *Weapon Systems*

Weapon systems shall preferably be test barrels, however conventional weapons may also be used to achieve velocities. The testing agency shall display complete work instructions related to setup and maintenance of the weapons prominently near the weapon stand. Remote triggering shall be preferably used (*see* Fig. 9). Reports shall clearly mention whether weapons or test barrels were used along with their registration numbers.

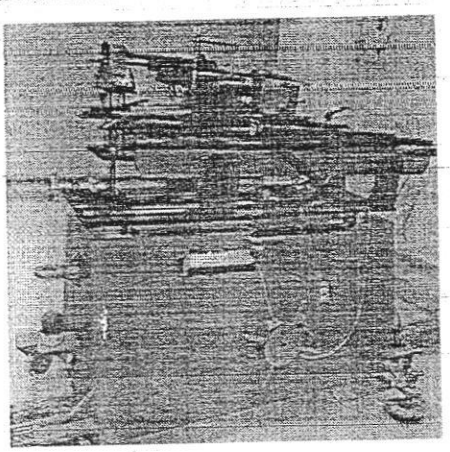


FIG. 9 REMOTE WEAPON STAND

9.1.4 *Target Stand*

The target stand shall preferably have provision for X-Y-Z movement and angular rotation (*see* Fig. 10). The traverse systems shall be adjusted so that the entire test specimen along with the backing material can be targeted.

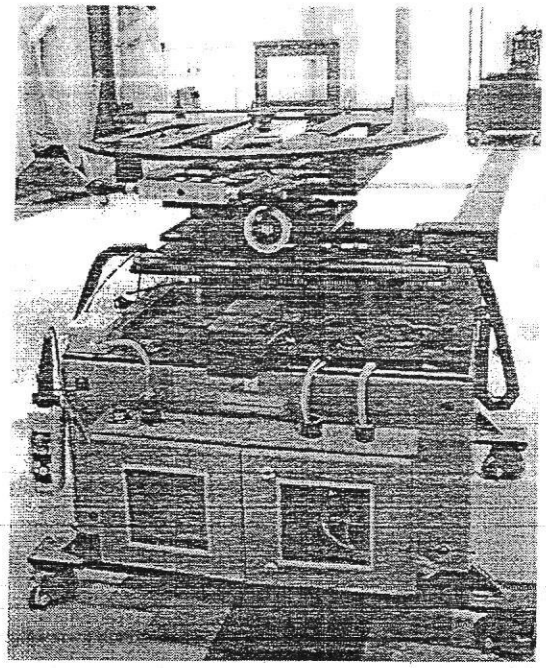


FIG. 10 EXAMPLE OF A TARGET STAND WITH X, Y, Z MOVEMENT AND ANGULAR ROTATION

9.1.5 *Diagnostics*

9.1.5.1 *Velocity measurement*

Preferably non-contact type discrete velocity screens (*see* Fig. 11) or doppler radar shall be used. Discrete velocity measurement screens shall be centered at 2.5 ± 0.025 m from the front face of the backing material fixture. Velocity of projectile at 2.5 m from the front face of backing material fixture shall be reported as impact velocity. Personnel conducting ballistic testing shall be properly trained in velocity measurement systems and doppler radars. The fineness unit for rounding off velocity data shall be 0.1.

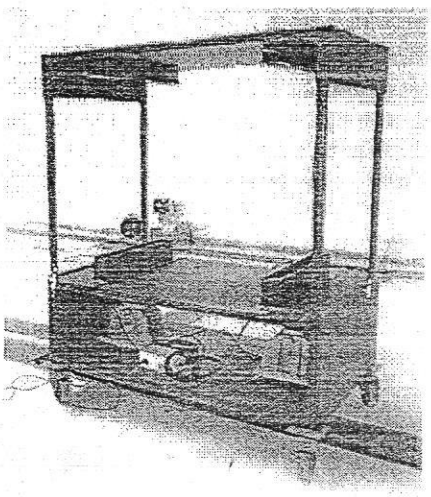


FIG. 11 EXAMPLE OF NON-CONTACT TYPE VELOCITY MEASUREMENT SYSTEM

9.1.5.2 *Other diagnostics*

Other diagnostics like yaw measurement system, coordinate systems, etc, may be used but are not essential for evaluation purpose. Care shall, however, be taken to keep the yaw of projectile within ± 3° of the angle of impact β_1 (*see* Fig. 8).

9.1.6 *Backing Material*

9.1.6.1 *Backing material fixture*

The inside dimensions of the backing material fixture shall be 610 mm × 610 mm × 140 mm with a tolerance of ± 2 mm on all dimensions. The edges shall be metallic to act as reference planes for the backing material. The back of the fixture shall be removable and made of wood.

9.1.6.2 *Preparation*

Roma Plastilina # 1 Grey® (RP#1) (*see* Note) or local oil/clay based sculpting material may be used for backing material. The properties of the local clay shall be close to RP#1 (*see* Annex K for more information on backing material). The clay in each fixture shall be filled in such a way so as to produce a block free of voids and a smooth front surface. Various striking devices and rollers may be used to ensure that the front surface of the backing material is even with the reference surface plane defined by the fixture edges. During repair and remaking of the surface, every effort shall be made to locate and remove any debris including bullets, fragments and other materials.

For non-planar test specimens, backing material shall be built to confirm to the required shape of the sample.

The backing material shall be changed annually or more/less frequently if necessary depending upon the calibration test results (*see* 9.1.6.4).

NOTE — Roma plastilina is a registered trade-mark of Sculpture House, Inc., 3804, Crossroads Parkwey, Fort Pierce, FL, 34945.

9.1.6.3 *Conditioning*

The backing material (along with the fixture) shall be conditioned evenly using conditioning chamber. The conditioning time and temperature is determined by the results of the calibration drop tests described in 9.1.6.4. However, it is recommended that the conditioning temperature of the backing material shall not exceed 35°C.

9.1.6.4 *Calibration*

The backing material shall be calibrated using drop test calibration method before every firing sequence. The equipment used in the method shall be as follows (*see* Fig. 12):

a) Drop weight material : Steel sphere
b) Drop weight size : 63.5 ± 0.05 mm (diameter)
c) Drop weight mass : 1 043 ± 5 g
d) Drop height : 2 000 ± 2 mm

e) Drop spacing : Minimum 76 mm from the fixture edge to indent edge and minimum of 152 mm between indent centres

The drop spacing criteria shall be considered only for pre-test drop calibration. Generally post-test drop calibration is not carried out. In case of specific requirement for post-test drop calibration, the backing material shall be flattened using rollers after the trial and drop test carried out.

The drop shall consist of a free release and targeted fall (preferably aided by aiming device). The average indentation of the five drops shall be considered. The arithmetic mean of the five indentation depth measurements shall be kept at 19 ± 2 mm. No indentation shall have depth of more than 22 mm or less than 16 mm.

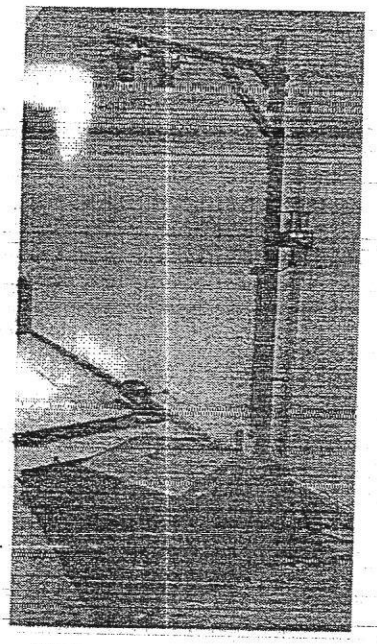


FIG. 12 EQUIPMENT FOR CALIBRATION OF BACKING MATERIAL

9.1.6.5 *Measurement of depth of indentation and back face signature*

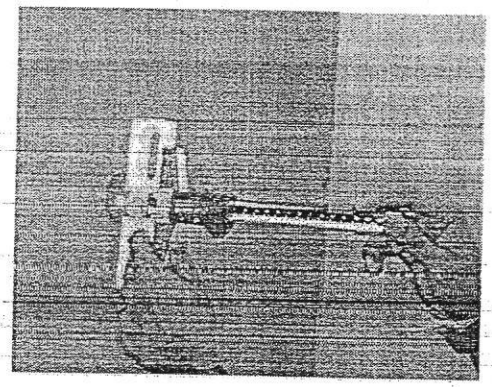
Preferably non-contact method shall be used for measurement of indentation and back face signature. In absence of such equipment, digital depth gauge with least count of 0.01 mm shall be used. The fineness unit for rounding off depth of indentation and BFS data shall be 0.1.

9.1.6.5.1 *Planar armour (Soft Armour Panel)*

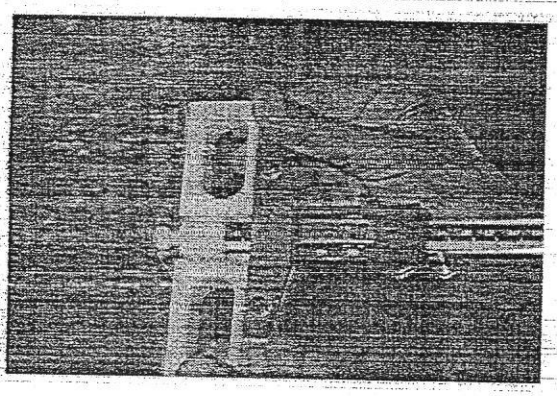
After each firing, the surface of the backing material shall be made even to the reference edge of the fixture. Any lip formation on the sides of the impact crater shall be removed carefully. This shall be carried out by removing the same using a scraper. The tip of the contact type measuring tool shall be spherical to avoid further indentation on the backing material. Maximum depth of indentation shall be measured and reported as BFS (*see* Fig. 13 A).

9.1.6.5.2 *Non planar armour (Hard Armour Panel)*

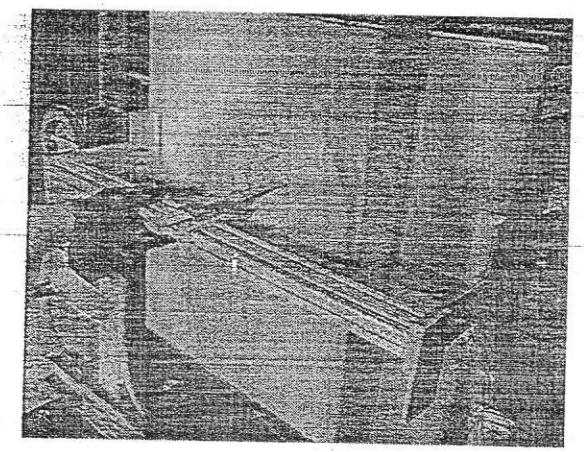
In case of non-planar armour like HAP/contoured rigid armour, after each firing, the contour of the backing material shall not be disturbed. Original reference plane of the contour shall be located and maximum depth of deformation at shot point shall be measured (*see* Fig. 13B and Fig. 13C).



A) FLEXIBLE ARMOUR



B) NON-PLANAR ARMOUR



C) NON-PLANAR ARMOUR (Alternate Method)

FIG. 13 MEASUREMENT OF BACK FACE SIGNATURE

9.2 P-BFS Test Procedure

9.2.1 *Armour Mounting*

The armour shall be mounted on the backing material fixture conditioned and calibrated as per 9.1.6.4. Care shall be taken while positioning the fixture as per the angle of bullet impact.

9.2.2 *Strapping*

Hook-and-loop fasteners of minimum 50 mm width shall be used for strapping of panels. The panel shall be positioned on the backing material such that the points of impact cover most of the area used for drop test calibration. The strapping arrangement of panel shall be as shown in Fig. 14. Two vertical and two horizontal straps shall be positioned such that they do not interfere with the impact points of the armour. For large armour with dimensions more than those of backing material fixture, curved shoulders shall be provided on both the sides and top of the fixture on which the panel shall be strapped using hook-and-loop fasteners. An example of such fixture is given in Fig. 15.

9.2.3 *Number of Shots*

Unless specified otherwise, the number of shots for P-BFS testing for front and back panels shall be 6 per panel. Groin protector, side protection or any other smaller panels shall be tested with three fair shots depending upon firing area. Details of shots to be fired on different panels are given in Table 11. The user may change the number of shots if required. However, at least two angular shots at 30° and 45° shall be fired on soft armour panel. In any other protection system, the number of shots shall be considered based on the fair hit criteria given in 9.2.4.

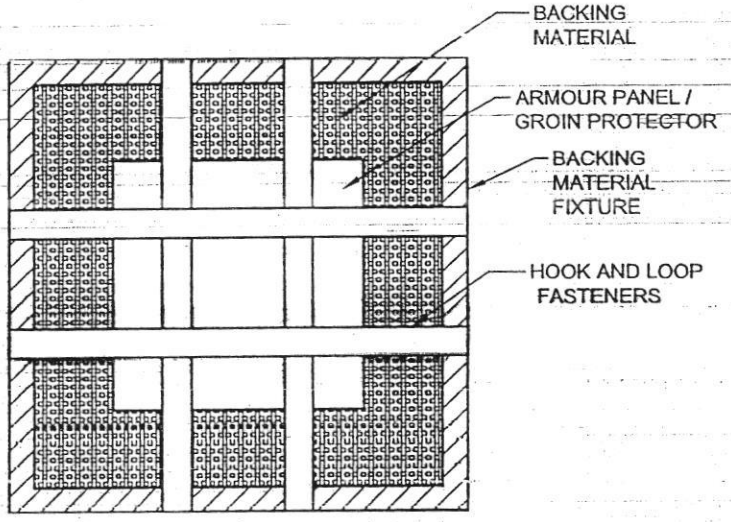


FIG. 14 STRAPPING ARRANGEMENT OF PANEL

FIG. 15 SHOULDERS ON BACKING MATERIAL FIXTURE FOR LARGE PANELS

Table 11 Number of Shots

(*Clause* 9.2.3)

Sl No.	Threat Level	Panel Type	Total Shots	At 0° Angle	At 30° and 45° Angle	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	1	Front/Back	6	4	2	—
		Groin/Other (*see* Note)	Max 3, Min 1	Max 3, Min 1	—	Depending upon fair hit
ii)	2	Front/Back	6	4	2	—
		Groin/Other (*see* Note)	Max 3, Min 1	Max 3, Min 1	—	Depending upon fair hit
iii)	3	Front/Back	6	6	—	—
		Groin/Other (*see* Note)	Max 3, Min 1	Max 3, Min 1	—	Depending upon fair hit
iv)	4	Front/Back	6	6	—	—
		Groin/Other (*see* Note)	Max 3, Min 1	Max 3, Min 1	—	Depending upon fair hit
v)	5	Front/Back	6	6	—	—
		Groin/Other (*see* Note)	Max 3, Min 1	Max 3, Min 1	—	Depending upon fair hit
vi)	6	Front/Back	6	6	—	—
		Groin/Other (*see* Note)	Max 3, Min 1	Max 3, Min 1	—	Depending upon fair hit

NOTE

1. Unless specified otherwise by the user, groin/side protectors shall be tested against three shots at 0° angle depending upon fair hit criteria. Other protectors like throat, collar, shoulders etc may be tested with one or more shots depending upon fair hit location.

2. In cases where size of armour is such that no fair hit is possible, user can forego fair hit criteria and test the armour, and undertaking from manufacturer can be taken with respect to the armour performance against the particular threat for which it has been designed.

9.2.4 *Fair Hit Criteria*

Unless specified otherwise, a shot is considered fair hit, if it impacts the panel and meets the following criteria:

a) From the edge:

1) At minimum distance of 51 mm in case of HAP (ICW or standalone configuration) or any flexible/rigid armour panel.

2) For SAP – between 51 mm and 70 mm from edge for shot numbers 1, 2, 3 (*see* **9.2.5.1**).

3) At less than 51 mm from edge but does not cause perforation or excessive BFS.

b) From a prior shot:

1) At minimum distance of 51 mm in case of SAP/ HAP (ICW or standalone configuration) or any flexible/rigid armour panel.

2) At less than 51 mm distance from the prior shot but does not cause perforation or excessive BFS.

c) Velocity:

1) At velocity within the specified range.

2) At a velocity less than the specified range but causes perforation or excessive BFS.

3) At a velocity more than the specified range and less than specified inter-shot distance and/ or less than specified edge to shot and does not cause perforation or excessive BFS.

Unless specified otherwise, in case of an unfair hit, maximum of two additional fair hit may be fired on any armour, depending upon the area of the armour and possibility of fair hit. However, the shots shall be fired on a panel, only if, all the fair hit criteria are complied with. In case of the additional hits being unfair, the armour shall be discarded and a fresh sample shall be taken for evaluation.

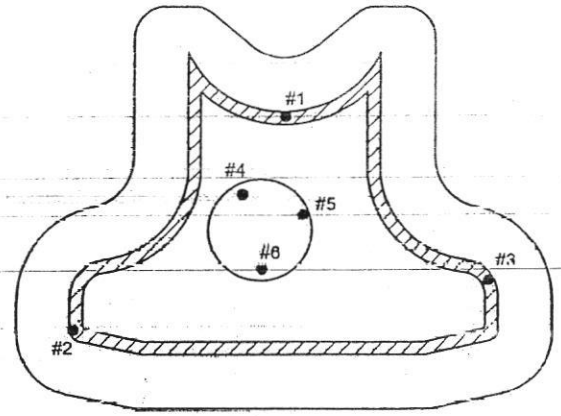
9.2.5 *Shot Locations*

9.2.5.1 *SAP/flexible armour*

Unless specified otherwise, the SAP shall be tested with six shots in the general pattern given in Fig. 16. Shot numbers 1, 2 and 3 shall meet the edge to shot distance requirements as given in **9.2.4** (a) (2). Shot numbers 1, 2, 3 and 6 shall be fired at 0° angle of impact of bullet with a tolerance of ± 1°. This means that the backing material fixture shall be at an angle of 0° with respect to the reference plane with a tolerance of ±1° ($\beta_1 = 0° \pm 1°$). Shot numbers 4, 5 and 6 shall meet the inter-shot distance requirements, but all three shots shall be located within a 100 mm (+ 25 mm/ -0 mm) diameter circle. Shot numbers 4 and 5 shall be fired at 30° and 45° angles of incidence,

respectively. This means that the backing material fixture shall be rotated at an angle of 30° and 45°, respectively with respect to the reference plane with a tolerance of ±1° (β_1 = 30/45° ± 1°). For angular shots, the backing material fixture shall be rotated in opposite directions (For example for 30° shot, if the sample is rotated in left direction then for 45°, the same shall be rotated in right direction).

For armours, where visible discontinuities/variance in material thickness or construction is observed, shots shall be so adjusted so as to exploit the weakest portion of the armour. In such case, deviation from set shot location shall be recorded in the report.



a) Shaded region – 51 mm to 70 mm from the edge,
b) Circled region – diameter 100 mm, and
c) Shot numbers 4 and 5 – Angular.

FIG. 16 GENERAL SHOT LOCATIONS OF SAP

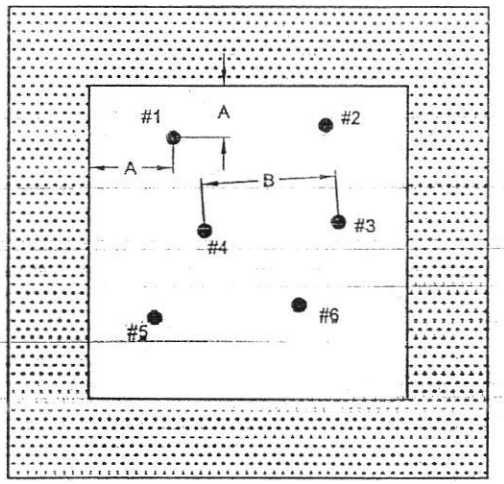
9.2.5.2 *ICW/Standalone HAP*

Unless specified otherwise, ICW or standalone HAP shall be tested with six shots in the general pattern given in Fig. 17. All shots shall be fired at 0° angle of impact of bullet with a tolerance of ± 1°. This means that the backing material fixture shall be at an angle of 0° with respect to the reference plane with a tolerance of ±1° (β_1 = 0° ± 1°). For armours, where visible discontinuities/variance in material thickness or construction is observed, shots shall be so adjusted so as to exploit the weakest portion of the armour. In such case, deviation from set shot location shall be recorded in the report.

For HAPs that have undergone in-transit conditioning or service life assessment tests, X-ray of the panel shall be taken and shot locations shall be modified to exploit the weak areas of the panel (*see* 8.3 and 8.4). In such case, deviation from set shot location shall be recorded in the report.

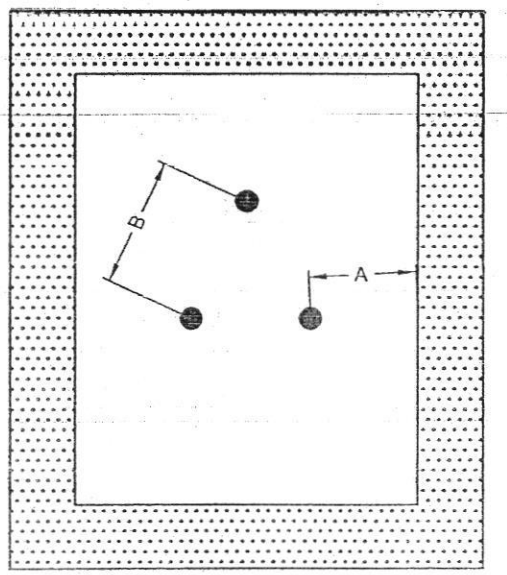
9.2.5.3 *Groin protector (with/without HAP) and side HAP*

Unless specified otherwise, the groin protector shall be tested with three shots in the pattern where the edge to shot and inter-shot distances requirements are fulfilled (*see* Fig. 18). Side HAPs shall also follow same pattern. For armours, where visible discontinuities/variance in material thickness or construction are observed, all the shots shall be so adjusted so as to exploit the weakest portion of the armour. For HAPs that have undergone in-transit conditioning or service life assessment tests, X-ray of the panel shall be taken and shot locations shall be modified to exploit the weak areas of the panel (*see* 8.3 and 8.4).



A: Edge to shot distance, minimum 51 mm
B: Shot to shot distance, minimum 51 mm

FIG. 17 GENERAL SHOT LOCATIONS IN HAP/SAP COMBINATION



A: Edge to shot distance, minimum 51 mm
B: Shot to shot distance, minimum 51 mm

FIG. 18 GENERAL SHOT LOCATIONS IN GROIN PROTECTOR AND SIDE HAPS

9.2.5.4 *Any other protection panel*

Unless specified otherwise, number of shots shall be calculated based on fair shot criteria given in 9.2.4. For HAPs that have undergone in-transit conditioning or service life assessment tests, X-ray of the panel shall be taken and shot locations shall be modified to exploit the weak areas of the panel (*see* 8.3 and 8.4).

9.2.6 *Measurement of Back Face Signature*

The back face signature shall be measured using the apparatus and method described in 9.1.6.5.

In case of tender samples, where the maximum limit of BFS is specified, in event of the BFS exceeding the maximum permissible limit, two more readings, preferably by a second operator shall be taken and the average of three readings recorded. If the average BFS of three readings is still higher than the maximum permissible limit, further tests with the same and other remaining ammunitions on the same size of model shall be discontinued.

For lot testing, all BFS values of fair shots having 0° angle of impact of bullet with a tolerance of ± 1° of all the samples of the lot shall be taken to consider upper prediction limit.

9.2.7 *Test Sequence (P-BFS)*

P-BFS test shall be conducted for R & D samples, tender samples and lot testing samples as per the requirement of user. The sequence of firing for each type of panel shall be as given in Fig. 19. The details of each are given in 9.2.7.1 to 9.2.7.4.

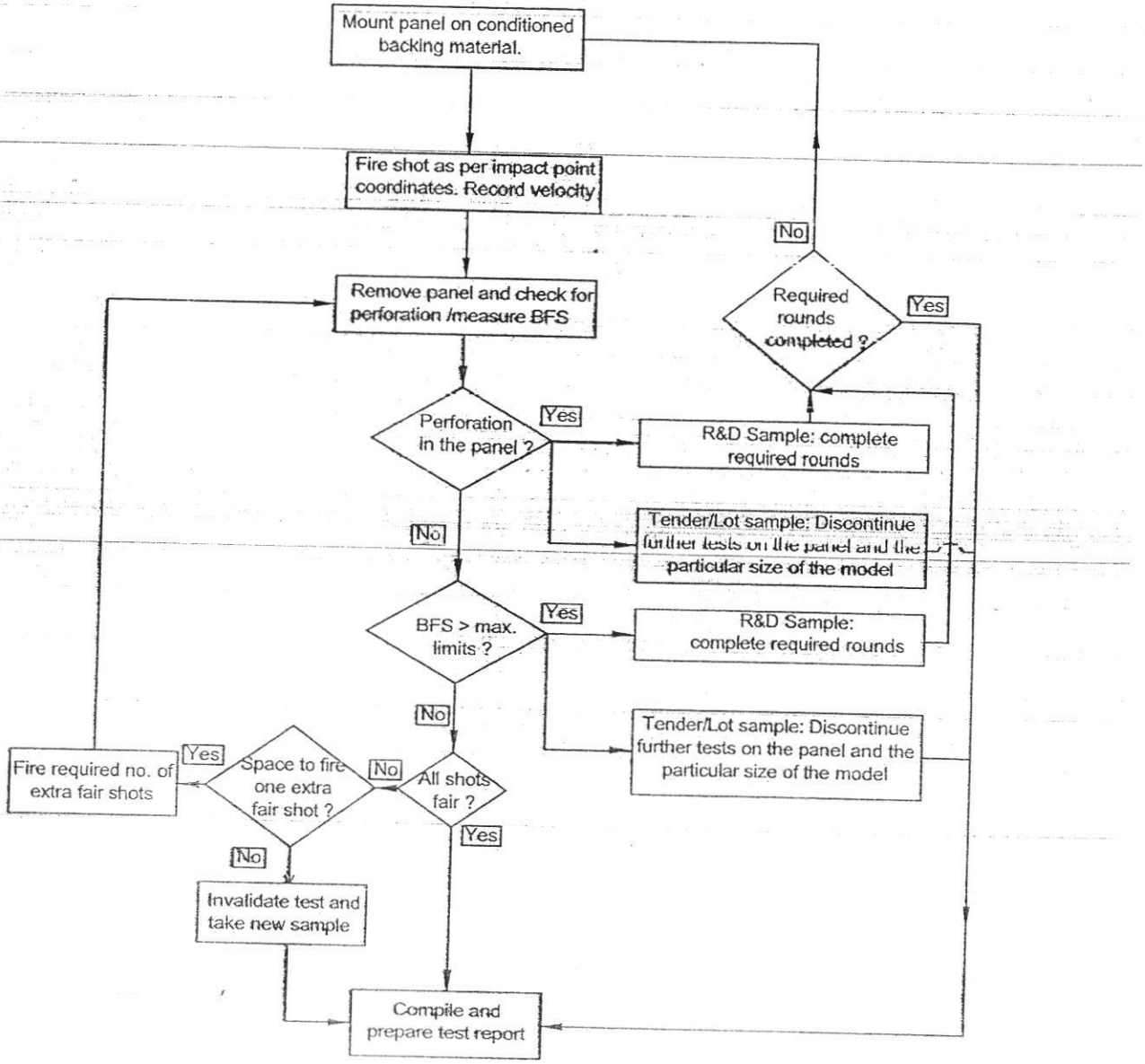


FIG. 19 P-BFS TEST LOGIC

Table 13 Details of Shot and Panel Requirements for Ballistic Limit Determination

(*Clause* 9.3.1)

Sl No.	Threat Level	Minimum Shots Required	Minimum Panels Required
(1)	(2)	(3)	(4)
i)	1	12	2
ii)	2	12	2
iii)	3	12 (for each ammunition)	2
iv)	4	12 (for each ammunition)	2
v)	5	12 (for each ammunition)	2
vi)	6	12	2 - 12

NOTES

1 For threat level 6, BL may be determined by either firing:

a) minimum 1 shot per panel, in which case 12 panels shall be tested;

b) maximum 6 shots per panel, in which case 2 panels shall be tested; and

c) any number of shots (between 1 and 6) per panel, in which case equivalent number of panels shall be required to cater for minimum number of shots to calculate ballistic limit (that is 12).

2 The method of measurement of ballistic limit for threat level 6 shall be defined after consultations with user, test agency and manufacturer.

3 When the armor's ballistic limit is sufficiently high that achieving the velocity necessary to perforate the armor is difficult or impossible, the test laboratory shall document that this situation has occurred. In such cases, the test shall be considered acceptable even if the minimum numbers of perforations are not achieved.

9.3.4 BL Performance Requirements

a) $V_{50,BL} \geq V_{50,Manufacturer}$ (permissible up to –10 m/s).

b) No perforations shall occur at or below the corresponding maximum fair hit velocity of a threat level. (*see* Table 7).

c) The estimated probability of complete perforation at the corresponding P-BFS reference velocity shall be less than 5 percent. In other words, $V_{05} \geq V_{ref}$ (*see* Annex L for explanation).

10 SAMPLE OWNERSHIP

10.1 R & D Samples

R & D samples belong to the manufacturer. The samples, after testing shall be returned back to the manufacturer. However, complete details of R & D samples (*see* Table 9) shall be provided by the manufacturer before testing and the details shall be retained by testing agency.

10.2 Tender Samples

Samples that comply with buyer requirements shall be considered property of the procuring agency. The samples shall be stored and subsequently disposed of as per the procurement plan of the buyer. Tender samples that fail to comply with the ballistic requirements shall remain property of the manufacturer and shall be returned accordingly.

10.3 Lot Samples

Samples that comply with ballistic requirements of the lot, are considered property of the procuring agency. The samples shall be stored and subsequently disposed of as per the procurement plan of the buyer. Test samples that fail to comply with the ballistic requirements of the lot shall also remain the property of the procuring agency. However, it is recommended that the procurement agency shall also make a handling and disposal plan of rejected samples during the supply to avoid mixing of samples from rejected lot.

11 DATA HANDLING AND REPORT GENERATION

11.1 Data Sheets

The ballistic data sheet shall contain all the details related to ballistic evaluation (excluding physical parameters). The data sheets shall comprise of weapon characteristics, ammunition parameters, sample ID, velocity and other diagnostic data, distance of impact, backing material calibration data, ballistic test results. Example of ballistic data sheet is given in Annex M for information only. Traceability of the data sheets shall be maintained with respect to indent/job number of ballistic evaluation.

Separate data sheets shall be generated for physical evaluation, conditioning protocols. Any deviation from set procedures shall be brought out clearly in the data sheets and endorsed by all stakeholders.

11.2 Trial Report

Trial report shall contain all information related to the physical and ballistic evaluation of the sample. The report shall include details on labelling of the sample, physical data, backing material calibration data, traceability of weapons and ammunitions used, conditioning details, ballistic evaluation data, test results and final decision, if relevant.

The report shall also contain a summary of the test conducted and relevant results.

12 MARKING

12.1 The 'Bullet resistant jacket' shall be legibly and indelibly marked with the following information on the product itself or on durable and securely attached labels:

a) Name of the product;

b) Manufacturer's name, initials or trade-mark;

c) Size designation;

9.2.7.1 *SAP/flexible armour*

Unless specified otherwise, front and back armour panel shall be fired with 6 shots in which 4th shot shall be at an angle of 30° and 5th shot at an angle of 45°. The rest of the shots are fired at 0° angle ($\beta_1 = 0°$). If an impact is not a fair hit, a second attempt shall be made to obtain a fair hit in the same general location of the first hit considering all the fair hit criteria defined in 9.2.4. This shall be done after completing the required test rounds. If more than two additional attempt is required to obtain a fair hit for any shot location, the whole test series on the panel shall be invalidated and test interruption form shall be filled and test shall be repeated on a new sample. BFS shall be measured after every shot and armour panel remounted without disturbing the backing material.

9.2.7.2 *HAP/rigid armour*

Unless specified otherwise, front and back armour panel shall be fired with 6 shots, all at 0° angle ($\beta_1 = 0°$). If an impact is not a fair hit, a second attempt shall be made to obtain a fair hit in the same general location of the first hit considering all the fair hit criteria defined in 9.2.4. This shall be done after completing the required test rounds. If more than two additional attempt is required to obtain a fair hit for any shot location, the whole test series on the panel shall be invalidated and test interruption form shall be filled and test shall be repeated on a new sample. The BFS shall be measured after every shot and the armour panel remounted without disturbing the backing material.

9.2.7.3 *Groin protector (with/without HAP)*

Unless specified otherwise, each armour panel shall be fired with 3 shots, all at 0° angle ($\beta_1 = 0°$). Unless specified otherwise, BFS shall be measured for first shot only and the armour panel remounted without disturbing the backing material.

9.2.7.4 *Any other protection panel*

Unless specified otherwise, the required number of shots shall be fired, all at 0° angle ($\beta_1 = 0°$). The BFS shall be measured after every shot and the armour panel remounted without disturbing the backing material.

9.3 Ballistic Limit Test Procedures (BL)

Ballistic limit testing is an optional test which shall be carried out during lot testing where the supply/lot quantity is more than 500 numbers. Ballistic limit values shall be provided by the user and shall be endorsed by the manufacturer in the technical bid. Ballistic limit may not be tested for tender sample evaluation. Vendor shall provide the V_{50}/BL value of the panels that shall be matched during BL test. The user/purchasing agency shall clearly mention requirement of BL test for lot testing.

9.3.1 *Test Procedure for Ballistic Limit*

The angles of incidence for all shots shall be 0° ($\beta_1 = 0°$). All samples shall be tested dry. No conditioning shall be done on samples meant for BL testing. The process of ballistic test is given in Table 12.

Table 12 Test Parameters for Ballistic Limit Test

(*Clause* 9.3.1)

Sl No.	Parameter Description	Value
(1)	(2)	(3)
i)	Velocity of first shot	The reference velocity for the armour type and caliber
ii)	Velocity step until first reversal	a) – 30 m/s, if first shot was a perforation
		b) + 30 m/s, if first shot was a stop
iii)	Velocity step until second reversal	± 22 m/s, depending on result of previous shot
iv)	Velocity step after second reversal	± 14 m/s, depending on result of previous shot

Shooting shall continue until either 12 shots or maximum number of shots allowed on the panel has been reached. For panels where 12 shots are not possible to fire, firing sequence shall be continued on additional panels till 12 shots are reached. Details of minimum shots and panels required in each threat level are given in Table 13. Ballistic limit shall be calculated as per procedure given in Annex L.

In case sufficient data is not available in 12 shots to calculate the BL, number of shots may be increased, however, it shall always be in multiples of 12. In such case, more than minimum number of panels (*see* Table 13) may be required. These panels shall be of the same configuration as submitted for tender sample evaluation.

9.3.2 *Backing Material Conditioning*

The backing material fixture shall be prepared and conditioned to the same temperatures as that used to conduct ballistic evaluation. Drop test validation shall be performed before each series. The wooden cover at the back of backing material fixture shall be removed during BL testing.

It is recommended that separate backing material from the one used for BFS testing shall be used for BL testing.

9.3.3 *Fair Hit Criteria and Shot Locations*

An impact shall be considered fair when a projectile strikes the target material at a distance of at least two projectile diameters from any previous impact or disturbed area resulting from an impact, or from any crack, or from any edge of the test panel.

d) Instructions for storage and care;

e) Batch number;

f) Date of manufacture; and

g) Any other information required by the law in force and/or by the buyers.

12.2 BIS Certification Marking

The 'Bullet resistant jacket' may also be marked with the Standard Mark.

12.2.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 2016 and Rules and Regulations made thereunder. The details of the conditions under which the licence for use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
1070 : 1992	Reagent grade water — Specification (*third revision*)
2454 : 1985	Method for determination of colour fastness of textile materials to artificial light (Xenon lamp) (*first revision*)
2500 (Part 1) : 2000	Sampling procedure for inspection by attributes: Part 1 Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection (*third revision*)
3951	Sampling procedures for inspection by variables
(Part 1) : 2013	Specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL
(Part 2) : 2013	General specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection of independent quality characteristics
(Part 3) : 2007	Double sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
(Part 4) : 2011	Procedures for assessment of declared quality levels
(Part 5) : 2006	Sequential sampling plans indexed by acceptance quality limit (AQL) for inspection by variables (Known standard deviation)
6911 : 2017	Stainless steel plate, sheet and strip — Specification (*second revision*)
7016	Methods of test for coated and treated fabrics
(Part 1) : 1982	Determination of roll characteristics (*first revision*)
(Part 2) : 2015	Determination of tensile strength and elongation at break (*second revision*)
(Part 3) : 1981	Determination of tear strength (*first revision*)
(Part 7) : 2009	Rubber-or plastics-coated fabrics — Determination of resistance to penetration by water (*second revision*)
8156 : 2014	Fastners for consumer goods — Synthetic hook and loop tape — Specification (*third revision*)
11871 : 1986	Methods for determination of flammability and flame resistance of textile fabrics

ANNEX B

(*Clause* 4.1)

CHECKING OF BASIC ERGONOMIC FEATURES OF BULLET RESISTANCE JACKET

B-1 This annex informs how some basic ergonomic features can be checked for bullet resistance jackets (BRJ) in a pragmatic way. This annex is not intended to replace ergonomic testing required by the user for individual assessment of BRJ at a specific workplace. In general carrying out ergonomic assessments can help improve bullet resistance jacket and detect major deficiencies.

B-2 In principle, one or more experienced assessors should examine the BRJ after reading the information supplied from the manufacturer. The BRJ of suitable size should be put on together with combat dress/uniform as is intended to be worn, and ergonomic features relating to the practical performance of the bullet resistance jacket should be checked. Some relevant questions that may be asked to the wearer are set out in Table 14.

NOTE – An assessor may have difficulties deciding whether the product is acceptable or unacceptable. It is recommended that the product should be compared with similar items in the market. If it is significantly worse ergonomically, without redeeming features such as enhanced protection, it can be regarded as unnecessarily uncomfortable. Care shall be taken if there are no directly comparable products.

B-3 GROUNDS FOR CONCLUDING THAT A PRODUCT IS UNACCEPTABLE

The following are obvious reasons for concluding that the BRJ is unacceptable and not fit for use:

a) Personnel it should fit cannot wear it.

b) It does not stay closed or it will not stay in place.

c) It compromises a vital function, such as breathing.

d) It compromises vital performance, such as firing (standing and/or lying).

e) Simple tasks to be performed wearing it are impossible.

f) The subject refuses to continue this assessment due to pain or excessive secondary loads on neck and back (due to loose fit and changes in centre of gravity).

g) It prevents the wearing of basic combat dress/ uniform.

Table 14 Relevant Questions that may be Asked to the Wearer

(*Clause* B-2)

Sl No.	Parameter	Activity	Question
(1)	(2)	(3)	(4)
i)	Visual	Inspect the BRJ visually for any defects	Is the BRJ free from any sharp or hard edges, rough surfaces or other items on the inner or outer surface that are likely to cause harm?
ii)	Size	Wearing of suitable size of BRJ over combat dress/uniform/jersey	1) Is it too tight for deep breathing? 2) Is it loose even after tightening buckles, velcro tapes and kamarbandh? 3) Does it protect vital parts as per requirement?
iii)	Restriction of movement	Personnel to be made to carry out battle/patrol/ (any other) drill wearing the BRJ a) Crawling b) Running c) Kneeling – firing position d) Lying – firing position e) Standing – firing position	1) Does the BRJ ride up during the aforementioned activities? 2) Is the thickness of the jacket a hindrance in carrying out the activities? 3) Any hindrance in arm movements (especially armpit regions)? 4) Any hindrance groin/crotch region? 5) Any hindrance while moving the neck and/or head? 6) Any displacement in panels during the aforementioned activities?
iv)	Ease of handling weapon	Personnel to be made to fire using service weapon wearing the BRJ a) Kneeling b) Lying c) Standing	1) Does the weapon stock fit properly while firing? 2) Does the stock slip from shoulder while firing?
v)	Pockets	Place service ammunition magazines and grenades in the pouches and remove them?	Is it easy and fast to remove magazines and grenades from pouches?
vi)	Donning and removal	Put on the BRJ and remove it (with/without assistance as given by the manufacturer)	1) Is it easy to put on the jacket without help? 2) Is it easy to take off the jacket without help?

ANNEX C

(Clauses 5.2.4 and 5.2.5)

MAXIMUM POSSIBLE WEIGHTS OF BULLET RESISTANT JACKETS (KG)

C-1 STANDALONE CONFIGURATION

C-1.1 BFS: 25 mm

Size	XS			S			M			L			XL		
Threat Level	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2
1	1.34	1.66	1.97	1.40	1.74	2.06	1.48	1.83	2.15	1.54	1.92	2.25	1.62	2.02	2.35
2	3.47	4.84	6.13	3.64	5.08	6.39	3.83	5.33	6.68	4.01	5.60	6.97	4.21	5.88	7.28
3	3.60	5.04	6.39	3.78	5.28	6.66	3.97	5.55	6.96	4.17	5.83	7.26	4.37	6.12	7.59
4	4.54	6.43	8.21	4.76	6.74	8.56	5.00	7.09	8.94	5.25	7.43	9.33	5.51	7.80	9.74
5	5.07	7.22	9.25	5.32	7.58	9.65	5.59	7.96	10.07	5.87	8.35	10.51	6.16	8.77	10.97
6	6.81	9.81	12.63	7.14	10.29	13.17	7.50	10.80	13.75	7.87	11.34	14.35	8.26	11.91	14.98

C-1.2 BFS: 44 mm

Size	XS			S			M			L			XL		
Threat Level	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2
1	1.18	1.42	1.66	1.23	1.49	1.73	1.30	1.57	1.81	1.36	1.64	1.89	1.43	1.73	1.98
2	3.34	4.64	5.87	3.50	4.87	6.12	3.68	5.12	6.40	3.86	5.37	6.67	4.05	5.63	6.97
3	3.34	4.64	5.87	3.50	4.87	6.12	3.68	5.12	6.40	3.86	5.37	6.67	4.05	5.63	6.97
4	4.27	6.03	7.69	4.48	6.33	8.02	4.71	6.65	8.38	4.94	6.97	8.74	5.18	7.32	9.13
5	4.67	6.63	8.47	4.90	6.95	8.83	5.15	7.30	9.22	5.40	7.65	9.63	5.67	8.05	10.05
6	6.54	9.41	12.11	6.86	9.87	12.63	7.21	10.37	13.18	7.56	10.88	13.76	7.94	11.42	14.36

Standard: Front and Back Protection

Upgrade 1: Front, Back and Sides protection

Upgrade 2: Front, Back, Sides, Groin and Throat protection

C-2 ICW CONFIGURATION

C-2.1 BFS: 25 mm

Size	XS			S			M			L			XL		
Threat	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2
1	2.93	2.93	2.93	3.21	3.21	3.21	3.50	3.50	3.50	3.79	3.79	3.79	4.08	4.08	4.08
2	4.93	5.91	6.83	5.31	6.34	7.28	5.71	6.78	7.74	6.10	7.23	8.22	6.51	7.69	8.62
3	5.06	6.11	7.09	5.45	6.55	7.55	5.85	7.00	8.02	6.26	7.46	8.51	6.67	7.94	8.92
4	6.00	7.50	8.91	6.43	8.01	9.45	6.88	8.53	10.00	7.34	9.07	10.58	7.80	9.62	11.04
5	6.53	8.29	9.95	6.99	8.84	10.53	7.47	9.41	11.14	7.96	9.99	11.76	8.45	10.59	12.25
6	8.27	10.87	13.33	8.81	11.55	14.06	9.38	12.25	14.81	9.96	12.98	15.60	10.56	13.72	16.18

C-2.2 BFS: 44 mm

Size	XS			S			M			L			XL		
Threat	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2
1	2.39	2.39	2.39	2.61	2.61	2.61	2.84	2.84	2.84	3.07	3.07	3.07	3.30	3.30	3.30
2	4.39	5.37	6.29	4.71	5.74	6.68	5.05	6.12	7.08	5.38	6.51	7.50	5.73	6.91	7.84
3	4.39	5.37	6.29	4.71	5.74	6.68	5.05	6.12	7.08	5.38	6.51	7.50	5.73	6.91	7.84
4	5.32	6.76	8.11	5.69	7.20	8.58	6.07	7.65	9.06	6.46	8.12	9.56	6.86	8.60	9.96
5	5.73	7.36	8.89	6.11	7.82	9.39	6.52	8.31	9.91	6.93	8.81	10.45	7.35	9.33	10.86
6	7.46	9.94	12.27	7.93	10.53	12.92	8.43	11.15	13.59	8.93	11.80	14.28	9.45	12.46	14.80

Standard: Front and Back Protection

Upgrade 1: Front, Back and Sides protection

Upgrade 2: Front, Back, Sides, Groin and Throat protection

ANNEX D

(*Clause* 6.2.2)

NOTES ON BACK FACE SIGNATURE (BFS)

D-1 Bullet resistant jacket may be used for various applications for example protection measures, law and order or tactical applications like military operations, etc.

D-2 Maximum permissible back face signature (BFS) of 44 mm is followed by US army, US federal security forces, UK police forces (for very low threats), Indian navy, Indian coast guard etc. Permissible BFS of 25 mm is followed by UK police forces (High threat levels), Indian army, bullet resistant jackets for Indian CAPFs.

D-3 The qualitative requirements and trial directives issued by BPR&D suggest use of 25 mm for bullet resistant jackets and 44 mm for bullet resistant vests.

D-4 For applications that involve minimum risks, use of concealable armour and ease of medical assistance in case of casualty, bullet resistant jacket with higher BFS (44 mm) may be selected.

D-5 For applications that involve medium to high risks (automatic guns, rifles, etc) like military operations, patrolling of sensitive/terrorist prone areas or remote/ inaccessible areas and use of overt armour with hard armour panels, bullet resistant jacket with lesser BFS (25 mm) may be selected.

D-6 Panel designed for 25 mm BFS against a particular threat is likely to be slightly heavier than a similar panel designed for 44 mm BFS against the same threat. The user/purchaser shall take into account the weight aspect while drafting qualitative requirement.

D-7 This standard does not advocate selection of any specific BFS, the threat perceptions shall be seriously considered before choosing the maximum permissible back face signature.

ANNEX E

(*Clause* 6.4.1)

NOTES ON UPPER PREDICTION LIMIT (UPL)

E-1 Measurement of back face signature involves conditioning and calibration of backing material and use of handheld equipment during measurement. Despite the measures taken to minimize variation, these activities introduce inherent variability in the test results. The probability of an acceptable design failing the ballistic trials increases due to these variations.

E-2 For this reason, probability of allowing excessive BFS within permissible limits is relevant for lot testing. In case any BFS exceeds the permissible limit, there shall be 95 percent confidence that 90 percent of all BFS depths shall be less than or equal to maximum permissible limit. This is explained in detail in **E-3** to **E-5** (95 percent confidence level and 90 percent probability).

E-3 It can be assumed that the population of BFS measurements follows normal distribution (*see* Fig. 20). Difference between confidence and prediction levels is given in Fig. 21. In Fig. 21, the interval range extends beyond the tail areas of the actual population distribution (solid line). This is because the tolerance interval takes into account the uncertainty of knowing the true location of the mean of the population distribution. This uncertainty is represented by the confidence level associated with the interval. The confidence level indicates the likelihood that the interval covers the desired proportion of the population.

E-4 The upper prediction limit is a prediction of the upper tail of a normal distribution which provides

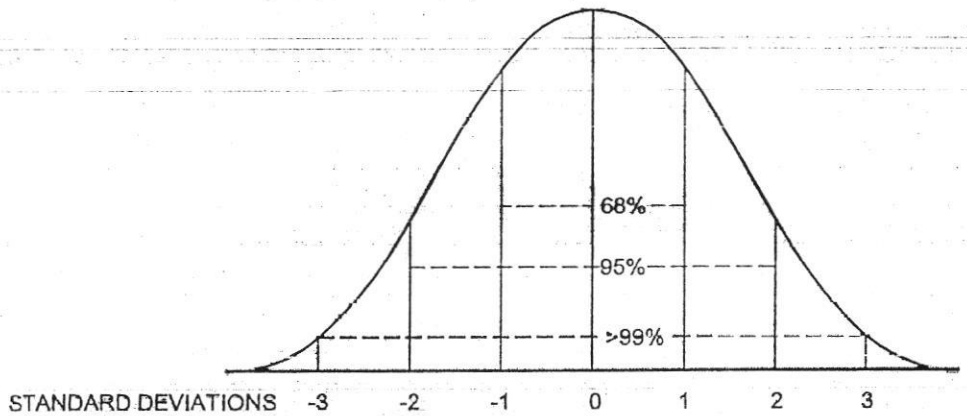


FIG. 20 NORMAL DISTRIBUTION (PERCENT VALUES ARE THE CONFIDENCE LIMITS)

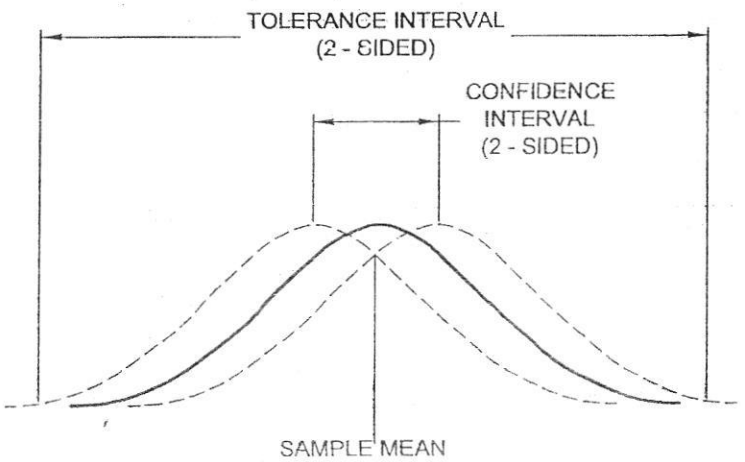


FIG. 21 DIFFERENCE BETWEEN CONFIDENCE AND PREDICTION LEVELS

a value which the next shot is unlikely to exceed (probability) that is

$$X_U = \bar{X} + K\sigma \quad \text{--- (7)}$$

Where X_U is the Upper Prediction Limit, $\bar{X}$ is average of BFS, σ is standard deviation and K is the constant determined by the probability and confidence levels.

$$K = \frac{Z_{1-p} + \sqrt{Z_{1-p}^2 - ab}}{a} \quad \text{--- (8)}$$

where,

$$a = 1 - \frac{Z_{1-\beta}^2}{2(N-1)} \qquad b = Z_{1-p}^2 - \frac{Z_{1-\beta}^2}{N}$$

p = 0.9 that is probability that no BFS exceeds maximum limit shall be at least 90 percent;

β = 0.95 that is confidence level of 95 percent; and

N = number of BFS readings.

Considering one-sided critical z-values in normal distribution

$Z_{1-p} = 1.28$ and $Z_{1-\beta} = 1.645$

E-4.1 Value of K for different BFS readings as per the equation 8 are given in Table 15.

Table 15 K Values for 90 Percent Probability at 95 Percent Confidence Level

(*Clause* E-4.1)

Sl No.	No. of BFS Readings	Constant K	No. of BFS Readings	Constant K
(1)	(2)	(3)	(4)	(5)
i)	3	7.61	23	1.85
ii)	4	4.25	24	1.84
iii)	5	3.38	25	1.82
iv)	6	2.96	26	1.81
v)	7	2.71	27	1.80
vi)	8	2.54	28	1.79
vii)	9	2.41	29	1.78
viii)	10	2.32	30	1.77
ix)	11	2.24	31	1.76
x)	12	2.18	32	1.75
xi)	13	2.13	33	1.74
xii)	14	2.08	34	1.73
xiii)	15	2.04	35	1.72
xiv)	16	2.01	40	1.69
xv)	17	1.98	50	1.64
xvi)	18	1.95	60	1.60
xvii)	19	1.93	80	1.55
xviii)	20	1.91	100	1.52
xix)	21	1.89	200	1.45
xx)	22	1.87	500	1.38

E-5 EXAMPLE OF UPL CALCULATION

E-5.1 Example 1

a) User requirement : Threat Level 2, Maximum BFS : 25 mm

b) Armour design : Front and back, 6 shots each, all shot at 0° angle ($\beta_1 = 0°$)

c) BFS values

Shot No.	*Front*	*Back*
1	20	17
2	25.2	18
3	20	19
4	18	20
5	19	21
6	19	22
Average	19.85	
Standard Deviation	2.17	
K (for 12 shots)	2.18	

Upper Prediction Level (*see* Equation 7) = 24.5 mm

As UPL < 25 mm, Shot. No. 2 on the front panel with BFS > 25 mm shall be accepted as major defect during lot testing [*see* **6.5.2**(b)].

E-5.2 Example 2

a) User requirement : Threat Level 2, Maximum BFS : 25 mm

b) Armour design : Front and back, 6 shots each, all shot at 0° angle ($\beta_1 = 0°$)

c) BFS values

Shot No.	*Front*	*Back*
1	23	22
2	21	20
3	22	23
4	19	22
5	24	23
6	22	22
Average	21.91	
Standard Deviation	1.37	
K (for 12 shots)	NA	

As all the shots are less than maximum permissible limit (25 mm), the jackets shall be accepted without any defect.

ANNEX F

(*Clauses* 6.5.2.1 and 7.2)

SAMPLING PLAN AND AQL FOR BALLISTIC EVALUATION

F-1 During lot testing, samples of complete jacket shall be drawn from the manufacturer site. Ballistic evaluation shall be conducted on the panels removed from the bullet resistant jacket. These panels shall include front/back, groin, side or any other panels designed for specific threat level. In this case, the sample size shall mean the panels that need to be evaluated against lot size of complete armour. Sample size code letters is given in Table 16.

F-2 Generally, one bullet resistant jacket comprises of minimum two panels (for example front and back). In such case, 08 sample size means four (04) bullet resistant jacket. In case bullet resistant jacket comprises of more than two panels, sample size shall be increased to incorporate drawing of complete bullet resistant jacket from manufacturer site. The AQL shall remain same as that given in Table 17. An example illustrating sampling of armours is given below.

Table 16 Sample Size Code Letters

(*Clause* F-1)

Sl No.	Lot Size	Special Inspection Levels				General Inspection Levels		
		S-1	S-2	S-3	S-4	I	II	III
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	2 to 8	A	A	A	A	A	A	B
ii)	9 to 15	A	A	A	A	A	B	C
iii)	16 to 25	A	A	B	B	B	C	D
iv)	26 to 50	A	B	B	C	C	D	E
v)	51 to 90	B	B	C	C	C	E	F
vi)	91 to 150	B	B	C	D	D	F	G
vii)	151 to 280	B	C	D	E	E	G	H
viii)	281 to 500	B	C	D	E	F	H	J
ix)	501 to 1 200	C	C	E	F	G	J	K
x)	1 201 to 3 200	C	D	E	G	H	K	L
xi)	3 201 to 10 000	C	D	F	G	J	L	M
xii)	10 001 to 35 000	C	D	F	H	K	M	N
xiii)	35 001 to 150 000	D	E	G	J	L	N	P
xiv)	150 001 to 500 000	D	E	G	J	M	P	Q
xv)	500 001 and over	D	E	H	K	N	Q	R

Table 17 Single Sampling Plans for Normal Inspection

(Clause F-2)

Sample Size Code letter	Sample Size	Acceptance Quality Limit, AQL, in Percent Non-conforming Items and Non-conformities per 100 Items (Normal Inspection)																																					
		0.010		0.015		0.025		0.040		0.065		0.10		0.15		0.25		0.40		0.65		1.0		1.5		2.5		4.0		6.5		10		15		25		40		65		100		150		250		400		650		1 000	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A	2	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇩		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22	30	31
B	3	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22	30	31	44	45
C	5	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22	30	31	44	45		
D	8	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22	30	31	44	45				
E	13	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22								
F	20	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22										
G	32	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22												
H	50	⇩		⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22														
J	80	⇩		⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22																
K	125	⇩		⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22																		
L	200	⇩		⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22																				
M	315	⇩		⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22																						
N	500	⇩		⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22																								
P	800	⇩		0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22																										
Q	1 250	0	1	⇧		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22																												
R	2 000	⇧		⇧		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22	⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧		⇧	

⇩ = *Use first sampling plan below arrow. If sample size equals, or exceeds, lot or batch size, carry out 100% inspection.*

⇧ = *Use first sampling plan above arrow.*

Ac = Acceptance number

Re = *Rejection number*

F-3 EXAMPLE OF SAMPLING AND LOT TESTING

a) Type : Bullet resistant jacket

b) User requirement : Threat levels: 1 and 3, Maximum BFS: 25 mm

c) Armour design (ICW) : Level 1 (SAP): Front, back and groin (3 panels per jacket)
Level 3 : Front, back, side-L, side –R (4 panels per jacket)

d) Inspection level : S-4

e) AQL defect rate (of Panel) : 2.5 percent

Example 1

LOT 1 = 100 jackets, sample code D (Table 16)

Threat Level	*Minimum Panels Required for Testing as per Tables 16 and 17*	*Panels Tested*	*Jackets drawn*	*P/NP*	*BFS Results*
1 (only SAP)	08	09	03	All NP	**BFS > 25 mm : 01** **UPL < 25 mm**
3 (7.62 × 39 MSC)	08	08	02	All NP	BFS > 25 mm : NIL
3 (7.62 × 51)	08	08	02	All NP	BFS > 25 mm : NIL
Decision	**Critical Defect: NIL, Major Defect: 01** **REJECT LOT**				

Example 2

LOT 2 = 200 jackets, sample code E (Table 16)

Threat Level	*Minimum Panels Required for Testing as per Tables 16 and 17*	*Panels Tested*	*Jackets drawn*	*P/NP*	*BFS Results*
1 (only SAP)	13	15	05	All NP	BFS > 25 mm : NIL
3 (7.62 × 39 MSC)	13	16	04	**1 shot stopped by SAP**	BFS > 25 mm : NIL
3 (7.62 × 51)	13	16	04	All NP	UPL < 25 mm
Decision	**Critical Defect: NIL , Major Defect: 01** **ACCEPT LOT**				

Example 3

LOT 3 = 1500 jackets, sample code G (Table 16)

Threat Level	*Minimum Panels Required for Testing as per Tables 16 and 17*	*Panels Tested*	*Jackets drawn*	*P/NP*	*BFS Results*
1 (only SAP)	32	33	11	**P : 01**	BFS > 25 mm : NIL
3 (7.62 × 39 MSC)	32	32	8	All NP	BFS > 25 mm : NIL
3 (7.62×51)	32	32	8	All NP	BFS > 25 mm : NIL
Decision	**Critical Defect: 01, Major Defect: NIL** REJECT LOT				

ANNEX G

(*Clause* 7.3)

CALCULATION OF NUMBER OF SAMPLES

G-1 EXAMPLE 1 (TENDER SAMPLE)

G-1.1 Requirements

a) Size : Three (Small, Medium, Large)

b) Threat level : 5

c) Operational requirements : 1) Fluid exposure (water);
2) Low temperature test;
3) Normal range parameters; and
4) Life assessment.

G-2 For level 5, the material has to clear levels 1 and 3 as well. Therefore, 3 threat levels to be tested. Calculation of number of samples shall be as given in Table 18

Table 18 Calculation of Number of Samples

(*Clause* G-2)

Sl No.	Threat Level	Size	Operating Condition	No. of Jackets	Total Samples Required for Ballistic Testing
(1)	(2)	(3)	(4)	(5)	(6)
i)	1 (only if the design is ICW)	S, M, L (any one size)	Water	1 (Only SAP)	04 (+ 04 standby)
			Low temperature	1 (only SAP)	
			Normal range	1 (only SAP)	
			Life assessment	1 (only SAP)	
ii)	3 (7.62 × 51)	S	Water	1 (HAP + SAP)	04 (+ 04 standby)
			Low temperature	1 (HAP + SAP)	
			Normal range	1 (HAP + SAP)	
			Life assessment	1 (HAP + SAP)	
		M	Water	1 (HAP + SAP)	04 (+ 04 standby)
			Low temperature	1 (HAP + SAP)	
			Normal range	1 (HAP + SAP)	
			Life assessment	1 (HAP + SAP)	
		L	Water	1 (HAP + SAP)	04 (+ 04 standby)
			Low temperature	1 (HAP + SAP)	
			Normal range	1 (HAP + SAP)	
			Life assessment	1 (HAP + SAP)	
iii)	5 (7.62 × 39)	S	Water	1 (HAP + SAP)	04 (+ 04 standby)
			Low temperature	1 (HAP + SAP)	
			Normal range	1 (HAP + SAP)	
			Life assessment	1 (HAP + SAP)	
		M	Water	1 (HAP + SAP)	04 (+ 04 standby)
			Low temperature	1 (HAP + SAP)	
			Normal range	1 (HAP + SAP)	
			Life assessment	1 (HAP + SAP)	
		L	Water	1 (HAP + SAP)	04 (+ 04 standby)
			Low temperature	1 (HAP + SAP)	
			Normal range	1 (HAP + SAP)	
			Life assessment	1 (HAP + SAP)	
iv)	Total Bullet Resistant Jackets required per design				28 (+ 28 standby)

ANNEX H

(*Clause* 8.0)

OPERATING CONDITIONS

H-1 Bullet resistant jacket used by various agencies is expected to be subjected to various operating and environmental conditions based on their location and usage. Many of these conditions affect the service life of the bullet resistant jacket and can result in its degradation. It is important for the procuring agency to formulate detailed environmental test plan to incorporate most detrimental conditions that the bullet resistant jacket may face during its service/storage.

H-2 Major factors that the bullet resistant jacket is likely to face during its service are extreme temperatures, contamination with fluids, in transit drop and vibrations, and general climatic changes. General test plans for these conditions have been given in detail in clause 8. The standard does not advocate testing under any particular operating condition. The procuring agency shall choose any of these conditions depending upon usage of bullet resistant jacket. The procuring agency may also add new test plans after discussions with manufacturers and testing agencies. Table 19 gives the reason for each test plan and the agencies where such tests are relevant.

Table 19 Test Standards for Various Operating Conditions

(*Clause* H-2)

Sl No. (1)	Test Type (2)	Reason for Testing (3)	Relevance (4)
i)	High temperature	Transportation/Storage (Open and shelter) in hot regions	All agencies
ii)	Low temperature	Transportation/Storage (Open and shelter) in cold regions	Agencies where jackets are exposed to sub-zero temperatures
iii)	Fluid exposure	Continuous or temporary exposure to degrading fluids	All agencies
		For sea and coastal regions	Navy/Marine and coastal agencies
iv)	In-transit conditions	Accidental drop during transit	All agencies
		Article free to bounce, collide with other articles/sides of vehicle Article is not secured to vehicle floor	All agencies

ANNEX J

(*Clause* 8.4.3)

TEST INTERRUPTION FORMAT

J-1 TEST INTERRUPTION FORMAT (EXAMPLE)

Trial ID	
Date of trial	
Sample ID	
Reason for interruption/invalidation	
Corrective actions taken	
Decision on interruption	

Trial In-charge User/Manufacturer

ANNEX K

(*Clause* 9.1.6.2)

BACKING MATERIAL

K-1 The main purposes of backing material are twofold:

a) to mark the extent of BFS during ballistic evaluation; and

b) to simulate tissue response appropriately beneath the point of impact so that the BFS can be correlated to human injury to some extent[1].

K-2 Backing materials used during ballistic evaluation are generally oil based non-firing clays which soften on exposure to temperature, and exhibit shear thinning and thixotropic properties. These can be mineral clay where one of the main components is kaolin, or polymeric clay which use petroleum jelly and long chain aliphatic acids. However, as these are commercial materials, their exact composition is undisclosed and keep changing with time. The rheological and mechanical properties of these materials are influenced by the composition and additives used. Prior usage of the backing material also changes its subsequent properties because of thixotropicity. Knowledge of the backing material helps in understanding its behaviour under thermal and shear loads and also its service period.

K-3 Some of the properties of Roma Plastilina#1 (RP#1) are given in Table 20. Any new backing material can be analysed for these parameters using a rheometer. The new backing material can then be subjected to dynamic tests and ballistic evaluation and the results compared with RP#1 as control material[2].

Table 20 Rheological Properties of Roma Plastilina#1

(*Clause* K-3)

Sl No.	Parameter	Approximate Values
(1)	(2)	(3)
i)	Density (g/cc)	1.3 – 1.6
ii)	Linear viscoelastic region (LVE, percent)	0.01 percent
iii)	Storage modulus (Pa) at LVE	8×10^6
iv)	Loss modulus (Pa) at LVE	1.8×10^6
v)	Storage modulus (GPa, at temperatures 25 – 40°C)	7×10^6
vi)	Loss modulus (GPa, at temperatures 25 – 40°C)	2×10^6

1) Lehowicz L.G., Clay and Backing Materials — Chapter 4. Testing of Body Armor Materials for Use by the U.S. Army — Phase III: Letter Report, Committee to Review the Testing of Body Armor Materials for Use by the, U.S. Army, (National Academies Press Online, ISBN 978-0-309-25599-8, 2012) pp. 46-50.

2) Bhattacharjee, D., Kumar A., Biswas, I., Verma, S., and Islam, E., Rheological and Energy Absorption properties of Backing Materials for Measurement of Behind Armour Blunt Trauma, *Proc. of 29th International Symposium on Ballistics, Eds. Clive Woodley and Ian Cullis*, 9-13 May, 2016, Edinburgh, Scotland, UK.

ANNEX L

(*Clauses* 9.3.1 and 9.3.4)

BALLISTIC LIMIT

L-1 The ballistic limit or limit velocity is the velocity required for a particular projectile to perforate an armour 50 percent of the time.

L-2 Ballistic limit generally follows a logistic regression curve given by Fig. 22. The equation of logistic regression is given by:

$$p(v) = \frac{e^{\beta_0+v\beta_1}}{1+e^{\beta_0+v\beta_1}} \qquad \text{--- (9)}$$

Where $p(v)$ is the probability of complete perforation happening at velocity v.

L-3 β_0 and β_1 are logistic constants that can be obtained by fitting the velocity and perforation/non-perforation data in the above equation. There are many software which may be used to fit the data curve to obtain the two logistic constants.

Once the constants are obtained, V_{50} is given by:

$$V_{50} = -\frac{\beta_0}{\beta_1} \qquad \text{--- (10)}$$

L-4 The velocity at which the probability of complete perforation is x percent that is V_x is given by:

$$V_x = \frac{\ln\left(\frac{x}{1-x}\right)-\beta_0}{\beta_1} \qquad \text{--- (11)}$$

L-5 This equation shall be used to find the velocity at which probability of perforation is 5 percent as per 9.3.4(c). However, the data set shall be large enough for correct analysis. Hence minimum number of shots shall be maintained.

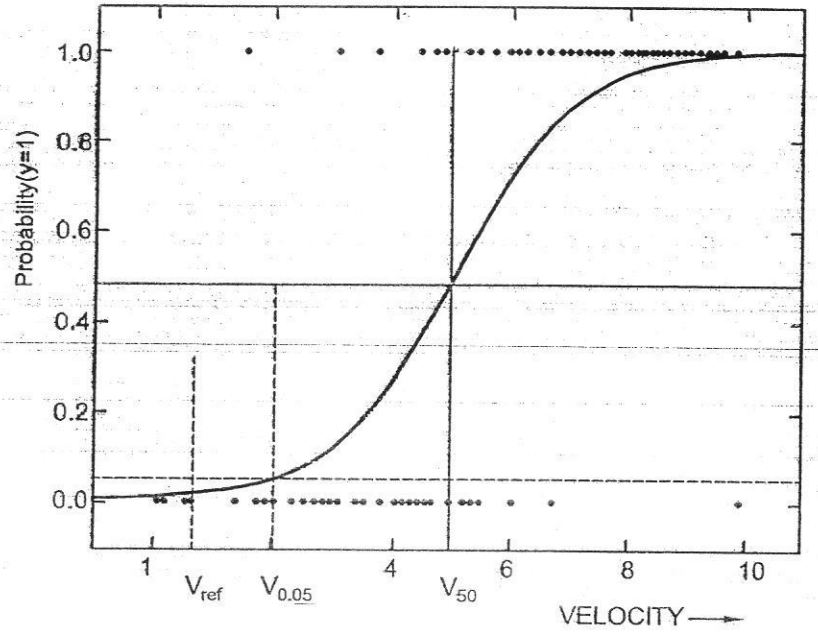


FIG. 22 LOGISTIC REGRESSION CURVE

ANNEX M

(*Clause* 11.1)

EXAMPLE OF BALLISTIC DATA SHEET

TP No.: ..... Trial date: .....

Trial indent No. and date:..... User: .....

Test stores:

Weapon/Barrel: **Registration No.:**

Sl No.	*Sample Code*	*Ammunition/ Lot*	*Conditioning Time*			*PVMS (m/s)*			*Impact result*		
			Time Start	*Time Stop*	*Time Taken/ Drying Time*	V_1	V_2	V_3	P/NP	*BFS*	*Observations*

Drop Test Results on conditioned backing material:-

Distance from target (m):-

1. Weapon		4. V_3	
2. V_1		5. LAOT	
3. V_2		6.	

Sample no.	**1**	**2**	**3**	**4**	**5**	**AVERAGE INDENTATION (mm)**	**Ambient Temperature (°C)**	**Ambient Humidity (%)**

Notes:

Trial Officer

ANNEX N

(Foreword)

COMMITTEE COMPOSITION

Textiles Protective Clothing Sectional Committee, TXD 32

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SCIENTIST 'D' (TXD), BIS

(*Continued from second cover*)

The composition of the Committee responsible for the formulation of this standard is given in Annex N.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Review of Indian Standards

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This Indian Standard has been developed from Doc No.: TXD 32 (12594).

Amendments Issued Since Publication

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AMENDMENT NO. 1 JULY 2020

TO

IS 17051 : 2018 TEXTILES — BULLET RESISTANT JACKETS — PERFORMANCE REQUIREMENTS

(*Page* 3, *clause* **3.20**) — Insert the following new clause after **3.20**:

'**3.21 Perforation** — Any impact that creates a hole passing through the armor. This may be evidenced by any of the following: (a) the presence of the projectile, a projectile fragment, or an armor fragment in the clay backing material; (b) a hole that passes through the armor and/or backing material; or (c) any portion of the bullet being visible from the body side of the armor panel.'

(*Page* 4, *clause* **5.1.1**) — Insert the following new note at the end:

'NOTE — The shelf life of outer carrier fabric without use in ambient prevailing conditions in India shall be 10 years minimum. However, the service or usage life of outer carrier shall be decided by the users.'

(*Page* 4, *clause* **5.1.4**, *line* 1) — Substitute 'A' *for* 'An additional'.

(*Page* 5, *clause* **5.1.8**) — Insert the following new note at the end:

'NOTE 2 — Quick release mechanism shall work along with double locking of kamarbandh.'

(*Page* 7, *clause* **5.2.7**) — Substitute the following for the existing:

'**5.2.7** *General Requirements for SAP and HAP*

The supplier shall declare the type of materials, number of layers, and their areal density in technical bid of tender and shall have to maintain the same in bulk supply. The information shall be kept in sealed/secured condition and shall only be opened in case of failure of lot during bulk testing for comparison.

NOTE — The sealed/secured packet is permitted to be opened by Technical Evaluation Committee (TEC) and after verification shall be kept in sealed/secured condition for future reference. This sealed packet may be retained for successful bidder and be returned for rest of bidders.'

(*Page* 7, *clause* **6.1.3**) — Substitute the following for the existing:

'**6.1.3** Threat level 2 onwards may be ICW or standalone configuration. In case of former, the flexible armour panels shall be compliant to threat level 1 in all cases. In case of standalone configuration samples, they shall be compliant to the required threats. Threat levels 3 shall also be compliant to threat level 2. Threat levels 4 and 5 shall also be compliant to threat level 3. For threat level 6, no other compliance is required'

Price Group 2

(*Page* 8, *Table* 7) — Substitute the following for the existing:

Table 7 Threat Levels

(*Clause* 6.1.1)

Sl No.	Threat Level	Ammunition	Bullet Weight (*see* Note 1) g	Bullet Type	Impact Velocity m/s	Distance of Impact m	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1	9 × 19 mm	7.4 - 8.2	FMJ/Pb	430 ± 15	5 ± 0.5	For all flexible panels (*see* Note 2)
ii)	2	7.62 × 39 mm	7.45 - 8.05	FMJ/MSC	710 ± 15	10 ± 0.5	—
iii)	3	7.62 × 51 mm	9.4 - 9.6	FMJ/Pb	838 ± 15	10 ± 0.5	In addition, shall be compliance with threat level 2
iv)	4	5.56 × 45 mm	3.5 - 4.0	FMJ/(SI+Pb)	890 ± 15	10 ± 0.5	In addition, shall be compliance with threat level 3 only
v)	5	7.62 × 39 mm	7.45 - 8.05	HSC	700 ± 15	10 ± 0.5	Compliance to threat level 2 is not required.
vi)	6	7.62 × 54R	10.3 -10.5	API	830 ± 15	10 ± 0.5	Compliance to threat level 2 to 5 is not required.
vii)	Special	Any other requirement by the user. Complete details of ammunition shall be stored for future upgradation of the standard.					

NOTES

1 Routine ballistic evaluation may use service ammunition where bullet weight is not considered. Bullet weight shall be considered for reloaded ammunitions.

2 In case of ICW configuration, for threat level 2 to 6, the flexible armour panels shall be compliant to threat level 1 in all cases.

FMJ:	Full Metal Jacket	Pb:	Lead Core
MSC:	Mild Steel Core	SI:	Steel Insert
HSC:	Hard Steel Core	API:	Armour Piercing Incendiary

(*Page* 9, *clause* **6.5.2.1**) — Substitute the following for the existing:

'**6.5.2.1** *Decision on major defect*

Lot shall be rejected, if the non-conformities are equal to or more than the rejection number corresponding to AQL of 2.5 percent (*see* Annex F)

NOTE — Constituent panels of a lot size shall be tested for non-conformities. For example, with a lot size of 100 bullet resistant jackets, 8 panels shall be tested for non-conformities (*see* Annex F).'

(*Page* 9, *clause* **7.1.2**, *sentence* 4) — Substitute the following for the existing:

'In the event of failure, subsequent testing on the same size shall not be permitted, but for other sizes may be permitted.'

(*Page* 9, *clause* **8.0**, *sentence* 1) — Substitute the following for the existing:

'Operating conditions as given in **8.1.1** (low temperature), **8.2.1** (water resistance), **8.2.2** (sea water resistance) and **8.3.2** (vibration test) shall be considered before ballistic evaluation of the bullet resistant jackets.'

(*Page* 9, *clause* **8.0**) — Insert the following note at the end:

'NOTE — If desired by the user, testing of panels in dry condition (range condition) may be excluded, if the panels are tested for other severe conditions (*see* **8.1.1**, **8.2.1**, **8.2.2** and **8.3.2**).'

(*Page* 10, *clauses* **8.1**, **8.1.1** *and* **8.1.2**) — Substitute the following for the existing clauses:

'**8.1 Extreme Temperatures**

Both SAPs and HAPs shall be subjected to the test specified in **8.1.1**.

8.1.1 *Low Temperature*

Sample shall be cooled to minus 40 ± 5°C for 4 h ± 10 min. The material shall be examined for delamination, matrix cracking, component separation, or any other visual defects. The samples shall be kept in range conditions (*see* **8.4.3**) for minimum 12 h before conducting ballistic evaluation.'

(*Page* 11, *clause* **8.3**, *line* 4) — Delete '**8.3.1** and'.

[*Page* 20, *Table* 11, *Sl No.* (ii), *col* 5] — Substitute '6' for '4'.

[*Page* 20, *Table* 11, *Sl No.* (ii), *col* 6] — Substitute '—' for '2'.

[*Page* 29, *clauses* **C-2**, **C-2.1** *and* **C-2.2**] — Substitute the following for the existing:

C-2 ICW CONFIGURATION

C-2.1 BFS: 25 mm

Size	XS			S			M			L			XL		
Threat	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2
1	2.26	2.43	2.93	2.54	2.71	3.21	2.83	3.00	3.50	2.99	3.19	3.79	3.28	3.48	4.08
2	4.26	5.41	6.83	4.64	5.84	7.28	5.03	6.28	7.74	5.30	6.63	8.22	5.71	7.09	8.62
3	4.39	5.61	7.09	4.78	6.05	7.55	5.18	6.50	8.02	5.46	6.86	8.51	5.87	7.34	8.92
4	5.32	7.00	8.91	5.76	7.51	9.45	6.21	8.03	10.00	6.54	8.47	10.58	7.00	9.02	11.04
5	5.86	7.79	9.95	6.32	8.34	10.53	6.79	8.91	11.14	7.16	9.39	11.76	7.65	9.99	12.25
6	7.59	10.37	13.33	8.14	11.05	14.06	8.71	11.75	14.81	9.16	12.38	15.60	9.76	13.12	16.18

C-2.2 BFS: 44 mm

Size	XS			S			M			L			XL		
Threat	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade 1	Upgrade 2	Standard	Upgrade	Upgrade 2
1	1.88	2.01	2.39	2.10	2.23	2.61	2.33	2.46	2.84	2.46	2.61	3.07	2.69	2.84	3.30
2	3.88	4.99	6.29	4.20	5.36	6.68	4.53	5.74	7.08	4.78	6.06	7.50	5.12	6.46	7.84
3	3.88	4.99	6.29	4.20	5.36	6.68	4.53	5.74	7.08	4.78	6.06	7.50	5.12	6.46	7.84
4	4.81	6.38	8.11	5.18	6.82	8.58	5.56	7.27	9.06	5.86	7.67	9.56	6.25	8.15	9.96
5	5.21	6.98	8.89	5.60	7.44	9.39	6.00	7.93	9.91	6.32	8.36	10.45	6.74	8.87	10.86
6	6.95	9.56	12.27	7.42	10.15	12.92	7.91	10.77	13.59	8.33	11.34	14.28	8.84	12.01	14.80

Configuration	SAP	HAP
Standard	Front, back and side protection	Front and back protection
Upgrade 1	Front, back and side protection	Front, back and side protection
Upgrade 2	Front, back, side, groin and throat protection	Front, back, side, groin and throat protection
NOTE — Shoulder protection SAP shall need to be specifically mentioned by the user with additional weight.		