[with imagery]

LEARNING OBJECTIVES

After reading this article, you should be able to:

- Describe general ballistic requirements, such as components of ballistic rounds and sizing of rounds
- List the types of glazing systems typically tested and applied based on specific attacks expected for a given building or occupancy
- Discuss the differences between prevalent ballistic standards and product ratings, as well as the general ballistic testing parameters employed
- Explain how the various ballistic standards and their ratings help determine the suitable kinds of glazing systems and fenestration products for a given situation

Ballistic Glazing: Windows and Doors Designed for Security and Protection

For building teams choosing and applying bullet-resistant glass systems, understanding test criteria and ballistics attack types is essential

By C.C. Sullivan

With concerns about domestic and overseas terrorism, increased gun ownership and carrying, and the prevalence of gun use in crimes, more building teams are incorporating ballistics knowledge into their design and construction competencies. In particular, practitioners need to know how ballistic rounds and threat types impact the specification, installation and operation of glazing systems. For certain building types and end-users, knowledge of ballistics performance for fenestration systems is vital — from schools and financial institutions to government buildings and high-end retailers.

Today, windows and doors can be engineered with frames and glazing that are highly resistant to expected threats. Laminated glazing products have been developed with laminates consisting of multiple plies of glass and sometimes with acrylic or polycarbonate panels, all bonded together with interlayers of polyurethane or other formulations. Employing one of the most referenced test standards, Underwriters

Ratings of Bullet Resistant materials as identified by UL 752:

Rating	Ammunition	Weight	(g)	Velocity min max fps	 mps	No. of Shots
LEVEL 1	9mm Full Metal Copper Jacket with Lead Core	124 grains	8	1175 1293	358	3
LEVEL 2	.357 Magnum Jacketed Lead Soft Point	158 grains	10.2	1250 1375	385	3
LEVEL 3	.44 Magnum Lead Semi-Wadcutter Gas Checked	240 grains	15.6	1350 1485	411	3
LEVEL 4	.30 Caliber Rifle Lead Core Soft Point (.30-06 Caliber)	180 grains	11.7	2540 2794	774	1
LEVEL 5	7.62mm Rifle Lead Core Full Metal Copper Jacket, Military Ball (.308 Caliber)	150 grains	9.7	2750 3025	838	1
LEVEL 6	9mm Full Metal Copper Jacket with Lead Core	124 grains	8	1400 1540	427	5
LEVEL 7	5.56mm Rifle Full Metal Copper Jacket with Lead Core (.223 Caliber)	55 grains	3.56	3080 3380	939	5
LEVEL 8	7.62mm Rifle Lead Core Full Metal Copper Jacket, Military Ball (.308 Caliber)	150 grains	9.7	2750 3025	838	5
Supplementary Shotgun	12-Gauge Rifled Lead Slug and 12-Gauge 00 Lead Buckshot (12 pellets)	1 oz.	28.3	1585	483	3
				1744		
		1.5 oz.	42	1200	366	3
				1320		

Laboratories (UL) 752, glazing laminators can determine the minimum thickness required for a given application or desired performance, which may be 3/4 inch or 3/8 inch, for example, to achieve the minimum protection rating of Level 1 for the resulting ballistic-rated glazing laminates. These transparent panels are designed to repel three rounds from a .9mm handgun.

Most building teams are familiar with glass interlayer products used for typical safety and security glazing, but interlayers for ballistic-resistant glass must achieve a significantly higher level of performance. These strong, sticky formulations such as copolymer polyurethane or thermoplastic polyurethane (TPU) are robust enough to hold together the mass of glass and polycarbonate and acrylic shattered under tremendous force. As a result, the glazing mass becomes a bullet-resisting, protective shield.

When and where is this impressive level of performance required?

Projects teams, led by knowledgeable owner organizations and key consultants, make hazard threat assessments that can be translated into smart design and construction decisions for any individual case. In the United States, most ballistic attacks come from handgun use, with the most likely weapons including .357 Magnum and the aforementioned 9mm models. Overseas, building teams encounter more use of larger weapons, such as the AK-47 assault rifle or the M-16 assault rifle found in greater use in South America. In any case, weapons are often aimed at prominent glass openings of buildings, where the target of the violence tends to be more visible.

That said, what do building teams need to understand in the area of ballistics? To develop their general ballistic knowledge, building teams could start by considering the term ‘bulletproof.” What does this mean, exactly? The fact is, there is no such thing as a bulletproof building assembly. There are many different kinds of bullets, or ammunition projectile rounds, and they are made with different weights and designed for traveling at specified velocities. In this way, they correspond to varying levels of threat, impact and force. Understanding those is the key to interpreting key standards and ratings that inform building application choices.

Basic Ballistic Concepts

Because of the variety of threats that may occur, the severity of these hazards are defined and calculated based on the type of firearm used, and the type of bullet or *round* discharged.

In this way, ballistic protection is defined by level ratings that reflect (a) the number of rounds and (b) the size of the weapons posing the threat. These range from small-caliber handguns to high-caliber rifles which may have high-velocity projectiles; each delivers a predictable amount of force in impacting a building exterior or opening. In general, a ballistic round comprises four components: the *bullet* (which may have a metal jacket); the *casing*; the propellant *powder* within; and a *primer*, the device or chemical (or both) that initiates propellant combustion to launch the projectiles.

Ballistic cartridges are designated by the diameter of the round, given first, followed by their cartridge length: for example, 7.62 mm x 51 mm. Ballistics experts will know that an Uzi, for example, shoots 9mm x 19mm rounds, while and AR15 or M16 shoots a 5.56mm x 45mm round (the same dimensions as the .223 Remington round, which is fired at lower pressures). The AK-47 shoots a 7.62mm x 39mm round, and M1, M14 and M60 machine guns shoot a 7.62mm x 51mm round (similar to .308 Winchester rounds). In addition, the weights of these bullets are known. (See Table 1.)

Bullet Weight

TABLE 1.

NOTE TO PRODUCTION: PLEASE CHANGE TABLE COLUMN HEAD TO “Bullet Weight” AND CHANGE TEXT AS GIVEN

Rifle	Cartridge	**Bullet weight**
M14 (1959)	7.62×51mm NATO	150 grains (9.7 g)
M16 (1962)	.223 Remington (M193 5.56×45mm	55 grains (3.56 g)
AK-47 (1949)	7.62×39mm	123 grains (7.9 g)

Rifle	Cartridge	**Bullet weight**
M14 (1959)	7.62×51mm NATO	150 grains (9.7 g)
M16 (1962)	.223 Remington (M193 5.56×45mm	55 grains (3.56 g)
AK-47 (1949)	7.62×39mm	123 grains (7.9 g)

With these characteristics of rounds in mind, products can be built to specific levels of threat and designed for resistance to those threats.

Ratings of Bullet Resistant materials as identified by National Institute of Justice (NIJ) 0108.01:						
Threat Level Rating	Ammunition	Weight grains	(g)	Velocity min	Velocity max	No. of Shots
LEVEL I	.22 long rifle high velocity lead	40 gr	2.6g	320+/-12 m/s	1050+/-40 ft/s	5
LEVEL I	.38 special round nose lead	158 gr	10.2g	259+/-15 m/s	850+/-50 ft/s	5
LEVEL IIA	357 mag. jacketed soft point	158 gr	10.2g	381+/-15 m/s	1250+/-50 ft/s	5
LEVEL IIA	9 mm full metal jacket	124 gr	8.0g	332+/-12 m/s	1090+/-40 ft/s	5
LEVEL II	357 mag. jacketed soft point	158 gr	10.2g	425+/-15 m/s	1395+/-50 ft/s	5
LEVEL II	9 mm full metal jacket	124 gr	8.0g	358+/-12 m/s	1175+/-40 ft/s	5
LEVEL IIIA	.44 mag. lead semi-wadcuttergas checked	240 gr.	15.55g	426+/-15 m/s	1400+/-50 ft/s	5
LEVEL IIIA	9 mm full metal jacket	124 gr	8.0g	426+/-15 m/s	1400+/-50 ft/s	5
LEVEL III	7.62mm (308 Winchester)full metal jacket	150 gr	9.7g	838+/-15 m/s	2750+/-50 ft/s	5
LEVEL IV	.30-06 armorpiercing	166 gr	10.8g	868+/-15 m/s	2850+/-50 ft/s	1

For example, body armor and other antiballistic components are tested to the U.S. National Institute of Justice (NIJ) "*Performance Standard for Ballistic Resistance*." This standard outlines handgun (HG) or rifle threat levels and associated test ammunition, which is used to support standards for products designed to resist impact from a specific caliber of threat ammunition. For example, common ballistic threats begin at *Level 1* (or NIJ Level 1) at the least impactful end of the spectrum, which includes a .22 long rifle and a .38 special handgun. *Level 2* threats include 9mm and .357 Magnum handguns, ammunition threats that are more powerful and potentially dangerous.

NIJ also promulgates a standard called the NIJ 0108.01, "*Ballistic Resistant Protective Materials*," which is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Bureau of Standards. It is organized by a list of 10 defined threat level ratings indicated from Level I and Level II-A through Level III-A, Level III, and Level IV. The threat level III-A was added in the 1980s to reflect a classification for the .44 Magnum and Submachine Gun 9 mm projectiles. Overall, the standard provides requirements for workmanship, labeling, and ballistic resistance.

Ratings of Bullet Resistant materials as identified by ASTM F1233						
THREAT LEVEL RATING	Ammunition	Weight grains	(g)	Velocity ft/s min	Velocity ft/s max	No. of Shots
LEVEL I	.38 special round nose lead	130 gr	8.0g	1230	1330	3
LEVEL 2	.44 mag. lead semi-wadcutter gas checked	240 gr.	15.55g	1400	1500	3
LEVEL 3	9 mm x 19mm (Submachine Gun)	124 gr	8.0g	1350	1450	3
LEVEL 4	7.62mm (308 Winchester) full metal jacket (M80)	150 gr	9.7g	2750	2850	3
LEVEL 5	.30-06 armor piercing (AP, M2)	166 gr	10.8g	2725	2825	3

The most common ballistic standards are the NIJ standards as well as **UL 752**, "Standard for Bullet-Resisting Equipment," mentioned above. UL 752 defines protection capacities from *Level 1* – three shots of a .9mm full-metal copper jacket round with a specified lead bullet core – through *Level 10*, with a minimum performance of resisting a single shot of a .50 caliber full metal jacketed lead round.

Other standards that specifically address building materials and glazing include **ASTM F 1233**, "Standard Test Method for Security Glazing and Systems." This standard rates bullet-resistant materials for threat-level ratings given as *Level 1* through *Level 5*. Unlike the NIJ and UL 752 tests for ballistics only, ASTM F 1233 allows for the testing of ballistics, physical attack, or a combination of both.

Two other important standards for building materials and systems are described later in this course: the *Walker-McGough-Foltz & Lyeria Test Procedure* for ballistic, physical and flame attack – better known as the **WMFL test** in many document references – and the U.S. Department of State Anti-Terrorism Standard **SD-STD.01.01** "*Forced Entry/Ballistic Resistant (FE/BR), Rev G*." This government-issued testing and certification protocol is used to verify that "specific building components utilized in U.S. diplomatic facilities constructed overseas provide protection to building occupants."

These standards set forth valuable methods for determining that building products are designed to resist impacts from a specific caliber rounds and, in some of the standards, other force, heat and chemical threats.

In designing building enclosures and especially openings for entries, windows and glass-and-metal exterior systems, antiballistic performance is considered as absorbing energy from those anticipated threat projectiles. The enclosure and fenestration systems are designed based on those specific projectiles traveling at a specified velocity. The target materials are also tested based on the standards' requirements for a specified pattern and shot spacing. Passing these tests to meet the standards means the building products meet the requirements but only for those projectiles employed and only at the speeds tested. If a larger, faster, or better penetrating projectile is used against these products, then failure can result.

As ballistics experts often say, "Someone always has a bigger gun." Building teams respond by planning on worst-case threat levels.

Ballistic Testing Parameters

Another consideration is that all building components and materials in a given assembly must be considered in ballistic testing – not just the glazing or the frame. For example, an opening's framing should prevent partial or complete ballistic penetration, and retain the glazing it holds – for this reason, bullet-resistant glazing provides limited protection if it is set within frames that are not certified for ballistic resistance.

Understanding the general ballistic testing parameters for glass and glazing offers building teams valuable insights into expected performance – and protection afforded – in real-world applications. In particular, the typical requirements for testing covers the following parameters:

- Weight restriction on rounds
- Shape and configuration of the projectile

- Velocities of rounds
- Number of shots required
- Location of shots
- Temperature of test specimen
- Penetration/spall
- Testing of glazing or entire fenestration system

In defining the above parameters, building teams can understand the effects of ballistic projectiles and their impacts on glazing, among other materials. For example, one key testing parameter is *spall*, defined as the material ejected from the rear surface of a bullet-resistant glass when the "strike side" or *attack face* is struck by a projectile. Spalling from glass comprises shards of glass that break away on the safe or protected side of the glass panel. The flying glass debris can cause eye trauma and other significant injuries including death in some instances.

Not surprisingly, spalling is a key consideration in selecting and specifying ballistic glass. Two general types of glass can be applied for ballistics-rated openings and glass enclosure systems: *Low-spall glass* is formulated to allow a small fractional percentage of spall – as compared to sample weight – to enter the protected area. Alternatively, *no-spall glass* is engineered to allow for no spall whatsoever. A no-spall glass laminate may combine a ballistic glass or acrylic panel with polyurethane film or polycarbonate panels on the protected side, for example. These sandwich materials are designed specifically to absorb ballistic forces while controlling material spall on the protected side of the enclosure.

Glass spalling is one failure mode for ballistic glass systems. A second important parameter for ballistic glazing materials and framing is *penetration*. If a bullet penetrates the fenestration system, that is considered a failure for ballistic testing — whether the failure occurred in a glazed lite or in a framing member. In addition, if only a minor piece of the round's bullet goes through the fenestration system, that is also considered a failure.

Whether the entire ballistic round or just the fragment create a through-hole in the fenestration assembly, it is a penetration and therefore a failure. By definition, a ballistic threat is the projectile fired from a weapon, and that action may lead to a full or partial penetration of materials. That penetration creates dangers for building occupants, and so must be prevented wherever possible.

Detailed Look at Standards

A number of standards govern ballistic performance, and none of them allow penetration. Some of them allow for use of low-spall products in meeting the project requirements, while some standards such as UL 752 do not allow for low-spall products. Of the critical standards to understand, these five are most relevant in the United States. A number of others used overseas are also described below.

• ***Standard UL 752.*** The standard UL 752 provides a rating system for interpreting ballistic protection in the specifying and application of glazed building assemblies. The rating levels may be viewed as ways to define a particular product type, which helps building teams conveniently identify the ballistic protection solution ideal for the application in question.

One of the pass/fail criteria for UL 752 is demonstrating the absence of glass spall toward the observer. This requirement for absolute protection from the ballistic threat is true at all rating levels of UL 752.

• ***Standard ASTM F1233.*** This standard evaluates the resistance of security glazing materials and systems against ballistic impact and impacts by blunt and sharp tools, as well as their resistance against thermal stress and chemical deterioration. According to the standards body ASTM, "This test method is based on field experience rather than laboratory analysis," and is meant to allow for "comparative evaluation of ballistic/forced entry/containment resistance of security glazings and systems." It is not used for determining "the absolute prevention of forcible entries or forced exits," however.

In the ballistic portion of the security glazing standard, glazing is subjected to impacts of three shots by various firearm types. The results are given as one of five performance levels, and they are generally applicable to laminate assemblies of at least 1-1/4 inches to 3 inches or more in thickness.

• ***NIJ 0108.01 Ballistic Standard.*** As described above, the NIJ is best known for its body armor standard and product ratings, and its standard 0108.01 is easy to apply though it reflects the era of its initial release in the mid-1980s before the proliferation of many larger-capacity, larger-caliber pistols seen today.

Manufacturers can self-test their products using NIJ's detailed standard, and many do. The NIJ ratings may be less granular than others — for example, a glass product meeting NIJ Level III may not qualify for any UL 752 ratings, because UL requires no penetration and no injurious spall, while NIJ tests for "complete perforation" of the test material. In other cases, the NIJ Level III product could also qualify under UL 752 for its Level 5, Level 7 or Level 8 ratings. For this reason, some savvy building teams may seek ratings beyond NIJ for their projects.

• ***WMFL Test Procedure.*** Named for the architects who defined and developed the standard, the Walker McGough Foltz Lyeria (WMFL) Test Procedure combines ballistic ratings with physical/flame attack, known in some literature as forced-entry/ballistic-resistant (FE/BR) testing. Along with a .44 Magnum ballistic test of 25 rounds, the procedure includes a battery of impacts from a sledgehammer and pipe to application of a propane burner. WMFL designates three resistance ratings with a survival time associated with each. Only one of those, Level I at 60 minutes, includes the 25 shots from the .44 Magnum. Level II and Level III are 60 minutes and 30 minutes, respectively, of physical attack without any ballistic impact.

Like most FE/BR standards, WMFL's time periods help building teams match perimeter reinforcing with how long it takes to reach building egress or safe zones.

• ***Department of State SD-STD-01.01.*** The Department of State's own rating protocol, standard SD-STD-01.01, is another FE/BR test developed uniquely for the needs of overseas buildings such as embassies and consulates. Preparing for threats such as military actions or mob attacks, the requirements include references to guideline specifications for products including doors, windows, modular panels, glazing materials and louvers.

Also a timed rating, SD-STD-01.01 has a 5-Minute threat-level rating with no ballistics test, and three others — 15-Minute, 60-Minute, and 15-Minute Fire Rated — with three different ballistic discharge impacts along with attacks by heavy hand tools. When a defined shape can pass through the glazed barrier, a failure has occurred and a timed rating is given. This *delay time*, as security experts define it, is a way to help ensure building occupants under threat will be able to secure documents, move to safe locations, and receive aid from local authorities.

A World of Safety Standards

The test protocols and ratings detailed above are by no means the only ones in use globally. In fact, a range of other ballistics standards and related codes await building teams active on projects overseas. Among the most common are UL 752 and the German standard **DIN 52290**, "Testing of Security Glazing for Bullet Resistance," promulgated by the Deutsches Institut fur Normung E.V. (DIN), which is similar to the European standard EN 1063, sometimes given as CEN 1063. The German protocol provides for shooting tests using different caliber rounds with various bullet cores and nose shapes, and it confers Class rating levels 1 to 5, with the higher numbers tested for NATO rifles at the highest velocities.

With a similarly structured test protocol, the **EN 1063** standard, created by the European Committee for Standardization, also resembles UL 752. There are seven standard threat ratings for small arms, from BR1 to BR7, which are also seen as B1 to B7 in product and testing literature, and two for shotgun munitions, SG1 and SG2. The European body also promulgates a standard for attack-resistant glazing, EN 356, which rates resistance against manual attack such as burglary.

In Australia and New Zealand, the two countries employ a joint standard — AS/NZS 2343:1997, "*Bullet Resistant Panels and Elements*" — which tests for ballistic resistance and includes requirements for spalling protection. Panel classifications span from Class G0 to Class G2 at the lower resistance levels to Classes R1, R2, S0 and S1 at the most robust, corresponding to more powerful munitions at greater velocities. Some tests also require specific patterns of strikes.

While the Australian, British, European, and German standards join the UL and ASTM protocols as by far the most prevalent in use worldwide, other local jurisdictions and agencies have codified their own ballistics tests and ratings. Some of these are summarized in tabular form in ASTM F1233 and referenced in U.S. Department of State and Department of Defense manuals.

The point of all the standards is similar: to be able to identify the material thickness required to stop ballistic attacks for a given product choice. In this way, the UL 752 standard provides a valuable visual guide for ballistics-rated projects. [See TABLE 02, page [NOTE TO PRODUCTION: PAGE NO. HERE].] For UL Level 1, for example, which is three shots of a 9 mm firearm, an all-glass or all-acrylic opening would require a material thickness of 1.25 inches. This compares to 0.875 inches for a glass-clad polycarbonate glazing, 1 inch for all polycarbonate, or 3/4 inch for an acrylic/polycarbonate panel. The UL 752 ratings also give minimum effective thicknesses for aluminum frames, steel frames and fiberglass wall armors.

TABLE 02 **Material Thickness Per Ballistic Assault**

	UL Level 1	**UL Level 2**	**UL Level 3**	**UL Level 4**	**UL Level 5**	**UL Level 6**	**UL Level 7**	**UL Level 8**
	3 shots	3 shots	3 shots	1 shot	1 Shot	5 Shots	5 Shots	5 Shots
	9 mm	.357 Mag.	.44 Mag.	.30-06 Rifle	7.62 mm	9 mm AK-47	5.56 mm	7.62 mm
All Glass	1.25"	1.75"	2.25"	2.25"	2.25"	1.8125"		2.4375"
Glass Clad Polycarbonate	.875"	1.0"	1.0"	1.25"	2"	1.25"	2"	2"
Arcylic/Polycarb.	0.75"	X	X	X	X	1.25"	X	X
Acrylic	1.25"	1.25"	1.25"	X	X	X	X	X
Polycarbonate	1.0"	1.0"	1.25"	X	X	X	X	X
Aluminum Frame	0.5"	0.5"	0.5"					
Steel Frame	0.25	.25"	.25"	.5"	.5"	.5"	.5"	.5"
Fiberglass Wall Armor	.1875"	0.3125"	0.4375"	1.1875"	1.4375"	1.1875"	1.1875"	1.4375"

These thicknesses vary depending on the manufacturer. What's noticeable in the table, however, is that some data is missing and that some material thicknesses are given as X marks, indicating that it *is not possible for that material or product to stop the particular ballistic threat*. In particular, acrylic-polycarbonate products, for example, cannot pass the testing protocols for UL Level 2, Level 3, Level 4, Level 5, Level 7 or Level 8. A panel of 1.25-inch-thick acrylic polycarbonate can stop five shots from a 9 mm AK-47, though, to meet UL Level 6. In fact, the acrylic and polycarbonate testing, alone and in combination, leaves some gaps in application possibilities.

As a last consideration, building teams and their suppliers and manufacturers can work with a range of testing agencies in order to determine suitable specifications for projects where ballistics ratings are essential to occupant and building safety. For this reason, working with the proper testing agency is critical to project performance.

Experienced building teams work with experienced manufacturers of certified ballistic-, attack- and blast-resistant products. These suppliers tend to have the toughest products for varied applications and price points. Even more important, they meet or exceed the most rigorous testing criteria – proven by the leading testing agencies conducting certification protocols and giving ratings. These include highly experienced agencies in certifying to the Department of State, UL, H.P. White, NIJ, and ASTM testing criteria.

[end – about 3,200 words]

[captions to come]

[TEST]

GLAZING EDUCATION MODULE –
QUIZ AND ANSWERS

ANSWERS

1. D
2. B
3. B
4. A
5. A
6. C
7. A
8. C
9. B
10. D

QUIZ

Questions

1. To achieve significantly higher levels of performance, ballistic-resistant glazing employs robust interlayer materials between thin panels of glass, polycarbonate and acrylic to form a force-resistant …

A. ... thermoplastic polyurethane.

B. ... framing member.

C. ... no-spall panel.

D. ... glazing mass.

2. Potential threats that may necessitate use of ballistic-resistant glazing are classified according to severity based on …

A. the thickness of glazing required.

B. the type of bullet or round.

C. the type of propellant employed.

D. total force, given in Newton-meters.

3. Bullets are designated by what characteristic, typically given first in their descriptions?

A. the length of the round

B. the diameter of the round

C. the bullet’s casing

D. the propellant combustion

4. Which rating refers to the least impactful ballistic threat level in the U.S. National Institute of Justice (NIJ) “*Performance Standard for Ballistic Resistance*”?

A. Level 1

B. Level 2

C. 15-minute

D. 60-minute

5. Unlike the NIJ and UL 752 tests for ballistics only, the standard ASTM F 1233, “Standard Test Method for Security Glazing and Systems,” rates materials based on testing of …

A. Ballistic threat and forced entry
B. Ballistic threat and blast resistance
C. Ballistic threat and hurricane impact resistance
D. Ballistic threat and acoustic resistance

6. Which key testing parameter examines the amount of material ejected from the rear surface of a bullet-resistant glass when the “strike side” or *attack face* is struck by a projectile?

A. Ballistic resistance
B. Threat level rating
C. Spalling
D. Complete perforation

7. An important parameter for ballistic glazing systems is penetration, which is considered a failure if a bullet …

A. … penetrates glazing materials or framing members
B. … penetrates a glazing lite only
C. … completes full penetration only
D. … penetrates as an entire bullet only

8. Which standard does NOT evaluate based on a combined forced-entry/ballistic-resistant (FE/BR) testing protocol?

A. SD-STD-01.01G
B. ASTM F1233
C. NIJ 0108.01
D. Walker-McGough-Foltz & Lyerla (WMFL)

9. The standards Walker-McGough-Foltz & Lyerla (WMFL) and the U.S. Department of State's SD-STD-01.01 test for resistance to forced entry with results given as:

A. Force values (Newton-meters)

B. Timed ratings

C. Pass-fail (penetration)

D. None of the above

10. According to the standard UL 752, acrylic-polycarbonate products are able to pass the testing protocols for UL Level 2, Level 3, Level 4, Level 5, Level 7 or Level 8.

A. UL Level 2

B. Level 3 and Level 4

C. Level 8

D. None of the above