TECHNICAL GUIDE

Integrated Security Glazing

Combined fire, forced-entry, ballistic and blast performance in a single assembly

A window asked to resist fire, forced entry, gunfire and blast is not four products stacked together. It is one assembly that must satisfy four unrelated test regimes simultaneously — and the measures that satisfy one routinely degrade another.

This guide sets out the four performance families, the standards that govern each, and — most importantly — the interaction effects that determine whether a specified combination is buildable at all.

1 · The four families, and why they do not add up

Each family is defined by a different physical event, measured by a different test, and expressed in a different vocabulary. There is no common unit and no conversion between them.

Family	The event	What is measured	Governing standards
Fire	Sustained heating to a standard furnace curve	Integrity, radiation, insulation over time	EN 13501-2 / EN 1634-1 / EN 1364-1 ASTM E119 · UL 263 · NFPA 252 / 257 · UL 9 / 10C
Forced entry	Sustained manual attack with tools	Time to breach, and whether a man-passable opening is created	ASTM F1233 · ASTM F3561 HPW-TP-0500.03 · SD-STD-01.01
Ballistic	Discrete high-velocity projectile impacts	Penetration, and whether spall is released on the protected face	UL 752 · NIJ 0108.01 · ASTM F1233 EN 1063 (glass) / EN 1522 & 1523 (assembly)
Blast	Transient overpressure and reversal	Where the glass ends up relative to the occupant	GSA-TS01-2003 · ASTM F1642 / F2912 EN 13541 / 13123 / 13124 · ISO 16933 / 16934

THE GOVERNING PRINCIPLE

A build-up certified to one family carries no standing in another. Ballistic certification implies nothing about blast; blast certification implies nothing about fire; and none of them implies forced-entry resistance. Each has to be evidenced separately, and each has to be evidenced for the **same physical assembly** — the same glass, interlayer, frame, bite, gasket, hardware and fixing.

2 · Forced entry

Forced-entry resistance is a **time** standard, not a strength standard. The assembly is attacked by trained operatives with a defined tool set for a defined period; it passes if no man-passable opening is created within that period. Glass that breaks but does not open is a pass.

Standard	Origin and application	How it is graded
ASTM F1233	The general architectural forced-entry standard for security glazing materials and systems	By class, reflecting the tool set and attack duration. Lower classes address basic hand tools; higher classes address heavy hand tools sustained over several minutes
HPW-TP-0500.03	US Department of State physical security test protocol, applied to diplomatic and mission entry-control glazing	By level, generally aligned to a stated attack duration
SD-STD-01.01	US Department of State forced entry and ballistic standard for certified protective glazing	Commonly quoted at 5, 15 and 60-minute forced-entry durations
ASTM F3561	Newer standard addressing combined forced entry and ballistic attack	Sequential ballistic attack followed by forced-entry attack on the weakened assembly

The consequence for glass make-up. Forced-entry resistance at the higher classes cannot be achieved with conventional polyvinyl butyral. Standard PVB is ductile and tears progressively under repeated tool strikes. Ionoplast interlayers — SentryGlas and equivalents — are approximately two orders of magnitude stiffer at room temperature and retain post-breakage structural capacity, which is why they are specified as mandatory above the lower classes. Polycarbonate composite strike faces are an alternative, at a cost in optical quality, abrasion resistance and thickness.

> **THE PARAMETER THAT IS ALWAYS MISSING**
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> Forced-entry duration is the parameter most often omitted from a specification. “Class III” without a stated attack time, tool set and reference protocol cannot be procured or verified, because the classes in the architectural and diplomatic standards are not interchangeable.

3 · Ballistic

Ballistic classes are defined by cartridge, bullet construction, mass, impact velocity, firing distance and number of shots. Moving up a class does not mean more of the same threat — it generally means a different weapon.

3.1 UL 752 — the assembly standard used in North American practice

Level	Cartridge	Bullet	Shots	Velocity (ft/s)
1	9 mm	Full metal copper jacket, lead core	3	1,175–1,293
2	.357 Magnum	Jacketed lead soft point	3	1,250–1,375

Level	Cartridge	Bullet	Shots	Velocity (ft/s)
3	.44 Magnum	Lead semi-wadcutter, gas checked	3	1,350–1,485
4	.30-06 rifle	Lead core soft point	1	2,540–2,794
5	7.62 mm NATO (.308)	Full metal copper jacket, military ball	1	2,750–3,025
6	9 mm	Full metal copper jacket, lead core	5	1,400–1,540
7	5.56 mm (.223)	Full metal copper jacket, military ball	5	3,080–3,388
8	7.62 mm NATO (.308)	Full metal copper jacket, military ball	5	2,750–3,025
9	.30-06	Armour piercing	1	2,715–2,987
10	.50 BMG	Full metal copper jacket, military ball	1	2,810–3,091

Levels 1 to 3 are handgun; 4 and 5 are single-shot rifle; 6 to 8 repeat the handgun and rifle threats at higher shot counts and, in the case of Level 6, higher velocity. A specification citing a level should be checked against the cartridge, because level numbers and threat descriptions are frequently transposed in project documents.

3.2 EN 1063 and EN 1522 / 1523 — the European system

Class	Cartridge	Bullet	Mass	Velocity	Range
BR1	.22 LR	Lead, round nose	2.6 g	360 m/s	10 m
BR2	9 × 19 Luger	Full jacket, round nose, soft core	8.0 g	400 m/s	5 m
BR3	.357 Magnum	Full jacket, cone, soft core	10.2 g	430 m/s	5 m
BR4	.44 Rem. Magnum	Full jacket, flat nose, soft core	15.6 g	440 m/s	5 m
BR5	5.56 × 45 (.223)	Full jacket, pointed, soft core, steel penetrator	4.0 g	950 m/s	10 m
BR6	7.62 × 51 NATO	Full jacket, pointed, soft core	9.5 g	830 m/s	10 m
BR7	7.62 × 51 NATO	Full jacket, pointed, **hardened steel core**	9.8 g	820 m/s	10 m
SG1 / SG2	12/70 shotgun	Solid lead slug — one shot / three shots	31 g	420 m/s	3 m

BR IS NOT FB

BR classes under EN 1063 apply to the glazing alone, tested as a 500 × 500 mm specimen. **FB** classes under EN 1522 and EN 1523 apply to the complete assembly including frame, seals, hinges and fixings. BR7 glazing in an untested frame is not an FB7 window — a round that cannot pass through the glass will pass through a bead, a gasket line or a fixing that was never tested.

3.3 Spall — the criterion that decides where people can stand

A build-up may stop the projectile and still eject fragments from the protected face at velocities capable of causing serious injury. EN 1063 records this as a suffix: **NS** where no splinters are released, **S** where they are. UL 752 requires no spall at the ratings it grants. NIJ 0108.01 does **not** assess spall at all, which is a material limitation when that standard is cited for occupied positions.

Where an operator sits directly behind the glazing — a counter, a gatehouse, a screening position — two mitigations are conventional, and they are not equivalent:

- **Canting the glazing** from vertical, typically by around ten degrees, so that a round strikes obliquely and any spall is directed away from the operator. This is a frame and architectural decision that must be taken at design stage, not at shop drawing stage.
- **An anti-spall film** on the protected face, typically 350 micron. Effective, but it becomes part of the tested assembly and cannot simply be added to a certified build-up without re-establishing the classification.

4 · Blast

Blast is the only one of the four families where the specification routinely fails to define the demand at all. A hazard rating states the acceptable outcome; it does not state the load. Both are required.

4.1 Defining the load

A blast load is described by peak reflected overpressure, positive phase duration and reflected impulse. Idealising the decay as linear, $i_r \approx \tfrac{1}{2} \cdot P_r \cdot t_d$, so any two define the third. Which parameter governs the response depends on the ratio of load duration to the natural period of the glazing, which for architectural panes is typically in the region of ten to thirty milliseconds.

Regime	Condition	Governing parameter	Typical source
Impulsive	Load duration well below the natural period	Impulse	High-explosive detonation, close in
Dynamic	Load duration comparable to the natural period	Both — full pressure-time history required	Detonation at moderate standoff
Quasi-static	Load duration well above the natural period	Peak pressure	Vapour cloud explosion or gas deflagration

THE QUESTION THAT CHANGES THE ANSWER BY 100%

Incident or reflected must be stated. A free-field side-on gauge and the building face read different pressures. At the low overpressures typical of process facility design the reflection factor is approximately two, rising sharply with pressure. A specification that gives a pressure without declaring which it is, is at minimum a factor of two ambiguous — and that ambiguity propagates through glass selection, frame sizing, anchorage design and structural verification.

4.2 Defining the acceptable outcome

GSA-TS01-2003 measures outcome by where the glass lands relative to a witness panel three metres behind the opening. The distinction between Condition 2 and Condition 3 is fundamental: Condition 2 requires the glazing to be **retained by the frame**; Condition 3 permits failure and controls only the travel distance.

Condition	Definition	Hazard	Protection
1	Glass not cracked. Fully retained by the frame. No fragments either side	None	Very high
2	Glass may crack but is **retained by the frame**. Dusting or very small fragments near the sill acceptable	Very low	Very high
3a	Glass fails and is **not retained**. Fragments land on the floor within approximately 1 m of the opening	Low	High
3b	Glass fails and is not retained. Fragments land within approximately 3 m	Low	High
4	Fragments travel beyond 3 m and impact a vertical surface below approximately 600 mm above floor level	Medium	Medium

Condition	Definition	Hazard	Protection
5	Fragments impact a vertical surface above approximately 600 mm — head and torso height	High	Low

WHERE THE MONEY IS

The cost difference between Condition 2 and Condition 3a is substantial and structural. Retention in the frame demands greater bite depth, a stiffer frame section, engineered anchorage in both directions and, frequently, structural silicone at every bonding line. Where a specification cites a Condition number alongside a descriptive text, and the two do not correspond, this must be resolved before any assembly is selected.

4.3 The European and international classifications

EN 13541 classifies glazing by pressure *and* impulse jointly, over a positive phase of not less than 20 milliseconds. A load satisfying the pressure band but not the impulse band does not fall within the class.

Class	Peak reflected pressure	Positive impulse	Duration
ER1	50 – 100 kPa	370 – 900 Pa·s	≥ 20 ms
ER2	100 – 150 kPa	900 – 1,500 Pa·s	≥ 20 ms
ER3	150 – 200 kPa	1,500 – 2,200 Pa·s	≥ 20 ms
ER4	200 – 250 kPa	2,200 – 3,200 Pa·s	≥ 20 ms

Suffix **NS** denotes no splinters detached from the protected face; **S** permits splintering. EN 13123 and EN 13124 extend classification to complete windows, doors and shutters — EPR classes by shock tube, EXR classes by open range test. ISO 16933 provides open-arena classification with EXV vehicle-bomb and SB satchel-bomb classes; ISO 16934 the shock tube equivalent.

NO CROSS-WALK EXISTS

None of these systems converts into any other. An EN 13541 ER2 classification carries no GSA Performance Condition and no ASTM hazard rating, and the reverse holds equally. Where a project cites more than one system, each must be evidenced independently for the assembly as supplied.

5 · Fire

European classification to EN 13501-2 uses three criteria, each with a period in minutes: **E** integrity, the exclusion of flame and hot gases; **W** radiation, limiting radiated heat on the unexposed face; **I** insulation, limiting temperature rise on the unexposed face. The subscripts EI_1 and EI_2, applicable to doorsets only, differ in the location of temperature measurement relative to the frame and glazing edge.

North American practice divides fire-rated glazing into **fire-protective** products, tested to NFPA 252 / UL 10C and NFPA 257 / UL 9, which exclude flame and smoke but not radiant heat and are therefore subject to area limitation; and **fire-resistive** products, tested to ASTM E119, UL 263 or NFPA 251 to the same criteria as a wall, and consequently not area-limited. Assemblies rated above 20 minutes must additionally survive the hose stream test.

FIRE-PROTECTIVE AND FIRE-RESISTIVE

The functional distinction is between excluding flame and excluding heat. It maps loosely onto the E and EI classes but is not an equivalence: the furnace curves, pass criteria and hose stream requirement differ, and a product classified under one system holds no standing under the other.

6 · Interaction effects

This is where combined-performance specifications succeed or fail. The measures that satisfy one performance family frequently degrade another, and several combinations that appear reasonable on paper are not buildable as certified assemblies.

6.1 Fire and ballistic are largely mutually exclusive

Insulating fire-rated glazing achieves its EI performance through intumescent interlayers that expand and opacify under heat. These layers are formulated for thermal behaviour, not structural capacity; they are not ballistic interlayers and cannot be substituted for one. Conversely, a ballistic build-up of thick glass plies and ionoplast interlayers has no fire classification and will fail an integrity test rapidly. Products combining both exist, but they are specific certified constructions — not a matter of adding plies. Where a single opening is required to be both fire and ballistic rated, this must be identified at design stage, because the available product set is narrow and the lead times are long.

6.2 Interlayer selection is a four-way compromise

	Standard PVB	Ionoplast (SGP and equivalents)
Stiffness	Ductile; low shear transfer between plies	Approximately two orders of magnitude stiffer at room temperature; substantial shear transfer
Post-break behaviour	Membrane action; retains fragments but offers little residual structure	Retains significant post-breakage structural capacity
Forced entry	Tears progressively under repeated tool attack; inadequate at higher classes	The conventional requirement above the lower classes
Blast	Ductile membrane response, well suited to fragment retention	Stiffer response, higher reaction into the frame and anchorage
Temperature	Softens appreciably; performance is temperature dependent	Better retained stiffness at elevated temperature, relevant in Gulf service conditions

The consequence is that specifying ionoplast to satisfy forced entry **increases** the reaction delivered into the frame and anchorage under blast, because a stiffer pane transmits more load and absorbs less through deflection. The forced-entry decision and the anchorage design are therefore not independent.

6.3 Glass type: the blast and ballistic requirements pull apart

- **Annealed float** fractures into large, sharp shards. It is the worst performer under blast and should not appear on the protected face of any security assembly.
- **Fully tempered** is substantially stronger and dices on failure, but releases the entire pane at once and stores significant strain energy — under blast the failure is sudden and total.
- **Heat-strengthened** offers intermediate strength with a larger fracture pattern that laminates hold together more effectively. It is frequently the preferred substrate for laminated blast glazing for precisely this reason.
- **Laminated** construction is what actually delivers retention. The glass carries load until it breaks; the interlayer carries it thereafter.

6.4 Insulating unit orientation

In an insulating glass unit the outer lite is effectively sacrificial under blast: it fails first and its fragments are ejected outwards. The inner lite governs what enters the occupied space. Placing the laminated security build-up on the outer position and a monolithic pane on the inner position therefore inverts the intended protection — the laminate absorbs energy the occupant never sees, while the unlaminated inner pane becomes the fragment source.

> **A SPECIFICATION WORTH CHALLENGING**
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> Where an insulating unit is required for thermal reasons in a blast-rated zone, the security laminate belongs on the **inboard** lite. Where a specification shows the reverse, it should be queried before procurement. Where thermal performance is not required — internal partitions, screening counters, gatehouse vision panels — a monolithic laminate is both better performing and considerably less expensive than an insulating unit.

6.5 Thermal stress in Gulf service

Thick multi-ply laminates absorb substantially more solar energy than conventional glazing. Combined with high ambient temperatures, partial shading from deep reveals or canopies, internal blinds close to the glass, and any solar-control coating, the resulting temperature differential across a pane can exceed the thermal stress capacity of annealed glass. Any annealed component in a security build-up should be assessed for thermal stress, and heat-strengthening specified where the assessment requires it. This is a routine cause of unexplained glass breakage in the region and it is unrelated to the security performance.

6.6 The weight cascade

Soda-lime glass masses approximately 2.5 kg per square metre per millimetre of thickness. A combined forced-entry, ballistic and blast build-up of the order of 40 mm of glass, plus interlayers, approaches **100 kg/m²**. A single unit at 1.5 × 2.5 m therefore approaches **375 kg**.

That figure propagates through the entire design:

- **Frame section** must carry the dead load in addition to the blast reaction
- **Hinges and operating hardware** on any opening leaf must be rated for it, and must themselves form part of the tested assembly
- **Anchorage and substrate** must be verified for the combined dead load and reversing blast reaction
- **Structural slab and lintel capacity** must be confirmed by the project structural engineer
- **Installation method** requires mechanical lifting and glazing robots, with implications for access, programme and site logistics
- **Transport and handling** — units of this mass frequently exceed the safe manual handling capacity assumed in standard facade programmes

7 · Frame, bite and anchorage

In published blast trials the recorded failures are overwhelmingly failures of the frame, the fixings and the adhesive bonds — not of the glass. The load must travel from the glass surface through the bite, the gasket, the bead or pressure plate, the frame section, the anchor and into the structure, and it will find the weakest element on that path.

- **Bite depth** governs whether the pane can pull out of the rebate before the glazing has developed its capacity. Higher performance levels demand deeper bite, which increases frame depth and reduces vision area — an architectural consequence that must be resolved early.
- **Edge cover and setting blocks** determine how load is introduced into the glass edge. Concentrated bearing at the corners initiates failure well below the theoretical capacity.
- **Reversal.** The negative phase of a blast reverses the reaction at every fixing. Details that bear only in compression release the glazing on rebound. This is a documented failure mode, not a theoretical one.
- **Anchorage reactions** must be calculated, stated and issued to the project structural engineer for verification of the receiving structure. A correctly engineered window fixed into inadequate construction is not a rated installation.
- **Structural sealant** grade and cure regime form part of the certified assembly. Single and two-component silicones are not interchangeable where the specification distinguishes them, and full cure periods are measured in weeks, not days — a programme item, not a detail.

8 · Test evidence, and what invalidates it

Every one of the four families is a test standard. There is no analytical route to a glazing classification, because interlayer behaviour, adhesive peel and tear initiation are not calculable with the confidence a classification implies. Frame and anchorage capacity may properly be established by calculation; the glazing classification may not.

A valid test report identifies, at minimum:

- The accredited laboratory, a unique report number and the date of test
- The complete specimen as tested — glass build-up ply by ply, interlayer type and thickness, frame section, bite depth, gasket, sealant, anchorage method and fixing centres
- The measured loading actually applied, not the nominal target
- The outcome specimen by specimen, with the classification stated as an explicit verdict

THE LIMITS OF A TEST REPORT

A report attests to the specimen tested. Any material departure — glass make-up, interlayer, overall size, aspect ratio, frame section, bite, fixing centres or the addition of an applied film — places the installed configuration outside the tested envelope. A tested product installed to an untested detail is an uncertified product, and extension beyond the tested envelope requires documented engineering justification, declared on the submittal.

9 · The specification failures that cost most

	The failure	Consequence
1	A blast Performance Condition stated with no design load	The demand is undefined. No laboratory can certify and no engineer can verify. The package cannot be procured as written
2	A pressure stated without declaring incident or reflected	A factor of two on the design load, propagating through glass, frame, anchorage and structure
3	A condition number contradicting its own descriptive text	Frame retention versus controlled fragment travel — a structural difference in the assembly and a substantial difference in cost
4	A ballistic level number contradicting the cartridge described	Handgun and magnum threats demand materially different build-ups, weights and frame sections
5	A forced-entry class with no attack duration or reference protocol	Architectural and diplomatic forced-entry classes are not interchangeable and cannot be priced against one another
6	The security laminate placed on the outboard lite of an insulating unit	Inverts the protection. The occupied side is left with the unlaminated pane
7	An insulating unit specified where no thermal requirement exists	Significant unnecessary cost at internal partitions, counters and gatehouse vision panels
8	Applied film added to a certified assembly after the fact	Places the installation outside the tested envelope unless the film formed part of the test
9	Security zones described in prose rather than scheduled against type tags	The scope cannot be measured, priced or verified on site
10	Weight and handling addressed at shop drawing stage	Discovered when the structure, openings and installation method are already fixed

10 · Information required to specify or price with confidence

Family	Required inputs
Fire	Classification and period, by system (EN or US). Compartment drawing. Whether the element operates. Wall build-up at the junction
Forced entry	Class, reference protocol, attack duration and tool set. Whether combined ballistic-then-forced-entry sequencing applies
Ballistic	Class and standard. Spall requirement (NS or S). Threat face. Whether glazing alone or complete assembly is to be classified. Operator proximity and any cant requirement
Blast	Peak reflected overpressure, positive phase duration and impulse — or charge weight, TNT equivalent, standoff and detonation geometry. Incident or reflected. Required hazard rating or Performance Condition. Whether the negative phase is to be considered
Common	Element schedule with type tags mapped to security zones and areas. Substrate type and structural capacity at anchorage points. Thermal, acoustic and solar requirements. Whether existing test evidence is acceptable or new testing is required, and whose scope that testing sits in

11 · Capability

British Aluminium engineers, fabricates and installs certified glazing assemblies across all four performance families, in aluminium and in steel, to both European and North American standards. Our work begins where the catalogue ends — at the performance a specific opening has to deliver, and at the evidence required to demonstrate it.

Range	Products	Standards
Fire-rated doors	Hinged, pivoted, sliding and automatic sliding; solid and glazed	EN 13501-2 / EN 1634-1 · UL 10C / NFPA 252
Fire-rated windows and screens	Fixed and operable windows, glazed screens and partitions	EN 13501-2 / EN 1364-1 · UL 9 / NFPA 257 / ASTM E119
Fire-rated curtain wall	Stick-built and unitised, internal and external	EN 1364-3 · ASTM E119 / UL 263
Blast-resistant systems	Curtain wall, windows, aluminium and steel blast doors, bunker and hangar doors	EN 13123 / 13124 / 13541 · GSA-TS01 / ASTM F1642 / UFC
Ballistic-resistant systems	Aluminium and steel framed glazing, doors and public counters	EN 1522 / EN 1063 · UL 752 / NIJ 0108.01
Acoustic systems	80 mm and 100 mm double-glazed partitions, acoustic doors and screens	EN ISO 10140 / EN ISO 717-1 · ASTM E90 / E413 / E1332
Combined performance	Fire with blast, ballistic with acoustic, and other multi-requirement assemblies	Certified per configuration

- **In-house design office** — structural calculation, thermal and acoustic modelling, blast assembly engineering and bespoke detail development. Every project is engineered as a complete frame, glass and hardware assembly.
- **Controlled standards library** — American and European fire, forced-entry, ballistic and blast standards, so design work begins from the correct performance criteria rather than from an assumption.
- **Accredited third-party testing** — products are developed towards, and validated by, independent test at accredited laboratories, with the tested configuration fully recorded.
- **Certified detail discipline** — the tested detail is treated as fixed. Any proposed departure is handled as a formal deviation and disclosed, not absorbed silently into the shop drawings.

How to start. Issue the elevations, the door and window schedule with type tags, the compartmentation and security zoning drawings, and whatever performance criteria have been established. Where the criteria are incomplete — and in combined-performance packages they usually are — we will set out precisely what is missing, what we have assumed in the interim, and what the assumption is worth in cost terms, before anything is priced.

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Issued for information. Selection of fire ratings, forced-entry classes, ballistic levels, design blast loads and hazard ratings is the responsibility of the project's fire engineer, security consultant, blast engineer and the authority having jurisdiction. This document does not constitute fire, security or blast engineering advice. Threat data and classification descriptions are summarised for guidance; classification for any assembly is established solely by test to the governing standard. Standards are cited as at the date shown and this guide is revised without notice; always work from the current issue.