
**Glass in building — Explosion-resistant
security glazing — Test and classification
for arena air-blast loading**

*Verre dans la construction — Vitrages de sécurité résistant à
une explosion — Essai et classification par charge circulaire d'air*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16933 was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 2, *Use considerations*.

Introduction

This International Standard provides a method for carrying out arena blast tests in order to assess and classify the response of glazing to the overpressure and impulse characteristics of high-explosive blasts. This International Standard provides criteria for rating the level of damage to the glazing and the hazard consequences to the area located behind the glazing. The increasing use of glazing designed to protect persons and property from accidental explosions, and from the effects of terrorist attacks with high explosives, has prompted the preparation of this International Standard.

Structural response to blast loading is dependent upon specimen size and edge constraint as well as material composition and thickness. The classifications and test results derived by using this International Standard can be used in conjunction with calculation procedures and further validation tests on framed glass during the process of designing complete glazing systems against explosive threats.

The following annexes are included in this International Standard:

- Annex A (normative) Blast parameters and derivation
- Annex B (informative) Characteristics of blast shock waves and explosives
- Annex C (informative) Nominal charge size and standoff distances
- Annex D (informative) Fragment dimensions and criteria comparisons

Glass in building — Explosion-resistant security glazing — Test and classification for arena air-blast loading

1 Scope

This International Standard provides a structured procedure to determine the air-blast resistance of glazing and sets forth the required apparatus, procedures, specimens, other requirements and guidelines for conducting arena air-blast tests of security glazing. Seven standard blasts simulating vehicle bombs and seven standard blasts simulating smaller satchel bombs that can be used to classify glazing performance are incorporated in this International Standard and cover a broad range of blast parameters.

Security glazing, including that fabricated from glass, plastic glazing sheet material, glass-clad plastics, laminated glass, insulated glass, glass/plastic glazing materials and film-backed glass, can be tested and classified in a standard frame or tested but not classified in frames provided with the glazing.

Classification and ratings are assigned based on the performance of glazing loaded by air-blast pressures and impulses, and are specific to the blast characteristics under which the test takes place. Glazing that has received an air-blast classification and rating is suitable for use in blast-resistant applications only for blasts of comparable characteristics and only if installed in a properly designed frame. Design based on knowledge of the air-blast resistance reduces the risk of personal injury.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 48:1994, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

air-blast pressure history

description of the pressure of a reflected or free-field air blast, as measured at a point on the surface and consisting of two separate phases:

- positive phase, which is characterized by a nearly instantaneous rise to a maximum pressure followed by an exponential decay to ambient pressure;
- negative phase, immediately following the positive phase, during which the pressure decreases below ambient for a period of time before returning to ambient

3.2

ambient temperature

temperature at which the test is conducted

3.3

blast mat

steel or concrete pad upon or above which a high explosive may be detonated to reduce the incidence of ejecta

3.4

breach

any perforation or opening through the test specimen or between the test specimen and the support frame, evident after the test, through which a 10 mm diameter rigid bar can be gently passed without force

NOTE An opening may be caused by the glazing sheet infill pulling away from the rebate sufficiently to result in a visible gap that exposes the edge of the sheet.

3.5

cartridge paper

thick white paper for pencil and ink drawings, typically about 130 g/m²

3.6

free-field air-blast pressure

blast pressure acting at any given point in the free field, where there is no structure or other object disturbing the blast wave propagation

NOTE Also referred to as incident pressure, being the pressure measured on surfaces incidental to or parallel with the direction of travel of the blast front.

3.7

fragment

any particle with a united dimension of 25 mm (1 in) or greater

NOTE The united dimension of a glass particle is determined by adding its width, length and thickness. Glazing dust, slivers and all other smaller particles are not accounted as fragments.

3.8

glazing

glass or plastics glazing sheet material, including glass/plastic combinations

3.9

indents

any detectable deformation of the foil or cartridge paper surface of the witness panel caused by impact of any material as a result of the blast

3.10

peak-positive air-blast pressure

maximum measured positive phase air-blast pressure

NOTE If the measured pressure-time trace has sharp irregularities, the trace should be smoothed to produce a pressure-time trace that closely matches the mean path of the recorded trace. The peak pressure, $P_{\max}$, of relevance is the resulting smoothed value.

3.11

perforations

any holes in the foil, cartridge paper or plain surface of the witness panel caused by impact of any material as a result of the blast

3.12

positive phase impulse

integral of the measured positive phase air-blast pressure history

3.13

reaction structure

all elements of the structure designed to support the test frame or alternative means for holding the glazing to be tested

3.14**reflected air-blast pressure**

pressure increase that a surface, oriented other than parallel to the line from the detonation point to the surface, experiences due to the detonation of a high-explosive charge

3.15**standoff distance**

perpendicular distance from the plane of the front surface of the glazing to the centre of the explosive charge or from the centre of the glazing if not perpendicular to the explosive

3.16**test frame**

reaction structure, to which are fastened all elements that are used to directly support the glazing during classification of the glazing

3.17**witness panel**

panel of deformable material positioned behind the test specimen in order to register the incidence of material forcibly detached from the test specimen during test

NOTE The composition and location of the witness panel is described in 6.6.

4 Hazard rating

A hazard rating is applied to glazing based on its performance under the blast conditions chosen for the test. The rating is specific only to those blast conditions.

5 Test specimens**5.1 Number of test specimens**

For the purpose of classifying glazing a minimum of three test specimens, each $(1\,100 \pm 5\text{ mm})\text{ mm} \times (900 \pm 5)\text{ mm}$ shall be tested at a given level of air blast, defined in terms of peak positive air-blast pressure and positive phase impulse. One additional specimen shall be provided for pre-test measurements. Glazing of other sizes may be tested if the manufacturer supplies framed glazing or frame specifications. As such non-standard glazing assemblies may only be tested but not classified in accordance with this standard, the number of test specimens will be as agreed prior to test.

5.2 Multiple specimens

The air-blast resistance capacity of glazing does not imply that a particular specimen resists the specific air blast for which it is rated with a probability of 1,0. However, the probability that a single glazing or glazing system will resist the specific air blast at the particular level for which it is rated increases proportionally with the number of test specimens that successfully resist that air blast at that level. The protection afforded against a blast by a single item of glazing depends not only upon the glazing but also upon the manner in which it is attached to the structure in which it is mounted.

5.3 Handling and storage

The test specimens shall be handled and stored in compliance with the manufacturer's instructions.

5.4 Marking

Each specimen shall be marked with the manufacturer's model and serial numbers and the date of manufacture. The attack side is intended to be oriented towards the explosive charge and shall be marked by