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Road vehicles — Determination of resistance to forced entry of security glass constructions used in vehicle glazing — Test of glazing systems

Véhicules routiers — Détermination de la résistance à la force d'intrusion des constructions de vitres de sécurité utilisées dans les vitrages de véhicules — Essai des systèmes de vitrages

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 35, *Lighting and visibility*.

Introduction

The vast majority of potential attacks using hand-held implements can be narrowed down to two basic types of attack: attack with a sharp instrument and attack with a blunt instrument. Such attacks are reproduced by these procedures using standardized tests. The levels of energy/force used in the tests are designed to reflect strength of attack that is within the limits of human capability.

As the construction of the window frame plays a particularly important role in providing resistance to forced entry, any glazing requiring classification approval by this International Standard needs to be tested within its own original car body section, e.g. its own door assembly.

By defining performance levels of attack resistance, it is possible to classify the intruder resistance properties of a given glazing within a system part.

Road vehicles — Determination of resistance to forced entry of security glass constructions used in vehicle glazing — Test of glazing systems

1 Scope

This International Standard provides test procedures that are designed to assess levels of resistance to forced entry provided by security glazing used in vehicles. Security glazing to be tested shall provide a certain (higher) level of protection against vehicle intrusion than standard safety glazing. This International Standard does not apply to conventional safety glazing material that meets the requirements of international automotive glazing material standards similar, but not limited to ECE R43.

This International Standard's goal is to quantify how much resistance can be provided by particular system parts (security glazing with associated part of the car body) against rapid unauthorized entry into vehicles. The test methods used have been designed more to simulate opportunist theft attacks using simple implements, which could be easily carried about a person rather than by "calculated theft" using specialist tools which a professional thief might use. That range of tools is limited to hand-held and non-powered instruments that could physically provide access to a vehicle.

2 Normative references

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

ISO 513, *Classification and application of hard cutting materials for metal removal with defined cutting edges — Designation of the main groups and groups of application*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 4130, *Road vehicles — Three-dimensional reference system and fiducial marks — Definitions*

EN 10027-2, *Designation systems for steels — Part 2: Numerical system*

DIN 5131, *Hatchets*

DIN 7287, *Steel axes and hatchets — Technical specifications*

DIN 53479, *Testing of Plastics and Elastomers; Determination of Density*

3 Terms and definitions

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

3.1
attack test
predetermined series of blows to a specific area of a *system part* (3.13) applied with well-defined energy levels and a *standardized tool* (3.12)

3.2
blunt attack
attempt to break into a vehicle where the energy of attack is exerted onto the *system part* (3.13) by a blunt or rounded impacting tool

3.3
cutting attack
attempt to break into a vehicle where the energy of attack is exerted onto the *system part* (3.13) by a tool with a sharp cutting edge

3.4
displacement test
test to evaluate the level of retention of glazing within its frame or the associated car body using a spherical-faced tool constantly moved against the inside centre of the glazing until a well-defined level of force is reached

3.5
effective mass
mass of a freely moving implement that, driven by the same kinetic energy, would hit the *system part* (3.13) with the same speed as the *effective tool* (3.6) implemented in the test apparatus

Note 1 to entry: Implements with the same effective mass and with same kinetic energy will develop same speed; kinetic energy and speed are the fixed parameters to study interaction between *standardized tool* (3.12) and system part. For technical reasons, additional construction elements are required moving with the standardized tool affecting the relationship between kinetic energy and speed. A procedure is given to measure the effective mass for a given design and facilitate countermeasures.

Note 2 to entry: The effective mass is calculated out of measurement results from a drop test using the effective tool's gravitational force, the stroke height, and the speed at the *impact point* (3.8) as shown in 5.2.

3.6
effective tool
mechanical unit consisting of the standardized tool and all moving parts attached to it

Note 1 to entry: During the entire test procedure, only the *standardized tool* (3.12) itself shall come into contact with the *system part* (3.13).

3.7
forced entry testing
standardized test procedure in two parts (*attack test* (3.1) sequence with blunt tool and attack test sequence with cutting tool) to assess the resistance of glazing within a given part of a car body against forced entry

3.8
impact point
location on the *standardized tool* (3.12) at which first contact to the *system part* (3.13) is made during the *attack test* (3.1)

3.9
level of attack resistance
measure in five discrete steps of the ability of a *system part* (3.13) to resist a forced entry of a certain strength specified by the number of tool impacts, their energies, and forces for displacement

Note 1 to entry: For higher levels of attack resistance, a larger number of impacts as well as higher energies and forces are required.

Note 2 to entry: If a system part passes the *forced entry testing* (3.7) as described, then the system part meets the requirements of the specific level of attack resistance for which it was tested. If the results for the *attack test* (3.1) sequences with cutting and blunt tool are different, the overall test evaluation will correspond to the lower level of the two results.

3.10
pointed attack
attempt to break into a vehicle where the energy of attack is exerted onto the *system part* (3.13) by a pointed tool

Note 1 to entry: Pointed attack can cause the glazing to crack or to develop full, localized penetration of the glass pane.

3.11
resistance to forced entry
ability of a glazing to resist the attempt to penetrate glazing using simple tools

Note 1 to entry: The strength of resistance will be quantified by use of distinct levels called levels of attack resistance.

Note 2 to entry: This property is only appropriate for the *system part* (3.13) under test using standardized conditions and does not take into account all aspects necessary to evaluate resistance to forced entry of a complete vehicle. For example, location of glazing in the vehicle or strategy of the attack could affect this property and are out of the scope of this International Standard.

3.12
standardized tool
testing device that simulates forced entry by cutting, pointed, and *blunt attack* (3.2)

Note 1 to entry: Each device aims to represent a respective category of tools that could potentially be used for forced entry into a vehicle.

3.13
system part
original security glazing and the associated part of the car body (e.g. the window pane and door of a given vehicle)

3.14
test element
part of the *attack test* (3.1) sequence referring to an attack test using one of the *standardized tools* (3.12)

3.15
tool axis
construction line that passes through the tool's *impact point* (3.8) and is in line with the direction of movement immediately before it hits the system part (direction of action)

3.16
tool's direction of action
direction in which the tool is moving immediately before it hits the *system part* (3.13)

Note 1 to entry: If the tool is following a circular path, the direction of action is the tangent to the circular path at the *impact point* (3.8), immediately before tool applies force to the system part.

4 Principle

A wide range of attacks using various hand-held tools will be simulated by only two different test procedures applied to the same kind of system part. The results of both tests will be taken to generate a classification of resistance to forced entry by the use of levels of attack resistance.

Both test procedures, called "attack test sequence with blunt tool" and "attack sequence with cutting tool" cover three test elements, each applied to the same kind of system part, representing all relevant elements of a forced entry with handheld tools.

In a first step of an attack test sequence, the glazing is impacted by a pointed tool. This reflects the attempt to destroy the integrity of the brittle glazing component(s) for a forced entry as a first step, getting access to the vehicle straight away or weaken the system part for further attacks with cutting or blunt tools to finally create a sufficient opening for access.

For the second step of an attack, test sequence attempts are made to create an opening in the glazing, or between the glazing and the surrounding frame large enough to get access to the vehicle. This is done by striking the glazing system part repeatedly using specific tools which represent groups of blunt tools on one hand or cutting tools on the other hand.

If this does not provide the intended opening, the third step of the attack test sequence provides an attempt to remove the remainder of the damaged glazing from the surrounding frame and to thereby create an opening large enough to gain entry.

For a forced entry testing, both attack test sequences are required, consisting of three test elements each (pointed attack, cutting attack, displacement for the first attack test sequence, and pointed attack, blunt attack, displacement as the other attack test sequence).

5 Apparatus

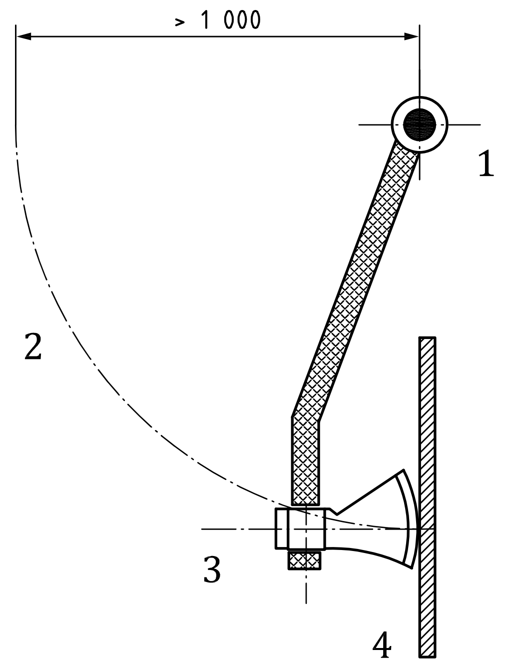
5.1 Description of the apparatus

5.1.1 General

The forced entry testing for a system part consists of two attack test sequences (with blunt and with cutting tool), each with three test elements (pointed attack, cutting or blunt attack, and a displacement test). The three elements of each attack test sequence shall be performed one directly after the other on the same system part, without any need for the part to be taken out of the support frame (see 6.1) during test.

Attack tests are carried out using a mechanical apparatus. This apparatus has one degree of freedom for movement and directs standardized tools, along a circular path with a minimum radius of 1 m and at a well-defined energy, in such a way that the tool axis of the standardized tool is perpendicular to the surface of the glazing at the impact point (see Figure 1). At the moment of impact, the tool axis and impact point's speed vector must be parallel. Construction elements that are fixed to the standardized tool (effective tool) shall be designed in a way that the tool's impact point makes the first contact to the system part. The effective tool shall be designed in a way that distance between its centre of gravity and the rotation axis is at least 0,7 times the distance between the rotation axis and the impact point.

Dimensions in millimetres



Key

1 axis of rotation

2 travelling path of impact point

3 tool axis

4 system part

Figure 1 — Schematic representation of the effective tool

The position of the effective tool as shown in Figure 1 shall be the position at rest. The centre of gravity shall be vertically and directly below the axis of rotation. Special measures to facilitate that are not shown here.

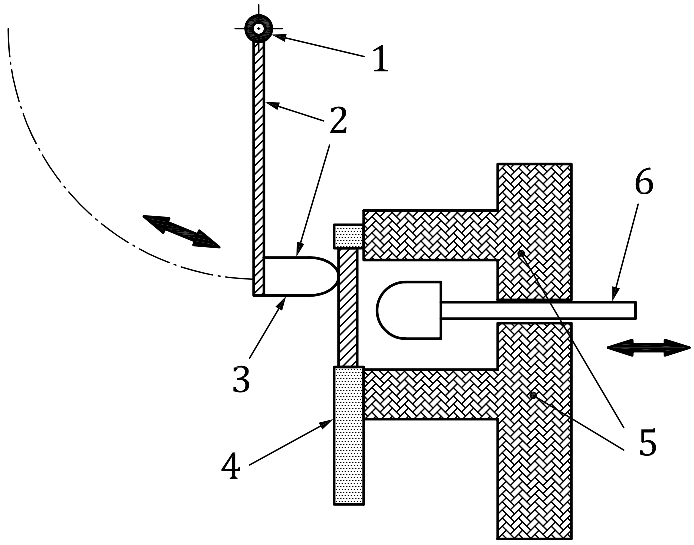
Often, the level of energy for effective tool just driven by gravity is not enough to perform the test according to this International Standard. An additional mechanism is therefore required to accelerate the tool. Description of an apparatus to increase the tool's energy is not given in this International Standard and can be designed according to technical requirements as long as it meets this International Standard's requirements. In this respect, care shall be taken to ensure that the required level of energy is achieved as the tool hits the glazing, and that thereafter, no additional energy is applied. The drive unit delivering the energy must be mechanically disconnected from the effective tool before the tool makes contact with the system part. When idle and disconnected from drive unit, the effective tool shall come to rest and remain static at the intended point of contact with the system part. This shall be the case if the rotation axis is vertical above the effective tool's centre of gravity. There shall be a possibility to adjust the point of contact as well as the orientation of the system part relative to the axis and impact point of the idle standardized tool.

The required level of energy shall be evaluated by measuring the travelling speed of the standardized tool's impact point immediately before hitting the system part under test. Speed measurements must be accurate to ±2 %. The standardized tool's impact point must hit the intended position on the glazing with an accuracy of ±5 mm.

The way in which security glazing is installed for test purpose shall match realistic conditions as closely as possible. Glazing and the associated car body part (see 6.2), jointly referred to here as the "system part," are held by a support construction (described in 6.1) in a fixture.

The fixture shall be rigid in itself and shall be solidly fixed to a firm surface.

The fixture for the system part includes an integrated spherical-faced tool that can be moved against the inside of the glazing with well-defined travelling speed.



Key

1 rotation axis

2 effective tool

3 standardized tool

4 system part: Glazing with section of car body

5 support frame

6 displacement apparatus

Figure 2 — Schematic representation of how the test equipment is arranged

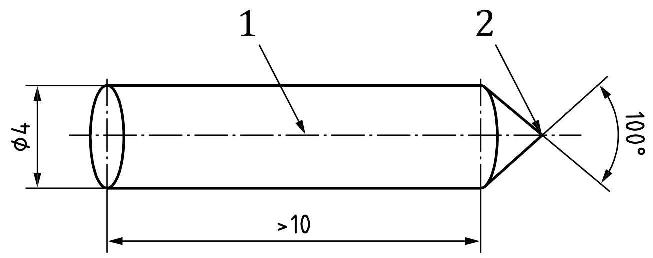
5.1.2 Tool for pointed attack

The effective tool is made up from the moving parts of the test apparatus and also from a tool adapter and a fixing shaft for a hardened steel pin (see Annex B). The pin is pointed in a conical front end and is at least 10 mm long (standardized tool, see Figure 3). The effective tool's effective mass for the pointed attack test is 3,5 kg ± 0,07 kg. The impact point is the pointed end of the hardened steel pin. The tool's axis is the pin's symmetry axis. The tool adapter and the fixing shaft are specific to the individual construction of each testing machine. They shall resist the forces generated during attack testing without being damaged or deformed. They shall also ensure that during testing, no other parts of the effective tool get in touch with the system part.

The steel pins are made of hardened steel type P20 according to ISO 513. They are 4 mm ± 0,05 mm in diameter and at least 10 mm long. At least one end of such pins is ground into a cone shape at an angle of 100° ± 5°.

The tool's movement shall be restricted to ensure that the tip of the tool cannot penetrate deeper than 10 mm.

Dimensions in millimetres



Key

1 tool axis

2 impact point

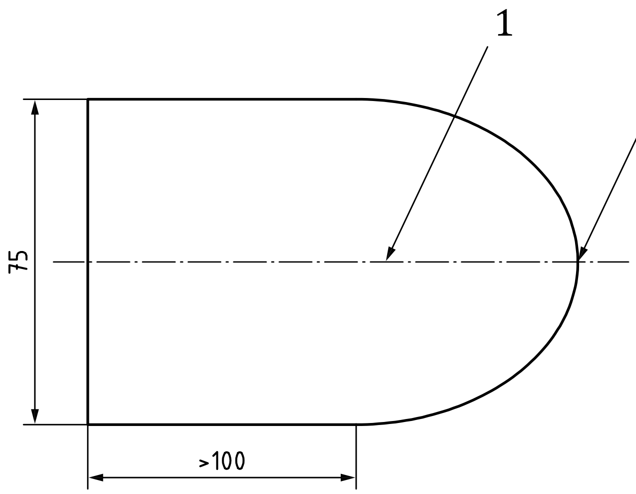
Figure 3 — Schematic representation of the standardized tool for pointed attack

5.1.3 Tool for blunt attack

The standardized tool used for a blunt attack (see Figure 4) consists of a cylindrical steel body with a diameter of 75 mm ± 1 mm. It is at least 100 mm long and has a hemispherical end with a diameter of 75 mm ± 1 mm. It shall be made from steel 1.0060 according to EN 10027-2. Construction elements used to guide the standardized tool shall be designed in such a way that they do not alter test results and are able to resist forces generated during test without continuous deformation. In addition, during test, they shall not get in touch with the system part, its support, or the fixture.

The impact point is the spot shown in Figure 4 in the middle of the hemispherical end of the tool. The tool's axis matches the symmetric axis of the standardized tool. Elements of the rig used for guiding the tool (effective tool) shall be built in such a way that an effective mass of 3,5 kg ± 0,07 kg is produced.

Dimensions in millimetres



Key

1 tool axis

2 impact point

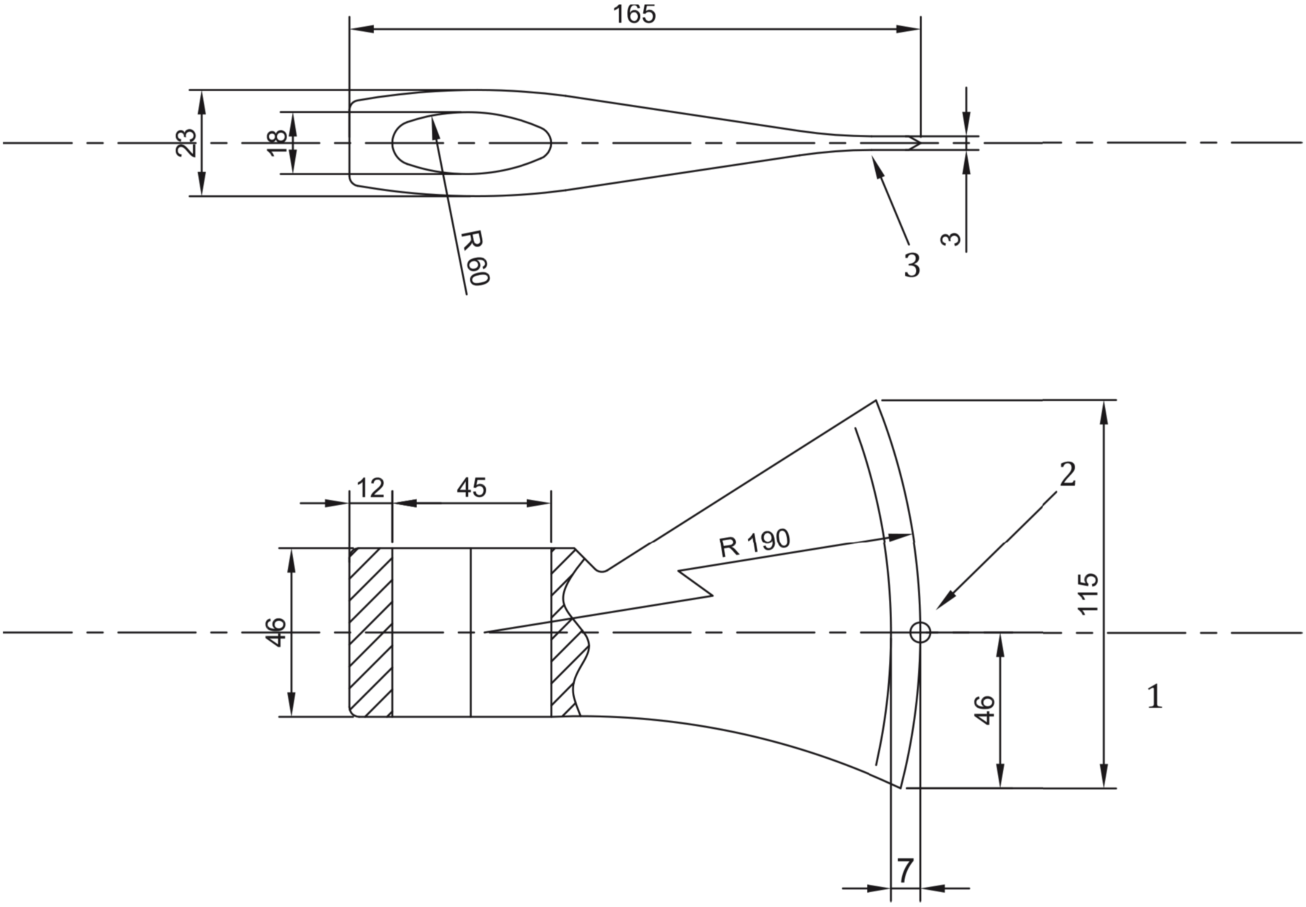
Figure 4 — Schematic representation of the tool for simulating attack with a blunt instrument

5.1.4 Tool for cutting attack

The standardized tool for cutting attack (see Figure 5) consists of an axe head with a weight of 800 g and conforms to German standard DIN 5131. The axe is used without shaft and is made of hardened steel conforming to DIN 7287, Güteklasse B (Beil 800 II DIN 5131-B). Construction elements used to guide the standardized tool shall be designed in such a way that they do not alter test results and are able to resist forces generated during test without continuous deformation. In addition, during test, they shall not get in touch with the system part, its support, or the fixture.

The impact point and the tool's axis are shown in Figure 5 (the impact point is the position designated a_2 in DIN 5131, and the tool axis runs through the middle of the shaft hole). Construction elements to guide the tool shall be designed to give an effective mass of 3,5 kg ± 0,07 kg.

Dimensions in millimetres



Key

1 tool axis

2 impact point

3 convex edged

Figure 5 — Schematic representation of the standardized tool for cutting attack

5.1.5 Tool for displacement test

The standardized tool (see Figure 6) consists of a spherical-shaped tool as described in FMVSS 217. In place of the spherical-shaped tool stipulated in FMVSS 217, the standardized tool can also be made out of polyamide 6 as resin, as per Figure 6. There shall be no visible rotary grooves on the resin body surface, which shall in case be smoothed down with 180-grain sandpaper. The permissible dimensional tolerance is ±0,5 mm.

The spherical-shaped tool shall be mounted on its flat side to a round retaining plate with a diameter of 140 mm ± 1 mm. The whole surface of its flat side shall be fixed against the plate.

If the surface becomes badly scarred during displacement testing, it shall be smoothed down using 180-grain sandpaper. If it cannot be smoothened, the spherical-shaped tool shall be completely replaced.

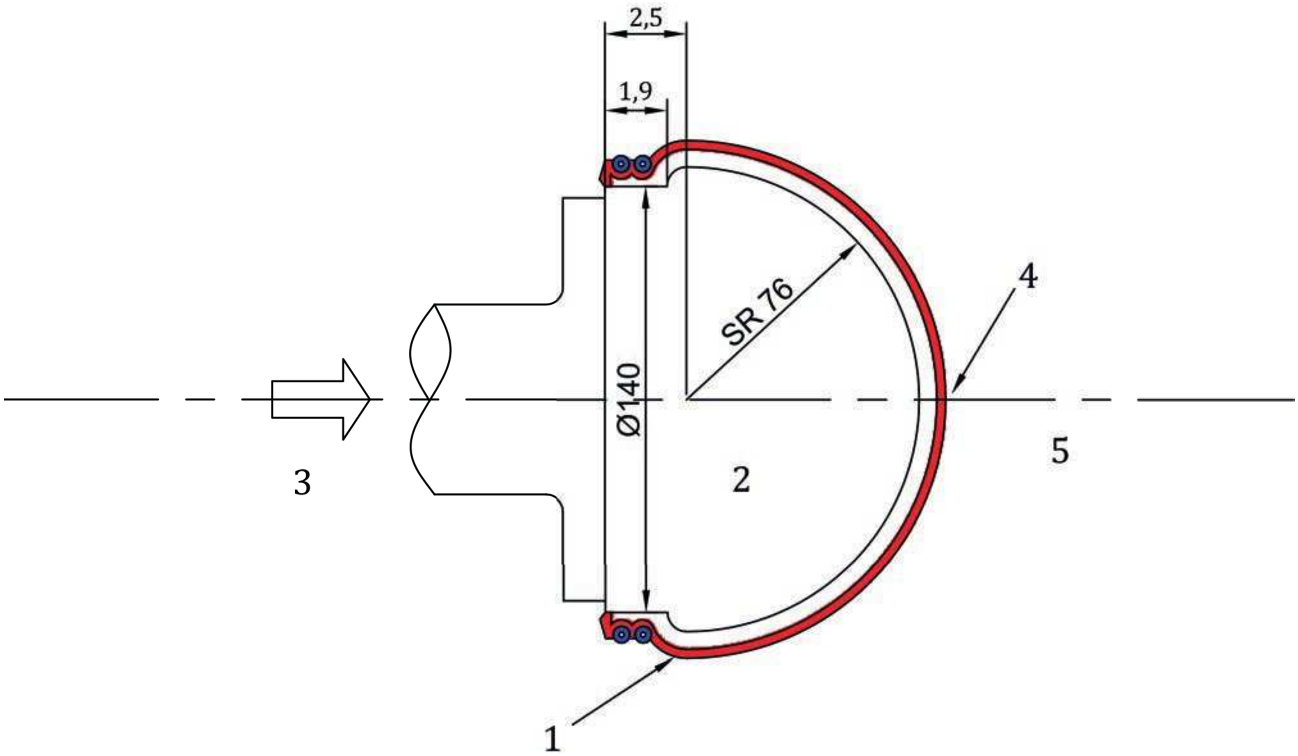
The material used as resin as per Figure 6 shall meet the following requirements.

Density according to	DIN 53479	:	1,14 g/cm^3 ± 0,01 g/cm^3
Tensile strength according to	ISO 527-2	:	70 MPa ± 10 MPa
Young's Modulus according to	ISO 527-2	:	2 250 MPa ± 750 MPa
Elongation at break according to	ISO 527-2	:	115 % ± 85 %

Parts of the set-up rig that act as guides for the standardized tool shall be designed in such a way that they do not influence test results. They shall also be designed to be able to resist to the forces generated during testing without permanently going out of shape. In addition, during the course of the test, they shall not come into contact with the system part, the sub-lining, or the retaining apparatus.

The tool shall be set up against the centre of area of the pane, parallel to the tool's direction of action. It is propelled with a constant traverse speed of 100 mm/min ± 5 mm/min until it reaches the maximum force shown in Table 2 or Table 3. The strength of resistance in the direction that the tool is moving shall be continually recorded with an accuracy of ±2 % from the test value. When forwards propulsion is switched off, the test tool shall remain in the position that it has reached.

Dimensions in millimetres



Key

1 leather

2 resin

3 direction of movement

4 impact point

5 tool axis

Figure 6 — Schematic representation of the tool for the displacement test

5.2 Checking the equipment

5.2.1 Determining the effective mass and checking the speed measuring apparatus

This subclause describes how to determine the effective mass of the apparatus with the standardized tool in use. Remove any system part from the instrument before following this procedure.

The construction of the test apparatus shall be designed in such a way that the axis of the standardized tool can be aligned vertically and the effective tool can move freely between this and the position where the standardized tool is intended to hit the system part (position at rest or equilibrium position). In addition, the energy supply mechanism shall be disconnected from the tool for the full range of movement between the two positions in the same way as this is a requirement described in 5.1.1, where this requirement is restricted to that position where the standardized tool is hitting the system part under test.

To measure the gravitational force G exerted at the impact point of the standardized tool, the effective tool is moved to the position where the standardized tool's axis is vertical and measure the force at the tool's impact point required to keep the tool in that position with a suitable device to within a precision of at least 0,1 N. In addition, the vertical distance between the impact point of the tool in this position and the position of the impact point when hitting the system part (equilibrium position) should be measured as the stroke height H to within a precision of 1 mm.

In the next procedure, the effective tool's effective mass M_w is calculated. Effective mass is used during testing to help work out the kinetic impact energy of the effective tool from tool speed measurements. For this purpose, the potential energy of the tool, known from gravitational force and stroke height H, is assumed to be converted during drop to kinetic energy at the impact point which can be calculated from measured speed of tool and the effective mass. For this purpose, the effective tool (as before disconnected from the energy supply mechanism) is then lifted from its equilibrium position until the tool's impact point has reached the stroke height H. The effective tool is then released and the speed V of the tool's impact point is measured as it passes the equilibrium position.

Speed of the tool's impact point shall be determined without contact, e.g. by means of a distance and time meter triggered by photo-electric sensors. Measurements shall be taken as close as possible but before the tool meets the intended point of first contact with the system part (i.e. the equilibrium position). The measurement values shall be calculated to get the speed of the impact point at the equilibrium position, the precision shall be ±2 %. The speed value used for determination of effective mass shall be taken as the average value of three individual measurements.

The effective mass can now be calculated using Formula (1):

$$M_w = 2 \cdot G \cdot \frac{H}{V^2} \tag{1}$$

where

M_w is the effective mass given in kg;

G is the gravitational force given in N;

H is the stroke heights given in m;

V is the speed at the impact point given in m/s.

This process shall be repeated for at least five different stroke heights chosen across the range of stroke heights which can be achieved due to the design of the apparatus. The corresponding tool positions could be below as well as above the position which corresponds to the vertical tool axis. The stroke heights shall be measured as the vertical distance between the tool's impact point before releasing the tool and the equilibrium position as described above. The value of effective mass to be applied for testing shall be the arithmetical mean of the values M_w of all individual tests for the different stroke heights.

Effective mass is used to facilitate calculation of impact energy of the effective tool only by measurement of travelling speed immediately before impact. The energy supplying mechanism, if in use for testing, will then facilitate to reach higher levels of energy than could be reached by use of gravitational force only. To limit the potential error for calculation of energy, the equipment should not be used for impact energies higher than four times the maximum energy (calculated as $G \times H$) used for the above procedure.

5.2.2 Pointed attack

Determining effective mass:

As described in 5.2.1, by use of the standardized tool for pointed attack.

Checking the speed measuring apparatus:

As described in 5.2.1, by use of the standardized tool for pointed attack.

Checking the tool (tool life):

Before the start of every series of tests, the tool shall be inspected for damage. If damage is detected, (e.g. tool is chipped or deformed) it shall be replaced. Tools are to be used for a maximum of 20 tests.

5.2.3 Blunt attack

Determining effective mass:

As described in 5.2.1, using the standardized tool for blunt attack.

Checking the speed measuring apparatus:

As described in 5.2.1, using the standardized tool for blunt attack.

Checking the tool (tool life):

Before the start of every test, the hemispherical surface of the tool shall be inspected for scratches, grooves, or other similar impact damage. If such damage exists, it shall be smoothed down with an appropriate tool.

5.2.4 Cutting attack

Determining effective mass:

As described in 5.2.1, using the standardized tool for cutting attack.

Checking the speed measuring apparatus:

As described in 5.2.1, using the standardized tool for cutting attack.

Checking the tool (tool life):

A new tool shall be used for each test. The tool must not be changed during a test.

5.2.5 Displacement test

Checking measurements of force and traverse controls:

Measurements of force are checked by taking control measurements using a calibrated load dynamometer. Traverse speed is ascertained using an appropriate distance and time meter.

Checking the tool (tool life):

Before the start of every new test, a visual inspection shall be made to check that the tool's spherical surface is free of any damage, such as perforations or tears, and that no foreign bodies are squashed into or stuck to it. By manually touching and pressing the tool, it shall also be inspected to check that its surface is fixed and that the filling is rigid and does not deform. If defects are discovered, or if in doubt, the tool shall be repaired or replaced.

6 Test pieces

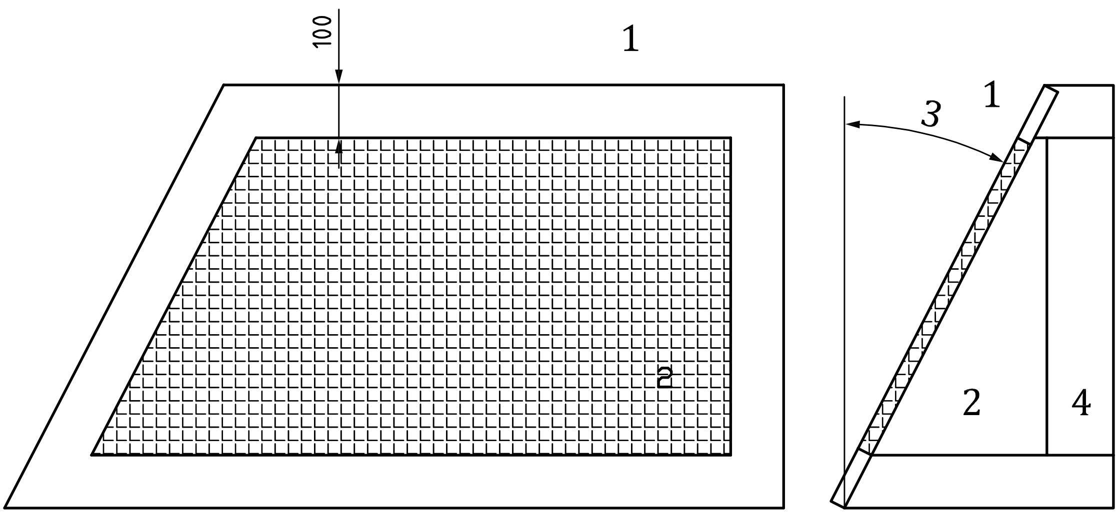
6.1 Support frame for the system part

The system part (e.g. a door) is held in a support frame. The number of clamping points used shall be such that forces are uniformly distributed.

6.2 Associated sections of the car body

The test object consists of the glazing due to be tested and an associated section of the car body. The glazing is fixed via the associated section of the car body to the support frame in a way that replicates how it would be installed in the relevant vehicle. A sensible way of doing this for movable glazing, such as doors or hatches, is to use rubber trims along the seals of the given part and to support it on an appropriately shaped support frame. This support frame thus takes on the function of the main car body. This procedure is also described, by way of example, in BS AU 209-4 or SAE J2568. If a fixed glazing and the associated car body shall be tested, then the relevant car body or an appropriate part of the car body shall be used to hold the glazing in place. The car body section can also be prepared in such a way that relative to the outer edge of the glazing, there is a metal support trim used, running around the glazing with a width of at least 100 mm. Ideally, the car body section shall be mounted in an appropriately shaped wooden frame, held in place at the installation angle (see Figure 7).

Dimensions in millimetres



Key

1 car body section

2 glazing

3 installation angle

4 support frame

Figure 7 — System part set-up (shown schematically)

6.3 Security glazing

Glazing to be tested is security glazing and glazing materials, which could be approved as such.

Those installed panes of security glazing shall not be tested for which it is not possible to fit a circle with 100 mm radius into the transparent surface.

6.4 Number of panes of glazing

At minimum, three glazing samples shall be tested for each test position and level of attack resistance.

7 Test conditions

Condition the test pieces for a minimum of 4 h at (20 ± 5) °C and (60 ± 20) % relative humidity, unless otherwise specified. The test shall be carried out in the same conditions.

8 Test procedures

8.1 General

This International Standard is intended to classify the intrusion resistance of system parts components in levels of attack resistance. Five levels of intrusion resistance are defined in 8.2.5 and 8.3.5, varying from short-term protection against “smash and grab” attacks to protection against attacks using high levels of energy over an extended period.

The procedure as described in 8.2 and 8.3 checks whether a component fulfils the requirements of a given level of attack resistance. This procedure consists of two attack test sequences (the attack test sequence with a “blunt tool” and the attack test sequence with a “cutting tool”). Each of these test sequences consists of three elements (pointed attack, cutting/blunt attack, displacement) and is carried out at one particular location of the component. This location is referred to as the test position.

System parts from different areas of a vehicle are tested according to Table 1.

Table 1 — Test positions

Window pane description	Location of test position
Windscreen	Top corner, driver’s side
Front side window	Bottom rear corner
Front triangular window	Bottom rear corner
Front, movable window pane	Top rear corner (see Figures 8 and 9)
Mid side window	Top rear corner
Rear, movable window pane	Top front corner
Rear triangular window	Bottom front corner
Rear side window	Bottom front corner
Hatch window	Top corner, driver’s side
Roof glazing	Front corner, driver’s side
Alpine window	Front corner, driver’s side

The examples as described in 8.2 and 8.3 are related to the test of a vehicle’s front door.

The point of impact for installed panes of security glazing with transparent surfaces of ≤1 000 cm^2 is the centre of the pane.

8.2 Attack test sequence with blunt tool

8.2.1 General

The attack test sequence with a "blunt tool" investigates the resistance levels of a system part when attacked with blunt tools as hammers, iron bars, and so on. It consists of the following three elements:

— a single impact with a pointed tool (pointed attack, see 8.2.2);

— repeated impacts with a standardized blunt tool (blunt attack, see 8.2.3);

— single displacement test at the centre of the pane (displacement test, see 8.2.4).

The test is performed at the positions indicated in Table 1 (see Figure 8). The test sequence requirements are met only in case all three test elements fulfil the requirements of the specific level of attack resistance.

8.2.2 Test element pointed attack

The pointed attack is performed using the tool described in 5.1.2 and prior to the test described in 8.2.3 at the location described in 8.2.5. The kinetic energy used for the pointed attack is specified in Table 2. During this test, care shall be taken to ensure that only the actual standardized tool comes into contact with the system part and not the structure in which the tool is mounted or any other parts of the test apparatus.

After the pointed attack, the further test procedures are carried out as described in 8.2.3, irrespective of whether the pointed tool has penetrated the glazing or not.

8.2.3 Test element blunt attack

Impact with the blunt tool, as described in 5.1.3, the location described in 8.2.5, n times with an energy W. The number of impacts n and the level of energy W are set according to the intended level of attack resistance as listed in Table 2.

If, after the final impact, a hole has been created (by penetration) within the glazing, or between the glazing and the frame, large enough for a 75 mm diameter ball to be pushed through, from either the inside or the outside and using no more than 50 N of force, then the system part has failed the test, and the attack test sequence can be aborted. In this case, the test sample did not meet the requirements of the level of attack resistance it has been tested for. If no opening has formed as specified before, the test shall be continued according to the conditions described in 8.2.4.

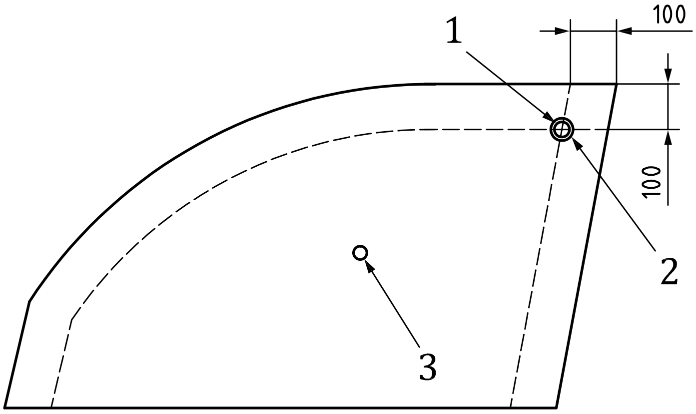
8.2.4 Test element displacement

If a pane of security glazing passed the test described in 8.2.3, the resistance of the glazing remaining in the frame is tested for its ability to stay in place with an apparatus as described in 5.1.5. If application of the maximum force F (as specified in Table 2) does not create a hole within the glazing, or between the glazing and the frame, large enough for a 75 mm diameter ball to be pushed through, from either the inside or the outside and using no more than 50 N of force, then the sample passed the complete attack test sequence with blunt tool.

8.2.5 Test position and requirements for different levels of attack resistance

The attack test sequence with blunt tool is carried out at the test position described in Table 1. The test position is determined as the intersection of two lines drawn on the surface of the glazing parallel to the edges of the glazing at a distance of 100 mm. In the case of a front door, this is near the corner, between the upper edge of the pane and the B-column, i.e. carried out at a very rigid point of the system (see Figure 8).

Dimensions in millimetres



Key

1 pointed attack

2 blunt attack

3 displacement

Figure 8 — Top corner test position for attack sequence with blunt tool, taking a front door window as an example

For each of the resistance categories being tested, the levels of energy and force in Table 2 shall be applied.

Table 2 — Test parameters for attack test sequence with blunt tool

Level of attack resistance	1	2	3	4	5
Energy for pointed attack [J]	50	75	130	200	200
Pointed tool's impact speed [m/s]	5,35	6,55	8,62	10,69	10,69
Number, *n,* of blows – blunt attack	3	3	6	12	15
Impact energy, *W,* for blunt attack [J]	25	65	100	150	300
Blunt tool's impact speed [m/s]	3,78	6,09	7,56	9,26	13,09
Maximum force, *F,* used in displacement test [N]	400	400	800	1 000	1 000

8.3 Attack test sequence with cutting tool

8.3.1 General

The attack test sequence with a "cutting tool" investigates the resistance levels of a system part attacked using tools with a cutting edge as axes, hatches, and so on. It consists of the following three elements:

— a single impact with a pointed tool (pointed attack, see 8.3.2);

— repeated impacts with a standardized cutting tool - position of each blow is varied in a way that an opening can be created (cutting attack, see 8.3.3);

— single displacement test at the centre of the pane (displacement test, see 8.3.4).

The test is performed at the position indicated in Table 1 (see Figure 9). The test sequence requirements are met only in case all three test elements fulfil the requirements of the specific level of attack resistance.

8.3.2 Test element pointed attack

The pointed attack is performed using the tool described in 5.1.2, prior to the test described in 8.3.3 at the location described in 8.3.5. The kinetic energy used for the pointed attack is specified in Table 3. During the test, care shall be taken to ensure that only the actual standardized tool comes into contact with the system part, and not the structure in which the tool is mounted or any other parts of the test apparatus.

After the pointed attack, the further test procedures are carried out as described in 8.3.3, irrespective of whether the pointed tool has penetrated the glazing or not.

8.3.3 Test element cutting attack

Using the standardized tool for cutting attack (see 5.1.4), position 1 of the impact pattern (see Figure 9) is initially impacted *n* times with an energy level *W*. The number of impacts *n* and the level of energy *W* are set according to the intended level of attack resistance, as listed in Table 3. Subsequently, position 2 of the impact pattern is hit *n* times in the same way using the same level of energy. Finally, position 3 of the impact pattern is also hit *n* times.

If, after the final impact, a hole has been created (by penetration) within the glazing, or between the glazing and the frame, large enough for a 75 mm diameter ball to be pushed through, from either the inside or the outside and using no more than 50 N of force, then the system part has failed the test and the attack test sequence can be aborted. In this case, the test sample did not meet the requirements of the level of attack resistance it has been tested for. If no opening has formed as specified before, the test shall be continued according to 8.3.4.

8.3.4 Test element displacement

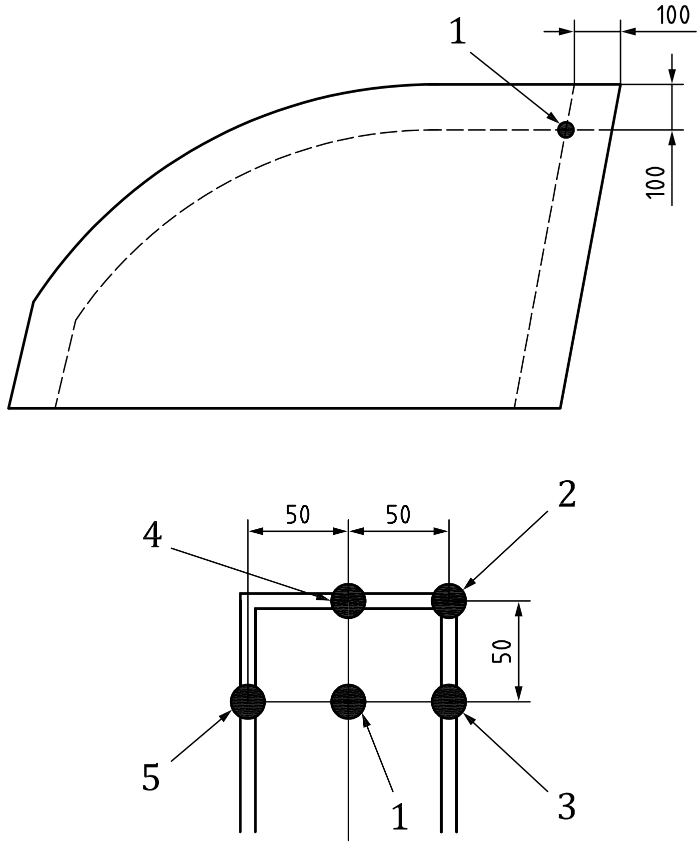
If a pane of security glazing passed the test described in 8.3.3, the resistance of the glazing remaining in the frame is tested for it is ability to stay in place with an apparatus as described in 5.1.5. If application of the maximum force *F* (as specified in Table 3) does not create a hole within the glazing or between the glazing and the frame large enough for a 75 mm diameter ball to be pushed through, from either the inside or the outside and using no more than 50 N of force, then the sample passed the complete attack test sequence with cutting tool.

8.3.5 Test position and requirements for different levels of attack resistance

The attack test sequence with cutting tool is carried out at the test position shown in Table 1. In the case of a front door pane, this is near the corner between the upper edge of the pane and the B-pillar, i.e. a position where the system part is expected to have high stiffness. A single penetration of the glazing with an axe will not create an opening that would enable someone to get inside the vehicle, and for that reason, a series of strokes are performed in such a way that a pattern is obtained, which is expected to create an appropriate opening. The strike pattern is laid out as three sides of a square, each 100 mm long. The centre of the square shall be aligned with the test position as shown in Figure 9.

The impact pattern shall be oriented to the Cartesian coordinates of the vehicle as described in ISO 4130. The line of contact between the cutting edge of the axe and glazing during tool impact, shall be oriented perpendicular to the axis of the coordinates of the vehicle. For positions 1 and 3, this shall refer to the x-axis and for position 2, the z-axis. If required, the test position shall be moved in a way that no corner of the impact pattern goes nearer to the frame of the glazing than 50 mm. The impact point of the cutting edge of the axe shall be positioned to the centre of each side of the square. The longer parts of the cutting edge shall be oriented toward the corner positions of the impact pattern.

Dimensions in millimetres



Key

1 test position
2 impact position for pointed attack
3 impact position 1 for first attack with cutting tool
4 impact position 2 for second attack with cutting tool
5 impact position 3 for third attack with cutting tool

Figure 9 — Location of the test position (illustration above) and strike pattern (illustration below) for the cutting attack test, taking a front door window as an example

For each of the levels of attack resistance being tested, the levels of energy and force in Table 3 shall be applied.

Table 3 — Test Parameters for attack sequence with cutting tool

Level of attack resistance	1	2	3	4	5
Energy for pointed attack [J]	50	75	130	200	200
Pointed tool's impact speed [m/s]	5,35	6,55	8,62	10,69	10,69
Number, *n*, of blows – cutting attack on each point of the strike pattern	1	1	2	4	5
Strike energy, *W*, for cutting attack [J]	25	65	100	150	300
Cutting tool's impact speed [m/s]	3,78	6,09	7,56	9,26	13,09
Maximum force, *F*, used in displacement test [N]	400	400	800	1 000	1 000

9 Classification

In order to be classified in a particular performance level for resistance to forced entry, three system parts shall fulfil the requirements of each of the two attack test sequences. The level of attack resistance that a system part has achieved is therefore the lower of the attack resistance levels achieved by the attack test sequences with cutting and with blunt tool. The test evaluation report shall report the level of attack resistance of the system part, as well as the attack resistance levels achieved in each attack test sequence as described in 8.2 and 8.3.

10 Test report

The test report shall indicate with reference to this International Standard, i.e. ISO 23013—,

— the name and address of the test house;

— the name and address of the applicant;

— the vehicle manufacturer name, model, and year in which the vehicle was constructed;

— the date of receipt of test sample;

— the type and description of security glazing;

— the thickness of the glazing in mm;

— the construction of the glazing;

— the description of the system part;

— the set-up for testing of the security glazing (installation position and test conditions);

— the glazing pre-treatment;

— the number of panes of glazing;

— the test temperature in °C;

— the test humidity in %;

— the impact speed of the tools;

— the measurement tolerances;

— the test date;

— a statement about penetration and/or glass splinters on the inside;

— the level of attack resistance and the level of attack resistance for each of the attack test sequences as applied for and tested;

— any deviations from this International Standard;

— the remarks about special observations and conclusions from the testing process;

— the observations of noticed security weaknesses of glazing or frame (system part);

— the number and date of the test report;

— the notice to a certificate issued, if any.

11 Test certificate

The test certificate shall indicate with reference to this International Standard, i.e. ISO 23013—,

— the name and address of the test house;

— the name and address of the applicant;

— the vehicle manufacturer name, model, and year in which the vehicle was constructed;

— the test report number;

— the test date;

— the test procedures and test requirements (cross-referenced to International Standards, guidelines, etc.);

— the classification according to Clause 9;

— the notice to the validity and distribution of the test certificate.

Annex A
(informative)

Comments

A.1 If there is any deviation from the test temperature (see Clause 7), the temperature of the system part and the ambient temperature during the test shall be reported.

A.2 In Clause 8, the impact pattern for both the blunt instrument test and the cutting instrument test are described. The choice of impact points for these patterns is in no way arbitrary. Depending on material, dimensions, and construction of the frame, different types of glazing show various levels of resistance at different points on their surface. Within the scope of the work done by the NMP 361 committee, attempts were made to work out which were the relative weak spots on system parts most commonly used at present. The results of this study form the basis for how the attack areas were chosen for this International Standard. It is, of course, quite possible that future types of glazing will show lower resistance at different areas. The idea of establishing weakest spots individually for every type of glazing has, however, been rejected, as this would make comparison impossible. The NMP 361 committee is of the opinion that updating International Standards at the interval of five years, as usual, is sufficient to ensure that proper account is taken of any future developments.

A.3 In 8.2.5 and 8.3.5, the levels of energy for striking the glazing are stipulated for both the blunt and cutting instrument tests for each of the given attack resistance categories. Resistance level 1 should represent an attack with small, lightweight hand-held tools. The NMP 361 committee came to the conclusion that 25 J, as the energy level for resistance category 1, was about the amount of energy that an average person could create with small hand-held tools (similar to ENV 1630, tool set A). The short period attack reflects what would be expected for level 1 of attack resistance.

A.4 A note on fatigue caused to system parts by the high levels of energy used striking the glazing in the blunt and cutting instrument attacks:

The system part is subjected to substantial forces during the course of the attack tests with the blunt and cutting instruments, especially during those for the higher categories of attack resistance. Therefore, it shall be considered that components of the system part may become worn out (e.g. window winding mechanisms, window guides, etc.). Such fatigue can have a negative effect on the results of all three test elements (i.e. the “blunt attack” test, the “cutting attack” test, and the displacement test). This can lead to glazing being classified in a resistance category lower than it should have been. It is therefore recommended that after every test sequence, a check is made on the condition of critical components supporting and holding the pane in place. If the condition gives cause for any doubt, such components should be replaced.

Annex B
(informative)

Source of steel pin for the pointed attack tool

An example of a suitable commercial source is given below. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products:

Hahn and Kolb, Borsigstraße 50, 70469 Stuttgart (Germany).

Bibliography

[1] BS AU 209-4, *Vehicle Security — Part 4: Specification for security glazing for passenger cars and car derived vehicles*

[2] FMVSS 217, *Bus emergency exits and window retention and release*

[3] SAE J2568, *Intrusion Resistance of Safety Glazing Systems for Road Vehicles*

ICS 43.040.65

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