Windows, doors and shutters — Explosion resistance — Requirements and classification —

Part 1: Shock tube

The European Standard EN 13123-1:2001 has the status of a British Standard

ICS 13.230; 91.060.50

National foreword

This British Standard is the official English language version of EN 13123-1:2001.

The UK participation in its preparation was entrusted by Technical Committee B/538, Doors, windows, shutters, hardware and curtain walling, to Subcommittee B/538/2, Doors, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 June 2001

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Windows, doors and shutters — Explosion resistance — Requirements and classification — Part 1: Shock tube

Fenêtres, portes et fermetures — Résistance à l'explosion — Prescriptions et classification — Partie 1: Tube à effet de souffle (shock tube)

Fenster, Türen und Abschlüsse — Sprengwirkungshemmung — Anforderungen und Klassifizierung — Teil 1: Stoßrohr

This European Standard was approved by CEN on 7 March 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 33, Doors, windows, shutters, building hardware and curtain walling, the Secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2001, and conflicting national standards shall be withdrawn at the latest by October 2001.

This European Standard is one of a series of standards for windows, doors and curtain walling. The requirements and classification relate to a test specified in EN 13124-1.

Annex A is normative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies the criteria which windows, doors and shutters shall satisfy to achieve a classification when submitted to the test method described in EN 13124-1.

This European Standard concerns a method of test against blast waves generated by using a shock tube facility to simulate a high explosive detonation in the order of 100 kg to 2 500 kg TNT at distances from about 35 m to 50 m.

This European Standard is applicable to blast overpressure generated in a shock tube test facility used to simulate a high explosive detonation on windows, doors and shutters, complete with their frames and infills, for use in both internal and external locations in buildings. It gives no information on the explosion resistance capacity of the wall or other surrounding structure.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 13124-1:2001, *Windows, doors and shutters — Explosion resistance — Test method — Part 1: Shock tube*.

3 Terms and definitions

For the purposes of this European Standard the terms and definitions given in EN 13124-1 apply.

4 Requirements

Resistance to perforation and pressure shall be classified in accordance with clause 5. To achieve a particular class of explosion resistance, the test specimen shall:

(a) be subjected to not less than the corresponding level of each of peak pressure, positive specific impulse and minimum duration specified in clause 5, Table 1; and

(b) show no perforation or damage exceeding that specified in 9.2 of EN 13124-1:2001.

After the test, the door leaf and/or any opening sash shall remain retained in the closed position whether the opening mechanisms shall be still operable or not. It shall not be possible to gain unauthorized access from the attack face as a result of damage or exposure during the test of any security closure mechanisms which were intentionally secure prior to the test. It is not a requirement of the test that performance in other respects such as air permeability, watertightness, wind resistance, etc. be maintained.

If the intended application of the window, door and shutter is such that it will be specifically subjected to climatic extremes, the test specimen shall be tested at these climatic extremes.

NOTE Care should be taken to ensure that all joints between the wall and the window or door have protection which is at least equal to that of the window or door.

5 Classification of the level of explosion pressure resistance (EPR)

The classes EPR1 to EPR4 given in Table 1 are in order of increasing explosion pressure resistance. When a window, door or shutter achieves a particular class it also automatically achieves all lower classes.

Table 1 — Characteristics of the shock wave

Minimum values of:		
Classification code	**Peak pressure** P_{max} bar [a]	**Positive specific impulsion** i_+ bar-ms
EPR1	0,50	3,7
EPR2	1,00	9,0
EPR3	1,50	15,0
EPR4	2,00	22,0
[a] The duration of the positive phase (t_+) shall be not less than 20 ms		

NOTE 1 The classification refers to the reflected pressure values which the test specimen experiences.

NOTE 2 A latitude of -5 % is permitted on the pressure value to allow for gauge reading tolerance. No reduction is permitted on the impulse and duration values which shall be determined in accordance with annex A. The decay coefficient defining the shape of the mean pressure trace lies within the values 0 to 4.

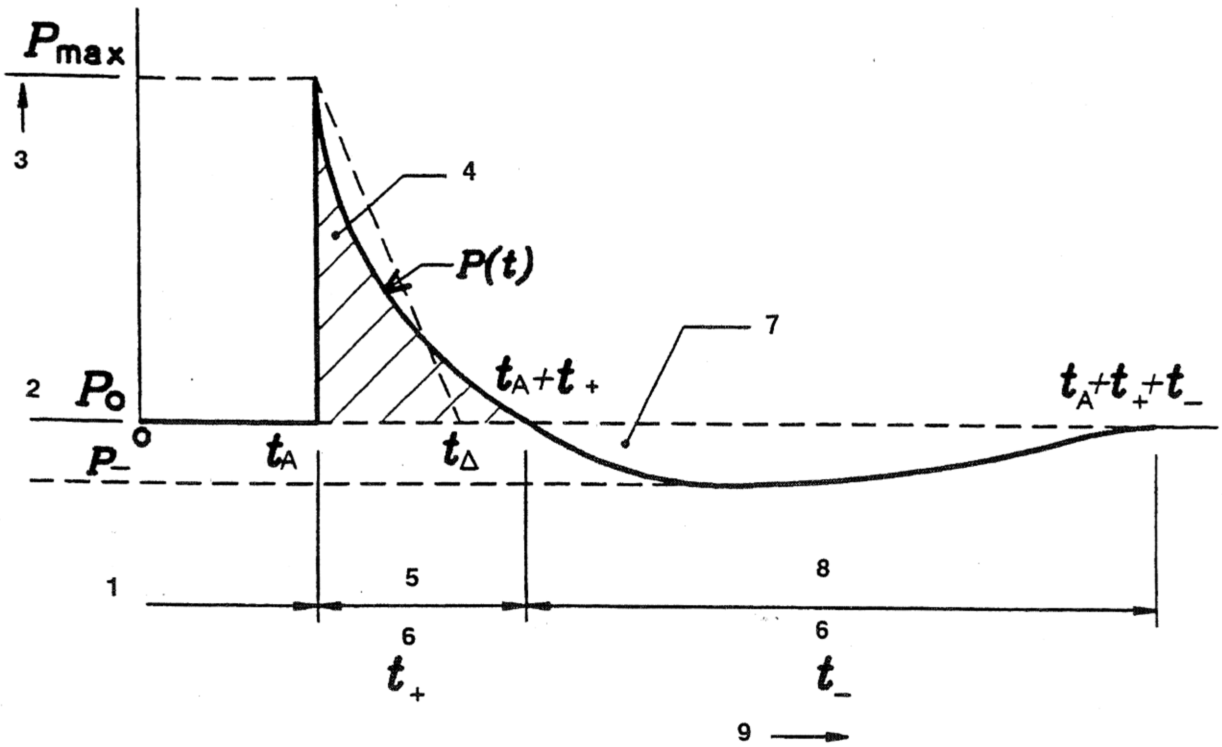
NOTE 3 The testing authority is required to ensure that the pressure and impulse values for any one classification test remain below that of the next higher classification or, in the case of EPR4, the upper bound values given as P_{max} = 2,5 and i_+ = 32 (see Figure A.1 in annex A).

NOTE 4 Results of the tests are further notated with an addition of an “S” or “NS” suffix with regard to the presence or absence of splinters originating from the rear (protected) face of the test specimen.

Examples:

EPR1 (S) = Splinters ejected from rear (protected side) of the glass or infill material.

EPR1 (NS) = No splinters ejected from rear (protected side) of the glass or infill material.



Key

1 Time of arrival
2 Ambient pressure
3 Pressure
4 Positive specific impulse, i_+
5 Positive phase
6 Duration
7 Negative specific impulse, i_-
8 Negative phase
9 Time after explosion

NOTE With a blast wave generated by a shock tube the negative phase may not be present.

For definitions refer to clause 3.

Figure 1 — Idealized pressure-time variation for a blast wave

Annex A
(normative)

Blast parameters and derivation

A.1 Scope

This annex sets out the procedures to be followed by the testing authority to achieve consistent measurement and derivation of the test blast parameters for comparison against the classification parameters defined in requirements and classification clause 5, Table 1.

A.2 Symbols

$P(t)$	=	Pressure, above ambient pressure, at time t
P_c	=	Classification peak pressure
P_{max}	=	Peak pressure derived from measured test values
i_{+c}	=	Classification positive phase specific impulse
i_+	=	Positive phase specific impulse calculated from measured test values
t_{+c}	=	Classification positive phase duration
t_+	=	Positive phase duration derived from measured test values
$t_{\blacktriangle c}$	=	Triangular duration calculated from classification values of P_c and i_{+c}
$t_{\blacktriangle}$	=	Triangular duration calculated from P_{max} and i_+

A.3 Units

Parameter	Units	Equivalent units	
Pressure	bar	= 100 kPa	- (kilopascal)
		= 100 kN/m^2	- (kilonewton/m^2)
Duration	ms	= ms	- (milliseconds)
Impulse	bar-ms	= area enclosed by pressure-time curve	

A.4 Mathematical relationships

The relationship between the parameters P_{max}, i_+, t_+ and $t_{\blacktriangle}$ can be expressed as functions of the exponential decay shape of the idealized pressure-time trace using the following formulae:

(a) The modified Friedlander equation:

$P(t) = P_{max}\{1 - t/t_+\} \times \exp\{-A \times t/t_+\}$;

where:

A is the decay coefficient or form parameter.

(b) The integration of the modified Friedlander equation to express the calculated impulse, which is the area under the positive phase of the pressure-time trace, as:

$i_+ = P_{max} \times t_+\{(1/A) - (1/A^2) \times [1 - \exp(-A)]\}$.

(c) $t_{\blacktriangle} = 2 \times i_+/P_{max}$;

giving the equivalent triangular duration for the limiting case when the value of the decay coefficient, A, would be zero and the trace would be a straight line, which idealized case is often used in carrying out response calculations.

A.5 Classification blast pulses

Figures A.1 and A.2 illustrate the idealized shape and relationships of the classification blast pulses which would occur with a value for the decay coefficient of A = 1. These values of P_c (less than 5 %) and i_{+c} are the minimum permissible to achieve the appropriate classification and are related to each other and t_{+c} by the same formulae as in clause A.4:

(a) $P(t) = P_c\{1 - t/t_{+c}\} \times \exp\{-A \times t/t_{+c}\}$;

(b) $i_{+c} = P_c \times t_{+c}\{(1/A) - (1/A^2) \times [1 - \exp(-A)]\}$.

Different shape classification pulses may similarly be derived ranging from sharper curves having a steeper initial decay rate but longer final duration for A = 4 down towards the limiting case of a straight line corresponding to A = 0 when:

(c) $t_{+c} = t_{\blacktriangle c} = 2 \times i_{+c}/P_c$.

In all cases, the values of all three blast parameters, peak pressure, impulse and duration and the value of the decay coefficient A shall comply with clause 5. It shall be noted that:

(d) for example, when A is less than 1, the value for the impulse may have to be higher than the minimum classification value in order to comply with the requirement for the duration to be not less than 20 ms;

(e) often the duration shall exceed 20 ms in order for the impulse not to be less than the classification minimum.

A.6 Method of recording test parameters

The test blast parameters shall be obtained using electronic recording equipment capable of recording and reproducing, on screen and in the form of a hard copy visual trace, the pressure-time history of the blast pulse in steps of not more than 0,1 ms. This shall be done for each of the two blast gauges receiving the blast pressure (normally the reflected values) experienced by the attack face of the test specimen. The pressure-time history shall be recorded and reproducible over the positive phase period in detail and also over the subsequent period of not less than 10 times the duration of the positive phase. By agreement with the applicant, the equipment may incorporate devices to filter and/or smooth the pressure-time history to a mean trace. If such devices are used, details of the method and effect of filtering or smoothing shall be stated in the test report.

A.7 Criteria for compliance of the pressure wave

A pressure wave in accordance with the classification will be achieved if the measured and calculated parameters are not less than the corresponding minimum values set out in clause 5, Table 1. The upper tolerance values for each class are imposed on the testing authority in order to ensure that test specimens are not subjected to unfairly over onerous or destructive loads.

A.8 Procedure for verifying compliance of the pressure wave

Measured and recorded pressure-time traces may follow an irregular shape, therefore it is necessary to carry out a recognized procedure, such as that following, in order to prove compliance with the classification parameters:

— Draw a smooth curve through the trace to produce a mean pressure-time trace that most closely matches the mean path of the recorded trace. In the first instance this may be done by eye. Alternatively a best fit curve may be derived using mathematical methods.

— Establish the value of the resulting measured peak pressure (P_{max}) from the point at which the mean pressure trace crosses the time of arrival axis. Note that this may differ slightly from a recorded instantaneous peak value.

— Establish the duration t_+ of the mean pressure trace from the time of arrival to the point at which it crosses the ambient pressure axis. Note that the recorded trace may fluctuate below and above the line or may not cross the ambient line for a period significantly longer than t_+.

— Calculate the value of the impulse i_+, i.e. the area under the trace, over the duration t_+. This will be derivable from the digital record.

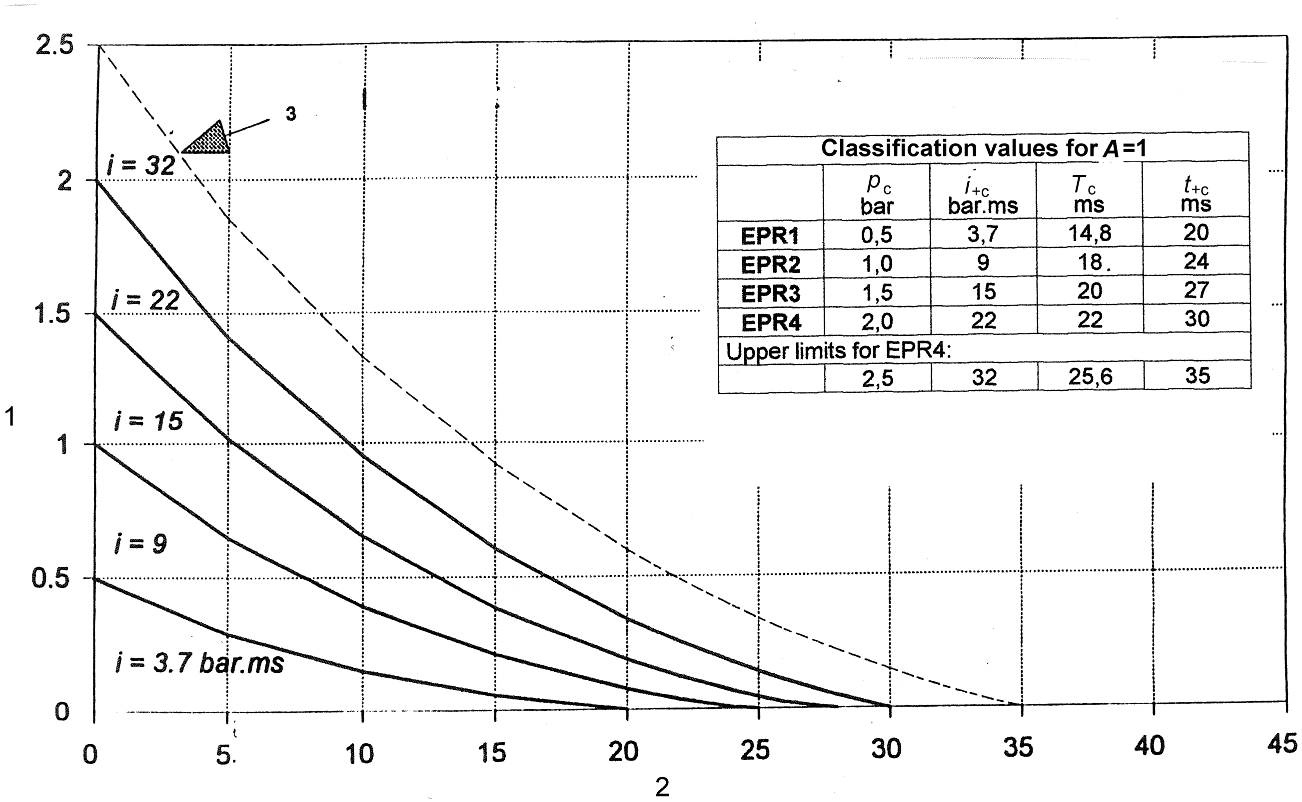
— Compare the shape of the mean trace with an idealized (Friedlander) curve having the same values of peak pressure, duration and impulse. Determine the value of the decay coefficient A. Iterate the process if necessary to obtain the optimum idealized mean pressure trace.

A.9 Verification

Compare the shape of the resulting mean pressure trace with a Friedlander curve conforming to the classification parameters. Verify that the values of peak pressure, duration, impulse and decay coefficient derived above all comply with clause 5 of the requirements and classification.

A.10 Measurement using two blast gauges

The above procedure shall be followed for each of the two blast gauges.



	p_c bar	i_{+c} bar.ms	T_c ms	t_{+c} ms
EPR1	0,5	3,7	14,8	20
EPR2	1,0	9	18	24
EPR3	1,5	15	20	27
EPR4	2,0	22	22	30
Upper limits for EPR4:				
	2,5	32	25,6	35

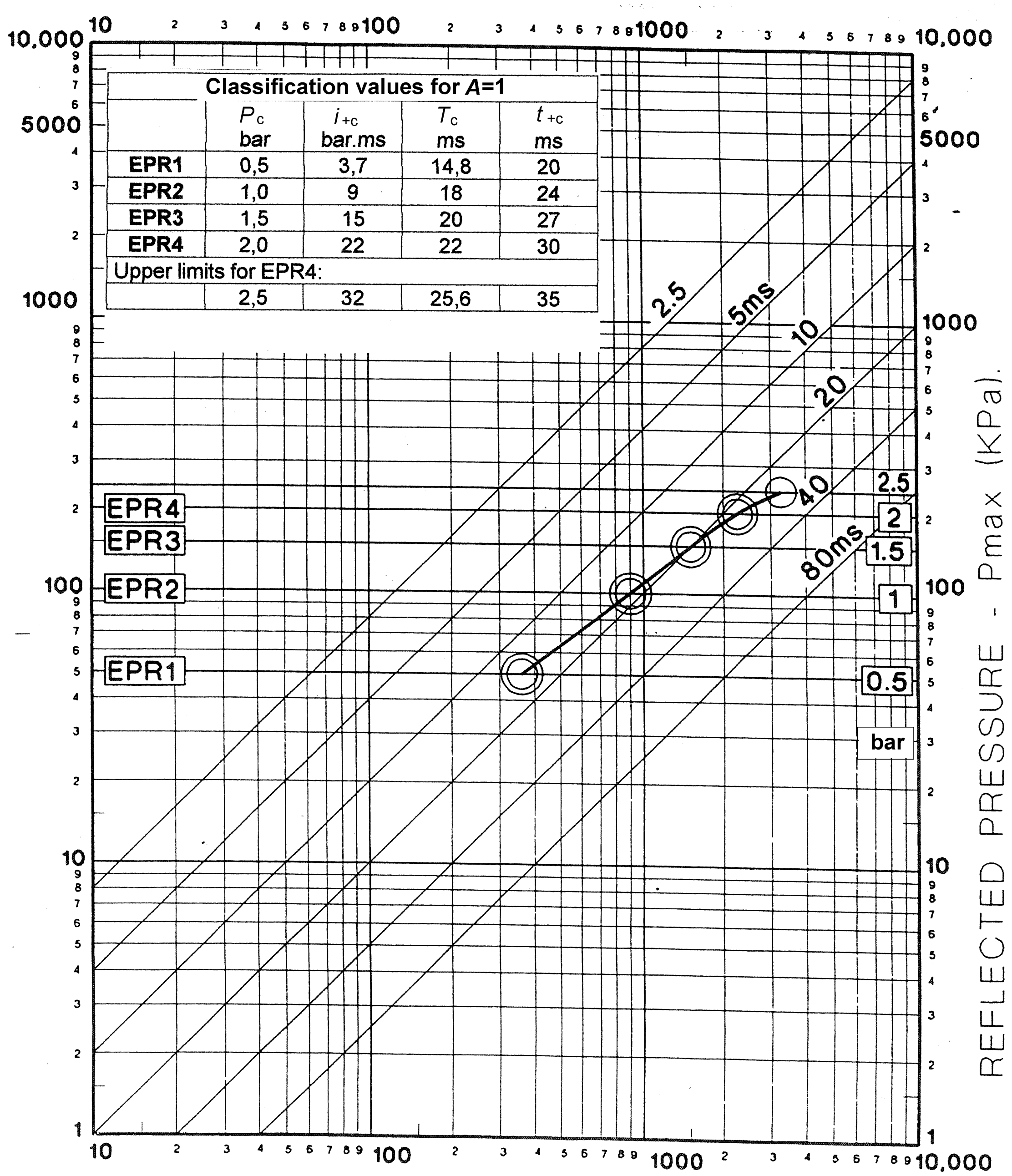
Key

1 Pressure (bar)

2 Time (ms)

3 Upper limit for 2,0 bar test

Figure A.1 — Idealized classification blast pulses for shock tube, decay coefficient A = 1



Classification values for *A*=1				
	P_c bar	i_{+c} bar.ms	T_c ms	t_{+c} ms
EPR1	0,5	3,7	14,8	20
EPR2	1,0	9	18	24
EPR3	1,5	15	20	27
EPR4	2,0	22	22	30
Upper limits for EPR4:				
	2,5	32	25,6	35

Reflected impulse i_+ (kPa·ms),
showing equivalent triangular durations $t_\blacktriangle$ (ms).

Figure A.2 — Shock tube test — Pressure impulse plot of Table 1 — Classification values

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