

**CPNI**

Centre for the Protection  
of National Infrastructure



**Curtain Walling – Explosion Resistance – Requirements**

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# **CPNI Test Standard**

## **Explosion Resistance of Curtain Walling**

### **Part 1: Requirements and Classification**

Version 1.0

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Physical Security

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## FOREWORD

The CPNI Test Standard for the Explosion Resistance of Curtain Walling<sup>1</sup> consists of two complementary documents:

Part 1: Requirements and Classification

Part 2: Test Method

This part of the Test Standard provides a method of specifying the criteria which curtain walling systems must satisfy when submitted to the test described in Part 2: Test Method

The Test Standard does not include all of the necessary provisions of a contract for test and evaluation services. It is limited to the methodology and specifications of the tests themselves. Users of this Test Standard and the guidance set out in this document, whether test clients or test facilities, are responsible for its correct application and remain entirely responsible for compliance with any applicable law and regulations.

**Compliance with this test standard does not necessarily, or of itself, confer immunity from any legal obligations and your attention is drawn to the important disclaimer on the contents page of this document.**

This standard does not supersede or replace any other test methods or test standards.

In cases where sufficiently detailed information is held in existing test records, it may be appropriate for systems previously tested in accordance with other test standards to be reclassified in accordance with this test method as a user-defined loading category (VXRU) by the original test house. Such reclassification will be subject to demonstrating that the test specimen, test set up and reporting have all fully met the requirement stated herein.

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<sup>1</sup> This Test Standard has been developed by the Defence Science and Technology Laboratory (Dstl) as part of a programme of work funded and directed by CPNI.

# 1 INTRODUCTION

## 1.1 Background

Current available test standards covering range or arena testing are designed to accommodate windows (with dimensions of approximately 1.5 m by 1.2 m) and so are not directly applicable to the large sizes of pane and framing arrangements used in modern glazed facades.

Such standards include, but are not limited to, the following:

- BS EN 13123 – 2:2004, Windows, doors, and shutters – Explosion Resistance – Requirements and Classification – Part 2: Range Test.
- BS EN 13124 – 2:2004, Windows, doors, and shutters – Explosion Resistance – Test Method – Part 2: Range Test.
- ISO 16933:2007, Glass in building – Explosion-resistant security glazing – Test and classification for arena air-blast loading.
- GSA-TS01-2003, US General Services Administration, Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings.
- ASTM International, F 1642-17, Standard Test Method for Glazing and Glazing Systems Subject to Air-blast Loadings.
- ASTM International, F 2912-17, Standard Specification for Glazing and Glazing Systems Subject to Air-blast Loadings.

This leads to users with a requirement to test curtain walling choosing either to test products broadly in accordance with the nearest applicable standard or to develop a bespoke test for a particular product. This can cause difficulties in forming direct and detailed comparisons of the performance of similar systems which have been tested under different regimes.

This test standard presents a framework for determining the explosion resistance of curtain walling by arena testing. It uses ISO 16933:2007 as a basis for assessment.

This Requirements and Classification document and the method described in the CPNI Test Standard for the Explosion Resistance of Curtain Walling – Part 2: Test Method provide a structured testing procedure to determine the resistance of curtain walling, installed vertically (to  $\pm 15^\circ$ ), to blast loading against a range of explosion threats located externally to a structure. It also provides a structured assessment procedure to determine the hazard created by the test specimens, both internal to (behind glass) and external to the test specimen.

This document also incorporates the general recommendations for testing<sup>2</sup> developed by the European Research Network for Critical Infrastructure Protection (ERNICIP) Resistance of Structures to Explosion Effects Thematic Group.

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<sup>2</sup> Recommendations for the improvement of existing European norms for testing the resistance of windows and glazed facades to explosive effects, European Commission Joint Research Centre (JRC) Ispra, 2015, ISBN 978-92-79-53394-5

## 1.2 Loading categories

The method includes standard loading categories plus user-defined loading categories to allow flexibility for user-defined/project-specific requirements to be tested and assessed using the same method.

The loading categories are based on vehicle-borne improvised explosive devices (VBIED) detonated in the open. The test client should ensure that the selected loading category takes due account of any blast reinforcement that may be caused by recesses and overhangs, adjacent buildings or other structures.

The loading categories present typical blast parameters to assess test specimens spanning at least one floor as a whole system, as well as structural connections and individual components (such as transoms, mullions, glazing and fixing components). These typical parameters are based on the loading that would be experienced by the test specimen when forming part of a full-scale, curtain wall installation. The test method does not consider the effects of fragment impact or the loading from the negative phase of the blast wave.

Test clients may wish to engage a competent blast engineer<sup>3</sup> for support in confirming or developing the appropriate loading categories.

## 1.3 Hazard assessment

The hazard assessment process is defined separately for the internal hazard behind the facade and for the external hazard in front of the facade.

The internal hazard ratings are:

- A - No Break
- B - No Hazard
- C - Minimal Hazard
- D - Very Low Hazard
- E - Low Hazard
- F – High Hazard

The external hazard ratings are:

- X – No Hazard
- Y – Limited Hazard
- Z – High Hazard

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<sup>3</sup> A competent blast engineer should be a member of the Register of Security Engineers and Specialists ([www.rses.org.uk](http://www.rses.org.uk)) or be able to demonstrate a similar level of competence.

## 1.4 Classification

Classifications and ratings are based on the performance of the system loaded by the blast parameters applied during the test and are specific to those conditions.

Test clients and test facilities can follow this test method while conducting tests to either a pre-defined standard loading category or to a user-defined loading category.

The classification will be reported as a series of alphanumeric sets identifying the predefined loading category, the internal hazard rating and the external hazard rating, such as VXR2/C/X.

For a user-defined loading category, the classification will be reported as the relevant reflected pressure (kPa) and reflected specific impulse (kPa-ms) achieved in the test, quoted in parentheses and prefixed VXRU, followed by alphanumeric sets defining the internal hazard rating and the external hazard rating, such as VXRU(235/1130)/C/Z.

However, if a test specimen meets all the requirements for a lower loading category it may be classified with that category of explosion resistance and the internal and external hazard ratings recorded.

Curtain walling that has been tested in accordance with this method and has received a classification and rating based on this method are suitable for use in blast-resistant applications only for blasts of comparable characteristics to the original test and only if the system is installed in the same manner that was used for the test.<sup>4</sup>

## 1.5 Number of test samples

It is the test client's responsibility to identify the number of test specimens to be tested and, whilst it is recommended that multiple specimens are tested, it is acknowledged that economic pressures may restrict users to testing a single specimen.

In order to gain a classification, a minimum of one test specimen shall be tested. If multiple test specimens are tested only the worst classification achieved is applicable to the test specimen system.

CPNI recognises that a single test for the purposes of classification of a system is not statistically valid. However, testing of a single target may be considered acceptable by the test client due to economic constraints and may be considered to demonstrate a reasonable assessment of the likely performance of the system, as far as is reasonably practicable.

## 1.6 Applicability

The test method has been developed for flat, vertical (to  $\pm 15^\circ$ ) facades with the charge normal to the centre of the facade. If it is necessary to test a system against an oblique blast wave, or if the system includes significant overhangs or recesses that may enhance the blast loading, then specialist advice should be sought from a competent blast engineer<sup>3</sup> to develop a suitable test set up.

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<sup>4</sup> A test client, with suitable specialist advice provided by a competent blast engineer<sup>3</sup>, may decide that the system is appropriate for use in other situations. Any such decision will include an element of risk which must be fully assessed. Extrapolation of test results is generally discouraged.

This test method only gives information on the performance of the test sample subjected to explosive blast loading. It gives no information on the behaviour, when subjected to any other type of loading, of the test sample as a whole or of individual component units

This test method is appropriate for stick, unitised, semi-unitised and point-fixed types of curtain walling systems.

The test method specifies that the inside and outside surfaces of the glazing in the test specimen should be at a temperature of  $20^{\circ}\text{C} \pm 10^{\circ}\text{C}$  at the time of the test unless the test client has other requirements.

## 2 SCOPE

This document specifies the criteria which curtain walling, installed vertically (to  $\pm 15^{\circ}$ ), shall satisfy to achieve a classification when subjected to the associated test method described in Part 2 of this standard.

This method gives no information on the explosion resistance capacity of any structure or components not forming an integral part of the curtain walling being tested.

It is the test client's responsibility to confirm the competence of the chosen test facility to safely and effectively conduct the required test(s). This can be demonstrated by being accredited to ISO/IEC 17025<sup>5</sup> with a recognised accreditation organisation such as UKAS<sup>6</sup>. The accreditation should include this CPNI standard.

A test client must specify the blast loading category against which the curtain wall should be tested.

## 3 NORMATIVE REFERENCES

This document 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 in the bibliography.

For dated references, subsequent amendments to or revisions of any of these publications apply to this test method only when incorporated in it by amendment or revision.

For undated references the latest edition of the referenced publication applies (including amendments).

## 4 TERMS & DEFINITIONS

For the purposes of this part of the Test Standard, the terms and definitions given in Part 2: Test Method apply.

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<sup>5</sup> ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories

<sup>6</sup> United Kingdom Accreditation Service [www.ukas.com](http://www.ukas.com)

## 5 REQUIREMENTS

To achieve a particular category of explosion resistance, the test specimen shall be subjected to peak reflected pressure and peak reflected specific impulse loading for the relevant loading category as specified in Table 1 and in full accordance with the method described in Part 2: Test Method, and subject to the tolerances in that document.

## 6 CLASSIFICATION OF EXPLOSION RESISTANCE

The categories VXR1 to VXR6 in Table 1 are listed in order of increasing explosion resistance with respect to the peak reflected specific impulse parameter.

When a system achieves a particular VXR classification it also automatically achieves all other classes where both the peak reflected pressure and the peak reflected specific impulse parameters were exceeded, with the same internal and external hazard classifications achieved in the original test being applied.

**Table 1: Minimum loading requirements for standard loading categories**

Loading Category	Peak reflected pressure, $P_r$ (kPa)	Peak reflected specific impulse, $I_r$ (kPa-ms)
VXR1	55	400
VXR2	65	440
VXR3	90	540
VXR4	140	690
VXR5	275	960
VXR6	185	1370
VXRU	User defined	User defined

The load category pressure and impulse parameters are derived from the Kingery-Bulmash<sup>7</sup> equations based on a hemispherical surface burst and have been rounded up,  $P_r$  to the next 5 kPa and  $I_r$  to the next 10 kPa-ms.

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<sup>7</sup> The pressure and impulse parameters can be obtained using the CONWEP software tool which uses the Kingery-Bulmash equations.

## REFERENCES

BS EN 13123 – 2:2004, Windows, doors, and shutters – Explosion Resistance – Requirements and Classification – Part 2: Range Test.

BS EN 13124 – 2:2004, Windows, doors, and shutters – Explosion Resistance – Test Method – Part 2: Range Test.

ISO 16933:2007, Glass in building – Explosion-resistant security glazing – Test and classification for arena air-blast loading.

GSA-TS01-2003, US General Services Administration, Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings.

JRC 98372 Recommendations for the improvement of existing European norms for testing the resistance of windows and glazed façades to explosive effects, ERNCIP Resistance of Structures to Explosion Effects Thematic Group, 2015.

ASTM International, F 1642-17, Standard Test Method for Glazing and Glazing Systems Subject to Air-blast Loadings.

ASTM International, F 2912-17, Standard Specification for Glazing and Glazing Systems Subject to Air-blast Loadings.

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