Institute for Atomic and Molecular Physics
Kruislaan 407 Amsterdam
The Netherlands

**Explosion Release Control, type B, for application in exterior wall elements. AMOLF Test Report V.**

Initiator: Gorter Bouwprodukten BV
Executor: FOM-AMOLF, Afdeling Mechanisch ontwerp
Date: 24-07-2006

Contents page

1 **Introduction** 2

2 **Design** 2

3 **Determination of the opening pressure** 4

3.1 General 4
3.2 Test method according to prEN14797 4
3.3 Opening force – test set-up 6

4 **Tests and results** 7

5 **Further tests and requirements** 8

6 **Conclusions and recommendations** 9

## 1 Introduction

Gorter Bouwprodukten BV invited FOM-AMOLF to design, prototype and test an Explosion Release Control suitable for Gorter vertical door systems.

As a result from earlier studies; 'Innovatie van een veiligheidssluiting (Innovation of a safety latch) I, II, III, & IV' following design of an explosion release control is presented. The prototype has been build and tested. This report describes the design and testing in detail.

## 2 Design

The Explosion Release Control, further referred to as ERC type B for flush installation, is designed for doors made from extruded aluminum system profiles. The ERC is to be used in combination with a standard cylinder lock, and replaces the standard stationary catch. The opening force is specified at approximately 100 kgf (980 N) (see **3**)

The ERC consists mainly out of two stainless steel sheet mounting brackets and a catch from stainless steel strip. The brackets are folded out of 75 x 23 x 2 mm strip. The catch is made out of a strip 170 x 18 x 2 mm with two ends 19 mm folded up. In the folded sides are welded hinge pins. A shaft which holds the eyes of one end of the tension springs runs through the catch. Another shaft runs through the two brackets and hold the other ends of the springs.

Fig. 2.1 Explosion release control

The catch is held into its closed position by the tension of the springs. A specific pressure on the door in the opening direction will force the catch to rotate around the hinge pins; this movement increases the tension of the springs. The chosen dimensions of the springs result in a maximum tension force at minimum building space.

Both slam lock and dead bolt engage the catch. The bolts of the standard cylinder lock each show their specific momentum as they are placed in different positions and have different dimensions. The dead bolt is longer and situated lower than the slam lock. Therefore a 2 mm thick stainless steel strip is bolted onto the catch. To enable application into left and right turning doors the strip can be positioned in 2 ways. The

slam lock and dead bolt actuate the catch with different opening forces. When locked (i.e. with engaged dead bolt) the opening force will be 35% higher than in the non-locked position (i.e. only the slam lock engaged)

The opening force is down scalable; two, four, or more springs and springs with smaller wire diameters can be mounted.
The design has been optimized to a maximum reproducible opening force into the specified housing construction.

The following springs are used; Tevema Tension spring art. no. T32300, wire thickness 2.00, diameter 8.00, untensioned length 31.6 mm, 220 N at 5.9 mm, C=31.8 N/mm. (www.tevema.com)

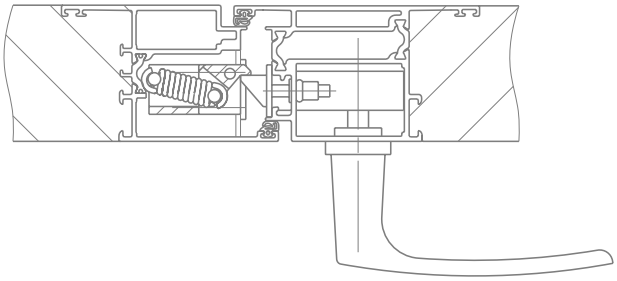

Fig. 2.2 Cross section drawing

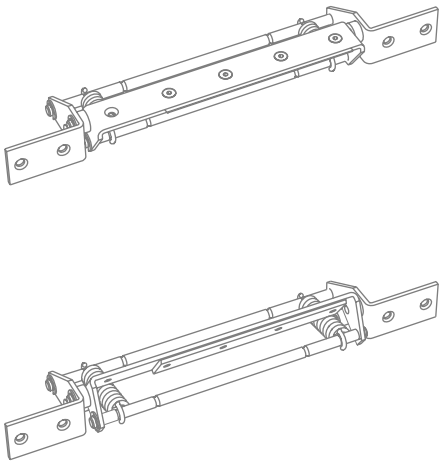

Fig. 2.3 Drawing of the ERC in closed and opened configuration.

## 3 Determination of the opening pressure

### 3.1 General

The pressure value at which an explosion release control should open is not specified in NEN 6702 or prEN14797.
prEN 14797: the static activation pressure shall be stated including the tolerance range by the manufacturer.

In theory a door without any opening resistance will be most effective. This cannot be realized (1) for technical reasons, (2) inadvertent opening by pressure differences in a building (for example caused by wind pressure) must be prevented and (3) the fact that unauthorized personal can open the door with the same force from the outside.

THE NFPA 68 Guide for Venting and Deflagrations: 2002 Edition recommends a release pressure between 0.14 psi and 0.21 psi. (965 $N/m^2$ up to 1448 $N/m^2$)

Based on these considerations a releasing force at the lock side of a hinged door has been chosen of approximately 100 kgf, i.e. 980 N.

### 3.2 Test method according to prEN14797

The tests are conducted in accordance with prEN14797, Art. 7.2.3; ‘Mechanical test method’. By applying continuously increasing mechanical forces on the venting element, the activation of the explosion release control is effected. The direction of the force is normal to the venting element. The point of application of the force depends on the design of the explosion release control.’

Since the tested door is hinged, and the manufacturer specifies an opening force at the opening end of the door, the point of application of the force as mentioned above is direct at the position of the lock & explosion release control.

A hinged door is held at one side by hinges at the other by the explosion release control. This means that the ERC should release the door at a force equivalent to half the force on the door at the critical pressure.

The maximum measured opening force at the latch is 820 N (see **4**). The force acting at the middle of the door = 820 N x 2 = 1640 N.

The specific opening area of the door requires a pre-set static activation pressure. Since the type of doors are made to custom dimensions (no standard sizes) following general guide table is made, on request by the manufacturer.

| Area ($m^2$) | S.A.Pressure ($N/m^2$) (1640 N / Area) | |
|---|---|---|
| | 4 springs | 2 springs |
| 0.5 | - | 1640 |
| 0.75 | - | 1093 |
| 1.0 | 820 | - |
| 1.25 | 1312 | - |
| 1.5 | 1093 | - |
| 1.75 | 937 | - |
| 2.0 | 820 | - |
| 2.25 | 728 | - |
| 2.5 | 656 | - |
| 3.0 | 547 | - |

The static opening pressures of the areas from 1,0 down to 2,25 $m^2$ are considered within specifications (the 25% lower opening pressure than stated in NFPA68 is considered acceptable). Opening areas larger than 2 $m^2$ can be equipped with two or more ERC's.

When the explosion release control is fitted with four springs, it meets the demands in terms of access security (opening form the outside) of all areas.

3.3. Opening force - test set-up

To measure the opening force following test stand has been set up. A complete aluminum door construction was supplied by Gorter (size 2300 x 1000 mm). The frame was clamped onto a heavy steel table. The tackle of an overhanging manual hoist is connected to the load cell that is hooked up to the door with a special aluminum attachment.

Fig.4.1 Door fixed to steel table

Fig.4.2 Load cell

When the hoist is operated an opening force is applied to the door. The force is measured by the load cell equipped with a digital readout. The load cell is zeroed with the door lifted thereby compensating for the weight of the door (18 kg).

Fig.4.3 ERC in frame

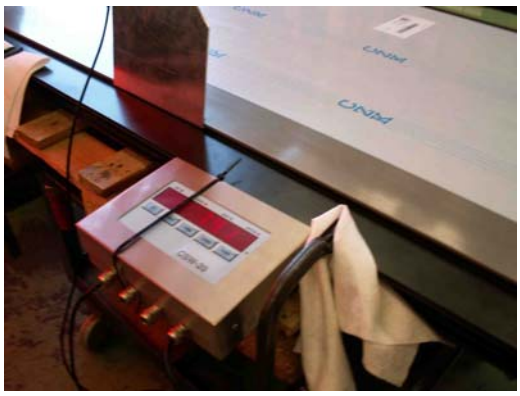

Fig.4.4 Digital load-cell readout

## 4 Tests and results

Measurements were carried out using a Zemic H8C-C3-2.0t-4B Class 3 load cell, with an absolute accuracy of +/- 0.1 kg. During the measurements the hoist was manually operated and the force was gradually increased until the explosion release control opened. The opening force in kg was read out from a digital display. The force increased linearly until release. Each value at which the explosion release control opened was recorded. The test was repeated 10 times. Two series of tests were conducted on the ERC equipped with four springs. One series of 10 with activated dead bolt and one series of 10 with non-activated dead bolt.

| | Slam latch and activated dead bolt | Slam latch only |
|---|---|---|
| Test# | Force (Max.) kgf. | Force (Max.) kgf. |
| 1 | 84.0 | 51.6 |
| 2 | 82.7 | 50.8 |
| 3 | 80.7 | 51.1 |
| 4 | 84.0 | 53.8 |
| 5 | 83.0 | 50.8 |
| 6 | 82.5 | 50.6 |
| 7 | 80.0 | 51.5 |
| 8 | 82.7 | 53.0 |
| 9 | 79.5 | 54.0 |
| 10 | 80.7 | 53.5 |
| Average | 82.0 | 52.7 |

The average measured value turned out to be 82 kgf ±1.5 kgf (= absolute precision and readout resolution combined). The measuring errors introduced by the system, measuring device and procedure were neglected (within 10 %).

The value of 82 kg is within an acceptable tolerance range of the set specification of 100 kgf. (a lower activation pressure is acceptable)

## 5 Further tests and requirements

**NEN 6702**
Specifies a door weight < 25 kg per $m^2$. **The tested door cover did not exceed that weight.** According to the door weight table as provided by Gorter (see encl.).

Confirms the need to calculate the specific venting surface in a building. A calculating method is not specified.

**The NFPA Guide 68: 2003**
The door, or parts of it, may not become projectiles in case of an explosion.

Doors must be sufficiently anchored to the building.

The place of the relieving openings must be chosen in a way that personnel can not be exposed to the explosion force or material ejection.

Loads (by for example snow) may not disturb the functioning.

Door construction must be maintained properly.

The Guide gives methods for calculating the dimension of the required relieving openings in the building.

**prEN14797:**

Art. 7.3.3. - Mechanical strength test:
On customer request Gorter doors can be tested at ± 3000 Pa by the Stichting Kwaliteit Gevelbouw (SKG).

Art. 7.3.2.1. - Venting efficiency calculation:
Hinged doors show a lower venting efficiency than venting devices regarded as inertia free (e.g. rupture foil). A direct determination method of the venting efficiency is given by comparison of an inertia free device with a hinged door vent.
**At the moment there are no test data or calculations available.**

Art. 7.3.2.2.3 - Inertia greater than 10 kg/m2
Inertia will influence the venting efficiency. A comparison method is given for covers with inertia greater than 10 kg/$m^2$, this method is similar to article 7.3.2.1.
**At the moment there are no test data or calculations available.**

Art. 7.4. - Leak testing
Only if required by the purchaser or a notified body.
See Art 7.3.3: SKG can test the door on air loss according to EN 1026.

## 6 Conclusions and recommendations

The testing of the laboratory build prototype of the explosion release control was successful.

Further test procedures have to be carried out according to prEN 14797 - Art. 7.3.2.1. and Art. 7.3.2.2.3.

Explosion release controls have to be tested according to prEN 14797, Art. 7.2.3. and Art. 7.2.5.2. to determine that they function in conformity with the tested prototype.

The functioning of the mechanism is reproducible.

The goals and specifications given by the initiator are obtained.

I. Cerjak
- Mechanical engineer –

Prof. Dr. P.G. Kistemaker
- Advisor –

Approval:
Gorter Bouwprodukten BV
P. Hoogerdijk
- Director -

Sources:

- prNEN-EN 14797:2003 Explosion Venting Devices
- Richtlijn EG/94/9:1994, bijlagen I t/m XI
- NEN 6702: 2001, artikel 9.3 en toelichting
- TNO Prins Maurits Laboratorium: ‘Gas Explosions’en ‘Blast research’
- Drukontlasting van gasexplosies in stookruimten
- Chapter 5 and 6 of NFPA Guide 68: 2002 (authority in the US)
- Gorter Weight Calculation of July 2006