**A NEW BUILDING FOR THE EUROPEAN COMMISSION IN BRUSSELS**
**THE BERLAYMONT IS DESIGNED TO ENHANCE TRANSPARENCY AND OPENNESS**
**THE FIRE SAFETY ENGINEERED APPROACH**

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## ABSTRACT

In December 1991 some 3 000 EU officials left the historic Berlaymont Building in Brussels, accompanied by mountains of packing cases and files. The building had served as the seat of the European Commission since 1969. Asbestos contamination had necessitated the Commission's removal to other premises, while the Berlaymont was "decontaminated". When the renovation work began in 1995, the removal of the approximately 4 000 tons of asbestos was expected to take until the end of 1996. However, various difficulties have occurred, and the scheduled completion date of the asbestos removal is now the end of 1998. The costs of the building repairs are estimated at approximately two billion ECU (1 ECU = 9 HK$).

The Commission should be able to move back into the Berlaymont Building in the year 2000, by which time all the planned refurbishment and new parts will have been completed. Thus, the next European Commission will be housed in surroundings appropriate to its standing. Until then the Berlaymont will look as though Christo has chosen to wrap it up: it is clad in white plastic. The construction work is being carried out by the "Berlaymont 2000" company, which is owned by the Belgian state (70%) and two banks (30%).

***"Cold Monster" will become more transparent and accessible***

(docs Berlaymont 2000)

The plans envisage a structure that complies with high environmental and energy-saving standards and is fully integrated in its urban surroundings. Frequently described by the Belgian press as a "cold monster" and a symbol of "eurocratic" ivory-tower attitude, the new Berlaymont Building will be - so the Commission hopes - literally transparent and directly accessible. The façade will be changed, although the architecture will not be fundamentally altered. The building's future residents will enjoy modern standards of comfort and convenience, with air conditioning and natural daylight.

(doc Berlaymont 2000)

## 1. INTRODUCTION

### ***<u>1.1. Description of the building</u>***

The Berlaymont project is generally subdivided into two elements:

- the serving space (infrastructure)
- the serviced space (superstructure)

The superstructure, once asbestos free and with the old finishings removed, will retain de same structure.

The offices will be rearranged following a new model spacing. The climatic comfort, hygienic, physical, psychological and visual criteria will be redesigned following the new codes.

The external façades will be replaced and a louvred façade will be installed 80 cm in front of all façades. The louvres in the external façades will be moveable to control light & solar heat gain. New meeting rooms will be integrated.

The infrastructure will be the serving space and mainly consists of circulation and meeting spaces. Further servicing spaces like restaurant, archives office, press center and shops will be integrated.

### ***<u>1.2. Big challenge towards Fire Safety: No compliance with new prescriptive Belgian Standards</u>***

In July 1994 new rules were made mandatory by a so-called "Royal Decree on the determination of the basic standards for prevention of fire and explosion to which new buildings must comply". Their rules were also mandatory for the refurbishment of existing buildings such as the "Berlaymont" building. These rules are applicable to all buildings without any subdivision towards purpose or occupancy. (Although not valid for domestic houses and special rules are about to be put in place for industrial buildings). The only distinction is made between low buildings ($h \leq 10$ m), middle high buildings ($h \leq 25$ m) and high buildings ($h > 25$ m). As the "Berlaymont" qualifies as a high building, the most severe rules were applicable and so there were a lot of constraints which made it impossible to be a "transparent" and "directly accessible" complex.

The main departures from the prescribed constraints were:
- fire compartments bigger than 2 500 m²
- the presence of an atrium of 4 storeys high with a glazed roof and an inner street of 2 storeys high with a glazed roof
- the new conference block was to be built between two wings of the existing building, very close to both
- evacuation stairs did not directly open to the exterior at evacuation level but ended in the middle of a concourse
- excess travel distance on evacuation routes in the lobby and connecting corridors.

Introducing a "Fire Safety Engineering" reconciled these differences. The law (here the Royal Decree) made it possible to ask for a departure from the standards by submitting and discussing a design with engineered solutions to a nominated body - the so-called "derogation committee" - appointed by the Ministry of the Interior. The main concern of this committee is to be sure that the proposed solution (to the question of non-compliance of the building to the legislative standards) offers at least the <u>same</u> level of fire safety. Only then they will give a derogation from the law.
Acceptance from the Fire Service Department had to be reached as well.

### ***1.3. What about the "louvred" curtain wall?***

The new façades of the superstructure of the building will be equipped with glazed louvres over the entire height and perimeter of the building to control the solar heat gains through the glass. With the gap between these louvres and the façade being 80 cm, so creating vertical shafts, questions had been raised whether the position of the louvres would endanger the upper storeys in case of a fire adjacent to the façade.

A CFD modelling exercise has been done using JASMINE to investigate the effect of wind and the position of the louvres on the movement of smoke from a fire in one of the offices in the building.

The simulations have indicated that in the absence of louvres the interaction of fire gases with the wind was clearly visible at wind speed above 5 m/s. Above this velocity smoke and hot gases from the fire are rapidly diluted and cooled as they leave the office, however the wind forces burning gases to leave the office space preventing the conventional layer and fire plume developing.

This study has indicated that

- A "chimney" effect can occur if the louvres are closed increasing the risk of external fire spread to floors above the fire.
- The louvres should "fail-safe" to the open position when their control receive a signal from the smoke detection system.
- With the louvres in the open position smoke and heat are rapidly dispersed by winds of 10m/s and above. This will prevent windows on floors above the fire breaking and allowing external fire spread. There is some evidence that at these wind speeds a vortex on the trailing edge of the louvre enhances the dilution mechanism.
- At lower wind speeds (5 m/s) the open louvres neither enhance or inhibit the mixing of smoke and hot gases leaving the burning office compared to the "no-louvre" case.
- The risk of external fire spread to floors above the burning office when the louvres are in the open position is no worse than a building without louvres and may be lower at higher wind speeds (> 10 m/s).
- For a “medium” rate of fire growth the time for windows breaking on floors above the fire are sufficient to allow attendance of firefighters. A time of attendance of 10 min. has been given by the Brussels Fire Department.

## 2. FIRE SAFETY ENGINEERED APPROACH

The various active fire protection possibilities are not mentioned in the "Royal Decree" or are at least not mandatory (automatic fire detection, sprinklers, active smoke exhaust, dynamic way-finding in case of evacuation). By introducing these techniques, by proposing fire prevention "house-rules", and by establishing a consequent evacuation and intervention plan, the level of fire safety was improved significantly. The "Berlaymont 2000" consortium expects that the derogation committee will follow this point of view.

### ***2.1. Description of the fire risks***

The building is divided into offices, meeting rooms and restaurants, which all have a "low hazard" or "ordinary hazard I" classification. The spaces with a higher risk such as the archives, the plant rooms, high tension, waste disposal, and the computer rooms are all provided with extinguishing installations.

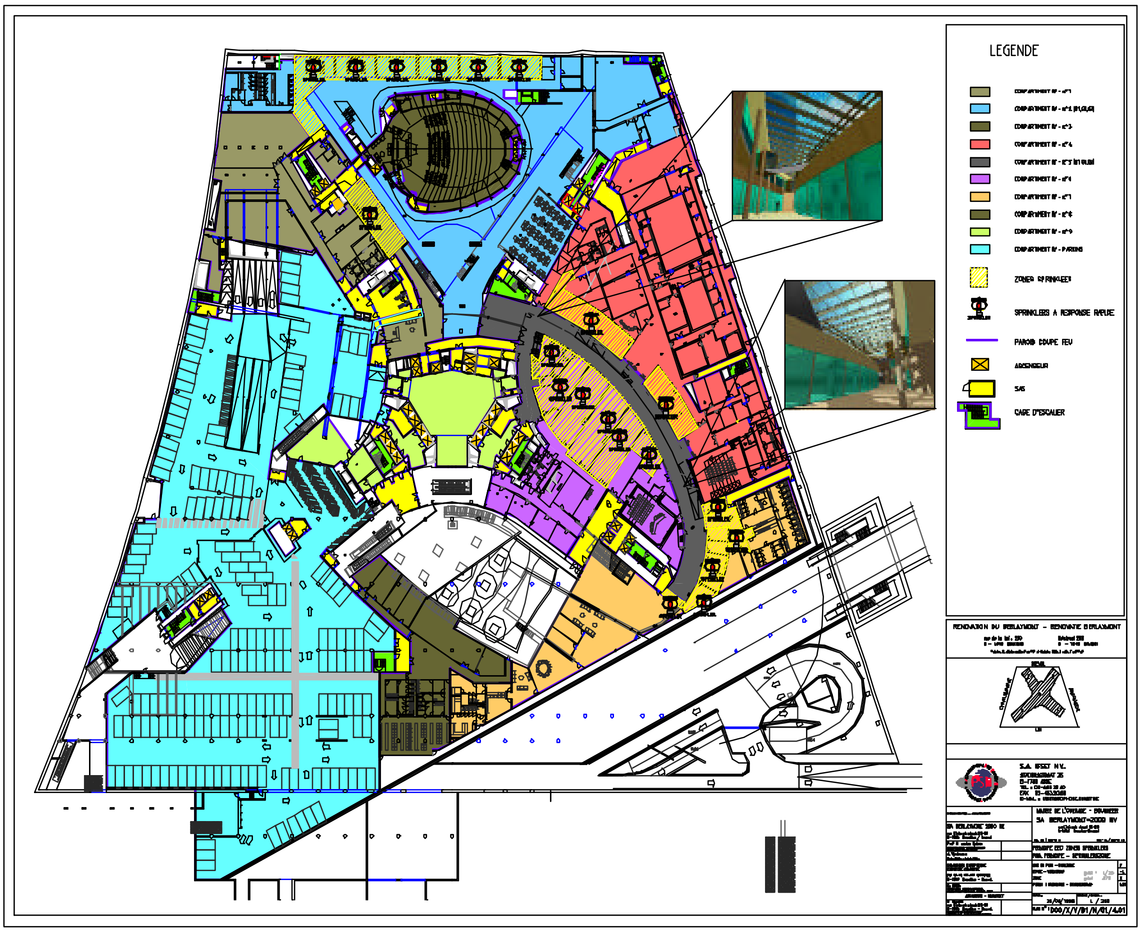
Five criteria were considered whilst developing solutions for 10 different zones.

The criteria were:

- necessary evacuation time for the persons present and the evacuation routes which needed to be followed
- compartmentation and spread of fire, depending on the contents of a particular area
- smoke and heat development, what are the means of exhaust?
- detection of a fire and which consecutive actions need to be taken
- fire extinction (manual or automatic).

The following zones were identified:

- underground carpark with 4 levels
- archives in the basement
- technical installations in the basement with maintenance rooms and technical rooms
- auditorium for press conferences, conference rooms above and a surrounding void on 4 levels (block F)
- communication centre with recording studios, conference rooms and logistic spaces
- concourse area with VIP reception, in connection with the communication centre via an inner street on two levels and in connection with lobby, piazza, self-service and restaurant
- little central meeting rooms with 2 level concourse (with void) and internal garden (7 typical storeys)
- offices with connecting corridors (towards the staircases) and sanitary blocks (13 typical storeys)
- restaurant on the 13$^{th}$ floor
- "European Commission" - conference room on the 13$^{th}$ floor.

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## *2.2. Evacuation of the building*

In order to evacuate a possible 3 000 persons in the building by 8 staircases, a study was performed to introduce the idea of phased evacuation. This means that first the affected floor is evacuated, then the levels above and after that the lower levels. This evacuation is guided by the fire detection and public address systems and will be tested yearly by all the users of the building to ensure that most of them are familiar with it.

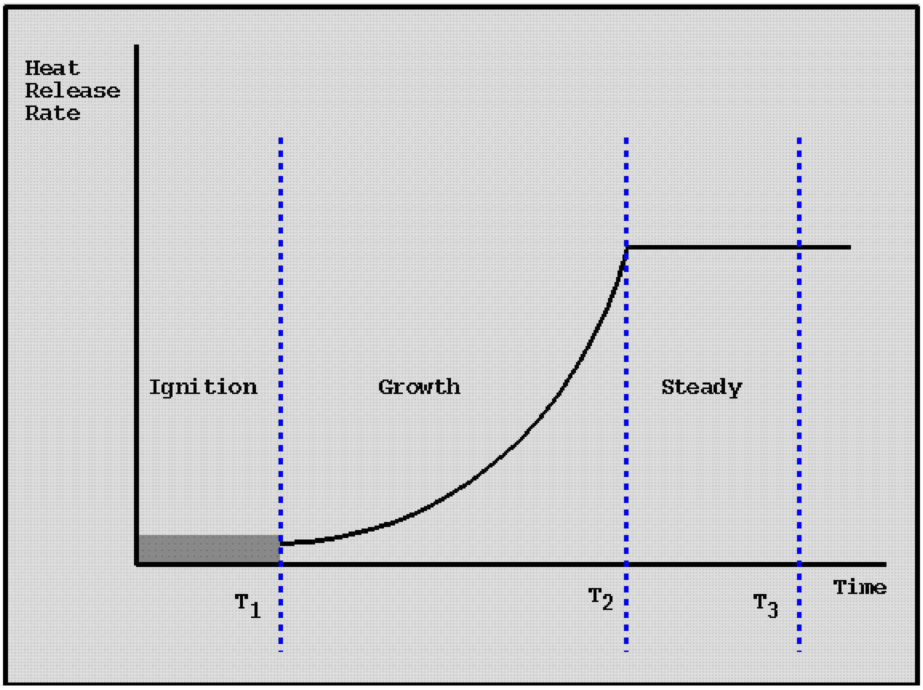
Special attention is drawn to 2 potentially crowded locations: the press conference room (330 persons) and the self-service restaurant (900 persons). The calculated evacuation times out of these spaces are respectively 3 minutes and 4,5 minutes, taking into account the presence of disabled people, the travel distance and the number of exit doors. These evacuation times were then compared to the fire development time in the subsequent space and were found to be adequate.

## *2.3. Determination of different fire scenarios*

According to NFPA 92B a growing fire is adopted to be the design fire in the difference zones.

$$\mathbf{Q = \alpha t^2 \ (kW)}$$

The figure below shows the development of fire with time following NFPA 92B.

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From 0 to T1 the fire develops from the initial ignition source (such as discarded smoking materials) to a sustained flaming fire that would be readily detected. This period could be from a few seconds to several hours depending on the exact nature of the ignition source and combustible materials involved.

From T1 to T2 the fire grows so that the heat release rate can be taken to be dependent on the square of the elapsed time. The table below reproduces the growth rates given in NFPA 92B for materials.

| **Materials** | **Growth Rate** |
|---|---|
| **Computer Workstation (Free burn)** | **Slow-Fast** |
| **(Compartment)** | **Very Slow** |
| **Shelf Storage** | **Medium to 200s then fast** |
| **Office Module** | **Slow-Medium** |

From NBSIR 88-3695

| **Values of α :** | |
|---|---|
| **Slow** | **0,0029** |
| **Medium** | **0,012** |
| **Fast** | **0,047** |
| **Ultra fast** | **0,19** |

Where Q is the heat output after a period t (s), taken into account the fire growth coefficient $\alpha$ (kW/s²). For most calculations in the present study this value is set to 0,012 which corresponds to "medium growth" or a heat release of 1 MW after 300 seconds.

The following fire scenarios were considered:

***a) fire in a compartment next to the atrium***

A dangerous situation can occur in the atrium when a fire develops in an adjacent room at level -1. The propagation of smoke in the atrium is determined by three parameters:

- the heat output in the room
- the width and height of the opening towards the atrium.

The installation of sprinklers was shown to be necessary to lower the smoke temperature (from flashover temperature to 280 °C) and to reduce smoke production (11 kg/s entering the atrium) towards the atrium.

***b) fire in a compartment next to the inner street***

Identical to scenario a) but as the ceiling is lower, the sprinklers will trigger sooner and the smoke volume towards the inner street is less than half the one in the atrium (4,77 kg/s).

***c) fire in the self-service restaurant***

As this space is well occupied and has the presence of a low false ceiling, it is imperative to install sprinklers as well. The extensive lateral spread of the smoke under the false ceiling (as well as cooling by sprinklers) guarantees a smoke temperature not exceeding ± 100 °C while using a well-designed smoke extract system. The smoke layer base can be held at 2,50 m.

***d) fire in the lobby (concourse)***

Due to the function of the lobby the fire risk can be neglected and thus not sprinklered. Nevertheless, a smoke exhaust is used to keep the lobby smoke free at all times as the two main staircases (from storeys 1-13) lead into this zone.

***e) fire in a room of aisle B & E at level +1 to check the radiation towards F***

Although the offices are small and separated from each other by walls with fire resistance of ½ h, a fully involved fire will cause too much heat radiation towards block F. Therefore, sprinklers are installed in every office nearer than 8 m to block F. The calculated safe distance regarding radiative heat transfer is 3,7 m with sprinklers.

***f) fire in the press conference room***

As the number of people can reach 330 persons, a smoke filling time is calculated which is then compared with the evacuation time (= 3 minutes, see 2.2.). Using the ventilation HVAC system and taking into account an unsprinklered "medium" to "fast growing" fire, the smoke will reach the critical height of 2,5 m after more than 5 minutes (with a temperature of 155 °C). This is sufficient to allow the necessary escape time.

***g) fire in an office room at a typical storey***

As all offices have windows towards the outside, a possible fire could cause the window glass to break and smoke to flow to the exterior. Although the doors are kept closed with doorsprings, it is still possible that they may be prevented from closing. Smoke flowing in the corridors will be extracted at high level while the staircase at each end of the corridor will be kept in overpressure.

***h) fire in the car parks***

All parking garages are equipped with sprinklers so that a design fire of 4 MW and 9 m² will produce a smoke flow of 10 kg/s, keeping the smokefree zone at 1,8 m. The normal parking exhaust system also runs at 200 m³/h per car and can also be used in case of fire.

***i) fire in a typical meeting room***

Identical to scenario f) but the number of people is not too large. The critical height of 2,5 m is reached after 2,5 minutes, the temperature at that time is 75 °C. (An exhaust capacity of 3 000 m³/h is in place.

Scenarios a) to e) and the consequent measures to tackle the possible danger were decisive in establishing the engineered solution as an alternative to the prescriptive codes.

## 3. SMOKE CONTROL SOLUTIONS

2 particular zones can be smoke logged within minutes if an adequate smoke control system is not installed:

- the inner street with entrance, lobby, piazza plus self-service
- the atrium from block F.

### ***3.1. The atrium of block F***

a) design calculation
The design fire is located in a room at -1 (see also 2.3.d.) with following parameters (sprinklered room !):

Qw = 500 kW (heat output at the window) after triggering of the sprinklers (200 s = heat release 500 kW)
Ww = 15 m (width of the window)
Pf = 8 m (perimeter of the fire)
Hw = 4,3 m (height of the window)

The smoke flow out of the compartment into the atrium is (according to BR 258):

$$Mw = \frac{0{,}21 Pf Ww Hw^{3/2}}{\left[ Ww^{2/3} + \frac{1}{0{,}65}\left[\frac{0{,}21 Pf}{2}\right]^{2/3}\right]^{3/2}} = 11{,}03 kg/s$$

This value is then used in a spill plume calculation (BR 258) in the atrium.

Adopted parameters are:

- extra rise in the atrium of 1 m above the top of the window
- the maximum temperature of the smoke is 50 °C to avoid breaking of surrounding glass
- adhered smoke plume with entrainment into one side only
- the use of fans to avoid possible adverse wind effects.

The result is an exhaust flow of 21,7 m³/s. This can be achieved by installing one or more fans.

All free walking zones in the atrium (escape route and bar at +1, platforms at 0 and +1 need to be separated from the atrium by retractable smoke curtains (see picture).

b) other zones

Smoke from a fire at the bottom of the atrium as well as smoke from one of the platforms situated in the atrium can be controlled by the installed smoke extract installation (as calculated under 3.1.a). The exact operation of the retractable curtains is described under "scenarios and consequent automatisms.

## *3.2. Inner street*

a) design calculation

The design fire is located in one of the "archive treatment" rooms at -1 (see also 2.3.b).

With following parameters (sprinklered room!):

Qw = 500 kW
Ww = 10 m
Pf = 8 m
Hw = 2,6 m

The smoke flow out of the compartment into the inner street is:

$$Mw = \frac{0{,}21 Pf Ww Hw^{3/2}}{\left[ Ww^{2/3} + \frac{1}{0{,}65}\left[\frac{0{,}21 Pf}{2}\right]^{2/3}\right]^{3/2}} = 4{,}77 kg/s$$

This value is then used in a spill plume calculation (BR 258) in the inner street.

Adopted parameters are:

- 3 m clear zone above piazza level
- free smoke plume with entrainment into both sides
- the use of fans to avoid possible adverse wind effects.

The result is an exhaust flow of 35 m³/s. Due to the critical layer depth 8 fans of each 4,4 m³/s were installed in order to avoid "plugholing".

b) self-service restaurant

By using only 2 pre-calculated fans (8,8 m³/s in total) and the appropriate channelling, a clear layer of 2,7 m is kept in the self-service. Due to the large area, smoke curtains were used to divide the area into two different smoke zones.

c) piazza

The piazza is separated from the lobby by a retractable smoke curtain. For a non-sprinklered fire of 1 MW (3 m x 3 m) an exhaust flow of 17,5 m³/s is required to maintain a clear layer of 4 m. This can be provided by half of the installed fans in the inner street.

d) lobby

As presumed in 2.3.d. the lobby is a zone with negligible fire load. Therefore sprinklers are not installed. A hypothetical fire 2 m x 2 m and 500 kW results in an exhaust flow of 7,7 m³/s which can be provided by the normal ventilation unit.

## 4. SOLUTIONS / FINAL BUILDING DESIGN

### 4.1. *Limitation in fire spread*

Following measures were taken to confine a possible fire to a defined area:

- fire resistance of the walls of the different spaces
- all openings are fire-stopped
- all ductwork is provided with dampers with the same fire resistance where fire-resisting walls are crossed
- other openings like doors and serving-hatches are self-closing in case of fire.

The main fire compartment boundaries have a FR-rating of 2 hours, the separation walls have FR ½ h. Where compartments are larger then 2 500 m², active measures (such as smoke curtains and smoke control systems) are used (see plan).
Special attention is given to the combustibility of the furniture.

### 4.2. *Automatic extinguishing*

The following "high hazard" areas are provided with sprinklers:

- archives
- stock
- waste disposal.

As only few people are present in these rooms, the purpose of the sprinklers is to protect the contents.

All parking garages are provided with sprinklers. The area (see chapter 3) are equipped with sprinklers only to reduce the fire spread and to limit the amount of smoke, are indicated on the plan views.

### 4.3. *Generalised fire detection*

The fire detection installation has a triple purpose:

- to detect a fire in a non-occupied room
- to detect the presence of smoke in one of the evacuation routes in order that this route is not used
- push buttons in all occupied zones in order to react very quickly at a possible fire.

The signal, entering the detection control panel, will directly activate the automatisms, which are linked to the triggered zone (e.g. ventilation, smoke exhaust, smoke curtains, closing of fire doors, …). The detection system is also linked to the public address system and the sirens in order to guide a possible phase evacuation.

### 4.4. *Pressure differential system in staircases*

All eight vertical evacuation staircases are provided with an overpressure installation, giving additional protection to the associated.
Ten air changes per hour are a "rule of thumb" value in Belgian standards in order to maintain an overpressure of 50 Pa in the staircase. The air, extracted at high level in the corridors, can also act as smoke removal if any smoke would have entered the corridor (see also 2.3.g.).

## 4.5. ***Emergency lighting and signs***

The indication of evacuation routes, exit doors, fire extinguishers, dangerous places, hydrants will be executed following the Belgian Code "Protection of Working Conditions". Some of the signs are according the new European Standard, also introduced as a Belgian Standard (e.g. hose reels).

The emergency lighting will be executed according to a Belgian Standard as indicated in the Royal Decree article 6.5.4.

In order to achieve a phased evacuation from the 13 storey high wings, a dynamic signalisation is foreseen, lighting up when an evacuation of a particular floor is requested.

## 5. FIRE SAFETY MANAGEMENT

In order to have full benefit of all the adopted solutions, several schemes need to be put in place to have a good follow-up maintenance of the installations and to ensure accurate intervention (and evacuation) when a fire eventually occurs.

### 5.1. *Fire scenarios + automatisms*

The whole building has approx. 500 different fire compartments: very large ones such as the parking and lobby for instance, but also small plant rooms. Due to the fully addressable fire detection installation, different actions can be triggered from the detection control panel, depending on the place where detection took place. The following actions/automatisms can take place:

- stopping normal ventilation
- overpressure in staircase
- smoke and heat exhaust from the affected zone
- lowering of smoke curtains
- closing of fire doors (normally kept open by electromagnetic holders)
- releasing of security doors in the evacuation route (normally bolted or badge-controlled)
- activating dynamic signs
- closing of fire dampers in ducts
- activation of the public address system
- warning of responsible people
- putting the lifts out of order and bringing the cages to evacuation level.

These automatisms need to be put in place for every fire compartment (= scenario) and tested at the delivery of the installations. Every month 5 scenarios need to be tested. All installations need a yearly control check by an official body.

### 5.2. *First intervention and evacuation procedures*

The building will be equipped with manual fire extinguishers (1 unit/150 m²) and hose reels. Responsible people have to be trained to use these devices with a refresher course once a year. A first intervention team is appointed for critical zones.
Others will be responsible in case of evacuation of (a part of) the building. Procedures will be put in place so that everyone will be guided to the assembly places safely and that full assistance will be given to the fire brigade when they enter the building.
An evacuation exercise is held every year.

### 5.3. *Fire plans and fire brigade intervention file*

At every floor, next to an escape staircase door, a fire plan can be seen by the occupants. This plan indicates all evacuation routes, location of fire extinguishers, hose reels, emergency phones and fire push buttons in their area.
Rooms with hazardous contents or electrical danger can be indicated as well.
The fire brigade has a comprehensive file, indicating all primary and secondary entrances to the building, all priority lifts and hydrant points, plus eventual dry risers.

A good overview of all typical floors as well as complex zones as the atrium and lobby/piazza e.g.

An indication panel at the entrance gives the status of important devices as ventilation units, fire dampers, smoke exhaust units, …

Also indicated are hazardous rooms, sprinkler control rooms, gas valves, main electric board, emergency power supply, …

This fire brigade intervention file needs to be updated every 3 months so that an accurate building-overview is available at all times.

## CONCLUSIONS

Although the Berlaymont Building does not comply with the requirements of the Royal Decree for Fire Safety (being too prescriptive and restrictive to architects & designers) due to the Performance Based Fire Safety Engineered approach solutions for Fire Safety have been adopted for the building offering a satisfactory level of safety, which has been accepted by the Fire Brigade Department.

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