Safety Guideline SG-FS-0-0-2

SMOKE EXTRACTION SYSTEMS

**Purpose:** This Safety Guideline is intended to provide guidance for compliance with Fire Safety requirements for smoke extraction systems installed in surface buildings located in French territory.

**Reference documents:**
CERN Safety Rules:
French legislation:
- Articles R4216-13 à R4216-16 du Code du Travail relatif aux obligations du maître d'ouvrage pour la conception des lieux de travail concernant le désenfumage
- Arrêté du 5 août 1992 pris pour l’application des articles R. 235-4-8 et R. 235-4-15 du code du travail et fixant des dispositions pour la prévention des incendies et le désenfumage de certains lieux de travail;
- Arrêté du 26 février 2003 relatif aux circuits et installations de sécurité;
- Arrêté du 21 novembre 2002 relatif à la réaction au feu des produits de construction et d’aménagement.

Standards:
- EN 12101-1 – Smoke and heat control systems – Part 1: Specification for smoke barriers;
- EN 12101-2 – Smoke and heat control systems – Part 2: Specification for natural smoke and heat exhaust ventilators;
- EN 12101-3 – Smoke and heat control systems – Part 3: Specification for powered smoke and heat exhaust ventilators;
- EN 12101-6 – Smoke and heat control systems – Part 6: Specification for pressure differential systems - Kit;
- EN 12101-7 – Smoke and heat control systems – Part 7: Smoke duct sections;
- EN 12101-8 – Smoke and heat control systems – Part 8: Smoke control dampers;
- EN 12101-10 – Smoke and heat control systems – Part 10: Power supplies;
- EN 13501 – Fire classification of construction products and building elements;
- Instruction Technique (IT 246) – Relative au désenfumage des Établissements Recevant du Public
- NF S 61-937 – Systèmes de sécurité incendie (S.S.I.) – Dispositifs actionnés de sécurité (D.A.S) ;
- NF S 61-938 – Systèmes de sécurité incendie (S.S.I.) – Dispositifs de commande manuelle (D.C.M.) - Dispositifs de commandes manuelles regroupées (D.C.M.R.) – Dispositifs de commande avec signalisation (D.C.S.) - Dispositifs adaptateurs de commande (D.A.C.) ;
- NF S 61-939 – Systèmes de sécurité incendie (S.S.I.) – Alimentations pneumatiques de sécurité (A.P.S.) - Règles de conception ;

**TRACEABILITY**

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1 INTRODUCTION

This Safety Guideline offers the user a set of Safety requirements issued from applicable regulations and common standards when designing, specifying and/or installing smoke extraction systems and the actions on the general HVAC installations upon fire detection.

2 PURPOSE AND SCOPE

This Safety Guideline is applicable for the design and/or installation of smoke extraction systems for tertiary buildings installed on the surface of French territory. It is based on the French guideline for smoke extraction systems IT246 and, according to Article 14 of the Arrêté du 5 août 1992, the Safety requirements are applicable also for the French “Code du Travail” and CERN Safety Code E.

Please note, that in this Safety Guideline the use of "shall" indicates a mandatory Safety requirement issued from applicable regulations or common standards.

Underground installations, radioactive areas and buildings classified as “ERP” (Établissements Recevant du Public) will be issued in a dedicated Safety Guideline and therefore are out of the scope of this document.

3 FIRE SAFETY REQUIREMENTS FOR SMOKE EXTRACTION

The aim of smoke extraction is to extract smoke from the premises in the event of a fire in order to:
- allow people and emergency services to take the escape routes;
- limit the propagation of the fire by removing heat, gases and unburnt products.

According to the French “Code du Travail” (Art. R.4216-13), a smoke extraction system is required in:
- Premises located on the ground floor or on the upper floors with a surface area exceeding 300 m²;

![Image of a premises that requires smoke extraction]

Figure 1 – Example of a premises that requires smoke extraction

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1 Instrumentation Technique 246 relative au désenfumage dans les établissements recevant du public (Arrêté du 22 mars 2004)
- Blank rooms (rooms without windows connecting to the exterior) and basement premises with a surface area exceeding 100 m²;

![Figure 2– Example of a premises that requires smoke extraction](image)

- In all staircases used as emergency exit. According to IT 246, if natural smoke extraction is not feasible, the staircase shall be pressurised.

**Note:**
Premises with a surface area exceeding 2000 m² or with a length exceeding 60 m shall be divided in smoke zones with a maximum surface area of 1600 m² and a maximum length of 60 m. Roof screens between smoke zones can be made out of structural components (beams, walls), stiff fixed screens in non-combustible material (B-s3,d0 in compliance with Euroclasses defined by NF EN 13501-1+A1) with a fire resistance of at least ¼ h or movable curtains in non-combustible material (B-s3,d0) with a fire resistance of at least ¼ h. The height of roof screens shall be 25% of the average height building when this height is less than 8 m, or 2 m when the height building is more than 8 m.
3.1 Natural extraction

Smoke extraction via natural means is achieved by the extracting of smoke and intake of fresh air communicating either directly, or by ducts, to the exterior. This allows a significant “renewal” of the air while replacing the smoke with fresh air coming from outside.

Natural smoke extraction in premises is only feasible if the openings are in direct contact with the exterior (outside), e.g. façade or roof, and if it respects the Safety requirements listed below.

3.1.1 Extraction opening

In order to be able to design a natural smoke extraction system (e.g. via skydome, openings in the façade, or vents), the following prescriptions from IT246 apply:

- space available on the roof with a direct connection with the exterior;
- the total geometrical surface area\(^2\) of the opening (ABCD on figure 4), for the smoke extraction, shall be greater than 1% of the floor area of the concerned zone and shall have a minimum cross-section of 1 m\(^2\);

- the useful effective surface area of the opening (A'B'C'D' on figure 4), for the smoke extraction, shall be greater than 0.5% of the floor area of the concerned zone (the effective surface area is obtained by the product of the geometrical area by the efficiency coefficient of the smoke vent);

\[ A_{\text{total}} \times A_{\text{effective}} > \text{Total surface area of the opening} (< 1 \text{ m}^2) \]

An example is shown in Annex (c.f. § 6 )

- each opening should serve a maximum floor area of 300 m\(^2\);
- distance between openings shall be less than 4 times the average height of the building, and less than 30 m in any cases;
- the snow load shall be considered and classified as SL 250 (250 N/m\(^2\)) for altitudes lower or equal to 400 m and SL 500 (500 N/m\(^2\)) for altitudes between 400 m and 800 m;

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\(^2\) The total area in which the air flow is released (cf. figure 3)
- the openings shall have a reliability class of RE 300 (300 operating cycles). If the opening is also used as normal HVAC system, the reliability has to be verified after 10 000 opening/closing tests at ventilation conditions;

- the openings shall have a classified as T00 (0°C ambient temperature) and have a resistance to heat classification of at least B 300 30 (300°C during 30 min);

- each opening shall have a minimum length of 0.20 m in order to be considered as a smoke extraction mean; the relation between the length and the width of the opening shall be less than 2;

- the opening shall be, at least, 4 meters away from a window in nearby buildings. If this distance is not achieved, all provisions, such as installing a “smoke deflector”, shall be taken into account to prevent the propagation of the fire to the adjacent buildings;

- the location and orientation should take into account direction of predominant winds;

- if an horizontal ductwork is needed between the premises and the opening, it shall be no more than 2 meters in length, unless the extraction flow rate is justified;

- the manipulation of the openings shall be easily accessible from the floor; if the building is equipped with smoke detector (Système de Sécurité Incendie catégorie A according to NF S61-931), the manipulation shall be done from the fire alarm control centre (CMSI: Centralisateur de Mise en Sécurité Incendie).

3.1.2 Fresh air intake

In order to be able to create the necessary pressure difference in the premises and ensure the air renewal, the natural fresh air intake (e.g. openings in the façade, doors connecting to exterior or vents) shall respect the following conditions:

- installed at a lower level (as close as possible to the ground floor), e.g. large doors or gates, to ensure the “stack effect” and induce a significant air renewal;

- the total surface area of the opening shall be 100% of the total effective surface area of the natural smoke extraction opening;

- shall be oriented, as best as possible, towards the predominant wind.

3.1.3 Enclosed staircases

In case of a staircase used as an emergency exit from the premises, means for providing a smoke-free evacuation shall be foreseen. In this case, for natural smoke extraction:

- a skydome or vent shall be installed on the roof of the staircase, with a geometric surface of 1 m², or

- an opening shall be made on the façade of the last story of the building, with a free surface of 1 m², for the smoke to pass.

The manipulation of the opening shall be easily accessible in the stairwell, from the floor. The rearmament shall be accessible from the floor or from the last level.

In any case, an opening shall be made on the façade of the 1st story of the building, with a geometric surface of 1 m², to provide the fresh air supply.
3.1.4 Documentation for Safety File, according to CERN Safety Code E

The necessary documents to complete the Safety File of the installation are:

- execution drawings;
- material/product certification;
- certificate of installation;
- system test certificate;
- regular maintenance by a qualified professional (to be updated regularly).

3.1.5 Conformity checklist

The recommended checklist to verify the conformity of the natural ventilation system during the “Safety Reception” includes the presence of:

1. validation form of execution drawings;
2. installation certificate;
3. test certificate.
3.2 Mechanical extraction

Smoke extraction via mechanical means (i.e. forced ventilation) is achieved by extracting smoke via exhaust ventilators. The intake of fresh air could either be natural, in this case shall respect the Safety requirements in § 3.1.2, or, mechanical, using ventilation to compensate the extraction flowrate. In both cases, the fresh air intake, shall allow a significant “renewal” of the air by replacing the smoke with fresh air coming from the exterior.

3.2.1 Extraction system

The mechanical smoke extraction system shall comply with the Safety requirements provided in CERN Safety Code E, in particular:

- follow the EN 12101-3 standard;
- be made via an extractor (ventilator) and ducts equipped with smoke control dampers, both designed and installed to withstand specific conditions during a fire (cf. § 4);
- have a minimum extraction flow rate of 1 m\(^3\)/s per 100 m\(^2\) of surface area to protect the premises;
- an existing HVAC system might be used as a mechanical smoke extraction if the Safety requirements mentioned above and in § 4 are respected;
- whenever a smoke extraction system (e.g. smoke extraction ducts) penetrates a fire compartment inside a premises, it shall respect at least one of the two following Safety requirements:
  - the penetrating element (e.g. duct) shall have the same fire resistance as the compartment it penetrates, or
  - a smoke control damper, with the same fire resistance as the compartment being penetrated, shall be installed;
- before the extraction system is switched ON, the other HVAC systems (if installed) shall be switched OFF and the fire dampers placed in “closed” position;
- the extraction system shall be installed on a secured electrical network (interruptible power supply or similar).

3.2.2 Fresh air intake

In order to ensure the necessary air renewal, the fresh air intake can be made mechanically (e.g. supply ventilator) or naturally (e.g. openings in the façade, doors connecting to exterior or vents).

3.2.2.1 Mechanical fresh air intake

The mechanical fresh air intake shall respect the following provisions, according to CERN Safety Code E:

- the supply openings or louvers shall be connected, by ductwork, to the supply ventilator;
- the ductwork shall respect the characteristics mentioned in § 4;
- the maximum velocity in the supply dampers shall be of 5 m/s;
- the supply flow rate shall be determined as a function of the extraction flow rate, in order to ensure a significant under pressure in the premises:

\[ Q_{\text{supply}} = 0.6 \times Q_{\text{extraction}} \]

### 3.2.2.2 Natural fresh air intake

The natural fresh air intake shall respect the following provisions according to CERN Safety Code E:
- be installed at a lower level (as close as possible to the ground floor), e.g. large doors or gates, to ensure the “stack effect” and induce a significant air renewal;
- be oriented, as best as possible, towards the predominant wind.

Although the regulations do not provide a clear value on the size of the opening, this Safety Guideline recommends to install an opening that respects the supply flow rate mentioned in § 3.2.2.1, by using the maximum velocity of 5 m/s, e.g.:

\[ Q_{\text{extraction}} = 10000 \text{ m}^3/\text{h} \text{ (mechanical)} \]
\[ Q_{\text{supply}} = 6000 \text{ m}^3/\text{h} \text{ (natural)} \]

\[ \text{Area}_{\text{opening}} = \frac{6000}{5} = 0.33 \text{ m}^2 \]

### 3.2.3 Documentation for Safety File, according to CERN Safety Code E

The necessary documents to complete the Safety File of the installation are:
- design report;
- execution drawings (including air flow rates, fire resistance and compartments);
- material/product certification;
- declaration of performance;
- certificate of installation;
- system test certificate;
- maintenance reports.

### 3.2.4 Conformity checklist

The recommended checklist to verify the conformity of the natural ventilation system during the “Safety Reception”:
1. validation of smoke extraction design report;
2. validation of execution drawings;
3. presence of the installation certificate;
4. presence of the test certificate.
4 CHARACTERISTICS OF EQUIPMENT INSTALLED IN SMOKE EXTRACTION SYSTEMS

4.1 Extraction dampers

If the damper is connected to ductwork, the fire resistance shall have the same classification as for the duct.

4.2 Supply dampers

If the damper is installed in a façade, it shall not be obstructed by any type of material or equipment.

If the damper is connected to ductwork, it shall be “pare-flame” with the same classification as for the duct, unless a smoke control damper is installed for a single compartment extraction duct.

4.3 Smoke extractors

The extractors shall be tested according to EN 12101-3 and be certified for at least F400 60. They shall bear the CE marking.

The extractors shall be installed outside or in premises with a fire resistance of at least 1 hour; in that case, the door shall present a fire resistance of at least ½ hour and a door-closer.

The connection between the ductwork and the extractor shall be made of non-combustible material.

4.4 Extraction ducts

The ductwork shall be made out of non-combustible material (M0 in compliance with NF P92-507, or A2-S2, d0 in compliance with NF EN 13501-1+A1) with a fire resistance of at least ¼ h. If the ductwork is penetrating a static confinement belonging to a fire compartment, it shall have the same fire resistance as the compartment it penetrates.

The ducts shall be product compliant with EN 12101-7.

4.5 Smoke control dampers

The smoke control dampers shall be compliant with EN 12101-8 and shall bear the CE marking.
5  FIRE SAFETY RECOMMENDATION FOR VENTILATION SYSTEMS UPON CONFIRMED FIRE DETECTION

The following actions matrixes are recommended related to air management and/or ventilation systems upon confirmed fire detection:

1. Switch OFF the HVAC system automatically in order to mitigate the propagation of the smoke. After the Alarm Level 3 is reset, the ventilation system should remain in shutdown mode with dampers closed and the Alarm Level 2 remain on.

2. Automatically/manually turn ON the smoke extraction system. Currently at CERN the activation is made manually by fire brigade, but one could also investigate if it is possible to activate automatically. Taking into account best practices from Fire Safety and Fire Intervention domains, the suggestion would be to request the automatic triggering of the smoke extraction system as default. Although a case-by-case analysis might be necessary.

6  ANNEX

6.1  Links to regulation

6.2 Example of data from declaration of performance of smoke vent ECODIS Ecofeu 160TC

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**Effective area**

- SL250
- SL500 possible sur demande
- Disponible en version accès toiture

**Standard**

- Aa standard (m²) / Aa avec grille RE (m²)
- With anti-infrarad shelf 1200 J

**Reliability class**

- Snow load
### 6.3 Example of natural smoke extraction calculation

Let’s consider a room with a floor surface of 2400 m²: this surface shall be divided in 2 equal smoke zones by a roof screen.

In each smoke zone of 1200m², the extraction openings shall respect the following dimensions:

- **Geometrical surface area** \( \geq 1200 \times 1\% = 12 \, \text{m}^2 \)
- **Effective surface area** \( \geq 1200 \times 0.5\% = 6 \, \text{m}^2 \)

For example, in each smoke zone, these requirements can be achieved by 6 smoke vents 2,00 m * 1,00 m “Ecofeu 160 TC Ecodis” equipped with anti-infraction shelf:

- **Geometrical surface area** \( 6 \times 2,00 \times 1,00 = 12 \, \text{m}^2 \) \( \geq 12 \, \text{m}^2 \) ✓
- **Effective surface area** \( 6 \times 1,28 = 7,68 \, \text{m}^2 \) \( \geq 6 \, \text{m}^2 \) ✓

Notice: the distance between smoke vents must be less than 4 times the average height.
### 6.4 Example of data from declaration of performance of damper ALDES Isone

<table>
<thead>
<tr>
<th>Caractéristiques essentielles</th>
<th>Performances</th>
<th>Spécifications techniques harmonisées</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditions nominales d'activation/de sensibilité :</td>
<td>Conforme</td>
<td>Montage dans une cloison en plaques de plâtre (EI 120) El 90 (Vₚ₋₁ →₀) S</td>
</tr>
<tr>
<td>• capteur de capacité de charge</td>
<td>Conforme</td>
<td>Montage dans une cloison en plaques de plâtre (standard) El 60 (Vₚ₋₁ →₀) S</td>
</tr>
<tr>
<td>• capteur de réponse en température</td>
<td>Conforme</td>
<td>Montage déporté d’un voile par l’intermédiaire d’un conduit en staf d’épaisseur 45 mm El 120 (Vₚ₋₁ →₀) S</td>
</tr>
<tr>
<td>Délai de réponse (temps de réponse) :</td>
<td>Conforme</td>
<td>Montage en traversée de voile en carreaux de plâtre d’épaisseur 70 mm El 60 (Vₚ₋₁ →₀) S</td>
</tr>
<tr>
<td>• temps de fermeture</td>
<td></td>
<td>EN 15650</td>
</tr>
<tr>
<td>Fiabilité opérationnelle :</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>• cycles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Résistance au feu : Fire resistance according to the support

Durabilité du délai de réponse :
• réponse en température et en capacité de charge du capteur : Conforme

Durabilité de la fiabilité opérationnelle :
• essais de cycles en ouverture et fermeture : 300