European Guideline

Smoke and Heat Exhaust Ventilation Systems Planning and Design

CFPA-E No 2X:201X F
FOREWORD

The European fire protection associations have decided to produce common guidelines in order to achieve similar interpretation in European countries and to give examples of acceptable solutions, concepts and models. The Confederation of Fire Protection Associations in Europe (CFPA E) has the aim to facilitate and support fire protection work in European countries.

The market imposes new demands for quality and safety. Today, fire protection forms an integral part of a modern strategy for survival and competitiveness.

This guideline is primarily intended for those responsible for safety in companies and organisations. It is also addressed to the rescue services, consultants, safety companies etc. so that, in course of their work, they may be able to help companies and organisations to increase the levels of fire safety.

The proposals within this guideline have been produced by the Swissi AG and the author is Hans-Heinrich Wolfensberger from Switzerland.

This Guideline has been compiled by Guidelines Commission and adopted by all fire protection associations in the Confederation of Fire Protection Associations Europe.

These guidelines reflect best practice developed by the countries of CFPA Europe. Where the guidelines and national requirement conflict, national requirements must apply.

Copenhagen, date name of month 201x
CFPA Europe

Jesper Ditlev
Chairman

Helsinki, date name of month 201x
Guidelines Commission

Matti Orrainen
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1 Introduction

In case of fire in a room, due to buoyancy the hot and smoky gasses are rising above the fire and spread at high level. Without a smoke and heat ventilation system the entire volume of the room will be smoke logged within minutes.

The smoke and heat ventilation systems (called further SHEVS) will make sure that a smoke free zone will be maintained at low level by extracting an amount of smoky gases out of the smoke compartment. The SHEVS are also used to extract the heat from a starting fire, it will help keeping the evacuation routes free of smoke and by doing so will help the evacuation of people from a building in fire and simultaneously reduce the damage directly due to the fire and the financial losses, reduce the smoke damage, allow the repression by the Fire Brigade by improving the visibility, reduce the temperature under the roof and reduce the horizontal spread of the fire.

2 Scope

The objective of this guideline is a tool to plan and design SHEVS without the aim of computer simulation for the following utilisation:

- Industry, production and storage buildings
- Office buildings
- Supermarkets
- Rooms with high number of people
- Car parks

This guidance is not applicable for large fire compartments over 10'000 m² or rooms with more than 2'000 people.

Reference

All figures und plans are extracted from technical bulletins of Gebäudeversicherung des Kantons Zürich.

3 Definitions

Under "Smoke and Heat Exhaust Ventilation Systems" is comprising all constructive and technical installations used in the system to extract the smoke and heat from a fire towards the outside. Hereto belong extract openings as well as other openings where the replacement inlet air flows in or an overpressure can be build down towards the outside.

3.1 Smoke extraction openings

Smoke extraction openings are openings towards the outside air (i.e. openings in facades and roofs, shafts and ducts used to extract the smoke and heat) allowing the fire brigade to use mobile smoke and heat exhaust systems (i.e. fire ventilator, heat extractors)

3.2 Air inlet openings

Air inlet openings are openings by which the fire brigade can blow air into a building with a fan. This must be possible through a door or indirectly through a stairwell following a corridor.
4 Meaning and objective

4.1 Objective
SHEVS have the following objectives:

- The installation must ensure that people can escape from a building without endangering themselves when leaving a fire compartment or a building towards the open air (self-evacuation).
- The installation must make sure that fire brigade intervention and repression are possible by maintaining acceptable smoke free conditions.
- The installation must make sure that the building and the production are protected by a controlled extraction of smoke and heat.
- The installation must make sure that after a fire a fast extraction of the smoke will take place (smoke extraction).

4.2 Design objectives
The design objectives for the application of this guidance are:

- Respect the fire regulations, more especially the requirements about “emergency and safety exits”
- Taking into account in the concept an intervention time for the fire brigade of 15 minutes being the repression time.
- Smoke extraction fans and pressure nozzles on the fire brigade vehicles for concepts that require a use by the fire brigade.

5 General requirements

5.1 Nature and efficiency
Smoke and heat vents must comply with the state of the art and be so designed, calculated, installed and maintained in such a way that they are effective and are ready for operation at any time.
- All system parts must be made of suitable materials and shall be calculated, assembled and installed to be able to withstand all requirements.
- The specifications of the manufacturer and manufacturer of the parts (e.g. Fans) and the maintenance and inspection intervals have to be part of it. The responsible person has to be determined.

5.2 Smoke and heat extraction
- Extraction openings for the removal of smoke and heat have to be arranged in such a way that an efficient extraction of smoke and heat can be ensured.
- If extraction openings cannot be installed in the roof, the necessary openings can be uniformly distributed as possible in two opposite facades.
- In large fire or smoke compartments, the roof shall be divided at roof level into smoke compartments to confine the smoke layer.
5.3 Shafts and smoke extraction ducts
- Shafts and smoke extraction ducts must be executed and installed in such a way that withstand the stresses and when extracting hot gasses fire and smoke, they will avoid further smoke propagation.
- When planning and executing the designer must look at the requirements for the ducts in case of fire
- Measures for linear expansion on fixed points must be taken into account and compensators have to be provided. Plastic anchors for the installation of power lines are not allowed. Power lines passing through fire walls need to be fully executed with the necessary fire e, are for the respective fire area with the necessary fire resistance.

5.4 Replacing air inlet/air inlet openings
The installation of smoke and heat extraction systems assumes that smoke can only be extracted when replacing air inlet can flow into the building.
Replacing air inlet openings (such as separate openings in walls/facades, doors, windows) must be planned at low level. The extract areas and air inlet areas have to be in accordance with each other.
For the smoke removal with Powered SHEVS, air inlet velocities of maximal 5 m/s is permissible. The pressure ratios must be such that the escape passage is not hampered.

5.5 Control and activation (see Annex)
- Smoke and heat extraction systems (SHEVS) must be controlled manually from a safe location in the event of a fire. The control boxes must be recognisable so that people can see that it is the control box for the SHEVS and also see when the installation is in operation
- The operation of fixed SHEVS has to be automatic (e.g. activation by sprinkler flow switch or fire alarm systems). In addition a manual operation for the fire brigade have to be foreseen.

5.6 Power supply in case of fire
SHEVS must have a dedicated emergency power supply independent of the main power.

5.7 HVAC Systems
The use HVAC installations (e.g. Ventilation and Air Conditioning) for the smoke and heat vent systems is permitted only if the HVAC installations fulfil the requirements for SHEVS (smoke and heat ventilation system).

5.8 Installation and maintenance
- All system parts must be made of suitable materials and shall be designed, calculated and installed to withstand severe conditions.
- The parts used in the systems such as fans, heat and smoke vents, etc. must have test certificates according to EN 12 101 series of standards.
- The specifications of the manufacturer of the parts (e.g. Fans) and the maintenance and inspection must be made available. The responsible persons must be indicated
- All the automatisms and activation schemes need to be documented. Tests must be carried out to verify the functionalities of the SHEVS
6 SHEVS Concepts

6.1 Natural smoke and heat extraction systems (N-SHEVS)
- Underground areas cannot use natural SHEVS as they are not effective.
- Production areas need a natural SHEVS with an aerodynamic area \( A_{aerodyn} \) of 0.7 % of the floor area of the smoke compartment.
- Smoke and heat vents must be installed at the highest point in the building, most of the cases in the roof or at the highest point in facades, the replacing air inlet has to be foreseen at low level.
- Smoke and heat exhaust systems must be able to function under every circumstance independently of the weather conditions and perform according to the design.
- If the smoke and heat exhaust ventilation systems cannot be installed in the roof, then they can be installed in two opposite facades at the highest level in these facades. The fire brigade must be able to open the SHEVS separately for each facade.
- The efficiency of natural smoke and heat exhaust vents can be negatively influenced by weather conditions (temperature, wind direction), fire scenario (size of the fire, flue gas temperature) and smoke logging degree (e.g. loss of thermodynamics).

The geometric surface area (wall opening) can be determined as follows:

\[
A = \frac{A_{aerodyn}}{c}
\]

\( A \): Geometric surface area (wall opening) \([m^2]\)
\( A_{aerodyn} \): Aerodynamic effective area \([m^2]\)
\( c \): Flow Coefficient (see table below)
\( \alpha \): Opening Angle

Table – aerodynamic flow coefficients \((c)\) for different opening types

<table>
<thead>
<tr>
<th>Öffnungsart</th>
<th>Öffnungswinkel ( \alpha )</th>
<th>Durchflussbeiwert ( c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>vollständig geöffnete Fläche</td>
<td>90°</td>
<td>0,65</td>
</tr>
<tr>
<td>Jalousien</td>
<td>( \geq 60° )</td>
<td>0,5</td>
</tr>
<tr>
<td>Dreh- oder Kippflügel</td>
<td>( \geq 45° )</td>
<td>0,4</td>
</tr>
<tr>
<td>Dreh- oder Kippflügel</td>
<td>( \geq 30° )</td>
<td>0,3</td>
</tr>
</tbody>
</table>

(Tabelle aus DIN 18232-2:2003-06, Anhang C-Tabelle C.1)

Dem in der Tabelle angegebenen Öffnungswinkel kann jeweils eine zulässige Abweichung von \( \pm 5° \) zugeordnet werden.
6.2 Smoke removal by the Fire brigade with extraction fans (FB-SHVES)

6.2.1 General information

- In underground fire and smoke compartments the smoke can only be removed with smoke vents when the construction has one floor below ground level, in deeper construction smoke vents are not allowed. Natural SHEVS Concepts in complex geometries are not applicable.
- The smoke removal with the fans of the fire brigade is applicable.
- For fire areas with a volume > 60'000 m³, natural smoke and heat ventilation systems are not sensible.
- The Fire Brigade responsible for the intervention in a building must use their extraction fans.
- The simultaneous use of more smoke vents requires a concept. In particular, make sure that the flow rate of the individual smoke extractors does not make a short circuit.

6.2.2 Air inlet openings

- The efficiency of the SHEVS assumes that in addition to the extraction replacement air inlet is also present. These must be so arranged that SHEVS can be operated efficiently.
- The place where the SHEVS are installed must be dimensioned in such a way that the air pattern of the air inlet covers the entire surface. This requires that the SHEVS are installed 3 to 4 meters before the air inlet.
- SHEVS should be installed in such a way that they directly or indirectly (e.g. via a staircase and/or a corridor) blow air into the fire room. Possible pressure losses shall be taken into account.

Is the direct air inlet into the fire room or in a previous room is not possible, the air can be brought in by the fire brigade into the fire room using pressure nozzles.
Volume flows of smoke fans (depending on the product):

- Standard smoke fan Ø 80 cm - 38,000 m³/hour (10.6 m³/s)
- Standard smoke fan Ø 100 cm - 50,000 m³/hour (13.9 m³/s)
- Large smoke fan 200,000 m³/hour (55.6 m³/s)

(volume flows of fans without pressure losses in an open field.)

**6.2.3 Extraction openings**

- The aerodynamically effective smoke exhaust area shall be approximately 1.3 m². SHEVS not used as air inlet openings can be divided into equivalent aerodynamic effective areas.
- In corners, larger niches, etc. additional SHEVS must be foreseen to avoid areas without smoke and heat exhaust. The arrangement of the SHEVS and the replacing air inlet openings has to be done in such a way that short-circuits cannot occur.
- SHEVS are always installed at the highest point in the roof, or at the highest point in ceilings, alternatively at the highest point in facades.
- SHEVS must be controlled from a safe place and must be opened and closed from that safe place, the SHEVS installation must be able to open or close. The installation must be in operation in case of power failure.

**6.3 Automatic smoke and heat fans (M-SHEVS)**

**6.3.1 High temperature fans**

- MSHEVS High temperature fans are allowed only when tested by a recognised testing laboratory. The functionality of the MSHEVS must be guaranteed during 60 minutes at a temperature of 400 °C.
- In case lower temperatures of the smoky gasses are expected the temperature resistance of the fans can be reduced to 200 °C (i.e. sprinklered areas)

**6.3.2 Air inlet openings**

Air inlet openings (e.g. Doors, Gates, windows, separate openings in facades) must be installed at low level. They are sized in such a way that the inlet velocity of the incoming air does not exceed 5m/s. They should be foreseen in the fire brigade access and made compatible with the extract openings so that a well-directed air flow is taking place.

**6.3.3 Extraction points**

Extraction points are arranged under the ceiling and also the air inlet openings have to be arranged properly so that there is a good air flow in the building.
7 Smoke and heat vents-concepts for various uses

For all tables below the following conditions apply:

Natural SHEVS: in basements floors not allowed
B SHEVS: only applicable in buildings with 1 basement.
nn: SHEVS not necessary
-: not practical
o: limited suitability
+: possible concept

Sprinkler protected buildings

7.1 Industry, production and storage buildings

<table>
<thead>
<tr>
<th>Concept</th>
<th>Smoke control in in dependence of the size of the fire compartment in m² (incl. intermediate floors and galleries) HRR &gt; 250 MJ/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1200 – 2400 m²</td>
</tr>
<tr>
<td>N-SHEVS</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
<tr>
<td>FB-SHEVS</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
<tr>
<td>M-SHEVS</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
</tbody>
</table>

* only fire compartment with a volume < 60’000 m³

7.2 Office buildings

<table>
<thead>
<tr>
<th>Concept</th>
<th>Smoke control in in dependence of the size of the fire compartment in m² (incl. intermediate floors and galleries)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One or two floors</td>
</tr>
<tr>
<td>N-SHEVS</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
<tr>
<td>FB-SHEVS</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
<tr>
<td>M-SHEVS</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
</tbody>
</table>

Number of required air changes for B SHEVS and Mechanical SHEVS:

The number of air changes are in function of the height of the fire compartments

- Hight < 5.0 m: 8 air changes per hour
- Hight > 5.0 – 7.5 m: 6 air changes per hour
- Hight > 7.5 m: 4 air changes per hour
7.3 Supermarkets

<table>
<thead>
<tr>
<th>Concept</th>
<th>Smoke control in dependence of the size of the fire compartment in m² (incl. intermediate floors and galleries) and number of floors</th>
<th>1200 – 2400 m²</th>
<th>2400 – 4800 m²</th>
<th>1200 – 2400 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>single storey</td>
<td>single storey</td>
<td>open and multistorey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 1000 people</td>
<td>&lt; 2000 people</td>
<td></td>
</tr>
<tr>
<td>N-SHEVS</td>
<td></td>
<td>0</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>FB-SHEVS</td>
<td></td>
<td>+</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>M-SHEVS</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Number of required air changes for B SHEVS and Mechanical SHEVS:

Fire compartments (single storey) with an area of 1200m² to 4800m² and fire compartments (multi storey) with an area of 1200m² to 2400m² are to be equipped with a SHEVS designed on 8 air changes per hour.

7.4 Rooms with high number of people

<table>
<thead>
<tr>
<th>Concept</th>
<th>Smoke control depending on the number of people</th>
<th>300 - 1000</th>
<th>1000 - 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-SHEVS</td>
<td></td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>FB-SHEVS</td>
<td></td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>M-SHEVS</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Number of required air changes for B SHEVS and Mechanical SHEVS:

The fire compartments are to be equipped with smoke control based on 8 air changes per hour.

7.5 Car parks

7.5.1 Build separately

<table>
<thead>
<tr>
<th>Concept</th>
<th>Smoke control in dependence of the size of the fire compartment in m²</th>
<th>600 – 1200 m²</th>
<th>1200 – 2400 m²</th>
<th>2400 – 4800 m²</th>
<th>4800 – 9600 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>N-SHEVS</td>
<td></td>
<td>nn</td>
<td>0</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>FB-SHEVS</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>M-SHEVS</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nn</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
7.5.2 Multi storey with open connections between the storeys

<table>
<thead>
<tr>
<th>Concept</th>
<th>Smoke control in in dependence of the size of the fire compartment in m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>600 – 1200 m²</td>
</tr>
<tr>
<td>N-SHEVS</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
<tr>
<td>FB-SHEVS</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
<tr>
<td>M-SHEVS</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>nn</td>
</tr>
</tbody>
</table>

Number of required air changes for B SHEVS and Mechanical SHEVS:

In car parks and repair shops for motors, following number of air changes are required:

- Fire compartment ≤ 2400 m²: 8 air changes per hour
- Fire compartment ≤ 4800 m²: 7 air changes per hour
- Fire compartment > 4800 m²: 6 air changes per hour
Example 1
FB-NRWA, Warehouse, fire compartment ≤ 2400 m², second floor, without sprinkler
Example 2
M-NRWA, Hall, third floor, 800 people

8 Guidelines
Guideline No 1:2002 - Internal fire protection control
Guideline No 2:2007 - Panic & emergency exit devices
Guideline No 3:2003 - Certification of thermographers
Guideline No 4:2003 - Introduction to qualitative fire risk assessment
Guideline No 5:2003 - Guidance signs, emergency lighting and general lighting
Guideline No 6:2004 - Fire safety in residential homes for the elderly
Guideline No 7:2005 - Safety distance between waste containers and buildings
Guideline No 8:2004 - Preventing arson – information to young people
Guideline No 9:2005 - Fire safety in restaurants
Guideline No 10:2008 - Smoke alarms in the home
Guideline No 11:2005 - Recommended numbers of fire protection trained staff