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Powered smoke exhaust systems

1. Concepts, designations, guidelines

According to DIN 18232-1, a distinction must be made between smoke and heat exhaust systems (RWA) operating on a thermal principle (NRA, WA) on the one hand, and powered systems (MRA and RDA) on the other.

The above German abbreviations have the following meanings:

NRA: Natural smoke and heat exhaust system

WA: Heat exhaust system

MRA: Powered smoke exhaust system

RDA: Pressurized smoke control system

A product testing standard for smoke exhaust fans is defined in DIN 18232-6. The product standard for pressurized smoke control systems (RDA) has not progressed beyond the handout stage (18232-7) due to a standstill agreement with the European Union. Powered smoke exhaust systems are dimensioned according to DIN 18232-5. Since the inclusion of smoke exhaust fans into the Building Rules List "B" of the German Institute of Building Technology (DIBt) in 1998, the above standards have been forming the basis for building approvals involving these products. The application and use of smoke exhaust fans is regulated nationally via the so-called "general building supervision approval."

Mention should also be made here of a guideline issued by the VDMA association, viz., VDMA Standard Sheet 24177 (Guidelines for Fans Providing Smoke and Heat Control in Buildings in the Case of a Fire).

To a large extent, the above concepts have also been adopted in the DIN EN 12101, Part 1-10, standard series mandated at the European level. Pure heat exhaust systems (WA) as contemplated in DIN 18232-4 are not extant in this standard series.

Pressurized smoke control systems (RDA) are appropriately referred to as pressure differential systems in prEN 12101-6. At the time of writing, this standard is being prepared for the final questionnaire survey.

The product testing standard for smoke exhaust fans, DIN EN 12101-3, has already been published in the EU's Official Journal in March 2004.

The published part prEN 12101-5, which addresses powered smoke exhaust systems, has been given the status of a Technical Report and thus has no normative force.

The general building supervision approvals previously relied upon in Germany will be replaced, as it were, by the CE-marking of smoke exhaust fans. Fans bearing such a CE mark which will be commercially marketed following a coexistence phase.

It is currently popular to link this CE mark to the CE marking of products under the Machinery Directive.

However, Annex ZA ("informative"1) to the European standards series 12101, Parts 1 - 10, and the classification standard prEN 13501-4 prescribe specific testing and application criteria for smoke exhaust fans as construction products.

This means that the relevant CE marking will be carried out by authorized European testing bodies.

http://europa.eu.int/comm/enterprise/nando-is/cpd/notifiedbody/index.cfm.

As regards functional testing, maintenance and upkeep of these construction products under the European standards series 12101, Parts 1-10, no universally consistent point of view can be identified at present.

Notwithstanding, the trend already emerging at the national level is for producers and operators of smoke exhaust systems to carry liability.

http://age-info.de

As an example of how these construction products will be CE-marked in the future, let us consider the case of a smoke exhaust damper:

CE **0123**
John Smith, Inc. **04** **0123-CPD-001**
EN 12101-8 **Smoke exhaust damper** **EI 60 S vedw hodw 1000 i <-> C10.000 A4 multi**

1) "What the CEN refers to as 'informative' is, in fact, the only binding part of the standard", estimates Mr. Bedotti from the DG Enterprise-Construction Unit

2. Protection objectives

Under section 17(1) of the Model Building Code (MBO), smoke and heat exhaust systems (RWA) must meet the following requirement:

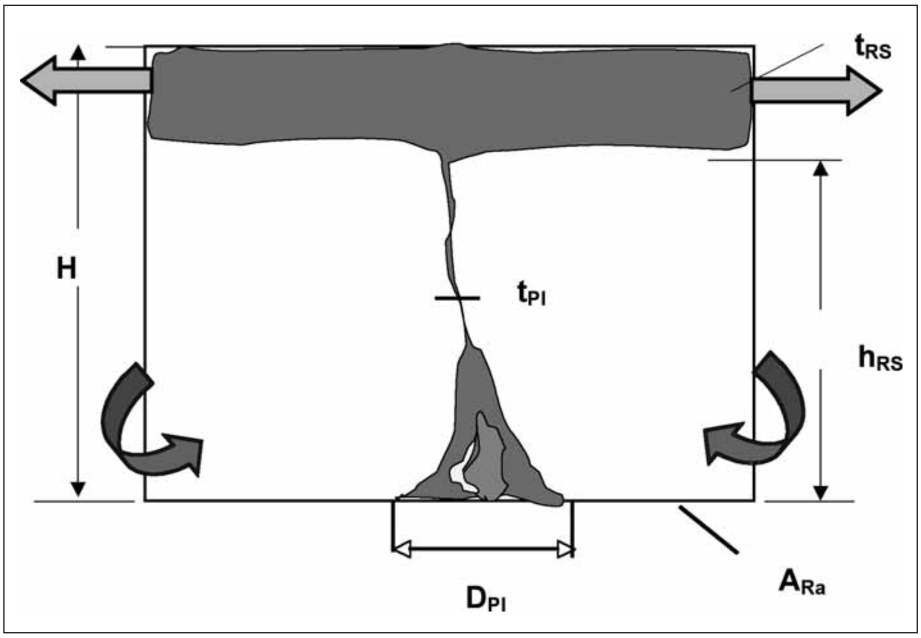
"Structures shall be designed such that the outbreak of fire and the propagation of flames and smoke are effectively prevented, and that humans and animals

can be rescued and an effective fire-fighting effort can be launched should a fire nevertheless occur."

At a more specific level, these general basic requirements have given rise to the demand that "low-smoke layers" should be created by smoke and heat exhaust equipment.

Another established protection objective is to prevent an ingress of smoke or to delay its transmission into adjoining areas, respectively.

This objective is addressed by pressurized smoke control equipment (RDA) and pressure differential systems as defined in prEN 12101-6.



Underneath the smoke-filled zone near the ceiling of the room, a low-smoke (or, in European terms, "smoke-free") layer hRS is maintained to facilitate occupant escape and fire fighting measures.

An appropriate overpressure is produced at the top edge of the door separating the fire zone from the stairwell. The resulting dynamic energy counteracts the transmission of smoke.

A fact often neglected here is that the success of this principle depends on the presence of a flow through the fire zone. A defined outgoing airflow from the fire zone ensures a flow through the open door openings, which are thus "sealed off" against the transmission of smoke [1].

Further protection objectives for smoke and heat exhaust (RWA) systems are not known, neither at the national nor at the European level.

This deficit becomes readily evident in situations involving room heights below 3 m, interior windowless corridors, and subterranean buildings.

An alternative might consist in providing an air supply/exhaust flow opposed to the direction of occupant escape.

3. Dimensioning

The standard DIN 18232-5 provides planners with a two-zone model based on the plume approach of Thomas and Hinkley [2]. With the aid of this model, it is possible to determine the requisite exhaust air volume flows and smoke layer temperatures as a function of the desired height of the "low-smoke" layer for two energy release rates, i.e., 300 kW/mÇ and 600 kW/mÇ. However, this standard does not yield a dynamic picture of the evolution of fire in time. It merely provides a quasi-steady model of conditions in a fully developed fire.

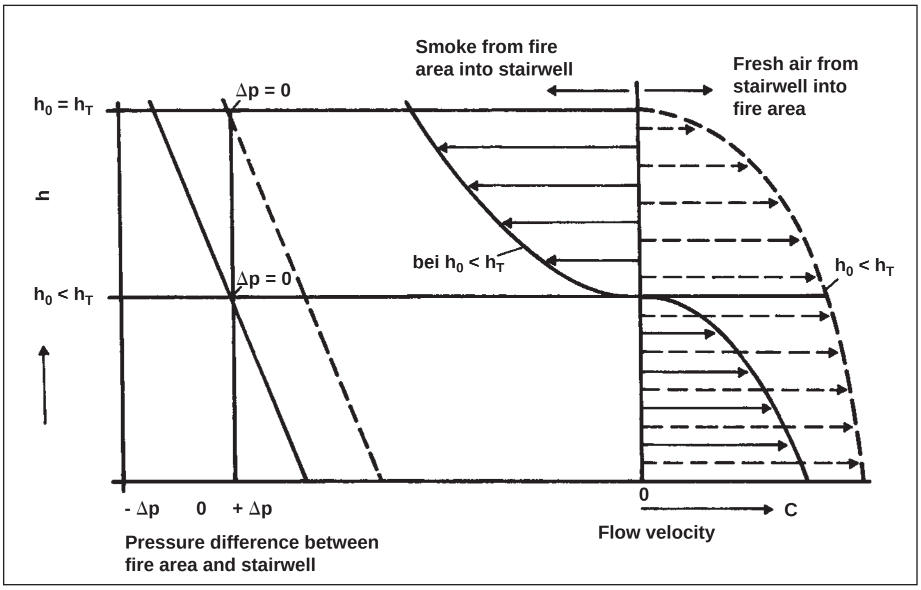
With the increasing acceptence of fire protection engineering methods, this guideline has come under criticism.

Moreover, a literature survey [3] of known plume models has been published with information about the confidence ranges of the relevant applications.

VDI 6019-1 (2004), Engineering methods for dimensioning building smoke exhaust systems, outlines a number of methods for a detailed analysis of fire developments and fire phases. A distinction is made here between low-energy and high-energy fires.

In addition, this publication suggests a simple method for determining sprinkler release times.

Information about the heat release rates of office furniture, derived from real-life fires, give a starting point for model trials aimed at verifying smoke



flows in practice and for assessing the effectiveness of smoke exhausts. The appropriate transfer functions based on similitude laws in fluid mechanics are likewise provided.

For highly complex building configurations, field model analyses are conducted with the aid of CFD programs.

The results thus obtained are subject to some controversy. Missing turbulence equations and unsuitable grid generating functions have repeatedly given rise to critical assessments of the method's capabilities.

Nevertheless, CFS analyses using realistic heat release rates in less complex building situations give valuable insights specifically into the fire origination phase. In some cases these analyses have revealed astonishing facts [4].

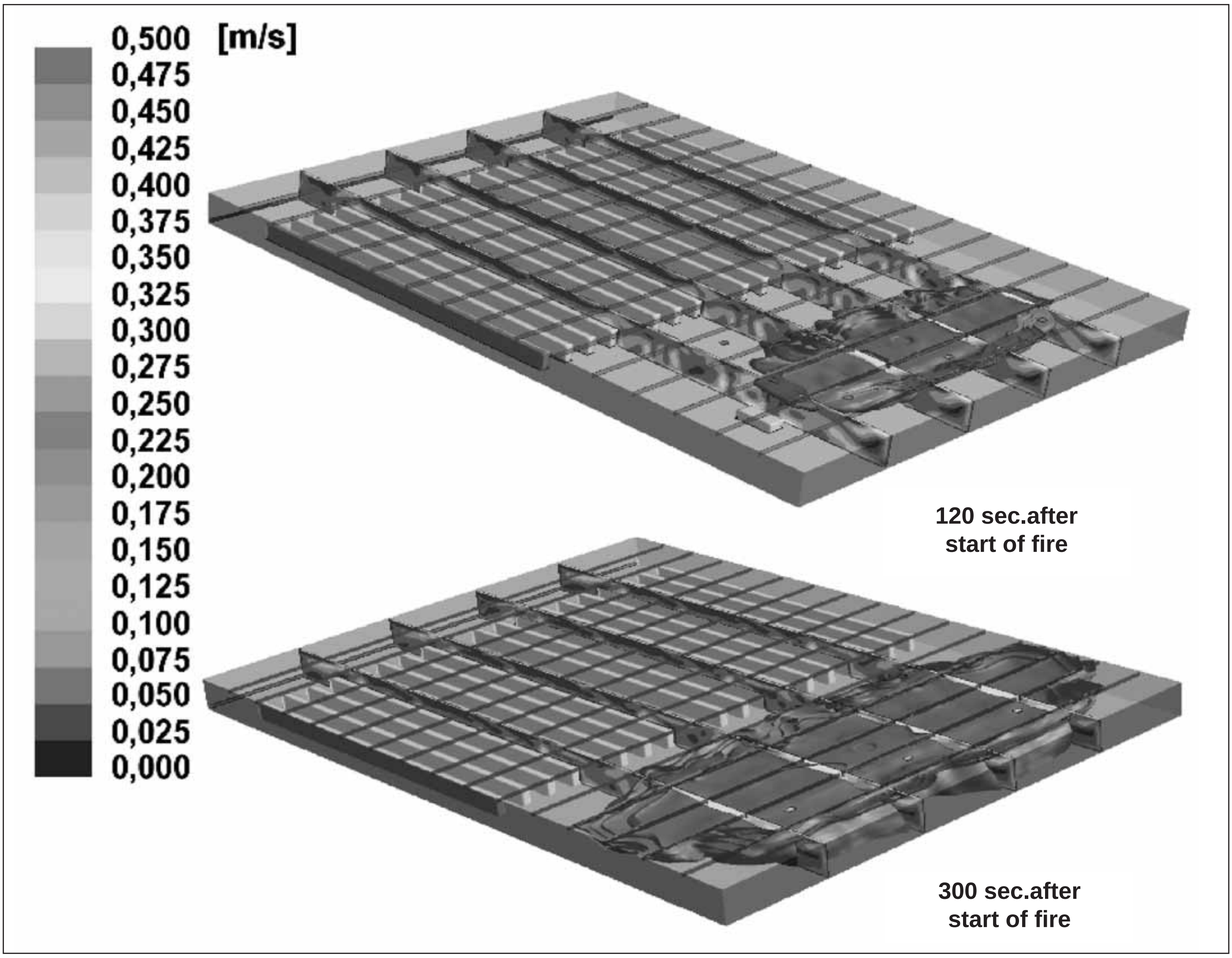
The 5-minute isometric graph of a sales floor fire originating in a checkout cash register illustrates the operation (and, in part, the mutually counteractive effects) of a natural smoke and heat exhaust (NRA) system quite impressively.

For the first 10 minutes of the fire, smoke temperatures remain below 35 °C so that the sprinkler systems cannot be triggered.

afhttp://age-info.de

As regards ratings for occupant escape and evacuation times, documentary evidence has so far been demanded for special-purpose buildings only. These calculations are based mainly on experimental statistics of occupant flows in stairwells and corridors.

Evidence of such assessments have actually resulted in building modifications is not available anywhere.



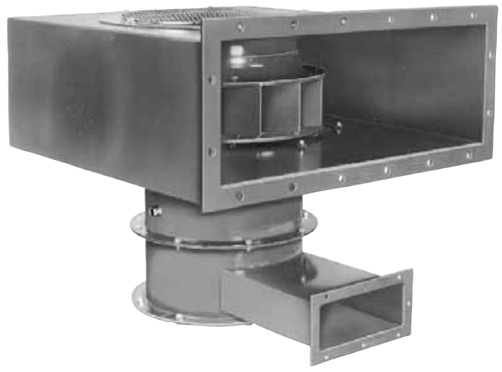
4. Overview of approved smoke (fume) exhaust fans *

(tested by the Technical University of Munich, building supervision approvals issued by the German Institute of Building Technology / DIBt, Berlin)

Axial-flow smoke exhaust fans

Temperature/time category according to EN 12101, Part 3

Series BVAXO	F 200	200°C - 120 min.
	F 300	300°C - 120 min.
Series BVAXN 12/56	F 200	200°C - 120 min.
	F 300	300°C - 120 min.
	F 400	400°C - 120 min.
Series BVZAXN 12/56	F 200	200°C - 120 min.
	F 300	300°C - 120 min.
	F 400	400°C - 120 min.
Series BVAXN 8/56	F 600	600°C - 120 min.



Centrifugal smoke exhaust fans **(wall mounting)**

Temperature/time category according to EN 12101, Part 3

Series BVW-R	F 600	600°C - 120 min.
Series BVW-A	F 600	600°C - 120 min.
Series BWAXO	F 200	200°C - 120 min.
	F 300	300°C - 120 min.
Series BWAXN	F 200	200°C - 120 min.
	F 300	300°C - 120 min.
	F 400	400°C - 120 min.

Garage smoke exhaust fans (Jet-Fans)

Temperature/time category according to EN 12101, Part 3

Series GAXN	F 200	200°C - 120 min.
	F 300	300°C - 90 min.

Smoke exhaust fans **(roof mounting)**

Temperature/time category according to EN 12101, Part 3

Series BVD	F 400	400°C - 120 min.
	F 600	620°C - 120 min.
Series BVW-D	F 600	600°C - 120 min.

Centrifugal smoke exhaust fans **(for central installation)**

Temperature/time category according to EN 12101, Part 3

Series BV-REH	F 400	400°C - 120 min.
Series BVRA	F 600	620°C - 90 min.
Series BVW-R/B	F 600	600°C - 120 min.
Series BVW-A/B	F 600	600°C - 120 min.

***Excerpt from the product range of TLT-Turbo GmbH, Bad Hersfeld**

5. Powered smoke exhaust systems - current status

Under German building regulations, it was unlawful for powered smoke exhaust fans to serve day-to-day ventilating purposes if the system included a smoke exhaust damper.

Following the approval in 2004 of smoke exhaust dampers with a ventilation function ("combination damper"), the above restriction on smoke exhaust fans has ceased to apply.

The use of frequency converters on smoke exhaust fans is regulated in Germany by the German Institute of Building Technology (DIBt) in Berlin.

Under DIBt rules, the drive motors of smoke exhaust fans operating directly in the smoke flow must not be powered via frequency converters.

For all other applications deviating from the above scenarios, an initial test must be conducted in accordance with DIN EN 12101-3 to demonstrate the system's safe operation.

With the publication of DIN EN 12101-3 in the European Official Journal in March 2004, SC1 delegated the tasks of revising this standard directly to WG3 of TC 127.

In the three meetings held to date, a number of controversial issues have emerged. These mainly concern the individual motor tests, calculation models for geometrically similar and non-similar smoke exhaust fans, and the necessary installation instructions and instructions for use.

It is to be expected that the results of this review will have a direct impact on the classification standard prEN 13501-4.

The DIN main committee 00 35 00 has delegated a review of the DIN 18232-5 dimensioning standard for up-to-dateness and revision requirements to an "ad-hoc group".

A major dimensioning parameter for overpressure ventilating systems for stairwells is the pressure loss which takes place in the stairwell.

The results of some experimental trials on this issue are presented in [5].

In recent times, crowd behaviour in buildings under normal occupancy and emergency conditions has once again become a subject of research.

D. Helbing has published a number of basic scientific findings regarding human behaviour. It is evident from his work that hazards can only be avoided successfully by exerting an appropriate influence on on building structures and design.

www.helbing.org

Other publications are still limited in scope to an "ex post facto" analysis of existing buildings and prospective evacuation times.

www. rimea.de

6. Literature

[1] John, R.: Druckbelüftungsanlagen zur Rauchfreihaltung von Treppenräumen [Overpressure ventilation systems for smoke control in stairwells], s+s report, 5/2000

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[3] Brein, D.: Review of the Literature: Anwendungsbereiche und -grenzen für praxisrelevante Modellansätze zur Bewertung der Rauchausbreitung in Gebäuden (Plume-Formeln) [Fields and limits of application of practically relevant models for evaluating smoke propagation in buildings (plume equations)], University of Karlsruhe Fire Protection Research Unit, December 2001

[4] Klingsch, W., Detzer, R., Lehnhäuser, F.: Rauchausbreitung in Räumen während der Initialbrandphase [Smoke propagation in rooms during the initial fire phase], VfdB 3/2004

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