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Department of Fire Protection Engineering and Risk Management

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Performance based design of fire protection in building ventilation systems

- to prevent spreading of fire and fire gases throughout the building

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Today´s Presentation

- •CPD 89/106/EEC (Construction Products Directive)
- •Fire growth diagram
- •How fire gases spread through out the building ventilation systems
- •Denmark
  - DN 428
- •Sweden
  - BBR
- •Formulas for calculations
- •3 Case studies

CPD 89/106 EEC

CPD 89/106/EEC (Construction Products Directive) was published on December 21, 1988 by the European Council on the approximation of laws, regulations and administrative provisions of the Member States.

It was then amended by the Council Directive 93/68/EEC on July 22, 1993 and Regulation (EC) No 1882/2003 on September 29, 2003. The directive harmonizes all construction products subject to regulatory controls for CE marking purposes.

CPD 89/106 EEC

The main goal of the Construction Products Directive is to improve the framework conditions for the competitiveness of the construction and construction products industries.

The directive requires that construction products are suitable for use in construction works.

Therefore, the essential requirements regarding safety, public health, protection of citizens, and the environment must be fulfilled.

Common framework

CPD 89/106 EEC is a common framework.

It is then up to each member to select the appropriate safety level to lay down in their building regulations for the country.

Denmark: DS 428; Code of practice for technical measures for fire protection in ventilation systems

Sweden: BBR 08; Building Regulations ;5.65 Air handling installations

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Products

Products used shall be in complience with the standards that exists for that product.

For example Fire dampers:

They shall be tested accoding to 1366-2 in Sweden SS / EN 1366-2 and in Denmark DN / EN 1366-2

And classified according to 13501-3

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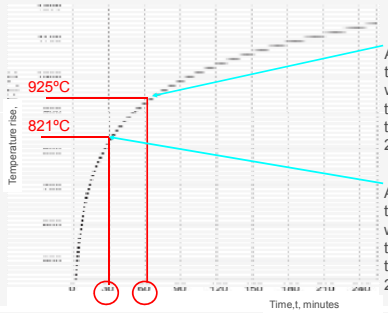
Fire Growth diagram EN 1363-1



After 60 minutes the temperature will be 945°C if the starting temperature is 20°C

After 30 minutes the temperature will be 841°C if the starting temperature is 20°C

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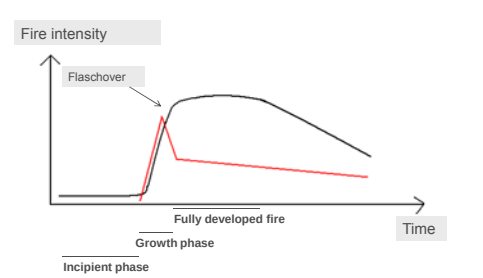
Fire growth diagram



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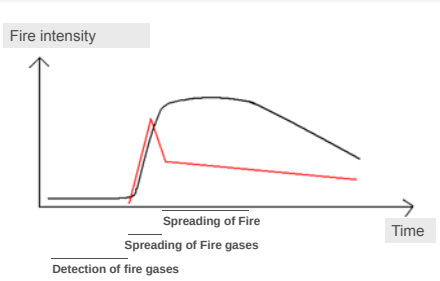
Fire growth diagram



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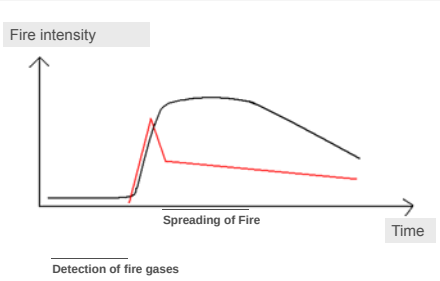
Fire growth diagram



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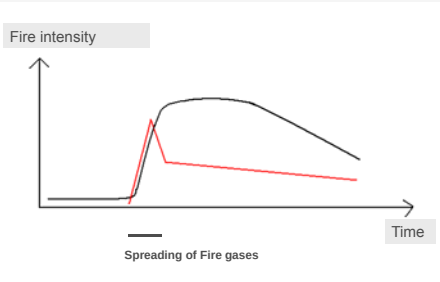
Fire growth diagram



Flow of firegases (Fireflow)

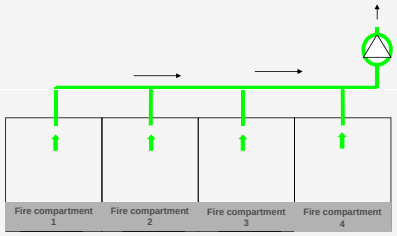
When air is heated it will expaned, thermal expansion.

This results in an flow of firegases, m^3/s. A fire will allways result in a flow of firegases.

We call it "Fireflow" in sweden.

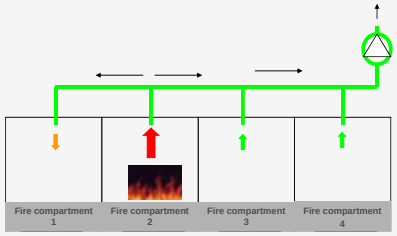
In an almost sealed room this flow will result in a pressure rise. It is this preassure rise that will spread firegases throuht the building. Some gases will be spread through holes in the buildning and some through the ventilation systems.

Exhaust ventilation system

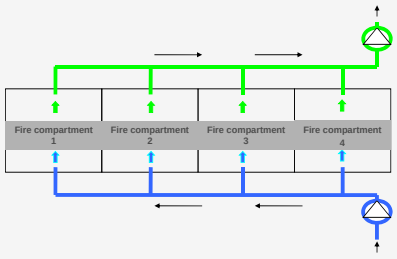


Exhaust ventilation system

Firegases will spread throughout the building through the ventilationsystem

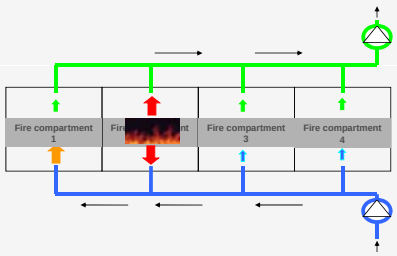


Supply & exhaust ventilation system



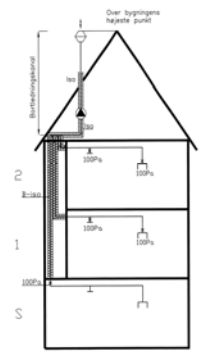
Supply & exhaust ventilation systems

Firegases will spread throughout the building through the ventilationsystem



DN 428

DN 428 Clearlys specifies how to design and install ventilation systems, for example how much pressurefall over exhaust and supply units shall be to prevent spread of firegases between fire compartments.



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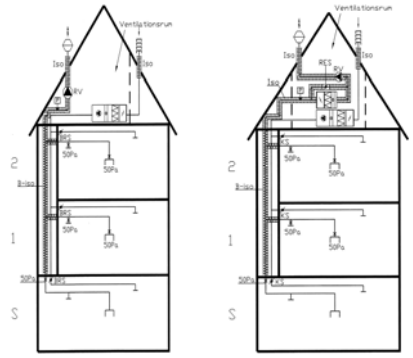
DN 428



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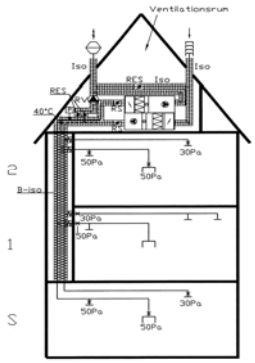
DN 428



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DN 428

DN 428 also gives an opportunity by showing with calculations that fire gases are allowed to enter the ventilation system but by designing the ventilation system in such a way that the spread of fire gases between fire compartments not reaches unacceptable levels.

Calculations shall also show that temperatures not exceed the levels that the exhaust fan manage.

PERFORMANCE BASED DESIGN

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BBR 2008

Air handling installations shall be designed so that satisfactory protection is achieved against the spread of fire gases between fire compartments.

Satisfactory protection against the spread of fire gases may be obtained by:

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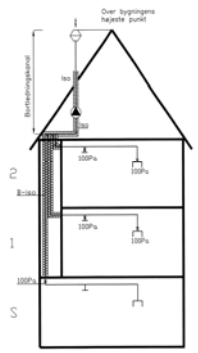
- providing separate ventilation systems for each fire compartment right up to the external air
- providing special pressure relief devices
- providing fire smoke dampers with equivalent fire resistance as the confines of the fire compartment in question

OR



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BBR 2008

allowing fire gases to enter the ventilation system but designing the system in such a way that the spread of fire gases between fire compartments is prevented or considerably impeded depending on the design and the nature of the premises.

The spread of fire gases should be prevented for escape routes and bedrooms.

PERFORMANCE BASED DESIGN

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PERFOMANCE BASED DESIGN

How will this ventilationsystem in this building will perform incase of fire?

How shall the ventilationsystem for just this building be designed to fullfill the requirements of the building regulation?

How much smoke are allowed to be spread?

What is the temperature of the air inside the ducts and fan?

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PERFOMANCE BASED DESIGN

-How much smoke will be pressured into the ventilationsystem?

There are meny ways to determine how much "fire flow" will be produced, by computersimulations, full scale test, simple overall calculations.

Mr Lars Jensen have made a lot of work to determine what is affekting the firegrowth to be able to make formulas to determine :

1) What the "fireflow" will be(q_b)?
2) When the maximum fireflow will occure (t_b)?
3) What the temperatur in the firegases will be (T_b)?

Mr Lars Jensen´s work is based on earlier works from Mr Bengt Hägglund *"Simulating fires in natural and forced ventilated enclosures" 1988* and Mr *Särdqvist, "Initial fires", 1993*

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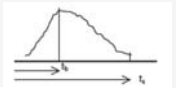
PERFOMANCE BASED DESIGN

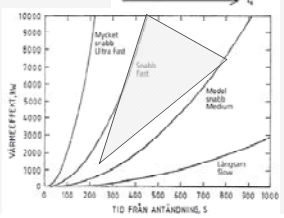
$q_b = 0{,}0137 \cdot \alpha^{0,4231} \cdot V^{0,5134}$ (m^3/s)

$t_b = 86{,}677 \cdot \alpha^{-0,3328} \cdot V^{0,3492}$ (s)

$T_b = 379{,}29 \cdot \alpha^{0,0695} \cdot V^{0,0035}$ (K)

α= firegrowth speed (W/s^2)
V= the volyme of the room in which the fire starts in.





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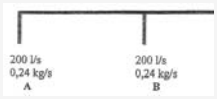
Temperatur over the exhaust fan

$m_b / m_n = (T_{nK} / T_{bK})^{0,5}$



m_n = 0,24 kg/s m_b = 0,12 kg/s

T_{AB} = (0,12 • 1218 + 0,24 • 293) / 0,36 = 601 K (328˚C)

1:4 => 150ºC 1:10 => 63ºC

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PERFOMANCE BASED DESIGN, simulation 1

Exhaust system

The largest room in the firecompartment is 45m^2, the hight is 2,7m.

This will generate q_b = 0,78 (m^3/s)
t_b = 129 (s)
T_b = 507 (K)

The leakage is determined according to the building regulations of 0,6l/s*m^2 at 50Pa overpressure, the area of the walls facing the outside is in this calculation 18m^2.

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PERFOMANCE BASED DESIGN, simulation 2

Supply and Exhaust system, converted into exhaust system incase of fire

The largest room in the firecompartment is 45m^2, the hight is 2,7m.

This will generate q_b = 0,78 (m^3/s)
t_b = 129 (s)
T_b = 507 (K)

The leakage is determined according to the building regulations of 0,6l/s*m^2 at 50Pa overpressure, the area of the walls facing the outside is in this calculation 18m^2.

PERFOMANCE BASED DESIGN, simulation 3

Exhaust system with pressure release

Summery

Swedish and Danish building regulations are based on the european CPD

Swedish and Danish building regulations are verry similar

- Separate ventilation systems
- Dampers
- Preassure release
- Performance based design

THANK YOU !