VSB - Technical University of Ostrava
Faculty of Safety Engineering

FIRE PROTECTION OF BUILDING IN THE CZECH REPUBLIC

Meeting of CTIF Commission "Fire Prevention"
21st July 2009 in Ostrava

Petr Kučera

HISTORY OF FIRE PROTECTION OF BUILDING

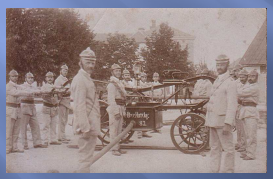
14th Century **Fire Order in Prague** (1350, Latin)
obligatory help during fire

15th Century **Economic, Farm, Police and Town Rules** content
Fire Codes about behaviour of subjects and feudalists

HISTORY OF FIRE PROTECTION OF BUILDING

19th Century **Fire Brigades** – voluntary and professional

20th Century **New Rules and Codes**

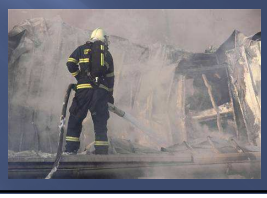


FIRES

HISTORY Problem with spread of fire between building

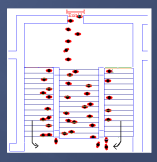
TODAY

- Problem of spread inside building
- Used of plastic materials (toxicity, flammability)
- Internal fitting (electrical set, air condition)
- Thin-wall profile (steel construction)
- Installation of fire safety equipments
- Space dimensions, high-rise building,...

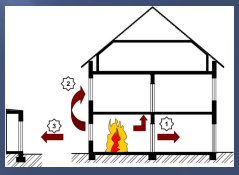


REQUIREMENTS ON FIRE SAFETY

- **Prevent a risk lives of people in the building**



- **Prevention of fire spread in the building**
- **Prevention of fire spread to the nearby building**
- **Protection of fire intervention (fire brigade)**



MAIN CZECH FIRE RULES

rule N. 133/1985 Coll. **about fire safety (several times revised)**

not. N. 246/2001 Coll. **notice about fire prevention**

not. N. 23/2008 Coll. **notice about technical conditions of fire safety of buildings**

MAIN TECHNICAL STANDARDS

DESIGN — **Fire protection of buildings (FPB)**

CSN 73 0802	Non-industrial buildings
CSN 73 0804	Industrial buildings
CSN 73 0810	General requirements
CSN 73 0831	Assembly rooms
CSN 73 0833	Buildings for dwelling and lodging
CSN 73 0834	Changes of buildings
CSN 73 0835	Buildings for sanitary maters and social care
CSN 73 0845	Storage rooms
OTHERS...	

MAIN TECHNICAL FIRE STANDARDS

TEST

Definitions of fire test standard and assessment of requirement properties
CSN EN a CSN EN ISO (about 36 standards)

CLASSIFICATION

Fire classification of construction products and building elements
(e.g. classification using test data from reaction to fire tests) - CSN EN

VALUE

Chosen values of fire technical properties
(e.g. values of fire resistance, heat values) - CSN

SUBJECT

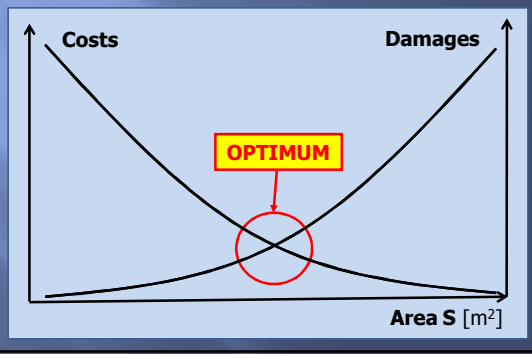
Technical conditions of fire safety facilities
(e.g. equipment for fire-water supply) - CSN

CSN 73 0802
FPB – NON-INDUSTRIAL BUILDINGS

- **Partition to fire compartments**
- **Determination of fire risk**
- **Level of fire safety (construction)**
- **Dimension of fire compartment (verification)**
- **Requirement to building constructions**
- **Escape routes**
- **Safety distances**
- **Building equipments**
- **Conditions for fire intervention**

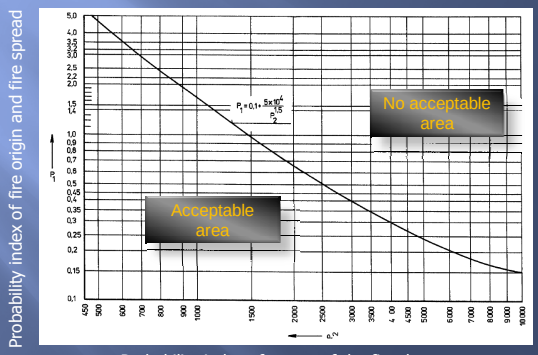
FIRE COMPARTMENT

Bounded space of building with fire dividing constructions



FIRE COMPARTMENT

FPB – industrial buildings



FIRE RISK
FPB – NON-INDUSTRIAL BUILDINGS

computing fire load ..... p_v [kg.m^{-2}]

expressive of theoretical intensity of fire and FPB

Conversion of heat value all flammability material in fire compartment to nominal heat value of wood

COMPUTING FIRE LOAD

$p_v = p \,.\, a \,.\, b \,.\, c$ [kg.m^{-2}]

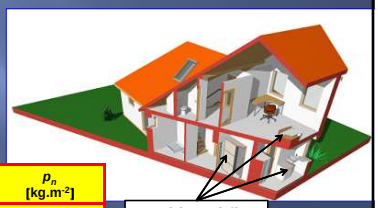
- Fire load [kg.m^{-2}]
- Factor of fire safety equipments
- Factor of rate of burning (structural conditions)
- Factor of rate burning (character of flammability materials)

$p = p_n + p_s$

- Accidental fire load [kg.m^{-2}]
- Steady fire load [kg.m^{-2}]

ACCIDENTAL FIRE LOAD

p_n [kg.m^{-2}] – combustible materials (facilities)



Accidental fire load p_n

Annex A.1 CSN 73 0802

Type of duty	p_n [kg.m^{-2}]
Office	40
Library	120
Boardroom, Bank hall	20
Dance hall	15
Chemist	60
Perfumery	60
Ironmonger s	30
Boiler-room	15
Cloak-room	50

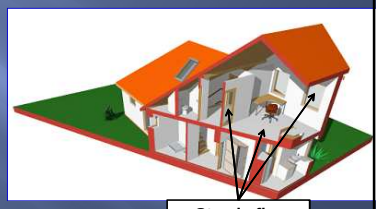
NO paint of technological arrangement

STEADY FIRE LOAD

p_s [kg.m^{-2}] – combustible materials (construction)

Combustible door, windows, floor, lining...

NO fire dividing and load bearing construction



Steady fire load p_s

Table 1 CSN 73 0802

Area of room	p_s window [kg.m^{-2}]	p_s door [kg.m^{-2}]	p_s floor [kg.m^{-2}]
to 500 m^2	3,0	2,0	5,0
above 500 to 1000 m^2	1,5	1,0	5,0
above 1000 m^2	0,7	0,5	5,0

COEFFICIENT A

Coefficient expressive rate of burning in term of character of combustible material

$$a = \frac{p_n \,.\, a_n + p_s \,.\, a_s}{p_n + p_s}$$

a_s = 0,9 (constant)

coefficient of steady fire load

a_n - Annex A1 CSN 73 0802 - calculation

coefficient of accidental fire load

Type of duty	a_n
Office	1,0
Library	0,7
Boardroom, Bank hall	0,9
Dance hall	1,2
Chemist	1,1
Perfumery	1,15
Ironmonger s	0,8
Boiler-room	1,1
Cloak-room	1,0

COEFFICIENT B

Coefficient expressive rate of burning in term of construction conditions (influence venting)

range $0{,}5 \le b \le 1{,}7$

Area fire compartment — coefficient k

$$b = \frac{S \,.\, k}{S_o \cdot \sqrt{h_o}}$$

Area window — Heigh window in external walls and roof

COEFFICIENT C

COEFFICIENT EXPRESSIVE FIRE SAFETY EQUIPMENTS

Value this coefficient always $c \le 1$

(c = 1 .... It means than there isn t fire safety equipments)

Values c_1 until c_4 no count up

⇒ It is possible used only one coefficient

At every combination fire safety equipments

⇒ It is possible to reduce value of coefficient c (in %)

Coeff. c	Equipments	Range	Tables CSN 73 0802
c_1	Fire detection	0,7 – 1,0	tab. 2
c_2	Fire brigade	0,5 – 0,95	tab. 3 a 4
c_3	Sprinkler	0,5 – 0,8	tab. 5
c_4	Exhaust of smoke	0,6 – 0,9	tab. 6

COEFFICIENT C

Advantages utilization this coefficient

1) **Reduction of fire risk (i.e. fire load)**
2) **Expansion of limiting dimension of fire compartment**
3) **Expansion of limiting dimension of size exit ways in this fire compartment**

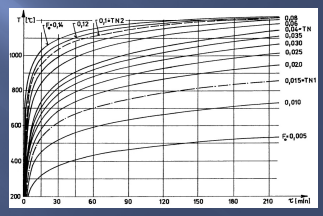


FIRE RISK
FPB – INDUSTRIAL BUILDINGS

Probably time fire duration ..... τ [min]

⇩

There is fire intensity that is characterized by probably fire duration **τ** and corresponding probably temperature of combustion gases T_g



Temperature of gases in burning spaces T_g according to venting parameter F_0 [$m^{1/2}$]

REQUIREMENTS OF BUILDING PRODUTS




TESTING AND CLASSIFICATION OF BUILDING PRODUCTS

CSN EN 13501-1 **„REACTION TO FIRE TESTS"**

Fire classification of construction products and building elements dividing to 7 classes **(A1, A2, B, C, D, E, F)**

CSN 73 0863

Determination of flame propagation along the surface of building materials

index of flame spread i_s (mm/min)

REQUIREMENTS OF BUILDING CONSTRUCTIONS


CLASSIFICATION OF BUILDING CONSTRUCTIONS

CSN EN 13501-2 **Classification using test data from resistance fire tests**

- **Classification time of fire resistance [min]:**
  10, 15, 20, 30, 45, 60, 90, 120, 180, 240, 360
- **Limiting states:**
  - **R** capacity and stability
  - **E** integrity
  - **I** isolation function – limitation of temperature in no heated surface
  - **W** limiting density of thermal flow in in no heated side
  - **S** transmission of smoke products (smoke resistant)
  - **C** self-closing facilities
  - **XX** others parameters

SORTING OF CONSTRUCTIONAL PARTS

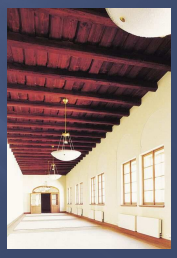
QUESTION

Is it material of construction flammability?

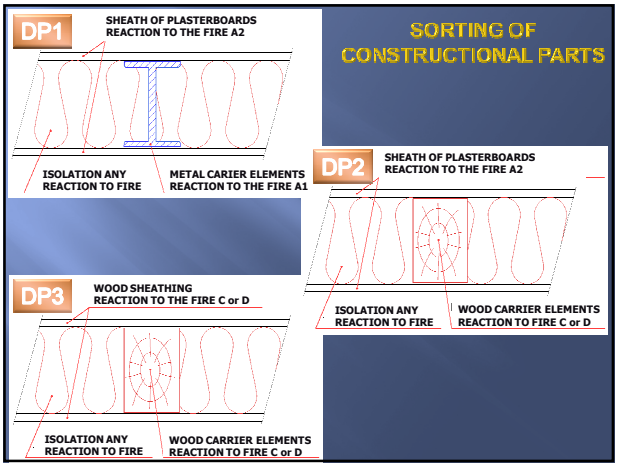
YES

- It influences to capacity of elements
- If effects to fire severity

	DP1	DP2	DP3
capacity	no	yes	yes
fire severity	no	no	yes



SORTING OF CONSTRUCTIONAL PARTS



CONSTRUCTIONAL SYSTEM OF BUILDING

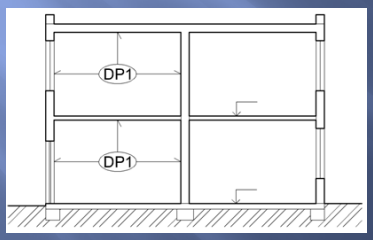
Constructional system of building forms:

- **Carrier construction ensuring stability of building**
- **Fire dividing construction**

CONSTRUCTIONAL SYSTEM OF BUILDING

INCOMBUSTIBLE

Vertical and horizontal construction must be DP1

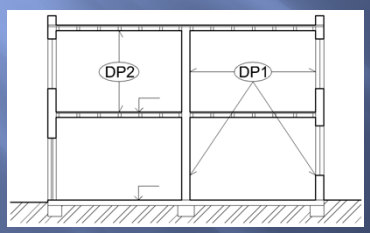


Example:
Brickwork building with concrete, ceramic or combined ceiling
(steel beam + ceramic boards)

CONSTRUCTIONAL SYSTEM OF BUILDING

MIXED

Vertical construction must be DP1
Horizontal construction can be DP2

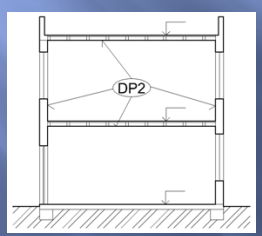


Example:
Building with wood beam ceiling with subfloor and plaster soffit

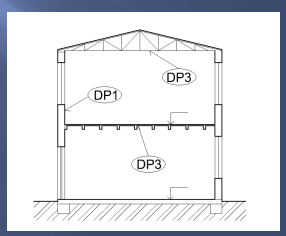
CONSTRUCTIONAL SYSTEM OF BUILDING

COMBUSTIBLE

Variant 1)
Vertical and horizontal carrier construction and fire dividing **DP2**



Variant 2)
Some vertical and horizontal carrier construction and fire dividing **DP3**



ASSESSMENT OF FIRE RESISTANCE

requirement fire resistance ≤ **real fire resistance**

CSN 73 0810
⇒ **limiting states** (R, E, I,...)

CSN 73 0802 or 04
⇒ **time** (minutes)
⇒ **type of constructional part** (e.g. DP1)

FIRE TEST
⇒ **test report**
⇒ **tables CSN 73 0821**

EUROCODES
⇒ **calculation**

EUROCODES BUILDING THE FUTURE

REQUIREMENT FIRE RESISTANCE

CSN 73 0810 Defined limiting states, Example:

REI bearing fire dividing constructions (walls and ceiling)

CSN 73 0802

Example requirement fire resistance fire wall:

III. SPB

⇩

REI 45

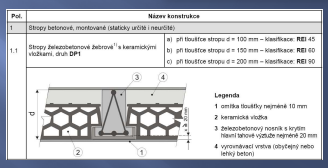
Fire dividing and bearing construction	p_k computational fire load in fire compartment [kg.m^{-2}]	SPB - Lowest fire safety degree in fire compartment						
		I.	II.	III.	IV.	V.	VI.	VII.
		Height of building h [m]						
incombustible system	15	12	30	60	no limiting			
	30	O	12	30	no limiting			
	45	O	6	22,5	45	no limiting		
	60	O	6	12	30	45	no limiting	
	90	O_1	O	6	12	30	45	no lim

	Building construction	Fire safety degreein fire compartment						
		I.	II.	III.	IV.	V.	VI.	VII.
		Fire resistance of building construction						
1	Fire walls and fire ceilings							
	a) in background floor	30 DP1	45 DP1	60 DP1	90 DP1	120 DP1	180 DP1	180 DP1
	b) in over ground floor	15	30	45	60	90	120 DP1	180 DP1
	c) in last over ground floor	15	15	30	30	45	60 DP1	90 DP1
	d) between building	30 DP1	45 DP1	60 DP1	90 DP1	120 DP1	180 DP1	180 DP1

REAL FIRE RESISTANCE

FIRE TEST

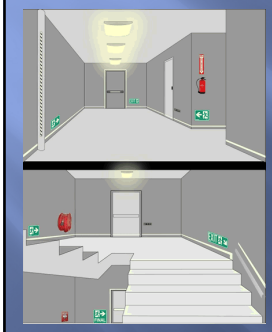
CSN 73 0821



EUROCODES

Design fire scenario → Design fire → Thermal analysis → Mechanical analysis

EVACUATION



BASIC REQUIREMENTS

Evacuation of People

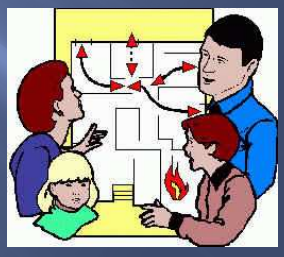
ensure protection of people
⇒ before fire (temperature, flames,...)
⇒ before hot smoke (design of smoke venting)

Problem with evacuation
⇒ assembly buildings
⇒ building for dwelling and lodging
⇒ building for sanitary matters

..... organisational and technical provisions

EVACUATION

Type of escape route



TYPES OF ESCAPE ROUTES

Unprotected escape routes (NUC)

- each permanent free communication
- leads to exit from building or to protected escape route (CHUC)
- needn t to divide fire dividing constructions

Protected escape routes (CHUC) – type A, B or C

- each permanent free communication
- leads to exit from building (to esplanade)
- must be protected before fire (temperature, smoke) fire dividing construction (only DP1)
- is necessary to solve way of venting (natural, forced)

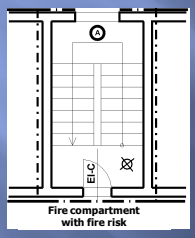
Design each type of CHUC is bound to height of building and number of floors

Alternative escape possibilities

Windows in down stair (store windows), escape ladders, sliding bar,...

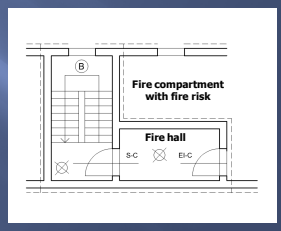
PROTECTED ESCAPE ROUTES (CHUC)

CHUC type A



time of safety stay
4 minutes

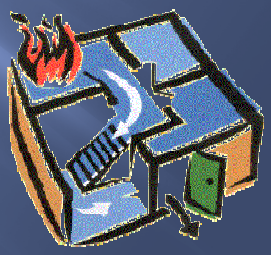
CHUC type B or C



time of safety stay
15 minutes (CHUC type B)
30 minutes (CHUC type C)

EVACUATION

Option of escape route



OPTION TYPE OF ESCAPE ROUTE

Unprotected escape routes (NUC)

→ escape from over ground floors to safety space (high of building $h \leq 9$ m)

→ escape from 1 underground floor to safety space,...

Protected escape routes (CHUC)

→ escape from multistory buildings (It decides requisite time for evacuation)

Number of escape routes from fire compartment, resp. building	Type of protected route (CHUC)					
	Over ground floors			Under ground floors		
	Height of building h [m]					
	to 22,5	above 22,5 to 45,0	above 45,0	to 4,5	above 4,5 to 8,0	above 8
One escape route	A	B	C or B + B	A	B	C
Other escape route	A	A	B	A	A	B

EVACUATION

Design of escape routes

DESIGN OF ESCAPE ROUTES

Number of evacuated persons (E)
according norm CSN 73 0818 (tabulated)

Type of room	Area (m²) to 1 person	Coefficient of design person
Office	5,0	-
Boardroom	1,5	-
Classroom	2,0	-
Sales area	1,5	-
Library	2,5	-
Flat	20	1,5

Example:

Office — S = 20 m²
Number E — E = 20/5 = 4 persons

DESIGN OF ESCAPE ROUTES

Conditions of evacuation (s)
physical and psychical ability

a) People of able self movement
- common people (students, adults)

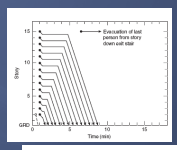
b) People with limited able of movement
- reduced move ability (handicapped people, patients,..)
- children from 3 to 6 years or elderly people (above 60years) (maternity school, rest home,...)

c) People of disable of movement
- blind people or immovable people (patients in the beds)
- children to 3 years (infantile institution, nursery)
- mentally deficient people (psychiatry)

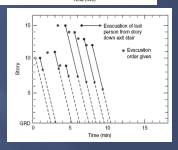
DESIGN OF ESCAPE ROUTES

Organization of escape

a) Simultaneous evacuation
- evacuation along NUC from fire comp.
- evacuation along CHUC from building (it goes into max. 3 fire compartment)



b) Sequential evacuation
- evacuation along CHUC from building (it goes into > 3 fire compartment)

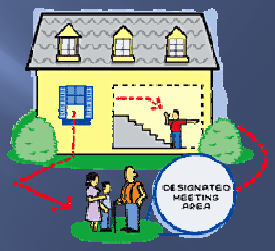


Calculation detailed design of evacuation
> 1000 people according CSN 73 0818
> 500 people in multi-storey building (h_p > 22,5 m)

Software: buildingEXODUS, SIMULEX,...

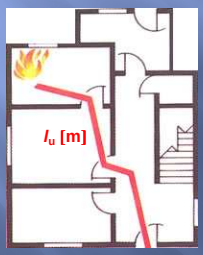
EVACUATION

Simple calculation of escape routes



Length of nonprotected escape route

Real length of NUC (nonprotected escape route)
It measures from most distant place fire compartment to exit from building (safety place) or to protected escape route.



Coefficient *a*	Maximal lenght nonprotected escape route $l_{u,max}$ [m]	
Fire compartment	One escape route over (ground) floors	More escape route over (ground) floors
to 0,3	45 (30)	90 (45)
0,4	45 (30)	80 (45)
0,5	45 (30)	70 (45)
0,6	40 (30)	60 (45)
0,7	40 (30)	55 (45)
0,8	35 (30)	50 (40)
0,9	30 (30)	45 (40)
1,0	25 (25)	40 (40)
1,1	20 (20)	35 (30)

Condition: $l_u \leq l_{u,max}$

Width of nonprotected escape route

Condition:
$u_{min} \leq u$

$$u_{min} = \frac{E}{K} . s$$

u_{min} - number of escape lane (e.g. 1; 1,5; 2; 2,5)
1 escape lane = 0,55 m

E - number of people (table CSN 73 0818)

u - real width of NUC (e.g. width of exit door)

s - coefficient of evacuation condition

	People	Type of evacuation	Value of coefficient s (NUC)
1	People of able self movement	simultaneous	1,0
		sequential	-
2	People with limited able of movement	simultaneous	1,5
		sequential	-
3	People of disable of movement	simultaneous	2,0
		sequential	-

K - capacity of one escape lane

Number of no protected routes from fire compartment		Number of escape people in one escape lane in NUC						
		Coefficient *a* of fire compartment						
		>1,3	1,1	1,0	0,9	0,8	0,7	0,6
One escape route	straight	-	40	55	70	80	90	100
	downstairs	-	30	40	50	60	70	80
	upstairs	-	25	35	45	50	55	60
Others escape routes	straight	55	80	105	120	135	150	160
	downstairs	40	60	80	90	100	110	120
	upstairs	35	50	65	75	85	95	100

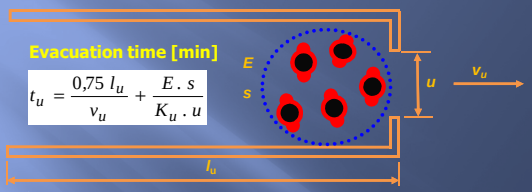
EVACUATION

Evacuation time Larger buildings

Evacuation time and Smoke time [min]

Evacuation time [min]

$$t_u = \frac{0{,}75\ l_u}{v_u} + \frac{E \,.\, s}{K_u \,.\, u}$$



where l_u is length escape route [m]
v_u velocity of people movement [m/min] 25-40
E number of people [people]
s coefficient of evacuation condition
K_u capacity of one escape lane [person/min]
u number of escape lane

Condition:

$$t_u \leq t_e$$

Smoke time [min]

$$t_e = 1{,}25 \,.\, h_s^{\,1/2} / a$$

where h_s is height of fire compartment [m]
a coefficient of burning velocity /fire load/

EVACUATION

Equipments on the escape routes

Equipments on the escape routes

Evacuation /resp. fire/ lifts
→ buildings of medial facility
→ buildings containing 10 persons with reduced mobility

Specificity:
- Standby supply (min. 45 min)
- Min. proportions of lift
- Incombustibility materials
- Travelling time (max. 2,5 min)

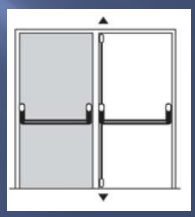
Fire lift

Evacuation lift

Equipments on the escape routes

Fire doors
→ opening door in direction escape (obligation for evacuation > 200 peoples)
→ door check (self closing device) for fire protected escape
→ automatic opening of door (it must be also manual)
→ door with door latch leave out to width escape route

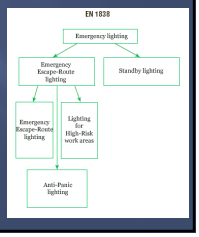
Door fittings



Equipments on the escape routes

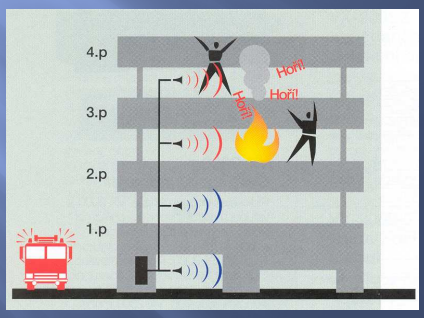
Emergency lighting
→ design according CSN EN 1838
→ protected escape routes – obligatory
→ accessories emergency lighting (2 independent energy resources)

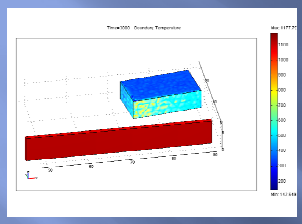
Safety marking of escape routes
→ design according CSN ISO 3864
→ escape routes must be clearly marked



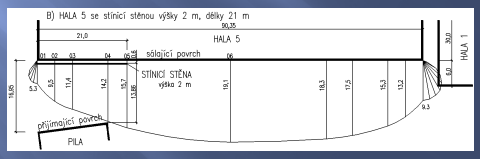
Equipments on the escape routes

Emergency Alarm (device)
→ > 200 people in the building or hotels,....





FIRE DISTANCES



Fire Distances

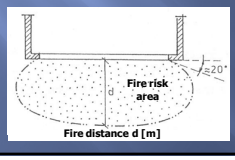
Occurrence of fire in the building

⇩

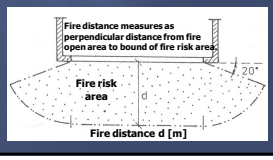
Radiation - throughout openings in external walls
- throughout roof cladding
(fully or partly fire open areas)

⇩

FIRE RISK AREA (FRA)



in practice ⇨



Calculation of fire distances

Fire distance is calculated:

a) **places of falling burning particles**
from external walls or roof cladding - d_1 [m]

b) **density of heat flow** - d_2 [m]

Than the equation is valid:

$$d_1 < d_{resulting} > d_2 \text{ [m]}$$

Calculation of fire distances

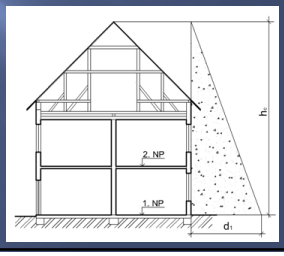
Falling burning particles from building

Fire distances is specified condition of falling burning particles (e.g. cladding of external wall - DP3).

It is assumed that falling burning particles falls under angle 20° from vertical of building.

Fire distance depends on total height of building

$d_1 = 0{,}36 \,.\, h_c$ [m]



Fire distances by force of radiant heat

METHODS OF ASSESMENT d_2

Calculation of density heat flow

Fire distance between building will be safety if it value of initial density of thermal flow I_0 on distance d between buildings falls down critical density of thermal flow I.

I = 18,5 kW/m² ..... about 450 °C

$$I = I_0 \,.\, \phi$$

ϕ is positional factor that is the function of dimension of external wall and distance d (by EUROCODE - CSN EN 1991-1-2)

Determination by table in Appendix F of CSN 73 0802

1. Computing fire load p_v [kg/m²]
2. Area of external wall of fire compartment [m²]
3. Fire open areas S_{po} [m²]
4. Percent of open area p_o [%]
5. Fire distance d [m]

Assessment of fire distance according to Table F

1. Computing fire load p_v [kg/m²]

Computing fire load changes according to construction systems:
- about 5 kg/m² for construction system - mixed
- about 10 kg/m² for construction system - combustible (DP2)
- about 15 kg/m² for construction system - combustible (DP3)

(Value p_v doesn t change for noncombustible system)

2. Area of external wall of fire compartment [m²]

$$S_p = l \,.\, h_u$$

l – length of external wall
h_u – height of external wall

Assessment of fire distance according to Table F

3. Fire open areas S_{po} [m²]

$$S_{po} = S_{po1} + k_2 . S_{po2} + k_3 . S_{po3}$$

S_{po1} – fully fire open area of external wall (opening glazed flat glass,...)
S_{po2} – partly fire open area of external wall (spandrel - lining between window)
S_{po3} – fire open area of roof cladding
k_2, k_3 – rate coefficients of density of thermal flow from radiant areas (in table)

4. Percent of open area p_o [%]

$$p_o = \frac{S_{po}}{S_p} . 100$$

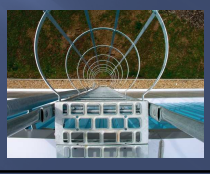
5. Fire distance [m]

Table F CSN 730802 as function (p_v , h_u , l , p_o)

Assessment of fire distance according to Table F

Height m	Length m	Percent of open area	Fire distance in m for computation fire load p_v in kg.m^{-2}									
			≤ 10	20	30	40	50	60	80	100	120	> 180
to 3,0	to 4,5	100	2,5	3,5	4,0	4,4	4,7	5,0	5,4	5,7	6,0	6,7
		80	2,1	2,9	3,5	3,8	4,1	4,4	4,7	5,0	5,3	5,9
		60	1,5	2,3	2,8	3,1	3,4	3,6	4,0	4,2	4,5	5,0
		40	0,2	1,5	1,9	2,3	2,5	2,7	3,0	3,2	3,4	3,9
	9,0	100	3,1	4,5	5,3	5,9	6,3	6,7	7,3	7,8	8,2	9,1
		80	2,5	3,7	4,5	5,0	5,4	5,8	6,4	6,8	7,2	8,0
		60	1,7	2,8	3,5	4,0	4,4	4,7	5,2	5,6	5,9	6,7
		40	0,3	1,7	2,3	2,8	3,1	3,4	3,8	4,2	4,4	5,1
	15,0	100	3,4	5,1	6,1	6,9	7,5	8,0	8,8	9,5	10,0	11,3
		80	2,6	4,1	5,1	5,8	6,3	6,8	7,5	8,1	8,6	9,7
		60	1,7	3,0	3,9	4,5	5,0	5,4	6,0	6,6	7,0	8,0
		40	0,3	1,8	2,4	2,9	3,3	3,7	4,2	4,6	5,0	5,9
	24,0	100	3,5	5,4	6,6	7,6	8,4	9,0	10,1	10,9	11,6	13,2
		80	2,7	4,3	5,4	6,2	6,9	7,5	8,4	9,2	9,9	11,3
		60	1,8	3,1	4,0	4,7	5,3	5,7	6,5	7,2	7,7	9,0
		40	0,3	1,8	2,5	3,0	3,4	3,8	4,4	4,9	5,3	6,3
	above 36,0	100	3,5	5,5	6,9	8,0	8,9	9,6	10,9	11,9	12,8	14,8
		80	2,7	4,3	5,5	6,4	7,2	7,8	8,9	9,8	10,6	12,3
		60	1,8	3,1	4,0	4,8	5,4	5,9	6,8	7,5	8,1	9,6
		40	0,3	1,8	2,5	3,0	3,4	3,8	4,5	5,0	5,4	6,5

EQUIPMENTS FOR FIGHT-FIGHTING INTERVENTION



Equipments for fight-fighting intervention

1) Communication

- **hardened communication** (load capacity 80 kN to axletree)
- **width of communication at least 3,0 m**
- **distance from building max. 20 m**

2) Gateway and Passage

- **min dimension 3,5 m x 4,1 m** (width x height)

Equipments for fight-fighting intervention

3) Ascending area for fire brigade

- obligatory for building ..... h > 12 m or for building with complicated access
- hardened communication
- width of this hard stand at least 3,5 m

ladder vehicle

Equipments for fight-fighting intervention

4) Safety ladder

- obligatory for area of plane roof S > 200 m²

5) Fire walkway

6) Internal fire-fighting ways

- obligatory for building ... h > 22,5 m
- generally protected escape routes type B and C

7) Fire lift

- obligatory for building h > 45 m

Equipments for fight-fighting intervention

8) External hydrants (rules in CSN 73 0873)

- max. distance from building
- max. distance between external hydrant
- dimension of flow rate [l/s]
- overpressure (min. 0,2 MPa)
- nominal inside diameter (DN)
- water reservoir (m^3)

9) Internal hydrants (CSN 73 0873)

$$p \cdot S > 9000$$

where S is area of fire compartment [m^2]
p fire load [$kg.m^2$]

Equipments for fight-fighting intervention

10) Fire extinguishers

- water, foam, powder,…
- in any fire compartment designates number of fire extinguishers:

$$n_r = 0{,}15\,(S \cdot a \cdot c_3)^{1/2} \geq 1{,}0$$

where S is area of fire compartment [m^2]
a coefficient of fire load [-]
c_3 coefficient of fire load [-]
(no sprinkler $c_3 = 1$)

Thanks for your attention