Characteristics and advantages of PVC in fire safety

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Characteristics and advantages of PVC in fire safety

- Introduction
- Basics about fire safety
- Reaction to fire properties and PVC
- Testing
- Statistics about fire
- Recent topics
- Conclusion

PVC and fire safety
Introduction

- Fire safety in general
  - Protection of life, environment, equipment
  - Material ≠ product ≠ system ≠ FSE
  - Passive + active measures
  - Risk ≠ hazard
- Construction Products Regulation (305/2011)
  - Safety in case of fire (BWR2)
  - Decision on the classification of the reaction to fire performance of cables (2006/751/EC, repealed by Delegated Regulation 2016/364)

PVC and fire safety
Introduction

- Often heard about PVC, in case of fire:
  - PVC is plastics, thus it catches fire easily
  - PVC can rapidly propagate fire
  - PVC generates flaming droplets that can propagate fire
  - PVC generates dense smoke
  - PVC generates more toxic gases than other materials
  - PVC releases HCl that is particularly toxic
  - PVC smoke is corrosive

PVC and fire safety
Introduction

- Reality about PVC, in case of fire:
  - PVC is plastics, thus it catches fire easily → **NO**
  - PVC can rapidly propagate fire → **NO**
  - PVC generates flaming droplets that can propagate fire → **NO**
  - PVC generates dense smoke → YES/NO
  - PVC generates more toxic gases than other materials → **NO**
  - PVC releases HCl that is particularly toxic → **NO**
  - PVC smoke is corrosive → YES/NO

PVC and fire safety
Basics about fire safety

- Fire safety objectives
  - Safety of life
  - Conservation of property
  - Continuity of business operations
  - Protection of the environment
  - Preservation of heritage
- Parameters to consider: local situation, type and density of occupation, escape means, fire scenario, alarms, detectors, smoke exhaust...

→ Fire safety: a diverse and complex matter !

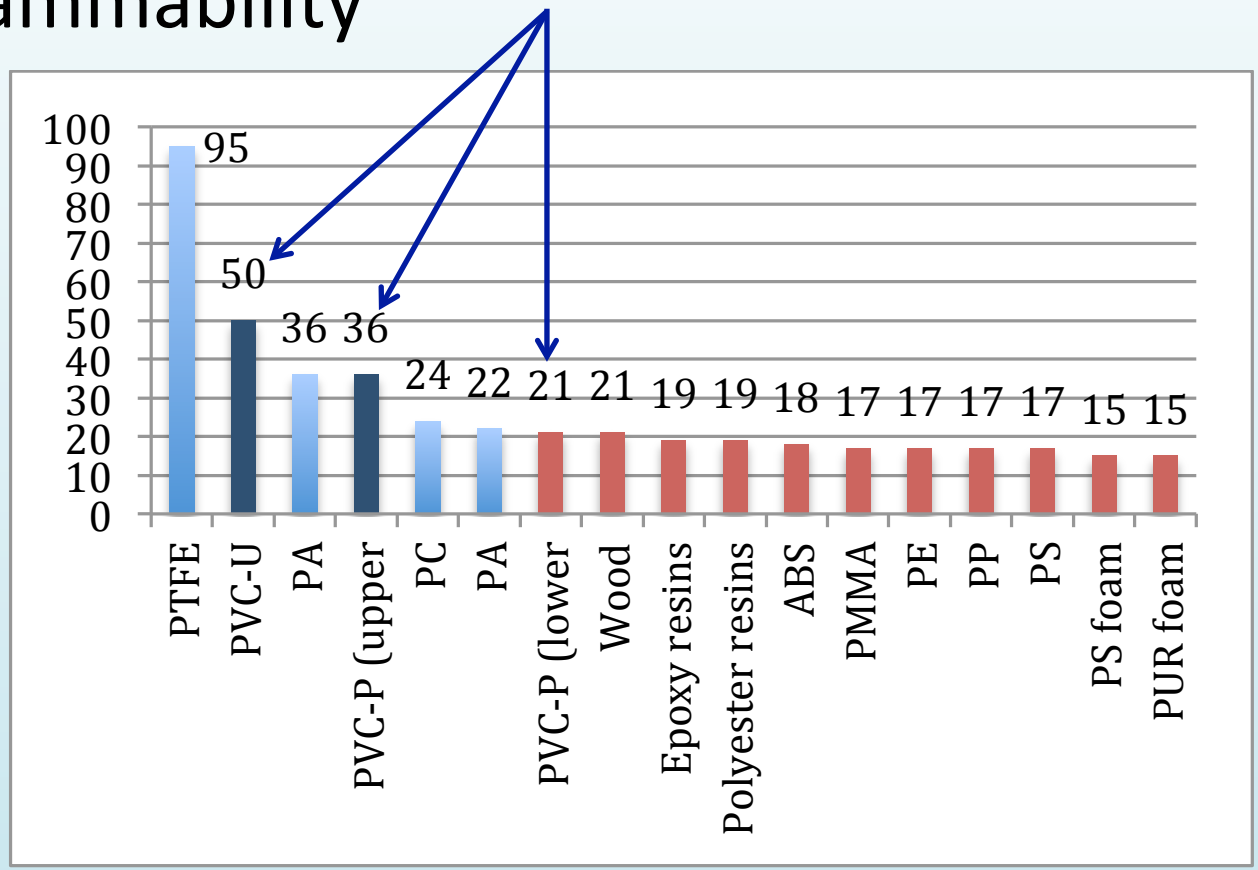
PVC and fire safety
Reaction to fire properties and PVC

- Flammability
- Heat release
- Smoke generation
- Toxicity of fire gases
- Corrosive potency
- Flame propagation

+ charring
+ intumescence

PVC and fire safety
Reaction to fire properties and PVC

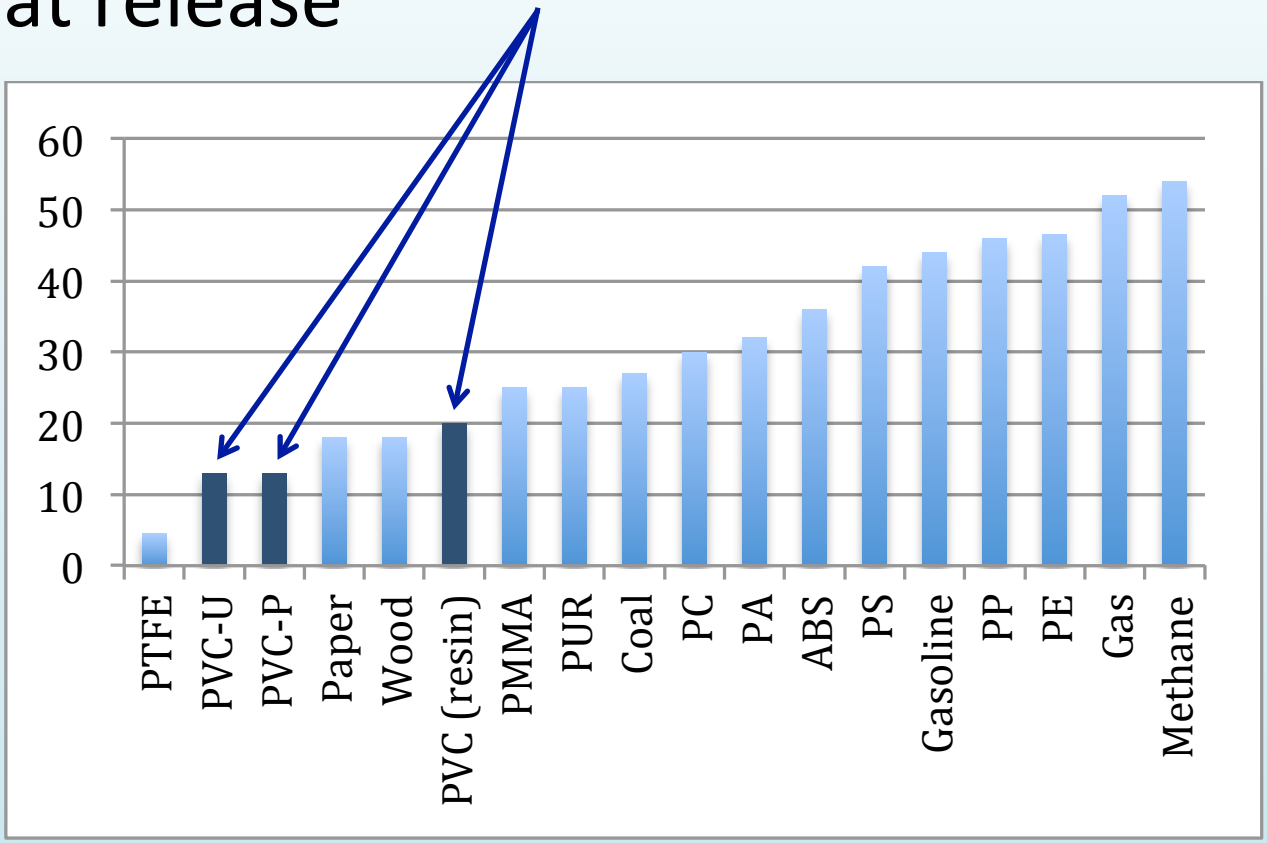
- Flammability



Limiting oxygen index (% O2)

PVC and fire safety
Reaction to fire properties and PVC

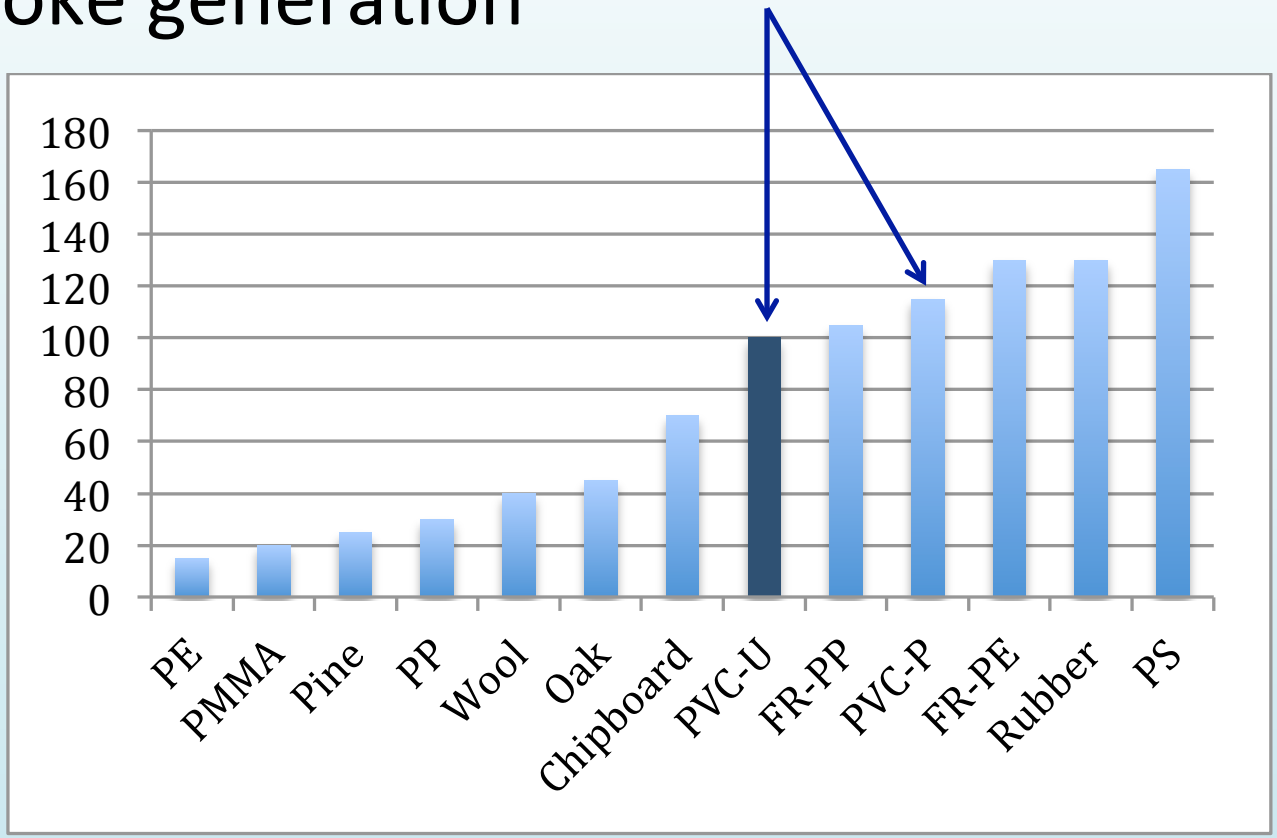
- Heat release



Inferior calorific value (MJ/kg)

PVC and fire safety
Reaction to fire properties and PVC

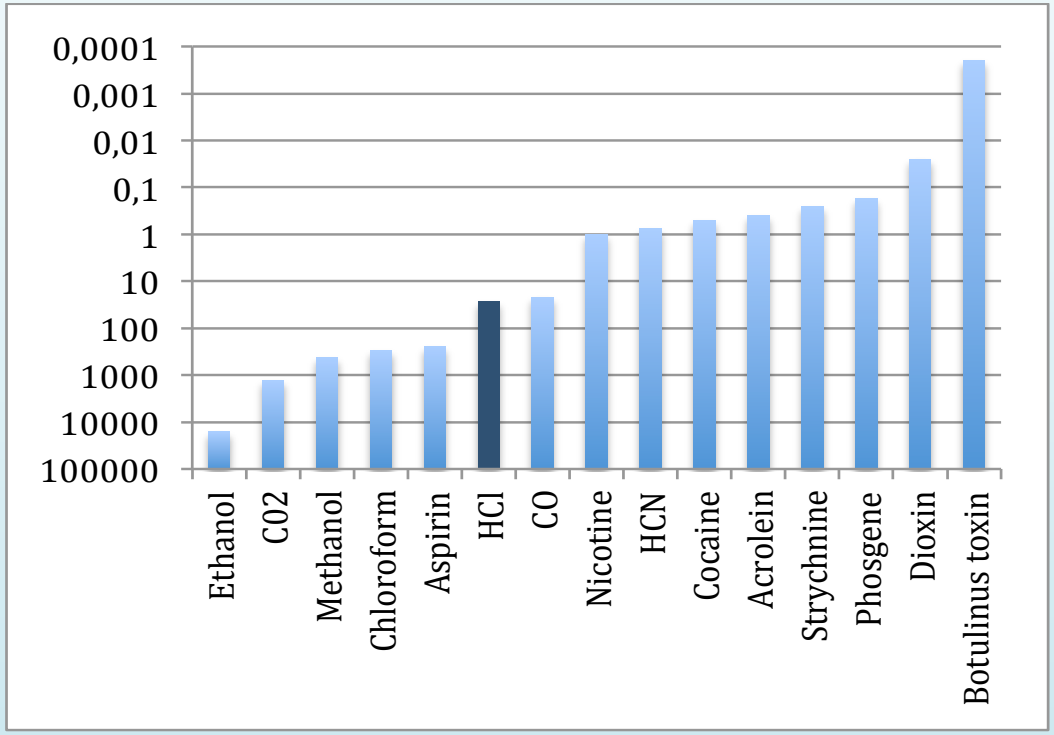
- Smoke generation



Estimate of smoke density under flaming conditions relative to PVC-U (%)

PVC and fire safety
Reaction to fire properties and PVC

- Toxicity of fire gases



Toxic level of combustion gases
compared with everyday materials (mg gas/kg body)

PVC and fire safety
Reaction to fire properties and PVC

- Toxicity of fire gases

ISO 13571:

Life-threatening components of fire – Guidelines for the estimation of time to compromised tenability in fires

ISO 13444:

Estimation of the lethal toxic potency of fire effluents

30 min LC50 values for rats (ppm vol), ISO 13344

HCl	3800
HBr	3800
HF	2900
NO_2	170
HCOH	750
SO_2	1400
Acrolein	150
CO	5700
HCN	165

F (ppm vol) according to ISO 13571 (FEC model)

HCl	1000
HBr	1000
HF	500
NO_2	250
HCOH	250
SO_2	150
Acrolein	30

PVC and fire safety
Reaction to fire properties and PVC

• Flammability	☑ High Oxygen Index
• Heat release	☑ Low calorific value
• Smoke generation	☒ Medium range
• Toxicity of fire gases	☒ Medium range
• Corrosive potency	☒ HCl (but slow)
• Flame propagation	☑ No flaming droplets *(PVC-U: Self-extinguishing)*
+ charring	☑ Yes
+ intumescence	☑ Yes (with additives)

PVC and fire safety
Testing

- Standardisation committees
  - ISO TC 92 (*WG8* - *WG13* - SC1 - *SC2* - SC3 - SC4)
  - CEN TC 127
  - IEC TC 89 (WG11 – WG12)
  - IEC TC 20 (WG18)
  - CLC TC 20 (WG10)
- Not all characteristics at the same time
- Relevance of test methods and difficulty for scaling up characteristics

PVC and fire safety
Relevance of test methods

Example for plastics

	Material		Product		System/installed product	
			Semi-finished product	Finished product	Large scale	Real scale
Scale of test	Bench	Small	Intermediate		Large	Real
What is seen	Matter	Matter Multilayer Charring Intumescence	Material Propagation Joints	Product Mounting Fixing Joints	Global Realistic environment System	System Real situation
Main user	Compound developer	Compound supplier	Product supplier	Product supplier	Prime contractor Regulator	Prime contractor Regulator
Ignition Flame spread	ISO 4589-2/3 ISO 9772 ISO 9773 ISO 12992 ISO 11925-1	ISO 5660-1	ISO 5658-2 ISO 5658 -4 ISO 21367	EN 13823	ISO 9705 ISO 13784-1/2	ISO 24473
Heat release		ISO 5660-1	ISO 21367	EN 13823	ISO 9705 ISO 13784-1	ISO 24473
Smoke		ISO 5659-2 ISO 5660-2	ISO 21367	EN 13823	ISO 9705	ISO 24473

ISO 15791-1: Plastics - Development and use of intermediate-scale fire tests for plastics products - Part 1: General guidance

PVC and fire safety
Relevance of test methods

Example for plastics

Applicability of test methods	Test methods			
	ISO 9239-1 ISO 9239-2	ISO 5658-4	ISO 21367	ISO 14696
Preselection test	Only for flat products	yes	yes	yes
End product test	Only for horizontal flat products	Only for vertical product Adaptation of specimen for profiled product	Only for vertical product Adaptation of specimen for profiled product	Only for vertical product Adaptation of specimen for profiled product
Additional parameters	Possible presence of joints	Possible presence of joints	Possible presence of joints	Possible presence of joints
Ignitability	Yes	Yes	Yes	Yes
Spread of flame	Only lateral spread of flame	Lateral and vertical spread of flame	Lateral and vertical spread of flame	Vertical spread of flame
Ignited droplets	No	Yes	Yes	Yes
Heat release	No	No	Yes	Yes
Smoke opacity	Yes	No	Yes	Yes
Smoke toxicity	No	No	No	No

ISO/DTS 15791-2.2: Plastics - Development and use of intermediate-scale fire tests for products

PVC and fire safety
Testing

- Acidity ≠ corrosivity ≠ toxicity ≠ incapacitation
  - smoke acidity: pH level of fire effluents found in smoke condensate and smoke particles *(ISO/NP 11907-1)*
  - smoke corrosivity: measured effect of material or product reduction in functionality due to the corrosive effects of smoke *(ISO/NP 11907-1)*
  - smoke toxicity: impact of toxic gases to a given target (generally people) in a specific exposure scenario. In general, this concerns acute toxicity, as defined in ISO 13943 *(ISO/NP 11907-1)*
  - incapacitation: state of physical inability to accomplish a specific task, e.g. escape from a fire *(ISO 13943)*
  - tenability (*opposite of incapacitation)*: ability of humans to perform cognitive and motor-skill functions at an acceptable level when exposed to a fire environment *(ISO 13571)*

PVC and fire safety
Testing

- Acidity ≠ corrosivity ≠ toxicity ≠ incapacitation
  - IEC 60754: Test on gases evolved during combustion of materials from cables
    - Part 1: Determination of the halogen acid gas content → material composition
    - Part 2: Determination of acidity (by pH measurement) and conductivity → corrosive potency

EU classification

  - Corrosivity linked to circuit integrity → also bridging by soot (quicker !)
  - Toxicity: many chemicals involved, but CO is N°1
  - Incapacitation: also thermal effect, O_2 depletion

PVC and fire safety
Statistics about fire

- Fire safety is a political responsibility since it addresses safety of life first

→ where are the priorities

  - in term of situations ?
  - in term of requirements ?

- Interest of statistics
  - ISO/TR 17755: Fire safety - Overview of national fire statistics practices
  - In parallel, workable data could be collected from several countries

PVC and fire safety
Topics under consideration (1)

- Heat release vs fire conditions (small scale testing) *(ISO TC 92 SC1)*
  - e.g.: vitiated atmosphere, low combustibility, smouldering products
- Scaling up toxicity of fire effluents *(ISO TC 92 SC3)*
  - toxicity of fire effluents is very much dependent on fire conditions
  - additional difficulty for materials that char or sustain induced chemical reactions

PVC and fire safety
Topics under consideration (2)

- Tenability and lethality *(ISO TC 92 SC3)*
  - Discussion/confirmation with ref. to paradigms
- Sub-incapacitating effects *(ISO TC 92 SC3)*
  - CO and disorientation
  - smoke density
  - impact on human behaviour
- Burning behaviour of PVC construction products *(ISO TC 61 SC4)*
  - Development of a ISO/TR at ISO TC 61 SC4

Real-scale fire tests and tenability assessment (LNE-LCPP)

- Statistics
  - 94 % fatalities come from dwelling fires (FR)
  - 70% of victims in sleeping rooms and lounges (US)
  - 70% of victims during the night (from 6 PM to 6 AM)
  - cigarettes/smoking responsible of ⅓ of all domestic fires
- Typical scenario
  - 9 m^2 sleeping room for one person
  - 2 common situations
  - large presence of PVC products
- Question:
  What is the determining tenability parameter ?

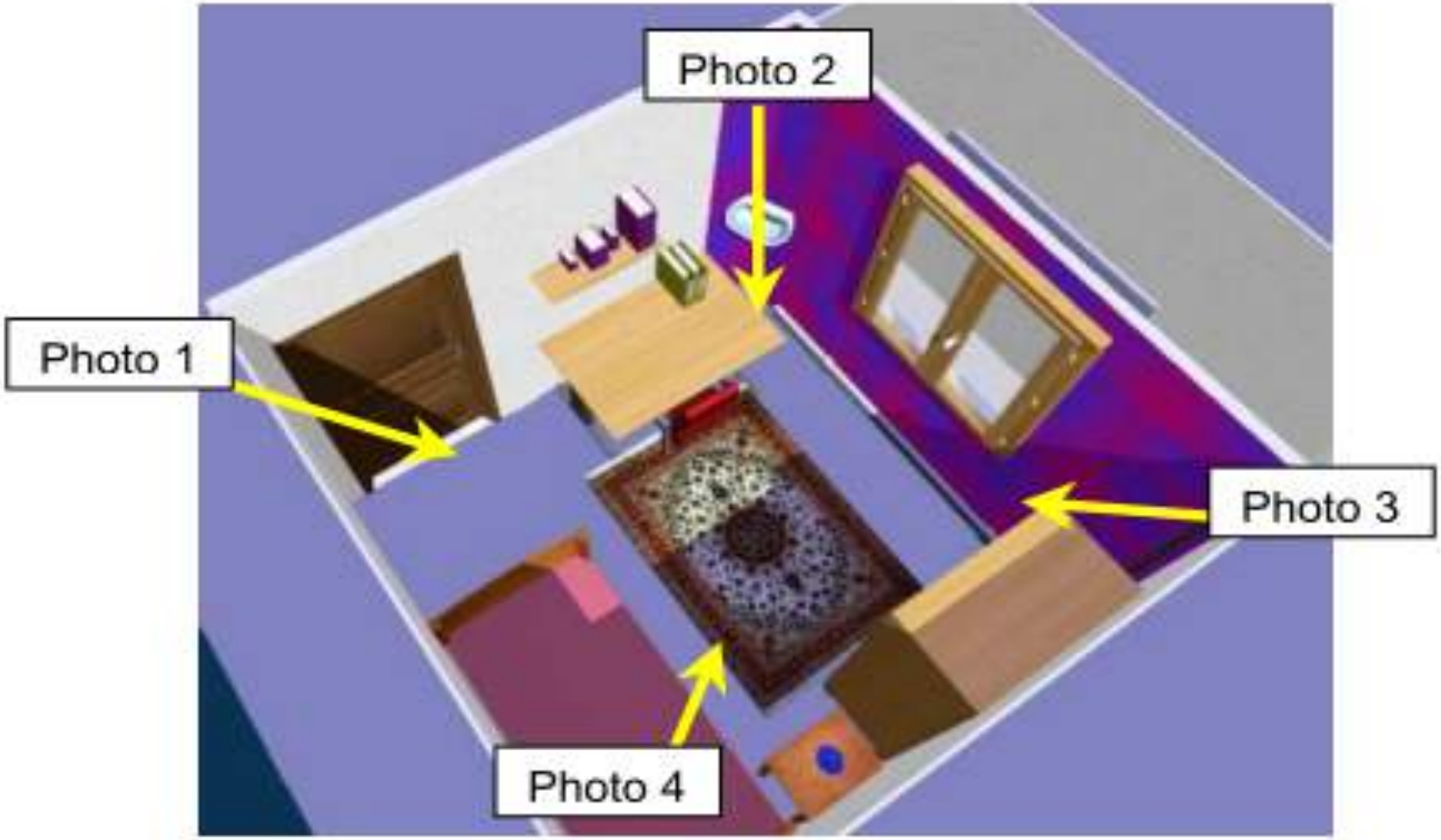


Photo 2
Photo 1
Photo 3
Photo 4

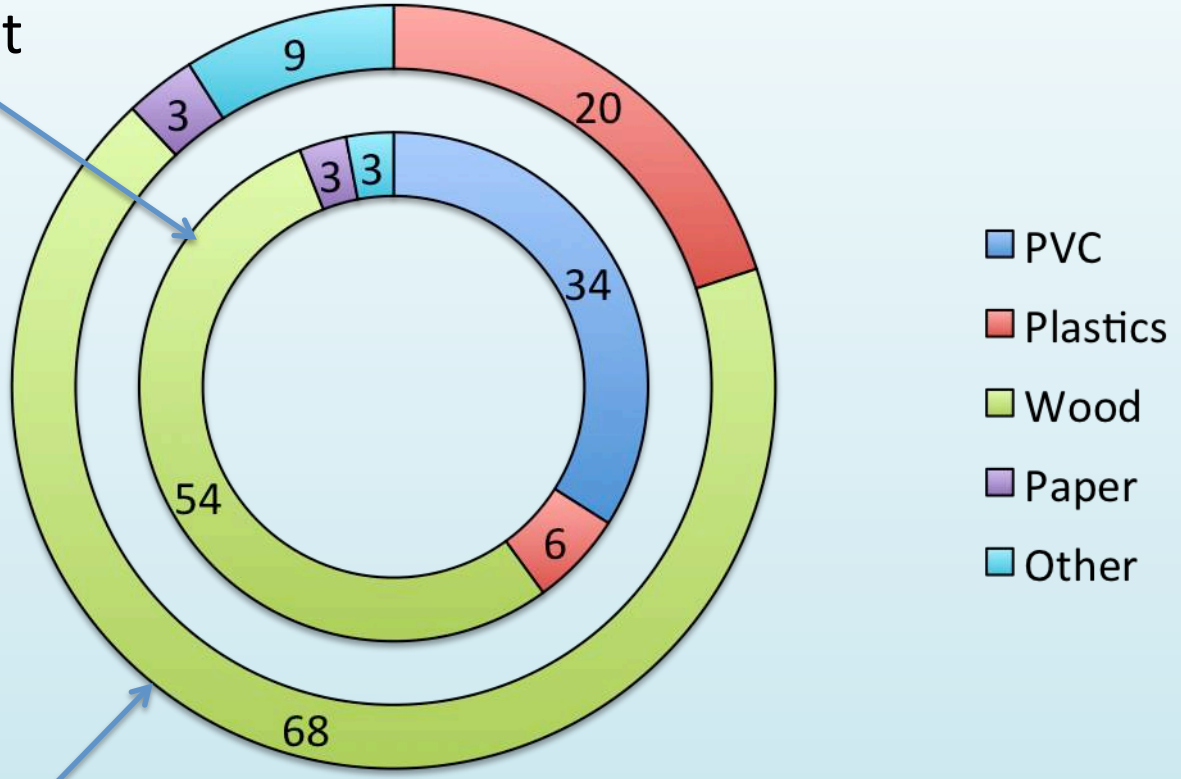
Photo 3

Photo 1

Photo 4

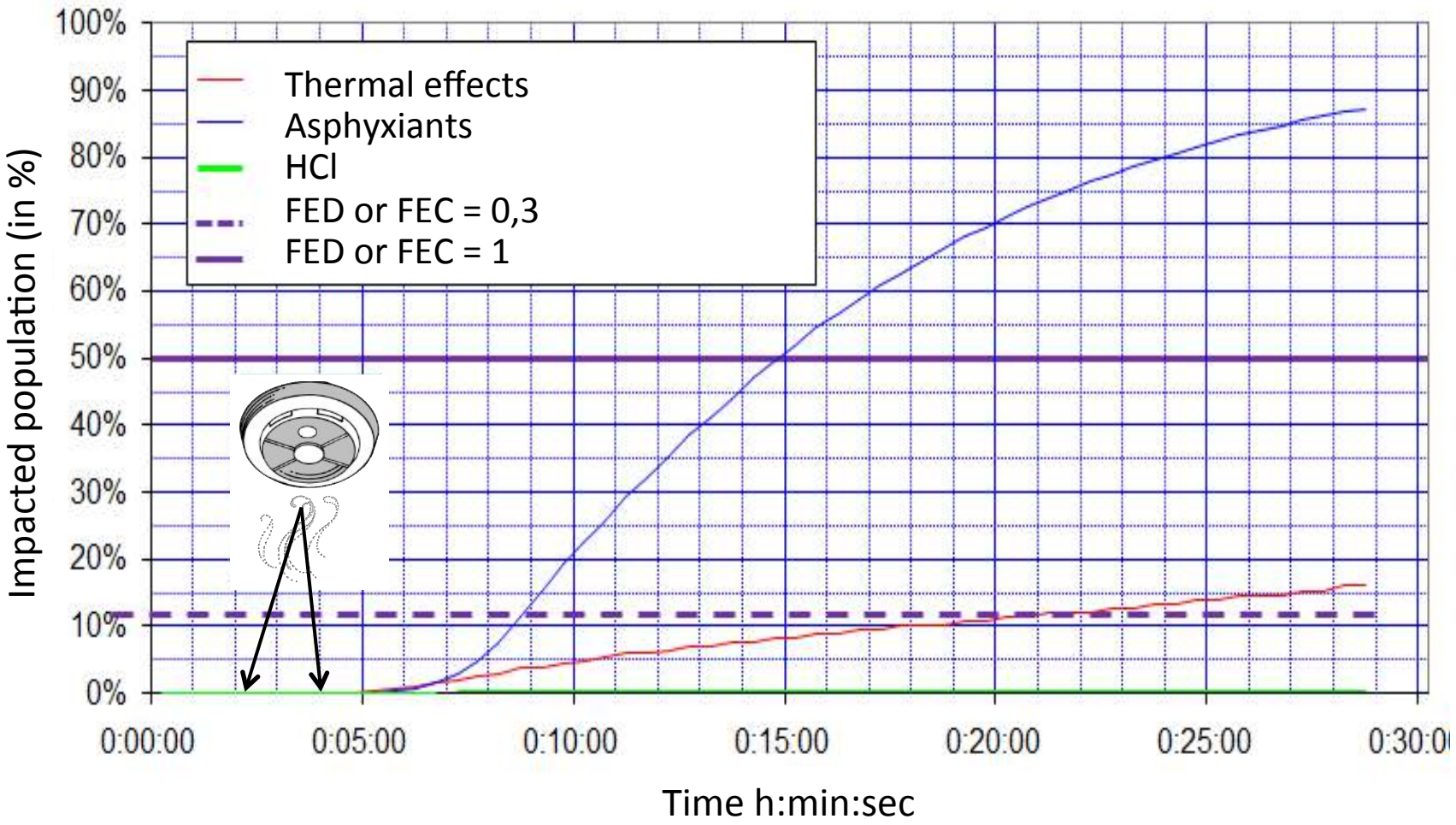
Material composition of the tested bedroom vs. typical bedroom

Real-scale test

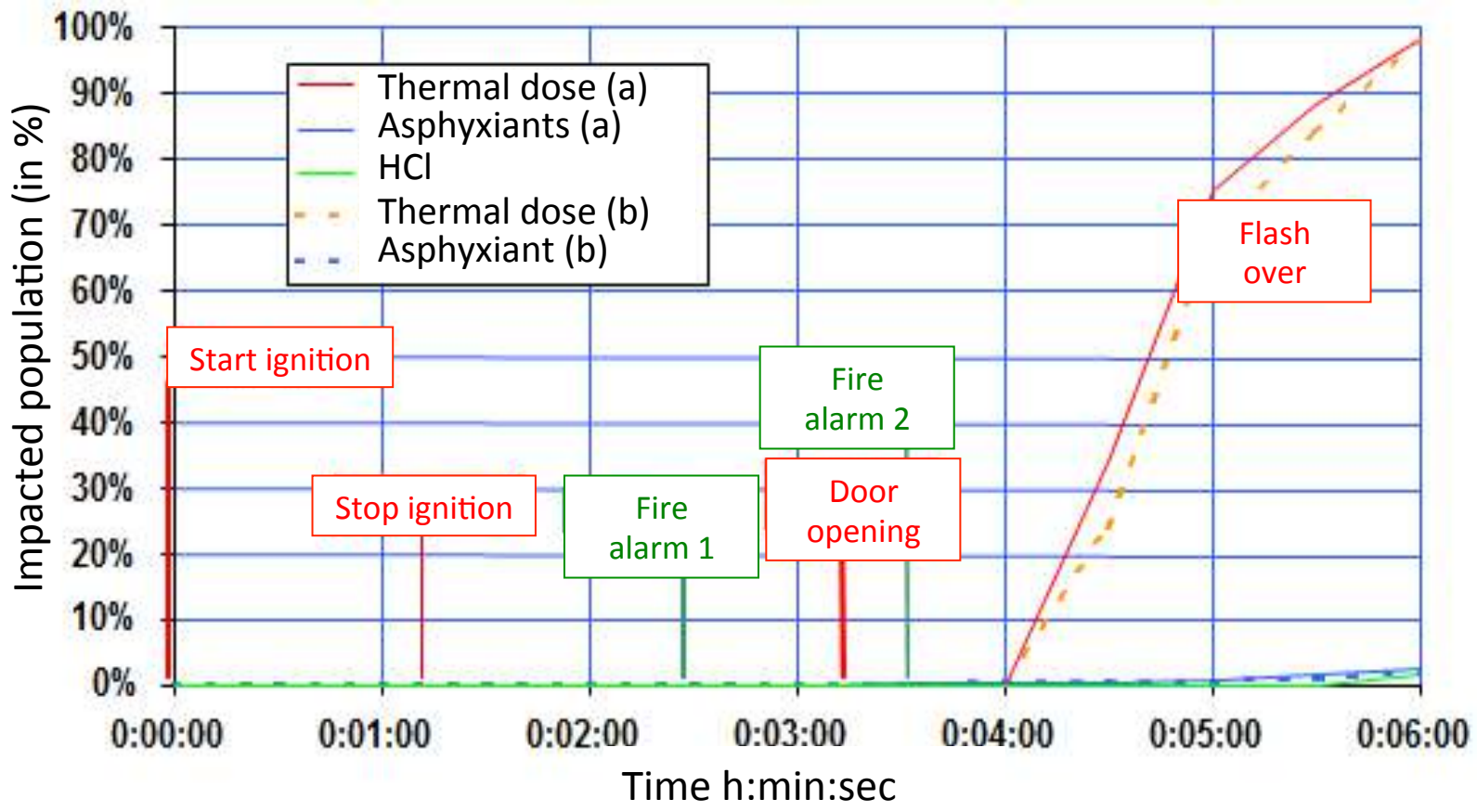


Typical bedroom such as in an hotel

Fire from quilt - Sleeping person
Bedroom remaining closed



Fire from paper bin - Active person Bedroom opened after approx. 3 min



Real-scale fire tests and tenability assessment (LNE-LCPP)

- Conclusion: **HCl never compromises tenability**
  - fire from quilt, sleeping person and room remaining closed
    - fire alarms → OK → waking up and escape possible
    - fire limited by ventilation
    - tenability: toxic effects of asphyxiant gases coupled with oxygen decay
    - thermal and irritants effects are negligible
  - fire from paper basket, active person, room opened after approx. 3 minutes
    - fire alarms → OK → escape possible
    - flash over a while after the door opening
    - tenability: thermal effects
    - toxicity of gases only after thermal effects

Characteristics and advantages of PVC in fire safety

- PVC is difficult to ignite, moderately releases heat and does not sustain combustion
- PVC does not ease flame propagation
- PVC does not generate flaming droplets
- PVC does produce opaque smoke, but comparable to various other materials depending on the fire scenario
- PVC does not emit more toxic gases than many other materials
- Except in specific situations, the argument of acid gases impact is not valid, in particular in B&C

Characteristics and advantages of PVC in fire safety

PVC4Pipes - 2017-02-28

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