BAM
Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

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FE 82.0728/2019 „DEVELOPMENT OF TEST FOR TOXICITY ASSESSMENT OF BUS INTERIOR MATERIALS“

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7.5 Technical Properties of Polymer Materials
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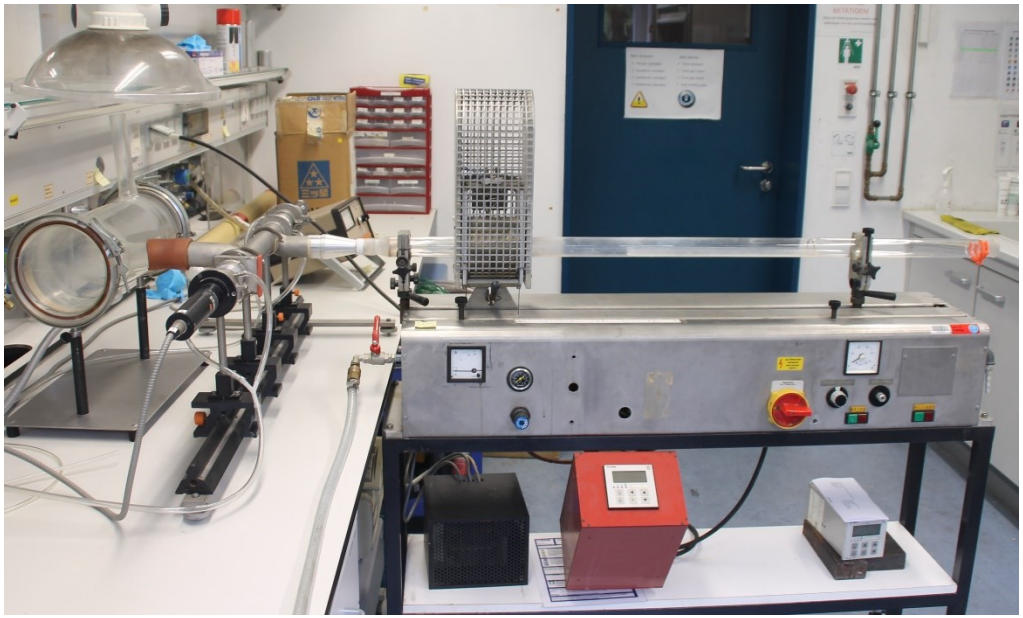
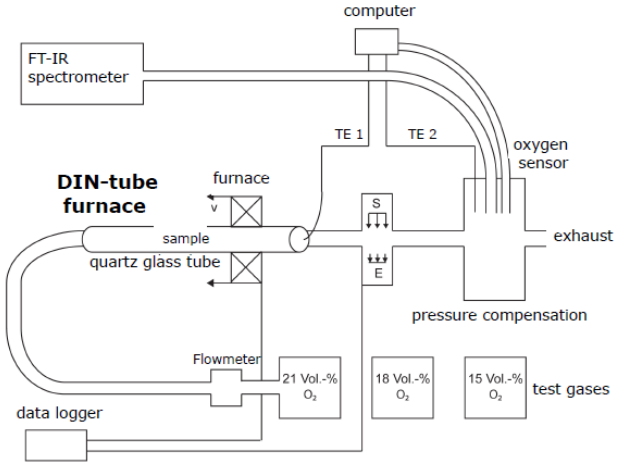
Overview

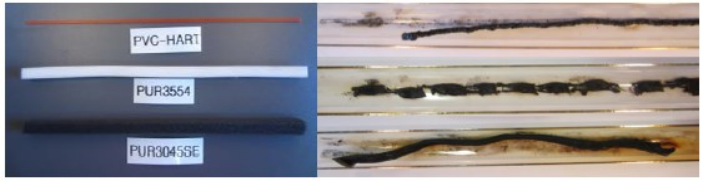
- Update on test apparatus and Fraction effective dose (FED) model
- Toxicitxy of smoke gas components
- Update on specimens
- Update on experiments with new bus materials
- Update on numerical investigations
- Conclusions

Toxicity of smoke gas components
DIN tube

- steady-state tube furnace methods: allow correlation to individual fire stages, good agreement with measured large-scale toxic product yields e.g. DIN 534436 furnace, Purser furnace BS 7990
- DIN tube furnace investigation of the smoke gas composition under smoldering conditions

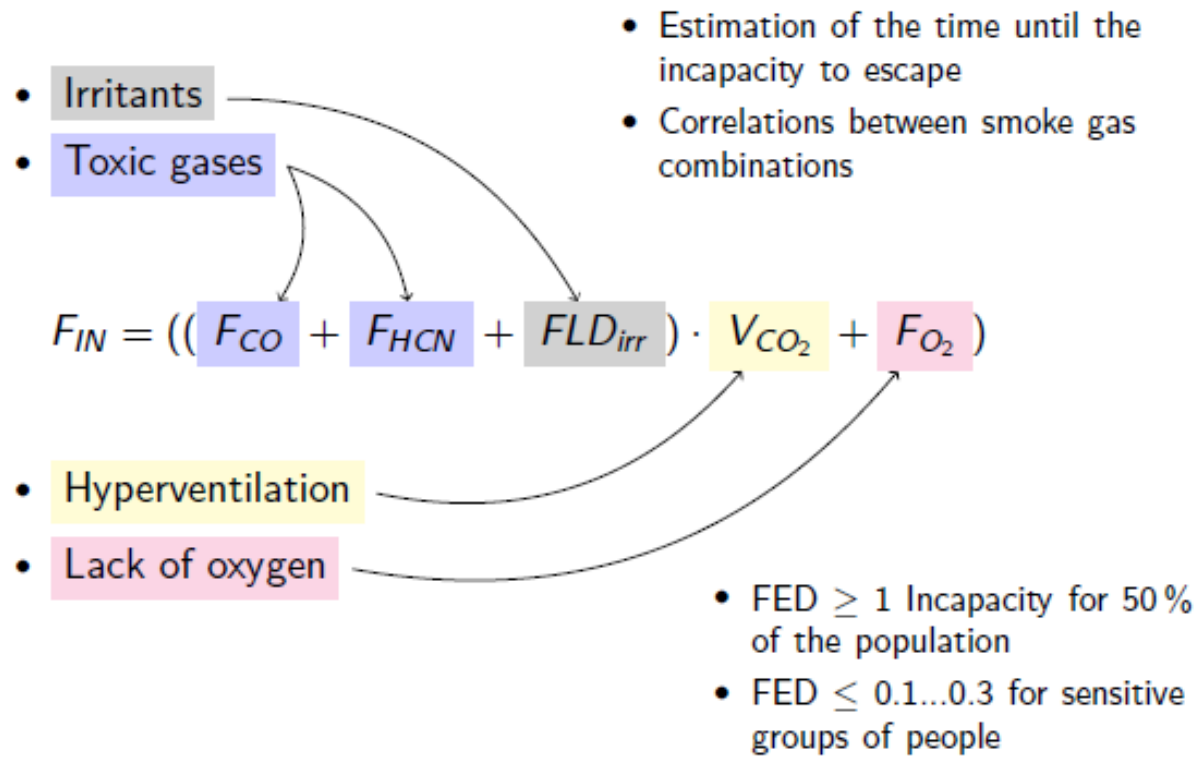






Toxicity of smoke gas components

- Fractional Effective Dose Model according D.A. Purser



Toxicity of smoke gas components

- carbon monoxide CO:
  - colorless, odorless and very toxic gas
  - substance group of carbon oxides
  - incomplete combustion
  - 210-fold higher affinity than oxygen to bind itself on hemoglobin
  - blocks oxygen transport in the blood suffocation

- carbon dioxide CO2:
  - arises from the complete combustion of carbonaceous fuels
  - colorless, odourless, non-flammable
  - up to 3 Vol.-% → hyperventilation
  - hyperventilation: disturbance of breathing; deep breathing
  - accelerated breathing increases the intake of toxic and irritating components

Toxicity of smoke gas components

- hydrogen cyanide HCN:
  - combustion of nitrogen-containing organic materials
  - usually with thermal-oxidative decomposition of polymers
  - nitriles, polyamides, polyurethane but also in the combustion of feathers or silk
  - aerobic metabolism is brought to a standstill ! Deficiency of the tissue with oxygen and hyperacidity of the blood
  - value of HCN in the case of re smoke poisoning is still a current important subject of research

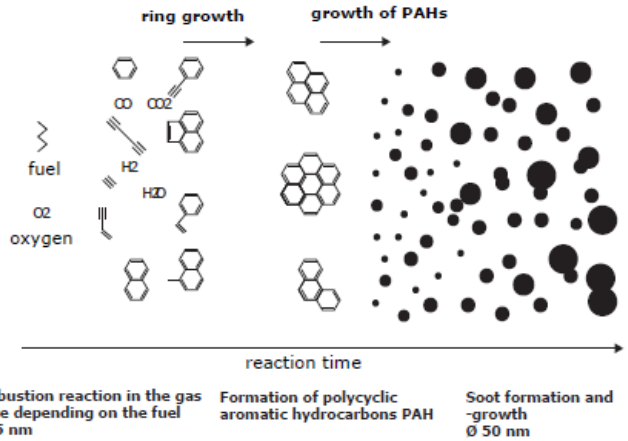
Toxicity of smoke gas components

- irritants:
  - sensory stimulus to human sensory organs → burns in the respiratory tract, lung damage etc.
  - e.g. hydrogen chloride HCl
  - hydrogen bromide HBr
  - hydrogen fluoride HF
  - sulphur dioxide SO2
  - nitrogen dioxide NO2
  - acrolein CH2CHO
  - formaldehyde HCHO

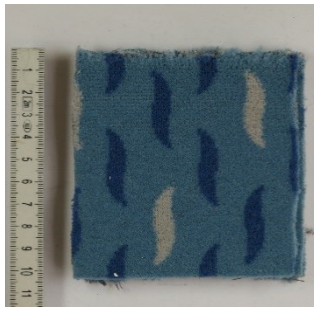
Toxicity of smoke gas components

- PAH and soot:
  - PAH (polycyclic aromatic hydrocarbons)
  - aromatic compounds with ring structure
  - formation during pyrolysis and incomplete combustion
  - hardly soluble in water and very stable
  - e.g. naphthalene C10H8
  - PAHs can be regarded as a kind of precursor of soot

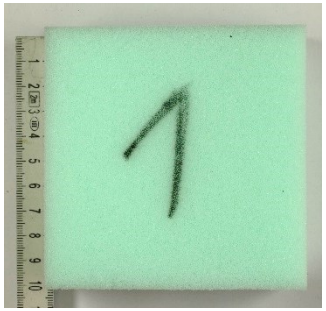
Soot growth according to Frenklach and Wang



Update on specimens -textiles

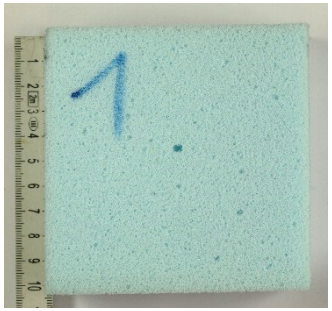
textiles				
upper layer	66 % polyester 28 % wool 6 % viscose	polyester/ polyamid	100% polyester	70 % polyester 30 % wool
basic layer/ lamination	60 % polyester 24 % viscose 15 % cotton 1 % elastane	polyethylene fleece	72 % polyester 28 % viscose	50 % polyester 50 % viscose
burning test acc.	UN ECE R 118 Nr. 2	UN ECE-R 118:03	Anhang 8 Beurteilung gem. DIN 5510 - 2 (05.09)	EN 45545- 2:2013 R21, ECE R 118.03

Update on specimens - foam



MA 4245 D

DIN 75200
FMVSS 302

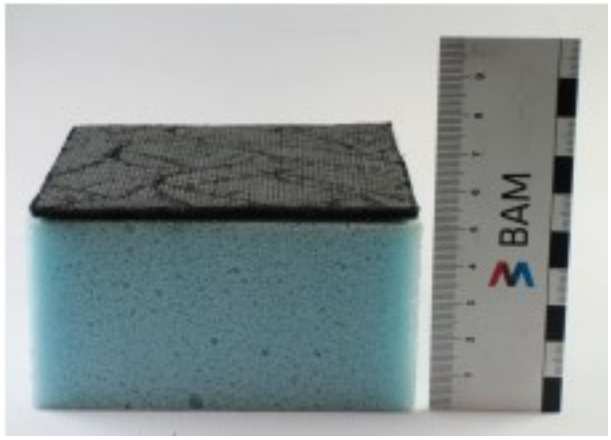


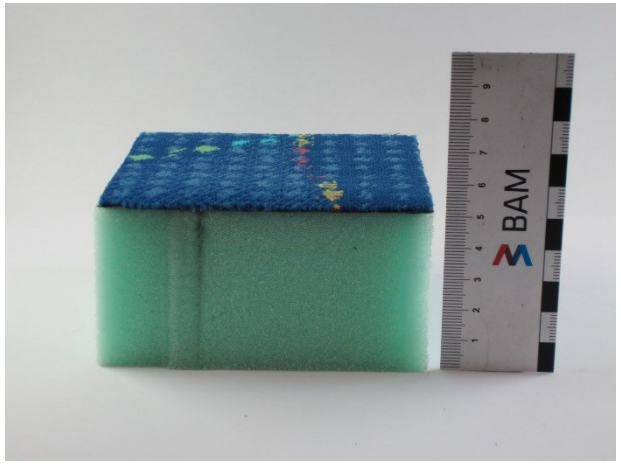
MR 5050 D

DIN 75200
FMVSS 302
DIN 4102 B2
FAR 25.853 a, Am. 25-72
Bunsenbrenner

upholstery
foam – no requirements

Update on specimens – foam and textile





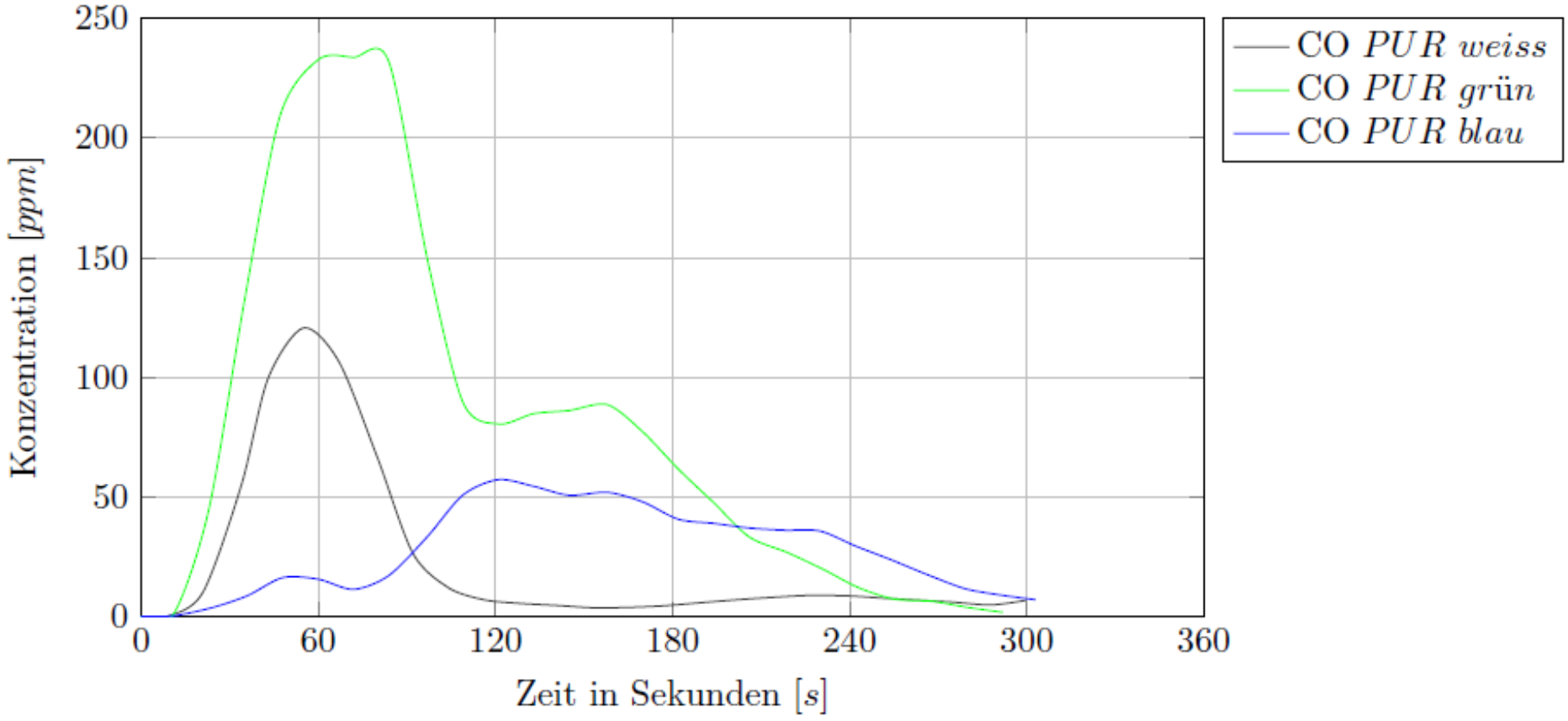
Update on experiments

- Cone Calorimeter / Vitiated Cone Calorimeter / Mass Loss Calorimeter
  tests performed for foam and textiles and combination of both

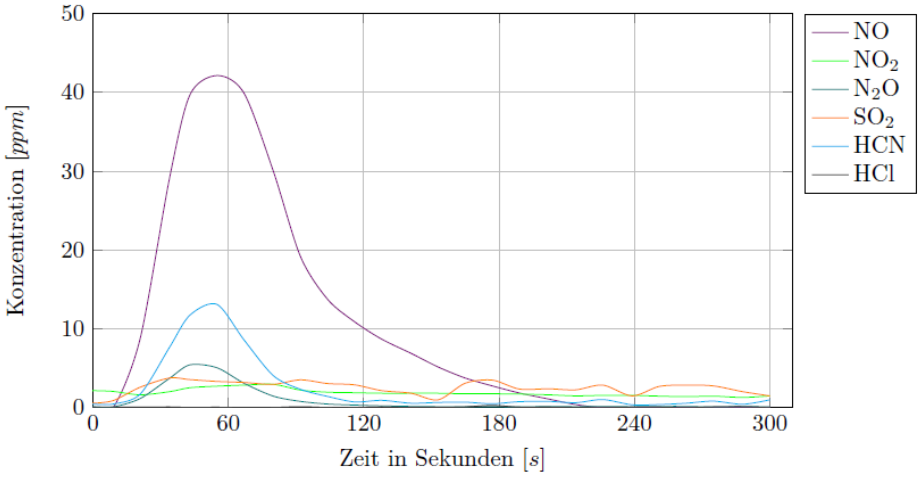
- Smoke Density Chamber
  to be tested in September

- DIN tube
  installation of test apparatus and first tests

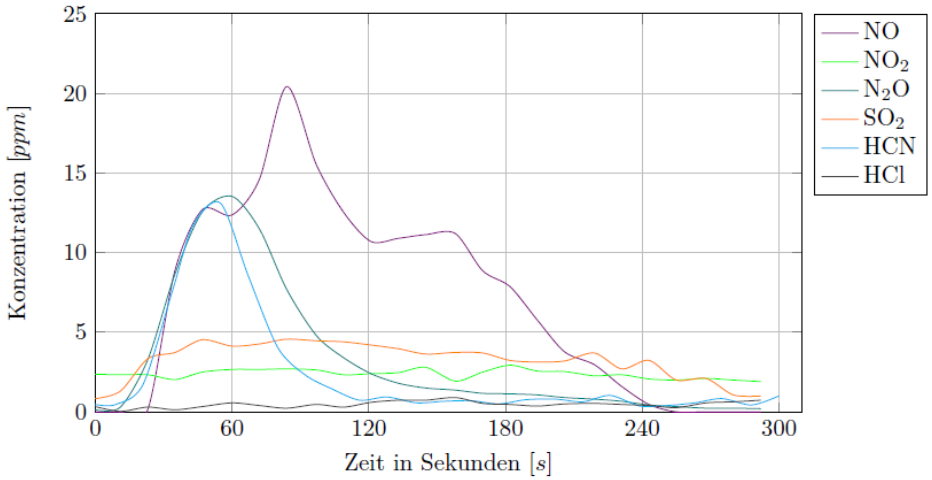
Cone Calorimeter Tests: PUR foams CO concentration



Cone Calorimeter Tests: PU foams – other smoke gases

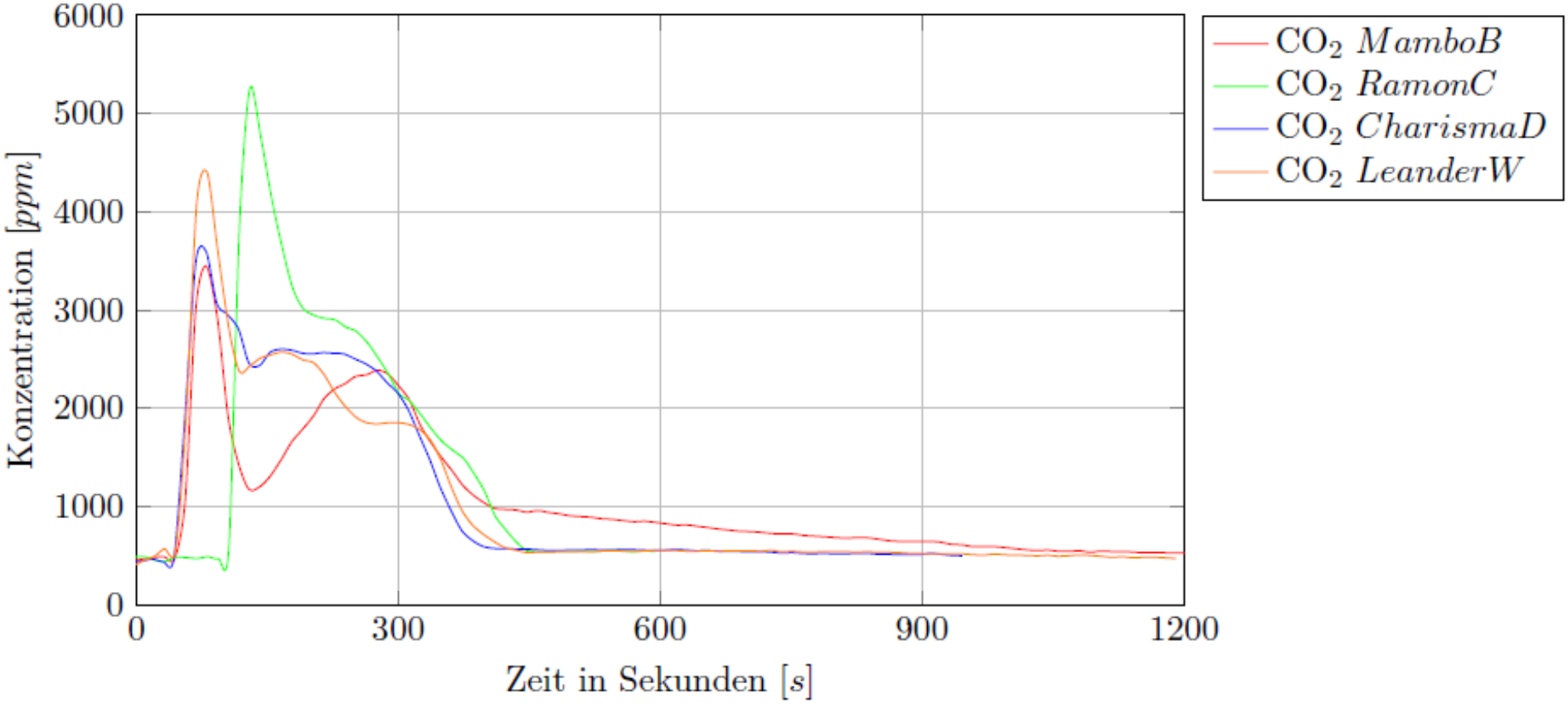


White foam (no requirements)

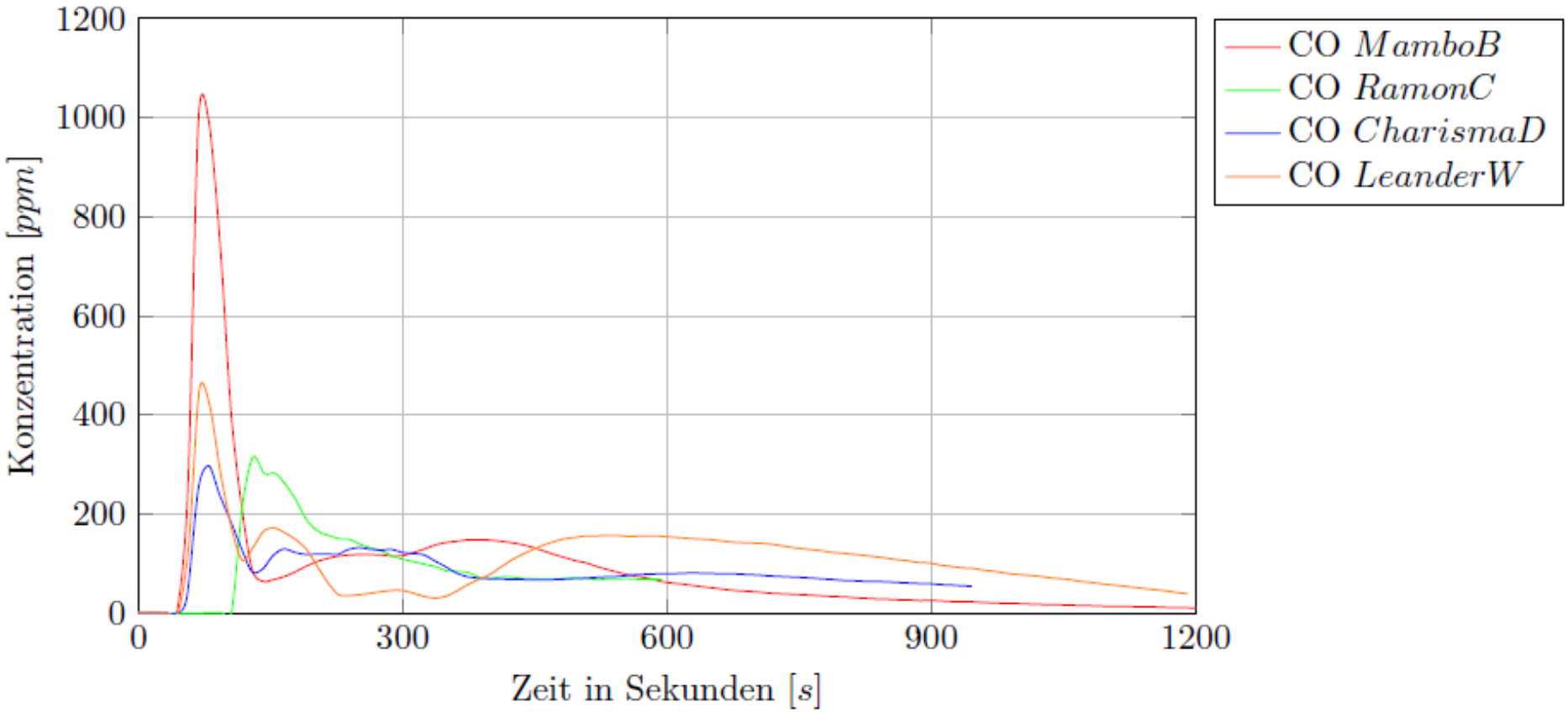


Green foam (new bus material)

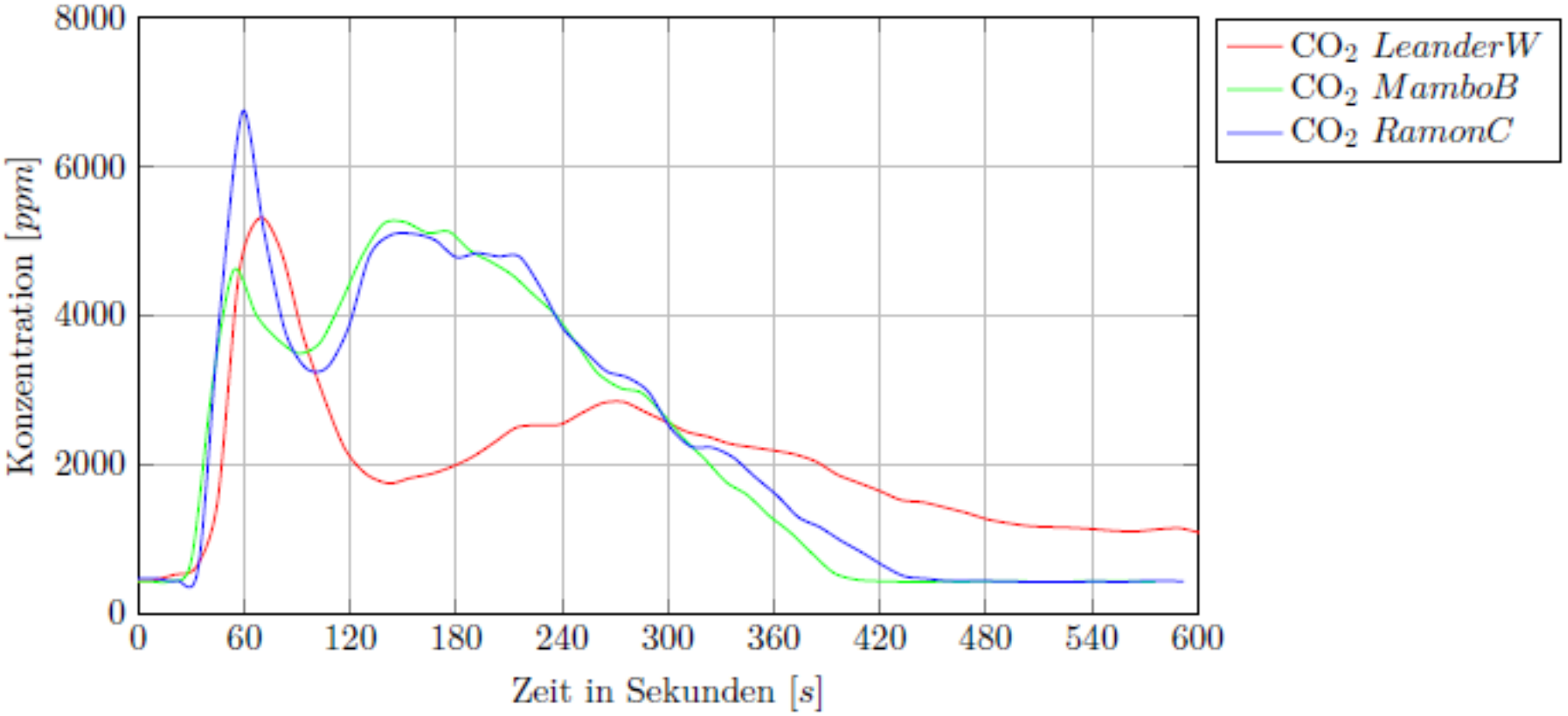
Cone Calorimeter Tests: textiles CO2



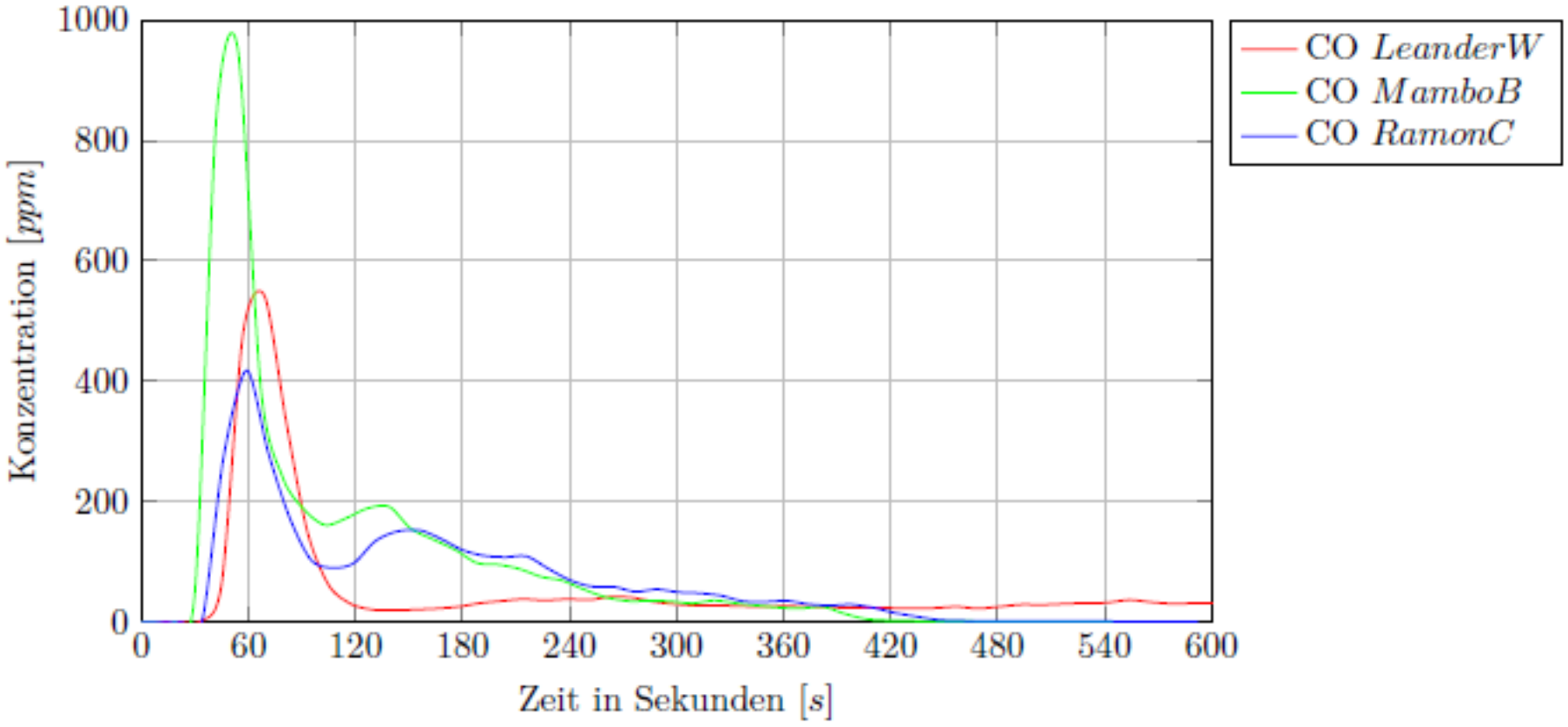
Cone Calorimeter Tests: textiles – other smoke gas components



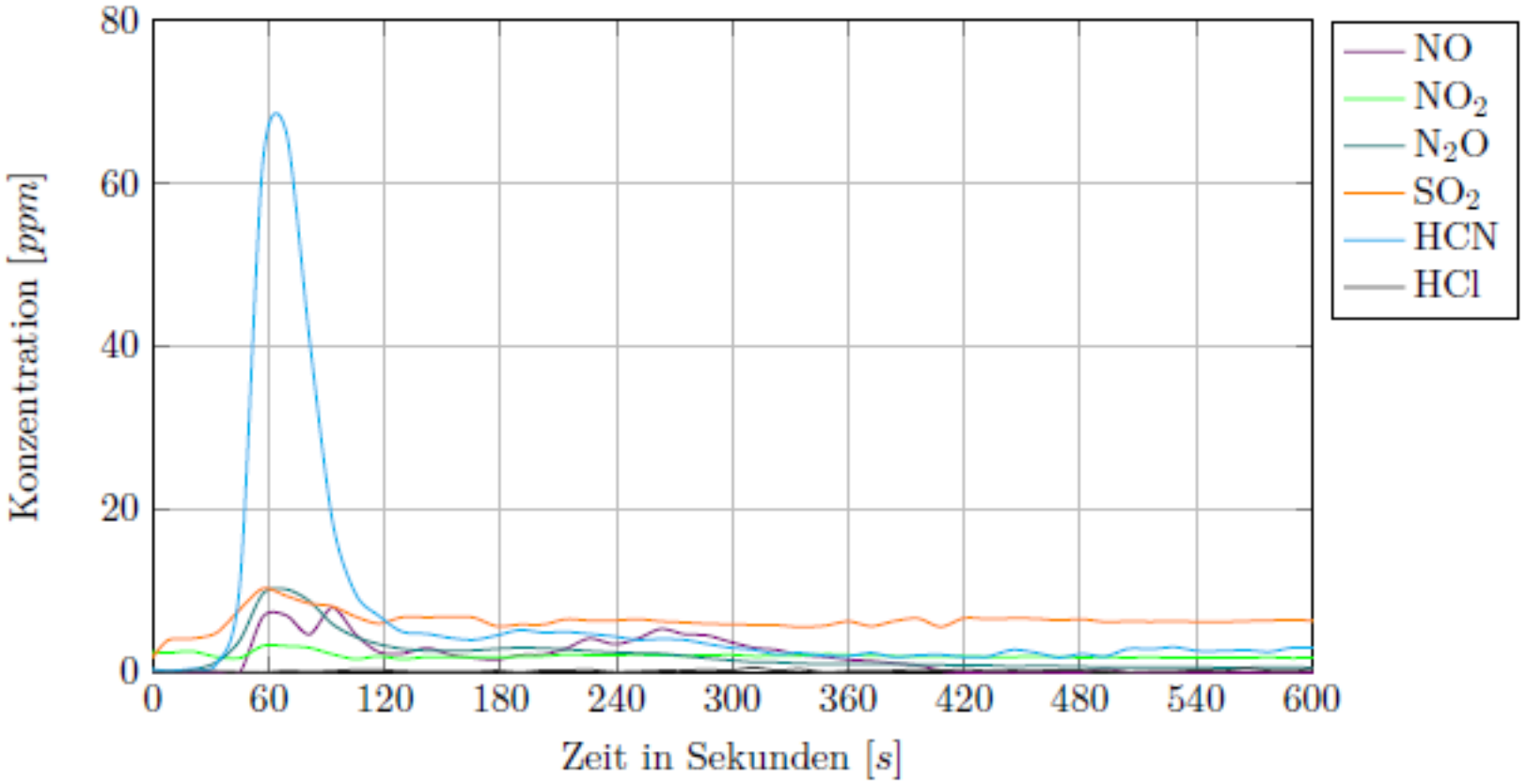
Cone Calorimeter Tests: combination of textile and green foam: CO2



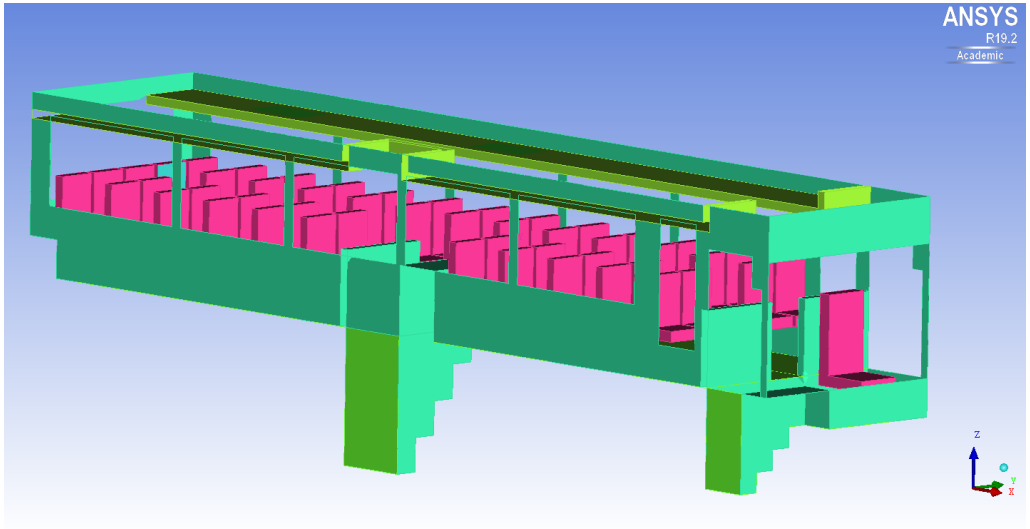
Cone Calorimeter Tests: combination of textile and green foam: CO

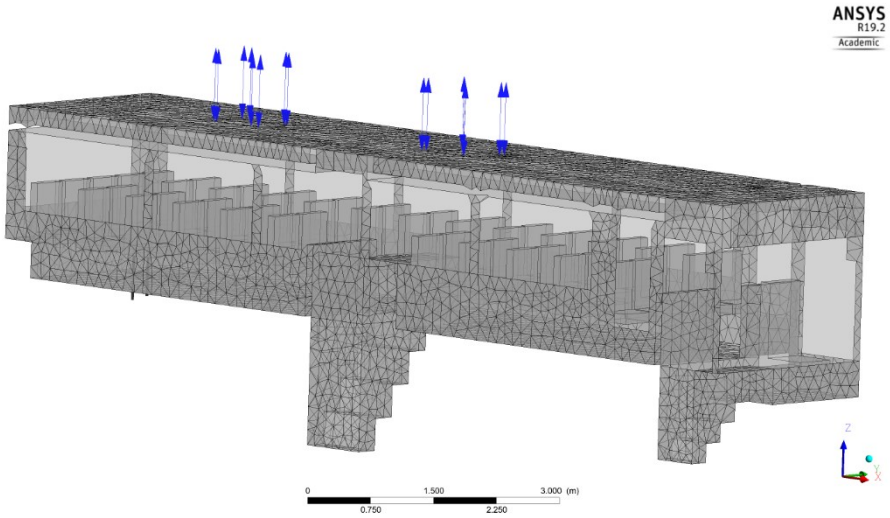


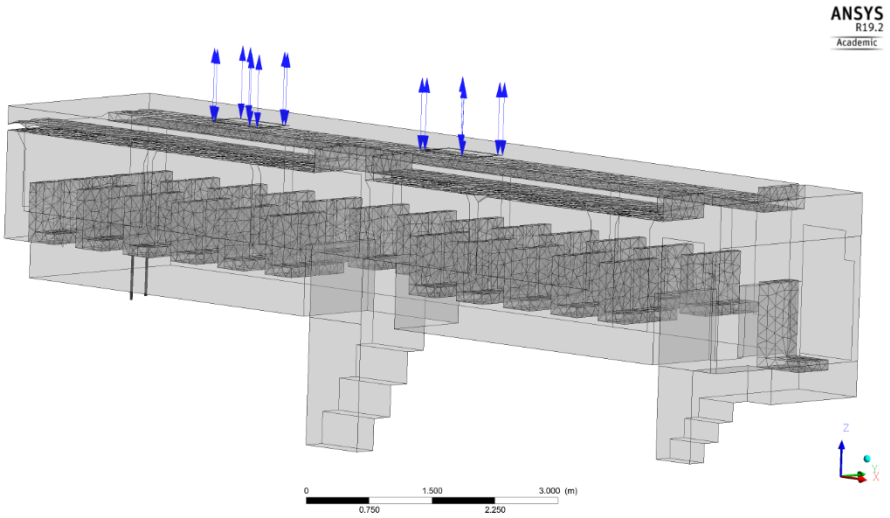
Cone Calorimeter Tests: combination of one textile and green foam



Implementation of bus cabin for numerical calculations in Ansys CFX

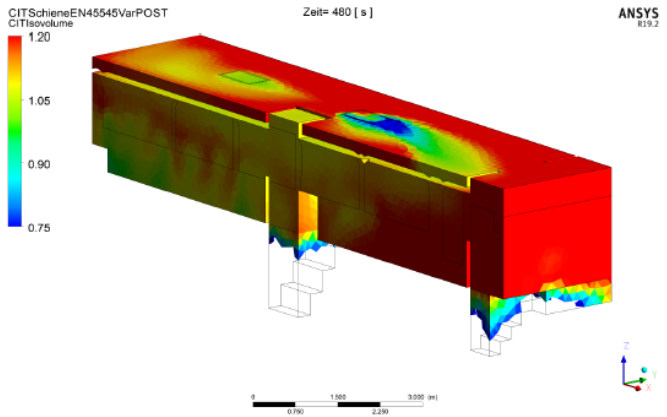




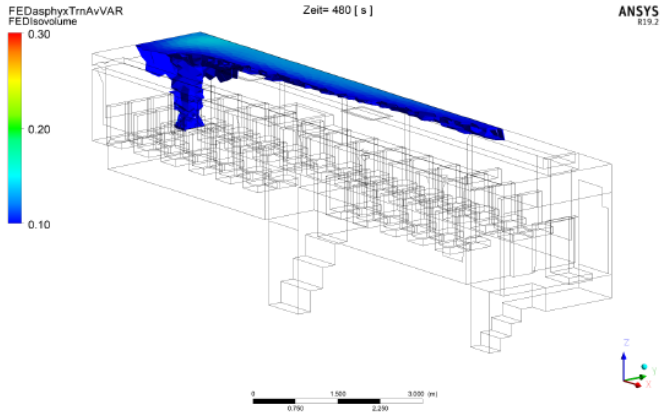


Implementation of bus cabin for numerical calculations in Ansys CFX

- graphical representation of toxicity assessment with
- Threshold values (color scale blue to red):
- CIT 0.75 to 1.2 (and above) from hazard classes in rail traffic
- FED 0.1 to 0.3 (and above) from reference values for personal safety
- CIT tends to be more conservative than FED (thresholds exceeded earlier)
- Simulation model set up and first calculations carried out
- Prediction of spatial spread of fire products for chosen scenario



$CIT,\ t = 480\,\mathrm{s}$



$FED,\ t = 480\,\mathrm{s}$

Conclusions

- Enhancement of bus requirements (vertical test)

  reduces flammability, but

  ⇒ does not reduce amount of toxic gases

  ⇒ does not reduce heat release rates, e.g. MAHRE

- Toxic smoke gas components and reduced visibility can prevent escape of passengers

- Limiting the amount and toxicity smoke gases gives time for escape of passengers in the event of fire

Thank you for your attention!