# Annex I – Some bus fires in the year 2010 in Germany

| Date | Location | | Date | Location |
|---|---|---|---|---|
| 02.01.2010 | Hofheim (Unterfranken) | | 12.04.2010 | Kirchheim |
| 03.01.2010 | Lehrte | | 05.04.2010 | Kaarst |
| 05.01.2010 | Solingen | | 06.04.2010 | Fernthal |
| 06.01.2010 | Wuppertal | | 24.04.2010 | Kröv |
| 08.01.2010 | Hittfeld | | 25.04.2010 | Graßlau |
| 13.01.2010 | Kreuzau | | 28.04.2010 | Mittelberg |
| 13.01.2010 | in Engelbergtunnel | | 29.04.2010 | Göttingen |
| 13.01.2010 | Walldorf | | 02.05.2010 | Niedernhausen |
| 13.01.2010 | Hohenwarsleben | | 02.05.2010 | Wildsachsen |
| 14.01.2010 | Steinsdorf | | 05.05.2010 | Baunatal Hertingshausen |
| 15.01.2010 | Vorsfelde | | 11.05.2010 | Sessenhausen |
| 18.01.2010 | Breckenheim-Wildsachsen | | 15.05.2010 | München |
| 20.01.2010 | Zwickau | | 17.05.2010 | Großmehring |
| 25.01.2010 | Steele | | 20.05.2010 | Emskirchen |
| 25.01.2010 | Essen | | 30.05.2010 | Hartenstein |
| 27.01.2010 | Ellenberg | | 30.05.2010 | Zwickau |
| 30.01.2010 | Lechenich | | 31.05.2010 | Stroh |
| 03.02.2010 | Puhlheim | | 07.06.2010 | Nürnberg/Feucht |
| 05.02,2010 | Weingarten | | 07.06.2010 | Bad Kreuznach |
| 11.02.2010 | Mariaweiler | | 14.06.2010 | Ettlis |
| 12.02.2010 | Alfter | | 23.06.2010 | Nersingen |
| 12.02.2010 | Schlangen | | 30.06.2010 | Plauen |
| 16.02.2010 | Neukirchen | | 17.07.2010 | Alsdorf |
| 17.02.2010 | Hamburg | | 24.07.2010 | Berlin |
| 18.02.2010 | Ingolstadt | | 27.07.2010 | Alsdorf |
| 27.02.2010 | Lichtenhagen | | 22.07.2010 | Hamburg |
| 27.02.2010 | Schwarzenbach | | 29.07.2010 | Wertheim |
| 27.02.2010 | Berlin | | 31.07.2010 | Berkhof |
| 05.03.2010 | Bad Kissingen | | 08.08.2010 | Diemelstadt |
| 06.03.2010 | Bad Kissingen | | 15.08.2010 | Pinggau |
| 08.03.2010 | Wilhelmsdorf | | 14.08.2010 | Laarbruch |
| 10.03.2010 | Ribnitz-Damgarten | | 23.08.2010 | Berlin |
| 22.03.2010 | Seelhorst | | 24.08.2010 | Rambin |
| 25.03.2010 | Haselhoff | | 31.08.2010 | Halbemond |
| 25.03.2010 | Lauf | | 29.09.2010 | Eltville |
| 31.03.2010 | München | | 18.10.2010 | Berlin |
| 01.04.2010 | Neustadt | | 09.11.2010 | Gusterath |
| 01.04.2010 | Frankfurt | | 16.11.2010 | Rottweil |

Some bus fires in 2010, Germany

# Annex II – Product list of the EN 45545-2

| Product No. | Name | Description | Requirement | Remark |
|---|---|---|---|---|
| ***IN*** | ***Interiors*** | | | |
| IN1 | Interior components – horizontal downward facing surface; horizontal upwards facing; surfaces within cavities, walls – vertical surfaces | Interior components (structure and coverings) such as ceiling panelling as also flaps, boxes, hoods, louvers, insulation material and the body shell in this area. Interior components (structure and covering) such as side walls, front walls / end-walls, partitions, room dividers, as also flaps, boxes, hoods, louvers, in this area, interior doors, interior lining of the front- /end-wall doors and external doors, luggage compartment, windows (plastics, glazing with foils) also body shell in this area; kitchen interiors surfaces (except those of kitchen equipment) | R1 | |
| IN2 | Limited surfaces | All listed products, which meet the requirements according 3.2.2 table of expression “limited surface“ (EN 45545-2) | R2 | |
| IN3 | Strips | Vertical cover strips on walls, lighting diffuser, light covering, covering for lamps (lamps itself and signal lamps are not within the scope) | R3 | |
| IN4 | Luggage storage areas | Overhead luggage racks, vertical luggage racks, luggage containers and luggage compartments | R1 | |
| IN5 | Driver’s desk | Panelling and surfaces of the driver’s desk | R1 | |
| IN6A | Interior surfaces of gangways<br>Type A | Interior side of gangway membrane (bellow), interior lining of the gangway, (except flooring of the gangway) if there is no fire barrier at both bulk-head sides of the gangway | R1 | |
| IN6B | Interior surfaces of gangways<br>Type B | Interior side of gangway membrane (bellow), interior lining of the gangway, (except flooring of the gangway), if there is a fire barrier at both bulk-head sides of the gangway | R6 | |
| IN7 | Window frame | Window frame | R1 | |
| IN8 | Curtains and sunblind in passenger and staff areas, staff compartments | Curtains and sunblind except where enclosed within a double glazed window | R1 | |
| IN10A | Tables, folding tables top, including toilette wash basins | Upward surface of the tables or toilet wash basins and surrounds | R2 | |
| IN10B | Tables, folding tables downward facing surface | Bottom surface of a table, the exposed vertical sides of drop down tables or any surface of a folding table that may become a bottom surface | R1 | |
| IN11 | Container | Outer surface of water container, air container | R2 | |
| IN12 | Interior surface of air ducts | Which are connected to the interior of the vehicle | R1 | |

| | | | | |
|---|---|---|---|---|
| IN13 | Exterior surface of air ducts | Which are interior installed to the vehicle | R1 | |
| IN14 | Air filter materials | Air filter materials for equipment ventilation heating and air conditioning | R4 | |
| IN15 | Devices for passenger info | Devices for passenger info | R1 | |
| IN16 | Floor composite | Includes the floor substrate, insulation and floor covering in end use condition | R9 | |
| ***EX*** | ***Exterior located*** | | | |
| EX1a | External body shell, walls | Vertical parts of external structure of body shell and door leafs (including paint/coating systems, films) | R6 | |
| EX1b | External cab housing | Front of the train until cab partition (including paint/coating systems, films) | R16 | |
| EX2 | External body shell, roof | External roof structure of the car body (including paint/coating systems, films) | R7 | Respect of R6 is considered complying R7 |
| EX3 | External body shell, underframe | External surfaces of underframe structure of the body shell (floor) including paint and coating systems (thermal, design and acoustic coating) and protective floor panelling | R6 | |
| EX4 | Exterior ducts | Exterior surface and interior surface of ducts which are not connected to the interior of the vehicle | R6 | |
| EX5 | External design features | External design features (e.g. streamlining parts, ventilation grills, flaps, skirts, coverings for HVAC systems, enclosures, etc.) | R6 | |
| EX6A | Container | Outer surface of water container, air container placed in the underframe | R6 | |
| EX6B | Container | Outer surface of water container, air container placed on the roof | R7 | Respect of R6 is considered complying R7 |
| EX7 | Outer membrane of intercommunication gangway's | | R6 | |
| EX8 | Bogie parts, structural | Bogie frames; spring leaf guide | R6 | |
| EX9 | Air bags for pneumatic suspension | Air bags for pneumatic suspension | R8 | |
| EX11 | Parts of the drive | Wheel sets, brake disc | R8 | |
| EX12 | Tyres | | R8 | |
| ***F*** | ***Furniture*** | | | |
| F1 | Complete passenger seat | Complete passenger seat including arm and head rests, separate pillows, tip up seats and driver seat accessible to the passenger | R17 | Extent of Vandalisation see Annex A and Annex B |
| F1A | Upholstery for passenger seats and head rest | Upholstery for seats and head rest | R20 | See Annex D |
| F1B | Armrest passenger seats – Upwards facing surface | Armrest – Surface on which the arm rests | R21 | See Annex D |

| | | | | |
|---|---|---|---|---|
| F1C | Armrest passenger seats – Vertical surface | Armrest – Inside surface (or outside surface on transverse seating) which is against the body of the seat occupant | R22 | Fire integrity 5.2.1.2 |
| F1D | Armrest passenger seats – Downwards facing surface | Armrest – Underside surface of the arm rest | R22 | Fire integrity 5.2.1.2 |
| F1E | Back shell; base shell of passenger seats | Back shell; base shell of passenger seats | R5 | Fire integrity 5.2.1.2 |
| F2 | Seats in staff areas | Tested as an assembled product from upholstery, back and base shall side | R18 | |
| F3 | Mattresses | Mattresses | R20 | See Annex D |
| F5 | Bed clothes for couchettes and beds (blanket, duvets, pillows, sleeping bags and sheets) | Bed clothes for couchettes and beds (blanket, duvets, pillows) | R19 | |
| F7B | Underside surface of couchettes and beds | Underside surface of couchettes and beds | R1 | Fire integrity 5.2.1.2 |
| ***E*** | ***Electronical Equipment*** | | | |
| E1A | Cables for interior | | R14 | |
| E1B | Cables for interior | | R15 | |
| E2A | Cable containment (linear product) for interior | Cable containment surface related (cable duct, cable conduit) | Different | See 5.3.4 |
| E2B | Cable containment (linear product) for exterior | Cable containment surface related (cable duct, cable conduit) | Different | See 5.3.4 |
| E3 | Enclosures | Enclosure for electrical equipment | R1 | |
| E4A | Arc resistant insulation materials Type A | Arc resistant insulation material; Arc barrier type A (See definition Part 5) | R10 | |
| E4B | Arc resistant insulation materials Type B | Arc resistant insulation material; Arc barrier type B (See definition Part 5) | R11 | |
| E4C | Arc splash barrier materials | Arc splash barrier (See definition Part 5) | R6 | |
| E5 | Flammable insulation liquid | Flammable insulation liquid | R13 | |
| E6 | Supply line system devices exterior | Surge arrester; isolators; switches; main circuit breakers | R24 | |
| E7A | Supply line system and high power devices Supposed as interior | Isolators; current and voltage transformers, main circuit breakers; contactors | R23 | |
| E7B | Supply line system and high power devices Supposed as exterior | Isolators; current and voltage transformers, main circuit breakers; contactors | R24 | |
| E8A | Choke and coils Supposed as interior | Chokes for supply line filtering, coils for air cooled transformers, including spacers and air guiding plates | R23 | |
| E8B | Choke and coils Supposed as exterior | Chokes for supply line filtering, coils for air cooled transformers, including spacers and air guiding plates and traction motor winding insulation | R24 | |

| | | | | |
|---|---|---|---|---|
| E9 | Brake resistors | Casing and any heat shields | R12 | |
| ***M*** | ***Mechanical Equipment*** | | | |
| M1 | Flexible metal/rubber units | Flexible metal/rubber units including elements in bogies | R8 | |

# Annex III – Material requirement list of the EN 45545-2

| Short name of requirement set (used for) | Test method reference | Parameter Unit | Requirement Definition | HL1 | HL2 | HL3 |
|---|---|---|---|---|---|---|
| R1 (IN1; IN 4; IN 5; IN6A; IN7; IN8; IN10B; IN12; IN13; IN15; F7B; E3; E2A 4.4.1; 5.3.4) | T02 ISO 5658-2 | CFE $kWm^{-2}$ | Minimum | 20[a] | 20[a] | 20[a] |
| | T03.01 ISO 5660-1: 50 $kWm^{-2}$ | MARHE $kWm^{-2}$ | Maximum | Not limited[a] | 90 | 60 |
| | T10.01 EN ISO 5659-2: 50 $kWm^{-2}$ | $D_s(4)$ dimensionless | Maximum | 600 | 300 | 150 |
| | T10.02 EN ISO 5659-2: 50 $kWm^{-2}$ | VOF4 min | Maximum | 1200 | 600 | 300 |
| | T11.01 EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$ dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R2 (IN2; IN10A; IN 11) | T02 ISO 5658-2 | CFE $kWm^{-2}$ | Minimum | 13[a] | 13[a] | 13[a] |
| | T03.01 ISO 5660-1: 50 $kWm^{-2}$ | MARHE $kWm^{-2}$ | Maximum | Not limited[a] | Not limited[a] | 90 |
| | T10.01 EN ISO 5659-2: 50 $kWm^{-2}$ | $D_s(4)$ dimensionless | Maximum | 600 | 300 | 150 |
| | T10.02 EN ISO 5659-2: 50 $kWm^{-2}$ | VOF4 min | Maximum | 1200 | 600 | 300 |
| | T11.01 EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$ dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R3 (IN3) | T02 ISO 5658-2 | CFE $kWm^{-2}$ | Minimum | 13[a] | 13[a] | 13[a] |
| | T03.01 ISO 5660-1: 50 $kWm^{-2}$ | MARHE $kWm^{-2}$ | Maximum | Not limited[a] | Not limited[a] | Not limited[a] |
| | T10.01 EN ISO 5659-2: 50 $kWm^{-2}$ | $D_s(4)$ dimensionless | Maximum | 600 | 480 | 240 |
| | T10.02 EN ISO 5659-2: 50 $kWm^{-2}$ | VOF4 min | Maximum | 1200 | 960 | 480 |
| | T11.01 EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$ dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R4 (IN14) | T05 EN ISO 11925-2 30 s flame application | Flame spread mm | Maximum | 150 (within 60 s) | 150 (within 60 s) | 150 (within 60 s) |
| | T03.02 ISO 5660-1: 25 $kWm^{-2}$ | MARHE $kWm^{-2}$ | Maximum | 50 | 50 | 50 |
| | T10.03 EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max. dimensionless | Maximum | 600 | 300 | 150 |
| | T11.02 EN ISO 5659-2: 25 $kWm^{-2}$ | $CIT_G$ dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R5 (E2A -5.3.4; F1E) | T03.01 ISO 5660-1: 50 $kWm^{-2}$ | MARHE $kWm^{-2}$ | Maximum | 90 | 90 | 60 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | T10.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $D_s(4)$<br>dimensionless | Maximum | 600 | 300 | 150 |
| | T10.02<br>EN ISO 5659-2: 50 $kWm^{-2}$ | VOF4<br>min | Maximum | 1200 | 600 | 300 |
| | T11.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R6 (IN6B; EX 1a EX3; EX4; EX5; EX6A; EX7; EX8; E2B 5.3.4; E4C 4.4.1) | T02<br>ISO 5658-2 | CFE<br>$kWm^{-2}$ | Minimum | 20[a] | 20[a] | 20[a] |
| | T03.01<br>ISO 5660-1: 50 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | Not limited[a] | 90 | 60 |
| | T10.04<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | Not limited | 600 | 300 |
| | T11.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | Not limited | 1,8 | 1,5 |
| R7 (EX2; EX6B) | T04<br>EN ISO 9239-1 | CHF<br>$kWm^{-2}$ | Minimum | 4,5 | 6 | 8 |
| | T03.02<br>ISO 5660-1: 25 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | Not limited | 50 | 50 |
| | T10.03<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | Not limited | 600 | 300 |
| | T11.02<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | Not limited | 1,8 | 1,5 |
| R8 (EX9; EX11; EX12; M1; E2B 5.3.4) | T03.01<br>ISO 5660-1: 50 kWm-2 | MARHE<br>$kWm^{-2}$ | Maximum | 90 | 90 | 90 |
| | T10.04<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | Not limited | 600 | 300 |
| | T11.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | Not limited | 1,8 | 1,5 |
| R9 (IN16) | T04<br>EN ISO 9239-1 | CHF<br>$kWm^{-2}$ | Minimum | 4,5 | 6 | 8 |
| | T03.02<br>ISO 5660-1: 25 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | Not limited | 50 | 50 |
| | T10.03<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | 600 | 300 | 150 |
| | T11.02<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R10 (E4A) | T02<br>ISO 5658-2 | CFE<br>$kWm^{-2}$ | Minimum | 30[a] | 30[a] | 30[a] |
| | T03.01<br>ISO 5660-1: 50 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | 60 | 60 | 60 |
| | T10.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | Ds(4)<br>dimensionless | Maximum | 600 | 300 | 150 |
| | T10.02<br>EN ISO 5659-2: 50 $kWm^{-2}$ | VOF4<br>min | Maximum | 1200 | 600 | 300 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | T11.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R11 (E4B) | T02<br>ISO 5658-2 | CFE<br>$kWm^{-2}$ | Minimum | 40[a] | 40[a] | 40[a] |
| | T03.01<br>ISO 5660-1: 50 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | 60 | 60 | 60 |
| | T10.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | Ds(4)<br>dimensionless | Maximum | 600 | 300 | 150 |
| | T10.02<br>EN ISO 5659-2: 50 $kWm^{-2}$ | VOF4<br>min | Maximum | 1200 | 600 | 300 |
| | T11.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R12 (E9) | T14<br>EN 13501-1 | Euroclass | Minimum | A1 | A1 | A1 |
| R13 (E5) | IEC/TS 60695-1-40 | Class K<br>Fire point °C | Minimum | 300 | 300 | 300 |
| R14 (E1A) | T09.1<br>EN 60332-1-2 | Unburned length<br>mm | Minimum | Burned part ≤ 540 and unburned part 50 | Burned part ≤ 540 and unburned part 50 | Burned part ≤ 540 and unburned part 50 |
| | T09.2<br>EN 50266-2-4 | m | Maximum | 2,5 | 2,5 | 2,5 |
| | T09.3<br>EN 50305:2002, 9.1.1 | m | Maximum | 2,5 | 2,5 | 2,5 |
| | T09.4<br>EN 50305:2002, 9.1.2 | m | Maximum | 1,5 | 1,5 | 1,5 |
| | T13<br>EN 61034-2 | Transmission<br>% | Minimum | 25 | 50 | 70 |
| | T12<br>NF X 70-100-1 and -2 600 °C | $CIT_C$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R15 (E1B) | T09.1<br>EN 60332-1-2 | Unburned length<br>mm | Minimum | Burned part ≤ 540 and unburned part 50 | Burned part ≤ 540 and unburned part 50 | Burned part ≤ 540 and unburned part 50 |
| | T09.2<br>EN 50266-2-4 | m | Maximum | 2,5 | 2,5 | 2,5 |
| | T09.3<br>EN 50305:2002, 9.1.1 | m | Maximum | 2,5 | 2,5 | 2,5 |
| | T09.4<br>EN 50305:2002, 9.1.2 | m | Maximum | 1,5 | 1,5 | 1,5 |
| | T13<br>EN 61034-2 | Transmission<br>% | Minimum | Not limited | 25 | 50 |
| | T12<br>NF X 70-100-1 and -2 600 °C | $CIT_C$<br>dimensionless | Maximum | Not limited | 1,8 | 1,5 |
| R16 (E2B, 5.3.4; EX1b, 5.3.1.2 Cavity surfaces) | T02<br>ISO 5658-2 | CFE<br>$kWm^{-2}$ | Minimum | 13[a] | 13[a] | 13[a] |
| | T03.01<br>ISO 5660-1: 50 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | Not limited[a] | 90 | 60 |
| | T10.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | Ds(4)<br>dimensionless | Maximum | Not limited | 600 | 300 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | T11.01<br>EN ISO 5659-2: 50 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | Not limited | 1,8 | 1,5 |
| R17 (F1) | T06<br>ISO 9705 | MARHE<br>KW | Maximum | 75 | 50 | 20 |
| R18 (F2) | T03.02<br>ISO 5660-1: 25 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | 75 | 50 | 20 |
| R19 (F5) | T07<br>EN ISO 12952-3/-4 | After burning time s | Maximum | 10 | 10 | 10 |
| | T03.02<br>ISO 5660-1: 25 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | 50 | 50 | 50 |
| | T10.03<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | 200 | 200 | 200 |
| | T11.02<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | 0,75 | 0,75 | 0,75 |
| R20 (F1A; F3) | T03.02<br>ISO 5660-1: 25 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | 75 | 50 | 50 |
| | T10.03<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | 300 | 300 | 200 |
| | T11.02<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R21 (F1B) | T03.02<br>ISO 5660-1: 25 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | 75 | 50 | 50 |
| R22 (F1C; F1D) | T03.02<br>ISO 5660-1: 25 $kWm^{-2}$ | MARHE<br>$kWm^{-2}$ | Maximum | 75 | 50 | 50 |
| | T10.03<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | 300 | 300 | 200 |
| | T11.02<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $CIT_G$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R23 (E7A, E8A, 4.4.1; 5.3.4) | T01 EN ISO 4589-2: OI | Oxygen content % | Minimum | 28 | 28 | 32 |
| | T10.03<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | 600 | 300 | 150 |
| | T12<br>NF X 70-100-1 and -2 600 °C | $CIT_{NLP}$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R24 (E6; E7B; E2B, 5.3.4; E8B, 4.4.1) | T01 EN ISO 4589-2: OI | Oxygen content % | Minimum | 28 | 28 | 32 |
| | T10.03<br>EN ISO 5659-2: 25 $kWm^{-2}$ | $D_s$max.<br>dimensionless | Maximum | 600 | 300 | 150 |
| | T12<br>NF X 70-100-1 and -2 600 °C | $CIT_{NLP}$<br>dimensionless | Maximum | 1,2 | 0,9 | 0,75 |
| R25 ( E2B, 4.3.4; 4.4.2 and 4.4.3) | T01 EN ISO 4589-2: OI | Oxygen content % | Minimum | 28 | 28 | 32 |

[a] If flaming droplets/particles are reported according 6.3.6 during the test ISO 5658-2, or for the special case of materials which do not ignite in ISO 5658-2 and are additionally reported as unclassifiable, the following additional tests shall be added:

— MARHE value for HL1,2,3 is 90 kw/m²;

— test according test method EN 11925-2 with the request 30 s flame application no spread > 150 mm within 60 s and shall not have burning droplets/particles.

# Annex IV – Measured gas concentrations in smoke

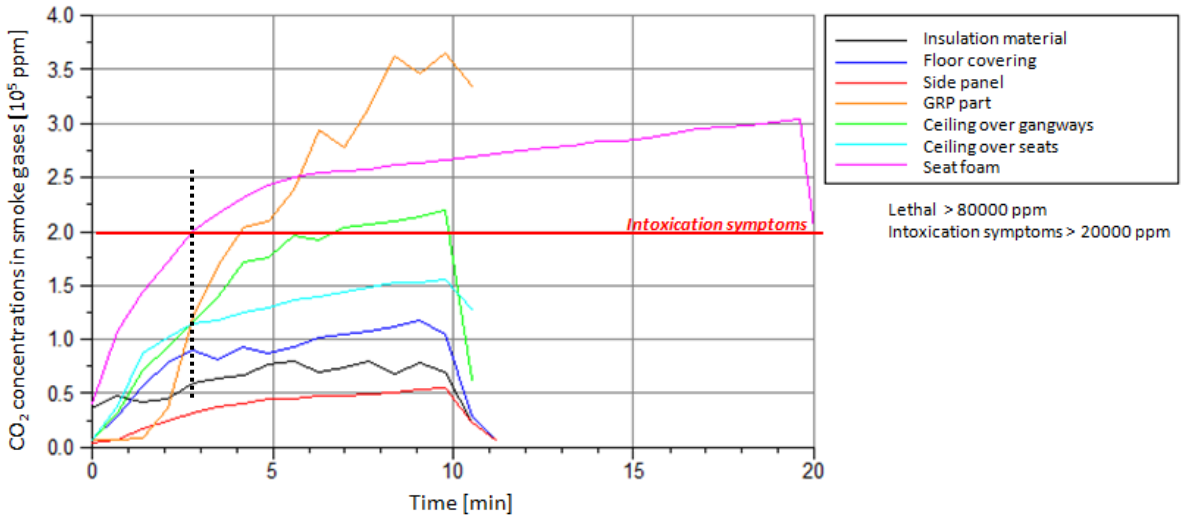


Figure 60 – Concentrations of $CO_2$ in smoke gases

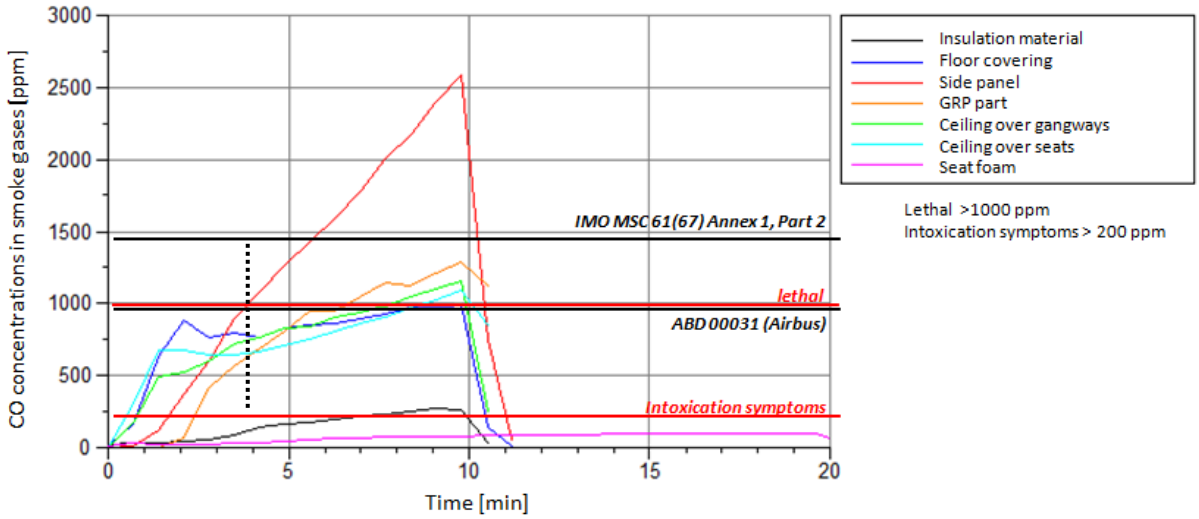


Figure 61 – Concentrations of CO in smoke gases

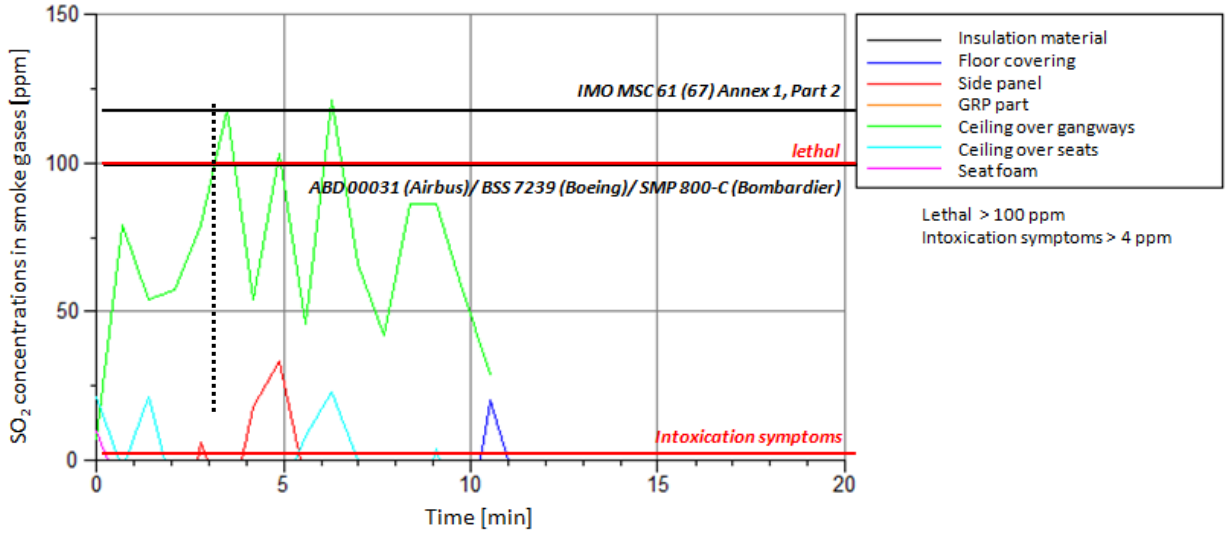


Figure 62 – Concentrations of $SO_2$ in smoke gases

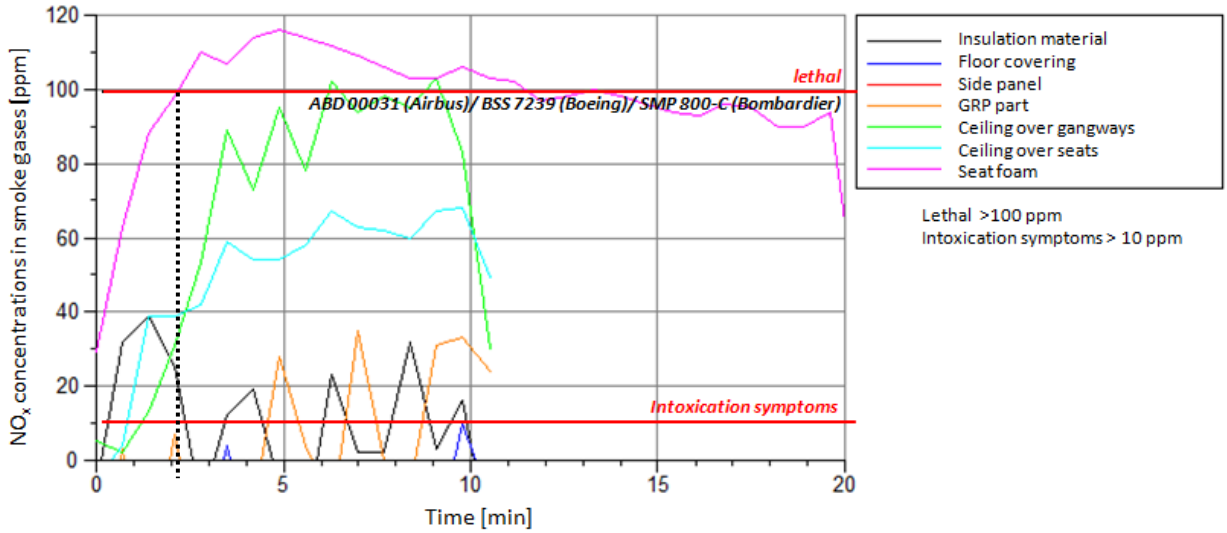


Figure 63 – Concentrations of $NO_x$ in smoke gases

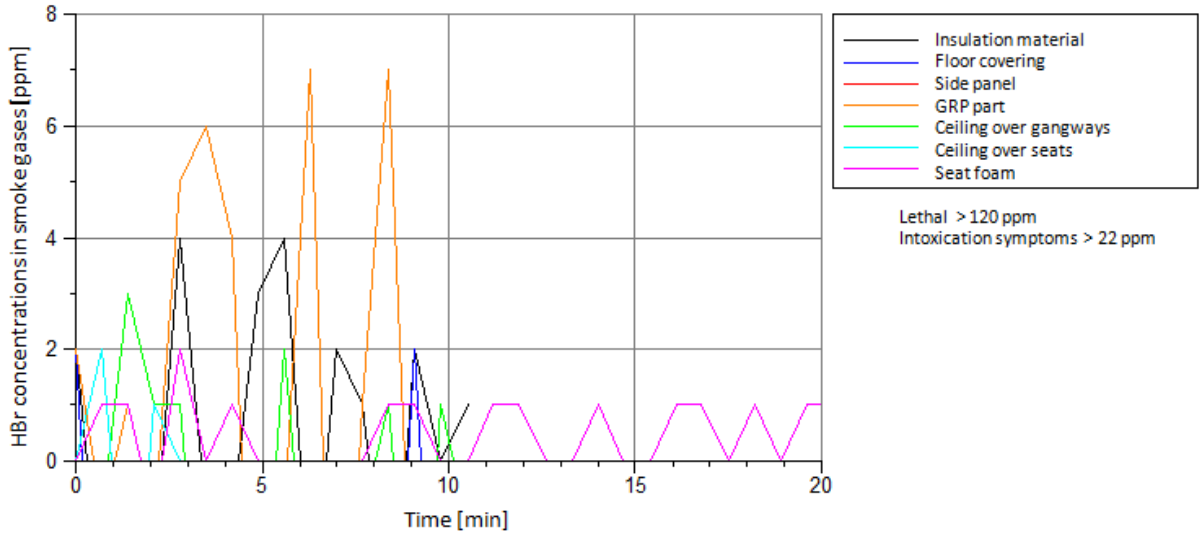


Figure 64 – Concentrations of HBr in smoke gases

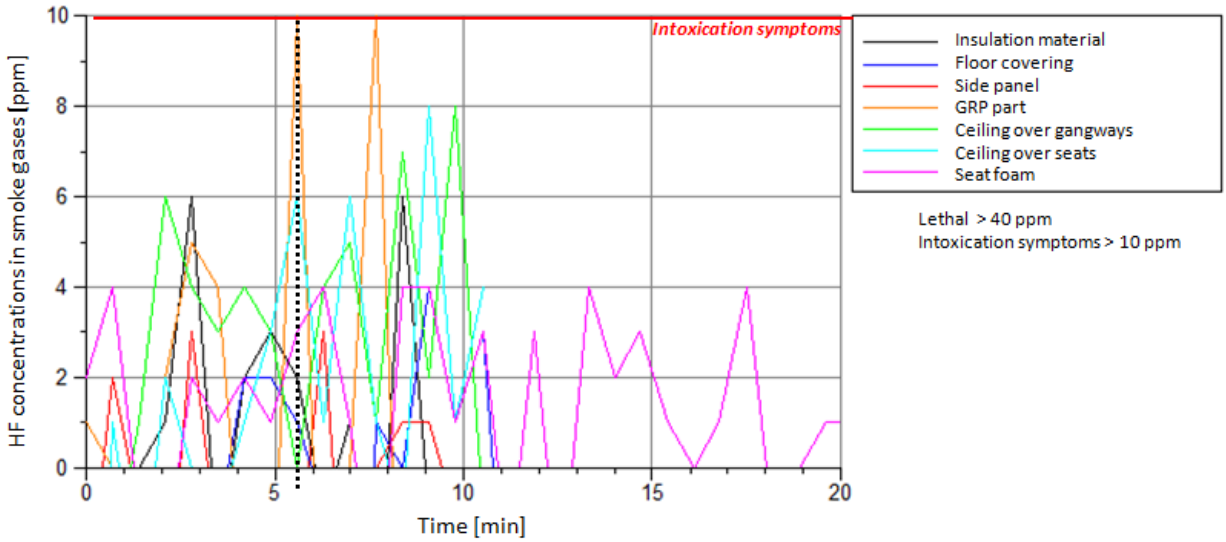


Figure 65 – Concentrations of HF in smoke gases

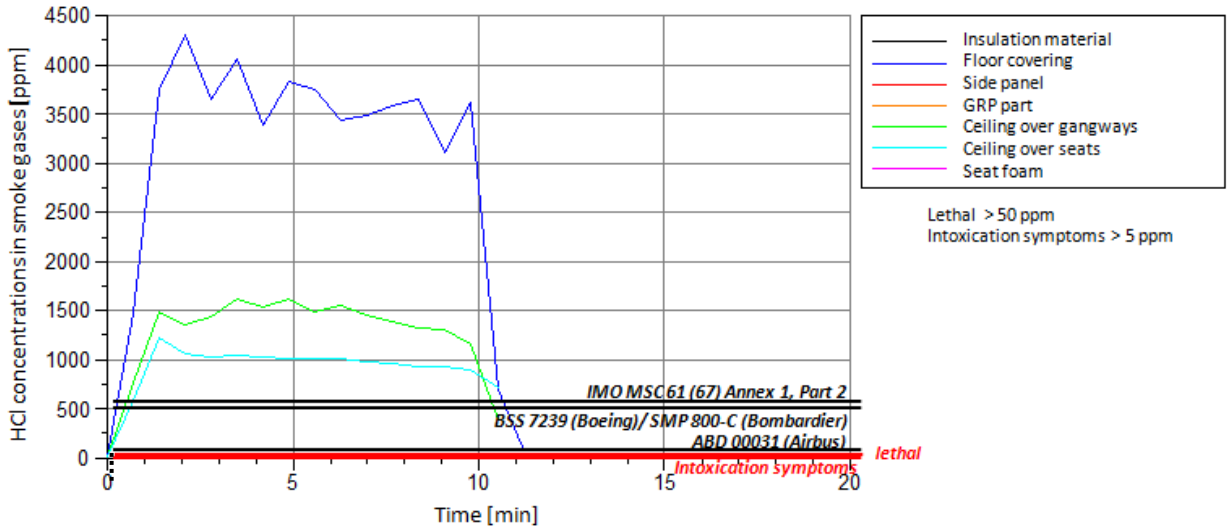


Figure 66 – Concentrations of HCl in smoke gases

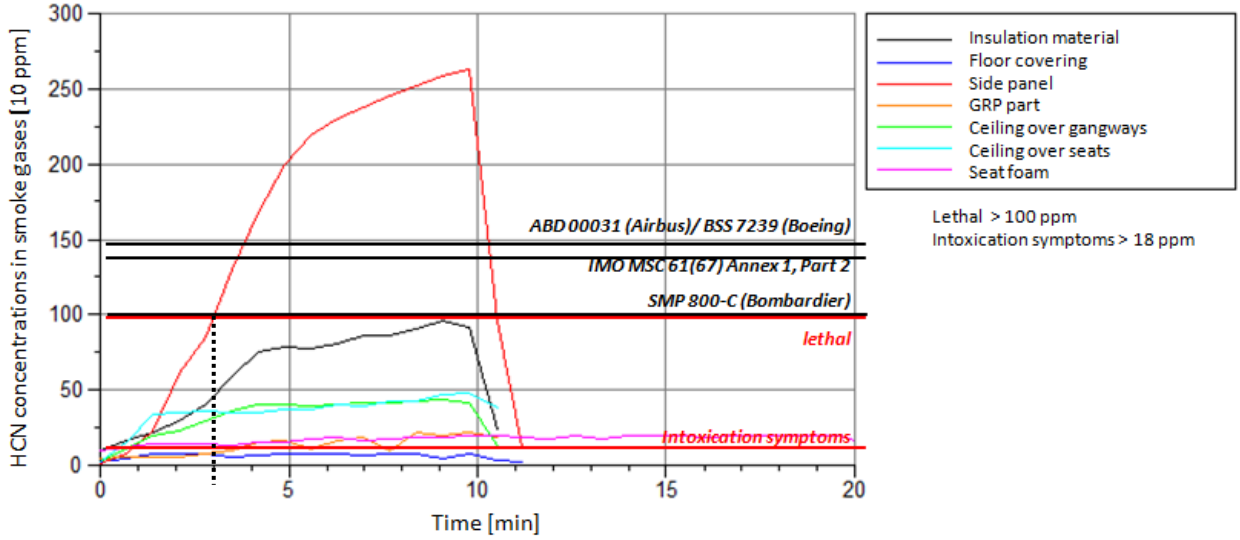


Figure 67 – Concentrations of HCN in smoke gases

# Annex V – List of publications

## Workshops

Hofmann, A., Dülsen, S. (2010): *Bus fire workshop*, expert meeting at BAM on behalf of BASt, 29.6.2011, Berlin

## Presentations

Gail, J.(Speaker), Dülsen, S., Hofmann, A (2013): *Fire Safety of Buses - Research Action for Improving Vehicle Regulations*, presentation at the "ESV 2013 - 23rd International Technical Conference on the Enhanced Safety of Vehicles" conference, 27. May 2013, Seoul

Hofmann, A.(Speaker), Dülsen, S., Klippel, A. (2013): *Bus Fire Safety – Recent Developments, Problems and Possible Solutions*, presentation at the "Fire and Materials", 28.-30. January 2013, San Francisco

Hofmann, A., Dülsen, S.(Speaker) (2012): *Fire safety of coaches and urban buses – experimental and numerical investigations and possible enhancements*, presentation at the "Fire Resistance in Plastics" conference, 27.-29. November 2012, Cologne

Hofmann, A., Dülsen, S.(Speaker) (2012): *Fire safety performance of buses*, presentation at the "2nd International conference on FIVE – Fires in Vehicles" conference, 27.-28. September 2012, Chicago

Hofmann, A.(Speaker), Dülsen, S. (2012): *Fires in Busses – Problems and possible enhancements*, presentation at the "Trends in Fire Safety and Innovative Flame Retardants for Plastics" conference from SKZ, 23.-24. May 2012, Würzburg

Dülsen, S.(Speaker) (2011): *Realbrandversuche an einem Nahverkehrsbus,* presentation at the Doctoral Student's Day from the Chair of Process Design and Safety (Prof. Ulrich Krause), 9. December 2011, Institute of Process Equipment and Environmental Engineering, Otto-von-Guericke-University, Magdeburg

Hofmann, A. (Speaker), Dülsen, S. (2010): *Aktueller Stand des Busbrandprojektes*, guest lecture at the -special comittee motor buses (FKT-SoA-KOM), 29. September 2011, Berlin

Dülsen, S.(Speaker), Hofmann, A., Krause, U. (2011): *Untersuchung zu Brandursachen und Brandverlauf bei Busbränden,* presentation at the „Vfdb Jahresfachtagung 2011", 30. May - 1. June 2011, Berlin

Hofmann, A.(Speaker) (2010): *Bus fire safety – experimental and numerical investigations*, presentation at the SKZ specialist conference: Trends im Brandschutz und innovative Flammschutzmittel bei Kunststoffen, 24.-25.November 2010, Würzburg

Hofmann, A.(Speaker), Krüger. S., Dülsen S. (2010): *Large scale experiment of a car fire and comparison with numerical investigations*, presentation at the "1st International Conference on FIVE – Fires in Vehicles" conference, 29.-30. September 2010, Gothenburg

Dülsen, S.(Speaker), Hofmann, A., Krause, U. (2010): *Entwicklung, Ausbreitung und Toxizität von Rauch bei Busbränden,* presentation at the workshop „Brandschutzforschung" of the vfdb within the „Magdeburger Brand- und Explosionsschutztag" conference, 4./5. October 2010, Magdeburg

Hofmann, A.(Speaker), Krüger, S., Klippel, A. (2010): *Experimental and numerical investigations of the burning behavior of vehicle materials: Small, intermediate and large scale investigations*, presentation at the "Interflam 2010" conference, 5.-7. July 2010, ISBN 978-0-9556548-7-9

## Articles

Gail, J., Dülsen, S., Hofmann, A (2013): *Fire Safety of Buses - Research Action for Improving Vehicle Regulations*, proceedings of the "ESV 2013 - 23rd International Technical Conference on the Enhanced Safety of Vehicles", 27.-May 2013, Seoul

Hofmann, A., Dülsen, S., Klippel, A. (2013): *Bus Fire Safety – Recent Developments, Problems and Possible Solutions*, proceedings of the "Fire and Materials" conference, 28.-30. September 2013, San Francisco

Hofmann, A., Dülsen, S. (2012): *Fire safety of coaches and urban buses – experimental and numerical investigations and possible enhancements*, presentation at the “Fire Resistance in Plastics” conference, 27.-29. November 2012, Cologne

Hofmann, A., Dülsen, S. (2012): *Fire safety performance of buses*, proceedings of the “2nd International conference on FIVE – Fires in Vehicles” conference, 27.-28. September 2012, Chicago

Hofmann, A., Dülsen, S. (2012): *Gefahren bei Busbränden und Empfehlungen zur Verbesserung der Sicherheit*, article in the magazine „Technische Sicherheit“ from the 2. September 2012, p. 33-40, ISSN 2191-0073

Hofmann, A., Dülsen, S. (2012): *Fires in Busses – Problems and possible enhancements*, proceedings of the “Trends in Fire Safety and Innovative Flame Retardants for Plastics” conference from SKZ, 23.-24. May 2012, Würzburg

Dülsen, S., Hofmann, A., Krause, U. (2011): *Brandschutzanforderungen an die Materialien von Kraftomnibussen - Signifikante Zunahme von brennbaren Kunststoffteilen stellt eine Gefahr dar*, article in number 7 of the magazine „Brandschutz“, 2011, p. 524-527, ISSN 0006-9094

Dülsen, S., Hofmann, A., Krause, U. (2011): *Untersuchung zu Brandursachen und Brandverlauf bei Busbränden,* proccedings of the „Vfdb Jahresfachtagung 2011“, 30. May - 1. June 2011, Berlin

Hofmann, A.(2010): *Bus fire safety – experimental and numerical investigations*, proceedings of the SKZ specialist conference: Trends im Brandschutz und innovative Flammschutzmittel bei Kunststoffen, 24.-25.November 2010, Würzburg

Hofmann, A., Krüger. S., Dülsen S. (2010): *Large scale experiment of a car fire and comparison with numerical investigations*, proceedings of the “1st International Conference on FIVE – Fires in Vehicles” conference, 29.-30. September 2010, Gothenburg

Hofmann, A., Krüger, S., Klippel, A. (2010): *Experimental and numerical investigations of the burning behavior of vehicle materials: Small, intermediate and large scale investigations*, proceedings of the “Interflam 2010” conference, 5.-7. July 2010, ISBN 978-0-9556548-7-9

## Research supporting companies

Berliner Verkehrsbetriebe (BVG)

Dafo-Deutschland GmbH

Firedect GmbH

Fogmaker International AB

HEKATRON Vertriebs GmbH

Kidde Technologies, Inc.

SP Technical Research Institute of Sweden (SP)

## Student research projects and theses

Gude, Nicolas (2011): *Experimentelle und numerische Untersuchung des Einflusses unterschiedlicher Materialien auf den Brandverlauf in Autobussen*, thesis, Chair of Fluid Dynamics (Prof. Christian Oliver Paschereit), Institute of Fluid Dynamics and Technical Acoustics, TU Berlin

Gude, Nicolas (2010): *Experimentelle und numerische Untersuchung von Fahrzeugbränden*, student research project, Chair of Fluid Dynamics (Prof. Christian Oliver Paschereit), Institute of Fluid Dynamics and Technical Acoustics, TU Berlin

Klippel, Alexander (2009): *Untersuchung von Bränden in Bussen*, student research project, Chair of Fluid Dynamics (Prof. Christian Oliver Paschereit), Institute of Fluid Dynamics and Technical Acoustics, TU Berlin

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**VII.39 Working group Fire scenarios and chemical analysis of fire products**

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