

Final results of project BRAFA

Full scale fire tests of Battery Electric Vehicles in Tunnels

Ao.Univ.-Prof. Dipl.-Ing. Dr.techn. **Peter Sturm**

Graz University of Technology, Institute of Internal Combustion Engines and Thermodynamics, Graz, AT, sturm@ivt.tugraz.at

Dipl.-Ing. **Patrik Fößleitner**, BSc

Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH, Graz, AT, foessleitner@ivt.tugraz.at

Overview

- **Duration 2019 – 2021**
- **Funding**



 Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology



- **Five project partners**



- **Test site „Zentrum am Berg“**

www.zab.at

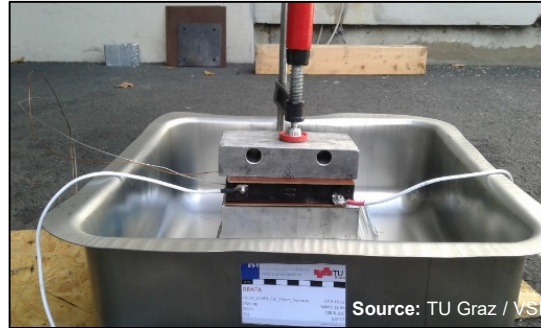


Motivation

- Increased share of battery-electric-vehicles (BEV) on roads
- Little knowledge about characteristics, released heat and smoke/gases from BEV-fires
- Little experience concerning fire extinguishing techniques
- No information how the risk for tunnel users changes with the increasing possibility of incidents with BEV

Experiments

- Single battery cells
- Battery modules
- Battery packs
- Vehicles

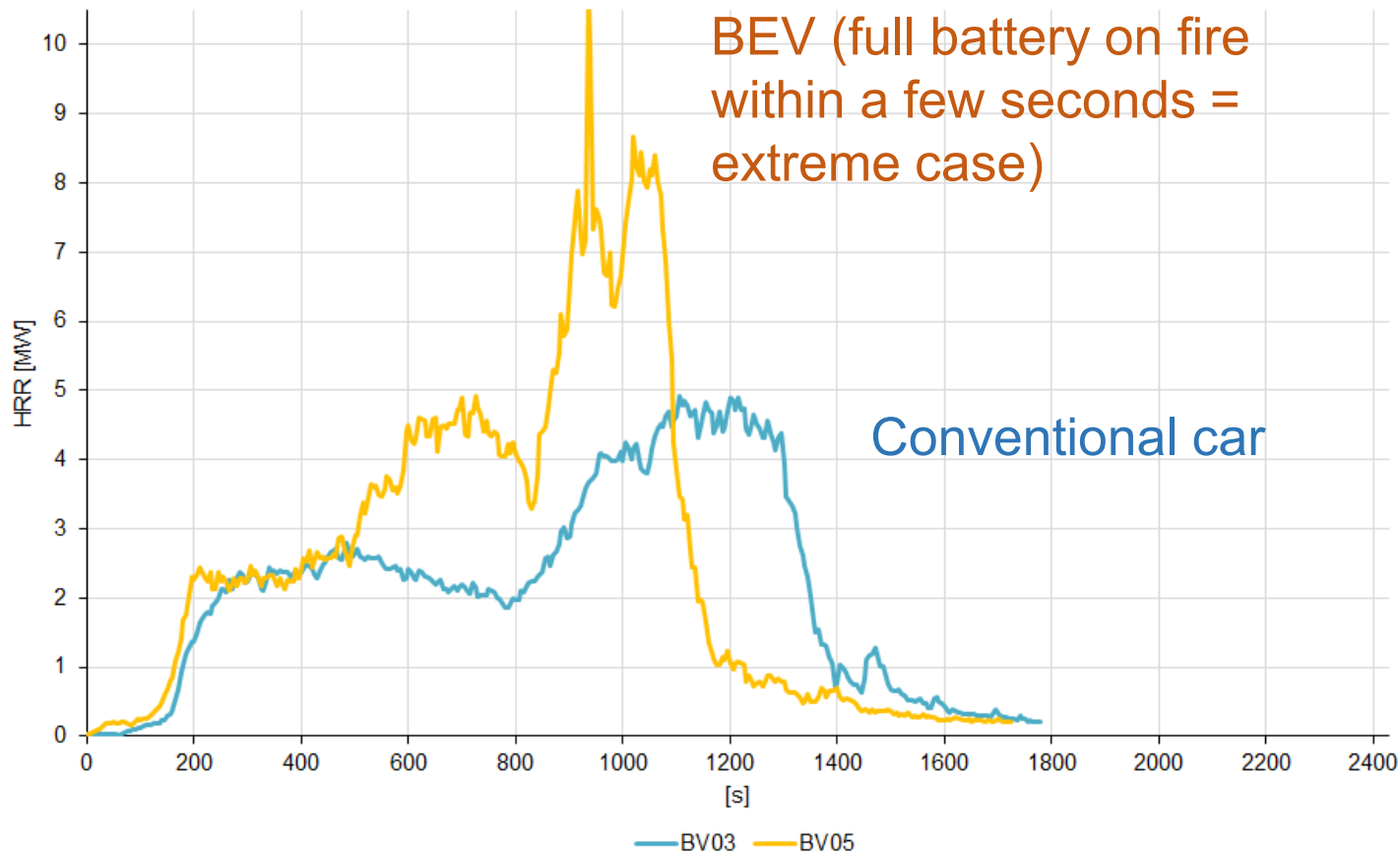


Experiments - Vehicles

No	Car type	Drive type	Ignition	Note
BV01	BEV compact car (2020)	ca. 80 kWh, NMC	Starting from battery: triggering a short circuit in the battery by flooding with NaCl_{aq}	Use of fire blanket
BV02	BEV utility vehicle (2016)	24 kWh, LMO	Starting from battery: External heat supply with gas burners	
BV03	ICEV SUV (2020)	Diesel	Starting from interior	
BV04	ICEV utility vehicle (2010)	Diesel	Starting from engine compartment	
BV05	BEV SUV (2020)	ca. 80 kWh, NMC	Starting from interior After 10 minutes: triggering a short circuit in the battery by flooding with NaCl_{aq}	Use of extinguishing nozzle

Note: NMC = nickel manganese cobalt; LMO = lithium ion manganese oxide

Results - Heat Release Rate



Results – Acid gases

№	SO ₂ [mg/Nm ³]			H ₃ PO ₄ [mg/Nm ³]			HCl [mg/Nm ³]			HF [mg/Nm ³]		
	6,4m	4,8m	1,6m	6,4m	4,8m	1,6m	6,4m	4,8m	1,6m	6,4m	4,8m	1,6m
Height	6,4m	4,8m	1,6m	6,4m	4,8m	1,6m	6,4m	4,8m	1,6m	6,4m	4,8m	1,6m
BV01 (BEV)	2,8	14,3	1,5	2,5	1,3	0,3	61,8	31,0	4,4	38,4	10,3	13,5
BV02 (ICE)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BV03 (BEV)	0,9	3,0	0,5	0,1	0,1	0,1	61,2	32,1	0,9	8,3	3,2	0,7
BV04 (ICE)	n/a	3,7	n/a	n/a	n/a	n/a	n/a	6,3	n/a	n/a	*	n/a
BV05 (BEV)	0,5	9,3	0,7	n/a	n/a	n/a	18,8	35,0	2,6	17,3	20,1	5,3
IDLH-30	286			1092			81			27		

Note: n/a = not analysed, * = value less than detection limit

Fire fighting

Fire blanket

- difficult to handle
- Battery supports fire by ,own‘ oxygen
- not successfully tested



Fire lance

- effective, as it brings water directly into the battery casing
- difficult to handle, needs special training



Conclusions

- Tests performed for
 - Battery cells, modules, packs
 - Vehicles (3 BEV, 2 ICEV)
- Comparison of BEV:
 - **HRR**: average HRR as ICEV, peak HRR higher
 - **Acid gases**: HF increased values
HCl similar to ICEV
- Extinguishing techniques:
 - **Fire blanket**: no successful application
 - **Extinguishing lance**: effective, but difficult to use
 - **Water (standard approach)**: currently still the standard recommended method for fire fighting

Acknowledgements

- **Institute of Internal Combustion Engines and Thermodynamics, Graz University of Technology, AT** <https://ivt.tugraz.at>
Peter Sturm, Daniel Fruhwirt, Philip Leonhardt, Thomas Nöst
- **Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH, AT** <https://www.fvt.at>
Patrik Fößleitner, Andrea Schirmer
- **Vehicle Safety Institute, TU Graz, AT** <https://www.tugraz.at/institute/vsi>
Simon Heindl, Alexander Hödl
- **Chair of Subsurface Engineering, MU Leoben, AT** <https://www.unileoben.ac.at>
Robert Galler, Bernhard Reinwald
- **ILF Consulting Engineers GmbH, AT** <https://www.ilf.com>
Oliver Heger, Bernhard Kohl
- **Austrian Firebrigade Association, AT** <https://www.bundesfeuerwehrverband.at>
Stefan Krausbar
- Special thanks to Dr. Reinhard Ellinger (**Laboratorium für Umweltanalytik GmbH, AT**) for chemical analysis of the experiments. <http://www.lua.co.at>



Thank you
for your attention

Documents: <https://www.ivt.tugraz.at/en/research/areas/vuu/examples-of-projects/brafa-en.html>

<https://projekte.ffg.at/projekt/3290205>

