ALBERO – WP4.3 Detection Development
GTE GmbH, Dr. J. Kelleter, 6th January, 2020, corrected 20th January, 2020

Detection of critical conditions at electrical vehicles

Subject:
charging of APV, detection variables gas emission and surface temperature

Measurements on 3 selected full-electric vehicles during charging at "normal state".“

Location:
FKFS, Stuttgart
16th December, 2019 and 17th December, 2019

Participants:
GTE GmbH, Dr. Kelleter
FKFS, Hr. Armbruster, Dr. Philipp (temporarily)

1 Vehicles and Charging Technology used

vehicle	charging technology	active battery cooling	notes
Mercedes B-Class (B250E)	„AC“, 10,6 kW	yes, continuous cooling water flow	nach 95 Minuten hat die 16 A Sicherung (Gebäudeseitig) ausgelöst
Citroen C-Zero	„AC“, 3,3 KW	yes, only for the charging electronics. cooling water flow intermittently, approx. 20 sec on, approx. 60 sec off.	The battery is air-cooled and can be actively flowed through; only active during DC fast charging.
Nissan Leaf E+	„DC“, 50 kW	no	Charging power after 40 min, already reduced to below 30 kW

2 Measurement technology used

temperature curve vehicle underbody:
IR sensor HTPA32x32 (Heimann Sensor GmbH) 1000 pixels,
temperature resolution 1K

gas emission:
gas sensor UST6xxx (Umweltsensortechnik)

both sensor types are integrated into GTE's own sensor platform and provide measurement data via GTE's own data bus (similar to M-Bus)

and additionally: thermal image handheld thermal camera FLIR E8

3 Measurement Results

Surface Temperatures

During normal charging processes, a slight increase in the battery surface temperature occurs in both vehicles. Both vehicles are actively cooled with circulating coolant. The third vehicle considered (Nissan Leaf e+) has no discernible liquid cooling; nevertheless, no significant temperature increase of the battery was observed either.

Gas Emission

During normal charging processes, no significant H_2 emission occurs in the immediate vicinity of the vehicle. Measurement limit: 0.1 ppm H_2

Summary regarding Detection

A detection technology based on the combination "temperature rise on battery surface" AND "H_2 gas emission" does not normally detect any H_2 due to the charging process and a increase of temperature, depending on the vehicle type, of a few K. If triggering thresholds of e.g. 1 ppm H_2 rise AND 10 K temperature rise (underbody), undesired triggering is not to be expected for the vehicle models considered.

4 Supplementary Notes

Locking

Follow the procedure of locking the charging cable:
- plugging the charging adapter into the socket of the vehicle.
- the vehicle locks the plug, it can no longer be pulled out as long as the vehicle is not unlocked.
- end of charging (because battery is full), the plug remains locked.
- opening of the doors, the plug is unlocked.

This means that if a vehicle is to be moved (e.g. towed), it has to be first be opened with the key. If the cable is also permanently mounted on the charging pole (not via a plug-in system), the vehicle is "chained" for the duration. For safety reasons, it is essential to avoid tearing off the cable.

Charging Power

AC-charging:
The charging power is determined by the charging system installed inside the vehicle. If the battery is empty and cool, charging can be performed at maximum power. Depending on the charging infrastructure used (household socket, CCE 16A, CCE 32A, wallbox and charging cable), the maximum possible power must be communicated to the vehicle. For this purpose, either a resistor coding (mode 2) or a PWM signal or communication between charging pole and vehicle (mode 3) can be used. If this power code does not match the real available power, the fuse of the charging point will respond (if available). There are adapters that can be used to manually set the power (sometimes without checking for consistency). In the further course of the charging process, the power drawn decreases, the complete charging process can thus be extended by many hours.

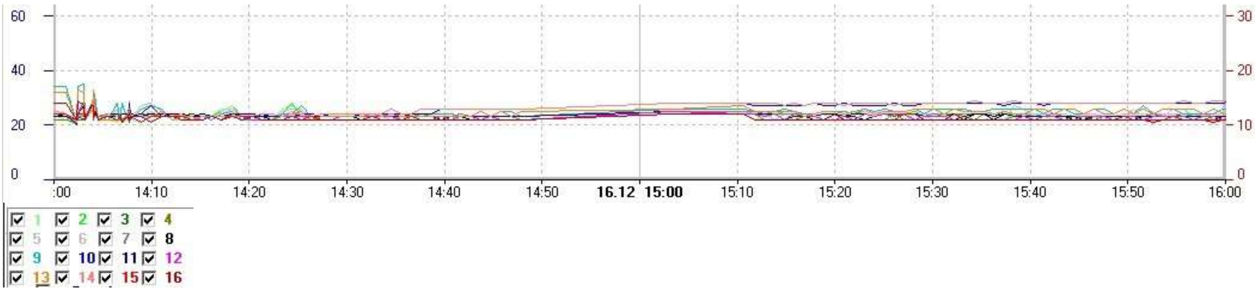
DC-charging:
In DC charging, the charging power is controlled by the rectifier of the charging station. This requires extended communication between the charging station and the vehicle (mode 4). The vehicle must continuously inform the charging station about the maximum possible charging power of the battery at the respective time.

Parking Position

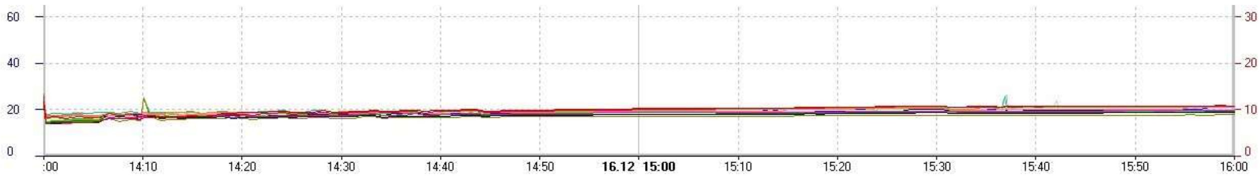
A parked electric vehicle cannot be moved with muscle power. However, only one axle (front or rear) is blocked (in the case of the vehicles considered here). If a driven wheel is lifted (rotating freely), the vehicle rolls on the remaining 3 wheels.
This behavior corresponds to that of a conventional vehicle with automatic transmission. By engaging the neutral gear (N), the vehicle can be pushed. In most cases, the ignition key is required to activate the electric release.

Appendix 1 – „B-Class“

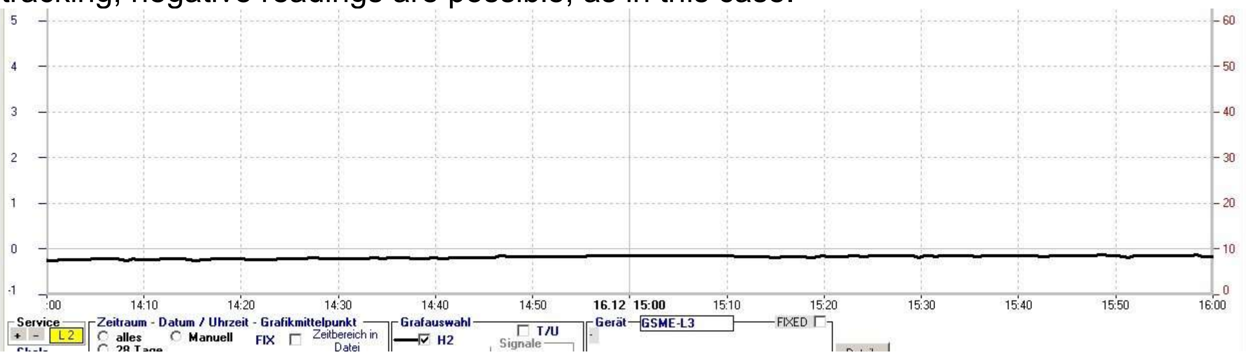
Course of average zone temperatures, view from the side on charging plug and charging adapter; Isolated peaks: people passing through. The charging adapter warms up by approx. 6K.



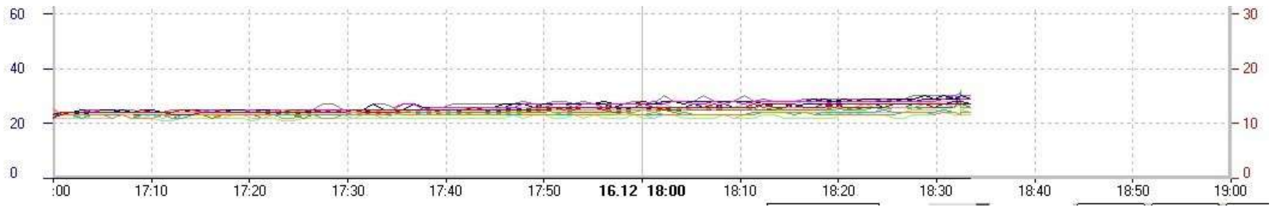
Course of average zone temperatures of the underside of the vehicle (view partly over a heat-reflecting plate); an increase of approx. 2 to 3 K can be observed.



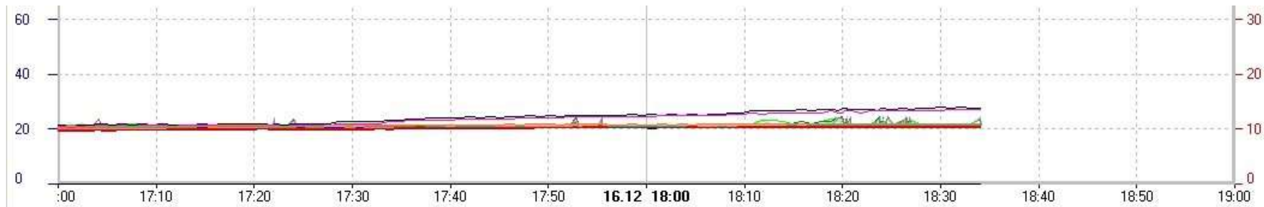
Hydrogen concentration curve recorded near the right rear wheel in the wheel arch; Fluctuations of approx. 0.1 ppm, not significant. Note: Due to sliding zero tracking, negative readings are possible, as in this case.



Appendix 2 – „Citroen C-Zero“
Course of average zone temperatures of the vehicle front (partial view into the radiator grille).
An increase of individual areas by approx. 5 K can be observed.

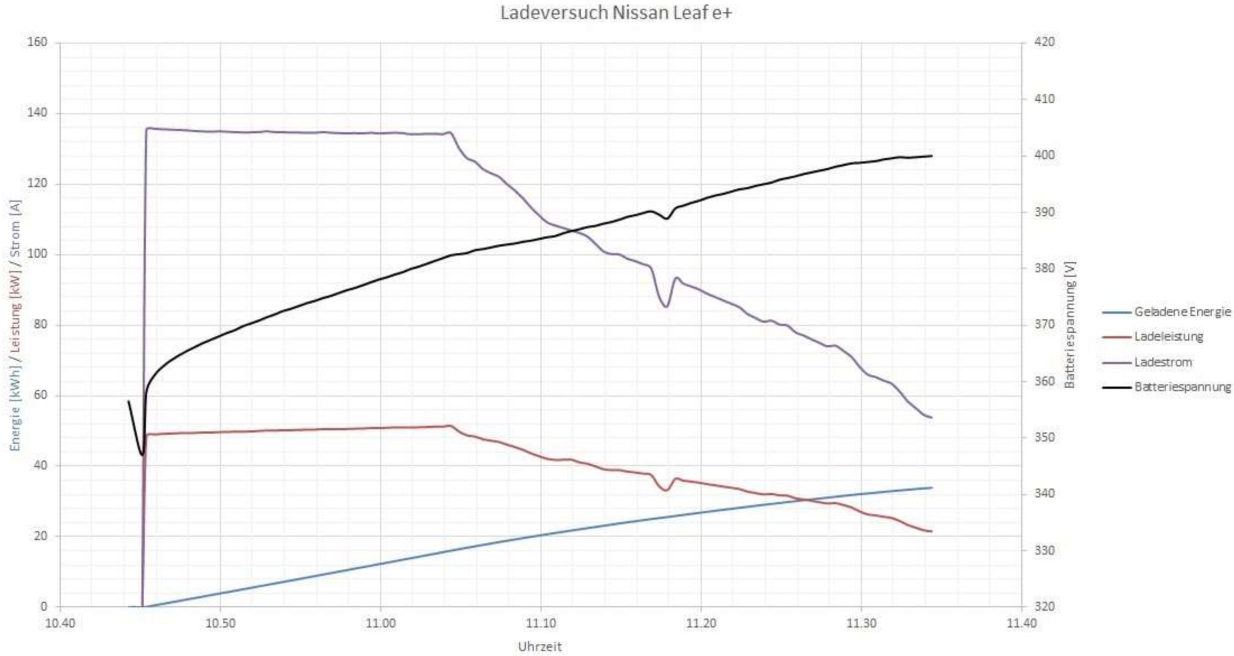


Course of average zone temperatures of the underbody of the vehicle (view partly over a heat-reflecting plate).
An increase of individual areas by approx. 7 K can be observed.



Course of hydrogen concentration recorded near the right front wheel in the fender; Fluctuations of approx. 0.1 ppm, not significant.
Note: Due to sliding zero tracking, negative readings are possible, as present here.

Appendix 3: Charging Diagram for „Nissan Leaf e+“:

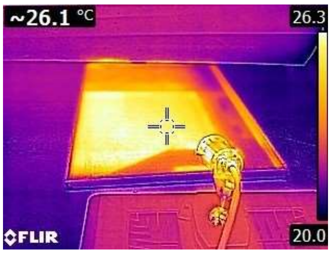


Start of the charging process at a state of charge of approx. 26%. Abort when charging power is reduced to below 20 KW(approx. 86%). Carrying outside the building in dry, cold conditions..

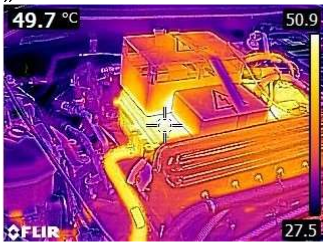
Appendix 4: (Pictures)

<u>Mercedes B-Class</u>

front cooler underbody, right without cover



„measurement" of the underbody temperature via mirroring



control electronics inside engine compartment, with water cooling

B-Class underbody

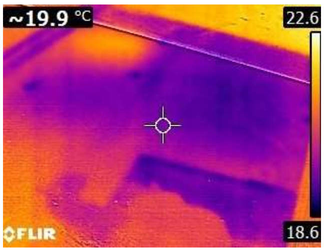
For the measurements during charging, one half of the cover has been removed:

The black anodized aluminum surface of the battery is revealed under the removed plastic cover. This is a battery from the manufacturer Tesla.

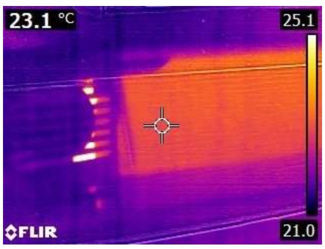
Regarding themography: the emission coefficient should be noted:

material	emission coefficent
aluminium blanc	ca. 0,1
aluminium anodized	ca. 0,55
„heat sink" aluminum black anodized	0,98
own estimation by measuring the mirrored temperature of the own hand: 28°C (real 32°, environment 20°)	ε = (28-20)/(32-20) ε = 0,6...0,7

Citroen C Zero

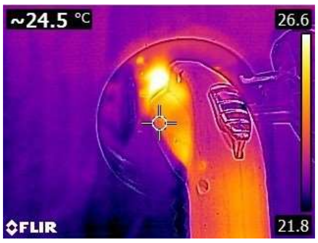


„measurement" of the underbody temperature via mirroring



radiator grillel

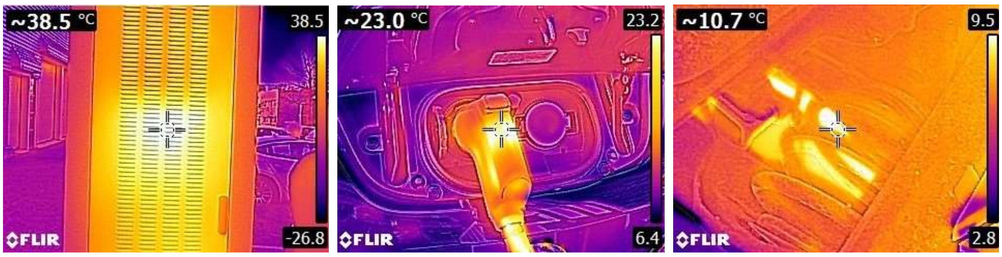
Citroen C Zero underbody



charging adapter charging plug

<u>Nissan Leaf (only) at the fast charging station</u>

thermal images:



The charging pole reaches 30 K above ambient on the exhaust side. The plug (possibly eletromagnet) reaches 13 K above ambient.
The "warmest" element inside the car (as far as directly accessible) reached 10°C (at 5°C environment) an increase of 5 K.


underbody, with plastic cover

Appendix 5: Vehicle Data Overview

vehicle	battery capacity	range	engine power	charging connectors
Mercedes B250e	28 kWh	155 km	132 kW	Typ 2
Citroen C-Zero	14,5 kWh	100 km	49 kW	Typ 1 / CHAdeMO
Nissan Leaf e+	62 kWh	385 km	160 kW	Typ 2 / CHAdeMO