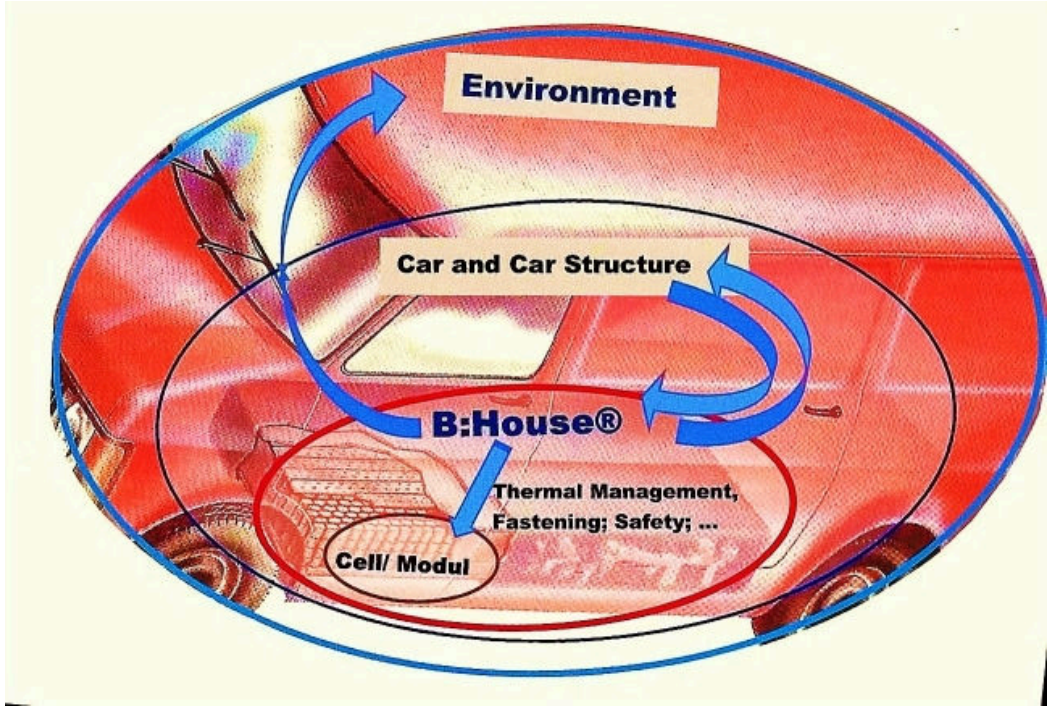
Challenge Battery-Safety



Advantages with Multifunctional Battery-Housings - B:HOUSE®

The Contents

1 Some Words regarding König Metall-GVI and TEB

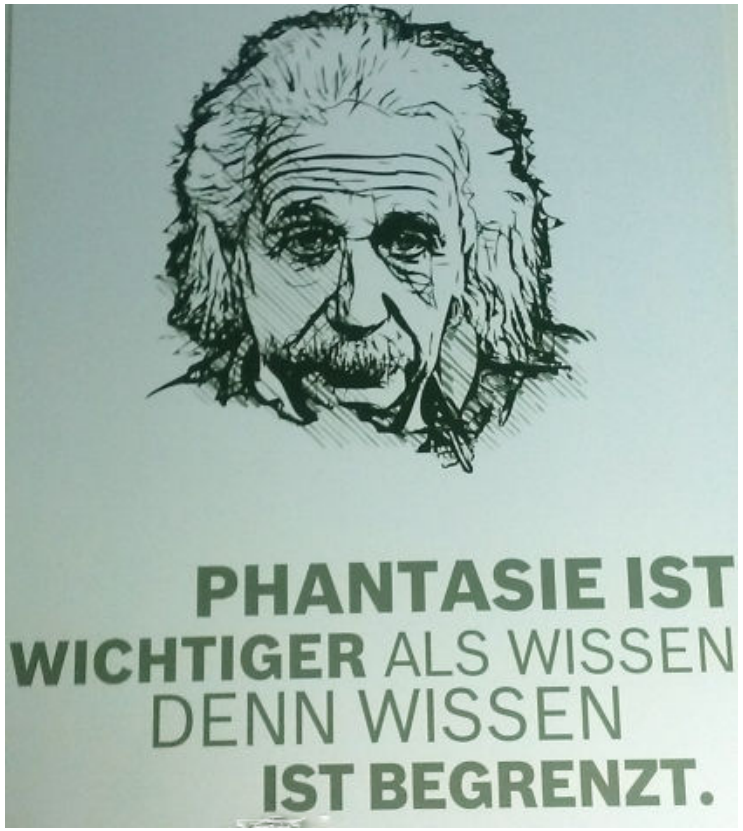
2 Functional and Safety Requirement for Lithium Batteries

3 The Influence of Temperatures

4 The GVI®-Technology

5 The B:HOUSE®-Concept

6 Perspectives

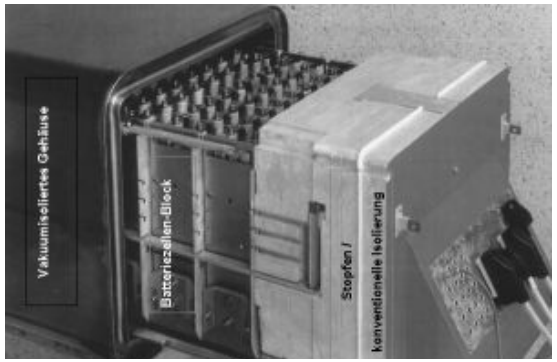


TEB (TechnologieEntwicklung & Beratung / Technology Development & Consultancy) was founded in 1985 by Dr.-Ing. Jobst Kerspe

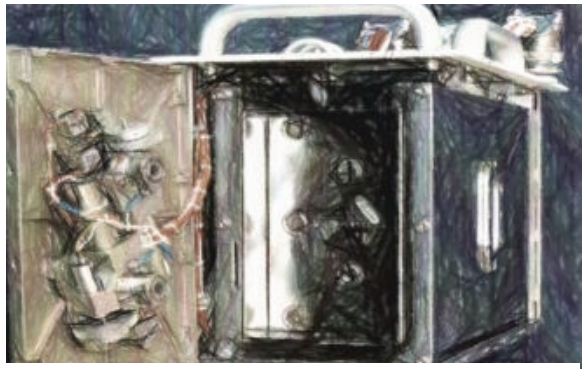
From 1981 to 1985 Dr. Kerspe was engaged in the R&D-project „Sodium-Sulphur-Battery“ of BBC/ ABB where he managed the battery shop.

TEB is focused on the development, Application and manufacturing of supported vacuum-insulations - GVI®

Different R&D-Projects together with well-known clients as well as industrial applications and a number of publications are document of state of the art of GVI®-Systems.



Early Sodium-Sulphur-Battery


Experimental Box (300°C) D2-Mission


Thermo-Jug


Big Tubes for District-Heating

More than 35 years of experience and basic know how are the input of TEB into the joint project

Some words regarding our cooperation

KÖNIG METALL TEB

Since 2013 König Metall in Gaggenau and TEB Dr. Kerspe in Mauer have bundled their competences into a joint venture, working together in the development, application and manufacturing of supported vacuum insulations (GVI®).

GVI® as well as B:HOUSE® and Kryo Safe® are registered trademarks of König Metall and TEB.
Furthermore many national and international patents are filed and held by us.

Together with other partners we are searching and working in different founded R&D-projects:

- Planßeta (High-energy Na/NiCl2-Batteries with planar ß-Aluminat): König Metall und TEB are responsible for the complete metal-works and especially the development and manufacturing of the battery- housing (funded by BMWI)
- SCORES (Self-Consumption Of Renewable Energy by hybrid Storage systems) – König Metall and TEB are responsible for design, development and manufacturing of huge heat-storage-units (EU-Project Horizon 2020)
- Member of the cluster „e-mobil BW“

Main requirements, when function and legal regulations meet the design of batteries and battery-housings:

- Active and passive thermal management to maintain the "battery feel-good temperature" as well as function and lifetime of the battery under all possible operating conditions - avoid Li-plating!
- The enclosure must provide the necessary protection against external mechanical influences (crash, vibration-proof fixation, safe removal of high battery weight forces and transmission of forces and moments in the vehicle structure)
- Protection against external fires as well as active environmental protection – which means encapsulation for every case of an accident (in some cases you will also find the trivialized description "Thermal Event").
- EMC resistance
- Space and resource-saving lightweight construction

Some battery-housings as we can see today

- Supporting platform
- Encapsulated Modules
- Hood

Materials: Aluminium, Steel and Plastics

Questions:

*** Fire-Protection??? *Crash-Protection ?**

*** Insulation/ Protection against outside temperatures?**

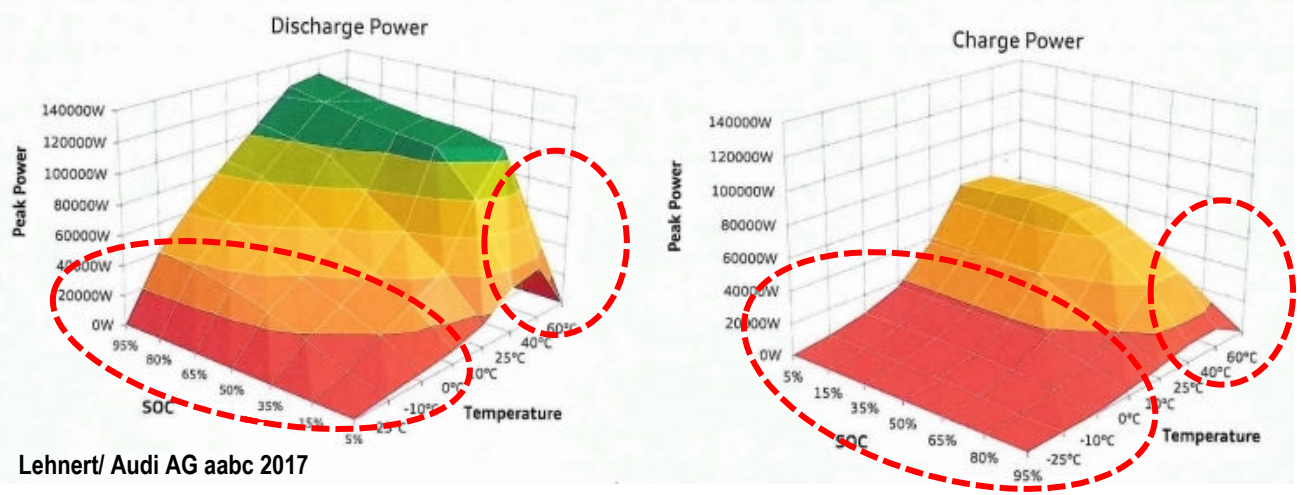
- Frame / supporting structure as part of the car-frame
- Bottom and Covering-Structure

Materials: Aluminium (??), Steel and Plastics;
Multitude of screws (weight!? EMC??)

Questions:

- **Fire-Protection???**
- **Insulation/ Protection against outside temperatures?**

The Influence of Temperatures



Lehnert/ Audi AG aabc 2017

Each chemical reaction is mainly driven by temperature: for Li-ion batteries at temperatures below 10°C capacity and charging decrease drastically – same with temperatures above 45°C

>> the battery has to be kept at "comfortable" temperatures

Another strong disadvantage is the so called "Li-Plating", as shown below.

The thermal problems do not only happen because of exothermal reaction in the cell itself - the temperatures of the environment are also influencing the temperatures inside the battery!

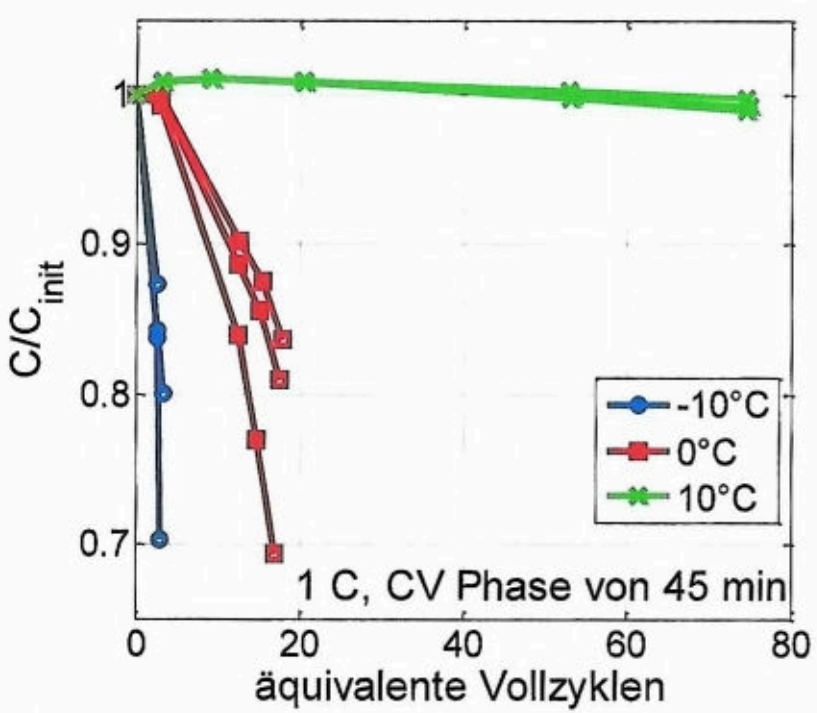
At most of the current vehicle-applications the cooling is done with an additional active cooling-system, to keep the temperatures in a good condition – but: **Active heating or cooling is realized with the help of the battery >> Reduction of the battery-capacity / reach-distance**

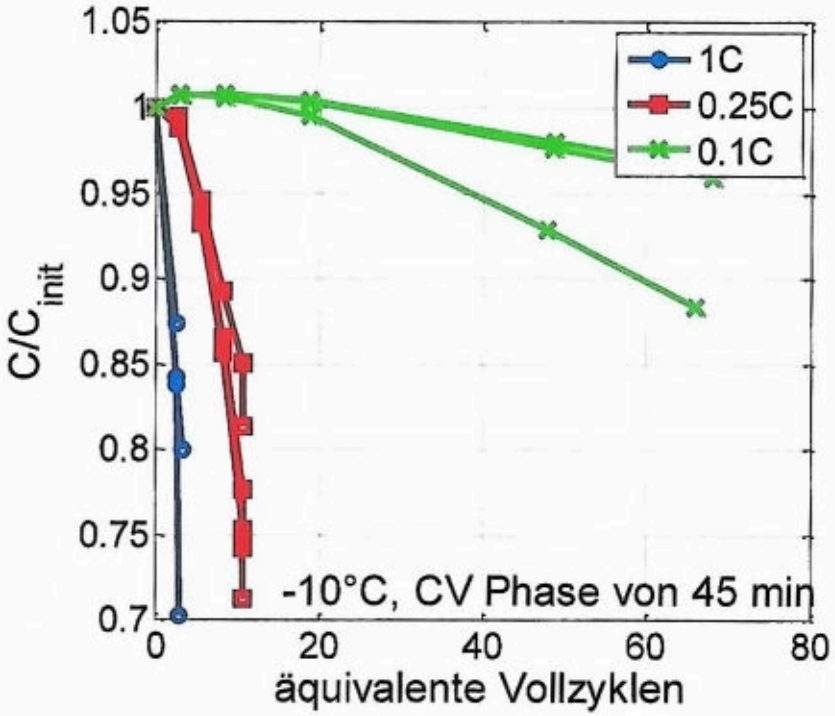
What are the alternatives?

Passive climate by the using of insulated Battery-Housings!

Influence of Temperatures – Li-Plating

Strong ageing even with low C-rates at temperatures below 0°C!!





D. U. Sauer; Battery Expert Forum; 12.04.19 Frankfurt

What to do??

Charging and discharging at "feel-good-temperature" by using GVI®

- **Usually there is no space to place a good working and efficient insulation >> Vacuum-Insulations are able to realize perfect thermal insulation with less insulation-thickness!**
- Thermos®-principle

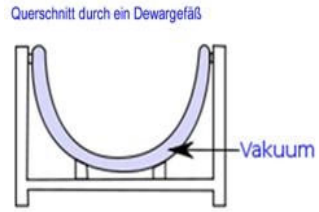
Thermos® or classical Dewar bodies aren‘t solutions for Battery-Housings, but therefore we have the so called „supported-vacuum-insulations“

- **Influence of the passive climatisation to the battery-temperature:**

  At an insulation thickness of around 10mm, we are able to keep the cell-temperature in a perfect area for hours (even at arctic cold or tropical heat), without additional energy!!!

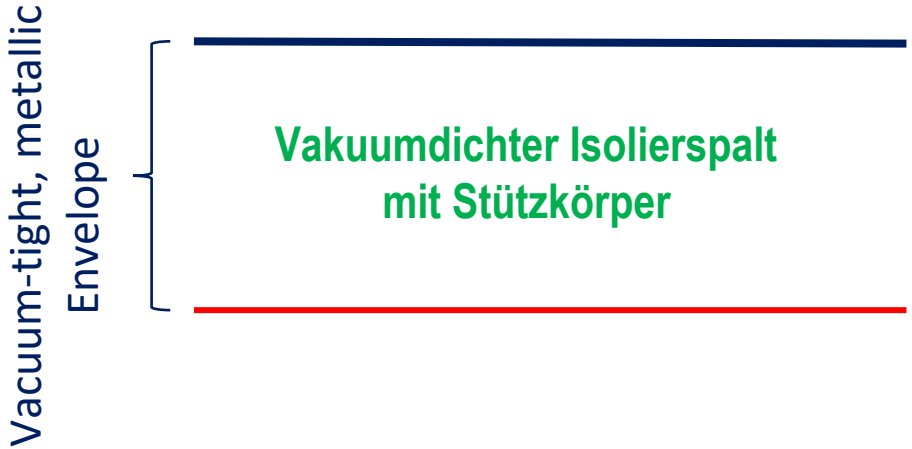
- **Additionally this structure of 10 mm thickness can withstand high mechanical stress!!**

A well known vacuum-insulation is the thermal jug "Thermos®-Kanne" – for lab applications also known as „Dewar-vessel" ; in Cryogenics the so called Multilayer-Insulations are common. For all these systems a good vacuum in the range of 10^{-4} mbar is obligatory – the insulation itself has to be supported and cannot be stressed. On Account of this the high-vacuum-insulations are expensive and massive!



In GVI®-Systems the insulation gap is filled with a microporous, stress resistant material - because of this, the system already works at rough vacuum conditions (about 0.1 and up to 20 mbar) and also can be stressed with high mechanical loads! GVI®-Systems can be realized in nearly every shape.

König Metall and TEB process specifically developed filler materials, to put into practice better insulation characteristics and additionally high load capacity!



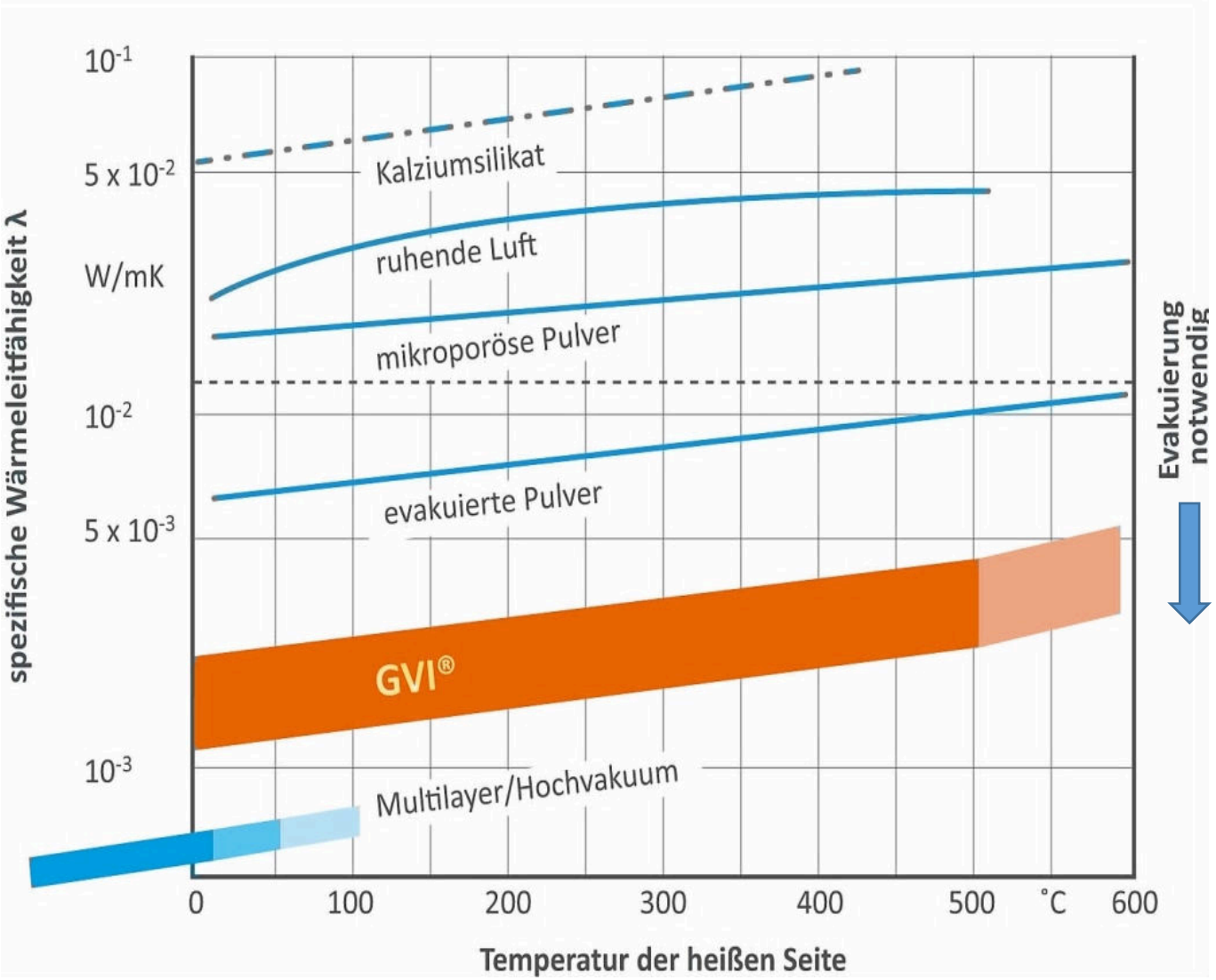
One main feature of an insulations system is its specific heat transfer rate λ

Here you can see a comparison of different kinds of insulation materials and systems

- **GVI® is about 20 to 30 times better than conventional insulation types!**

and

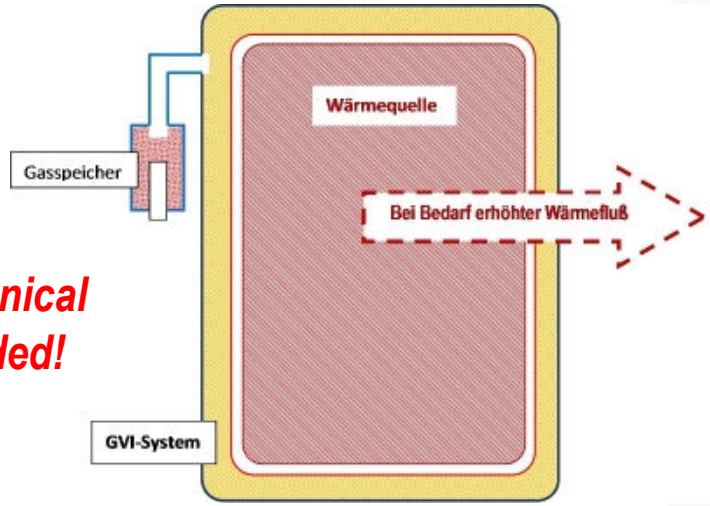
- **Even 2 to 5 times better than micro- or nanoporous insulation materials** (e.g. „microtherm ®“ and „aerogels“)



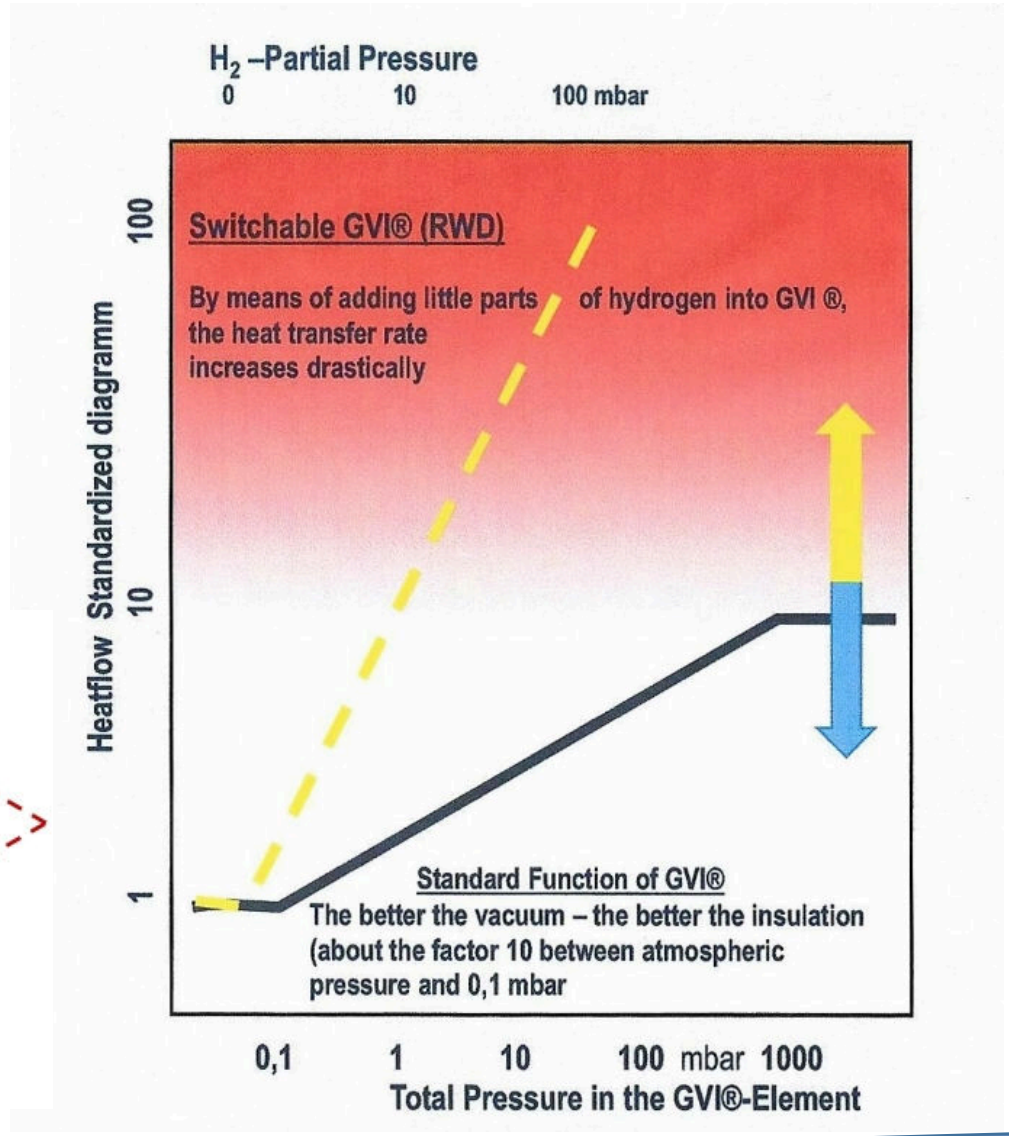
GVI® - Switchable Insulation

The insulation characteristic of GVI®-Systems can be controlled!

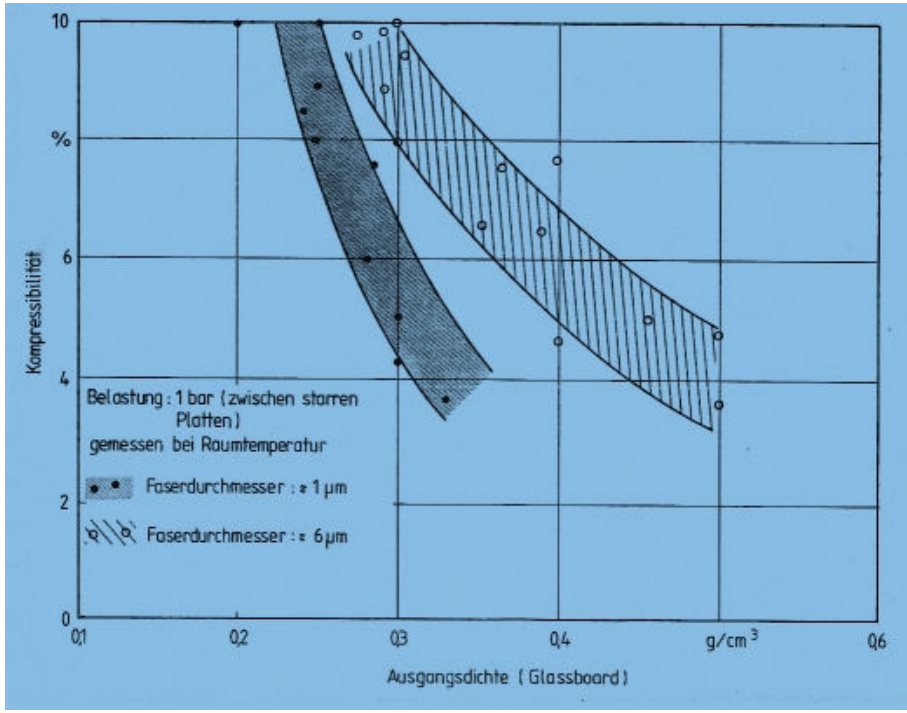
By means of adding little parts of Hydrogen (H_2) the heat transfer rate increases drastically.
The Hydrogen is stored in a getter material and can be casted out by heating up. – After cooling down the getter, the H_2 is gettered back again.



To run a switchable insulation, no mechanical working parts (pumps or valves) are needed!



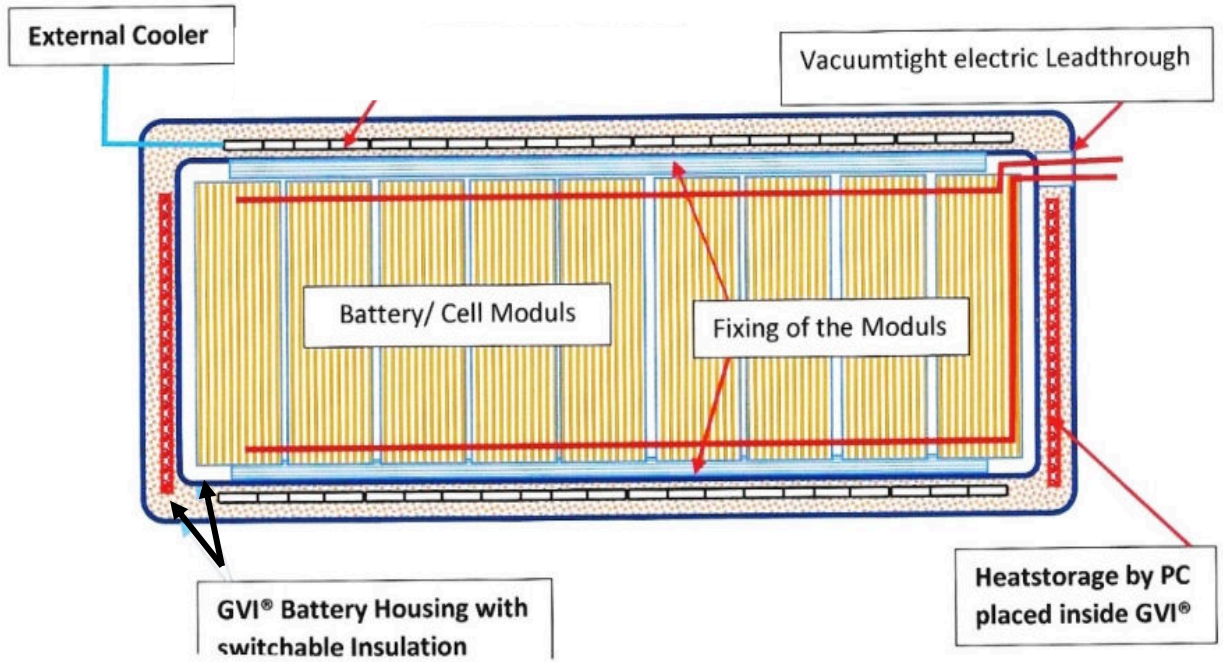
- When GVI®-systems are properly designed, evacuation results in rigging of the thin-walled shell material with the filler - the GVI®-structure behaves like a highly rigid sandwich structure.
- The supporting effect makes it possible to produce large-area, flat wall elements with thin shell walls (without ribbing) or to support large, heavy units (for example battery blocks) in the insulating layer against the outer vacuum jacket without additional support elements (thermal bridges!).
- The weight loads of a battery are conducted completely without additional support elements over the insulating layer on the outer supports!
- A GVI®-element can withstand forces (preferably pressure), shearing strain and moments, induced into a GVI® housing.



Several and <u>different</u> Thermo-functions may be integrated into the battery housing by implicating the GVI®-Technology - that´s an <u>economic and ecologic solution</u>!

➢ *Multifunctional Battery Housings enable an **<u>effective "Thermal Management"</u>** :*

a) *<u>Storage of additional heat/ energy in **PCMs**</u> – homogenizing the temperature*
b) *<u>Heat flow directly via the GVI®-Structure</u> - **<u>switchable insulation</u>***
c) ***<u>Active cooling</u>*** *(heat exchangers with cooling liquids)*
d) ***<u>Predictive real-time control</u>*** *- to improve the efficiency of the complete System.*
e) *Each function of the thermal management is integrated into the housing and separated from the cells!*

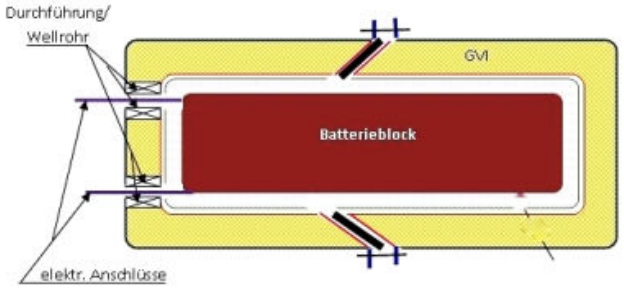


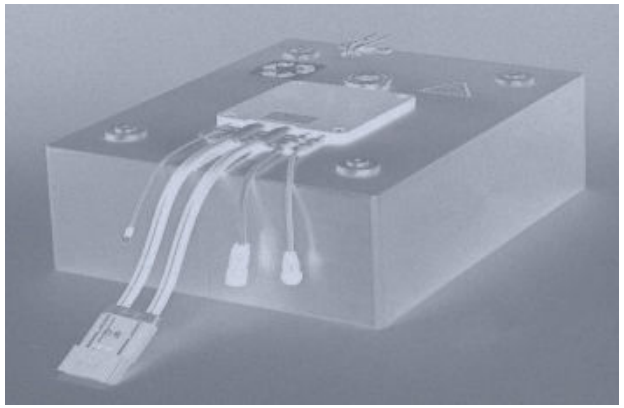
Different mechanical functions to be integrated into the battery housing by the GVI®-Technology

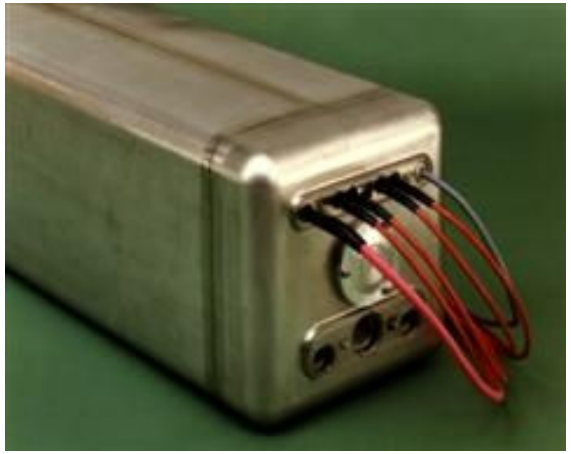
2) Multifunctional housings can fix all components shock proof and protect them in case of an accident!

3) With GVI®-housings the battery can be hermetically capsuled = sustainable environment protection

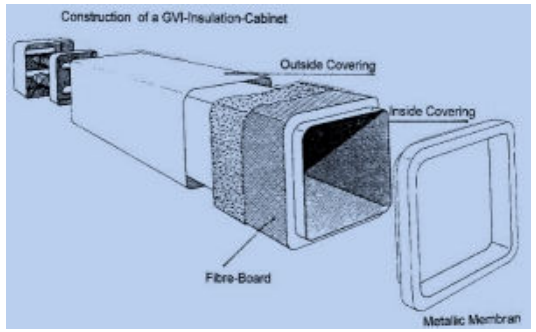
4) The high stiffness of GVI®-Structures enables the housing to be part of the car-/ body-structure - optimizing weight, available space and costs.







B:HOUSE - Perspectives - Examples of housing-concepts



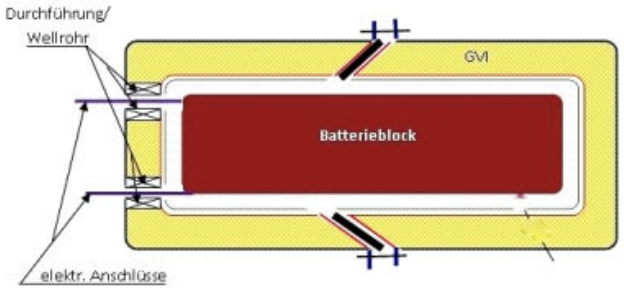
Tube-shape with one open end –only small heat bridge effect

Housings with one open end

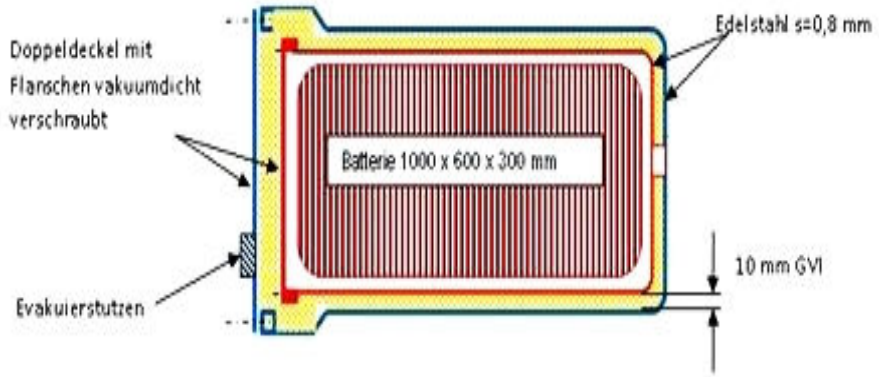
Upside opened Housing;

because of big sized opening, big heat bridge effect

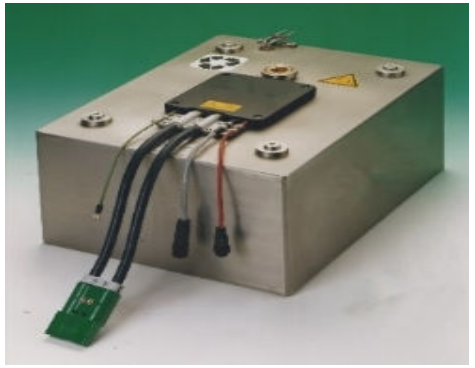
More or less total covering of the battery



Split-shape (Matruschka)



Openable / closeable integrated GVI®-Housing



Totally covered battery

Example of a large Truck Housing

Calculation for “passive Thermal Management”

The battery housing has an approx. 17 mm thick GVI® insulation - open on one side (tube model). The insulating effect is sufficient to keep the battery pack at operating temperature for more than 12 hours without additional heating:
ambient temperature - 20 °C; starting temperature of the battery 25 °C; temperature after 12 h still 20 °C !!

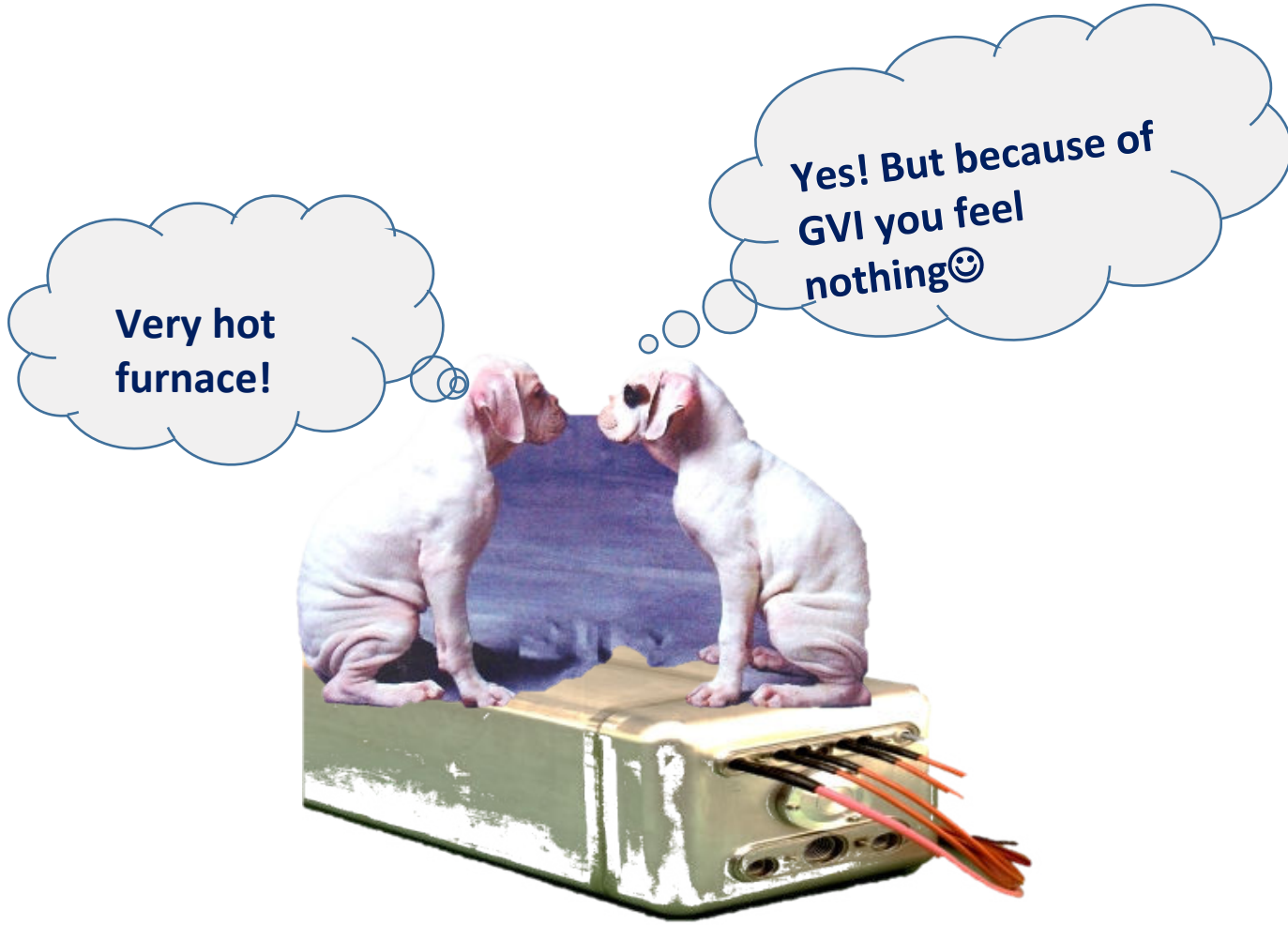
Weight ratios / carrying behaviour

In the largest version, the housing has the following internal dimensions: approx. 700 x 600 x 1800 mm. The total (double) wall thickness is about 17 mm - of which twice sheet thickness 0.8 mm. This housing weighs about 75 kg empty; the battery weighs about 1000 kg in this case. The entire battery is fixed to the side rails of the truck via three cantilever arms and straps.

Conclusion: The total weight forces of the battery (in the amount of 1000 kg) are completely supported by the lightweight housing and induced shockproof into the longitudinal structure of the truck.

Summery

- GVI®-Technology enables us to build up battery-housings for passive climatisation of batteries
- Additional elements for active thermo -management can be embedded into the double-walled housing-structure
- GVI® with its excellent mechanical behavior gives perfect protection and enclosure for cells and modules
- All these features are part of one concept / enclosure – this enables lightweight-design and saving of weight as well as space and material



Thanks for your attention !