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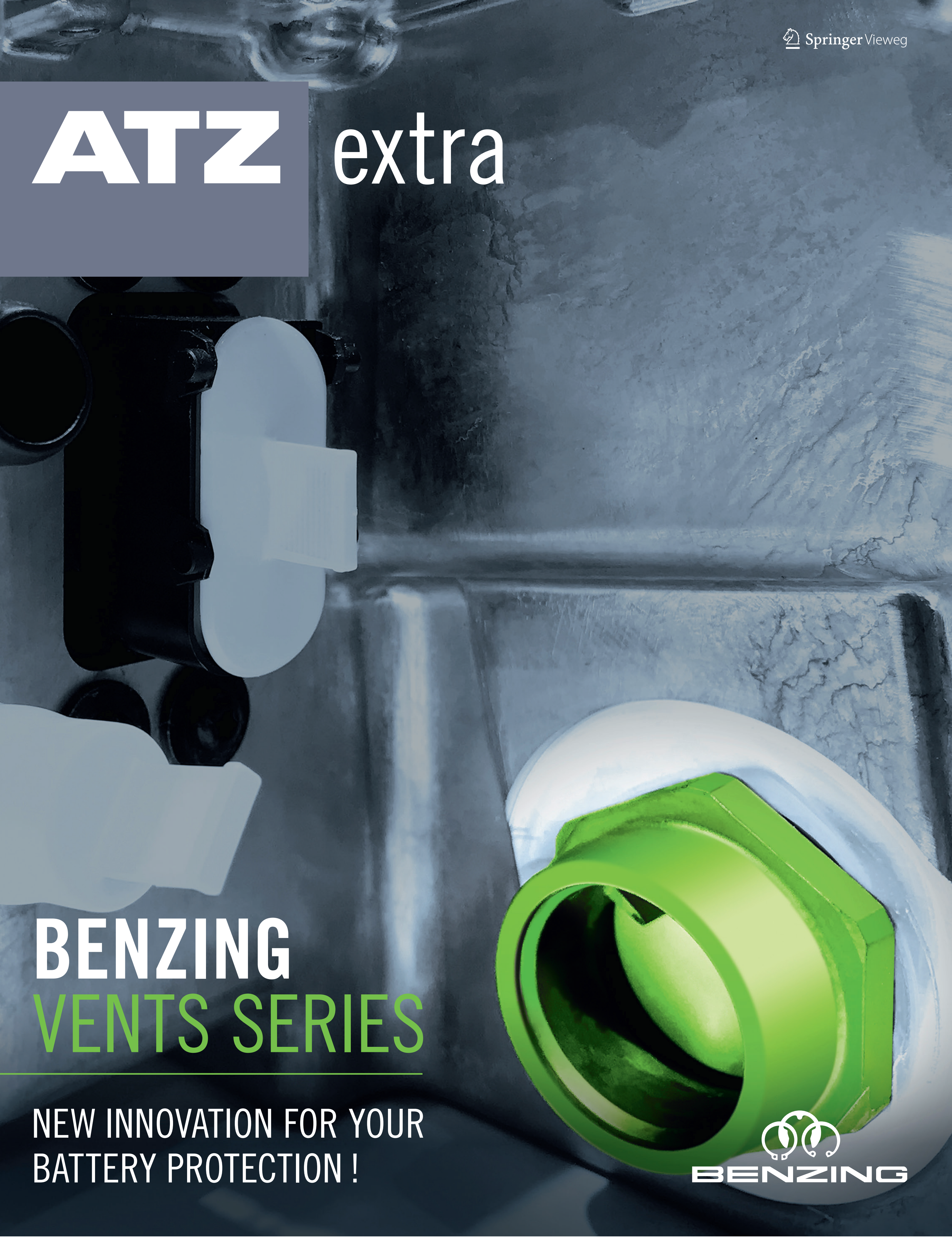

System-safe electric mobility

Dear Reader,

The success of electric mobility is above all also due to the system safety of current high-voltage batteries. If the lithium-ion cells in hybrid and electric vehicles are thermally stressed to such an extent that a chain reaction might occur – a phenomenon known as 'thermal runaway' – there is a high risk of explosion. This is an area in which the fastener manufacturer Hugo Benzing, which was founded in 1933, has been successfully working for some time now. It all began in the early 1990s, with a valve system for steering dampers which, when installed in a hydraulic steering system, prevented impacts from occurring in the hydraulic circuit. The foundation stone was laid.

This was followed by further projects related exclusively to safety-relevant issues in vehicles. In addition to the development of special non-return, pressure-relief, and shut-off valves that prevent backflow in the oil circuit, the engineers from Benzing have been involved in the development of safety elements for a premium manufacturer ever since the early days of lithium-ion battery technology for fuel cell and electric vehicles. Over the years, continuous verification has led to the development of a wide range of bursting discs, bursting membranes, and pressure equalization elements that are suitable for all applications in lithium-ion batteries.

The company uses its experience in the field of safety-relevant products for high-voltage lithium-ion batteries to offer customer-specific developments, in addition to numerous applications with standard products. Innovations from Hugo Benzing are valued not only by some of the leading companies in the automotive industry, such as BMW, Bosch, Daimler, Ford, Getrag, GM, Porsche, VW and ZF. The company based in Korntal-Münchingen on the outskirts of Stuttgart also has high-quality products for non-automotive applications in its portfolio.

Sincerly

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Lithium-ion Batteries – Safety Elements in the Case of a Fire Hazard and Mechanical/Thermal Influences

Lithium-ion cells in hybrid and electric vehicles may pose a high risk if they have been thermally stimulated so that a chain reaction is no longer mandatory. The air volume then escaping impacts the housing of a battery so much that it is possible to refer to it as an uncontrolled deformation. There are solutions to mitigate this case. Through the use of bursting diaphragms/rupture disks or pressure compensation elements, the housing is relieved so that temperature differences are compensated and unavoidable fires are delayed in time. Hugo Benzing explains the correlations.

THERMAL RUNAWAY

Each lithiumion cell (as installed in a traction battery) contains flammable components that are more or less reactive and hazardous, depending on the type of materials used. However, the hazards can be reduced through the use of safety measures. As such, in Chapter 6, the "Safety guidelines for lithium-ion domestic storage" [1] lists a large number of safety goals for cells, accumulators and a total energy storage system. As part of a risk analysis, the authors of the guidelines, which include the German Energy Storage Association (Bundesverband Energiespeicher e.V., BVES) and the Association for Electrical, Electronic and Information Technologies (VDE), recommend that the safety goals are considered as well as the general sources of hazards. A publication entitled "Thermal runaway experiments on consumer lithi-

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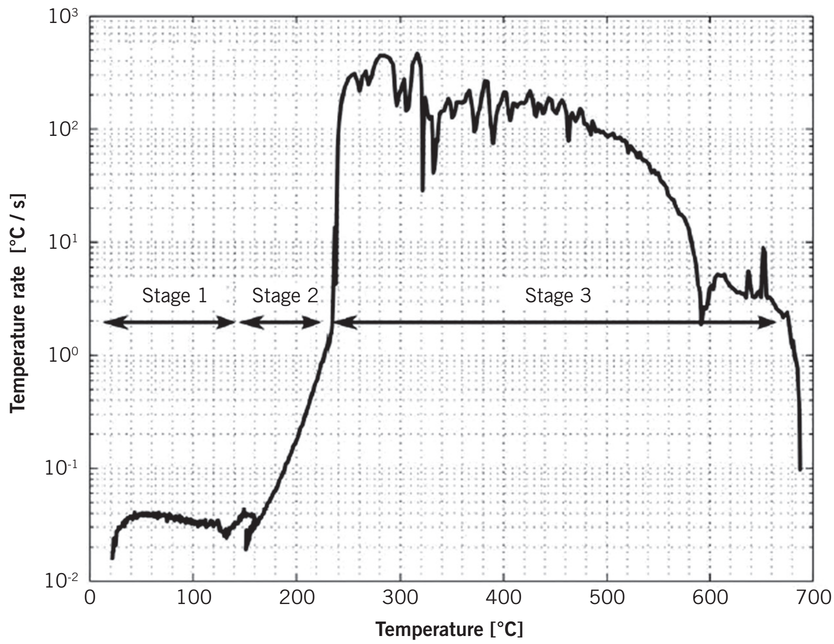

FIGURE 1 Temperature curve, from phase 2 thermal runaway (© Hugo Benzing)

um-ion batteries with metal oxide and olivin-type cathodes" [2] contains further details, especially for lithium-ion batteries.

This shows that no matter what lithium-ion cell types are used with respect to the cathode (LFP – lithium ferrous phosphate, NMC – nickel-manganese-cobalt, LCO / NMC – lithium-cobalt / nickel-manganese-cobalt), generates 30 % H_2 and 40 % C_2H in the battery, given right heating. This applies to temperatures above theta zero (θ_0). Above this temperature, an unstoppable process gets under way, the so-called "thermal runaway."

HAZARDOUS TEMPERATURE INCREASE

TABLE 1 shows how θ_0 differs, depending on the type of cell. The causes for the temperature increase are internal and external short circuits, over-discharge or depth-discharge as well as excess current and excess temperature. The temperature rise up to θ_0 is very slow in lithium-ion batteries. However, if the θ_0 point has been reached, the further increase in temperature takes place very quickly, **FIGURE 1**. The temperature rises to over 600 °C within seconds. Depending on the electrolyte, the temperature can also be up to 1200 °C.

Increased temperatures cause air to heat up and expand. This creates a volumetric flow. This volumetric flow can be 700 l/s for a high-voltage battery for an electric vehicle. This corresponds to a capacity of significantly more than three bathtubs within one second. This considerable amount of air should escape from the housing in a controlled way. The simplest solution would be the path through holes in the housing. However, as a result of mechanically accessible openings, penetrating moisture is created and dirt endangers safety.

FIRE RETARDATION AS A RESULT OF RUPTURE DISKS AND BURSTING DIAPHRAGMS

In the aforementioned safety guidelines, so-called rupture disks, **FIGURE 2**, are also described as one of the suitable corrective measures for automotive use. Rupture disks and/or bursting diaphragms are made from different materials. The decisive factor is the fact that they are defined at a low pressure and opened in a controlled manner (with disks) or burst (in the case of diaphragms). This pressure should be below or around 0.5 bar. A volumetric flow of around 240 l/s escapes at this pressure through a 50-mm opening. The opening should not be larger for EMC reasons. Very high requirements apply, especially for use in the automotive industry. Among others, these include:
- continuous gas permeation for pressure equalization
- high level of chemical and temperature resistance for adverse environmental conditions (this includes extensive testing coverage according to the LV 124 standard and exposures ranging from -40 to +125 °C).

FIGURE 2 Rupture disk for use in the battery housing (© Hugo Benzing)