HYDAC FILTERTECHNIK

Innovative Element Technology

Stat-Free®

E 7.017.2/11.16

1. Introduction

The use of modern environmentally-friendly hydraulic and lubrication oils, together with the trend towards ever more compact systems and finer filtration, has in the past few years exacerbated the problem of electrostatic charge and discharge. As a result, the components integrated into the system become severely restricted in their function or are even damaged. Electrostatic discharges destroy filter elements, damage valves and sensors and can even cause explosions in the hydraulic tank. In addition, they accelerate oil ageing.

To ensure that the whole system operates economically and without risk, it is essential to use filter systems which are capable of absorbing oil ageing products and which can prevent dangerous electrostatic discharges from occurring. Unscheduled and costly oil changes can be avoided by using this system of filters.

We have recognized the long-term problem of electrostatic discharge and with our innovative **Stat-Free® series of elements** have developed an effective solution to the occurrence of charging and discharging in the hydraulic and lube circuit.

With findings drawn from the specifically designed **Electrostatic Test Rig** which has been verified by TÜV as well as numerous field tests, we have been able to create an element technology which inhibits the phenomenon of electrostatic discharge in the filter element as well as significantly reducing the charge in the oil.

In the following pages, the principles and consequences of electrostatic charge and discharge in the hydraulic circuit are examined more closely and the advantages of the new Stat-Free® element technology are demonstrated.

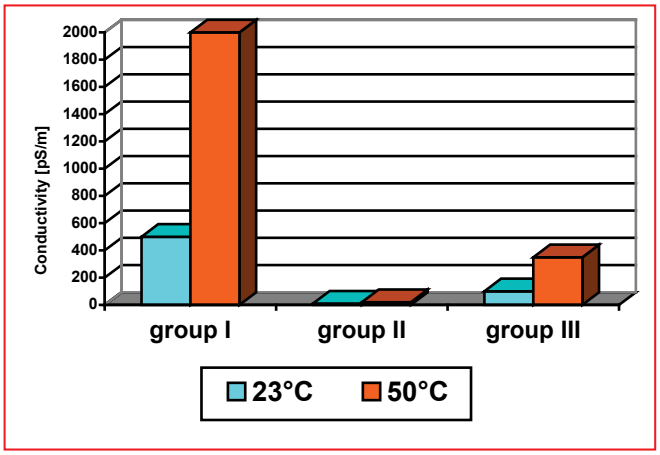
2. The Trend in Hydraulic Fluids

Globalisation of markets compels oil producers worldwide to supply consistently high quality hydraulic and lubrication oils to the manufacturers and operators of systems, such as compressor stations, large transmissions or machines. For category I base oils, where the molecular structure of the crude oil has not been changed, this is not guaranteed. Increasingly, therefore, base oils are used where the molecular structure has been broken down by hydrocracking and then selectively rearranged according to requirement.

Refinery capacities of oil producers all over the world are currently geared to this trend (in Asia and the USA, for example, predominantly category II base oils or higher are produced).

To achieve the oil characteristics guaranteed by the oil producers, additives (usually several, as an additive package) must be added to the base oil. Category I base oils contain aromatics most of which are toxic. In addition the additive packages contain zinc which is a heavy metal, and ash is produced on combustion. They therefore no longer comply with the current international environmental standards.

Hydraulic and lubrication oils in **category II and III** which are produced with appropriate additive packages, contain no toxins or carcinogens, are free of heavy metals and do not produce residues as a result of combustion. However, because they do not contain any metal, these oils have **low electrical conductivity**. When this oil flows through the filters in the hydraulic system, an electrostatic charge is generated. This can result in sparking in the system, which can cause considerable damage to hydraulic components.

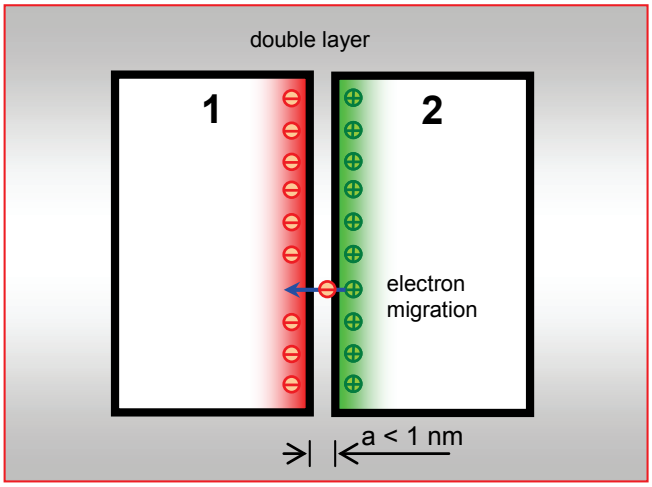


Examples of conductivity in oils of different categories

3. Theoretical Principles

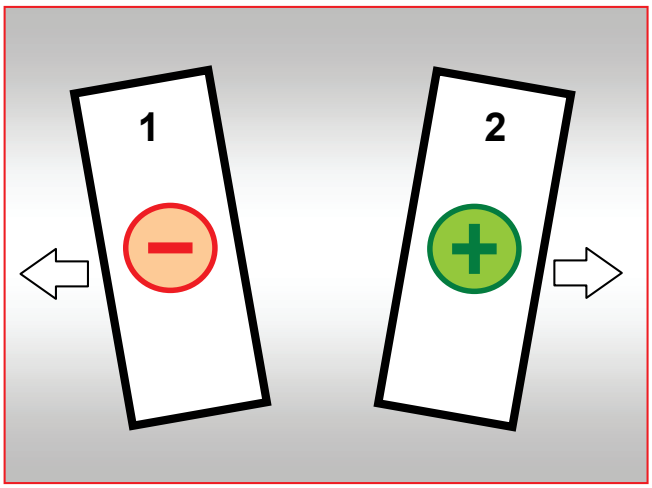
3.1 Electrostatic charging of solid particles

Every substance or material has a certain electron work function, i.e. the tendency to accept or release electrons. If two substances which have different electron work functions are then brought together (distance < 10^{-9}m) at the same temperature, then at the point of interface, electrons are transferred from the material with low work function to the material with higher work function. An electrical double layer is produced with a certain charge Q. There does not have to be any friction between the two materials. Friction merely reduces the distance between the substances involved.



Development of the double layer

If the two materials are separated and the distance between them is therefore increased, the capacitance is reduced and the potential difference (= voltage) is increased. Both materials are electrostatically charged.



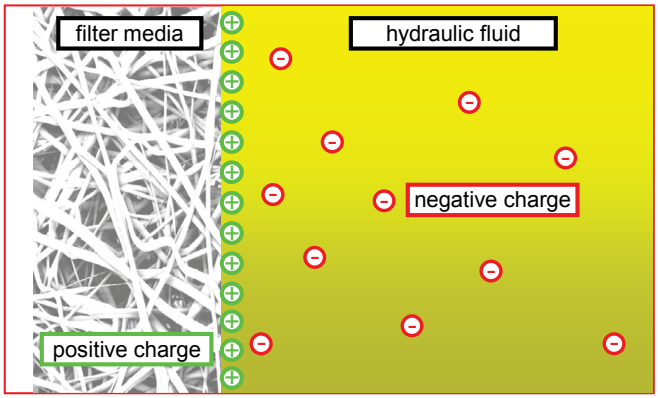
Separation of the two materials

The amount of charge is dependent on the speed of separation, amongst other things. If separated slowly, charge can be equalized over the last point of contact. The faster the separation occurs, the higher will be the charge.

If the voltage generated exceeds the specific limit of dielectric strength (in air approx. 3 kV/mm), there will be a sudden equalization of voltage which is usually in the form of discharge sparking.

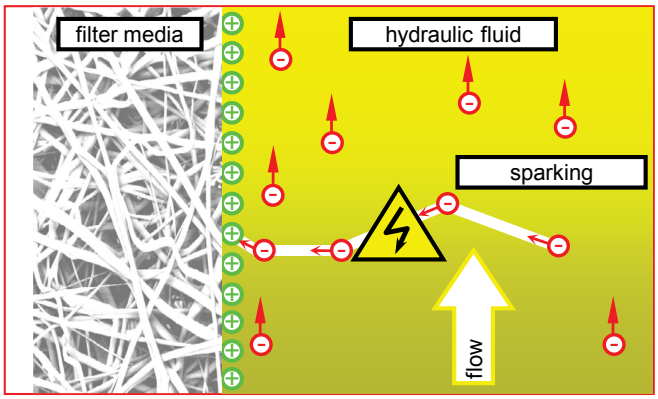
3.2 Charging of fluids

In fluid/solid systems as is the case in hydraulic systems (filter medium/oil) a double charging layer is also formed here at the phase boundary, as shown in the following diagram. Near the boundary, this double layer consists of a linked layer of charge carriers (in this case positively charged). In the oil there is a diffuse layer of opposing (negative) charge carriers.



Distribution of charge in fluid/solid systems

When the fluid then flows, the charge is carried downstream and creates a difference in potential. The faster the fluid is flowing, the higher the potential difference will be. If the voltage exceeds the dielectric strength of the oil, it will discharge in the form of sparking.



Sparking

The precondition for charge generation is that the fluid has a sufficiently low conductivity, otherwise the charges of the diffuse layer can flow back and can be equalized.

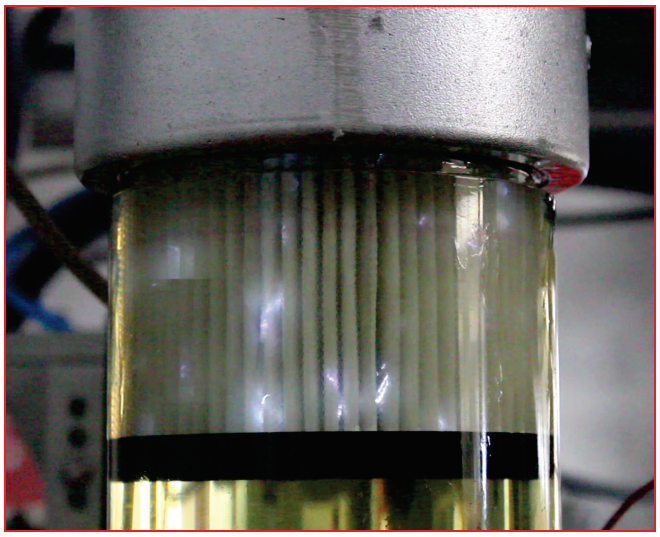
3.3 Main factors

The main factors influencing the electrostatic behaviour in hydraulic systems:

- **Electric conductivity**
  The lower the conductivity, the higher the charge
- **Filter medium**
  Different materials produce different charges depending on the electron work function
- **Temperature**
  In general the charge falls as the temperature rises
- **Flow velocity**
  The higher the flow velocity, the higher the charge
- **Contamination**
  Conductive particles or water increase the conductivity of the fluid which results in a lower charge

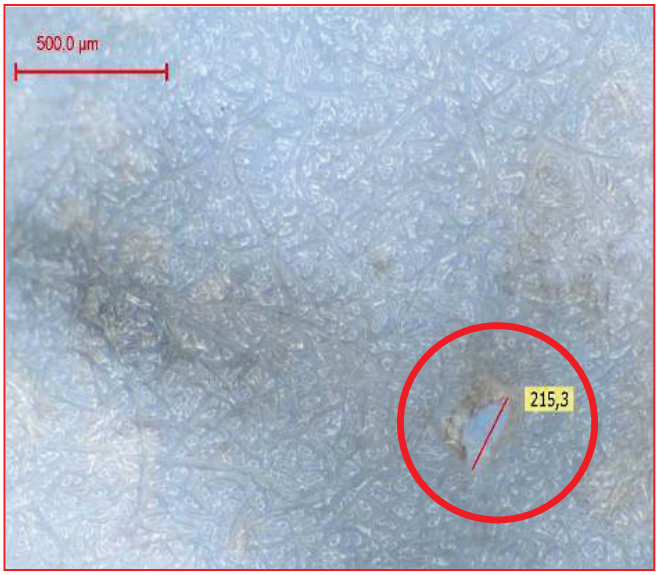
4. Consequences of Discharge

The consequences of electrostatic discharges can be serious.



Electrostatic discharging in the filter element

The discharge sparks can burn **holes**, for example, in the filter medium. The following picture shows a hole of about 200 µm in 3 µm filter media. The required oil cleanliness is therefore no longer achievable.



Burn hole in the filter material

Furthermore, when the charge is carried further downstream by the oil, uncontrolled discharges can occur in the hydraulic tank. Depending on the oil/air mixture in the tank, dangerous **explosions** are possible.

Breather filter burned as a result of explosion in the tank

The electrostatic discharges also cause **electromagnetic waves** which disrupt and damage sensitive sensors and electronic components in a hydraulic system.

It is not only hydraulic components but also the hydraulic oil itself which is damaged by discharges. The sparking cracks the molecules of the fluid and free radicals are formed. These radicals polymerize into long chains and this in turn leads to the **formation of varnish**. In addition, the free radicals accelerate oil ageing.

5. Measuring Equipment

5.1 Mobile measuring equipment

In order to examine more closely the electrostatic behaviour of a hydraulic system in the field, we have a range of test equipment.

With the aid of a **portable conductivity measurement instrument** we are able very quickly and simply to determine the electrical conductivity of the hydraulic fluid. It enables us to make an initial assessment as to whether the conductivity has fallen below a critical limit and can lead to electrostatic phenomena.

Furthermore, HYDAC has developed a special voltage sensor, the so-called **StatStick**. In conjunction with our widely-available portable device (HMG 3000) it is possible for our engineers in the field to measure the voltage in the oil directly in the system.

Innovative StatStick with HMG 3000

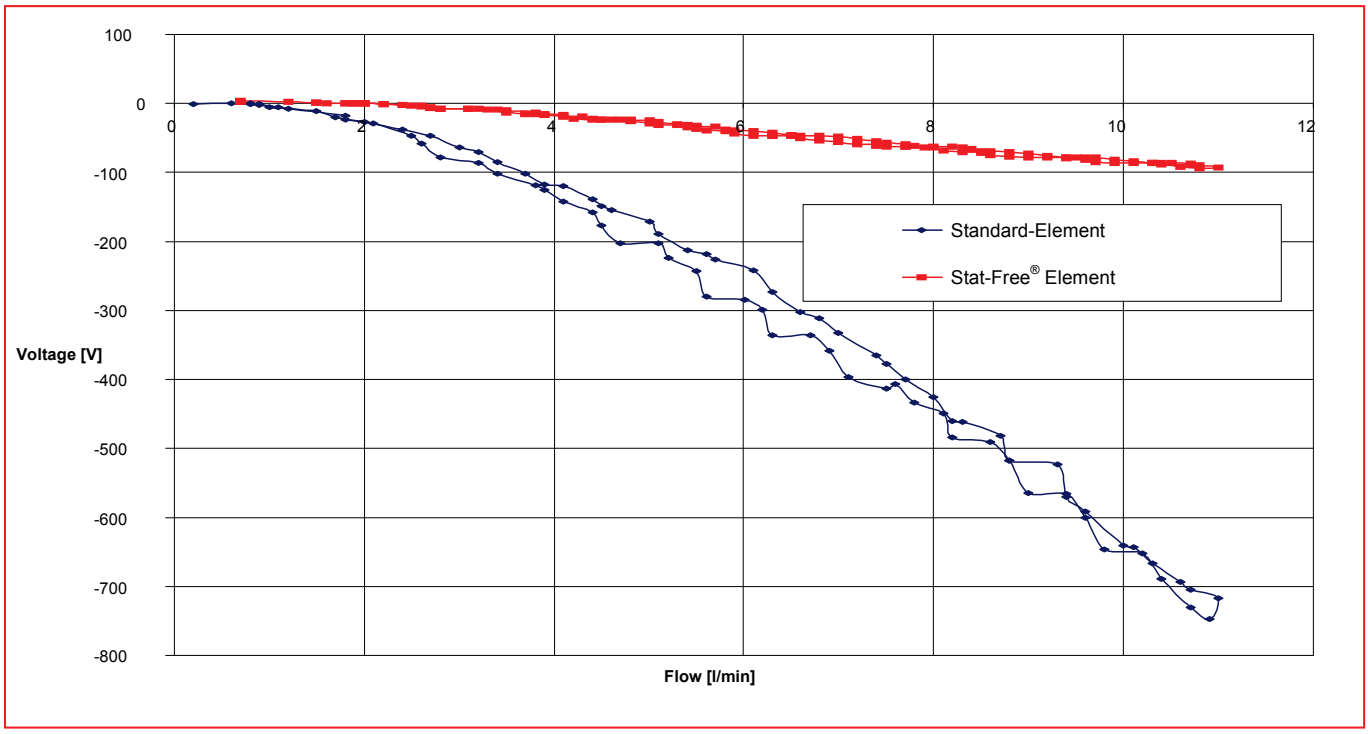
In the case of discharge sparking in the system, an oscilloscope can also be used as a measurement device. Owing to the high sampling rate of the oscilloscope, the transient discharges are shown as peaks on the display.

5.2 Stationary test rig

Our specially developed **test rig** which has been certified by TÜV is used to simulate real-world critical applications. With the help of the test rig, the electrostatic behaviour of the hydraulic filter in critical oils has been thoroughly analysed.

This has led to the development of the Stat-Free® filter element series which combats the problem of electrostatic discharge.

HYDAC Electrostatic Test Rig



Comparative measurement of a standard element versus a Stat-Free® element on the electrostatic test rig

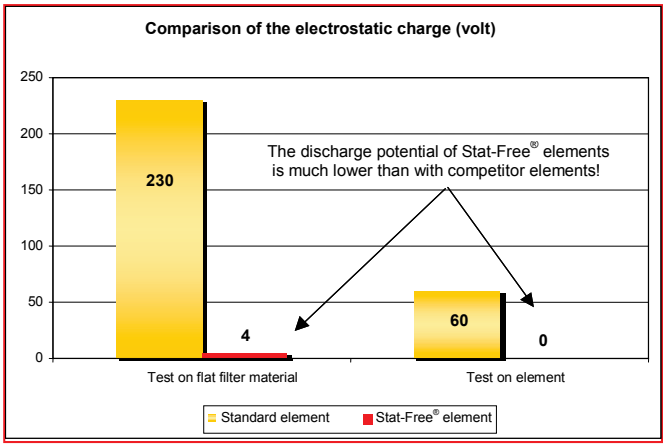
6. The Stat-Free® Technology

If a hydraulic system is using an oil with a **low conductivity** and a non-conductive filter element, the filter and the fluid can be **charged** electrostatically and can lead to electrostatic **discharges**.

A **purely discharge-capable** design without the addition of a special combination of media, indeed reduces sparking in the element but the oil continues to be charged. The charges at the interface of the filter can dissipate, but the fluid has an even **higher charge** because there is no sparking on the filter to neutralize the charge. The highly charged oil is transported further through the system and uncontrolled discharges are possible in other parts of the system which under certain circumstances can lead to serious damage (e.g. explosion in the tank).

Using a new type of filtration meshpack and element design, HYDAC has for the first time combined excellent electrostatic characteristics and filtratioin performance. Our Stat-Free® elements have achieved a previously **all-time low charge** of the filter element and the fluid during system operation. In addition the Stat-Free® elements are equipped with conductive O-ring caps and conductive core tubes.

The performance of Stat-Free® elements has been confirmed in thorough laboratory and field tests. By comparing the test diagram below, the Stat-Free® elements have a striking advantage over the conventionally designed standard elements, in terms of the oil charge generated.



Comparison of the electrostatic charge (volt)

The new Stat-Free® technology is available for the following HYDAC element materials:

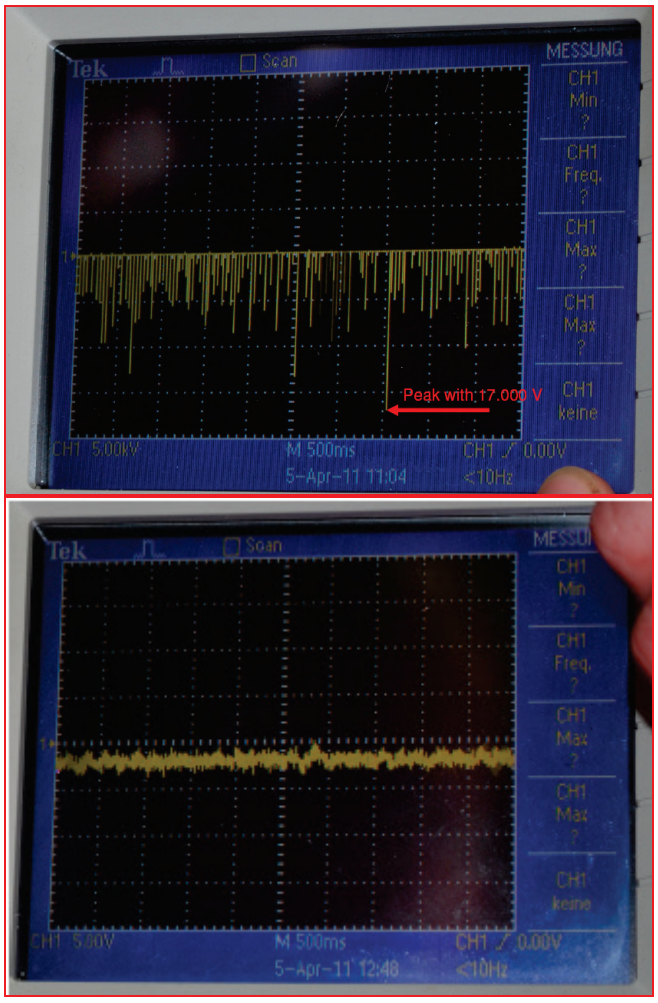
- **Mobilemicron (MM)**
  for filtration ratings 8, 10, 15 µm
- **Optimicron® (ON)**
  for filtration ratings 1, 3, 5, 10, 15, 20 µm,
  Optimicron® Pulp & Paper (ON/PP)
  for filtration rating 5 µm and
  Betamicron® (BN4HC, BH4HC)
  for filtration ratings 3, 5, 10, 20 µm
  In this case, please add **/-SFREE** to the element model code.
  Example: 2600 R 010 ON /-SFREE
- **Optimicron® Power (ON/PO)**
  for filtration ratings 5, 10, 20 µm and
  Optimicron® Pulse (ON/PS, OH/PS)
  for filtration ratings 3, 5, 10, 20 µm with SFREE inclusive

Stat-Free® elements are particularly suitable for applications in power plants, gas turbines, plastic injection moulding machines and calenders (paper industry) and in mobile hydraulics, as well as any other hydraulic and lubrication system which uses new low conductivity oils.

They guarantee a **high level of operating reliability**, since they prevent sparks, deflagration and sludge formation in the oil. **Longer oil change intervals** can be achieved through non-damaging filtration of the oil.

7. Real-World Example and Reference

HYDAC became aware of the possibility of explosions in the hydraulic tank of a large hydraulic system after breather filters were burned out. The filters concerned were competitor's filters which were not optimized for electrostatic charging. Measurements made on site using the StatStick revealed voltage peaks of **up to 17,000 Volt** and dangerous discharge sparks in the tank. Once retro-fitted with Stat-Free® elements, **no further discharges** could be detected and the voltage was just **2-3 Volt**.



Voltage measurement using StatStick (above: competitor's standard element voltage peaks up to 17kV [scaling: 5kV]; below: Hydac Stat-Free® element 2-3V [scaling: 5V])

A number of established companies in sectors such as turbine lubrication, presses, plastic injection moulding machines and mobile hydraulics have already named HYDAC as a reference with regard to finding a solution to the problem of electrostatic discharge, as indicated by the following quotation:

"Due to numerous, frequently recurring difficulties on actual systems, we urgently recommend using filter cartridges which inhibit electrostatic charging in oils with low electrical conductivity. ***These filters are available from HYDAC under the same model code, by adding "/-SFREE"."***

Moreover, the functionality of the Stat-Free® filter elements has been analysed by DEKRA EXAM GmbH, the German specialist unit for explosion protection at the mining test facility (BVS). The efficiency of the elements was confirmed in the expert report 13EXAM 10666 BVS-BI by DEKRA EXAM GmbH, Explosion Protection Department.

8. Summary

- The charge separation in **low conductivity oils** results in electrostatic charging and discharging.
- Electrostatic discharges can cause the following damage, amongst others:
  - Explosions in the hydraulic tank
  - Accelerated oil ageing
  - Damage to the filter element
  - Destruction of electronic components
  - Damage to cooler units
- A conductive design of filter element is **not** sufficient to reduce oil charging.
- HYDAC **Stat-Free® elements** ensure a very low charge in the filter element and the hydraulic fluid

Advantages:

- **High level of operating reliability**
  because discharge sparking, deflagration and sludge formation in the oil is eliminated
- **Longer oil change intervals**
  because filtration of the oil is non-damaging

Conclusion:

These developments prove that at HYDAC we will always find a solution to a customer problem. We not only provide an efficient result, but we will see you through the whole diagnostic process, especially in challenging cases.

We look forward to hearing about your new projects!

NOTES

NOTE

The information in this brochure relates to the operating conditions and applications described.
For applications or operating conditions not described, please contact the relevant technical department.
Subject to technical modifications.

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