

# Welcome to the “Next Generation of EV Battery Pack Vibration Testing” Webinar

The presentation will begin at 10am EST

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Tim Gardiner, Tim Bidwell, Tom Ulenaers  
September 2022

# Next Generation of EV Battery Pack Vibration Testing

DIGITAL LAUNCH EVENT

Tim Gardiner, Tim Bidwell, Tom Ulenaers

September 2022



CONFIDENTIAL

# Organizational Information

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- If you have additional technical questions, feel free to contact our technical support team at [support@usa.hbm.com](mailto:support@usa.hbm.com)

# Tim Gardiner

- ▲ Tim is the Product Manager for HBK VTS and have been with the business for 1 year
- ▲ On the panel, we have Tim Bidwell, Head of Technical Development & Tom Ulenaers VTS Solution Specialist

# Teaser Video

THE LDS V9940 + DPAK SHAKER SYSTEM

# Contents

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2. System components
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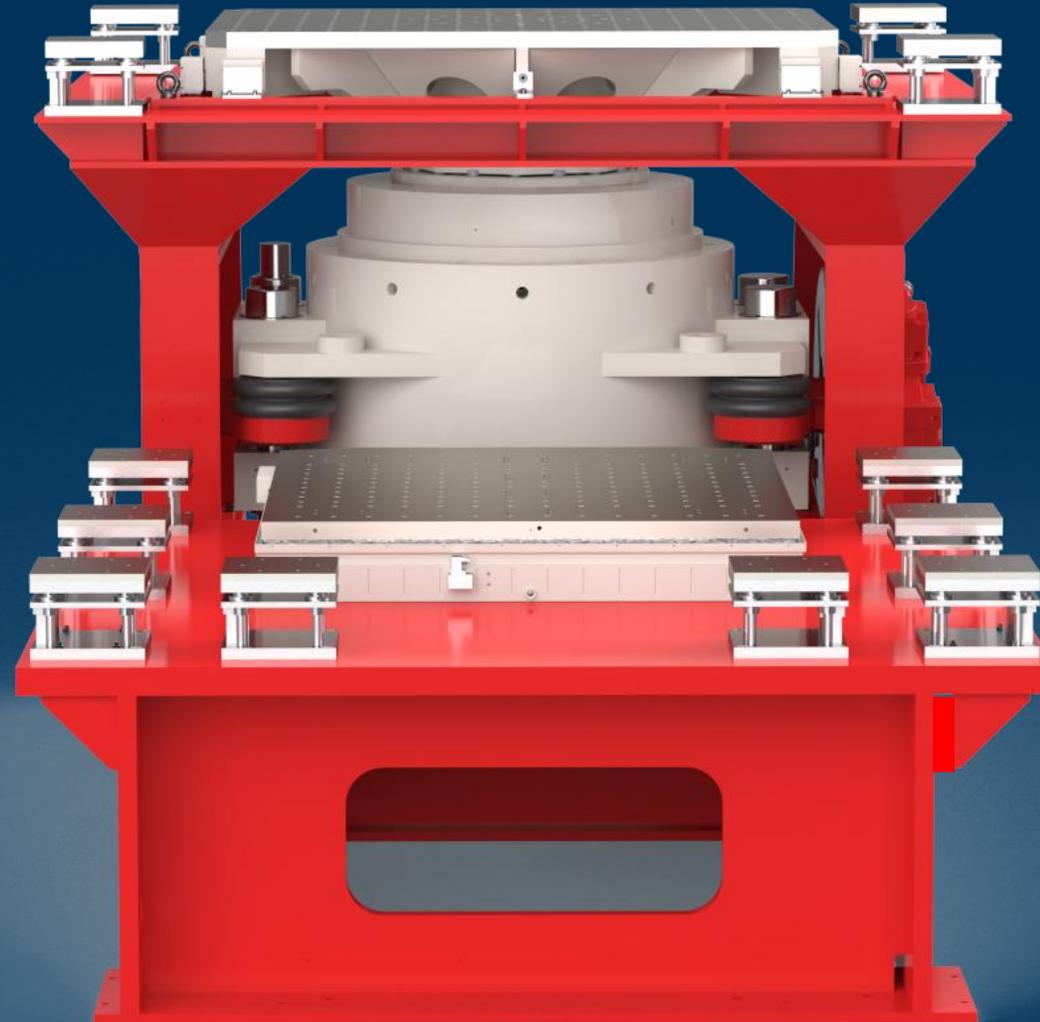
# Welcome

## V9940 + DPAK SHAKER SYSTEM

HBK has been one of the leading manufacturers and suppliers of quality 'advanced technologies' for the testing and measurement of sound and vibration

We offer standardized and custom solutions for a wide variety of applications and for items of virtually any size

Today we are pleased to introduce our next generation of vibration testing equipment: the HBK LDS V9940 + DPAK Shaker System



# V9940 + DPAK Shaker System

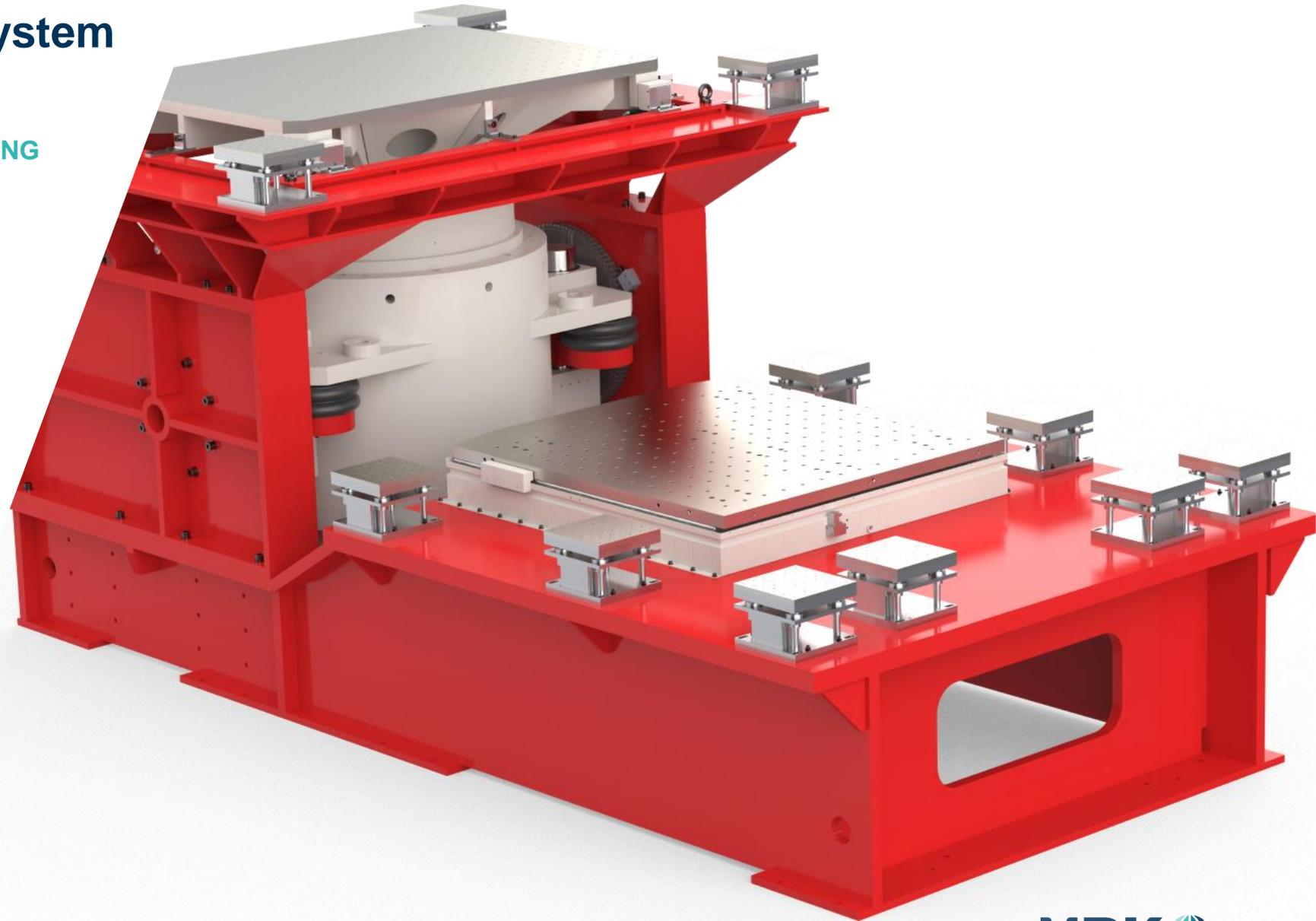
## DESIGNED SPECIFICALLY FOR EV TESTING

Reliable and proven shaker platform that is ideal for vibration and shock testing Electric Vehicle (EV) battery packs, axel and drive train assemblies.

Coming from the proven platform, the V994, used in varied applications throughout the world for many years.

The most powerful shaker in the HBK LDS range has been optimized for high acceleration shock tests to standards such as UN 38.3, ECE R100 and ISO 12405.

Project management & turnkey services to ensure lifelong performance of complete battery test solutions.



# Customers Needs vs HBK VTS USPs

Customers Needs	HBK LDS USPs
<p>Solution for battery pack vibration testing</p> <p>Building a new battery test facility is a high investment.</p> <ul style="list-style-type: none"><li>• Trust, credibility and reliability are important.</li><li>• Health and safety of employees in a hazardous environment</li><li>• Effective order handling/effective installation and siting of extra-large systems</li><li>• Global Service capabilities to ensure long-life of product as well as smooth test procedures</li><li>• Turn-Key solutions to provide everything for shaker vibration testing of battery packs.</li></ul>	<p>V9940 delivers high shock performance and vibration testing for large EV battery packs and EV assemblies (Axel/Suspension/Suspension)</p> <ul style="list-style-type: none"><li>• HBK offers a battery testing solution for mechanical vibration testing, thermal testing, and electrical testing, enabling a simultaneous measurement of mechanical vibration and battery life, such as cycle simulations, power cycling, charge and discharge rate.</li><li>• Through partnerships with environmental chamber manufacturers and system integrators, we are able to provide turnkey solutions to our customers.</li><li>• In over 50 years of HBK LDS, 10000 shaker systems have been delivered around the world, representing reliability and credibility in the marketplace.</li><li>• HBK's unique and global services enable long life and excellent warranty performance.</li><li>• Experience of working alongside 3<sup>rd</sup> parties such building contractors, system integrators and climatic chamber manufacturers</li></ul>

# The V9940 Shaker System

## V9940 SHAKER + DPAK AMPLIFIER

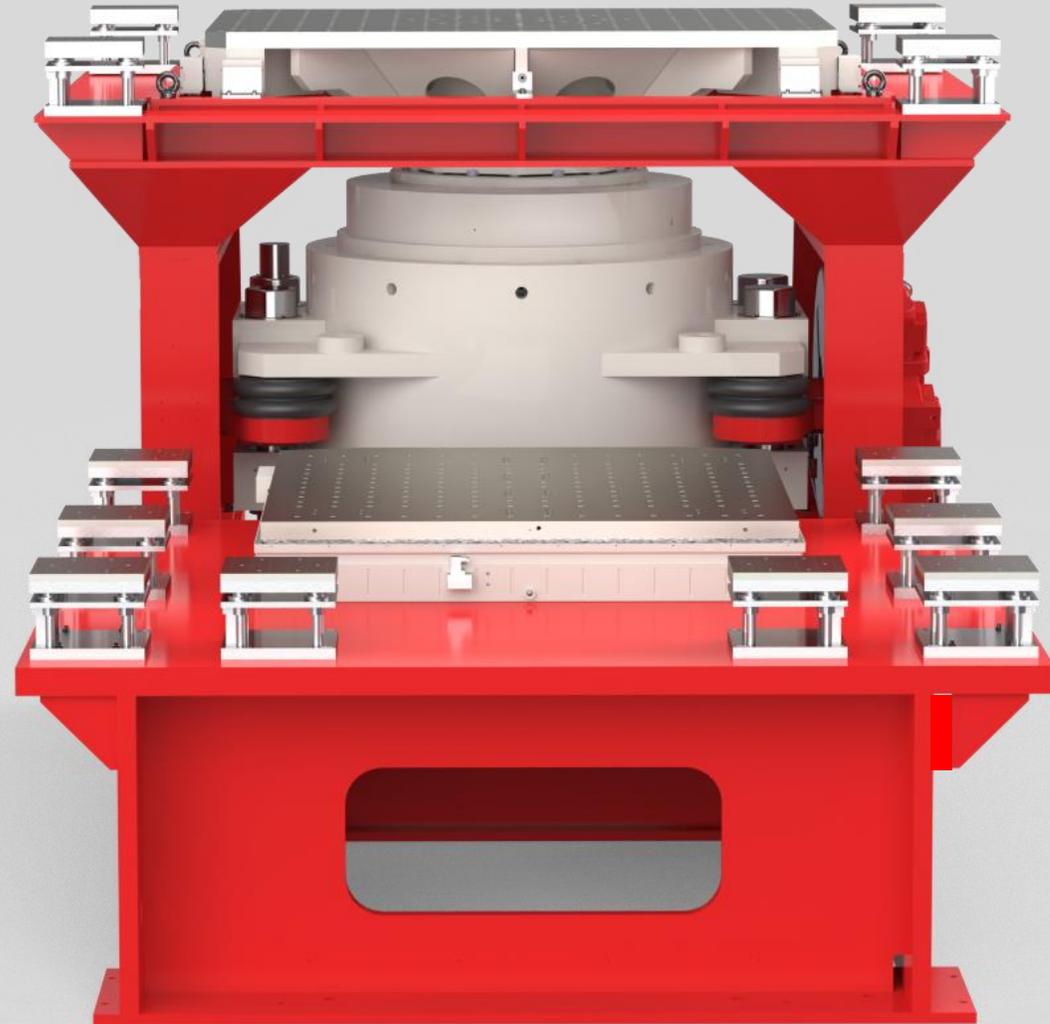
Half Sine Shock performance 800 kN (2 ms pulse)

Optimised slip table/head expander designs

Minimised moving masses

Payloads of up to 3m as standard (other sizes available on request)

Compatibility with climatic chambers with options for thermal management



# Vibration Test Systems for Small, Medium and Large Batteries

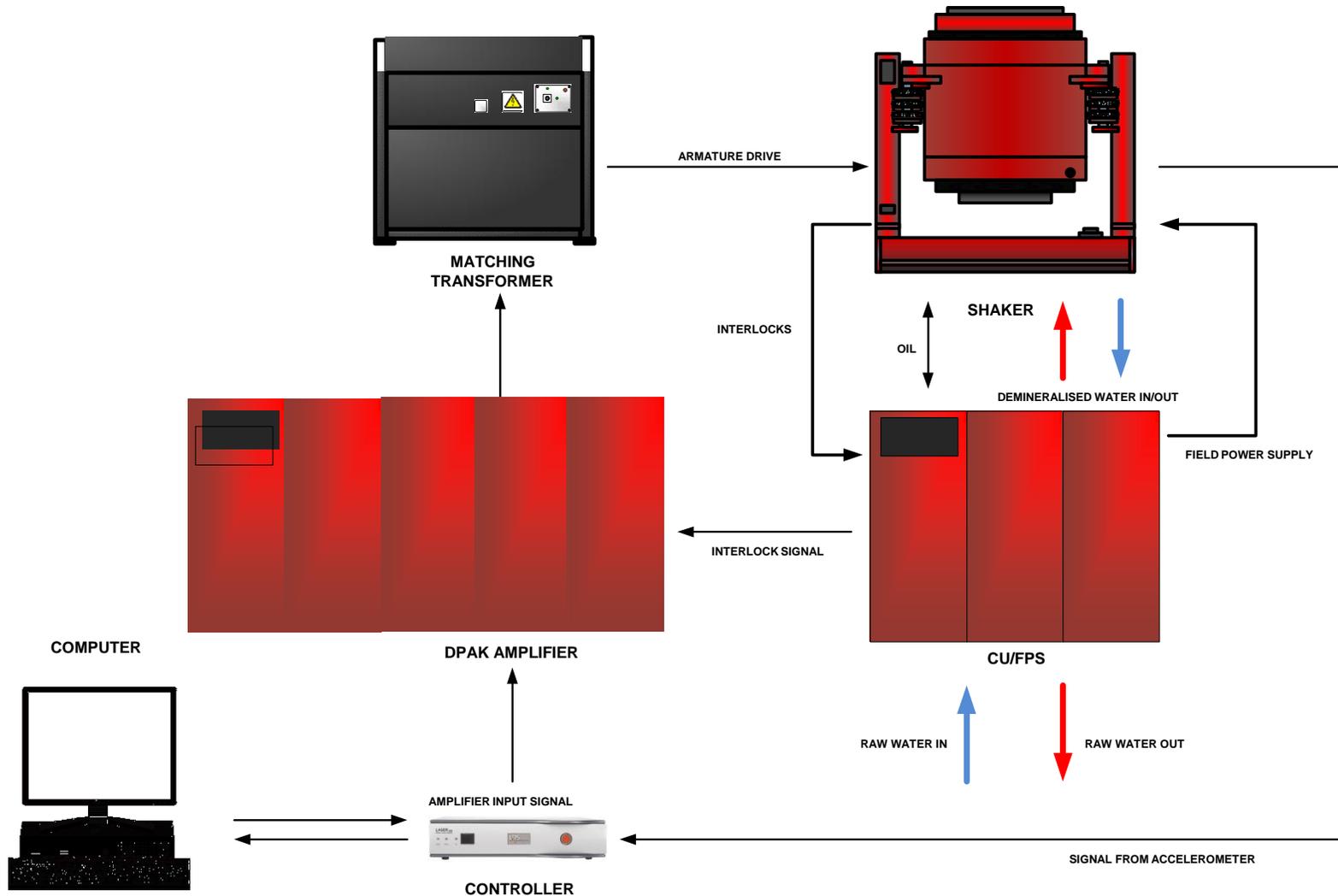


Shaker Model	V8750	V8900	V9940
Battery type	Cell	Module	Packs
Max. Sine Force	35.6 kN	80 kN	300 kN
Max. Shock Force	140 kN	254.1 kN	800 kN
Frequency	DC to 3,000 Hz	DC to 3,000 Hz	5 to 2000 Hz
Profile	AK LH 5.21, UN38.3, ISO 12405 50 g/6 ms shock 50 g/11 ms shock 25 g/15 ms shock 30 g/6 ms shock 30 g/11 ms shock 100 g/6 ms shock 100 g/11 ms shock LV124/VW80000, UL 1973, EN 61373		

- ▲ ECE R100 and ISO12405, have been developed to standardize the testing procedures of batteries and their subsystems
- ▲ Battery packs are always rectangular
- ▲ Always have a low centre of mass
- ▲ Typical sizes from 1.2 m length to 3 m
  - 2.4 m x 1.8 m battery is typical (family sedan, inc. fixture)
  - Typical DUT mass 700 kg, fixture 250 kg

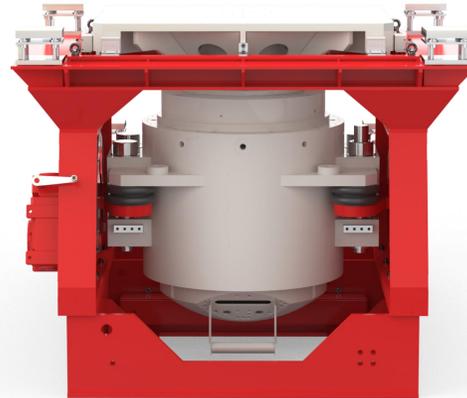
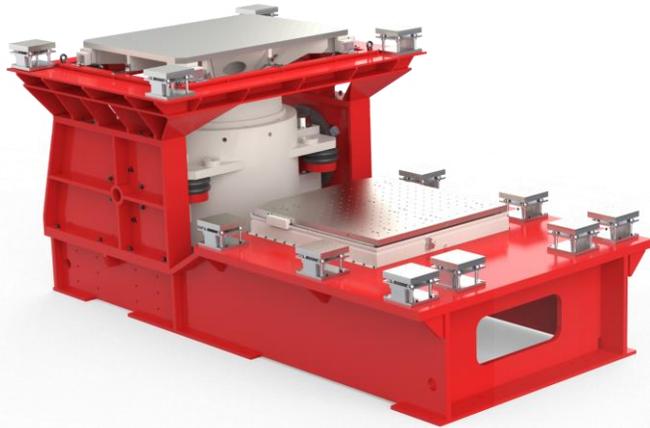
# V9940 System Components

# Overview of V9940 + DPA-K system

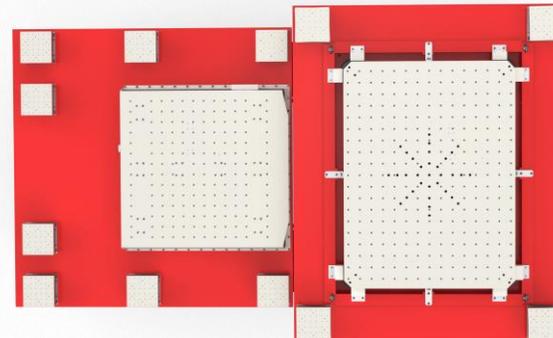


- ▲ Standard V9940 shaker offers multiple levels of isolation, avoiding dynamic loads being passed through the floor for frequencies > 5 Hz
- ▲ Seismic fundamentals not required for test > 5Hz
- ▲ Static mass of the complete system > 40 tonnes
- ▲ Contact us for more information regarding Seismic fundamentals and siting of very large shaker systems

# V9940 Shaker



V9940 Combo-Mounted with Head Expander and HBT1500 Expansion Slip Table with Pedestal Bearings



Typical mass with Head Expander: 35,000 kg/without Expander: 32,000 kg

Performance Parameters	
Armature Diameter	760 mm (29.92 in)
Sine Force (peak)*	300 kN (67,440 lbf)
Random Force (rms) †	266.9 kN (60,024 lbf)
Max. ½-Sine Shock Force (peak)†	800 kN (179,847 lbf) ∞
Armature Resonance (fn)	1325 Hz
Usable Frequency Range ‡	5 - 2000 Hz
Effective Moving Mass	254.9 kg (562 lb)
Velocity (sine peak) ~	2.0 m/s (78.7 in/s)
Acceleration (sine peak)*	100 g (980 m/s <sup>2</sup> )
Acceleration (random RMS) *	60 g (558 m/s <sup>2</sup> )
Shock Velocity (peak)	4.0 m/s (157.5 in/s)
Displacement (peak - peak) Continuous	50.8 mm (2.0 in)
Displacement (Transient) (shock operation)	63.5 mm (2.5 in)
Required Amplifier	DPA320K or DPA384K

# V9940 DPA-K Amplifier

## NEW DESIGN

- Two new variants of the established DPAK Amplifier range:
  - DPA320K
  - DPA384K
- 384 kVA variant is increased in height to 2080 mm
- The DPA320K and DPA384K amplifiers consist of a control bay and 4 power bays
- New supply transformer in each power bay – higher kVA and with high voltage tap
- Optimization of the power module, due to the increased high voltage output, a higher performance can be reached with the same kVA output power.
- The combination gives the shaker high shock performance. - max. shock force to >800 kN based on a 2 ms pulse.



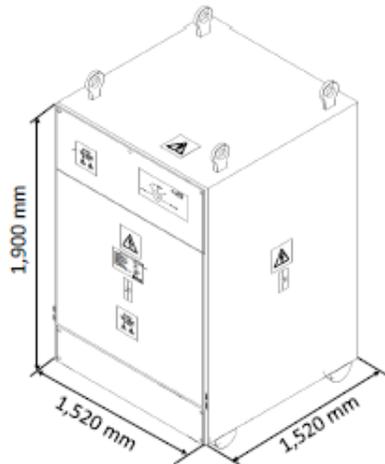
# V9940 CU/FPS

- ▲ The CU/FPS (Cooling Unit & Field Power Supply) is a multi-purpose assembly providing the following functions required by specific ranges of vibration test systems:
  - A demineralised water supply used to cool the vibrator's field and armature coils
  - A hydraulic oil supply, cooled, to operate the vibrator's hydrostatic guide bearing
  - The field power supply for the vibrator field coils



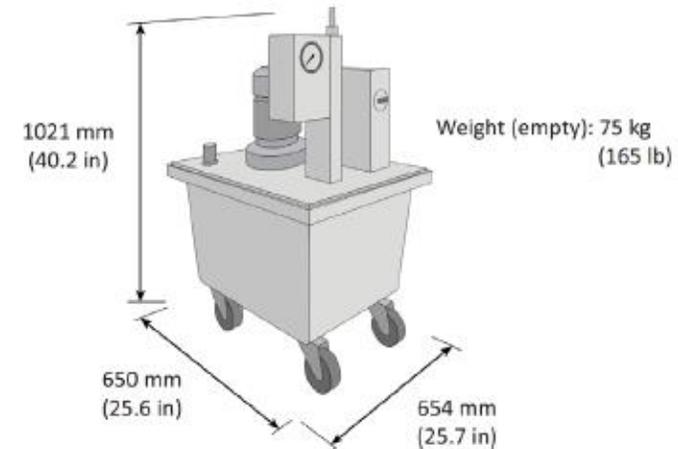
# V9940 Matching Transformer

- New Matching transformer
- Transforms extra power to a higher voltage (shock performance)
- Increased field power supply
- For a similar test, required output voltage of amplifier - armature supply will be significantly lower



# V9940 Hydraulic Unit

- HBT slip tables use a stand-alone hydraulic pump for the bearings.

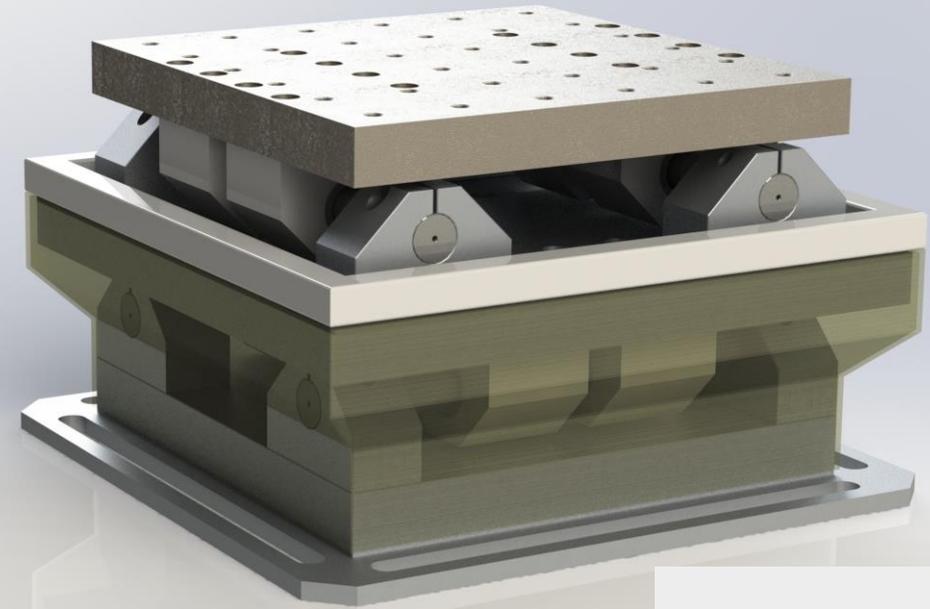


# Head Expander, Slip Table & Pedestal Layouts

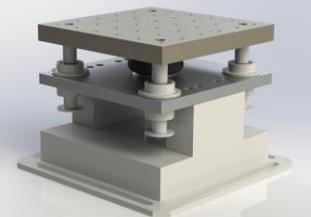
# V9940 Pedestal Bearings

## LARGE HEAVY EV BATTERY TESTING

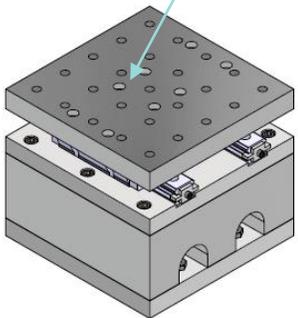
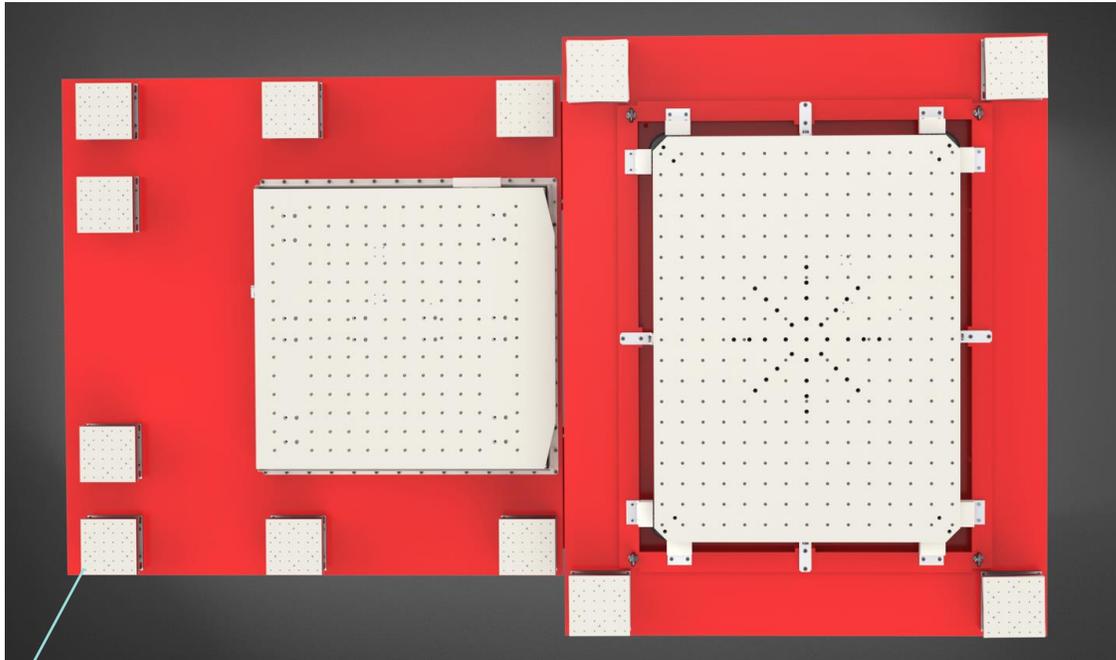
- Pedestal bearings are used to support the test load of large EV assemblies – instead of a full size slip plate
- Can be positioned around the perimeter of slip table to reduce moving masses
- 300 x 300 mm mounting surface
- Paired journal guide bearings for displacement in excitation axis
- Allows thermal expansion of EV battery
- PTFE lined housings



*The Vertical Pedestal Bearings combines four journal guide bearings and single load support airbag, giving a 300 x 300 mm surface area similar to a small head expander.*

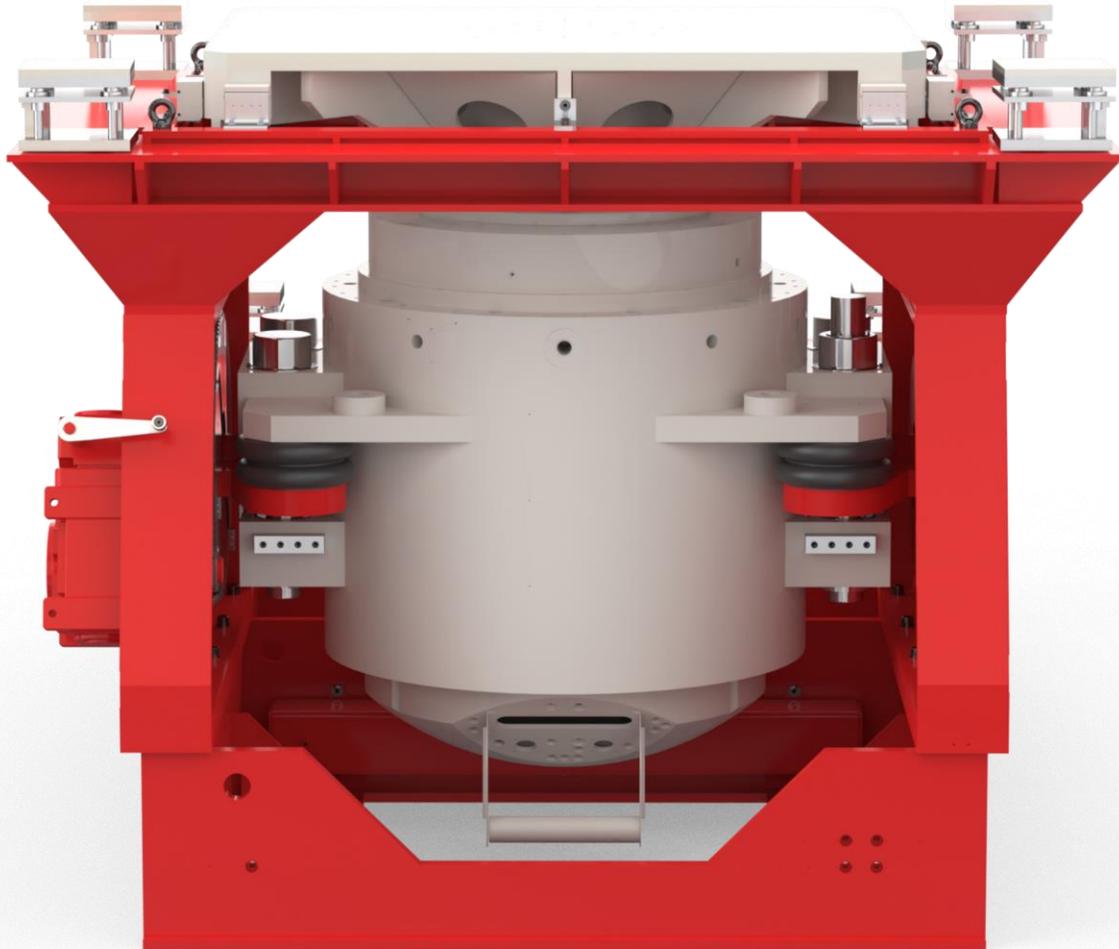


# Pedestal option for sliptable - smaller HBT1500 table with separate pedestal bearings

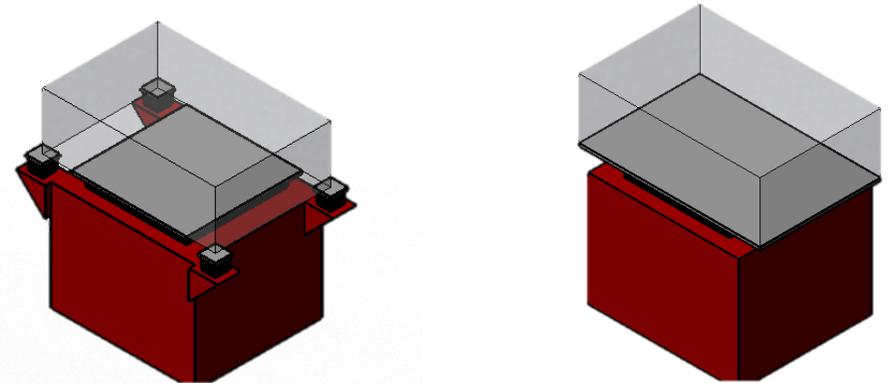


- Moving mass minimised for particular payload orientation / size
- Lower moving mass, higher resonance, improved dynamics
- Lower force required to achieve customer test
- Flexibility in number and positioning of Pedestal Bearings

# Pedestal option for Head Expander



- Moving mass minimised for particular payload orientation / size
- Lower moving mass, higher resonance, improved dynamics
- Lower force required to achieve customer test



## Sliptable – Option with single surface

### HBT2500 TABLE

#### Pros

- Simplest surface for attaching payloads

#### Cons

- Always have to move the full 2,5 x 2,5 m table
- **Higher moving mass, lower resonance** and therefore more complex dynamics than a smaller plate
- Higher force required to achieve customer tests



# Options for Slip Table Solutions –

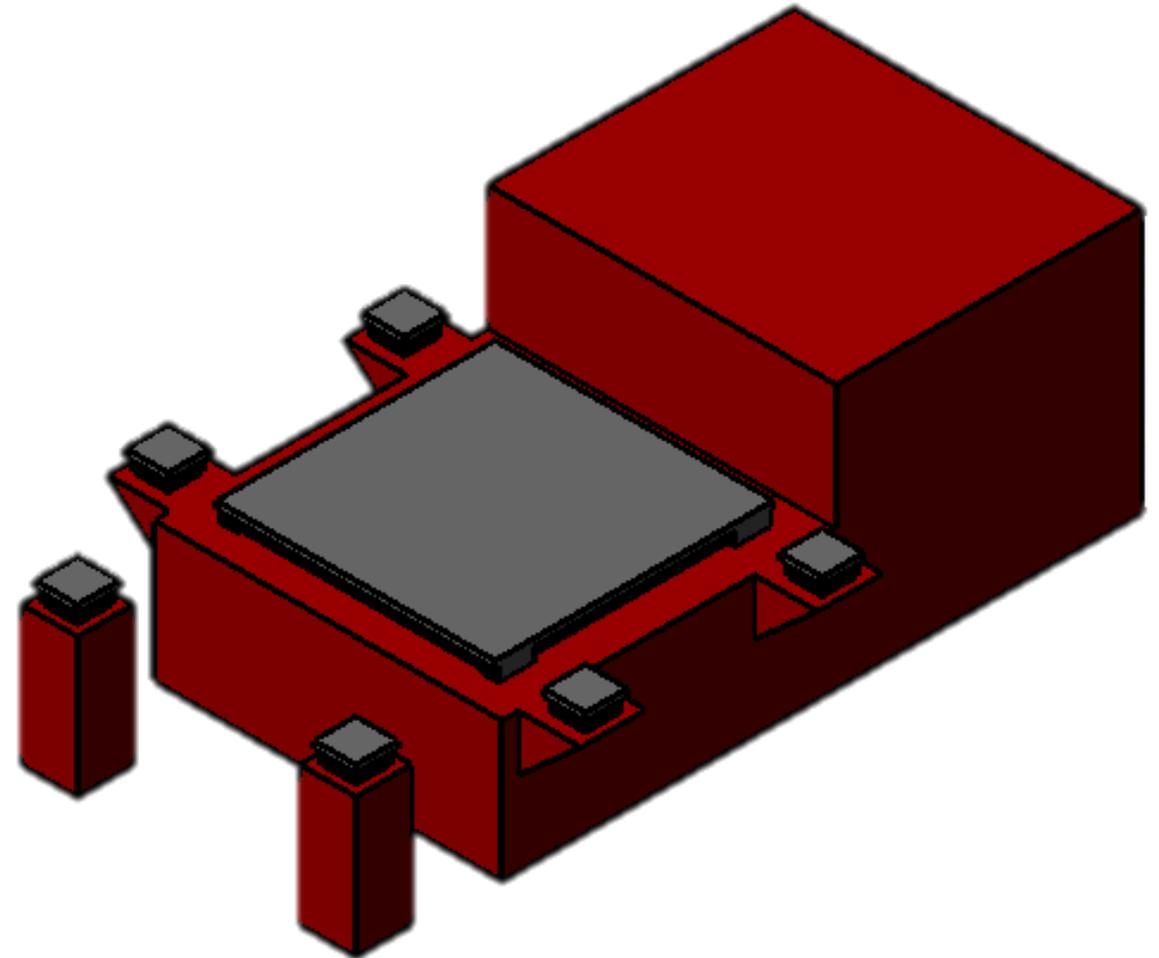
## SMALLER TABLE 2X2 WITH SEPARATE OUTRIGGER PEDESTAL BEARINGS

Pros (compared to 2x1.5)

- Less use of pedestal bearings for longitudinal testing

Cons

- Minimum moving mass for testing of smaller footprint payloads is increased



OTHER CONFIGURATIONS AVAILABLE ON REQUEST

# Increased System Performance

# V9940 + DPAK – System Performance

Technical specifications – payload mass (kg)

- ▲ Capacity can accommodate even the largest battery packs – up to 1.5 tonnes
- ▲ Hardest shock tests available even for XXL battery packs
- ▲ 50 g 6/11 ms small to medium battery sizes

Total Moving Masses, **excluding DUT and Fixture:**

Total Moving Mass  
(Vertical, Z):

## V9940 GHX1500 + Pedestals

450 kg GHX1500  
+ 85 kg Thermal Barrier  
+ 4x 16 kg Pedestals incl. TB

**599 kg**

Total Moving Mass  
(Horizontal, X/Y):

## V9940 HBT1500 + Pedestals

+ 440 kg Slip Table HBT1500 incl.  
HBT bearings, Drive Bar  
+ 32 kg Extension Bar  
+ 85 kg Thermal Barrier  
+ 4x 17 kg Pedestals

**625 kg**

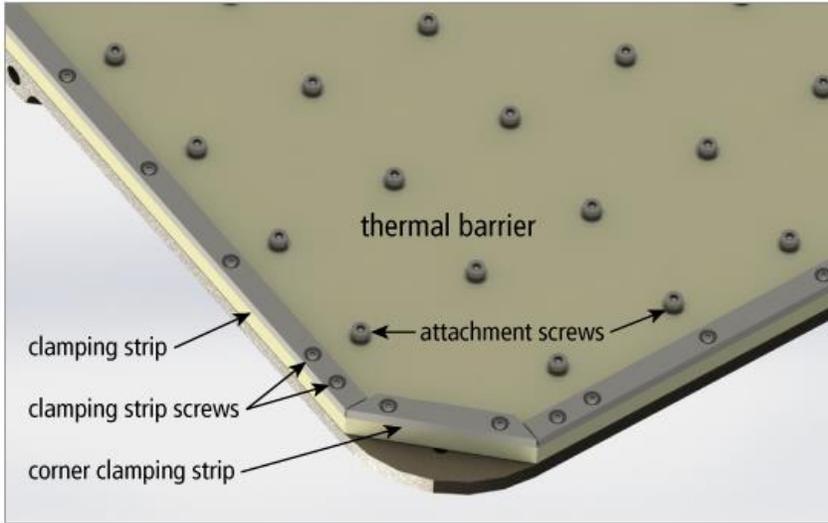
# V9940 Climatic Chamber Integration

# V9940 Shaker/Chamber Integration

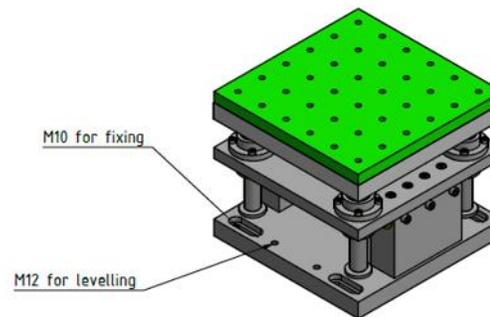
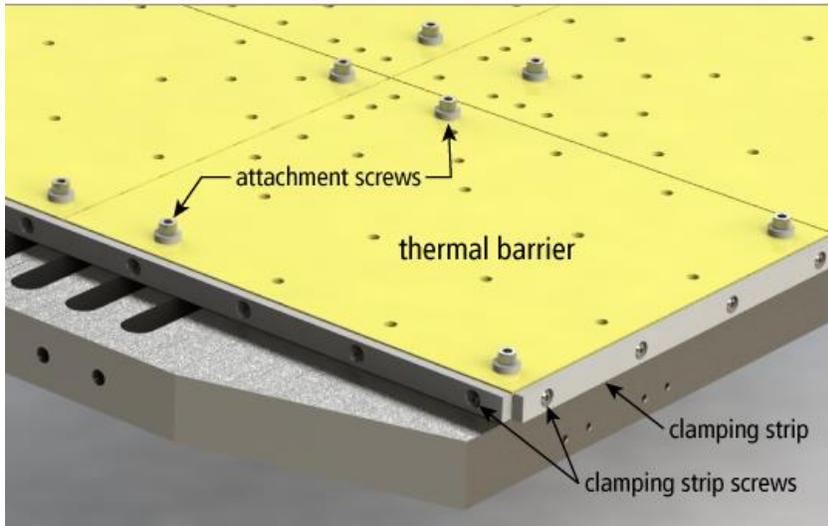


- ▲ The related parts of the control systems are designed so that they comply with Safety Performance Level **PL=d with structure category 2** as described in ISO 13849-1:2015. The installation will need to include interlocked gated access to the identified danger zones around each system.
- ▲ The V9940 shaker is **hermetically sealed** so is ideal in case of thermal runaway of the battery.
- ▲ **Communication with climate chamber and with a higher-level automation system** is possible with programmed Digital I/O signals from the controller. For safety-related signals potential-free contacts are provided as well.
- ▲ **Thermal management options** available for:
  - High pressure water spray/mist
  - Humidity
  - Flooding - New technical concept together with Weiss Technik...

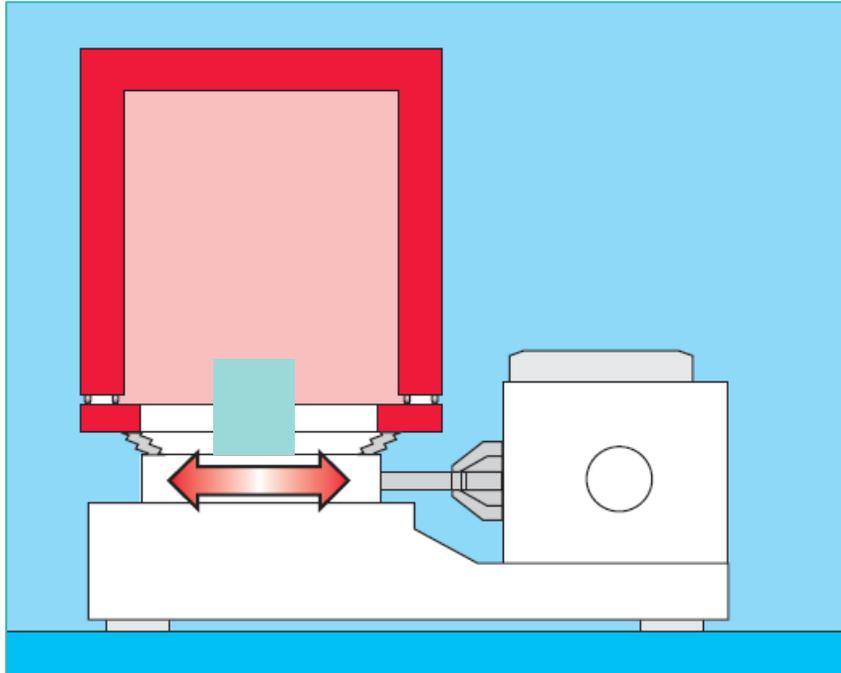
# Thermal Management Options



- Thermal barriers (on slip plate, head expander and pedestals)
- Low thermal conductivity with very high compressive strength
- Effective for battery testing application
- Resistant to: electrolytes, water-glycol coolant, gear box oils & gases (H<sub>2</sub>, CH<sub>4</sub>, CO, CO<sub>2</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, etc.)
- Hot and cold units used for tempering the slip plate and oil

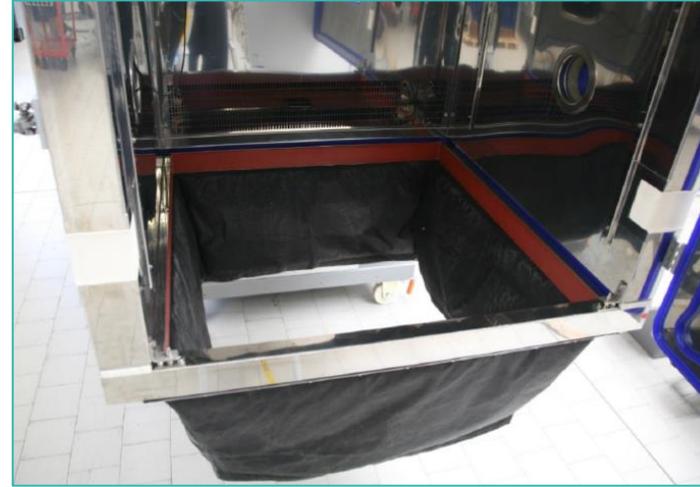


# Traditional Horizontal Connection to Slip Plates

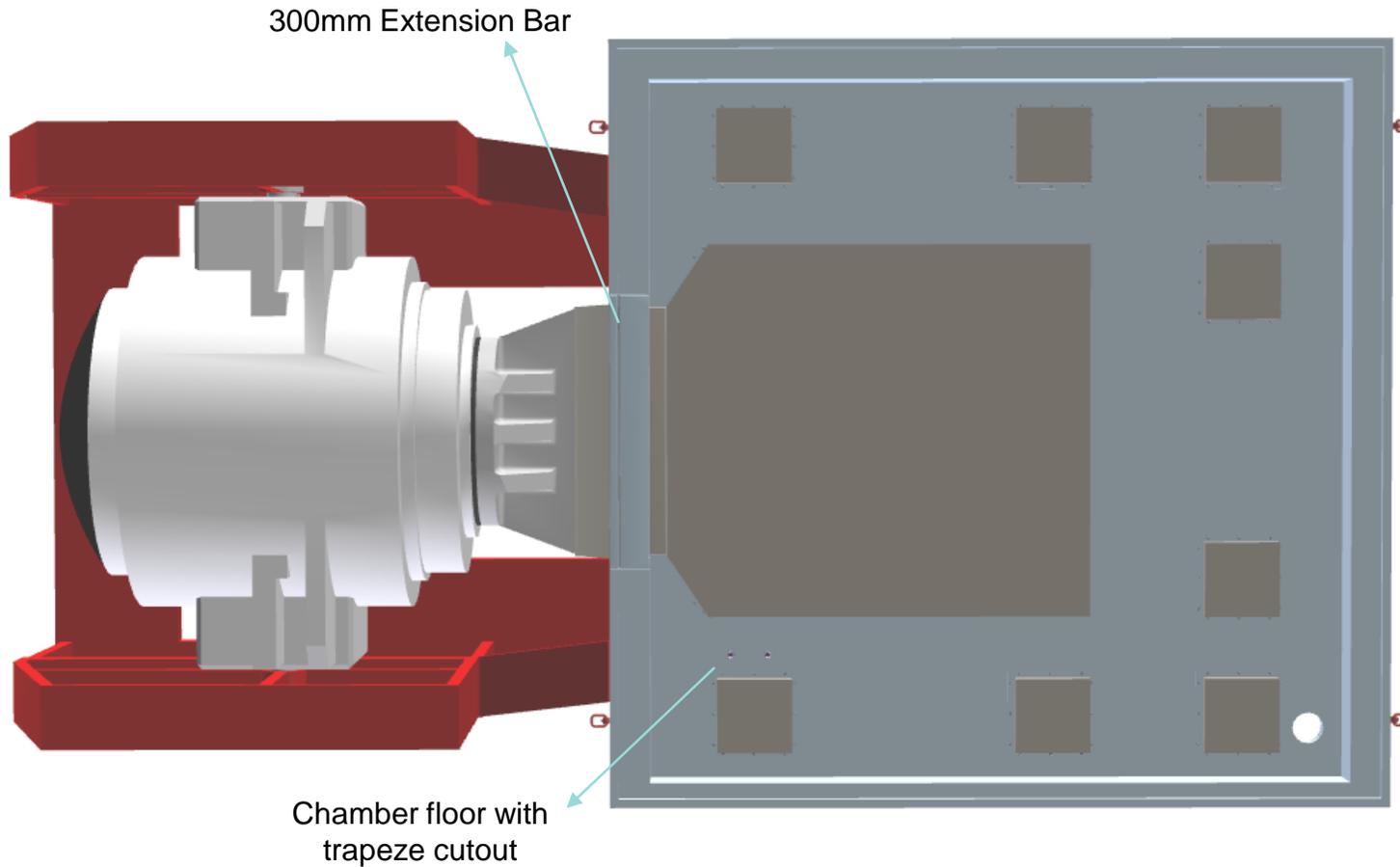


*Typical connection*

- Height difference between slip plate and chamber floor
- Outside of the chamber
- Standard sealing with clamping strips and membrane



# Special Horizontal Connection to Sliptable for V9940

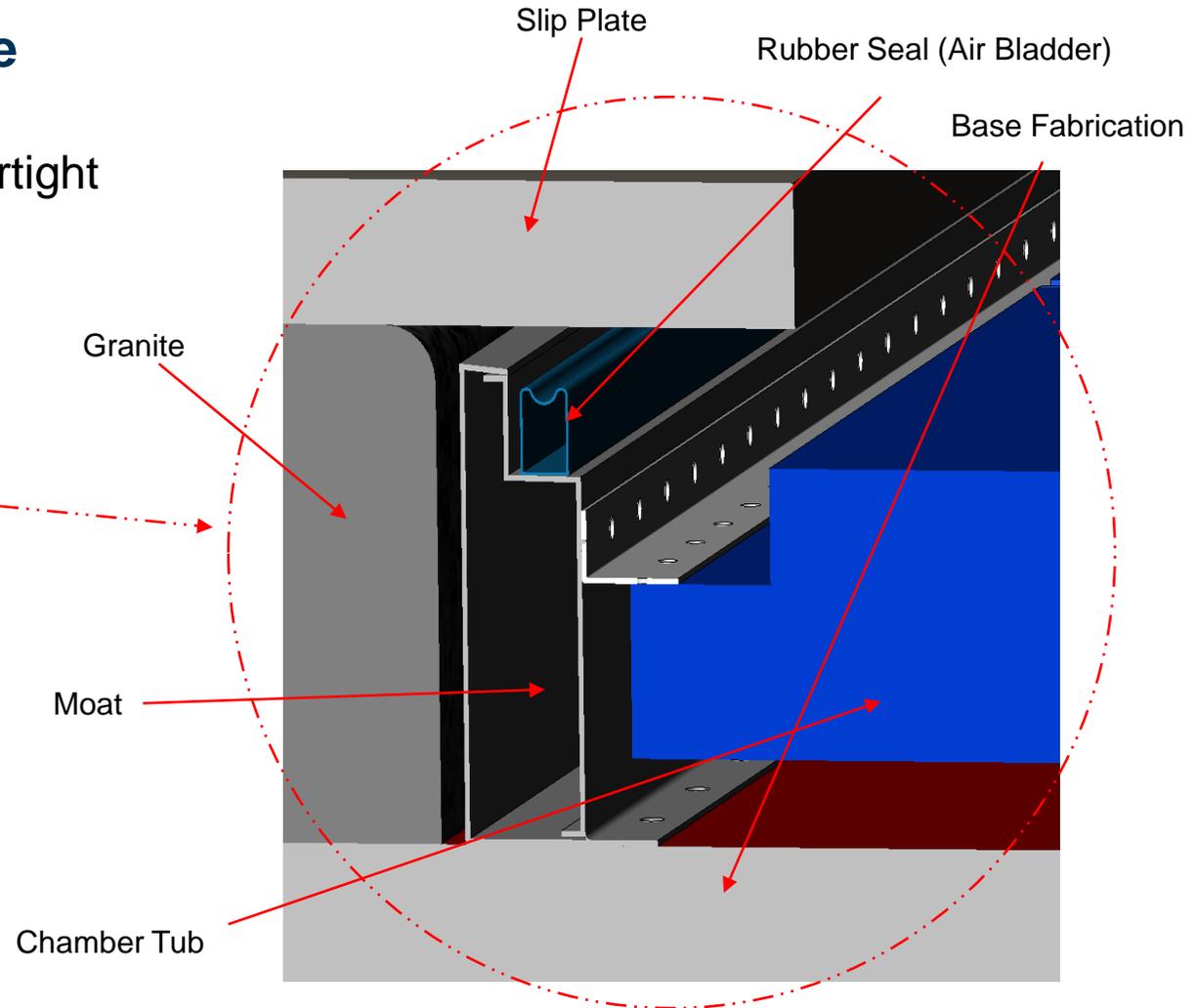
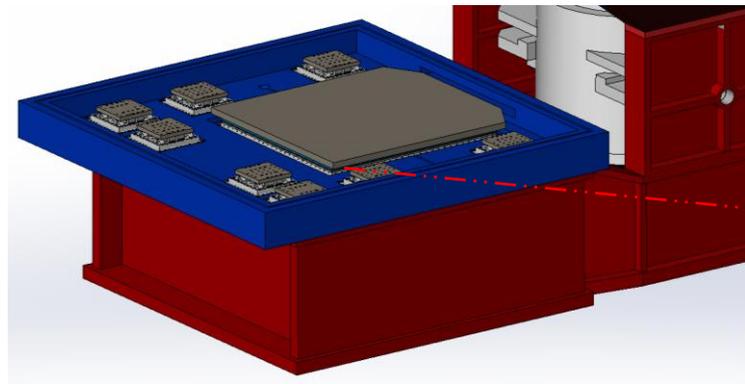


- Extension Bar for V9940 + Chamber floor with Trapeze Cutout
- With extra cutout for driver bar
- No height difference between slip plate and chamber floor
- DUT is housed well within the chamber

# Weiss Technik / HBK Flooding Concept

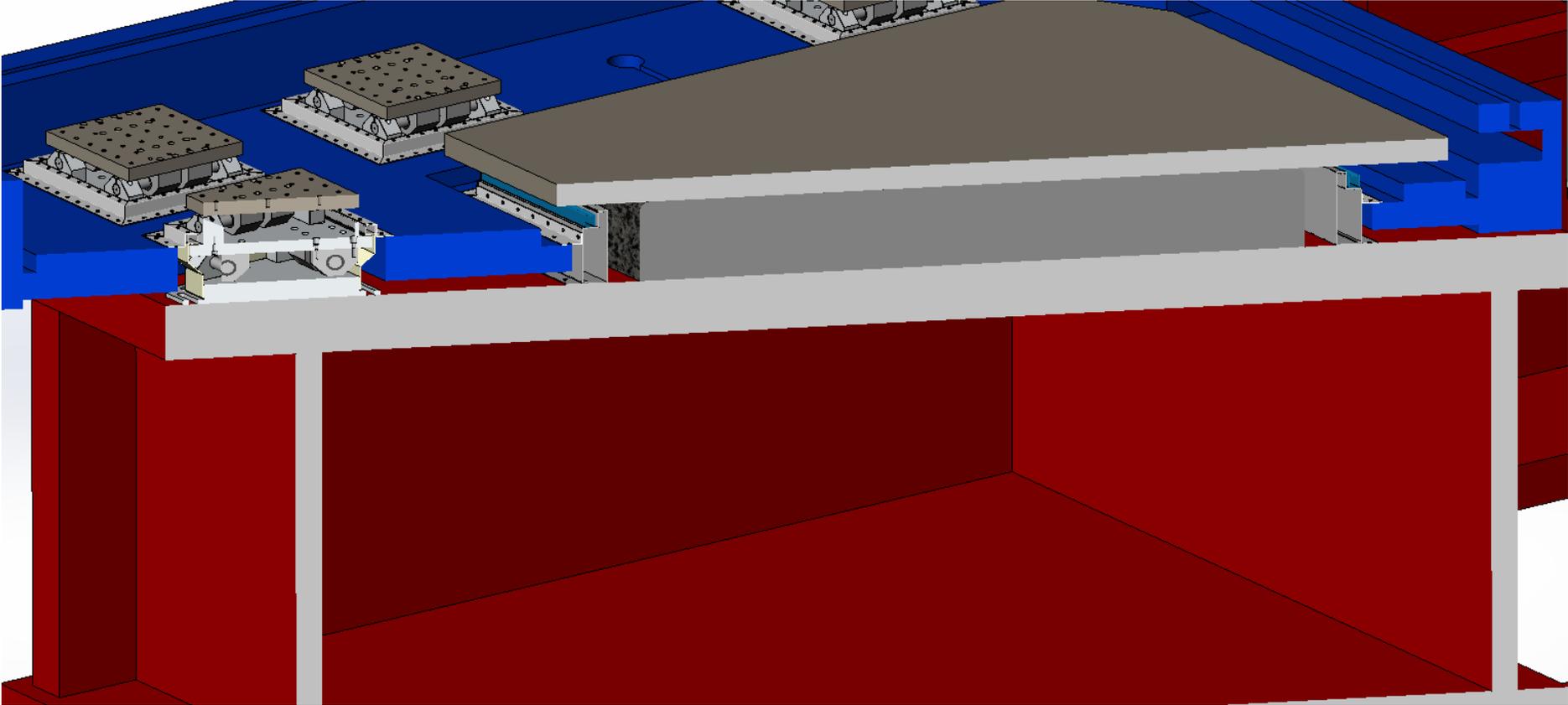
## Floodable system – Slip Plate

Air bladder inflates making a watertight seal

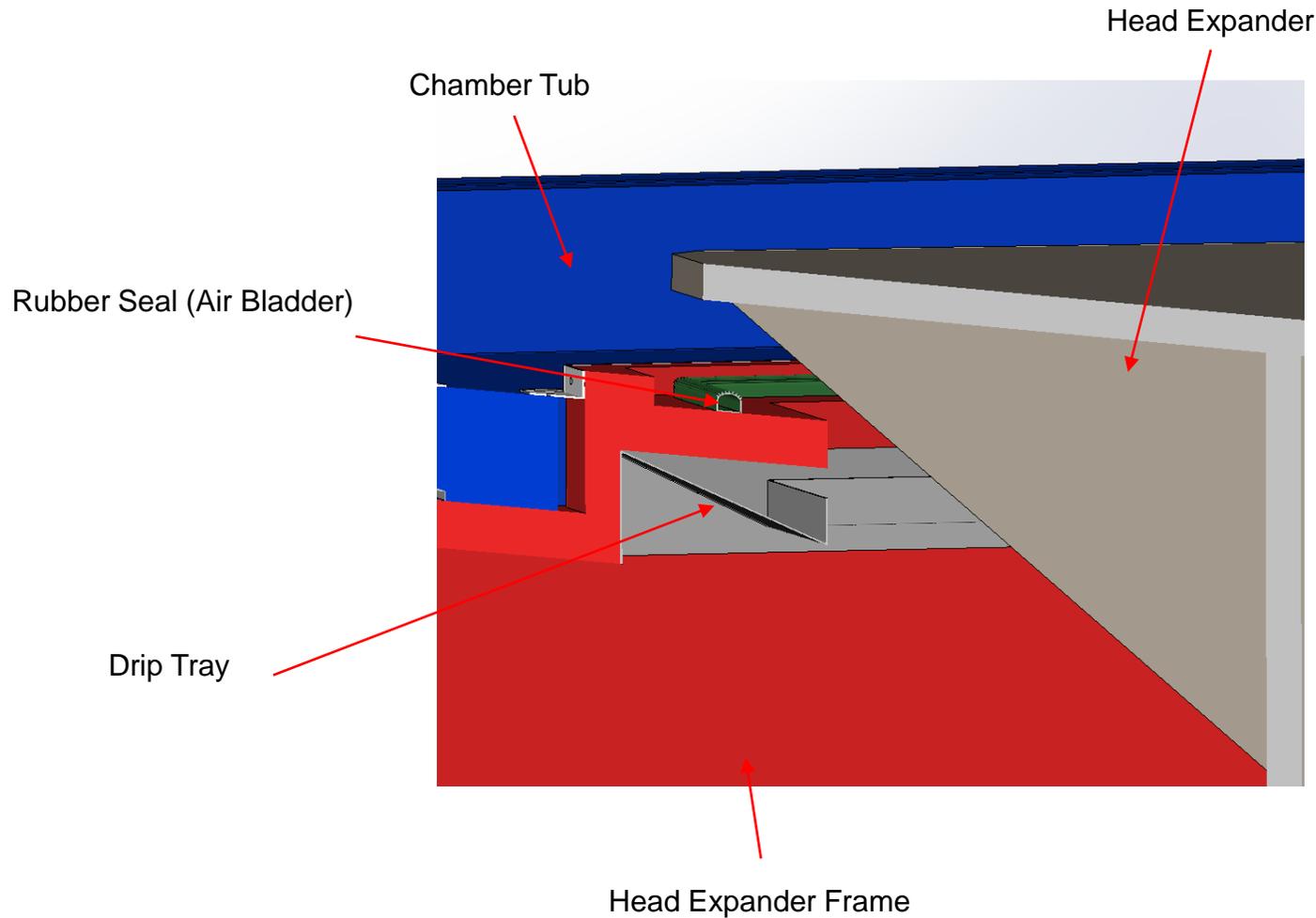


- With extra cut-out for driver bar
- No height difference between slip plate and chamber floor
- 300 mm extended driver bar

# Floodable system – Slip Plate - Concept



# Floodable system – Head Expander - Concept



When chamber needs flooding due to battery overheating, shaker armature drops into lowest position and air bladder inflates making a watertight seal. Water leakage protection of the shaker is a drip tray and channels taking any water away from the shaker system.

# The Customer Journey....

# The HBK VTS Customer Journey

## PROJECT SALES OFFICE

- ▲ High investment in a full battery testing solution comes with risk
- ▲ At HBK, the Project Sales Office handles requirements that lie outside standard specifications and, in many cases, makes customer visions a reality.
- ▲ Turnkey projects achieve Go-Live swiftly and smoothly, and provide customers with faster time-to-market.
- ▲ Services include:
  - ▲ Pre sales support
  - ▲ Project management
  - ▲ Engineering/technical support
  - ▲ Experience in working with system integrators, and 3<sup>rd</sup> parties for full turn-key offerings
  - ▲ FAT and SAT
  - ▲ Installation
  - ▲ Training from the HBK Academy
  - ▲ Decades of experience



The HBK VTS Royston, UK site - did you know?

- Runs on 100% renewable energy
- Holds accreditation to ISO Quality, Safety and Environmental Management
- UK designed, sourced and manufactured products
- Signed up to net zero by 2030



# Global Service Support

## GLOBAL SERVICE SUPPORT

- ▲ Our services are designed to minimize downtime, maximize the life of your equipment, and avoid unplanned repair costs.
- ▲ Improve test quality by keeping your vibration test system well maintained
- ▲ Increase the lifetime of your vibration test system with consistent professional servicing and maintenance
- ▲ Maintain your product's specifications by using HBK's own trained technicians
- ▲ Extend the intervals between servicing, and improve the return on your investment
- ▲ Manage operational costs through planned maintenance and servicing
- ▲ Multi-tiered service contracts, dependent on your needs



# V9940 + DPAK Shaker System – wrap up

- ▲ Half Sine Shock performance 800 kN (2 ms pulse)
- ▲ Optimised slip table/head expander designs
- ▲ Minimised moving masses
- ▲ Payloads of up to 3m as standard (other sizes available on request)
- ▲ Full project management support for turnkey solutions
- ▲ Compatibility with climatic chambers with options for thermal management
- ▲ Global Service Support with multi-tiered service levels



# Questions

Any questions, please contact  
[tim.gardiner@hbkworld.com](mailto:tim.gardiner@hbkworld.com)



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