Summary of Capabilities

1. Company Overview:

Established in 2018 aerospaceHV supports companies in the design of insulation systems for use in transportation applications. We support all stages of the product lifecycle ranging from design and development, testing and long-term asset management. aHV was incorporated based on a clear need for specialist capability to deliver testing associated with a move to higher voltage electrical propulsion systems.

Since 2018, aHV have established state-of-the-art lab space incorporating test capabilities that allow us to explore all key insulation degradation mechanisms including electrical, thermal, mechanical and chemical. We support our project delivery process with a robust quality management system as per our recommended ISO9001 and AS9100 certifications.

Our team of dedicated engineering staff have extensive experience and data-sets built up from the completion of over 130 projects to more than 30 customers[1]. Our project delivery philosophy is based on technical partnership and knowledge transfer to ensure our customers gain as much as possible from the testing we do together. Through this collaborative approach, our world leading experience and insight from thousands of data points enables us to ensure that the design of tests and analysis of our customer's product developments is completed as efficiently as possible.

This document provides an overview of our consultancy and test offerings that, paired together, provide a resource that is globally unique. We are passionate about helping accelerate the drive to Net Zero and love to talk technical. If you're interested in learning more about aerospaceHV, or have any technical questions, please get in touch with us using the contact details at the bottom of this brochure.

2. Consultancy Capability

aerospaceHV staff have been actively engaged in the electric transport sector over the past 20 years, working with some of the biggest names. We have contributed to the development of standards that support the creation of reliable, efficient, and power-dense solutions. Over this time these have developed proven design support solutions such as the following:

- Software calculators to assess the electrical clearances required in a system operating at varying temperature and pressure
- Design level partial discharge (PD) inception voltage assessment for cables, connectors and electrical machines including determining the classification of a machine as Type 1 or Type 2 according to IEC 60034-18-41/42 standards
- Detailed understanding of creepage distances and their specification as a function of the expected level of surface pollution
- Interpretation of data sheet information to ensure suitability of insulation systems for specific designs
- Data on insulation ageing mechanisms and likely impact on long term performance of component/ system
- FEA modelling capabilities including electric stress, temperature rise and mechanical stress.

[1] Data to September 2024

3. Test Capability

Our passion lies in the development of bespoke test systems to provide the most reliable, repeatable and, above all, representative test environments possible to help our customers to accelerate their design and validation processes while also supporting the condition monitoring through long-term testing of finished products.

The next pages provide an overview of our short and long-term test capabilities.

3.1 Short Term Testing

The following table provides details of our short-term test capability. This is often used in the development process of new products, as part of a quality assurance programme or to identify failure modes in existing products. Testing is generally carried out to recognised IEC / ASTM standards although these are often modified to account for the specific environment within which a device will be operated. All testing can be carried out at a range of pressures and temperatures as required. Measuring the quality of products before high voltage test is often desirable and is done using techniques such as insulation resistance measurement and dielectric spectroscopy. In addition to the below we therefore have a range of suitable equipment at aerospaceHV and access to a wider portfolio of advanced analysis equipment (such as X-ray tomography) through the Manchester based Royce Institute.

The following list is not exhaustive so please contact us if you have requirements that are now listed.

Test Type	Example Standards	Description	Technical Specification
Breakdown voltage testing	BS EN 60243-1:2013 ASTM D149-20	Manual and automated breakdown voltage testing where a sample is energised with a ramping voltage until the sample fails, or a predefined limit is reached. Testing usually results in the failure of the test object and many samples may be required to provide statistically significant data about a material or product choice.	Up to 30 kV – testing available using DC, AC frequencies between 50 Hz and 2 kHz and using square wave voltage pulses (frequency of up to 100kHz)
AC & DC Partial discharge testing	BS EN 60270:2001+ A1:2016	PD testing according to IEC 60270 and particularly suitable for off-line systems. Testing is more sensitive at lower levels of frequency (e.g. 400 Hz) but our capability allows for measurements using AC frequencies up to 2kHz and measurements with DC. Multiple samples are often required to provide statistically significant PDIV and PDEV test data.	Omicron PD measurement system suitable for use at AC frequencies of up to 2 kHz and for DC voltages of up to 15kV.
Partial discharge testing (IEC 61934)	BS EN 61934:2011	PD testing using antenna based detection methods according to IEC 61934 and provides an ability to measure partial discharge in systems energised by power electronic converters. The fast rise times of these converters render conventional partial discharge detection equipment unusable owing to high levels of noise.	Custom designed antenna (developed in project with NPL) detection system. Voltage sources can be provided by aerospaceHV (up to 6 kV at 20 kHz or 24kV at 100kHz) or supplied by the customer. Capability to measure PD in operating power converter.

Test Type	Example Standards	Description	Technical Specification
Temperature rise testing	BS EN 2591-202:1996 BS EN 2591-208:1996	Assessing the temperature rise of components as high current passes through them is often essential and with the increasing use of high frequencies, the consideration of the skin effect or proximity effect is vital.	Up to 2000 A (depending on the nature of the test object) at low voltage. DC and AC frequencies between 50 Hz and 2 kHz.
Creepage distance testing	IEC 60664-1: 2020 IEC /TS 60815-1:2008	To evaluate the suitability of creepage distances within the aerospace environment a unique test rig was developed. This subjects a component to a high voltage while it is cycled through multiple ascent / descents. Humidity is introduced into the chamber during the descent phase at appropriate pressure levels / altitude with the test object usually being cooled to ensure the control of the location where it is depositing the most condensation. Testing can indicate the number of cycles at a specific voltage until failure or can identify the level of voltage required for a specific leakage current to flow.	Up to 30 kV – testing available using DC, AC frequencies between 50 Hz and 2 kHz and using square wave voltage pulses (frequency of up to 100kHz).
Clearance testing	IEC 60664-1:2020	The voltage applied across two electrodes is increased at a steady ramp rate (usually 50 V/s) until flashover occurs.	Up to 30 kV – testing available using DC, AC frequencies between 50 Hz and 2 kHz and using square wave voltage pulses (frequency of up to 100kHz).
Pollution testing	IEC /TS 60815-1:2008 IEC /TS 60815-2:2008 IEC /TS 60815-3:2008 IEC 60507:1991 AST M D2303-13	Complex and simple systems can be coated at a known pollution level.	According to the type of the pollution level: Class 1: Low pollution severity Class 2: Moderate pollution severity Class 3: High pollution severity Class 4: Very high pollution severity. Insulation material selection, creepage distance and pollution performance are required.
Salt fog testing	ASTM B117 IEC 60068-2-11	Salt fog testing according to instructions in RTCA DO 160.	Testing uses the environmental conditions given in the standard within our salt fog tester to cover electrical and insulating test samples with a known level of contaminant.
Insulation dimensional measurements	ASTM D3032 ASTM D374	This test is to be used to determine the finished wire specimen diameter - the micrometer method for the equipment necessary to perform this test. For the wire weight testing a specimen at least 10 feet (3 m) long is required to convert these measurements to pounds per 1000 feet (kg per km).	Micrometer capable of measuring to the nearest 0.0001 inch (0.0025 mm). Determine the conductor diameter by measuring the outer diameter in at least three locations, approximately equally spaced along the length of the specimen.
Conductor resistance	ASTM B193-20 ASTM D257- 14	This test is to be used to measure or calculate the DC resistance per unit length of a conductor at 20 °C (68 °F).	A suitable DC current source for the resistance measurements.

Test Type	Example Standards	Description	Technical Specification
Dielectric constant testing	ASTM D150-20 ASTM D271-14	This test is to be used to determine the dielectric constant of an insulation and provides information that will help understand the electric field distributions and partial discharge inception voltage in a complete system.	Measure capacitance with LCR tester and dimensional measurements to determine the dielectric constant accurately. The equipment is able to measure the frequency range (20 Hz to 300 kHz) specified in the standard or required by the test.
Insulation resistance / Dielectric Withstand	ASTM D257 IEC 60243-1	This test is used to determine the insulation resistance of a finished wire specimen. Insulation resistance is of interest in high impedance circuits and as a measure of quality control. Changes in insulation resistance may indicate deterioration of other properties.	Dielectric Withstand tester with testing voltages up to 5 kV AC 22 mA and 4 kV DC 6mA.

3.2 Long Term Testing

The following table provides details of our long-term test capability. This is often used to understand the long-term failure modes of equipment and to estimate time to failure when operating in service. Other stressors (such as vibration) can be incorporated into the purpose built test systems that we have developed.

Test Type	Related Standard	Description	Technical Specification
Electrical endurance testing	ASTM D2275-22 and IEC 61252:2015	Generally testing up to 10 samples in parallel (depending on capacitance), our electrical endurance tests allow the time to failure of components to be measured when they are stressed with high voltage. Leakage current monitoring is usually used during testing to highlight any specific degradation that takes place during the course of the test. Testing can take a few hours through to a few weeks / months depending on the nature of acceleration applied to the test object.	Voltages up to 15 kV with DC, 30 kV to AC up to 2 kHz and up to 24 kV squarewave using 100 kHz squarewave voltage pulses.
Thermal ageing and cycling	ASTM D5374-22a, ASTM D5423-23, BS EN 60216: 2006 and BS EN 60216-7-2:2016	It is necessary to thermally age samples at temperatures of up to 300 °C with higher temperatures. Furthermore, there is a test rig that delivers specific temperatures by passing current through test samples. A rapid increase in load current can cause a significant temperature rise. Test samples can be used in an ambient environment down to around -45 °C with experience of cycling components at temperatures exceeding 200 °C. Thermal ageing / cycling can be combined with partial discharge and breakdown testing / microscopy to understand the impact of ageing on the electrical performance of the test object.	Thermal cycling: With AC using capacitive compensation and at frequencies from 400 Hz to 2000 Hz at currents up to 2000 A With DC at 10 V / 1020 A or 80 V / 340 A Thermal ageing: Temperatures of up to 600° C within a circulating air furnace. Also, oil flow can be used in this testing.

Test Type	Related Standard	Description	Technical Specification
Vibration	IEC 60034-18	Vibration shaker capable of sinewave or random testing. Generally used as stand-alone system following thermal ageing testing of insulation as part of lifetime analysis campaign.	Max force of approx. 1.5 kN and 100g maximum acceleration (DC to 5 kHz bandwidth).
Weight Loss Under Temperature and Vacuum	ASTM D3032	This test is used to determine the weight loss from a wire specimen when subjected to vacuum and temperature. Some preconditioning might be required.	Operation should be submitted to temperature and vacuum to reach 44.4 mbar or lower and a specific temperature up to 250 ° C.
High Temperature Endurance	ASTM D3032	This test determines the ability of the insulation to resist degradation due to exposure to a high temperature. Test sample shall consist of one continuous length of at least 24 feet (for inside the oven) and an additional length to attach to the current source outside the test oven.	Oven to manage testing at 250° C. AC or DC constant power supply.

4. Upcoming Capability

Test Type	Related Standard	Description	Technical Specification
Comparative tracking indices (CTI)	BS EN 60112:2003	Development of mechanical enclosure within which the CTI test can be operated, procurement of test electrodes, development of the electrical circuit and test.	Voltages up to 600 V at 50 Hz.
Oil flow	BS EN IEC 63177	By passing a high current through the windings and controlling temperature dissipation with oil flow through the sample. A capability to create a universal holder to be explored after initial testing is completed.	Oil flow up to 60° C and must not be hotter than 150 °C. Samples temperature must not be higher than 200 °C. Flow rate of the system should be regulated between 5 to 10 l/min.
Arcing	SAE AS4373 – Test Method 509: Wet Arc Propagation Resistance	The wet arc-resistance test for wire insulation provides an assessment of the ability of cable insulation to prevent damage when exposed to specific environmental and electrical conditions. It is a critical test for wire insulation to make sure they have an adequate behaviour under severe conditions. The insulation resistance to wet arcing is then measured by the extent of damage and the length of the propagation along the insulation surface.	80 V 340 A DC power supply is to be used with an appropriate arcing ignition mechanism.

5. Training Services

Empowering our customers through knowledge transfer is central to our vision of accelerating the journey to NetZero. We do this through delivering teaching products both face to face that cover the complete spectrum of electrical insulation system design and testing.

5.1 Face to face:

Leveraging our considerable experience in the development of high voltage insulation systems used in both electricity transmission / distribution and transport applications, we offer a range of training courses. All our face to face courses are delivered by our Technical Director, Prof. Ian Cotton who has a global reputation as one of the leading industry figures in electrical insulation system design. Ian has a lifetime of technical experience through his role teaching at the University of Manchester which he still performs on a part time basis. As well as the core training syllabus these sessions also provide a unique opportunity to tailor the material to specific client requirements.

5.2 Knowledge Transfer Portal:

Since 2018, Ian has delivered our courses to engineers working in some of the largest organisations from across the world. While these sessions are very well received, during the same period we have seen an unassailable increase in demand given the needs in the sector for skilled personnel. To help meet this growing customer base, aerospaceHV has recently launched a dedicated on-line training and knowledge transfer platform, found via portal.aerospacehv.com. While courses will be available for purchase at an individual level, our aim for the portal is to provide a long-term subscription based service to enable us to support the needs of our customers over the long term. Because we are constantly growing our knowledge from the tests we perform in the lab each year, so the information on the portal will too. This means that the portal will continually to grow in sophistication to meet the increasingly sophisticated of industry through the provision of:

1. **On-demand training** with dedicated courses ranging from basic to advanced

2. **Software calculation tools** to provide independent verification of user design calculations

3. **Materials Database** providing independent and consistent empirical information on the most frequently used materials and components.

4. **Frequently asked questions:** Portal users will have a capability to get answers to questions that they can't find within the courses. These answers will all be sanitised to ensure all confidentiality measures are met and then published in the FAQ section on the portal. Our aim is that never again will an engineer have to rely on unsubstantiated information found on google!

6. Contact Information

If you would like to know more about aerospaceHV, and any of services that we have described above, or simply have a technical question that you can't answer on google, then please get in touch using the contact details below:

David Chambers, Managing Director: d.chambers@aerospacehv.com +44 7866569641

Ian Cotton, Technical Director: ian.cotton@aerospacehv.com +44 7904183154

aerospaceHV contact number: +44 7410580864

7. Our team

Ian is Technical Director at aerospaceHV. He is one of the leading figures in the development of aerospace high voltage systems and has been involved in a number of research projects through his employment at The University of Manchester. He has worked in the area of aerospace HV systems for over ten years, ensuring he has state of the art knowledge. He is a Chartered Engineer registered with the UK Engineering Council and has been involved in the design and test of a number of systems in use on the Airbus A350 and Boeing 787 aircraft, working with the component supply chain to ensure their products were fit for use. More recently he has worked on some of the electrical platforms being developed by both start-ups and Tier 1 suppliers. His experience includes practical testing of systems within HV laboratory environment and the development of techniques to age equipment. Ian led the work to draft the SAE Aerospace Information Report 'High Voltage. Systems In Aerospace Environments'. He has provided training courses to a range of companies including Airbus, Boeing, Ultra Electronics, GE Aviation, Amphenol and GKN ad.

David is the Managing Director at aerospaceHV. He has a Master's degree in Mechanical Engineering and specialises in the innovation process with wide ranging technical experience across High Voltage equipment design, composite materials and testing, including the design and build of bespoke test rigs. David developed both a technical and commercial background through employment with composite materials consultants EPL Composite Solution Ltd (now Haydale Composite Solutions). Since leaving EPL in 2014, David then established his own engineering consultancy Innovation to Industry Ltd (I2I), with the objective of supporting companies in the safe introduction of cutting edge product solutions within their existing product portfolios. Through I2I, David has successfully delivered a range of projects for companies and institutions such as National Grid, The University of Manchester and Kinectrics Inc. He is a Chartered Engineer registered with the UK Engineering Council. In parallel with his extensive technical experience, David has over 15 years' of management experience within small, fast paced companies where the focus is on delivering exceptional quality and value and responsiveness, within un-paralleled lead times.

Richard is the Senior Engineer at aerospaceHV. He is a multidisciplinary engineer with a skillset based in research and development. He completed his undergraduate degree in mechanical engineering from The University of Manchester. He then completed an Engineering Doctorate (EngD) in modal testing of Magnetic Resonance Imaging (MRI) scanners. Following his doctorate, he continued his career in research by taking a role as research associate within the school of electrical engineering. This project focused on acoustic pulse reflectometry as a means to survey gas pipelines for blockages and leaks. In 2014 he moved into the high voltage group, still at Manchester University, and began working with insulation systems for the aerospace sector. This project focused on furthering the understanding of ageing mechanisms seen by electrical insulation systems on More Electric Aircraft. He further embedded himself within electrical engineer when he took the role of high voltage lab manager at Manchester, where he oversaw the design, build and commissioning of the state-of-the-art high voltage labs as part of a new campus development. In parallel with being high voltage lab manager, Richard began working part time to develop test capability for aerospaceHV. Finally, Richard moved away from academia to join aerospaceHV as a Senior Engineer. His area of interest is mainly in optimisation and automation of new and existing test rigs.

Hasti is the Research and Development Manager at aerospaceHV. Initially a graduate of Chemistry, Hasti conducted her research in the Electrical Materials area, investigating the implications of increasing high voltage on next generation hybrid electric aircraft. Her Ph.D. was part of the first hybrid electric aircraft demonstrator, the E-Fan X, launched and propelled by Rolls-Royce, Siemens and Airbus which proposed to hold a 2 MW motor. Hasti holds experience as a materials researcher, and commercial knowledge within the IP sector, and technical experience in the aerospace and automotive industry. Complementing her professional experience, Hasti has facilitated conversations within the SAE AE10 committee and involved in IEEE and RSC member events. Outside of her professional lifestyle Hasti enjoys visiting both local and lesser-known areas outside of the Northwest and beyond where she can hike, birdwatch, enjoy local food and live music, off the beaten track.

Abir is an electrical engineer, currently working as Quality Manager at aerospaceHV, where she ensures adherence to ISO 9100 standards and implementing a quality management system. Recently completing her PhD in HV engineering at The University of Manchester, Abir incorporates her practical experience to assist on projects related to high voltage and arc fault testing. Previously, she held the position of Graduate Teaching Assistant for three years at the University of Manchester where she was also Chair of the IEEE student branch and the IEEE IAS student branch chapters. During the course of her PhD, Abir actively engaged in the CleanSky ARCTRACK project under the Horizon 2020 programme.

Salvador earned his MEng in Mechatronic Engineering from The University of Manchester. During his final year, played an important role in developing an online partial discharge testing project, which earned the best demonstration from all 2022 MEng projects. This experience provided valuable insights into the high voltage challenges prevalent in the industry. Following graduation, he began his career at aerospaceHV as a Project Engineer and progressed to his current role of Test Development Engineer, where he leads technical expertise to nearly every project within the company.

Will is a mathematician with BSc at the University of Manchester. Will is the Resident Statistician at aerospaceHV. Utilising his Mathematics degree to develop models of lifetime analysis in application as well as being an integral part of the project management team delivering on time and high-quality testing to our clients. Also, consistently commended to problem-solving skills.

Juliana worked for three years as a part-time Test Engineer at aerospaceHV and now she is working full-time as Knowledge Training Manager where she is involved in the development of the company's portal with essential courses, training for aerospace and automotive companies and partial discharge testing. She completed her BSc and MSc degrees in electrical engineering at the Universidade Federal de Pernambuco in Brazil in 2019. At The University of Manchester in the UK, she recently completed her PhD in the Department of Electrical and Electronic Engineering, where her project involved investigating electrical trees at the interface of polymeric materials in the HV system from a void cavity. During her PhD, she worked as a Teaching Assistant for a year and was involved in conferences and published technical papers.