



Lightning Protection Systems

DESIGN & MANUFACTURE FOR THE WIND TURBINE INDUSTRY



PolyTech is a full service engineering and manufacturing business specialising in lightning protection systems primarily for the wind turbine generator and offshore sector.

PolyTech generates new ideas by applying science and technology to new concept creation, product development, system integration, manufacture and validation - achieving world-class LPS solutions to the highest customer and end-user requirements - at competitive prices.

8 STEPS All projects partnered with PolyTech as a Full Service Supplier are compliant with APQP4Wind and committed to these 8 key steps of design and development:



POLYTECH LIGHTNING PROTECTION KEY PRODUCT PORTFOLIO

- ✓ Aerodynamic Tip Receptors with integrated internal isolation
- ✓ Tip to blade interface protection
- ✓ Side receptor systems with integrated internal isolation
- ✓ Blade Surface Protection
- ✓ High Capability Cable connections
- ✓ High Voltage Down Conductor Systems
- ✓ Blade to Hub Current transfer systems
- ✓ Full nacelle LPS systems
- ✓ LPS sensor systems



Conceptual Design

Years of experience with lightning and its hazards shape the design and manufacture of the turbine blades our customers develop. Such hands-on know-how enables PolyTech to take an existing product concept and improve it, or develop totally new ones - achieving world-class LPS solutions to the highest customer and end-user requirements.

Best practice design skills strengthen this, so that every concept takes full advantage of PolyTech's blade manufacturing skill and materials expertise.

Planning starts with functional performance, durability and certification requirements, prior to addressing system topology, feasibility studies and customer approval. Only then does the project move to the virtual prototype phase.



Virtual Prototyping

Before physical hardware or resources are committed to a project, critical elements of the concept are analysed and tested as virtual entities.

A full array of tools are used to assess the specific sub-system and critical requirements, typically to predict current flow and differential voltages between the system. Both two-dimensional (2D) lumped circuit simulation and three-dimensional (3D) electromagnetic field modelling can be employed.

The physical capability of subsystem components can be simulated in a multi-physics environment to combine electrical characteristics with joule heating of the materials.

Material properties and geometry can also be simulated to optimise the conceptual design.

This approach gives confidence in critical aspects of the concept and allows for rapid iterations in design optimisation.



Prototype Development

Physical prototype parts of either the complete system or critical sub-systems are manufactured for de-risk testing. During this phase, design for manufacturing and production process optimisation is planned, with system and component requirements set up according to functional needs and durability requirements.

A full system and sub-component Design Failure Mode & Effects Analysis (DFMEA) and Process Failure Mode Effects Analysis (PFMEA) are also developed during this phase, with the output defining the Design Verification Plan (DVP).

mechanical and environmental tests defined by the output of the DFMEA.

Once completed, the conceptual system topology is fixed and the project moves to product design and integration.



Product Development

During this phase, the system and sub-component detail design, material development and integration takes place. This process can be conducted alongside the customer engineering team, which, for optimum performance, can include co-located engineers.

Further design iterations, improvements and changes are managed from this point via a change control process. Tooling and manufacturing processes are defined and set up during this phase, and risks highlighted in the PFMEA mitigated. Risks identified in the DFMEA are addressed by further analysis and engineering tests performed accordingly.

A large element of this phase is in integrating the product into the customer system, such as a wind turbine blade, in line with their prototype build program. Any issues and risks highlighted either with the design or manufacturing process are quickly resolved by close involvement. The Design Verification Plan and Report (DVP&R) is used to manage the status of the entire project and to drive the final validation test program.



Prototype sub-system validation

The prototype parts are then subjected to a mix of dielectric, initial leader attachment, Ultra High Voltage Direct Current (UHVDC), high current and high charge testing, to verify the design against the performance requirements.

Design optimisation will be made during this phase, if required, to ensure the design conforms to the agreed electrical performance requirements. With the electrical design frozen, prototype parts are subject to critical me-

Validation and Certification Testing

Following the design freeze, off tool parts are manufactured for final validation and certification testing, in line with the DVP and closing out all remaining issues identified from the DFMEA.

Environmental and mechanical testing is performed either at our own laboratory, one of our partner laboratories or a preferred laboratory of our customer. Electrical testing is also performed either by one of our partner laboratories or one preferred by our customer. We can take full ownership of managing and running the test programme.

Test | Environmental

Full system and/or individual systems will be subject to the tests defined in the DVP. Typical in-house test elements include:

- Hot soak
- Cold soak
- Thermal cycling
- Thermal shock
- Combined humidity/thermal cycling
- Salt mist
- Fluid ingress

- Chemical erosion
- Rain erosion
- Solar exposure
- Leading edge erosion

Test | Electrical

The system performance will be tested in accordance with the test methods identified in IEC 61400-24 and the test requirements defined in the DVP. In order to validate operational life of the system, the test regime often exceeds the requirements of IEC 61400-24.

The test program is divided into to three distinct elements:

Test | High Voltage (HV) Initial Leader Attachment

The installed system will undergo HV initial leader attachment testing on either a whole blade or blade section, to verify the lightning attachment effectiveness of the system, in order to demonstrate structural protection.

Test | High Pulsed Current

All lightning threat current conduction paths and component interfaces will be tested with high pulsed current. This verifies current handling capability in terms of thermal and electrodynamic effects of conductors, and that interfaces show no evidence of arcing or spark ejection.

Test | High Charge Open Arc

Elements of the system intended to intercept direct strike attachments will be high charge open arc tested using both high initial impulse current and high total charge delivery. This verifies the robustness of the receptor system and surrounding blade surface to repeated lightning strikes over the operational life of the system and blade.

Test | Mechanical

All applicable elements of the system will be tested to verify that the system is capable of withstanding the mechanical loads experienced during transportation, installation and operation as defined in the DVP. Typical test elements include:

- Static stress and strain
- Dynamic stress and strain
- Fatigue
- Shock loading
- Vibration

IEC 61400-24 Ed2 Certification

In addition to the engineering validation testing, we can also work directly with the certification authority with respect to developing the certification strategy, producing documentation and liaison with the authority on behalf of, or in support of the customer.

Global setup

With our global footprint, high volume production, full traceability and strategic logistics setup, PolyTech is positioned to supply customers and business partners globally.

Quality and Production Part Approval Process (PPAP)

Introduction

Following completion of the development program and prior to start-up of the initial full volume production run, a PPAP process is used with the customer. The PPAP process is used to establish that all agreed requirements and specifications have been met and to give confidence that processes are in place to deliver conformity of production quality at the agreed production volumes and rates.

Design Documentation

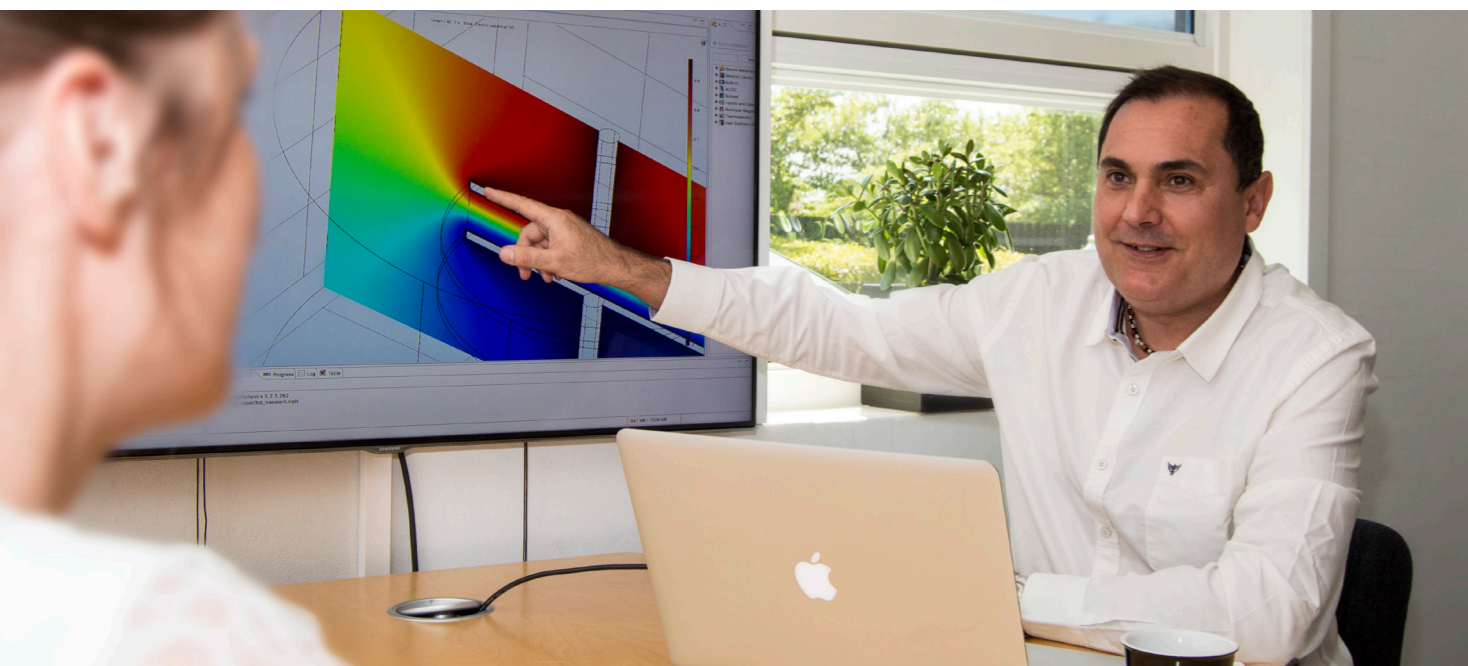
This includes all released drawings, Bill of Materials (BoM) and technical purchase specification documents. All which are critical to quality requirements shall be clearly identified.

Engineering Change Request's (ECR)

Documentation demonstrating authorisation of all changes made, and the detailed description of the changes. This document is used as a formal way for the customer to communicate all required changes and includes a complete register of them up until the PPAP.

Engineering Approval

This is a two-part approval, consisting of the minutes from the final readiness design review and the trial production run review. It signals both that the design is acceptable and manufacturing capable. In addition, it demonstrates that any certification requirements are also met - for example, by including the certificate of conformity from an approval authority.





Design Failure Mode & Effects Analysis (DFMEA)

The final DFMEA reviewed and signed-off by PolyTech and the customer shall be presented at the PPAP, ensuring that all critical and high impact risks have been mitigated.

Process Flow Diagram

The manufacturing Process Flow, indicating all steps and sequence in the fabrication process, from incoming inspection to shipping shall be reviewed and witnessed on site.

PFMEA

The final PFMEA reviewed and signed-off by the customer and PolyTech shall be presented at the PPAP, ensuring that all critical and high impact risks have been mitigated.

Quality Control Plan

The Quality Control Plan is reviewed and signed-off by the customer and PolyTech. The Control Plan refers to the PFMEA and Technical Purchase Specifications and identifies all the critical characteristics that will be measured and recorded during volume manufacturing.

Process Control and Traceability

All critical and high impact characteristics, will be measured and automatically recorded during volume production and assigned a unique identifying serial number via barcode for each part. As each Critical to Quality (CTQ) test is performed, the data from the test is automatically linked to the scanned bar code for that part and stored in a da-

tabase. A failed test prevents the specific part from progressing through the manufacturing process automatically. Statistical Process Control (SPC) is also applied to the recorded data and continually monitored.

The system also allows the final shipped parts serial number to be linked to the specific turbine or blade that the parts are fitted to.

DVP&R (Design Verification Plan and Report)

This document is the plan and status of every test performed on the system. It lists each individual test, the DFMEA reference, when it was performed, the specification, test procedure, results and the pass/fail assessment. The DVP&R will be reviewed and signed off by both customer and PolyTech.

Initial Process Studies

This report shows all SPC (Statistical Process Control) charts affecting the critical characteristics. The intent is to demonstrate a stable process in terms of variability to the nominal values.

Qualified Laboratory Documentation

Copy of all national standards certifications (DANAK/UKAS/DAkkS etc.) of the laboratories that performed the validation and certification testing.

Master Sample

A sample signed off by customer and PolyTech that is stored as a reference sample.

Customer-Specific Requirements

Each customer often has specific requirements, which will also be included in the PPAP package.

Part Submission Warrant (PSW)

This is the document that formerly summarises the approval of the whole PPAP process. This form shows the reason for submission (new system, design change etc.) and the level of documentation required and submitted linked to the specific release details of the parts.

Full service provider

Combining the skills of specialist engineers with in-house manufacturing capability and global supply chain, PolyTech is uniquely positioned to offer a complete lightning protection engineering service from concept design and development through prototype and validation testing to full volume manufacturing and systems integration.

PolyTech has been involved in the design and development of high volume products for over 15 years. This experience is available to support bespoke product design, development and manufacture according to individual customer and application requirements.

With a wide range of capabilities in engineering and scientific disciplines related to lightning protection, and experience of varied industry sectors, PolyTech provides a full service supply to the wind energy sector.

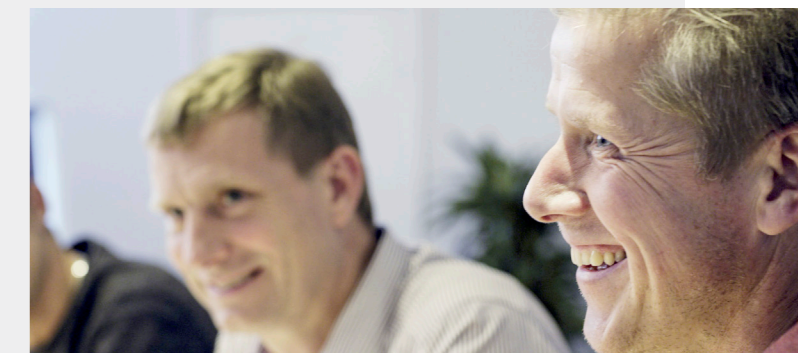
PolyTech lightning protection products and services are underpinned by wide core expertise and competencies in the creation and manufacturing of high capability advanced polymer materials integrated with electrical systems and composite structures.

PolyTech's core expertise and capability

PolyTech's comprehensive range of lightning strike engineering and manufacturing services are underpinned by extensive core expertise in electromagnetic compatibility engineering:

- In-depth knowledge of the physics and processes involved with respect to the direct and indirect effects of lightning strike attachment, propagation and damage characteristics of complex composite structures and electrical sub-systems.

- Computer simulation and modelling capability, including lightning current distribution and induced voltage prediction using 2D lumped element modelling, 3D electromagnetic field modelling and multi-physics modelling combining lightning current pulse threat with joule heating of materials through specific geometry and interfaces.



- In-depth knowledge of testing and measurement techniques for high pulsed current, charge damage tolerance, high pulsed voltage attachment, HVDC corona/streamer and dielectric breakdown.

- Extensive experience in the design and development of lightning, electromagnetic and electrostatic protection systems and best practice strategies from electronic sub-systems to wind turbine blades.

- Carbon fibre reinforced plastic protection integration, interfacing, composition and morphology expertise.

- Experience and expertise in inventing, developing and validating novel solutions, technologies and materials for electromagnetic protection and lightning protection systems.



0202-5029-4200

