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NIA Project Registration and PEA Document

Date of Submission

Jan 2020

Project Reference Number

NIA_NGTO047

Project Registration

Project Title

Challenging Composite Insulator Design Rules (Champions)

Project Reference Number

NIA_NGTO047

Project Licensee(s)

National Grid Electricity Transmission

Project Start

January 2020

Project Duration

1 year and 4 months

Nominated Project Contact(s)

Oliver Cwikowski

Project Budget

£200,000.00

Summary

This project will investigate three key areas for the design of OHL insulation systems and challenge the existing design rules, based on recent advances in composite insulation technologies.

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Problem Being Solved

Insulator design rules are based upon industry best practice from over the last 100 years. The design limitations for overhead line (OHL) insulators in the transmission network were mainly developed in the 1960s and were focused on the available technologies at the time; cap and pin ceramic insulators. Since the 1970s composite insulators have started to be used by electrical utilities. However, the physical structure and electrical characteristics of these insulators are very different to the traditional technologies that have been used. Despite these differences, the same design rules are often applied to these two very different insulator types; which may be leading to suboptimal performance of OHL insulation systems.

Method(s)

This project will review the design parameters used for designing the insulation systems when composite insulators are used in OHLs. This review will be supported by COMSOL simulations of the insulation systems and laboratory testing of short sections of insulators. The design calculations, simulations and testing will all be used to challenge the existing design rules used for composite insulators.

Scope

This project will focus on challenging the design rules across three work packages:

1. Characterisation and optimisation of the Composite Insulator Interface sealing

Many manufacturers use novel internal sealing mechanisms to prevent moisture ingress at the ends of composite insulators; where the metal end fittings are connected to the insulation. However, due to its simplicity and low cost, many are now using over moulding of the

end fittings during the injection moulding process. Others can rely on proprietary RTV sealants applied after the compression of the end fittings. Whilst this may not be so problematic for medium voltage insulators with low electric fields and discharge, it is considered undesirable for higher voltage insulators, such as those destined for transmission voltages.

Whilst composite insulators at extra high voltage are relatively new to the UK, elsewhere the technology is quite commonplace. During this project, it is proposed to conduct a comparison of various sealing technologies in order to inform our technical specifications and whole life value.

2. Controlled electric field distributions for composite insulators

The current practice enables replacement of conventional ceramic strings with composite insulators while using standard arcing horns. The current NG standard enables attachment of grading rings to insulators or to the metal fittings used to connect the insulator. From an insulator perspective, the accurate positioning of the grading ring is critical for electric field magnitudes and their distribution around the end fittings and along the insulator profile. Therefore, controlling such field parameters allows to improve the long-term performance of the insulator.

The design of arc protection is based on the historic designs of ceramic insulator strings, and these may not be the most optimum solution for composite insulators during fault/transient events. It is, therefore, proposed to study the effects of arcing horns and grading rings on the field distribution around polymeric insulator surfaces.

3. Challenging the length requirements for composite insulators

Insulator creepage distances are presently determined by historic practice applied to ceramic insulators (Porcelain & Toughened Glass). This has an impact on string length given the necessary geometry and size of traditional cap & pin insulators. The Basic Insulation Level (BIL) of the overhead line is managed via the application of known arc gaps to insulator strings which provides recoverable insulation in the event of transient overvoltages.

Given the variable parameters of composite insulators and indeed the improved hydrophobicity, there is an argument to suggest that the length of the insulators could be reduced to provide the equivalent BIL and maintain the existing creepage distances. Given the nature and hydrophobicity of composite insulators, there is an opportunity to challenge the existing creepage distances requirements.

The project will investigate insulator dimensioning based on theory and knowledge of the discharge thresholds (for axial length and surge overvoltage levels) and pollution performance to determine the specific creepage and the total creepage length of polymeric insulators. The gains and benefits of such investigations will be highlighted against existing practice based on National and international standard practices for insulator dimensioning.

Objective(s)

The objectives of this project are to:

1. Understand the impact of different molding techniques on the life of composite insulators in greater detail.
2. Identify if there are more suitable design rules for the electric field distribution along a composite insulator
3. Identify if the creepage requirements for composite insulators can be modified for different designs.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will be deemed successful if:

1. A value driven comparison between different end molding techniques can be made at the end of the project.
2. The suitability of the electrical stress control design calculations is identified and opportunities to improve the design recommendations identified.
The creepage requirements for composite insulators are understood in greater detail.

Project Partners and External Funding

-

Potential for New Learning

This project provides the opportunity to identify how different design parameters for composite insulators can impact the life and therefore the whole life value that composite insulators have to network utilities. This project will specifically challenge existing design rules in light of new composite manufacturing techniques that have recently been developed and understand the impact they can have on lifetime performance.

Scale of Project

This 15 month project was chosen to allow suitable calculations simulations and necessary testing to take place.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

Desktop Study and high voltage testing in a laboratory.

Revenue Allowed for the RIIO Settlement

none

Indicative Total NIA Project Expenditure

Total Cost: £200k

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

n/a

How the Project has potential to benefit consumer in vulnerable situations:

n/a

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

If discrepancies are found in the design rules for composite insulators, there are several ways this could deliver value to consumers. First, this could result in composite insulators having a longer estimated lifetime – which would provide better whole life value. Second, if the creepage distances can be reduced as well as the axial length of the insulators this could provide better clearances between the phase conductors and ground. This could provide the opportunity to uplift the ratings of existing OHLs by using shorter insulators. Third, for new OHL towers smaller insulators could provide a more power dense transmission method; providing network investment at a lower cost and lowering the impact on visual amenity.

Please provide a calculation of the expected benefits the Solution

Not applicable – research project.

Please provide an estimate of how replicable the Method is across GB

The outcomes from this project could be used to manage assets from across the entire UK.

Please provide an outline of the costs of rolling out the Method across GB.

This outcome of this project could be adopted by each licensee by updating their specifications. This is estimated to cost around £50,000 per licensee.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

- A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).
- A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)
- A specific novel operational practice directly related to the operation of the Network Licensees system
- A specific novel commercial arrangement

RIIO-2 Projects

- A specific piece of new equipment (including monitoring, control and communications systems and software)
- A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven
- A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)
- A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology
- A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution
- A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

The outcomes of this project will be useful to any utilities who owns or is evaluating the use of composite insulators. The information from this project will allow specifications to be improved and hopefully result in better whole life value being obtained from composite insulators.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

Asset Management

- Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

Is the default IPR position being applied?

- Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

There is no project duplication.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

n/a

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

As composite technology has only recently been deployed in the transmission network and the whole life costs are now understood to be much closer to that of traditional insulators, there hasn't been the driver to understand these technologies in greater detail. Now that they are becoming more prevalent and more design variations are entering the network it is worth exploring some of the finer details.

Relevant Foreground IPR

n/a

Data Access Details

n/a

Please identify why the Network Licensees will not fund the project as apart of it's business and usual

activities

As this project is challenging what are seen to be well established design rules there is significant risk that this project will not provide significant additional value to consumers in the short term. The scope of the project has also been chosen to ensure key questions are answered early in the project, which should provide a strong indication if the outcomes are likely to be successful. Given these financial risks, the business cannot justifiably cover these costs.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

The project can only be funded through the NIA as there are significant risks which warrant further investigation and development of this innovation topic, prior to its use within the business. The main risks are:

- No proven business case – While a value case has been defined for this project, it is contingent on obtaining an as yet unknown level of technical knowledge. No matter what the outcomes of this project are, these will be valuable to consumers, but in a more qualitative manner. However, the foreseen benefits are not sufficient for the business to justify the project's budget.
- Technical challenges – As this research is investigating the fundamental behaviour of composite insulators there may be technical challenges which are unsurmountable. However, these can only be identified through research and attempting to evaluate these new technologies. This may mean that more research is required to develop the new design rules to a point where they can provide direct value to the business. Without the NIA funding these risks would never be mitigated, and the business would justifiably not research this area; resulting in the potential benefits never being obtained or investigated.

This project has been approved by a senior member of staff

Yes