electricity north west

Bringing energy to your door

NIA ENWL012
Investigation of Switchgear Ratings

Closedown Report

31 July 2017

CONTENTS

VERSION HISTORY

Version	Date	Author	Status	Comments
V1.0	14 July 2017	M Kayes	Draft	

REVIEW

Name	Role	Date
L Eyquem	Innovation Programme Assistant	18 July 2017
G Bryson	Innovation Engineer	18 July 2017
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APPROVAL

Name	Role	Date
Steve Cox	Engineering & Technical Director	28 July 2017

GLOSSARY

Term	Description
STC	Short-Time Current
kA	kiloAmpere
MVA	Mega-Volt Ampere
kV	kiloVolt

1 EXECUTIVE SUMMARY

1.1 Aims

This project enabled Electricity North West to assess the correct fault level headroom on switchgear identified as having a fault level issue and allowed Electricity North West to target the fault level reinforcement programme more effectively.

1.2 Methodology

This project conducted a series of investigative fault withstand tests to enable the assignment of new short circuit ratings for legacy switchgear where fault level issues occur. New ratings can now be applied to devices based on network location and protection operating time.

1.3 Outcomes

The testing showed that some equipment has a higher fault rating than that displayed on the nameplate and advantage can be taken of this to target the fault level replacement programme more effectively. Further testing is required to complete the learning; Electricity North West will complete this as a business as usual activity.

1.4 Key learning

The project proved that the available legacy upgrades were a good and cost effective way to increase the rating of installed equipment of the same type with effective headroom in assets that could be realised. Certain assets were shown to be limited at their tested ratings which proved what was possible.

1.5 Conclusions

The testing confirmed that there was sufficient headroom in certain types of legacy switchgear. However, asset condition, maintenance requirements and network fault level would need to be considered. Electricity North West will complete further testing as part of a business as usual initiative, to take this learning further.

1.6 Closedown reporting

This project was compliant with the governance for Network Innovation Allowance (NIA) projects, and so this report has been structured to meet these governance requirements. The structure and headings in this report reflect these requirements.

A version of this report is available via the Energy Networks Association's Smarter Networks learning portal at www.smarternetworks.org.

This version of the report provides additional information that is useful in understanding the project.

2 PROJECT BASICS

Title	Investigation of Switchgear Ratings
Project reference	NIA_ENWL012
Funding licensee(s)	Electricity North West Limited
Project start date	December 2015
Project duration	12 months
Nominated project contact(s)	Matthew Kayes (matthew.kayes@enwl.co.uk)

3 PROJECT BACKGROUND

Historically DNO networks are designed to cater for unidirectional power flow, predictable fault current paths and predictable fault current levels. Due to government CO_2 targets there is an increasing amount of generation being connected to the network at all voltage levels resulting in bidirectional power flows, unpredictable fault current paths and higher fault current levels.

These generators provide an additional in-feed to the network and under fault conditions this in-feed will contribute to the level of fault current causing an increase which in some conditions may be quite significant. This results in more areas of the network running close to or possibly beyond the designed fault current rating.

Existing innovation projects, including the Electricity North West Second Tier Project Respond, are investigating methods of controlling this fault level and are particularly focussed on the 11kV primary substation circuit breakers.

Network operators have a significant population of 11kV (and other high voltage) distribution switchgear such as ring main units etc which will be expected to carry this increased fault current without damage. This equipment has a manufacturer's assigned rating which declares the level of current it can safely carry for three seconds.

In practice equipment will only be exposed to fault currents for a much shorter period of time owing to fast operation of protection to clear the fault. Further it is important to note that the fault current diminishes the further away from the primary substation source. Given these factors it would be beneficial to calculate the fault level headroom based on the equipment location on the network and the local protection operating times.

As part of the preparation work for Respond Electricity North West tested a small sample of the distribution switchgear population which successfully demonstrated its capability to carry this increased fault current for a shorter period of time. Building on this earlier work it is the intention of this project to develop a short circuit (fault withstand) performance 'envelope' for a range of the more commonly used distribution switchgear variants. This will allow 'tailored' replacement decisions based on the actual fault levels at the equipment location and the actual capability of the equipment.

This project will conduct a series of investigative short circuit tests at an independent testing station to create a short circuit performance 'envelope' detailing maximum levels of current at a range of times up to three seconds on a range of distribution switchgear. The fault level performance levels will be further informed by the age and condition of the equipment.

Electricity North West will use standard fault level calculation software to understand the actual fault level the distribution switchgear will be exposed to.

From the tests and the fault level calculations Electricity North West will then be able to assess the correct fault level headroom and target the fault level reinforcement programme more effectively.

4 PROJECT SCOPE

This project will conduct a series of investigative fault withstand tests to enable the assignment of new short circuit ratings which can be applied to devices based on the network location and protection operating time.

5 OBJECTIVES

- Carry out a series of investigative short circuit tests at an independent test station on a range of commonly used distribution switchgear and publish revised fault level ratings where appropriate
- Calculate the actual fault level at distribution substations and the level of typical attenuation
- Assess the available fault level headroom
- Publish a report outlining the details of the investigations and the potential for application of revised ratings.

6 SUCCESS CRITERIA

- Completion of the short circuit tests and reports
- Table of actual fault levels at distribution substations
- Table of actual fault level headroom.

7 PERFORMANCE COMPARED TO THE ORIGINAL PROJECT AIMS, OBJECTIVES AND SUCCESS CRITERIA

This project conducted a series of investigative fault withstand tests to enable the assignment of new short circuit ratings to devices based on network location and protection operating time.

As part of the First Tier LCN Fund project Fault Current Active Management, Electricity North West carried out some limited short circuit testing. The learning from this project led Electricity North West to take the project further and produce a (fault) performance 'envelope' for a wider range of switchgear types. From this envelope Electricity North West could determine whether the switchgear can safely remain on the network.

The items of switchgear which have a fault level issue were investigated and a representative sample was chosen based on volumes installed. The types of switchgear chosen are detailed in Section 8 with the test results.

The switchgear was taken to KEMA laboratories in Arnhem, Holland to repeat the short circuit tests on the busbars, switches and earth switches.

Electricity North West has significant volumes of Long & Crawford equipment. On discussion with Long Controls (who are the support for this legacy product) they suggested a possible upgrade to two of the chosen types so the testing was extended to include this upgrade.

The testing showed that Electricity North West could apply revised fault ratings to the Long & Crawford range and the upgrade to the two selected types gave further enhanced fault ratings. The new ratings are shown in Section 8.

This project effectively investigated the problem which was detailed in the NIA pro-forma by successfully completing a series of type tests to prove that headroom is available for the legacy switchgear.

It was possible to carry out a series of investigative short circuit tests at an independent test station on a range of commonly used distribution switchgear and publish revised fault level ratings where appropriate. This was based on the fact that for example the T3GF3 could achieve an increased rating of 16kA without the upgrade and 20kA with the upgrade.

The fault level at each substation is in itself dynamic as it relates to voltage and circuit configuration. Electricity North West decided that it was more beneficial to update the planning policy to give guidance on how the headroom can be realised rather than completing a table for the headroom available. This policy update will be completed in early course.

The final outcome was to publish a report outlining the details of the investigations and the potential for application of revised ratings.

Further testing is required to investigate other ranges of switchgear and assess the actual fault level rating. Electricity North West has decided to use the methodology developed in this project in a business as usual initiative.

8 THE OUTCOMES OF THE PROJECT

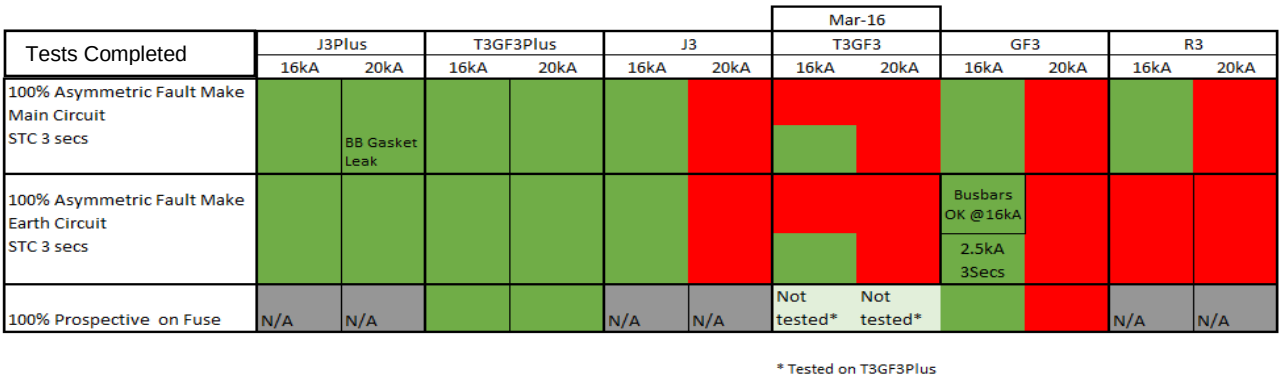
The items of switchgear taken for testing were as follows:

- R3 (RMU)
- T3GF3 (RMU)
- T4GF3 (RMU)
- J3 (switch)
- J4 (switch)
- GF3 (fuse switch)
- GF3D (fuse switch).

The T3GF3 and J3 were chosen for the suggested upgrade. These units were modified to include springs and contacts from standard T4GF3 RMU and J4 oil switch and then

rebadged as T3GF3plus and J3plus respectively. The upgrade kit was purchased from and installed by Long Controls Limited in St Helens.

For ease of testing the GF3, J3 and R3 were coupled as a conventional switch combination; the results for all tests were as follows:



Green indicates the test sequence was successfully completed, including supplementary tests such as power frequency withstand and no-load operation.

Red indicates a failure to meet the specified rating or requirements in one or more aspects when compared with the operative standard.

The Kema testing proved:

Plant type	Original rating	Tested rating
J3	13.1kA	16kA
J3plus	Original J3 was rated at 13.1kA	20kA
T3GF3	13.1kA	Passed through fault at 16kA but failed fault make therefore no upgrade possible
T3GF3plus	Original T3GF3 was rated at 13.1kA	20kA
GF3	13.1kA	16kA
R3	13.1kA	Passed through fault at 16kA but failed fault make therefore no upgrade possible

The T3GF3Plus and J3Plus are capable of 20kA 40kA peak and three seconds STC at 20kA.

The T3GF3 is capable of taking an STC of 16kA three-second rating but cannot handle the 40kA peak fault make associated with the fault make.

The J3 is capable of a 16kA rating for both fault make and short time current withstand but care must be taken to ensure the busbar joints are properly supported and that gaskets are correctly tightened.

The R3 is not capable of withstanding a 40kA peak during a fault make in the earth position. However, the R3 is capable of withstanding a 16kA STC including a 40kA peak.

Further work would be required to establish if an intermediate fault make capability can be assigned to the T3GF3 in the main circuit position and the R3 in the earth position.

However, if these ratings were to be realised then a full maintenance is required before applying the increased ratings to ensure the contacts are fit for purpose.

185mm^2 polymeric aluminium conductor cables were chosen by our contractor to connect the test equipment to KEMA's test circuits. However, we proved that they cannot withstand 20kA for three seconds. Evidence from more than one shows they are capable of 16kA ratings or 20kA for two seconds.

The fault level at each substation is in itself dynamic as it relates to voltage and circuit configuration. Electricity North West decided that it was more beneficial to update the planning policy to give guidance on how the headroom can be realised rather than completing a table for the headroom available. This policy update will be completed in early course.

9 REQUIRED MODIFICATIONS TO THE PLANNED APPROACH DURING THE COURSE OF THE PROJECT

9.1 Summary for Smarter Networks Portal

Electricity North West have decided to make a modification to the planning policy to use the methodology determined in this project to aid planners in determining which is the correct headroom analysis based on the equipment installed, network configuration and current fault level at the substation, plus whether the upgrade is utilised.

9.2 Cost variance table

This section does not appear on the Smarter Networks Portal.

Item	Category	Estimated costs (£k)	Final costs (£k rounded)	Variance
1	Project management and dissemination	75	73	-2
2	Materials and testing	225	213	-12
	Total	**300**	**286**	**-14**

10 LESSONS LEARNED FOR FUTURE PROJECTS

This project could be exploited further by looking at other manufacturers' switchgear where fault level is deemed to be over the fault level rating. The switchgear could then be re-tested to establish whether any headroom could be established.

Further work would be required to establish if an intermediate fault make capability can be assigned to the T3GF3 in the main circuit position and the R3 in the earth position.

The learning to date will be deployed on a large scale where Long & Crawford equipment is installed on the network and has a fault level issue. This will be by updating planning policy to allow the designers to calculate the available headroom.

The research into the headroom available was demonstrated as a success on the Long & Crawford equipment by realising the required headroom on the majority of equipment. However, the R3 plant would need to be replaced but this was also beneficial learning, as it would be replaced based on engineering judgement rather than condition assessments.

11 PLANNED IMPLEMENTATION

Electricity North West plans to modify its fault level asset replacement programme based on learning from the project. It is planned to complete further testing internally to realise further benefits from the project.

Electricity North West has already partly implemented this project. We have increased the fault level capability of a T3GF3 in central Manchester making it into a T3GF3 plus. This was deemed a success due to the nature of the location of the switchgear, making asset replacement costly, major disruption to the local area and to the customer's building where the substation is sited.

Electricity North West is currently embarking on a survey of the Long & Crawford equipment where it is earmarked for asset replacement to ascertain whether refurbishment and/or upgrades could be a better solution, based on the outcome of this project.

The learning from the project will be used to update our planning policy.

12 FACILITATE REPLICATION

Other DNOs are able to replicate the learning and make an engineering judgement on whether they wish to maximise the fault level headroom on Long & Crawford switchgear where they have it on their networks. The full type test reports and full details of the upgrades are available on request from Electricity North West.