PRODUCED BY THE OPERATIONS DIRECTORATE OF ENERGY NETWORKS ASSOCIATION

Engineering Report 135

Issue 1 2015

Performance review of vacuum interrupters in UK distribution networks

www.energynetworks.org

PUBLISHING AND COPYRIGHT INFORMATION

Operations Directorate
Energy Networks Association
6th Floor, Dean Bradley House
52 Horseferry Rd
London
SW1P 2AF

First published, September, 2015

Amendments since publication

Issue	Date	Amendment

Contents

Foreword 5
Introduction 7
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
4 Distribution of vacuum circuit breakers (VCBs) 9
5 Survey of reported VI incidents 9
6 Literature history 10
7 Discussion with industry experts 10
7.1 General 10
7.2 Vacuum pressure 11
7.3 Paschen curve 11
7.4 Design life 11
7.5 Life expectancy 12
7.6 Summary 13
8 Testing 13
8.1 General 13
8.2 Manufacturer testing 13
8.2.1 Sub-assembly leak rate check 13
8.2.2 Vacuum integrity testing 13
8.3 In-service testing 14
8.3.1 VCB switchgear design and service conditions 14
8.3.2 In-service vacuum measurements 14
8.4 DNO in-service test procedures 15
8.5 Summary 15
9 Testing of recovered sample VIs 16
9.1 General 16
9.2 Laboratory testing 16
9.2.1 VIL testing 16
9.2.2 Schneider Electric testing 16
9.2.3 Eaton Electrical testing 17
9.3 Testing method 17
9.3.1 External visual inspection 17
9.3.2 X-ray inspection 17
9.3.3 Power frequency withstand test (PFWT) 17
9.3.4 Lightning impulse test (BIL) 17
9.3.5 DC resistance measurement 17
9.3.6 Vacuum measurement 18
9.3.7 Contact force due to atmospheric pressure 18
9.3.8 Short-circuit switching tests 18
9.3.9 Internal visual inspection 19

9.4 Testing by others 19
9.5 Summary 20
10 Conclusions 20
11 Recommendations 21
11.1 General 21
11.2 Vacuum interrupters presently in service 21
11.3 Future installations 22
11.4 Importance of ongoing monitoring of DNO and third party reporting on VI performance 22
Annex A (normative) DNO maintenance and operation 23
A.1 DNO maintenance and operation summary 23
Annex B (normative) Test results — VIs supplied by DNOs 24
B.1 Central Networks testing by VIL 24
B.2 Schneider Electric testing by Sterling Power 26
B.3 Eaton Electrical Testing 27
Annex C (informative) ENA Working Group 28
C.1 Original members 28
C.2 Current members 28
Annex D (informative) Distribution of VCBs amongst DNOs 29
D.1 Population of VCBs within UK distribution networks 29
D.2 VCB manufacturer types > 20 years 29
D.3 Age profile of DNO installed VCB switchgear – June 2010 30
Bibliography 31

Figures

Figure 1 — Paschen curve for dry air 11
Figure 2 — VI life definitions 12
Figure 3 — Hypothetical failure rate of VIs over time 13
Figure 4 — X-rays of removed bellows 16
Figure 5 — Vacuum measurement result 18
Figure 6 — VI internal inspection 19

Tables

Table 1 — NEDeRS® postings for VCB switchgear > 20 years 9

Foreword

This Engineering Report (EREP) is published by the Energy Networks Association (ENA) and comes into effect from September 2015. It has been prepared under the authority of the ENA Engineering Policy and Standards Manager and has been approved for publication by the ENA Electricity Networks and Futures Group (ENFG). The approved abbreviated title of this engineering document is “EREP 135”.

This is the first issue and does not cancel or replace any other document.

This EREP has been developed in conjunction with the ENA Working Group on Vacuum Interrupters and includes all relevant findings from work carried out by the Working Group. The Working Group would like to acknowledge the contributions to this review provided by BEAMA, Eaton Electrical and Schneider Electric.

The intention is for this document to be used by ENA member companies to inform the development of maintenance and testing policies/procedures for distribution switchgear, which incorporates vacuum interrupters.

Where the term “shall” or “must” is used in this document it means the provision is mandatory. Where the term “should” is used in this document it means the provision is a recommendation. The term “may” is used to express permission.

NOTE: Commentary, explanation and general informative material is presented in smaller type, and does not constitute a normative element.

This page deliberately left blank

Introduction

At the meeting of the Energy Networks Futures Group (ENFG) - formally known as the Assessment and Specifications Group (ASG), held on 18th May 2006, it was agreed that an ENA Working Group would be established to consider the performance of vacuum interrupter circuit breakers installed in UK Distribution Network Operator (DNO) distribution networks. The performance review would be based on experience to date and consider all currently available knowledge of interrupter performance.

Subsequent to the ENFG meeting, the Health & Safety Executive (HSE) approached ENA regarding this issue, and a commitment has been given by ENA to liaise with HSE at appropriate intervals.

The ENA Working Group was convened under the chairmanship of Mr C Holdsworth of Northern Powergrid plc. A list of ENA Working Group members is provided in Annex C.

The terms of reference for the Working Group included investigations into known failure rates of VIs within the industry and gaining an understanding of the monitoring regimes associated with VCB switchgear practiced by DNOs.

Eaton Electrical provided a technical report on behalf of the Working Group titled: *Status Check of 25yr old VIL Type V803 Vacuum Interrupters*. This review draws on information and data provided in that report. The decision to undertake this review was, in part, driven by a presentation given by the Sterling Power Group of a paper [1] stating that vacuum interrupters (VIs) utilised within DNO vacuum circuit breaker (VCB) switchgear have a design life of only 20 years. This performance review examines the performance of VIs within the UK DNO population, in light of the potential failure issues identified in the paper [1], and considers whether the performance of in-service VCBs within DNOs exceeding a design life of 20 years should be a cause for concern and what in-service testing regime, if any, should be considered.

1 Scope

This report documents the findings and recommendations from the performance review of VIs in UK distribution networks. The risk of failure in VIs that have been in-service for greater than 20 years is explored based on a review of failure rates and the adequacy of existing test methods.

Recommendations are made on appropriate operational testing and maintenance regimes, based upon DNO in-service experience and knowledge of the performance of VIs obtained from this review.

2 Normative references

The following referenced documents, in whole or part, are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) apply.

Standards publications

IEC 60050, *International Electrotechnical Vocabulary*

IEC 62271-1, *High-voltage VCB switchgear and controlgear – Part 1: Common Specifications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.