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RE-VERIFICATION OF THE SHORT-CIRCUIT CAPABILITY OF THE 275KV OBR60 AND OBR60/72E CIRCUIT-BREAKER DESIGNS

PURPOSE AND SCOPE

This document summarises the results of short-circuit testing of re-furbished OBR60 and OBR60/72E circuit-breakers and makes recommendations regarding the continued use of these designs on the National Grid electricity transmission system. The testing demonstrated that the circuit-breakers, as re-furbished by National Grid at the Leicester refurbishment centre, retain their full short-circuit interrupting capability and are suitable for continued service.

PART 1 – REPORT DETAILS

1 BACKGROUND

As part of a combined replacement and refurbishment strategy for the life management of circuit-breakers, the OBR60 design was identified as a suitable candidate for refurbishment and a refurbishment scheme is ongoing. Since the refurbished circuit-breakers are expected to remain on the National Grid network for the next 20 years or thereabouts, it was considered prudent to repeat certain basic performance type tests on re-furbished units to ensure that the circuit-breakers have retained the expected capabilities.

2 TEST OBJECT

For the purposes of the testing a dedicated single phase test object was assembled consisting of an air receiver, mechanism, columns & heads. No isomaker was included since this was not required for the planned interrupting testing. Since, in normal operation, the isomaker drive mechanism also acts to interrupt the trip coil current, the mechanism was modified to incorporate a timed coil current interruption.

The columns and heads were re-furbished items from the Leicester refurbishment centre. Specific details of the scope of reconditioning activity can be found in EMI 882. Two heads (4 interrupters) were constructed to the standard 15GVA design and two were constructed to the enhanced 18GVA design as detailed in original Reyrolle documentation.

Prior to the testing the test object was fully assembled in the UK and was proven to operate identically to an installed circuit-breaker in all relevant respects.

3 TEST PROGRAMME

The test programme was designed to get maximum information about both the dielectric and thermal interrupting performance of each variant of the circuit-breaker whilst avoiding the need to refurbish the heads during the test programme. The chosen programme to achieve this was to perform short-circuit test duties T30, T100S and short-line fault L90 on each variant. The tests were performed as ½ pole tests with a voltage sharing ratio of 52%. The OBR60 tests were based on a rated current of 31.5kA. The OBR60/72E tests were based on a current of 40kA, rather than the rated value of 37.8kA, in an attempt to align the rating with IEC standard 40kA equipment.

All test procedure and the transient recovery voltage (TRV) parameters for T100s and SLF L90 were in accordance with IEC 62271-100 and applicable STL guidance. The TRV parameters for T30 were in accordance with National Grid's enhanced requirements as detailed in NGTS 3.2.1 Issue 3.

The tests were undertaken at the KEMA high power laboratories in Arnhem, the Netherlands.

4 TEST RESULTS

Detailed test results can be found in KEMA report number 233-06. The following sub-sections, where appropriate, provide more detailed analysis of these results.

4.1 OBR60

4.1.1 Test duty T100s

The test was successful and was without notable features.

4.1.2 Test duty SLF L90

The test was successful and was without notable features.

4.1.3 Test duty T30

At the test pressure (260 psig) the circuit-breaker was unable to achieve the full range of arc durations required to strictly demonstrate single phase interrupting ability i.e. 9ms between shortest and longest arc duration. Successful tests were made between 6.8ms arc duration and 14.2ms arc duration i.e. a range of 7.4ms. Tests with target arcing times of 16ms and 26.6ms suffered breakdowns at 155kV and 180kV respectively. The similarity in the failure voltage indicates that the test conditions are close to a fundamental dielectric limit of the interrupter design.

An additional test at a higher pressure (325 psig) demonstrated that, under normal operating conditions, the circuit-breaker is fully able to meet the test criteria.

A further pertinent fact is that the performance of the circuit-breaker at 260 psig was equal to that obtained during the original OBR60 type testing reported in document AR.288 from 1961.

4.1.4 T100s (40kA)

An additional test series was performed to further explore the limit of interrupting ability of the standard OBR60. A standard T100S test series was performed at an increased short-circuit current of 40kA. The test was successful and was without notable features.

4.2 OBR60/72E

4.2.1 Test duty T100s

The test was successful and was without notable features.

4.2.2 Test duty SLF L90

At the test pressure (260 psig) the circuit-breaker was unable to achieve the full range of arc durations required to strictly demonstrate single phase interrupting ability i.e. 9ms between shortest and longest arc duration. Successful tests were made between 8.8ms arc duration and 17.1ms arc duration i.e. a range of 8.3ms. Tests with target arcing times of 8.4ms and 19.3ms were unsuccessful.

4.2.3 Test duty T30

The test was successful and was without notable features.

4.2.4 Test duty T100a with 60ms dc time constant

This test was added to the programme to further explore the limit of performance of the OBR60/72E. The test was successful. Of note is the fact that, during test number 060303-5027, the first loop of the applied short-circuit current had a peak value of approximately 113kA.pk which significantly exceeds the rated value (96kA.pk), and the 40kA IEC equivalent value (100kA.pk). Further reference is made to this in clause 5.2 of this report.

4.3 Discussion

The test sequence demonstrated that the circuit-breaker designs in question, as refurbished by National Grid, perform well under 100% terminal fault interrupting conditions i.e. at their rated values of short-circuit current.

The main limitation of the design relates to the ability to withstand aggressive transient recovery voltage conditions such as short-line fault and transformer limited fault interruption. In these areas some minor deviations from modern testing acceptance criteria were noted, particularly regarding the necessary arc durations associated with single phase faults. This limitation under aggressive TRV conditions is a well known characteristic of UK produced air-blast circuit-breakers of 1960's design and the recent testing has fully replicated the original test performance in these areas. On this basis, and taking into account more than 30 years service experience, it not considered appropriate or necessary to de-rate the circuit-breakers on the basis of the recent testing.

5 POST TEST INSPECTION

5.1 Observations

Upon completion of the test series the test object was returned to the UK for dismantling and detailed inspection.

Inspection of the OBR60 heads revealed them to be in excellent condition with no significant wear or deterioration of the components. The photographs in Appendix A are indicative of the condition.

Inspection of the OBR60/72E heads revealed three of the four interrupters to be heavily worn and to have suffered significant contact erosion/damage. In particular the transfer blocks and the inner ends of the contact fingers showed significant signs of melting. In addition, one of these heads had suffered a detached finger which had fractured at the base. The adjacent finger was also bent outwards.

The location of the worst burning on the contact fingers, i.e. at the inner end of the contact fingers, was in the area which is in contact with the transfer block when the circuit-breaker is in the closed position.

The photographs in Appendix B show the condition of the OBR60/72E after test.

5.2 Interpretation

The condition of the OBR60 contacts indicate that the test regime undertaken, including the enhanced 40kA symmetrical interruption duty, was well within the withstand capabilities of the contact system.

The condition of the OBR60/72E indicated that the circuit-breaker had suffered some distress as a result of high (excessive) currents. Since both OBR60 and OBR60/72E were subjected to the 40kA symmetrical interrupting test and on the basis that the lower rated OBR60 suffered no significant degradation, this is unlikely to have been the cause of the damage to the OBR60/72E.

As noted above, the damage to the contact fingers was seen on three of the four OBR60/72E interrupters and was concentrated at the inner base which is in contact with the transfer block when the circuit-breaker is in the closed position. The similar damage across a number of interrupters suggests that the damage was as a result of genuine overstressing rather than component or assembly defect. The lack of damage to one of the three interrupters suggests that the damage resulted from a condition close to the limit of capability of the contact system i.e. in the region where allowable constructional and material tolerances might significantly affect performance.

The concentration of damage at the base of the fingers suggests that the contact burning occurred with the circuit-breaker in the closed position which in turn suggests that basic current withstand ability of the contact system was exceeded. With reference to clause 4.2.4 above, this was potentially the case during the pre-interruption phase of test number 060303-5027 where the peak current exceeded the rated value by approximately 18%. Furthermore, using some basic approximations, the energy in the first major loop during the test may have been 40-50% greater than the rated value.

Following this hypothesis, the fractured and bent finger could easily have occurred as a result of the first loop of short-circuit current prior to opening of the circuit-breaker.

The above cannot be categorically demonstrated from the remaining evidence however this is considered to be by far the most likely sequence of events. It is notable that, at no point, did the circuit-breaker exhibit signs of external distress or a noticeable deterioration in performance.

6 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn for circuit-breakers refurbished under scheme 14544 in accordance with EMI 882.

- a) The OBR60 and OBR60/72E retain their original short-circuit interruption capability and are suitable for continued service on the National Grid network.
- b) The OBR60/72E can be assigned an enhanced interrupting capability of 40kA for all National Grid applications.
- c) The OBR60 could be assigned a 40kA interrupting capability on a site specific basis and under certain system conditions e.g. low dc time constant, non-dielectrically aggressive TRV's.

7 FORMS AND RECORDS

Not applicable

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

8 DEFINITIONS

Not applicable.