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**National Grid
Commissioning
Handbook
Procedure 25**

**Primary and Secondary Injection of
Reactors and their Main Protections**

CH 25
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Fig No. B1 – HV Bushings CT ratio, Polarity and Relay Operation

Fig No. B2 – Neutral End CT ratio, Polarity and Relay Operation

Fig No. B3 – CT Matching and Relay Stability Test

Fig No. B4 – Relay Operation Test

Fig No. B5 – Secondary Injection Test – Setting Voltage Check

Fig No. B6 – 415 VAC Overall Stability Test

1 PURPOSE

The purpose of this procedure is to provide a model process for the checks and tests to be carried out when commissioning reactor protection. It specifies minimum requirements and may be added to by the contractor when devising test programmes.

This procedure is applicable to both Shunt and Series Reactors. In figures A1 to A5 and B1 to B5, dotted lines refer to primary configuration for Shunt Reactors only.

These checks and tests are required to ensure that:
The protection equipment is correctly aligned in phase and magnitude with its associated reactor.

2 GENERAL OVERVIEW

This commissioning handbook assumes that the reactor primary and protection configurations are generally in line with DH 01 Issue 1, TS 3.24.9 and TS 3.24.10 Protection Arrangements.

Although it is recognised that protection schemes may not exactly match those shown, it is likely that many reactors will have systems that comply. Further, the principles herein will provide a general guideline to be applied for most situations.

3 PROCEDURE

3.1 General

In accordance with UKBP/TP 106, a two stage commissioning procedure is required.

Checks on the correct installation and functioning of the new scheme are undertaken in Stage 1. Connection to the system, and consequent load and conjunctive tests are carried out in Stage 2.

3.2 Nameplate Diagram

Consult the reactor nameplate diagrams, overall A.C. main connections and protection circuit diagrams to establish plant data and confirm the correctness of protection diagrams. Also, confirm that actual nameplate data matches nameplate diagram, reactor test report and NG specifications.

3.3 Protection Scheme

Two alternative protection arrangements for reactors are described in this document:

- (a) Duplicate overall unit protection driven from common current transformers shall be provided at 400 and 275 kV if non-numerical relays are offered.

Informative: An example of an acceptable scheme is two high impedance circulating current relays providing the first and second overall unit protection.

- (b) A single numerical relay is acceptable for providing the main protection. The relay shall provide an overall unit protection function, which is responsive to both phase to phase faults and earth faults on the reactor and associated connections, and a unit protection function, as a minimum, responsive to earth faults on the reactor and associated connections.

Informative: An example of an acceptable scheme is a single overall biased differential relay providing the first overall unit protection with a restricted earth fault protection function providing the second unit protection.

These two should cover most installations. If other protection arrangements are provided the principles outlined in this document should be adapted to suit the installation. The figures attached are typical only and care should be taken to check against the actual site schematic drawings.

Numeric unit protections are now being installed which have integral Biased Differential and REF functions. These usually allow for CT ratios and vector groupings to be selected in the software settings. However it is essential to prove the CT ratios and grouping using the general principles outlined in this document.

Note

The reactor manufacturers use terminal phase designations A, B & C (or R, S & T). These do not necessarily relate to the system phase colours Red, Yellow & Blue respectively.

Relay manufacturers use A, B, C (or other designations). These will usually correspond to the system phase colours Red, Yellow & Blue but may not relate to the reactor terminal phase designations. The relationship between a, b, c terminals etc and actual phase should be clearly marked on the schematic diagrams.

3.4 Primary Injection

3.4.1 Stage 1: Preliminary Tests and Considerations

General guidance on commissioning protection equipment is given in Site Commissioning Test (SCT) Schedule 01.

Current Transformer 'flick' tests using suitable battery should have been carried out at an early stage on all CTs to establish the correct identity and phasing of primary, secondary and test winding terminals (P1, P2, S1, S2 etc). Refer to Commissioning Handbook 6 for details.

Current Transformer Magnetisation Tests should have been carried out and the results recorded. These should be compared with the manufacturer's works results to ensure that each of the CTs in the 'stack' has been used for its intended protection function. See SCT Schedule 20.1. Where CTs are fitted in the reactor's bushing turrets the reactor winding impedance will severely limit the amount of test current that can be injected. For this reason test windings are normally provided on such CTs to facilitate commissioning tests. However the polarity of the test windings with respect to their associated primary conductor and secondary winding must be established initially. If access to the CT stack is available prior to the insertion of the bushings then the test winding polarity can usually be established visually.

If not, 'flick' tests should be carried out using the reactor winding (which has a low resistance to DC) and compared with similar tests using the test winding.

Warnings:

Injected primary current will often flow through CTs other than the ones that are the object of the test. This possibility must be considered at the outset and steps taken to eliminate undesirable consequences. Particular attention must be paid to CTs feeding Busbar Protection, Circuit Breaker Fail Protection. If temporary shorts are applied these must be recorded so that they are not inadvertently left in place.

Ensure that CT secondary wiring has been completed before carrying out primary injection to avoid the high voltages associated with an open circuit CT. Earth fault relay coils, stabilising resistors, non-linear resistors etc are sometimes **short-time rated** and may be damaged by excessive injection duration. Test ammeters are often applied in parallel however as part of the test measurements. If primary or secondary equipment connections have to be altered to prove a protection operation and corresponding non-operation (i.e. to