Insulation resistance testing and SPDs

OBJECTIVE

This article provides a brief summary of the types of surge protective device likely to be present in an electrical installation, before discussing how to carry out electrical testing without causing damage to them.

Introduction

With perhaps the exception of low-rise domestic premises such as houses and bungalows, the use of surge protective devices (SPDs) is becoming more common in electrical installations. Indeed, in many more complex installations, a number of SPDs of differing types may be installed within a single premises. Their presence must be taken into account when carrying out testing during both initial and periodic verification.

What is a surge protective device?

An SPD is a device designed to limit transient overvoltage caused by lightning or switching by diverting any associated surge current to Earth, thereby limiting the overvoltage to a level insufficient to cause damage to an electrical installation or equipment installed therein.

Under normal operating voltages, the impedance of the SPD components is so high that the device 'sees' it as an open circuit. However, when a transient voltage in excess of the continuous operating voltage (*Uc*) of the SPD appears between live conductors and earth (CT1) or between line conductors and neutral or between neutral and earth (CT2), the part of the SPD subject to the transient voltage will start to conduct, limiting the voltage to which the installation downstream is exposed.

Appendix 16 of *BS 7671* provides examples of how SPDs may be installed in an installation.

Why is care required when testing an installation containing SPDs?

Insulation resistance should be measured between live conductors and between live conductors and the protective conductor connected to the earthing arrangement. During such testing, line and neutral conductors may be connected together (643.3.1).

For circuits, other than SELV and PELV circuits, of nominal voltage less than or equal to 500 V, such testing should generally be performed with an applied voltage of 500 V DC (643.3.2 and Table 64). This applied test voltage is in excess of the maximum continuous operating voltage (*Uc*) of an SPD (see Table 534.2 of *BS 7671*); as a result the SPD will to start to conduct as described earlier in this article.

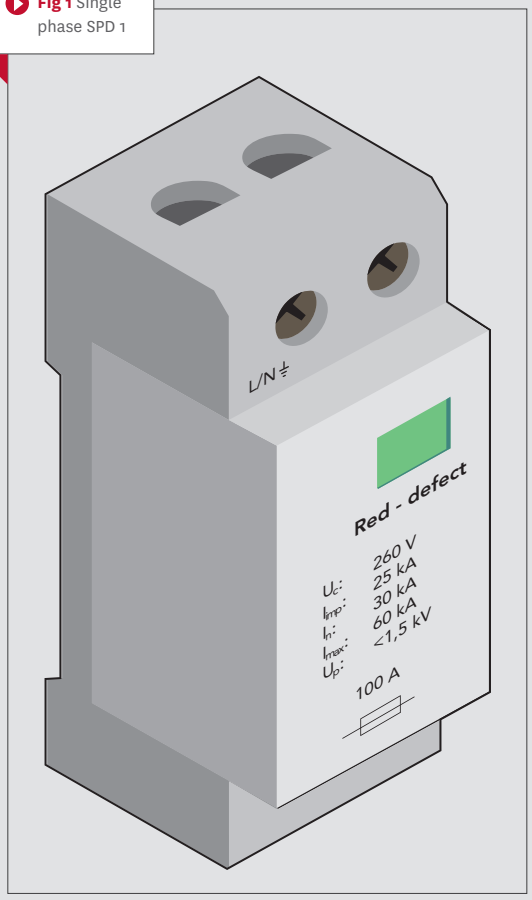
It is unlikely that an insulation resistance test will cause damage to an SPD. The 500 V DC test voltage is, relatively speaking, minimal in comparison to the voltages to which it is likely to be exposed in the event of an overvoltage, the test current is small (circa 1 mA), and the test is of short duration. However, the internal circuitry and the cross-connection between conductors caused by the SPD's operation will almost invariably affect the results obtained during testing, making them worthless for verification purposes.

How should insulation resistance testing be carried out when SPDs are present?

Prior to testing, SPDs should be inspected to confirm that they are operational (usually some kind of visual indication window). Typically when this window shows green the device is operational, whereas when it shows red the device or components thereof need replacing.

Regulation 643.3.2 permits the following actions when items of equipment such as SPDs are likely to influence the results of an insulation resistance test or may suffer damage as a result of an applied test voltage of 500 V DC:

Fig 1 Single phase SPD 1



- **Wherever possible, the equipment should be disconnected prior to carrying out the test.** In many cases, this is a practical option as the SPD will be installed in parallel and a means of isolation should have been provided to facilitate inspection and replacement of either component parts or the device. This is not such a practical proposition where an installation contains multiple SPDs incorporated into socket-outlets. Once testing is complete, it is essential that all disconnected SPDs are re-connected.
- **Where it is not reasonably practicable to disconnect the equipment, the test may be performed at 250 V DC.** This test voltage is sufficiently low that it will not be mistaken for an overvoltage.

Regardless of the applied test voltage, the insulation resistance should have a measured value of at least 1 MΩ (see Table 64 of *BS 7671*).

What are the drawbacks with these testing options?

Both of the above methods present some difficulties, which must be taken into consideration when deciding on what option to take.

Temporary removal of equipment permits the continuing effectiveness of the insulation of wiring to be verified after installation using a test voltage in excess of nominal voltage. Cables may have suffered damage during their installation while, for example, being drawn into conduit or trunking, or after installation but before first use by the activities of other trades.

However, whenever an installation is partially dismantled, there is always a risk that this disturbance will introduce a fault where one did not exist previously. There is also a possibility that the equipment will not be reconnected once testing is completed, removing the overvoltage protection.

250 V is less than both the maximum permitted tolerance for single-phase nominal voltage (253 V rms)[1] and also the peak voltage during normal service. Arguably, therefore, an insulation resistance test at this reduced voltage is less likely to detect anomalies in the insulation between parts intended to be at different potentials in service. However, it does permit some indication of insulation resistance to be obtained for recording on the Schedule of Test Results, as the SPD will not 'see' the test voltage as an overvoltage.

It is often overlooked that Regulation 641.1 requires, for initial verification, inspection and testing to be carried out, both **during** the construction process and **on completion** before the installation is put into use.

It is therefore strongly recommended that, wherever possible, insulation resistance testing is carried out at 500 V DC prior to the connection of equipment such as SPDs to verify the effectiveness of the cables after their installation. If the results of such testing are satisfactory, subsequent insulation resistance testing carried out on completion of work, the results of which will be used to populate the Schedule of Test Results which will accompany the Electrical Installation Certificate, may then be carried out at 250 V DC.

Summary

It is increasingly likely that an electrical installation will contain one or more surge protective devices. This may require those carrying out initial or periodic verification to disconnect the SPDs prior to performing insulation resistance testing to ensure that meaningful test results can be obtained. When, after proper consideration, such disconnection is deemed to be an impractical proposition, the insulation resistance testing can be performed at 250 V DC. However, regardless of the test voltage applied, the measured insulation resistance should be at least 1 MΩ.

1 See Paragraph 15 of Appendix 2 of *BS 7671: 2018*