FEATURE

Always on and on

Measuring without switch-off

The safe and reliable operation of electrical installations and equipment is only possible if their correct working condition is ensured over the long term. To this end the German ordinance on industrial health and safety (Betriebssicherheitsverordnung – BetrSichV) regulates the provision of equipment by the employer, the usage of equipment by the employees and the operation of installations* that require monitoring as per health and safety requirements. Here in particular there is the requirement to test prior to commissioning and to test regularly; the test intervals and types of tests for these regular tests are defined in the health and safety regulations (UVV) DGUV regulation 3 (formerly BGV A3).

The German ordinance on industrial health and safety (BetrSichV) has been in existance since 2002 and has been under extensive revision since 2010 to take into account European law, as well as new findings and the resulting requirements. On 1 June 2015 the amended issue with the modified full (translated) title: ordinance on health and safety on the usage of equipment (Verordnung über Sicherheit und Gesundheitsschutz bei der Verwendung von Arbeitsmitteln (BetrSichV)) came into force. With this amendment, which is aimed at all employers, employees and operating organisations, lawmakers have established a completely new basis for the testing of installations requiring monitoring.

Along with the protection objectives as a requirement on the safe use of equipment, the hazard assessment has been specified in greater detail and the rules on existing equipment clearly defined. The employer is only allowed to deliver equipment if a hazard assessment is available prior to usage for the

*These include installations from which special hazards such as falling, explosion, fire or pressure emanate.

first time, and health and safety are ensured on the intended use of the equipment.

For safe and reliable plant operation, which is the most important goal for an operator, there are numerous laws, regulations and standards that define the framework for safe operation. For the specific and reliable operation of all electrical installations and equipment as well as the safeguarding of correct working conditions during operation over the long term various safety aspects, such as the insulation resistance, dielectric strength, leakage current etc. must be taken into account and checked. For this, BetrSichV and the UVV DGUV regulation 3 prescribes regular tests.

Hazard assessment

Along with the requirement to undertake and document a hazard assessment prior to commissioning an item of equipment, the amended BetrSichV also prescribes regular hazard assessments. By undertaking a hazard assessment, the related state-of-the-art technology must be taken into account. The presence of a CE marking does not relieve the employer of the obligation to undertake a hazard assessment.

If the result of the hazard assessment is that hazards cannot be prevented or can only be inadequately prevented by technical protective measures using the state-of-the-art technology, corresponding organisational or personnel-related protective measures are to be taken. Technical protective measures always have priority.

If the technology is no longer state-of-the-art in relation to protective measures, this situation must be taken into account during the hazard assessment. In some circumstances this can mean that the protection concept used previously must be adapted to whatever is considered state-of-the-art.

How to undertake a hazard assessment is defined in the German technical rules on work safety (Technische Regeln zur Betriebssicherheit – TRBS).

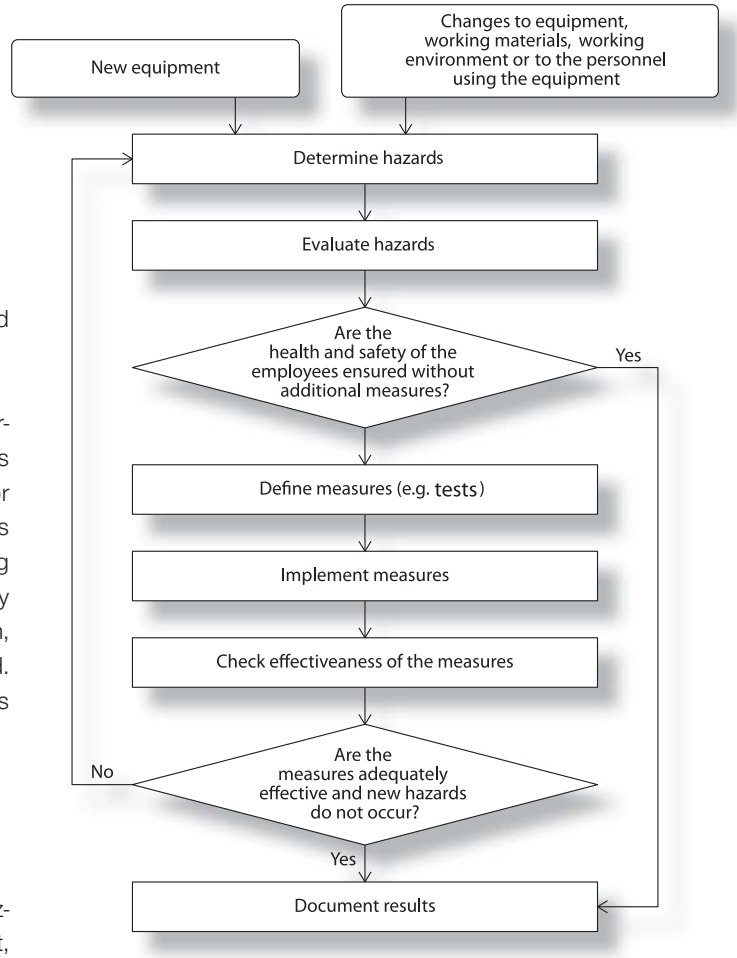


Fig. 1

Basic process for determining and assessing hazards as well as for deriving of measures. (Fig. 1 in TRBS1111, [1.2])

Insulation resistance measurement

Regular testing of the electrical installation can mostly be performed while the installation is in operation (e.g. visual inspection) – with the exception of the insulation resistance (cf. DIN VDE 0100-600:2008-06[1)]) and the measurement of the earth resistance.

The insulation resistance measurement, as part of the regular test on electrical installations, is undertaken using insulation resistance test devices according to DIN EN 61557-2 (VDE 0413-2):2008-02. This measurement between active conductors and the protective earth conductor can, as described in "the

[1)] DIN VDE 0100-600:2008-06 Low-voltage electrical installations – Part 6 Verification: 61.3.3 Insulation resistance of the electrical installation

Scope 1" of this standard, only be undertaken if the installation is shut down. Equipment and/or protective devices must be disconnected prior to the insulation resistance measurement, as they may not be able to withstand the test voltage used for the insulation resistance measurement, depending on their dielectric strength. Often such additional effort and the shutdown of the power supply involve high downtime costs. In addition, restarting the installation is complex or not possible at all (e.g. in computer centres, production plants or intensive care stations).

What the standard states

However, standards like DIN VDE 0105-100:2015-10 "Operation of electrical installations" and DGUV regulation 3 " Electrical installations and equipment " (formerly BGV A3) offer two alternatives for the safe monitoring of installations without shutdown, these alternatives must always be available:

- Continuous residual current measurement (earthed power supply)
- Continuous monitoring of the insulation resistance (unearthed power supply).

Continuous monitoring of insulation of the electrical installation permits the electrician to adapt the test intervals for the regular insulation measurements, if this procedure is approved by the insurer:

DIN VDE 0105-100:2015-10 Operation of electrical installations 5.3.101.0.4

In installations that, in normal operation, are subject to an effective management system for preventive maintenance and servicing, regular tests can be replaced with the appropriate implementation of continuous monitoring and servicing of the installation and all its equipment by electricians. Suitable documentation must be available.

DGUV regulation 3 also offers the possibility of adapting the tests for maintaining the correct working condition of the installation by means of continuous monitoring:

Implementation instruction for DGUV regulation 3:

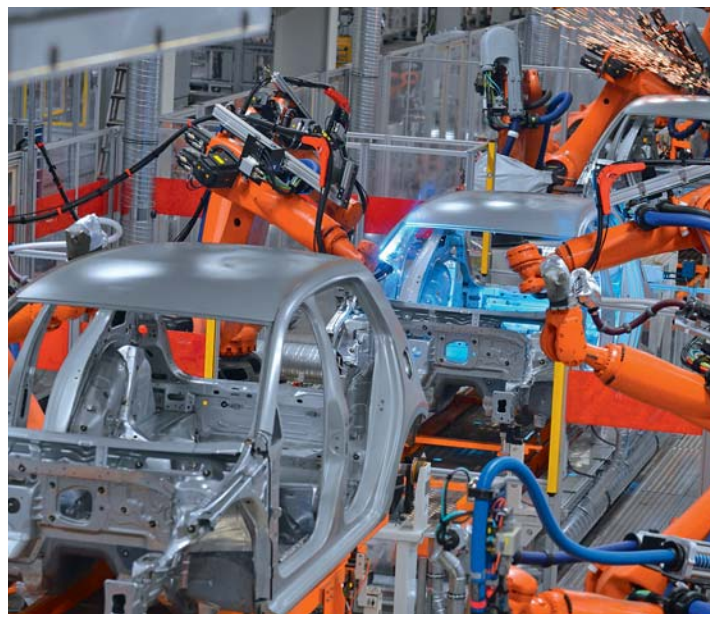
Fixed electrical installations and equipment are considered continuously monitored if they are continuously:

- Maintained by qualified electricians

and

- Tested by measurement methods during operation (e.g. monitoring the insulation resistance).

In the earthed power supply system (TN-S system) it is possible to continuously measure and evaluate the residual currents in the entire installation using residual current monitoring systems. During this process, degradations in the insulation resistance are detected and signalled. A further possibility is offered by the unearthed power supply (IT system) with an insulation monitoring device that continuously monitors the insu-



"**The availability** of an electrical installation is increased, interference currents are located during the early phase and the costs are minimised ..."

lation resistance of the installation. In neither case is it necessary to shut down the installation for the insulation resistance measurement during the regular test.

Earthed power supply (TN-S system)

Accordingly, earthed installations (TN-S systems) can be equipped with a selective system for residual current monitoring (RCM).

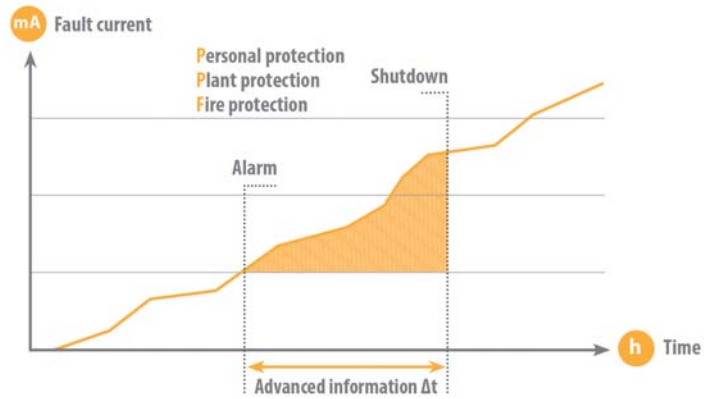
Continuous monitoring

As the residual current is representative of the insulation resistance, residual current monitoring systems (RCMS) can continuously detect a degradation in the insulation in fixed electrical installations and equipment. This degradation will cause a measurable change in the residual current in the installation, and as a result critical changes may occur in the system. RCMS not only detect fault currents during their evolution phase, but overloads on N conductors are also indicated at an early stage. In this way the risk of fire is significantly reduced. The operator is informed via an alarm message, e.g. by e-mail.

The residual currents measured can be unambiguously traced to the related electrical circuits and individual loads. The electrician can then isolate the faulty circuit or equipment from the system, repair it and perform an insulation test prior to placing it back in operation. If certain equipment is switched on and off during normal usage, the total insulation resistance and the residual current change. These changes must be taken into account during the installation of the monitoring device so that a change due to operation that does not involve a fault is not electrically interpreted as a faulty state. If some equipment is only switched on infrequently and is not connected to the installation when switched off, this equipment is not monitored – the operator must then analyse whether additional monitoring is necessary in this case.

Fig. 2

Preventive maintenance by residual current monitoring



Safety tests increase profitability

With residual current monitoring systems, it is also possible for the electrician to determine, specific test intervals and to define the intervals based on practice. The result can be a reduction or an extension of the test intervals for the insulation resistance measurement.

Depending on the utilisation of the equipment, it is possible to adapt the definition of the interval for the periodic testing involving insulation resistance measurements to suit safety and economic aspects.

Shutdowns for conventional insulation resistance measurements, even only for short times, are a thing of the past due to the specific usage of residual current monitoring systems (RCMS). The availability of an electrical installation is increased, interference currents are located during the early phase and the costs incurred for the insulation measurement during the periodic testing of electrical installations and equipment are minimised.

A vital point to consider during the safety tests according to BetrSichV are the maximum stipulated test intervals for instance for cranes, lifts or media equipment for event engineering.

Unearthed power supply (IT-system)

For installations in which a shutdown or unplanned stoppage would involve high costs, the unearthed system (IT system) offers an ideal alternative with numerous advantages.

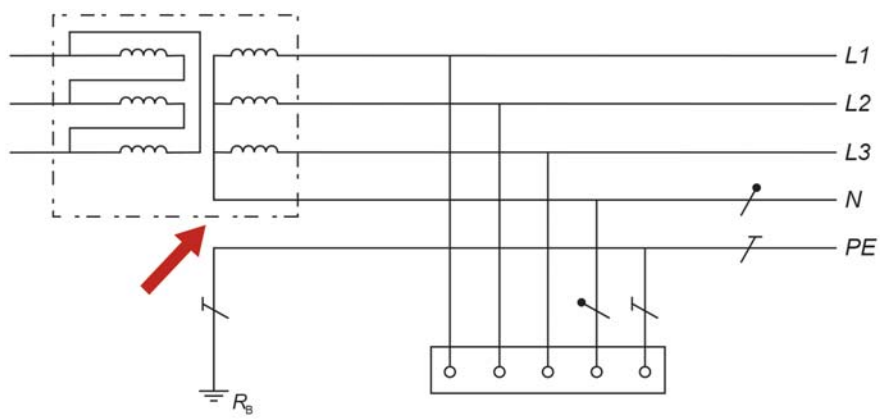
IT system – the better type of system

Unlike an earthed TN-S system, in the IT system no active conductor is connected to earth. Due to this conscious lack of a low-impedance connection between the transformer's star point and PE (Protective Earth), a high fault current does not flow on the occurrence of a first insulation fault. As a consequence the EMC characteristics are very good, there are no shutdowns and single-fault safety is provided.

In addition, on the occurrence of a first fault in an IT system, hazardous fault currents cannot flow due to the conscious lack of a low-impedance connection between N and PE; therefore the risk of fire is significantly reduced.

Fig. 3

In IT system, an active line has no conductive low-impedance connection to PE



"**Due to the continuous monitoring of the insulation resistance,**
it is not necessary to install additional protection
according to DIN VDE 0100-410:2007-06 Low-voltage electrical installations:
Part 4-41 Protection for safety - Protection against electric shock."

While installing an IT system and the calculation of the possible fault currents, however, the system leakage capacitance present in the system must be taken into account.

In principle, the IT system offers the highest security of supply of all types of system.

Compared to residual current monitoring, insulation monitoring in the IT system has a few additional advantages:

- Detection of symmetrical insulation faults and as a consequence increased fire safety.
- Detection of low-impedance insulation faults.
  Typically the measuring sensitivity is at least a factor of 100 greater, which enables a significantly earlier warning.

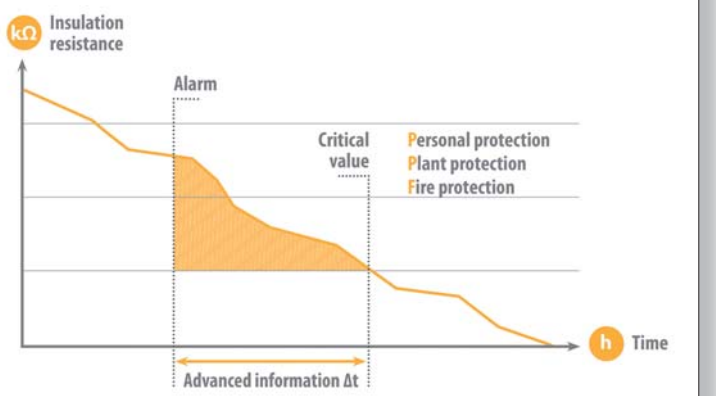
If a symmetrical insulation fault occurs in an IT system, each conductor has an identical lower insulation value in relation to earth. In this situation the fault current flows via earth between the faults and represents a load current for the power supply. If this fault current is significantly lower than the actual load current in the installation, it is not detected by the protection elements and can represent a fire risk.

As the product standard on insulation monitoring devices, IEC 61557-8:2014 stipulates that an insulation monitoring device must detect symmetrical and asymmetrical insulation faults. During the hazard assessment, it must be determining whether the insulation monitoring device used is state-of-the-art.

The significantly higher measuring sensitivity of insulation monitoring compared to residual current monitoring is achieved by determining the insulation values in the kOhm range. Here the operator of the installation receives information on the long-term evolution of the installation before the occurrence of a low-impedance state and can react to trends or intermittent degradations. By consistently monitoring a continuously reducing level of insulation, maintenance measures as well as their budget can be accurately planned.

Fig. 4

Preventive maintenance by insulation monitoring in the unearthed system



Less test effort, increased safety

A further feature of the IT system is that, due to the continuous monitoring of the insulation resistance, it is not necessary to install additional protection according to DIN VDE 0100-410:2007-06[2]. Avoiding the usage of residual current devices (RCDs) significantly reduces the test effort for the installation. A saving of 100 RCDs, for example, in the installation also means that 100 RCDs do not need to be checked cyclically.

The insulation resistance in the IT system is measured continuously by an insulation monitoring device that generates an alarm in the event of critical changes. A first insulation fault does not result in the automatic shutdown of the installation like in an earthed system, instead the installation can continue to operate in the event of a fault. Due to this special feature, an IT system is always used in particularly critical applications that cannot shut down on the occurrence of a first fault and that must guarantee an increased level of reliability (e.g. in intensive care stations, operating theatres, chemical plants etc.)

An insulation monitoring device in the IT system therefore meets the requirements according to DIN VDE 0105-100:2015-10 "Operation of electrical installations" and DGUV regulation 3 for continuous monitoring such that regular insulation measurement and installation shutdown are not necessary.

For completeness it should be mentioned here that all other tests, e.g. visual inspection, loop resistance measurement, still need to be undertaken. However, these can be performed while the installation is in operation.

Bender is supporting the introduction of modern continuous monitoring both in earthed and in unearthed power supplies with its know-how and the necessary technologies. ■

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[2] DIN VDE 0100-410:2007-06 Low-voltage electrical installations: Part 4-41 Protection for safety - Protection against electric shock