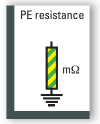
Test methods



PE resistance

The PE test is performed at devices of protection class I. It is checked, whether the PE resistance is below the normative limit value.

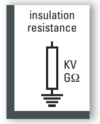
The test serves to detect, whether possible leakage currents inside the test object are grounded correctly. If the PE connection is not OK, this can result in too high a voltage at exposed metallic parts of the device.

In order to determinate the PE resistance, a very high AC test current (typically 10A or 25A/30A AC), conforming to standards, is led through the PE. Via the voltage-drop measurement at the PE resistance and the measurement of the test current, the tester calculates the PE resistance.

The PE test is performed with the precise 4-wire resistance measurement (Kelvin measurement). With this method, the resistance in the leads up to the test probe is compensated automatically.

PE tests are often performed by contacting the PE connection points manually with a PE test probe.

We supply testing devices with test currents up to 100A.



Insulation resistance

The insulation-resistance test is performed at devices of protection class I and protection class II. It is checked whether the ohmic insulation resistance exceeds the normative limit value.

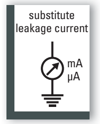
The test serves to detect, whether there is too high a leakage current in the test object. If the insulation resistance is too low or if there is a fault at the PE, this could cause too high a touch voltage at exposed metallic parts of the device.

In order to detect the insulation resistance, a test voltage (according to standards) as high as possible (typically 500V DC) is connected to the current-carrying leads (L+N) of the test object against PE. With the flowing current and the connected test voltage, the tester calculates the insulation resistance.

At devices of protection class II, the test is performed by means of a probe, which is held against the exposed metallic enclosure parts of the test object. In addition, the test can be performed between the current-carrying leads (L against N).

If required, the insulation-resistance test is performed with a security-current limitation to max. 3mA. This protects the operator if the test voltage is touched accidentally.

We supply testing devices with test voltages up to 40KV DC.

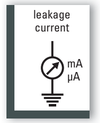


Substitute leakage current

Exactly like the insulation-resistance test, the substitute-leakage-current test is performed between the current-carrying leads L+N against PE. In contrast to the insulation-resistance test, the substitute leakage current test is, however, performed with AC voltage.

The test is called substitute-leakage-current test, because the test is not performed with the nominal voltage of the test object between L+N against PE, but with reduced test voltage. The test voltage and the leakage current are measured and afterwards the current is projected to the leakage current, that would be flowing with nominal voltage. It is checked, whether this leakage current is below the normative limit value.

I.e. it is checked with a low voltage, how the test object behaves under nominal voltage



Leakage current

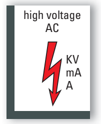
The leakage current test can be performed at devices of protection class I and protection class II. It is checked, whether, owing to the insulation, the leakage current is below the normative limit value.

For detecting the leakage current, the test object is usually operated with a test voltage “nominal voltage +10%”. The tester selects the measuring circuit matching the required standard.

At devices of protection class I, the earth leakage current can be measured in the PE. At devices of protection class I and II, the enclosure leakage current can be measured with a test probe at many different exposed parts.

At electro-medical products, all necessary tests according to standard EN60601 and other international standards can be performed, as well.

An increasing number of electronic products is operated with electronic modules and switching power supplies. Through this, leakage currents with the frequency of the fundamental wave (50Hz / 60Hz) and, additionally, with the clock frequency and various harmonic waves of the electronic modules are flowing. For measuring these high-frequency leakage currents, we offer a leakage-current test up to 1MHz according to standards.



High voltage HV-AC

The high-voltage test with AC voltage serves to find insulation faults at electric products of all kinds.

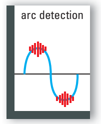
The level of the test voltage for the individual electronic products is determined in the respective standards.

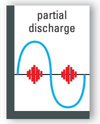
Testing with AC voltage is the most common high-voltage test method. However, the HV-test with AC voltage has disadvantages, that have to be considered. If there is a parasitical capacity in the insulation of the test object, this will cause a capacitive current during the test. This capacitive charge-discharge current can be much higher than the leakage current through the ohmic insulation resistance R_{Iso}, because R_{Iso} is mostly highly resistive. The result is, that the charge-discharge current through the capacitor, strongly superimposes the fault current that normally should to be measured. In addition, the charge-discharge current can affect the test object in a negative way.

The capacitive current is not a fault current caused by defective insulation, but inevitable based on physical facts. Because of the before mentioned points, it has to be kept in mind that the HV-test is more a breakdown test than an accurate measurement of the fault current via the insulation.

Touching currents over 3mA is for the operator potentially lethal. Testing devices with test currents over 3mA, therefore, must be operated with the respective safety measures. Suitable protection devices are safety test pistols or, ideally, test covers or test cages. High-voltage testers with currents below 3mA AC are referred to as “safety-current limited”.

We supply testing devices with up to 100KV test voltage and high test currents.

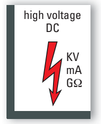




Partial discharge / ARC detection with HV-AC

Partial discharge describes the discharges at insulations, which can not be identified right away through a disruptive breakdown when connecting the high voltage. Only part of the isolator is damaged. The field strength at this damaged spot becomes so large that there is a partial discharge (PD). The remaining, good insulation still withstands the connected test voltage. This type of fault is detected in the isolator via ARC detection or a special partial-discharge measuring technique. This test is of special importance for the production of electric motors in order to locate production errors, like damaged windings.

It is often tried to distinguish between “inner PD” and “outer PD”. Outer PD occurs on surfaces – often between bare and damaged leads. Inner PD occurs within the insulating material, e.g. in the impregnating resin of the motor.



High voltage HV-DC

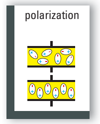
The DC high-voltage test serves to detect insulation faults at electric products of all kinds. The test with direct voltage can often be used as an alternative to the test with alternating voltage. In principle, this is the standard insulation-resistance test, often, however, with much higher test voltages. Therefore, a testing device evaluates either the current or the insulation resistance.

The capacitive current that is flowing during the test with alternating voltage, does not flow during the high-voltage test with DC. The capacities in the test object are charged only once. After this, only a leakage current is flowing through the ohmic resistance R_{Iso}. The high-voltage test with DC thus allows more precise statements on the quality of the insulation than it would be possible with AC. Since no permanent capacitive charge reversal takes place, the test object is not affected too much.

It must, however, be noted that currents over 12mA are hazardous for the life of the operator. Testing devices, which can supply test currents over 12mA, must, therefore, be operated with the respective safety measures. Suitable protection devices are safety test pistols or, ideally, test covers or test cages. High-voltage testers with currents below 12mA DC are referred to as “safety-current limited”.

The level of the test voltage for the individual electric products can be found in the respective standards. As a rule of thumb, however, the DC test voltage should be 1.5 times the AC test voltage.

We supply testing devices with test voltages up to 40KV.



Polarization index

The polarization index is a very important value to determine the quality of the insulation, which deteriorates with increasing age of the motor.

Polarization is the ability of the charge carriers in the isolator to spin and align to the electric field – i.e. to polarize. The mobility of the charge carriers deteriorates with increasing age of the insulation. This results in deteriorated insulating properties and the motor is more likely to be damaged.

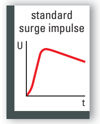
The force that is necessary to spin the charge carrier inside the isolator can be measured during the high-voltage test DC in the form of a small current.

The polarization of the charge carriers is not finished directly after connecting the test voltage – it can take up to 10 minutes. It is assumed that one minute after charging the capacity of the test object the polarization is still in process. The mobility of the charge carriers can thus be determined by the ratio between the strong spinning at the beginning and the reduced current after the spinning.

$$PI = \frac{\text{current}_{1\text{minute}}}{\text{current}_{10\text{minutes}}} \quad \text{or} \quad \frac{\text{insulation resistance}_{10\text{minutes}}}{\text{insulation resistance}_{1\text{minute}}}$$

In case of a good isolator, the current has, after 10 minutes, decreased by four our five times, because all charge carriers have polarized. The result is a good PI of, for example, 4 to 5. In case of a bad isolator, the current has hardly changed after 10 minutes, because the immobile charge carriers can no longer polarize correctly. This results in a bad PI of, for example, 1.5. In this case, the device needs urgent maintenance.

After the polarization, therefore, the real current is measured through the insulation resistance. If the insulation resistance of a motor is measured too fast, the resistance is indicated too low, because you are still measuring the charging of the capacity of the test object and the polarization.



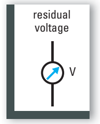
Standard surge impulse

The standard-surge-impulse test is another alternative to the high-voltage test AC and/or DC. The standard surge impulse is more like a lightning-impulse voltage.

The standard surge impulse has a temporal definition of the curve shape. Therefore, it is often defined as “1.2/50 impulse”. The two time values define the rise time and the falling time to half-value. The pulse shape during the test should differ from this definition only to a small extent.

The test impulse is created between the leads and between the lead and ground. During the test, the test impulse is applied between the leads and ground and/or successively between every lead and ground.

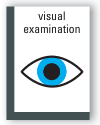
We supply testing devices with test voltages up to 6KV.



Residual voltage

The residual-voltage test serves to detect dangerous residual voltages at connection leads or at the mains plug of a test object after the mains voltage has been switched off.

Residual voltages are created through internal capacities inside the test object. For safety reasons, these electric charges must disappear within a time period defined in the standards.

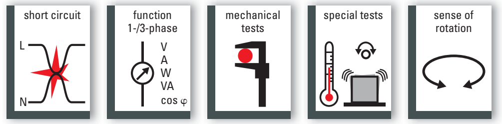


Visual examination

The operator checks and evaluates the test object visually. The result is entered manually at the tester.

In order to facilitate the testing procedure, it is, depending on the tester, possible to show digital photos on the monitor.

Visual examinations are performed as individual test steps or as combined test steps within a test process. Just like safety tests, the results of visual examinations are stored and documented in protocols.



Function

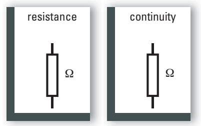
The safety tests are followed by the functional test. If the test object has no short circuit, the desired test voltage is connected to the test object.

The current consumption is the most commonly used criterion for the evaluation of the function. However, other electric variables, like power or phase shift can also be the basis of the evaluation. On top of that, it is possible to measure and evaluate other physical parameters like:

- RPM
- sense-of-rotation
- torque
- temperature
- pressure
- caliper measurement
- vibration
- noise
- flow rate
- optical measurements and more

Due to the modular design of our testing devices, we are in a position to offer both, simple functional tests and more complex and challenging functional tests, e.g. for vehicle drives.

We supply testing devices with functional tests up to 1000A.



Resistance

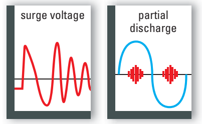
The ohmic resistance test is performed either in 2-wire configuration or in 4-wire configuration. With 2-wire configuration, the resistances of the test leads, the relay switch-overs and the contact points influence the test result. This variant is, therefore, only used for resistances over 1…10Ω – here, this fault is only a small percentage of the measured value.

In order to compensate the contact resistances in the test leads and at the contact points, it is, for low-resistance test objects, always necessary to use the 4-wire measurement configuration.

For an optimum 4-wire contacting, we recommend Kelvin clamps and 4-wire test probes.

When measuring temperature-dependent resistances, e.g. at motor coils made of copper wire, it is necessary to consider the temperature. For this purpose, either the ambient temperature or the temperature of the test object is measured. The measured resistances are converted to 20 degrees celsius temperature.

We supply testing devices with measuring ranges from 1µΩ to 1MΩ.



Surge voltage and partial discharge

For the surge test, the testing device connects a so-called surge capacitor to the desired test voltage. The testing device connects the charged capacitor abruptly to the winding to be tested. This takes only a few hundred nanoseconds. Subsequently, the surge capacitor and the winding to be tested form an RLC circuit. A surge oscillation, typical for the winding, appears in the RLC circuit.

For fractions of seconds, there are high voltage differences from turn to turn inside the winding, which can cause local flashovers at possible damaged spots. This way, winding errors can be detected even visually.

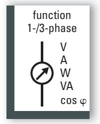
Inside the tester, the surge curves are digitized and indicated on the screen.

The evaluation takes place either through a visual examination by the operator or fully-automatically by the testing device. The automatic evaluation is based on the comparison between the windings of a stator or to a stored reference part.

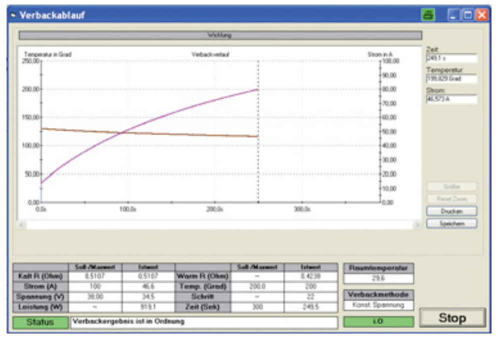
Various automatic analyzing methods allow precise statements on the equality of windings. Short circuits in the windings or in the phases of the winding cause asymmetries of the surge curves. They are detected by the software and automatically evaluated GO or NO GO. The process is performed reliably and doesn’t require any special knowledge from the operator.

We supply testing devices with test voltages up to 30KV.

Test methods



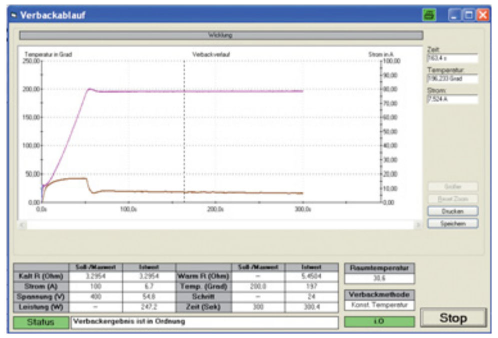
Bonding



Bonding with constant voltage – constant-voltage method
A constant voltage is connected to the winding to be bonded. The growing heat causes the resistance of the winding to rise, which results in a decreasing current. An increase of the temperature thus has the effect that less power is released to the winding.

The advantage of this method is that the temperature rises relatively slow, allowing the stator to be heated up evenly. When reaching the bonding temperature, the temperature difference between winding head and slot is, therefore, optimally low.

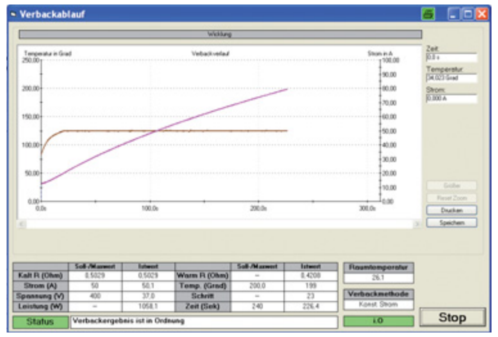
Since the maximum current density in the wire is only reached at the beginning of the bonding process, it is possible to achieve very short bonding times.



Bonding with constant temperature
If you use the constant-voltage method or the constant-current method, the bonding process stops as soon as the bonding temperature has been reached.

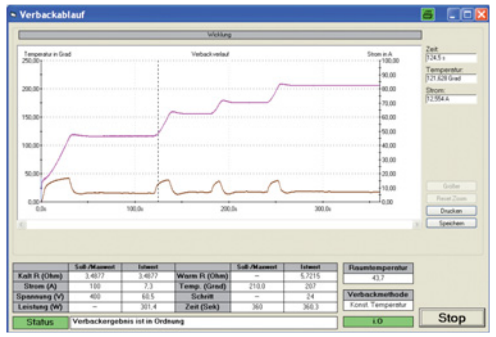
With these two methods, the time period, during which the coating of the enameled wire can melt and form a connection with the adjacent wires is relatively short. It is, therefore, possible that the wires are not bonded properly at those parts that go through the slot, because, owing to the winding head, at these points the wires are somewhat cooler.

When using the constant-temperature method, after reaching the target temperature, the temperature is kept at a constant level for a certain period of time. This prolongs the time during which the coating of the enameled wire can melt and form a connection with the adjacent wires.



Bonding with constant current – constant-current method
During the bonding process, this method keeps the current at a constant level. Owing to the increasing resistance, the current decreases. In order to stabilize the current, the bonding machine increases the voltage continuously during the bonding process. For this reason, the final temperature is reached much faster than with constant voltage. However, the temperature in the winding may be distributed unevenly.

The advantage of this method is that you can reach very short bonding times. In most cases, however, the temperature is distributed unevenly.



Bonding with temperature profile
In principle, bonding with a temperature profile corresponds to bonding with constant temperature. With this method, however, the process has several temperature steps.

The temperature difference between winding head and slot can be balanced, even in case of low initial temperatures, before starting the bonding process.

This method is primarily used in case of very long stacks compared to very short winding heads and/or if the stack is very large.

References

SCHLEICH
Advanced Test Technologies

ABB
AEG
Arcelik
Airbus Industries
Alcatel
AMK
Ansorg
ATB
Audi
AUMA
Aumann
Grundfos
Hanning
Heidelberger Druck
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Hirschmann
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