HAEFELY
HIGH VOLTAGE TEST

AC TEST SYSTEMS
Tank Type Transformers

Type PSK
20 - 1000 kV

Tank type test transformer 750 kV, 2100 kVA

Application

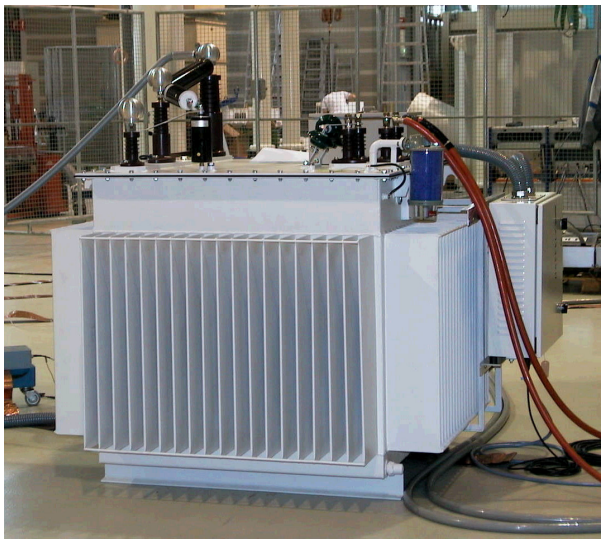
Conventional AC test transformers are especially designed for testing objects of medium capacitance in the factory, indoor or outdoor. These systems are particularly suited for tests requiring stable voltage even if the load changes under voltage (heavy corona, wet & pollution tests) or when the load is of inductive kind (inductive voltage transformers). The system duty cycle can be freely chosen and is insured by adding radiators or forced oil-cooling to the transformers. These systems are also suited for continuous duty, long duration tests.

User benefits

- Indoor or outdoor designs with adapted bushings, suitable also for pollution tests
- Large range of application and low acoustic noise level (approx. 65 dBA)
- Sophisticated protection features for optimal test object & personnel protection
- Possibility to use an external oil expansion vessel with Buchholz or DGPT 2 relay

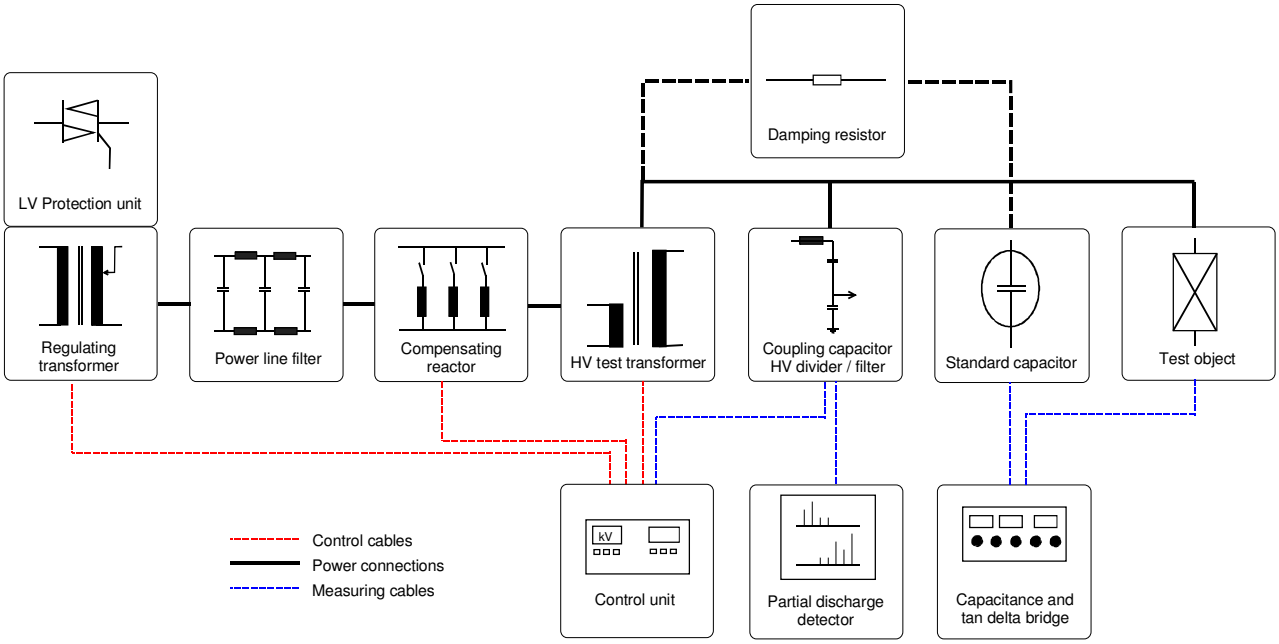
Quality

Haefely quality assurance complies with ISO 9001. The electronic measurement and control devices are designed and manufactured in-house. Our many years of experience in dealing with EMC is therefore an important asset.
The design of the test system complies with the VDE 0104 standard for optimal protection of the operating personnel. The test system is shut down in case of over-voltage, over-current and fast voltage transients. Damage at the fault area is minimised.



50 kV, 400 kVA test transformer

Block-diagram of a typical transformer test system (options also shown)



System configuration

The test system includes following main components:

- Regulating transformer
- Power line filter
- Compensating reactor
- Test transformer
- Coupling capacitor
- Control system OT 247
- HV and grounding connections between HV elements. Connection to test object usually not included.

Available Options

- HV filter inductance for coupling capacitor
- Damping resistance
- Low voltage protection unit
- Standard capacitor
- Control system OT 257 instead of the OT 247
- Additional HV connections
- Partial Discharge detectors
- Capacitance and power loss factor measuring bridges
- Other devices upon request.

Function of the test system

The conventional tank type test transformers type PK steps up the voltage coming from the regulating transformer type STL (air insulated) or STO (oil insulated).

The controls act on the regulating transformer to adjust precisely the input voltage of the transformer and thus the test voltage.

A compensating reactor type KDL is connected between the regulating and the test transformers and compensates the capacitive power required for the test object. This way, the regulating transformer and the power line filter ratings can be kept small. It reduces also the power supply requirements.
The voltage measurement is carried out by using a separate HV divider / coupling capacitor. It is also possible to use the capacitive graded bushing as HV part of the divider.

System components series PSK

These systems are usually customised designs. The table below only gives some typical examples. Rated voltages between 20 and 1000 kV and rated currents up to 5 A are available.

The duty cycle is also adapted to customers' needs and is therefore not stated in below table.

AC test system Type PSK kV - kVA	Test transformer Type PK kV - kVA	Regulating transformer Type STL or STO kVA for cont. duty	Compensating reactor Type KDL kVA for cont. duty	Coupling capacitor Type TK or KKF kV - nF
PSK 30-30	PK 30-30	STL 50	---	KK 50-1
PSK 70-70	PK 70-70	STL 75	---	KK 100-1
PSK 90-150	PK 90-150	STL 150	---	KK 100-1
PSK 100-600	PK 100-600	STL 200	KDL 800	KK 100-1
PSK 210-300	PK 210-300	STL 100	KDL 400	KK 300-1
PSK 400-1600	PK 400-1600	STO 500	KDL 2100	KK 400-1
PSK 700-1400	PK 700-1400	STO 400	KDL 2000	KK 700-1
PSK 900-900	PK 900-900	STO 300	KDL 1200	KK 900-1

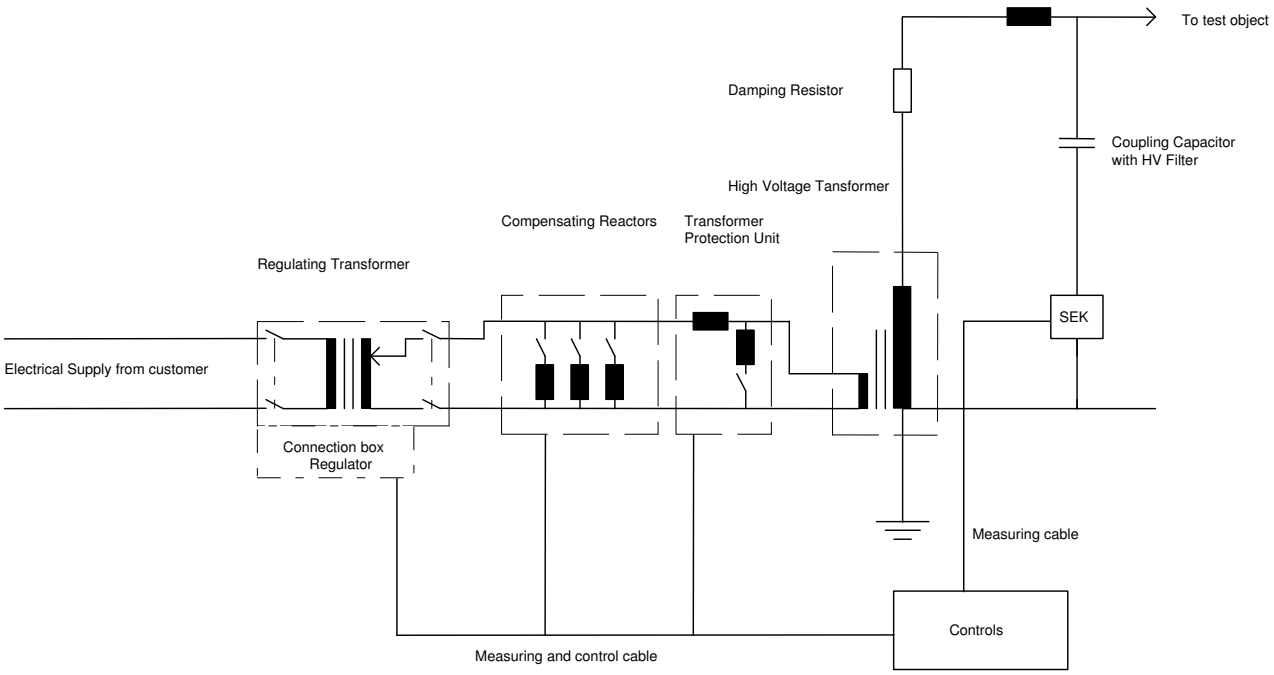
Usual system duty cycle is 1 h On, 1 h OFF, 2 times per day.

Standard ambient conditions for the AC test equipment

Height above sea level	≤ 1000 m
Relative humidity in main hall under non condensing conditions non condensing	≤ 90 %
- Temperature averaged over 24 h for H.V. components	min. 0 °C, max. + 30 °C
- Extreme temperatures for H.V. components	min. - 5 °C, max. + 40 °C
- Temperature for electronic controls and measuring (equipment to operate with the specified measuring errors)	min. + 15 °C, max. + 25 °C

For outdoor or pollution tests, special bushings having the required creeping distance are used, allowing higher relative humidity levels.

Electrical line diagram of a typical transformer test system

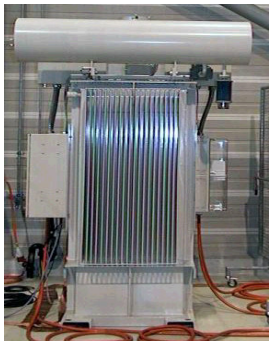


Only main components are shown.

Description of the test system components

Regulating transformer type STL and STO

Description



Regulating transformer type STO 300

The regulating transformer adjust the input voltage of the test transformer practically without steps. The unit is for indoor operation. The active part is air insulated (type STL) or oil insulated (type STO) and built into a cubicle or tank. The primary winding is galvanically separated from the secondary winding. The driving motor allows a slow and a fast regulating speed (40-240 s from 0-100 % of the voltage).
The primary breaker and secondary contactor are placed in the regulator cabinet.
The power line filter can be built-in or attached to the regulating transformer cubicle.

Technical data of the regulating transformer series STL

Type STL	Rated power kVA cont. duty	Secondary voltage V	Dimensions L x W x H m	Weight net, approx. kg
STL 50	50	400	1.6 x 0.6 x 2.0	570
STL 75	75	400	1.4 x 0.9 x 1.5	790
STL 100	100	400	1.7 x 0.9 x 1.5	990
STL 150	150	1000	1.0 x 1.8 x 1.5	1540
STL 200	200	1000	1.2 x 2.0 x 1.7	1700

Technical data of the regulating transformer series STO

Type STO	Rated power kVA cont. duty	Secondary voltage V	Dimensions L x W x H m	Weight net, approx. kg
STO 300	300	1000	1.6 x 1.4 x 2.9	5000
STO 400	400	1000	1.6 x 1.4 x 3.0	5300
STO 500	500	1000	1.7 x 1.6 x 3.0	6400
STO 800	800	1000	1.8 x 1.7 x 3.2	8600

Power line filters type NLFA

Description

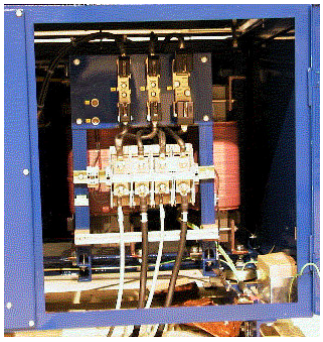
For the reduction of line carried noise from the mains. The power line filter filters both phase and is connected to ground. The filter is either built into the cubicle of air insulated regulating transformers. Special arrangements are possible for big systems depending of local installation conditions.

Their power rating is adapted to regulating transformer rated power.

Typical insertion loss per phase measured			
at 50 Ω / 50 Ω, MIL-STD 220 A	≥	80	dB
in the following frequency range of	14 kHz...	10	MHz

Compensating reactor type KDL

Description



Compensating reactor type KDL 180

For the compensation of the reactive power of capacitive test objects.
The air insulated compensating reactor is connected between the regulating transformer and the test transformer. Therefore, the power rating of the regulating transformer and of a possibly pre-connected power filter can be kept small.
The compensating reactor includes typically 3 inductances which can be combined to achieve up to 7 different power combinations. The re-connection is basically done manually. Upon request (option), a remote re-connection with switches actuated from the controls can be offered.

Technical data of the KDL compensating reactor series

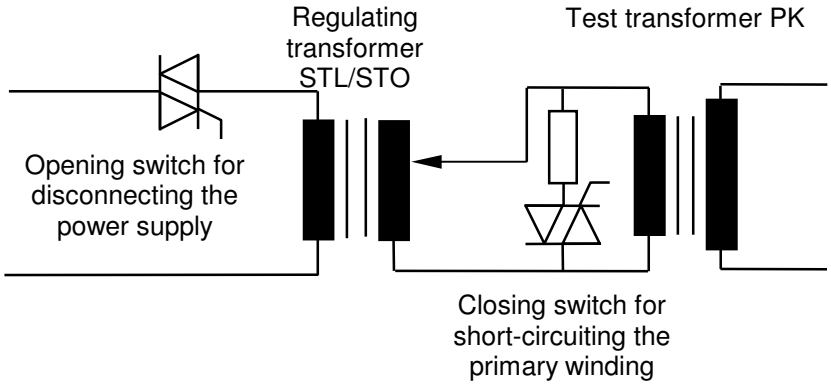
Type KDL	Rated power kVA cont. duty	Rated voltage V	Dimensions L x W x H m	Weight net, approx. kg
KDL 180	180	400	1.1 x 1.2 x 1.0	550
KDL 360	360	400	1.2 x 1.2 x 1.0	850
KDL 900	900	1000	1.6 x 1.3 x 1.4	1800
KDL 1800	1800	1000	2.5 x 1.3 x 1.5	3200
KDL 2800	2800	1000	2.7 x 1.4 x 1.5	4200

As the compensating reactors are designed specifically to the system specification, only a few examples are given in the above table.

Low voltage protection device type NSP

Description

To prevent inadmissible high recovery over-voltages on the test transformer in case of disruptive discharges on the test object. The low voltage protection device NSP acts by opening the power supply and by short-circuiting of the test transformer within a few hundred microseconds. This avoids repetitive flash-overs in the test object.



AC test transformer type PK

Description

Test transformers are used for the temporary or continuous generation of high AC voltages. An essential point lies in that the excitation of the low-voltage winding can be preset stepless from zero to the desired level, the „ON" period is different for the various applications. It varies from a one-minute to continuous duty.
The oil insulated transformer is built into a steel tank and can be used for indoor and outdoor operation.

The windings are of layer-wound design with a high capacitive coupling between layers and turns. This design provides a high transient voltage withstand capability in case of external breakdowns.

Primary winding

The primary winding is divided into two groups for 100 % output each. When the two winding groups are connected in parallel and the regulating transformer is set to 100 % voltage, the transformer attains its, nominal voltage. When the two winding groups are connected in series only 50 % of rated voltage are attained, with the same regulating transformer setting. This allows to set lower test voltages with higher accuracy. Changing of the connection is made by switching links.

High-voltage winding

The neutral end of the high-voltage winding is brought out insulated. The high-voltage end is connected to the transformer bushing.

Over voltage protection

Surge arresters are installed in parallel with the primary and the coupling winding to protect the transformer against over voltages in the case of flashovers. Moreover, surge arresters are installed between the primary winding and ground and between the coupling winding and ground.

Dielectric

The dielectric consists of paper, transformer board and mineral oil. The complete test transformer is dried under high vacuum and heat. The oil-impregnation and oil-filling processes are also made under vacuum. The insulating oil is Shell Oil Diala D.

Connection box

The connection box is a separate cubicle. One connector for the measuring cable going to the control desk is provided.

Cooling

The transformer tank can be fitted with cooling radiators. The insulating oil is conducted through this tank by natural convection, and it is thus cooled. Cooling type is ONAN.

Protection and safety features

In case of a breakdown on the Device Under Test (DUT), the integrated flash detector switches off the system immediately. The output current and voltage are measured and monitored at the control desk. The transformer is not completely filled with oil. The remaining air volume (air cushion) allows an oil expansion according to the oil temperature. This air cushion is connected to the outside via a Orange-gel dehydrator. An oil temperature indicator is mounted on each module.

Base

The transformer tank is provided usually with a flat base.

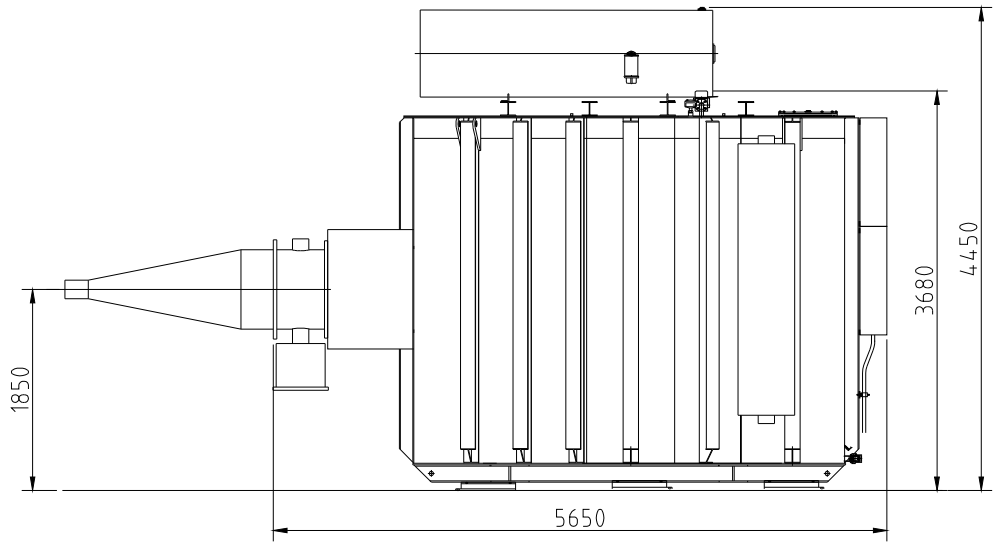
Dimensions and weights (some examples only)

Transformer type PK kV - kVA	Voltage U_n kV	Power P_n kVA	Dimensions L x W x H m	Weight of oil approx. kg	Total weight net, approx. kg
PK 30-30	30	30	0.8 x 0.8 x 1.2	170	600
PK 70-70	70	70	1.0 x 1.0 x 1.7	300	1300
PK 90-150	90	150	1.5 x 1.3 x 2.5	390	2500
PK 100-600	100	600	1.9 x 1.7 x 2.8	1'600	6'000
PK 150-75	150	75	1.1 x 1.4 x 2.9	600	1'600
PK 210-300	210	300	1.8 x 1.6 x 3.9	1'600	4'100
PK 250-50	250	50	1.8 x 1.2 x 3.3	800	2'400
PK 600-1'260	600	1'260	9.5 x 2.4 x 4.5	15'000	28'000
PK 900-900	900	900	12.0 x 2.4 x 6.0	19'000	35'000

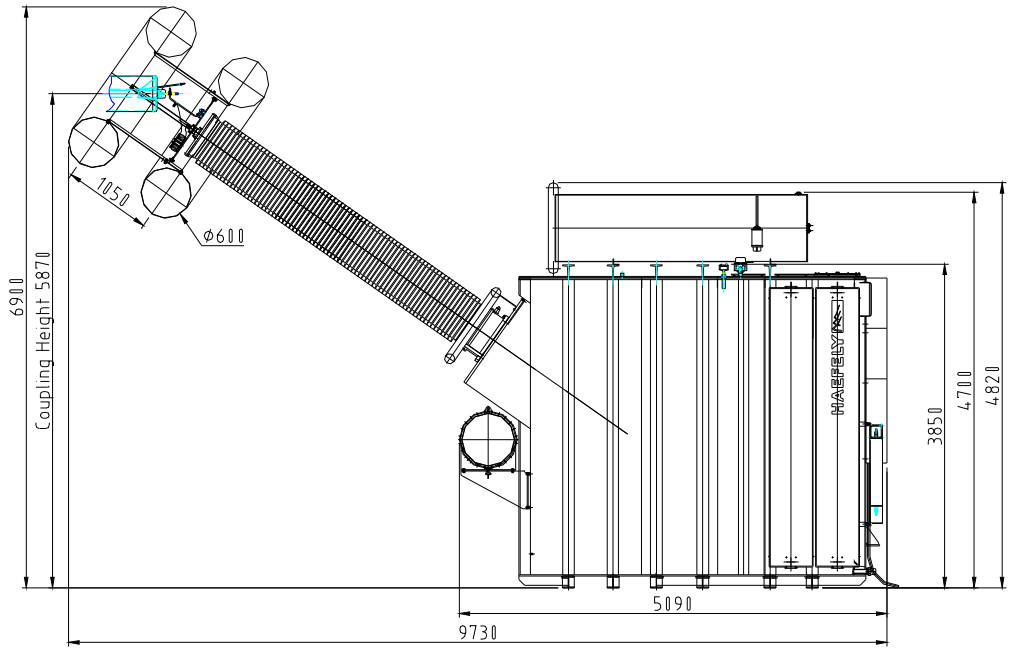
Other voltages, current or duty cycles are possible upon request !

Dimensions are given with HV bushing installed.

Example of a 700 kV, 2'100 kVA system with SF_6 bus comprising damping resistor, coupling capacitor & SF_6 - air bushing



Example of a 920 kV, 920 kVA transformer with oil - SF_6 bushing



Example of a 750 kV, 2'100 kVA transformer with oil - air bushing

Voltage divider / coupling capacitor / HV filter

The coupling capacitors of the series KK or TK (and 9230) consist of 1 or more modular units, built into glass fibre reinforced epoxy tubes. Their applications are:

- Partial discharge measurements with an optional coupling quadripole.
- Measuring AC voltages in the industrial frequency range.
- Attenuating interferences coming from the HV side (together with a HV inductance)

Technical data of KK series

Type KK	Voltage kV	Capacity nF	PD Level at Un pC	Type	Height H mm	Diameter top electrode D mm	Base frame dimension B mm	Weight net, approx. kg
100-1	100	1	≤ 1	B	720	300	350	15
200-1	200	1	≤ 1	B	1640	350	850	60
300-1	300	1	≤ 1	B	2600	660	1500	150
400-1	400	1	≤ 2	B	3300	1580	1500	270
600-1	600	1	≤ 3	C	4600	1900	2100	490
800-1	800	1	≤ 5	C	6000	1900	3100	650

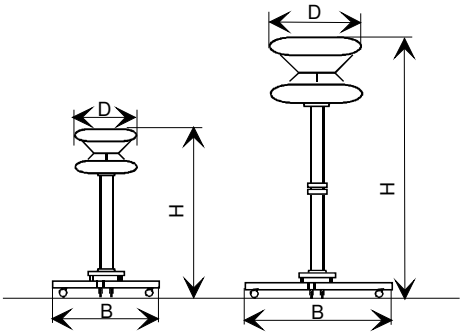
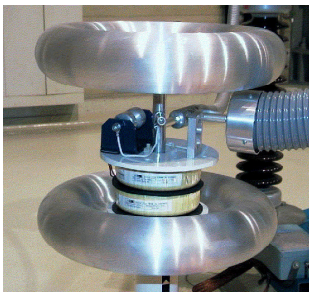


Fig. B Fig. C



Special HV filter inductance configuration.

High voltage filter for KK series (option)

By adding an inductance to the coupling capacitor, they form the high voltage filter KKF, which attenuates interferences coming from the high voltage reactor / transformer side. Following inductance is available:

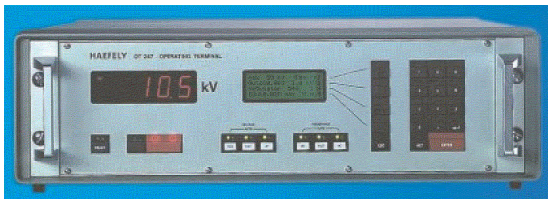
Type	Inductivity mH	Max. current A	Weight, net kg	Capacity of KK nF
F 600-2	600	2	3	≤ 1

Typical insertion loss (50 Ω / 50 Ω) at 40 kHz - 400 kHz ≥ 20 dB

Controls type OT 247

Description

The Operating Terminal OT 247 provides a safe and easy computer aided operation of transformer-type AC high voltage test systems. The unit is built into a standard 19" desktop housing. It has a high electro-magnetic compatibility and does not need additional screening. Due to the built-in safety interlocks the operator can fully concentrate on the test object.
As an option, the more sophisticated OT 257 can be offered.



Controls type OT 247

Software The program allows the following operations:

- Switching On/Off of the primary circuit breaker
- Switching On/Off of the contactor (High Voltage On/Off)
- Manual variation of the output high voltage, two speed levels
- Automatic zero start-up after switching off the high voltage
- Automatic setting of the output high voltage to a preset value with a pre-set speed (kV/s)
- Timer for switching off the high voltage after a preset time

At any time and in addition to the output high voltage a selection of four of the following information can be displayed:

- Status of the protection system
- Status of the safety circuit and the emergency trip
- Output voltage and current of the regulating transformer
- Timer

High Voltage measurement

The measuring signal is derived from the built-in HV divider of the PK type transformer. The value of the high voltage is permanently displayed, either as peak value/√2 or as RMS value. In case of flashover at the test object the control unit automatically stores the last voltage measurement.

Measuring error of the electronic	± 0.5 % of the measured value between 10 % and 100 % of the system output voltage
Measuring error of the complete measuring system (divider/coupling quadripole, electronic system) at 50 / 60 Hz.	± 1 % of the measured value between 10 % and 100 % of the output voltage

Special solutions

Damping resistor

Description

The damping resistor consist of 1 or more modular units, built into glass fibre reinforced epoxy tubes. Its application is.

- protecting the high voltage AC test transformer from transients when a flash-over occurs.

They are built for indoor use and connected between the test transformer and the voltage divider electrodes. Their resistance is in the range of 1 kOhm.

Typical damping resistor arrangement on a 300 kV system

Oil expansion device

Description

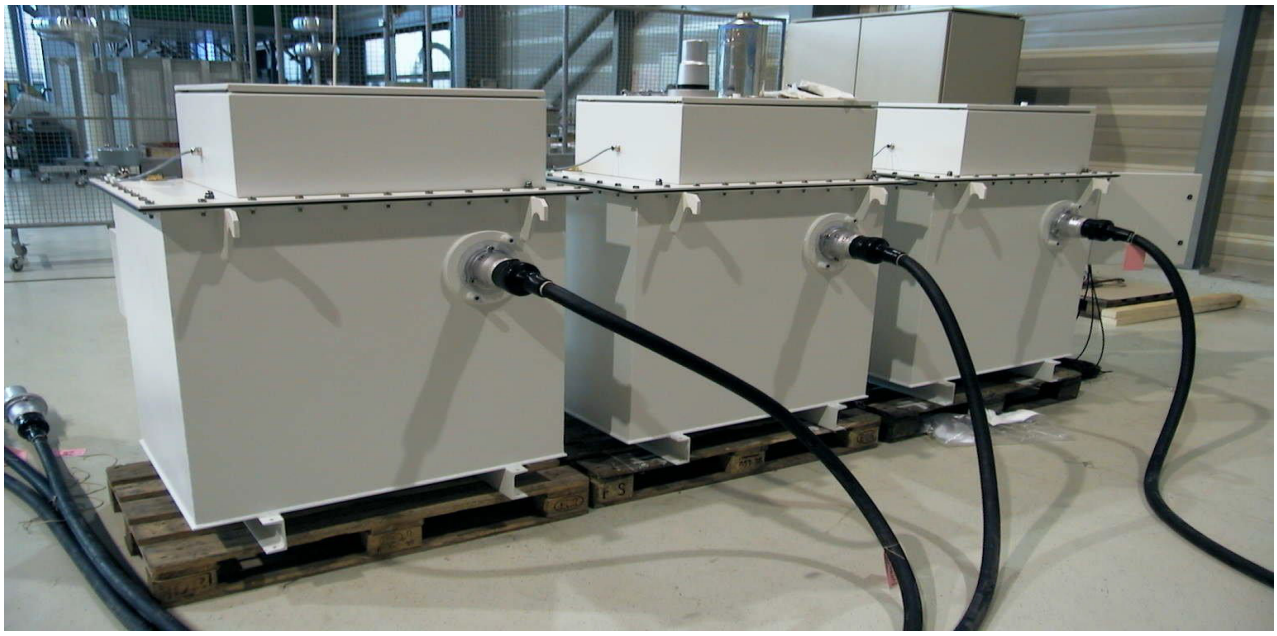
The transformer is fitted with an oil expansion device placed above its tank cover. The expansion device is connected to the tank through a Buchholz or DGPT 2 relay. The expansion device is not completely filled with oil. The remaining air volume (air cushion) allows an oil expansion according to the oil temperature. This air cushion is connected to the outside via an orange-gel dehydrator. For outdoor service, the air volume is enclosed in a rubber bubble, avoiding therefore direct contact with the oil. This prevents from oil pollution due to moisture.

Example of an oil expansion device

Special HV leads

Description

For special applications, the transformer is fitted with a standard MV connector to which a MV cable can be connected. This solution is however limited to MV applications. This allows to test devices having the same standard MV connectors and permits a confinement of the HV in shielded components and suppresses the use of oil-air bushings. Furthermore, this solution allows to carry out sensitive PD measurements in industrial environments and improves the safety of the operating personnel !



Example of a 3 phase 70 kV test system with MV cable connectors and leads

Technical services

Description

Haefely Test AG has a dedicated Technical Services dept. with an experienced team of engineers doing the internal tests as well as the commissioning on-site and final testing of the test installations. Our Technical Services dept. does also preventive maintenance, repairs and calibrations if required. This responsive team allows to minimise eventual down-times and assures the shortest possible reaction time should any question arise.

The full coverage of the warranty is granted only if Haefely Test AG has carried out the Technical Services. The charges for the delegation of our personnel are based on the terms and conditions of the Swiss Association of Machinery Manufacturers.

Installation

Big installations require our experienced team of mechanical erectors for supervising the assembly the test systems.

System and Acceptance Tests on Site

Once the system is erected, we delegate our engineers for doing the systems tests at the customers'. The system test shall proof that the system works according to the specification at customer's site and gives a first training to the operating staff.
These tests can also be done with a real test object.

Training of Operating Personnel

The training is carried out by the Haefely senior engineer immediately after the systems tests. Detailed explanations about the use of the system, controls and measuring instruments are given, in addition to the operating manuals.

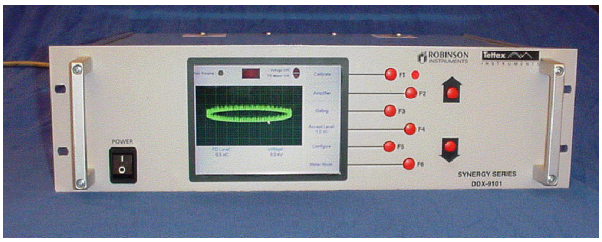
Preventive Maintenance & Service visits

Haefely Test AG can offer a regular service & maintenance visit on-site for checking the system condition & proposing necessary works. This is particularly appreciated for production line equipment.
This visit can also be combined with the system re-calibration.

Accessories

Measuring of Partial Discharges

By adding a coupling quadripole (option), the coupling capacitor type KK(F) or TK can be used for measuring partial discharges. Various coupling quadripoles can be used. Digital or analogue PD detectors can then be used depending of the customer's needs. Please consult the Tettex General Catalogue for more information.



Digital partial discharge detector type DDX® 9101.

Measuring of capacitance and tan δ

The standard capacitors type NK are used in conjunction with C & tan δ bridges for the accurate measuring of capacitance and tan δ values. Digital or analogue bridges can then be used depending of the customer's needs. For more details, see the Tettex General Catalogue.

The SF_6 insulated standard capacitor is used together with a C & tan delta measuring bridge (e.g. Tettex 2877) as a comparison standard for exact measurements of the capacitance and tan delta of H.V. equipment. The SF_6 insulated standard capacitor is designed for indoor service and is of mobile design.

Capacitance and tan δ bridge type 2877

Standard capacitor 600 kV

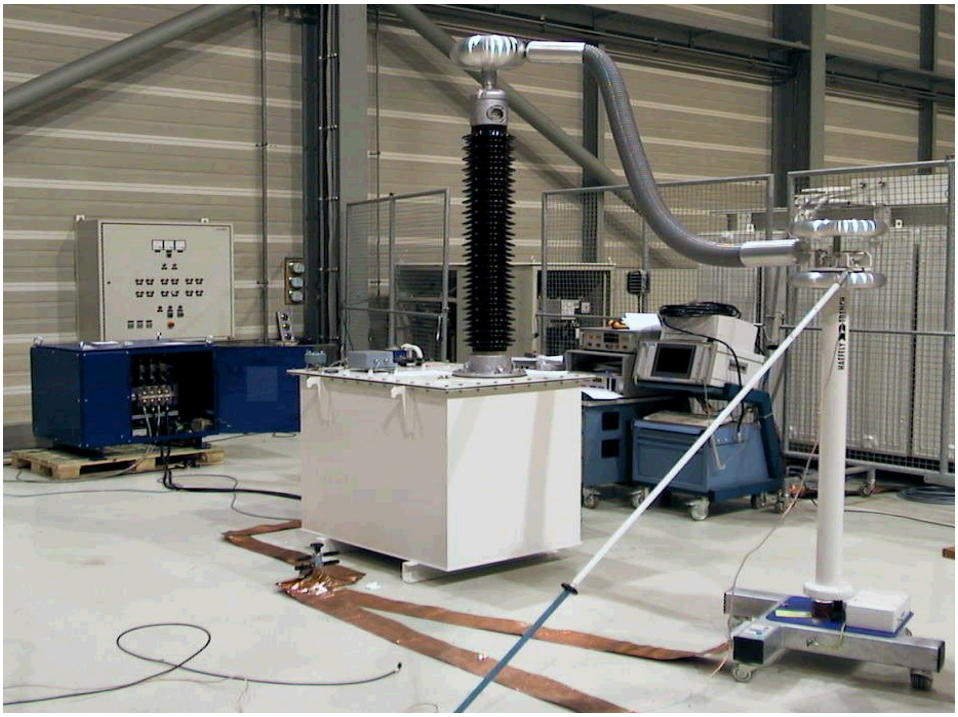
Order text

Description	Code
- Complete basic system	PSK ... kV, ... kVA
- HV transformer	PK ... kV, ... kVA
- Switching and regulating cubicle	STL ... kVA
- Compensating reactor	KDL ... kVA
- Control unit with set of control and measuring cables, 20 m	OT 247 in desk top housing
- Voltage measurement	incl. in OT 247
- One set of operating instructions and test reports	
Options	
- Power line & - HV filters	NLFA ... V, ... A F ... mH, ... A
- Computerised control unit with set of control and measuring cables, 20 m	OT 257 with desk and mini-rack
- Low voltage protection device	NSP 400 or NSP 1000
- Standard capacitor	NK ... kV, ... nF
- Technical services	DEL
- Partial Discharge detectors - C & tan δ measuring bridges	several models available, please see the Tettex General Catalogue
- Other possibilities	please contact us

250 kV, 50 kVA test transformer and HV divider

List of leaflets

Cylinder type resonant test systems up to 1800 kV, 40 A	E 152.51
Tank type resonant test systems up to 400 kV, 10'000 kVA	E 152.60
Instrumentation for Partial Discharge, C and tan δ, accuracy and resistance	Tettex General Catalogue
Haefely Test AG offers also a complete range of impulse test systems for both impulse voltage and impulse current applications.	



Test system 150 kV, 70 kVA

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12.2003

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