



High Voltage Modular Training Set HV 9000



HIGH VOLTAGE MODULAR TRAINING SET

Saving energy is becoming more and more important.
Saving energy can be done by reducing losses. An important factor to reduce losses is to transfer energy through High Voltage Transmission lines.
But High Voltage is also difficult to handle properly, and there is a lot of technical problems to overcome to make handling of High Voltage even more efficient.
With TERCO High Voltage Modular Training Set most of these problems can be studied.

Terco High Voltage Construction Kit HV 9000 is based on a system of components made with the highest precision and can be used to build systems both for teaching and research as well as for industrial routine and type tests.
The assembly of a required Test Set Up is easily done and requires no special toolings.
The system gives values with high accuracy and can even be used for calibration purpose.

General specifications:

Modular design make it easy and quick to set up different test circuits, allowing maximum time for experiments.
Easy to handle due to low weight. All components with exception for the test transformer can be handled by one person.
Special deigned joints facilitates the connection between components.
Specially designed to minimize partial discharge.
All oil filled components are leak proof.
Easy to follow equipment manuals and experiment manuals.

Test room

To have a special test room to house the HV 9000 is very important .

This has to be build by the customer in accordance with below guidelines and level of accuracy required as well as to follow local safety regulations.

For a single stage kit a floor space of 4 x 5 m is recommended, with a height of 2,5-3 m.

Since voltages in excess of 1000 V are generated the safety regulations must be carefully followed.

Fencing and grounding of the Test Room are very important.

Safety equipment

The test area should be enclosed by a metal fence of at least 1.8 m in height and the mesh width not to exceed 50 mm.

All doors leading into the test room must be equipped with door contacts, which close when the door is closed. All contacts shall be connected in series and fed to the appropriate sockets on the control desk. Red and green warning lamps must be installed on all doors leading into the test room. These lamps should be connected to the control desk.

Earthing (grounding)

Earthing is very important and absolutely necessary for a good test room, and a must for impulse voltage test equipment.

Connection should be done with low inductance connections (copper bands 100x0.6mm) which connect all components of the high-voltage circuit that must be earthed to ONE earth terminal.

Earthing connections should be done without loops. A modern way of doing earthing is to cover the lab floor with aluminium sheet (2mm thickness) which are bolted to the floor and connected internally with copper band and to earth.

Also the screening surfaces if any, as well as the test objects and the measuring instruments should be connected to the same earthing point, which should be inside the safety fence and have a lower earthing resistance than the surrounding building. In any case the earthing resistance should not exceed 2 ohm.

Screening

Screening or shielding as it is also called is used to eliminate all external and internal interference and can be achieved by building a Faradays cage. The easiest way to obtain this is to hung a close - meshed metal net on the walls of the laboratory. The unavoidable apertures for power and communication leads must be blocked for high -frequency currents with low-pass filters. Special attention must be paid to careful shielding of doors and windows. The floor should be covered with non-skid sheet metal. *The erection of a complete Faradays cage is necessary only when extremely sensitive partial discharge measurements are intended.* Experiments in a high -voltage practical course can normally be performed without screening.

BASIC CONFIGURATIONS FOR TEST SET-UPS

TERCO HV 9000

	Stages	AC TEST			DC TEST			IMPULSE		
		1	2	3	1	2	3	1	2	3
Basic Components										
HV 9103	Control Desk	1	1	1	1	1	1	1	1	1
HV 9105	Test Transformer 100 kV	1	2	3	1	1	1	1	1	1
HV 9106	High Voltage Connection		1	1						
HV 9107	Discharge Rod	1	1	1	1	1	1	1	1	1
HV 9108	Connecting Rod	2			3	3	3	2	4	7
HV 9109	Connecting Cup	1	1		3	10	14	7	13	21
HV 9110	Floor Pedestal	1			3	5	6	7	8	8
HV 9111	HV Rectifier				2	4	6	2	2	2
HV 9112	Smoothing Capacitor/Impulse capacitor				2	3	5	1	2	3
HV 9113	Measuring Resistor				1	2	3	1	1	1
HV 9114	Earthing Switch				1	1	1	1	1	1
HV 9119	Spacer Tube				2	5	7	5	8	9
HV 9120	Load Capacitor							1	2	3
HV 9121	Charging Resistor							1	2	3
HV 9122	Wave Front Resistor							1	2	3
HV 9123	Wave Tail Resistor							1	2	3
HV 9124	Insulating Rod				1	8	10	2	5	12
HV 9125	Sphere Gap							1	2	3
HV 9126	Drive for Sphere Gap							1	1	1
HV 9138	Top Electrode				1	11	17	1	1	1
HV 9139	Electrode 200		1							
HV 9140	Electrode 300			1						
HV 9141	Measuring Capacitor/100	1								
HV 9142	Measuring Capacitor/200		1							
HV 9143	Measuring Capacitor/300			1						

Measuring and Control Equipment

HV 9130	Low Voltage Divider							1	2	3
HV 9131	Triggering Device							1	1	1
HV 9132	Electronic Trigger Sphere							1	1	1
HV 9150	AC Peak Voltmeter	1	1	1						
HV 9151	DC Voltmeter				1	1	1	1	1	1
HV 9152	Impulse Volt Meter							1	1	1

Test Apparatus

HV 9118	Spacer Bar (for HV 9133)	1			1			1		
HV 9127	Load Resistor				1					
HV 9133	Measuring Spark Gap	1			1			1		
HV 9134	Vessel for Vacuum/ and Pressure	1			1			1		
HV 9135	Corona Cage	1			1					
HV 9137	Oil Testing Cup	1			1					
HV 9144	Compressed Gas Capacitor	1								
HV 9146	Capacitor Coupling	1								
HV 9153	Partial Discharge Meter	1								

TEST SET-UPS

AC Voltage — Typical Configurations

Single-stage		Two-stage		Three-stage	
Rated no load voltage kV (rms)	100	Rated no load voltage kV (rms)	200	Rated no load voltage kV (rms)	300
Output (kVA) : Continuous 1 Hr. on	5 10	Output (kVA) : Continuous 1 Hr. on	5 10	Output (kVA) : Continuous 1 Hr. on	5 10
Rated current (mA)	50 100	Rated current (mA)	25 50	Rated current (mA)	16 32
Impedance voltage (%) Approx.	4	Impedance voltage (%) Approx.	7	Impedance voltage (%) Approx.	11
Frequency (Hz)	50/60	Frequency (Hz)	50/60	Frequency (Hz)	50/60



TEST SET-UPS

DC Voltage — Typical Configurations

Single-stage		Two-stage		Three-stage	
Rated no load voltage kV	140	Rated no load voltage kV	280	Rated no load voltage kV	400
Rated current (mA)	13	Rated current (mA)	10	Rated current (mA)	7.5



TEST SET-UPS

Impulse Voltage — Typical Configurations

Single-stage		Two-stage		Three-stage	
Rated DC charging voltage	140 kV	Rated DC charging voltage	280 kV	Rated DC charging voltage	420 kV
Maximum stored energy with:		Maximum stored energy with:		Maximum stored energy with:	
1. CS 25 (25 nF)	245 J	1. CS 25 (25 nF)	490 J	1. CS 25 (25 nF)	735J
2. CS 50 (50 nF)	490 J	2. CS 50 (50 nF)	980 J	2. CS 50 (50 nF)	1.47 kJ
3. CS 100 (100 nF)	980 J	3. CS 100 (100 nF)	1.96 kJ	3. CS 100 (100 nF)	2.94 kJ
Voltage efficiency (Approx)	92 %	Voltage efficiency (Approx)	92 %	Voltage efficiency (Approx)	92 %



HV 9103 Control Desk



Technical data

Supply voltage:	230 V 50/60 Hz
Regulating transformer:	5kVA Continuous rating driven by 24 V DC geared motor drive.
Regulating Voltage:	220V/0-230 V
Output:	5kVA Continuous 10 kVA (short time duty 2 min.)
Size:	1220x105x800mm (h,w,d)
Weight:	275 kg

This control desk is used to control and operate high voltage AC/DC/Impulse test equipment. The desk contains operating and signal elements for the control circuit of the test equipment for warning and safety. The control desk is made to house the measuring instruments (Peak, Impulse and DC Voltmeter) and also the Trigger Device. Its fabricated of steel and stands on four wheels.

HV 9105 Test Transformer



Technical data

Ratio:	2x220V/100kV/220V
Rated cont. current:	2x11,4A/50mA/15.2A Continuous.
Output:	5 kVA, 10kVA for 60 min. outputs for AC.
Impedance voltage:	4% approx.
Frequency:	50Hz or 60 Hz
Partial discharge level:	at 100 kV _≤ 3pC.
Dimensions	
Height:	770 mm
Diameter:	550 mm
Weight:	215 kg

Application.

Test transformer with coupling winding for cascade connection to produce AC, DC and Impulse voltages. The transformer consist of three windings with insulating shell and top and bottom corona free aluminium shielding electrodes.

The insulation cylinder is made of epoxy resin with glass fibre reinforcement and coated with anti tracking varnish.

The (primary) exciter winding is a double winding: 2x220V for connecting to approx. 220V (parallel connection) or 220 + 220V for connecting to approx. 440V (series connection) The series connection will require 50% of the parallel connection current. Winding No.2 is the HV – winding of 100 kV connected in series.

The third winding known as “Coupler Winding” is provided for further cascade connections of transformers. The coil is vacuum impregnated and insulated with high quality grade transformer oil.

MEASURING & CONTROL EQUIPMENTS

Technical data

Application



HV 9150

Peak Voltmeter (Digital Display)

Supply voltage : 220 V 50 Hz
 Measuring Range : 100-1000 $\hat{U} / \sqrt{2}$ kV
 Weight : 2.8 kg
 Dimensions : 142 x 173 x 245
 (W X H X D)

Measurement of AC voltage Peak. For connection to the measuring capacitor, the compressed gas capacitor or the Coupling capacitor



HV 9152

Impulse Voltmeter (Digital Display)

Supply voltage : 220 V 50 Hz
 Measuring Range : 100-1000kV
 Weight : 3.4 kg
 Dimensions : 142 x 173 x 245
 (W X H X D)

Measurement of the Impulse Voltage peak. For Connection to the load capacitor



HV 9151

DC Voltmeter (Digital Display)

Supply voltage : 220 V 50 Hz
 Measuring Range : 140kV/280kV/400kV
 Weight : 3.0 kg
 Dimensions : 142 x 173 x 245
 (W X H X D)

Measurement of the DC Voltage. For Connection to the Measuring Resistor



HV 9131

Trigger Device

Supply voltage : 220 V 50 Hz
 Weight : 3.7 kg
 Dimensions : 142 x 173 x 245
 (W X H X D)

for Triggering the impulse voltage generator impulse voltage oscilloscope and chopping spark gap.

The trigger impulse is transferred to the high voltage sphere by means of a fibre optics cable . The impulse is amplified in the electronic trigger sphere



HV 9130 Low Voltage Divider

Measuring Ranges (Optional) : 450 kV
 300 kV
 150 kV
 75 kV
 37.5 kV

Incorporates the Low voltage capacitors and the 75 ohm cable adapter It is plugged in to the HF - Socket of the load capacitor and connection to the Impulse Voltage meter by means of co-axial cable.

HV 9132

Electronic trigger sphere

Diameter : 100 mm
 Weight : 0.7 kg

Suitable for use with the sphere gaps and measuring spark gaps . In conjunction with the triggering device . The impulse Volt Generator can be triggered and the voltage be chopped at a pre set instant with fibre optic cable 10 mtr long



BASIC ELEMENTS FOR AC/DC/IMPULSE SET-UPS

Capacitors



Technical data

Application

HV 9112 Impulse Capacitor

DC and Impulse voltages : 140 kV
Capacitance : 25 nF
Weight : 18 kg

Impulse capacitor for generation of impulse voltages. It can also be used as smoothing capacitor in DC voltage generation.

HV 9112-50 Impulse Capacitor

DC and Impulse voltages : 140 kV
Capacitance : 50 nF
Weight : 38 kg

Impulse capacitor for generation of impulse voltages. It can also be used as smoothing capacitor in DC voltage generation.

HV 9112-100 Impulse Capacitor

DC and Impulse voltages : 140 kV
Capacitance : 100 nF
Weight : 60 kg

Impulse capacitor for generation of impulse voltages. It can also be used as smoothing capacitor in DC voltage generation.

HV 9120 Load Capacitor

DC and Impulse voltages : 140 kV
Capacitance : 1.2 nF
Weight : 10 kg

Load capacitor and high voltage divider capacitor for measurement of impulse voltages.

HV 9141 Measuring Capacitor

AC voltages : 100 kV
Capacitance : 100 pF
Weight : 10 kg

High voltage divider capacitor for measurement of AC voltages.

HV 9142 Measuring Capacitor

AC voltages : 200 kV
Capacitance : 100 pF
Weight : (Approx.) 75 kg

High voltage divider capacitor for measurement of AC voltages.

HV 9143 Measuring Capacitor

AC voltages : 300 kV
Capacitance : 100 pF
Weight : (Approx.) 125 kg







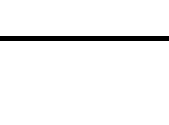

High voltage divider capacitor for measurement of AC voltages.

HV 9146 Coupling Capacitor

Rated Voltage : 120 kV
Capacitance : 1 nF
Partial Discharge : 5 pC
Height : 1300 mm
Weight : 56 kg

High voltage coupling capacitor to be used mainly for partial discharge measurements in HV testing.

BASIC ELEMENTS FOR AC/DC/IMPULSE SET-UPS

		Technical data	Application
	HV 9124	HV 9124 Insulating rod	Insulating component
		AC voltage : 100 kV DC and impulse voltage : 140 kV Weight : 1.5 kg	
	HV 9111 HV 9121 HV 9122 HV 9123	HV 9111 Silicon Rectifier	Rectifier for use in impulse voltage and DC voltage generation.
		Inverse Peak voltage : 140 kV Rated current : 20 mA Protective resistor : 100 k Ω Weight : 10 kg	
	HV 9125	HV 9121 Charging Resistor	Charging resistor for multistage impulse voltage test equipment and current limiting resistor in DC voltage generators.
		DC and Impulse voltages : 140 kV Resistance : 10 M Ω Weight : 6 kg	
	HV 9126	HV 9122 Wave front Resistor	For generation of impulse voltages the resistors determine the rise time of the Impulse voltage in lightning and switching impulse voltage generation.
		Impulse voltages : 140 kV Resistance : 350 Ω Weight : 5 kg	
	HV 9113	HV 9123 Wave tail Resistor	For generation of impulse voltages the resistors determine the time to half value of the Impulse voltage in lightning and switching Impulse voltage generation.
		Impulse voltages : 140 kV Resistance : 2400 Ω Weight : 5 kg	
	HV 9126	HV 9125 Sphere Gap	For Impulse voltage generation, for pre-setting of impulse voltage peak
		Impulse voltage : 140 kV Sphere Diameter : 100 mm Max. gap Setting : 80 mm With gap setting indicator Weight : 6 kg	
	HV 9126	HV 9126 Drive for Sphere Gap	The Sphere Gap setting is made over the insulating shafts, and clamped to the spacer tube.
		Input : 220 kV Frequency : 50 / 60 Hz Weight : 6 kg	
	HV 9113	HV 9113 Measuring Resistor	High voltage series resistor for measurement of DC voltages.
		DC voltage : 140 kV Resistance : 280 M Ω Rated continuous current : 0.5 mA Weight : 6 kg.	



HV 9106 HV Connection

Length : Approx. 0.7 m for 200 kV
Approx. 2.2 m for 300 kV

Flexible metal connection with connector for the test transformer and connecting Cup. For connection of a multi-stage AC voltage test equipment with the test transformer.



HV 9114 Grounding Switch, Electrically Operated

Impulse Voltage : 140 kV
DC Voltage : 140 kV
Service Voltage : 24 V, 50 / 60 Hz
Weight : 6.5 kg

For grounding the high voltage construction kit when de-energized.



HV 9138 Electrode

Diameter : 300 mm
Weight : 2 kg

Serves as termination in conjunction with Grounding switch for safety grounding. Also serves as corona free electrode.



HV 9107 Discharge Rod

Length : 2.5 m
Discharge Resistance : 100 Ω
Weight : 1.5 kg

For Manual discharging of equipment components.



HV 9109 Connecting cup

Aluminum cast
Weight : 2.5 kg

Conductive Element: four elements can be inserted in horizontal position and two in vertical position.



HV 9110 Floor Pedestal

Aluminum cast
Weight : 1 kg

Conductive Element: for mounting up to four Spacer bars horizontally and supporting one Component vertically.



HV 9108 Connecting Rod

Aluminum tube
Weight : 1 kg

Conductive connection element.



HV 9119 Spacer tube

Aluminum tube
Weight : 1 kg

Mechanical and electrical connection on ground level when inserted into floor pedestal

TEST APPARATUS

Technical data

Application



HV 9134

HV 9134 Vessel for vacuum and pressure

AC Voltage	100 kV
DC Impulse Voltage	140 kV
Max. operating pressure (abs):	0-6 bar
With different electrodes	
Sphere Electrodes	Dia. 50 mm Dia. 20 mm
Weight	12 kg

For the determination of the flashover voltage of electrode arrangement as a function of vacuum and pressure



HV 9135

HV 9118 Spacer Bar

Aluminium Tube

Length	652 mm
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For connection of a floor Pedestal with the vessel
For vacuum and pressure
HV 9133



HV 9137

HV 9135 Corona Cage

AC Voltage	20 kV
DC Voltage	
Weight	1.5 kg

For determination of the glow intensity as a function of the wire diameter.
The corona cage is inserted in to the HV 9134. Measurement can be made at vacuum and pressure



HV 9133

HV 9137 Oil Testing Cup

With electrodes having spherical caps gap setting 2.5 mm.

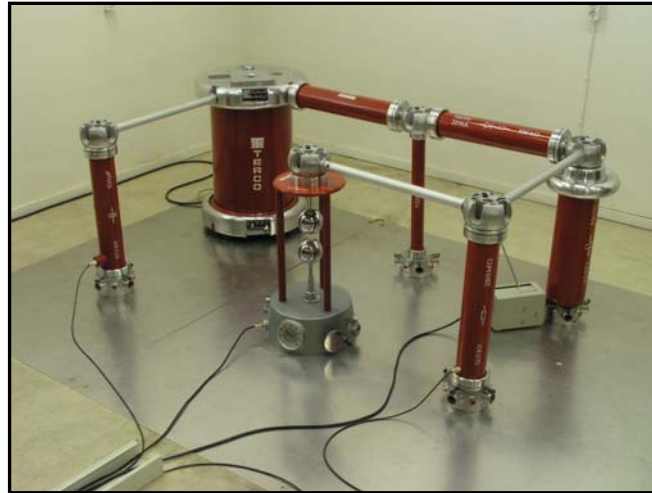
For the measurement of flashover voltage of insulating oil

HV 9133 Measuring Spark gap

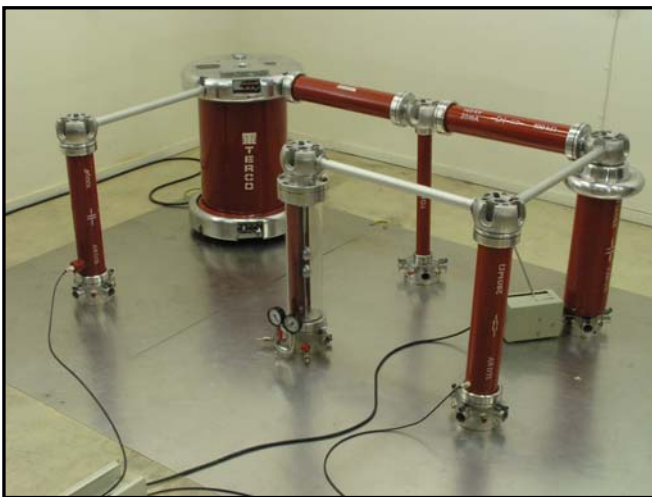
AC Voltage	100 kV
DC Voltage	140 kV
Impulse Voltage	140 kV
For manual and motor operation	220 V, 50 Hz
With different electrode	
Sphere Electrode	Dia 100 mm
Sphere Electrode	Dia. 50 mm
Rod type Electrode	Dia. 20 mm
Needle Electrode and flat electrode	
Weight	14.5 kg

For the measurement of the flashover voltage using various electrode arrangements.
For use as chopping spark gap after mounting the trigger sphere. With hand-wheel for manual gap setting.
Accessory : Connection cable 3 x 1 sq. mm 5 m long, to control desk.

Different Experiment setups and Safety Net Installation



Measurement of flashover



Measurement of flashover voltage in vacuum and under pressure



Impulse setup



Demonstrating easy assembly



Installation of Safety Net

List of experiments

1. Generation and Measurement of Alternating Voltage

2. Generation and Measurement of Direct Voltages

- i.) Load characteristics of Rectifiers
- ii.) Measurement of Ripple Factor

3. Generation and Measurement of Direct Voltages II

- i.) Greinacher Voltage Doubler Circuit
- ii.) Polarity effect and Insulating screens

4. Generation of Impulse Voltages

5. Measurement of Impulse Voltages

6. Power Frequency and Impulse Voltage Tests on Power Transformer

7. Experiment on Insulating Liquids.

- i.) DC Conductivity
- ii.) Measurement of Tan delta and Capacitance

8. Experiment on Solid and Insulating Liquids

- i.) Fibre- Bridge breakdown in Insulating Oil
- ii.) Breakdown Strength of Hard Board Plate

9. Experiment on Partial Discharge and Corona

- i.) Partial Discharges at Needle Electrode in air
- ii.) Measurement in Corona cage

10. Experiment on PD and Gliding Discharges

- i.) PD Measurement in High Voltage Insulation
- ii.) Measurement of Onset Voltages of Gliding Discharge

11. Break down of Gases