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CABLE FAULT LOCATING EQUIPMENT - SPECIFICATION

A Document of the Kenya Power & Lighting Company Plc
March 2020

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0.1 CIRCULATION LIST



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1	Manager, Standards
2	Electronic copy (pdf) on Kenya Power server (http://172.16.1.40/dms/browse.php?fFolderId=23)

REVISION OF KPLC STANDARDS

To keep abreast of progress in the industry, KPLC Standards shall be regularly reviewed. Suggestions for improvements to approved Standards, addressed to the Manager, Standards Department, are welcome.

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0.2 AMENDMENT RECORD

Rev No.	Date (YYYY-MM-DD)	Description of Change	Prepared by (Name & Signature)	Approved by (Name & Signature)
Issue 1 Rev 0	2016-04-22	New issue	Eng. S. K Nguli	Dr. Eng. P. Kimemia
Issue 1 Rev 1	2020-03-20	Scope: Additional requirement of Tan delta and PD on all VLF pressure testing and rating upto 80kV	Eng. S. K Nguli	Dr. Eng. P. Kimemia

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FOREWORD

This Specification has been prepared by the Standards Department in collaboration with Common Services Section of The Kenya Power & Lighting Company Plc (Kenya Power) and it lays down requirements for Cable Fault Locating Equipment. It is intended for use in purchasing the equipment.

This specification is reviewed to incorporate additional requirement of Tan delta and Partial discharge on all VLF pressure testing and rating upto 80kV.

The specification stipulates the minimum requirements for the Cable Fault Locating Equipment acceptable for use in the company. It shall be the responsibility of the supplier and manufacturer to ensure adequacy of the design, good workmanship, good engineering practice and adherence to standards, specifications and applicable regulations, and that the offered design is of the highest quality and guarantees excellent service to Kenya Power.

The following are members of the team that developed this specification:

Name	Division
Patrick Maguta	Infrastructure
Stephen Nguli	Standards

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1 SCOPE

- 1.1. This specification covers the design, manufacture, assembly, testing at manufacturer's works, supply, delivery, installation and commissioning of Cable Fault Locating Equipment for low, medium and high voltage power cables up to 72kV, complete with all materials and accessories for efficient and trouble free operation.
- 1.2. The Cable Fault Locating Equipments for use on power lines operating at voltages of upto 66kV (72kV) 50Hz covered by this specification are:
 - (a) Portable Cable Fault Location equipment with pre-location and DC pressure test 32kV
 - (b) Cable Identifying Sets
 - (c) Cable Sheath Testing equipment
 - (d) Low Voltage Fault Location Sets
 - (e) Cable Route Locators
 - (f) Portable DC pressure Test Sets
 - (g) VLF pressure testing with Tan delta up to 20KV
 - (h) VLF pressure testing with Tan delta up to 44KV
 - (i) VLF High Voltage Generator 80kV
- 1.3. The Equipment shall be suitable for the complete range of cable types and their accessories in all voltage ranges from 415V to 66kV.
- 1.4. For commissioning tests on 12kV, 36kV and 66kV cables, provision shall be given to perform VLF test up to 3U₀ with parallel PD measurement.
- 1.5. For maintenance test on 12kV, 36kV and 66kV cables provision shall be given to perform cable diagnostic up to 1.5U₀ with Tan Delta and Partial Discharge measurement.
- 1.6. The specification does not purport to include all the necessary provisions of a contract.

2. REFERENCES

- IEC 60502-2018: Power cables with extruded insulation and their accessories for rated voltages from 1kV (U_m = 1,2kV) up to 30kV (U_m = 36kV) - all parts
- IEEE 400.2-2013: IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF) (Less than 1 HZ)
- IEC 60060-3: High-voltage test techniques – Part 3: Definitions and requirements for on-site testing
- IEC 60520: Degrees of Protection (IP-Code System)

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2006/95/EC: CE-compliant in accordance with Low Voltage Directive

IEC 60229: Tests on Extruded Oversheaths with a Special Protective Function

3. TERMS AND DEFINITIONS

The terms and definitions shall be as per the reference standards

4.0. REQUIREMENTS

4.1. Service Conditions

4.1.1. The Cable Fault Locating Equipment shall be suitable for continuous use outdoors in the following tropical operating conditions: -

- a) Altitude: up to 2,200m above sea level;
- b) Temperature: average of +30°C with a minimum of -1°C and max +40 °C;
- c) Humidity: up to 95%;
- d) Pollution: Design pollution level to be taken as “Heavy” (Pollution level III) for inland and “Very Heavy” (Pollution level IV) for coastal applications in accordance with IEC 60815.
- e) Isokeraunic level: 180 thunderstorm days per year.

4.2. Specific Requirements

4.2.1. Portable Cable Fault Location equipment with pre-location and DC pressure test 32kV

- 4.2.1.1. The equipment shall be capable of locating all types of cable faults including open circuits, high resistance, low resistance, intermittent faults in XLPE and paper insulated cables and testing of surge arrestors.
- 4.2.1.2. The complete set functionality shall comprise of testing, converting faults, pre-location and pinpointing cable faults in low and medium voltage networks. The highest degree of safety to users shall be guaranteed. It shall be suitable for outdoor use.
- 4.2.1.3. The equipment shall have the following features:
 - (i) Easily transportable in a van with payload of 300kg.
 - (ii) Test range of at least 20km
 - (iii) Menu driven large screen color TDR (Time Domain Reflectometer)
 - (iv) User-friendly system software for simple, intuitive and safe operation
 - (v) High surge energy of at least 2,000 J in every range for acoustic pinpointing
 - (vi) Impulse voltage levels for medium-voltage cable of at least 016kV in ranges
 - (vii) Sheath fault locating
 - (viii) Impulse voltage levels for lower voltages 0 ... 4kV or 0 ... 8kV

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(ix) Modes of operation:

- (a) Insulation proof testing
- (b) Test up to at least 20kV with measurement of leakage current and automatic deactivation in case of breakdown
- (c) Breakdown detection with ramp function, automatic switch-off (discharging and earthing) in case of breakdown and display of breakdown voltage
- (d) Acoustic pinpointing

4.2.1.4. Pre-location procedure shall include most of the following:

- (i) Arc Reflection Method
- (ii) Impulse current coupling
- (iii) Decay voltage coupling
- (iv) Pulse reflection method
- (v) Secondary Impulse Method (SIM)
- (vi) Impulse Current Method

4.2.1.5. The equipment shall operate from 230V 50Hz AC supply.

4.2.1.6. The equipment shall be complete with the following Accessories:

- (i) Surge Generator
- (ii) TDR screen
- (iii) Pinpointing Receiver complete with ground microphone, earphones and cables.
- (iv) Mounting frame on wheels for ease of moving of the equipment
- (v) Operating manual
- (vi) Set of connecting cables
- (vii) Earth Spike

4.2.1.7. The equipment shall be complete with the following copper connecting cables (detachable):

- (i) High Voltage flexible coaxial test cable: minimum 15 m of 72kV, single phase
- (ii) Input power Supply: minimum of 15 m, 2.5 mm² single phase supply
- (iii) Earthing: minimum 15 m, 10 mm² complete with clamps

4.2.1.8. The equipment shall be supplied as complete stand-alone ready to use unit with all its accessories and Operating manual in English language

4.2.2. Cable Identifying Sets

4.2.2.1. The equipment shall be capable of clearly carrying out identification of a cable before it is cut as an important safety measure. It shall incorporate a mains supply unit and an inbuilt battery with a charging unit at 230V, 50Hz. The battery shall be 12V rechargeable with operating time of 4 hours

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4.2.2.2. The equipment shall be complete with the following features:

- (i) A current pulse generator/transmitter and receiver.
- (ii) Adjustable signal strength of deflection in the display.
- (iii) Necessary connection cables for signal coupling, mains lead and clamps.
- (iv) Precise cable identification even when many cables are buried together.
- (v) Carrying cases for both transmitter and receiver.

4.2.2.3. Technical Parameters

- (i) Pulse current of up to 180A
- (ii) Pulse voltage up to 300V
- (iii) 15 Impulses / min
- (iv) Fully automatic calibration of receiver
- (v) Digital display with clear indication of signal strength / current value / direction
- (vi) Signal verification with Amplitude / Time / Phase identification

4.2.2.4. The equipment shall be supplied as complete stand-alone ready to use unit with all its accessories and Operating manual in English language.

4.2.3. Cable Sheath Testing Equipment

4.2.3.1. The standalone equipment shall be used for cable and cable sheath fault pre-location as well as for pinpointing, cable testing of low voltage cables as well as cable sheath testing in power cables up to 10kV DC combined with the accurate prelocation of faults and pinpointing over the full request for field application.

4.2.3.2. Integrated high precision measuring bridge allows prelocation of cable faults and cable sheath faults at power cables according to Murray and Glaser. The measuring principle furthermore enables fault prelocation at control and lighting cables. For highest accuracy, also different cable sections with different conductor material and diameter can be defined and are considered in the result.

4.2.3.3. The full analysis shall be done automatically and results in digitally displayed distance to the fault. At the pinpointing mode, a DC pulse pattern with a voltage up to 10kV is released for cable and cable sheath fault pinpointing based on the step voltage measurement, with the pickup device in combination with two earth probes.

4.2.3.4. The equipment shall have the following mains features:

- i). Cable and Cable Sheath Testing up to 10kV
- ii). Resistance measurement
- iii). Cable and cable sheath fault prelocation with high precision measuring bridge according to Murray and Glaser up to 10kV, current limitation
- iv). Cable Sheath Fault Pinpointing

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- v). Built-in discharge unit
- vi). Stepless voltage adjustment 0 - 10kV, 10mA
- vii). Max. Output Current for sheath fault pinpointing 700 mA
- viii). Battery operation and mains operation
- ix). Battery operation more than 1.5 hours
- x). Fully menu guided and easy to use
- xi). Definable cable sections
- xii). Portable standalone unit
- xiii). Weight less than 20kg

4.2.4. Cable Sheath Fault Receiver

4.2.4.1. The cable sheath fault receiver shall be applied according to the step voltage method.

4.2.4.2. With two earth probes (dismountable for transportation), the cable route shall be followed.

4.2.4.3. Additionally, the battery-powered instrument shall be suitable for location of several successive sheath faults.

4.2.4.4. Equipped with an adjustable carrying strap, the sturdy instrument shall fulfil all requirements for a successful application in the field.

4.2.4.5. Accessories set for Cable Sheath Fault Location:

- i). Earth probe red
- ii). Earth probe blue
- iii). Measuring line 2m, blue
- iv). Measuring line 2m, red
- v). Auxiliary line 25 m on hand reel

4.2.5. Low Voltage Fault Location Sets



4.2.5.1. The equipment shall be suitable for the location of low resistance faults and interruptions in low and medium voltage cables.

4.2.5.2. The equipment shall be complete with an integrated battery power supply ideally suited for field use.

4.2.5.3. It should be conveniently button-operated and automatically shows the far end of the cable and fault distance. Even inexperienced users should easily be able to locate faults.

4.2.5.4. The equipment shall have the following features: -

- (i) Display color Screen.
- (ii) Systematic interactive menu guided control.
- (iii) Automatic far end indication and fault recognition with distance indication.
- (iv) To employ Impulse current and voltage decay mode, Arc Reflection, Time Domain Reflection (TDR) etc.

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- (v) To have Direct L1, Direct L2, and comparison mode L1 / L2 waveforms, which can be displayed at the same time.
- (vi) High resolution in the short range with great accuracy using special pulse forms
- (vii) Minimum measuring range of 10 Km.
- (viii) Zooming facility.
- (ix) Memory locations of at least 10 traces.
- (x) Power Supply: Mains 230 V, 50 Hz and battery operated.
- (xi) Rechargeable batteries with operation time of not less than 8 hours
- (xii) Lightweight.
- (xiii) Carrying case.

4.2.5.5. The equipment shall be supplied as complete stand-alone ready to use unit with all its accessories and Operating manual in English language.

4.2.6. Cable Route Locators

4.2.6.1. The cable route locator comprising of a transmitter and receiver shall be suitable for use in quickly locating routes of cables, measure how deep they are and find cable faults.

4.2.6.2. The transmitter shall be inductively and directly coupled.

4.2.6.3. The equipment shall have the following Features:

- (i) Precise direction guidance with right/left arrows to keep it directly above the line.
- (ii) Route sensor weighing less than 2 kg for ease of carrying.
- (iii) Multi-frequency operation- transmits at least two frequencies simultaneously.
- (iv) Combines the conventional Maximum and Minimum methods.
- (v) Detection of ground leakage fault
- (vi) Power Supply for transmitter: Mains 230 V, 50 Hz and battery operated.
- (vii) Output power of min. 5W
- (viii) Output frequencies of 815Hz, 8 kHz, 33 kHz, 82k Hz
- (ix) Integrated frame antenna
- (x) Inductive signal coupling coil, 82kHz, 100mmD
- (xi) Transmitter weight: max. 5kg
- (xii) Power Supply for receiver: To use rechargeable batteries or alkaline batteries.
- (xiii) Operating time for batteries shall not be less than 6 hours.
- (xiv) Digital display of cable depth.
- (xv) Current measurement for identification of target cable.
- (xvi) Automatic gain control by pushing a button.
- (xvii) Carrying case or soft protection bag

4.2.6.4. The equipment shall be supplied as complete stand-alone ready to use unit with all its accessories and Operating manual in English language.

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4.2.7. Portable DC Pressure Test Sets

4.2.7.1. The equipment shall be a DC Voltage testing set suitable for testing newly installed cables and splices and electrical installations before connecting to energized system.

4.2.7.2. The equipment shall have the following features:

- (i) The Test System capable of producing 0-25kV DC test voltage.
- (ii) With Control and power modules.
- (iii) With breakdown recognition and shutdown capability.
- (iv) With two (2) voltage ranges, 0-5kV, 0-25kV
- (v) Capable of DC leakage current measurement.
- (vi) Current measuring ranges: 50 nA to 1μA / 10μA / 100μA / 1 mA / 10 mA
- (vii) With integrated discharge facilities for safety of users.
- (viii) High voltage and ground connecting cables not less than 2.5 m long.
- (x) Mains power supply at 230V, 50Hz and built-in rechargeable battery making the test set independent of an external power supply.
- (xi) Minimum rechargeable battery operating time of 30min - 2 hours
- (xii) Maximum weight: 17kg

4.2.7.3. The equipment shall be supplied as complete stand-alone ready to use unit with all its accessories and Operating manual in English language.

4.2.8. VLF pressure testing set with tan delta upto 20KV

4.2.8.1. The Equipment shall be a portable Very Low Frequency Voltage (VLF) testing set suitable for testing XLPE cables with test voltage up to 24kVrms, sinusoidal waveform.

4.2.8.2. The mobile testing and diagnostic device shall be used for testing medium voltage cables and electrical equipment, for cable sheath testing and cable diagnostics including:

- (i) Fully integrated tan delta (TD) measurement.
- (ii) Pre-set program for testing and evaluation according to IEEE400.2-2013
- (iii) Monitored withstand test (MWT) with TD function integrated.
- (iv) Pre-set program according to IEEE400.2-2013
- (v) Partial discharge (PD) measurement
- (vi) Simultaneously TD and PD measurement for diagnostic test

4.2.8.3. The equipment shall have the following Features:

- (i) Cable sheath testing according to IEC 60502/IEC 60229
- (ii) Insulation tests on electrical equipment according to IEEE 433
- (iii) Tan delta diagnostics for electrical equipment and medium voltage cables up to 24kV
- (iv) Precise tan delta measurement with accuracy and resolution of 1×10^{-4} and 1×10^{-6} respectively

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- (v) Fully automated and individually programmable diagnostic sequences including evaluation
- (vi) No additional external hardware required for tan delta measurements - function integrated into VLF generator
- (vii) Integrated measurement data storage
- (viii) Data export via USB interface
- (ix) Measurement data shall be viewed in computer with Microsoft Excel, no additional software required.
- (x) Automatic discharging device
- (xi) Integrated cable compartment with HV connection cable

4.2.8.4. Technical Data - shall be as per Table 1

Table 1: Technical Data for VLF Testing Set

Item	Parameter description	Units	Value
General			
1	Frequency range	Hz	0.01-0.1
2	Input voltage	V/Hz	100-260,50/60 Hz
3	Max. power consumption	VA	300
4	Data interface	USB	2.0
5	Protection class	IP	54
6	EMC compatibility	compliance with EN 61010-1, EN 50191) and EMC guideline (EN 55011, EN61000-4)	
Output voltage			
1	VLF true sine Wave	kV rms	1...24.0(34.0kVpeak)
2	VLF rectangular wave voltage	kV	34
3	DC voltage	kV	±1..34
4	Resolution	kV	0.1
5	Accuracy	%	1
6	Load range	nF	1nF...8μF
Output current			
1	Max. load	uF at Hz, kVrms	0,5 μF at 0.1 Hz, 24kVrms 1μF at 0.05 Hz, 24kVrms 8 μF at 0.01 Hz, 18kVrms

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Item	Parameter description	Units	Value
Tan delta measurement			
1	VLF true Sine Wave	kV rms	1 ... 24
2	Load range	nF- μ F	10nF ... 8 μ F
3	Accuracy		1×10^{-4}
4	Resolution		1×10^{-6}
5	Measurement range		1×10^{-4} ... $21,000 \times 10^{-3}$
6	TD measurement frequency	Hz	0.1
7	Leakage current		Leakage current compensation of HV test lead

4.2.8.5. The VLF Testing and Diagnostic System shall also have ;

- (i) Tan Delta (TD) measurement device integrated in VLF source. No external TD measurement device accepted.
- (ii) Leakage current compensation of connection leads by integrated TD measurement device.
- (iii) Automatic testing programs integrated in VLF generator menu.
- (iv) Automatic testing sequence for MWT (Monitored Withstand Test) TD according to IEEE400.2-2013 with 1×10^{-4} accuracy and 1×10^{-6} resolution.
- (v) TD raw data files to be imported and exported to different computer.
- (vi) TD raw data files to be opened, viewed and edited with Microsoft Excel - no additional software required.
- (vii) TD Reports to be automatically generated in different formats such as PDF and Microsoft Excel. No additional software shall be required.
- (viii) Demo mode showing all functions of the TD without switching on the high voltage.
- (ix) Pre-programed test sequences according to the international standards CENELEC HD 620, IEC 60502 / IEC 60229, IEEE 400.2, VDE 0276-620, VDE 0276-621
- (x) Tan Delta and MWT measurements with table and diagram during the measurements as well as after the test performed.

4.2.9. Partial Discharge (PD) System

4.2.9.1. The portable PD and tan δ diagnostics system shall be used for carrying out:

- (a) Partial discharge measurement and location
- (b) Dissipation factor measurement (simultaneously with the PD test)

4.2.9.2. This shall provide a one-step 360° cable analysis with early detection and localization of weak points through the PD test, detection of moist points in joints,

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4.2.10. VLF pressure testing with Tan delta upto 44kV

4.2.10.1. The equipment shall be a Very Low Frequency Voltage (VLF) testing set suitable for testing XLPE cables with test voltage upto 40kV.

4.2.10.2. The mobile testing and diagnostic device shall be used for testing medium voltage cables and electrical equipment, for cable sheath testing and cable diagnostics including:

- (i) Fully integrated tan delta (TD) measurement.
- (ii) Pre-set program for testing and evaluation according to IEEE400.2-2013
- (iii) Monitored withstand test (MWT) with TD function integrated.
- (iv) Pre-set program according to IEEE400.2-2013
- (v) Partial discharge (PD) measurement
- (vi) Simultaneously TD and PD measurement for diagnostic test

4.2.10.3. The equipment shall have the following Features:

- (i) Cable sheath testing according to IEC 60502/IEC 60229
- (ii) Insulation tests on electrical equipment according to IEEE 433
- (iii) Tan delta diagnostics for electrical equipment and medium voltage cables up to 20.0kV
- (iv) Precise tan delta measurement with accuracy and resolution of 1×10^{-4} and 1×10^{-6} respectively
- (v) Fully automated and individually programmable diagnostic sequences including evaluation
- (vi) No additional external hardware required for tan delta measurements, function integrated into VLF generator
- (vii) Integrated measurement data storage
- (viii) Data export via USB interface
- (ix) Measurement data shall be viewed in computer with Microsoft excel, no additional software required.
- (x) Automatic discharging device
- (xi) Integrated cable compartment with HV connection cable

4.2.10.4. Technical Data shall be as per table 2

Table 2: Technical Data for VLF Testing Set

Item	Parameter description	Units	Value
General			
1	Frequency range	Hz	0.01-0.1
2	Input voltage	V/Hz	100-260,50/60
3	Max. power consumption	VA	300
4	Data interface	USB	2.0

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Item	Parameter description	Units	Value
5	Protection class	IP	54
6	EMC compatibility	compliance with EN 61010-1, EN 50191) and EMC guideline (EN 55011, EN61000-4)	
Output voltage			
1	VLF true sine Wave	kV rms	1...24.0(34.0kVpeak)
2	VLF rectangular wave voltage	kV	34
3	DC voltage	kV	±1..34
4	Resolution	kV	0.1
5	Accuracy	%	1
6	Load range	nF	1...8
Output current			
1	Max. load	uF at Hz, kVrms	1 μF at 0.1 Hz, 42.5kVrms 3μF at 0.03 Hz, 42.5kVrms 10 μF at 0.01 Hz, 10kVrms
Tan delta measurement			
1	VLF true Sine Wave	kV rms	1 ... 44
2	Load range	nF- μF	10 ... 10
3	Accuracy		1x10 ⁻⁴
4	Resolution		1x10 ⁻⁶
5	Measurement range		1x10 ⁻⁴ ... 21,000x10 ⁻³
6	TD measurement frequency	Hz	0.1
7	Leakage current		Leakage current compensation of HV test lead

4.2.10.5. The VLF Testing and Diagnostic System shall also have the following features;

- Tan Delta (TD) measurement device integrated in VLF source. No external TD measurement device accepted.
- Leakage current compensation of connection leads by integrated TD measurement device.
- Automatic testing programs integrated in VLF generator menu.

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- (iv) Automatic testing sequence for MWT (Monitored Withstand Test) TD according to IEEE400.2-2013 with 1×10^{-4} accuracy and 1×10^{-6} resolution.
- (v) TD Raw data files to be imported and exported to different computer.
- (vi) TD Raw data files to be opened, viewed and edited with Microsoft Excel, no additional software required.
- (vii) TD Reports to be automatically generated in different formats such as PDF and Microsoft Excel. No additional software shall be required.
- (viii) Demo mode showing all functions of the TD without switching on the high voltage.
- (ix) Pre-programed test sequences according to the international standards CENELEC HD 620, IEC 60502 / IEC 60229, IEEE 400.2, VDE 0276-620, VDE 0276-621
- (x) Tan Delta and MWT measurements with table and diagram during the measurements as well as after the test performed.

4.2.11. VLF High Voltage Generator 80kV

- 4.2.11.1. The system shall support cable fault location and all type of cable testing and diagnostic for installation, commissioning and maintenance testing in accordance with the valid IEC 60060-3, IEC 60502 and IEEE 400.2-2013 standards and regulations. It should be suitable for the complete range of cable types and their accessories in all voltage ranges from 415 V to 66kV.
- 4.2.11.2. For commissioning test on 11kV and 33kV cables provision shall be given to perform VLF test up to $3 U_0$ with parallel PD measurement according to IEC 60502. For maintenance test on 11kV, 33kV and 66kV cables provision shall be given to perform cable diagnostic up to $1.5 U_0$ (or maximum 57kVrms) with Tan Delta and Partial Discharge measurement according to IEEE 400.2-2013
- 4.2.11.3. The VLF high voltage generator (HVG) shall be true sinusoidal-digital with a power rating of 3kW adjustable output voltage. The HVG shall have manual or automatic test sequences, selectable with or without burn down mode in case of breakdown.
- 4.2.11.4. The VLF diagnostic system shall allow Tan Delta and Partial Discharge Diagnostic with the same connection setup with 0.1Hz sinusoidal voltage.
- 4.2.11.5. The HVG shall have the following features:
 - (i) Programmable test voltage: sine wave, square wave, DC
 - (ii) Fully symmetrical output voltage
 - (iii) Programmable test frequency 0.01 Hz to 1 Hz
- 4.2.11.6. Programmable output voltage:
 - (i) 0 to - 80kV DC
 - (ii) 0 to + 80kV DC
 - (iii) 0 to 57kVrms 0.1 Hz sine wave
 - (iv) 0 to 80kV 0.1 Hz square wave

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- (v) Max. capacitive load: 1.2 μ F @ 0.1 Hz, 57kVrms
- (vi) 3 μ F @ 0.1 Hz, 38kVrms
- (vii) 8 μ F @ 0.1 Hz, 18kVrms
- (viii) 20 μ F max. load @ reduced frequencies

4.2.11.7. Output currents:

- (i) 1.8 mA @ 80kV
- (ii) 10 mA @ 70kV
- (iii) 60 mA @ 50kV
- (iv) 90 mA @ 20kV
- (v) Maximum current: 120 mA
- (vi) Accuracy: 1%
- (vii) Resolution: 10 μ A

4.2.11.8. Tan Delta (Dissipation factor measurement):

- (i) Load range ≥ 10 nF
- (ii) Measurement range $0.1 \times 10^{-3} - 1,000 \times 10^{-3}$
- (iii) Resolution: 1×10^{-6}
- (iv) Display of individual Tan delta values 1×10^{-5}
- (v) Accuracy 1×10^{-4}

4.2.11.9. Partial Discharge Measurement:

- (i) Voltage range: up to 57 kV rms
- (ii) Measurement range 10 – 12,800 m (at 80 m/ μ s)
- (iii) Sampling rate 100 MSamples/s (10 ns)
- (iv) PD measurement range 5 pC – 100 nC
- (v) Accuracy 1% of cable length
- (vi) Resolution 0.1 pC / 0.1 m
- (vii) Velocity of propagation (v/2) 50 – 120 m/ μ s
- (viii) Weight of coupling capacitor including filter: maximum 21kg

4.2.11.10. The equipment shall have the following features:

- (i) Guard Ring application for compensation of termination surface leakage current.
- (ii) Compensation of test lead leakage current.
- (iii) Partial Discharge free VLF generator
- (iv) Tan Delta measurement device shall be integrated inside the VLF source.
- (v) Automatic evaluation of Tan Delta diagnostic results according to IEEE evaluation criteria as well as freely definable evaluation criteria.
- (vi) PD recording and display over different voltage levels
- (vii) PD localization evaluation based on cable length
- (viii) Automatic PD evaluation

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- (ix) Filtering functions
- (x) Gain and trigger setting possibility
- (xi) Calibration and measurement according to IEC 60270
- (xii) PD phase resolved pattern recognition
- (xiii) PD measurement throughout the 360 degrees of the sinusoidal VLF waveform over definable time
- (xiv) PD measurement during VLF withstand test up to 57kVrms

4.2.11.11. Pulse Reflection Test (PRT) System integrated in VLF Diagnostic system

- 4.2.11.11.1. For the localization of joints with water ingress, a specialized Time Domain Reflectometer (TDR) device shall be integrated in the diagnostic system. This shall be a computer aided test system designed as a pulse reflection-measuring instrument for fault location on single and three-phase cable systems.
- 4.2.11.11.2. The design shall incorporate an integrated 400 MHz transient recorder for the highest measuring accuracy. It shall be able to offer unique features for intelligent manual and automatic cable fault location.
- 4.2.11.11.3. The Software of the Pulse Reflection System shall be based on latest Windows OP system to allow every user an easy and fast operation of the system.
- 4.2.11.11.4. The PRT system shall have upto three cable fault location methods to be displayed at the same time on a 17" TFT-LCD display unit. The high resolution and zoom function shall be included to enable accurate pre-location of cable faults. There shall be a provision for easy transfer to any computer data files and the automatic reporting functions.
- 4.2.11.11.5. The following features and technical specification shall form part of the PRT test system:
- (i) Fully automatic measuring sequences;
 - (ii) Fully automatic cursor settings;
 - (iii) Three (3) phase measurement and display;
 - (iv) Memory for more than 100,000 waveforms (hard disk limit);
 - (v) TDR pulse width: 20 ns – 1.3 ms
 - (vi) Time Domain Reflectometer (TDR) output pulse from 20 to 200 V;
 - (vii) Output impedance: 12 – 2,000 Ohm
 - (viii) Sampling rate: 400 MHz
 - (ix) Input signal gain: -10 to +60 dB
 - (x) SIM/MIM: 20 TDR multi-shot measurements
 - (xi) Resolution (@ $v/2 = 80 \text{ m}/\mu\text{s}$): 0.1 m
 - (xii) Measuring ranges: 10m - 1000 km;
 - (xiii) Accuracy: 0.1% of measuring result

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- (xiv) Propagation velocity factor $v/2$ range: 20 – 150 m/ μ s
- (xv) Power supply: 100 – 260 V, 50/60 Hz
- (xvi) Power consumption: Max. 280 VA
- (xvii) Automatic reporting function;
- (xviii) Emergency Power Supply unit.

4.2.11.11.6. IR tests shall meet the following parameters;

- (i) Test voltage: up to 1000 V
- (ii) Measuring range: up to 5 G-Ohm
- (iii) Simultaneous for: L1/N, L2/N, L3/N, L1/L2, L2/L3, L1/L3

4.2.12. Full Monitor Withstand Test (MWT)

4.2.12.1. This shall enable measurement of dielectric losses and test the cable route for partial discharges during the VLF cable test providing condition-based test duration.

4.2.12.2. The features of this shall be as follows;

- (i) Parallel dissipation factor and partial discharge measurement
- (ii) Better overview of the cable condition with Full Monitored Withstand Test (VLF cable testing with parallel dissipation factor and partial discharge measurement)
- (iii) Coupling capacitor includes measurement impedance and PD measuring unit in one device
- (iv) PD phase resolving for classification of PD faults
- (v) Integrated filter for suppressing noise signals from the VLF generator
- (vi) Stable data transmission and power supply via a PoE cable (PoE = Power-over-Ethernet). No battery required.
- (vii) Partial discharge measurement and calibration of the measurement setup according to IEC 60270
- (viii) Detection of PD level, PD inception and extinction voltage as well as PD frequency
- (ix) Exact location of PD activities in cable insulation, joints and terminations
- (x) Excellent noise suppression due to compact structure, and galvanic isolation between PD measuring unit and laptop
- (xi) Central power supply
- (xii) Reliable Tan δ measurement results up to 72.5kV peak using proven technology
- (xiii) Integrated device for detecting leakage currents for dissipation factor measurement
- (xiv) Easy operation all-in-one software solution for measurement and auto evaluation
- (xv) Robust design and central power supply developed for mobile use

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APPENDICES

A. TESTS AND INSPECTION (Normative)

- A.1 It shall be the responsibility of the manufacturer to perform or to have performed all the tests specified. Tenderers shall confirm the manufacturer's capabilities in this regard when submitting tenders. Any limitations shall be clearly specified.
- A.2 Copies of Type Test Certificates and Type Test Reports issued by a third-party testing laboratory that is accredited to ISO/IEC 17025 shall be submitted with the tender for the purpose of technical evaluation. A copy of the accreditation certificate to ISO/IEC 17025 for the testing laboratory shall also be submitted. Any translations of certificates and test reports into English language shall be signed and stamped by the Testing Laboratory that carried out the tests.
- A.3 Each Cable Fault Locating Equipment shall be inspected and tested in accordance with the requirements of relevant international and national standards and provisions of this specification. It shall be the responsibility of the supplier to perform all the tests.
- A.4 Routine and sample test reports for each Cable Fault Locating Equipment to be supplied shall be submitted to KPLC for approval before shipment/delivery. KPLC Engineers will witness tests at the factory before shipment.
- A.5 On receipt of the goods, KPLC will perform any of the tests in order to verify compliance with this specification. The supplier shall replace without charge to KPLC Cable Fault Locating Equipment, which, upon examination, test or use fail to meet any of the requirements in the specification.
- A.6 **Testing Facility**
- A.6.1 The bidder shall provide current e-mail address, fax and telephone numbers and contact person at the Testing Laboratory where Type Tests and Special Tests were carried out.
- A.6.2 All test and measuring equipment to be used during acceptance testing shall have been calibrated and copies of valid calibration certificates shall be provided to KPLC Engineers. A detailed list of workshop tools, test/measuring equipment and list of tests that can be carried out by the manufacturer shall be submitted with the tender for evaluation.

B. QUALITY MANAGEMENT SYSTEM (Normative)

- B.1 The bidder shall submit a quality assurance plan (QAP) that will be used to ensure that the Cable Fault Locating Equipment design, material, workmanship, tests, service capability, maintenance and documentation, will fulfil the requirements stated in the contract documents, standards,

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specifications and regulations. The QAP shall be based on and include relevant parts to fulfil the requirements of ISO 9001:2015.

- B.2 The Manufacturer's Declaration of Conformity to applicable standards, this specification and copies of quality management certifications including copy of valid and relevant ISO 9001:2015 certificate shall be submitted with the tender for evaluation.
- B.3 The bidder shall indicate the delivery time of the Cable Fault Locating Equipment. A detailed list and contact addresses (including e-mail) of the manufacturer's previous customers outside the country of manufacture for exact or similar Cable Fault Locating Equipment sold in the last five years shall be submitted with the tender for evaluation.

C. DOCUMENTATION AND DEMONSTRATION (Normative)

- C.1 The bidder shall submit its tender complete with technical documents required for tender evaluation. The documents to be submitted (all in English language) for tender evaluation shall include the following:
- a) Fully filled clause by clause Guaranteed Technical Particulars (GTP) (Appendix F) signed by the manufacturer;
 - b) Copies of the manufacturer's catalogues, brochures, Cable Fault Locating Equipment manuals, drawings and wiring diagrams and technical data;
 - c) Sales records for the last five years and at least four customer reference letters,
 - d) Details of manufacturing capacity and the manufacturer's experience.
 - e) Copies of required Type Test certificates and Type Test reports by a third-party testing laboratory accredited to ISO/IEC 17025,
 - f) Copy of accreditation certificate to ISO/IEC 17025 for the third-party testing laboratory,
 - g) Manufacturer's warranty and guarantee; subject to 36 months from date of delivery to KPLC laboratory.
 - h) Manufacturer's letter of authorization, copy of the manufacturer's ISO 9001:2015 certificate.
- C.2 The successful bidder (supplier) shall submit the following documents/details to The Kenya Power & Lighting Plc for approval before manufacture:
- a) Fully filled clause by clause Guaranteed Technical Particulars (GTP) signed by the manufacturer;

Note: These are new and should not to be confused with the ones submitted with the tender.

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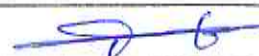
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- b) Design drawings and wiring diagrams of the Cable Fault Locating Equipment.
- c) Original software, software manuals and operation manuals shall be submitted,
- d) A training schedule of the Cable Fault Locating Equipments and software operation for KPLC staff operators in Nairobi,
- e) Quality assurance plan (QAP) that will be used to ensure that the design, material, workmanship, tests, service capability, maintenance and documentation will fulfill the requirements stated in the contract documents, standards, specifications and regulations. The QAP shall be based on and include relevant parts to fulfill the requirements of ISO 9001:2015.
- f) Detailed test program to be used during factory testing,
- g) Marking details and method to be used in marking the Cable Fault Locating Equipment.
- h) Manufacturer's undertaking to ensure adequacy of the design, good engineering practice, adherence to the specification and applicable standards and regulations as well as ensuring good workmanship in the manufacture of the Cable Fault Locating Equipment for Kenya Power;
- i) Packaging details (including packaging materials).

C.3 The successful bidder and manufacturer shall demonstrate to at least two KPLC staff at the manufacturer's factory.

D. TRAINING

D.1 TRAINING AT THE MANUFACTURER'S PREMISES

During the factory acceptance testing (FAT), the manufacturer shall conduct complete training for the Cable Fault Locating Equipment for at least two KPLC Engineers/Technicians.

This shall include theory followed by practical demonstrations. All the operational procedures shall be exhaustively explained and demonstrated.

The manufacturer shall plan adequate time for the training separate from the FATs. The duration of the training shall however not be less than one (1) eight hour working day for each of the two equipments. The Employer may send a separate team from the team witnessing the FATs to attend the training. The program and duration of the training shall be indicated in the bid.

The Training shall be considered to have been successful once the engineers/technicians are able to competently operate the equipment.

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The manufacturer shall conduct evaluation tests and give a feedback report on the training to the employer for each of the engineers/technicians.

The manufacturer shall meet the total cost of the factory training for their staff.

For KPLC staff the full cost of the visit, including air tickets and accommodation shall be borne by KPLC.

D2 LOCAL TRAINING (IN KENYA)

Following the delivery of the Cable Fault Locating Equipments, the manufacturer shall conduct training for the equipment for approximately twenty (20) KPLC Engineers/Technicians, in Nairobi Kenya. The training shall be conducted in one session of 20 engineers/technicians. The session shall last at least 3 (three) days for VLF pressure testing equipment and at least 2 (two) days for Cable Fault Location equipment.

The Training shall include theory on features and how the equipment works followed by practical demonstrations including parameter settings. All steps shall be exhaustively explained and demonstrated.

The Training shall be considered to have been successful once the engineers/technicians are able to competently operate the equipment.

The supplier shall meet all the costs for conducting the local training, including local accommodation and transport for their training staff. The supplier shall provide all the training materials including notes. However the costs do not include the transport and accommodation for KPLC engineers/technicians and the venue, which shall be borne by KPLC.

E. MARKING, LABELLING AND PACKING

E1: The Cable Fault Locating Equipment shall be marked legibly and indelibly in English with the following information:

- Name and trade mark of the manufacturer;
- Country of origin;
- Type/model;
- Serial no;
- Standard/s of manufacture

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f) The inscription "Property of K.P. & L. C."

g) Year of manufacture.

E2: The Cable Fault Locating Equipments shall be packaged in such a manner as to minimize damage and entry of moisture during transportation, handling and use.

E3: The Cable Fault Locating Equipments shall have a rugged casing for storage and transportation.

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F. GUARANTEED TECHNICAL PARTICULARS (GTP)

(to be filled and signed by the supplier/Manufacturer and submitted together with relevant copies of the Manufacturer's catalogues, brochures, drawings, technical data, sales records for previous five years, customer reference letters, details of manufacturing capacity, the manufacturer's experience and copies of complete type test reports for tender evaluation, all in English Language)

Tender No.

	Clause number	KPLC requirement	Bidder's offer (indicate full details of the offered equipment for each requirement of the specification)
	Name and address of the Manufacturer	State	
	Country of Manufacturer	State	
	Manufacturer's Letter of Authorization	Provide	
	Model/Type Reference No. of the offered Equipment	Specify	
	Item on offer	Specify	
	Manufacturer's warranty and guarantee for the offered Equipment	Attach	
1	Scope	State/List	
	Equipment Application	List and state	
2	Applicable standards	List	
3	Terms and definitions	Specify	
4.1.1	Operating Conditions	State	
4.2	Specific requirements		
4.2.1	Portable Cable Fault Location equipment with prelocation and DC pressure test 32kV		
4.2.1.1	Nature of faults the equipment shall be able to locate	Specify and List	
4.2.1.2	Functionality set and safety	Specify and list functions	

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	Degree of safety	Specify	
4.2.1.3	Features of the equipment	List/state	
	i). Transportability	Specify	
	ii). Test Range	State	
	iii). Display	State	
	iv). User-friendly system software	Specify	
	v). Energy surge it can withstand	Specify	
	vi). Impulse voltage(s) it can with stand	Specify	
	vii). Sheath fault locating	State	
	iii). Impulse voltage levels - lower voltages	specify	
	ix). Modes of operation and test range	List	
4.2.1.4	Pre-location procedures	Specify/List	
	i). Arc Reflection Method	Specify	
	ii). Impulse current coupling	Specify	
	iii). Decay voltage coupling	Specify	
	iv). Pulse reflection method	Specify	
	v). Secondary Impulse Method (SIM)	Specify	
	vi). Impulse Current Method	Specify	
4.2.1.5	Operating Voltage of equipment	State	
4.2.1.6	Equipment Accessories	List	
4.2.1.7	Connecting accessories	List	
4.2.1.8	Equipment completeness & manuals	State	
4.2.2	Cable Identifying Sets		

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4.2.2.1	Functionality of equipment and operating voltage, frequency and back up battery operating time	State	
4.2.2.2	Features & Functions	List & state	
4.2.2.3	Technical Parameters	List & state	
4.2.2.4	Accessories and Operating manual	List/To be provided	
4.2.3	Cable Sheath Testing Equipment		
4.2.3.1	Functionality of equipment	State	
	Rating	State	
4.2.3.2	Operating precision	State	
4.2.3.3	Nature of Analysis and display mode	Specify	
4.2.3.4	Features	List and state functionality	
4.2.4	Cable Sheath Fault Receiver		
4.2.4.1-4	Mode of operation	Specify	
4.2.4.5	i). Accessories	List	
	ii). Earth probe red	Specify	
	iii). Earth probe blue	Specify	
	iv). Measuring line 2m, blue	Specify	
	v). Measuring line 2m, red	Specify	
	vi). Auxiliary line 25 m on hand reel	Specify	
4.2.5	Low Voltage Fault Location Sets		
4.2.5.1	Key Functionality and elements	State	
4.2.5.2	Integrated battery	State	
4.2.5.3	Ease of use	State	
4.2.5.4	Features of the equipment	List	
4.2.5.5	Accessories & operations Manual	To provide	

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4.2.6	Cable Route Locators		
4.2.6.1	Key Functionality and elements	List and specify	
4.2.6.2	Mode of transmitter coupling	Specify	
4.2.6.3	Features of the equipment	Lists	
4.2.6.4	Accessories & operations Manual	To provide	
4.2.7	DC Pressure Test Sets		
4.2.7.1	Key Functionality and elements	Specify	
4.2.7.2	Features of the equipment	List	
4.2.7.3	Accessories & operations Manual	To provide	
4.2.8	VLF pressure testing with tan delta upto 20KV		
4.2.8.1	Functionality of equipment	State	
4.2.8.2	Test parameters	List	
4.2.8.3	Features	List	
4.2.8.4	Technical parameters		
	General	List	
	Output voltage	List	
	Output current	List	
	Tan delta measurement	List	
4.2.8.5	Additional requirements	List	
4.2.9	Partial Discharge (PD) System applications	Specify	
4.2.10	VLF pressure testing with Tan delta upto 44KV		
4.2.10.1	Key Elements and Functionality	State	
4.2.10.2	Test Functions	State/list	
4.2.10.3	Key Features	List	
4.2.10.4	Technical Parameters	Specify	
	General	List	
	Output voltage	List	
	Output current	List	
	Tan delta measurement	List	

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4.2.10.5	Features of the VLF Testing and Diagnostic System	List	
4.2.11	VLF High Voltage Generator upto 80kV		
	Testing and Diagnostic		
4.2.11.1	Key Elements and Functionality and tests	State	
	Applicable standards	State	
	Cable voltage ranges	State	
4.2.11.2	Provision for commissioning tests	State	
	Provision for maintenance tests	State	
4.2.11.3	Power rating of HVG	State	
	Features	State	
4.2.11.4	Tan delta and PD diagnostic frequency range	State	
4.2.11.5	Features of the HVG	List	
4.2.11.6	Programmable output voltage	List	
4.2.11.7	Output currents	List	
4.2.11.8	Tan Delta (Dissipation factor measurement)	List	
4.2.11.9	Partial Discharge Measurement	List	
4.2.11.10	Equipment features	List	
4.2.11.11	Pulse Reflection Test (PRT) System integrated in VLF Diagnostic system		
4.2.11.11.1	TDR device integrated in the system	specify	
4.2.11.11.2	Frequency of transient recorder and aid features	state	
4.2.11.11.3	Software for operating the system	Specify	
4.2.11.11.4	Features of the PRT	List	

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4.2.11.11.5	PRT features and technical specification	List	
4.2.11.11.6	IR tests parameters	List	
4.2.12	Full Monitor Withstand Test (MWT)		
4.2.12.1	Key Functionality	State	
4.2.12.2	Features of the MWT	List	
APPENDICES			
A.1	Test standards and responsibility of carrying out tests	Specify	
A.2	Copies of Type Test Reports submitted with tender & ISO /IEC17025	Provide	
A.3	Routine & Acceptance testing	List for each equipment	
A.4	Routine and sample Test Reports submitted for approval before shipment. KPLC engineers to witness tests at the factory before shipment	State & list	
A.5	Replacement of any defective equipment/spare during delivery to KPLC stores	Specify	
A6	Testing Facility		
A.6.1	Testing laboratory address details	Specify	
A.6.2	Valid calibration	State	
QUALITY MANAGEMENT SYSTEM			
B.1-B.3	Quality Management System	Provide/attach copies	
	Quality Assurance Plan		
	Copy of ISO 9001:2015 Certificate		

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	Manufacturer's declaration of conformity		
	Manufacturer's experience		
	Manufacturing Capacity (units per month)		
	List of previous customers		
	Customer reference letters		
C	DOCUMENTATION AND DEMONSTRATION (Normative)		
C1	Documents submitted with tender for evaluation	List	
C.2	Documents to be submitted by supplier to KPLC for approval before manufacture	List	
C.3	Demonstration at the factory	State	
	TRAINING		
D.1	TRAINING AT THE MANUFACTURER'S PREMISES		
	Program and staff evaluation criteria	Provide	
	Duration not less than one day	State	
	Confirmation of successful training	State	
	Training cost	State	
D2	LOCAL TRAINING (IN KENYA)		
	Program and staff evaluation criteria	Provide	
	Participants - at least 20	State	
	VLF pressure testing equipment at least 3 (three) days	Specify	
	Cable Fault Location equipment - at least 2 (two) days	Specify	
	Confirmation of successful training	State	

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	Clause number	KPLC requirement	Bidder's offer (indicate full details of the offered equipment for each requirement of the specification)
	Training cost	State	
E1	Markings	Specify	
E2& E3	Packing	Specify	
	Statement of compliance to Tender Specifications (indicate deviations if any & supporting documents)	Provide	

NOTE:

- 1) Bidders shall give full details of the items on offer as per the specification and applicable standards. The details provided shall conform to the test reports and their certificates, as well as labelled drawings complete with dimensions, catalogues and/or brochures for the purpose of tender evaluation.
- 2) Bidders should note that the above Guaranteed Technical Particulars Schedules must be fully completed and submitted with the bid. Wherever there is conflict between the GTPs and the clauses in the specification, the clauses in the specification take precedence. Failure to complete the schedules shall lead to rejection of the bid.
- 3) Guaranteed values shall be specified. * Words like 'agreed', 'confirmed', 'As per KPLC specifications', 'As per catalogue', etc. shall not be accepted and shall be considered non-responsive.

.....
Manufacturer's Name, Signature, Stamp and Date

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