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ELECTRICITE DU CAMBODGE

TECHNICAL SPECIFICATION

EDC-DTS-MV024

22kV Automatic Step Voltage Regulators (AVR)

February 2025

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22kV Automatic Step Voltage Regulators (AVR)

1 Scope

This specification covers the design, manufacturing, supply, delivery, testing and performance requirement for outdoor, single-phase and three phases oil-immersed Automatic (step) voltage regulators (AVR). The required voltage regulators are intended to regulate the 22kV, 50Hz networks of the power networks of Electricity du Cambodge.

The regulator shall be able to operate in either direction of power flow to boost/buck the supply voltage.

The life expectancy of this equipment shall not be less than 25 years.

2 Standards

IEC International Electro-technical Commission

IEC 60038	: IEC standard voltages
IEC 60076	: Power Transformers
IEC 60076-7	: Power Transformers - Part 7 Loading guide for oil-immersed power transformers
IEC 60076-20	: Power Transformers - Part 20 Energy efficiency
IEC 60076-21	: Power Transformers - Part 21 Standard requirements, terminology, and test code for step-voltage regulators
IEC 60137	: Bushings for alternating voltages above 1kV.
IEC 60214-1	: Tap-changers - Part 1: Performance requirements and test methods
IEC 60214-2	: Tap-changers - Part 2: Application guidelines
IEC 60296	: Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment
IEC 60255-1	: Measuring relays and protection equipment - Common requirements.
IEC 60255-21-1	: Measuring relays and protection equipment - Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Vibration tests (sinusoidal)
IEC 60255-26	: Measuring relays and protection equipment - Electromagnetic compatibility requirements.
IEC 60255-27	: Measuring relays and protection equipment - Product safety requirements
IEC 60529	: Degree of protection provided by enclosures (IP code)

IEC 61869-1 : Instrument transformers – Part 1: General requirements

IEC 61869-2 : Instrument transformers – Additional requirements for current transformers

IEC 61869-3 : Instrument transformers – Additional requirements for Voltage transformers

IEC 62262 : Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts.

ISO International Standard Organization

ISO 2063 : Metallic coating-protection of iron and steel against corrosion

ISO 9001 : Quality management systems – Requirements

ISO/IEC 17025 : General requirements for the competence of testing and calibration laboratories

The Supplier may propose alternative standards, provided it is demonstrated that they give an equivalent degree of quality as the referenced standard. Acceptability of any alternative standard is at the discretion of the Purchaser.

3 Definitions

The definition of the relevant IEC standards applies to this technical specification.

4 Testing and inspection

4.1 General Notes for Test

AVR shall be inspected at the manufacturer's factory by EDC's representatives.

The inspection and tests shall be carried out in accordance with the provisions of the relevant IEC or national recommendations.

Automatic Voltage Regulators shall be subjected to all tests as specified below.

4.2 Type Tests

All type tests required by the IEC 60076-20, IEC 60076-21 and IEC 60214-1 standards shall be mandatorily carried out.

Basically, the following type tests shall be made on representative voltage regulators to substantiate the ratings assigned to all other voltage regulators of basically the same design:

- Temperature rise test (Clause 9.10 of IEC 60076-21)
- Lightning impulse test (Clause 9.7.2 of IEC 60076-21)
- Short-circuit test (Clause 9.11 of IEC 60076-21)
- Sound level test. (Clause 9.12 of IEC 60076-21)
- Enclosure integrity tests (Clause 10.2 of IEC 60076-21)
- On-Load tap-changer tests (Clause 10.3 of IEC 60076-21)
- Control system tests (Clause 10.4 of IEC 60076-21).

Other type tests required by other above-mentioned IEC shall be mandatorily carried out.

4.2.1.1 Test reports

Type test reports shall be carried out by internationally recognized electrical testing laboratories.

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Full copies of type test reports shall be submitted within the bid of the manufacturer/supplier.

If type tests reports or test certificates issued by a world reputable utility or testing centre are not supplied within the offer, this one will be rejected.

Nevertheless, in case the testing laboratory is not internationally recognized, the testing laboratory shall be mandatorily accredited ISO/IEC 17025 by an international or national accreditation body specialized in testing laboratories accreditation/acceptance. In that case, the testing laboratory shall prove mandatorily its capability/capacity to carry out all type tests mentioned in the type tests reports by supplying full description of all tests the laboratory can carry out, list of testing equipment with full characteristics, drawing of testing rooms with location of testing equipment, ...etc., supported by pictures and copy of the ISO/IEC 17025 accreditation certificate.

Acceptability of any accredited testing laboratory is at the discretion of the EDC.

4.3 Routine tests

The Routine tests carried out by the manufacturer shall be backed by test reports signed by the factory's quality control department.

Routine tests shall be made in accordance with IEC 60076-21 on all voltage regulators per the following list:

- Leak test.
- Operational test of voltage regulator including all devices. Controlled devices such as on-load tap-changers, position indicators, etc., shall be operated for proper functioning.
- Resistance measurements of all windings (clause 9.2).
- Polarity test (clause 9.3).
- Ratio test (clause 9.4).
- No-load loss at rated voltage and rated frequency (clause 9.5).
- Excitation current at rated voltage and rated frequency (clause 9.5).
- Impedance and load loss at rated current and rated frequency (clause 9.6).
- Lightning impulse test (clause 9.7.3).
- Applied-voltage test (clause 9.7.4).
- Induced-voltage test (clause 9.7.5).
- Insulation power factor test (clause 9.7.6).
- Insulation resistance test (clause 9.7.7).
- On-load tap-changer tests (clause 9.8).
- Control system tests (clause 9.9).

4.3.1 Oil routine tests

Oil will be routine tested and analysed to prove PCB free as well as dielectric withstand, and the routine test report shall be sent to EDC prior the shipment for acceptance.

4.4 Inspection

AVR shall be subject to inspection by a representative of EDC at the place of manufacture and routine tests carried out in their presence.

At reception in EDC warehouse, the equipment will be verified, and routine tested by EDC staff in the presence of the supplier.

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5 Quality Management

Design, development and production of the proposed equipment shall be ISO 9001 certified. The ISO 9001 certificate shall be submitted within the bid.

Part of the equipment can be assembled in Cambodia; in that case the assembling shall be done under quality supervision of the manufacturer and the assembly workshop shall mandatorily implement a quality process satisfactory to EDC and/or Local Authorities.

6 Ambient conditions

The voltage and current transformers shall be suitable to operate in the ambient conditions described hereafter:

Altitude	Sea level to 1,000 meters
Climate	Tropical
Annual Rainfall	1,300 mm over 140 days
Monsoon Period	June to November
Ambient Air Temperatures:	
Average	27.5°C
Minimum	13.3°C
Maximum	40.5°C
Relative Air Humidity	65-100%
Solar Emissivity	0.8
Solar absorption	0.8
Wind Velocity:	
Average	37km/h (10.3m/s)
Maximum	72km/h (20m/s)

7 System parameters of 22kV voltage system

- Rated system voltage : 24kV
- Operating voltage : 22kV
- Frequency : 50Hz
- Neutral earthing : Earthed through neutral transformer and impedance limiting the fault to 783A.

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8 Requirements

8.1 Operating Conditions

The current transformers shall comply fully with the service conditions for outdoor AVR as per the IEC 60076 standard.

The Automatic voltage regulator shall be suitable for continuous outdoor operation in tropical areas with the above-mentioned atmospheric conditions:

8.2 General

The AVR shall be strictly conformed to the requirements of IEC 60076 and all concerned parts of this IEC as well as all above mentioned IEC and ISO standards.

8.3 Mechanical Design

3 phase AVR or 3 single phase AVR can be supplied indifferently.

Anyway, they must comply with the requirements of this technical specification.

8.3.1 Oil preservation system

Two kinds of oil preservation systems can be proposed:

a) Hermetically sealed tank, liquid-preservation system. Sealed tank construction is a construction in which the interior of the tank is sealed to prevent the introduction of external atmosphere into the tank. The voltage regulator shall remain effectively sealed for a top liquid temperature range of -20°C to 110°C for continuous operation at rated power. As a part of the normal operation, the tank shall be provided with a replaceable pressure-relief valve to relieve excess pressure due to normal temperature variation of top liquid and/or due to on-load tap-changer operations. The replaceable pressure-relief valve shall be located on the tank above the 110°C top liquid level. The valve shall be located so it does not interfere with the use of support lugs and lifting lugs. It shall not be located in the quadrant of the tank that contains the control enclosure. The top cover of the AVR shall be bolted to the main tank.

b) Breathing type AVR, in this case, the Voltage Regulator shall be fitted with an oil seal type silica gel breather. This breather shall be at least one size larger than would be fitted for use in a temperate climate. All breathers shall be mounted at a height not exceeding 1.5m above ground level. The top cover of the AVR shall be bolted to the main tank.

8.3.2 Cooling

Cooling is done by the natural circulation of the internal insulating oil and the external air (ONAN).

8.3.3 Tank

The tank fabrication shall be done with low carbon steel. Tank construction shall be sufficiently strong. Suitable sizes of stiffeners both vertical & horizontal shall be provided. The tank shall be mounted on skid or suitable frame to be installed on concrete basement (3 phases AVR or U beams on poles for 3 single phase AVR).

Tanks shall be designed in such a way that no rainwater is retained at cover of the tanks. For this purpose, tank covers shall be slopped on both sides.

Lifting lugs shall be provided to lift the complete voltage regulator ready for service.

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8.3.4 Radiators (if any)

Radiator(s), if provided, shall be designed so that all painted surfaces can be thoroughly cleaned and easily painted in site with brush or spray gun. The design shall also avoid pockets in which water can collect. If detachable type radiators are provided, they shall be connected directly to the tank and shall be provided with machined flanged inlet and outlet branches. Plugs shall be fitted at the top and bottom of each radiator for filling and draining.

8.3.5 Surface treatment

Transformers and smaller parts such as brackets, etc. shall be powder painting with Dark Grey colour-RAL 7033 or 7036.

As an alternative to powder painting the exterior of the tank of the transformers may be painted with a primer coat and not less than two-finish epoxy paint coats.

The inner surfaces of the tank and radiators (if any) shall be coated by an oil resistant paint.

Before painting the interior and exterior of the tank in a dismantled condition shall be abrasive blast cleaned to white metal. All surfaces (except those in direct contact with oil) immediately after cleaning and not less than four hours after cleaning shall be coated with the powder painting.

Before any topcoats are applied i.e. before assembly, the coating is to be primed in accordance with the paint manufacturer's recommendations.

The interior of the tank in contact with the oil shall be given at least one coat of non-chipping oil and acid resisting paint or varnish after cleaning as above.

The details of the paint system to be used, including the brand and type of paint to be used shall be included in the Bid documents.

The tank and its accessories shall be adequately protected against corrosion and the supplier shall include a statement of protection proposed.

All bolts, studs, nuts, and washers shall have corrosion proof locking features. They could be made of stainless steel or hot dip galvanized steel.

8.3.6 Valves

Complete set of valves shall be provided for draining, sampling, filtering, air release, and isolation purposes.

Valves shall be of the sluice type, have non-rising spindles, and shall be closed by turning the hand-wheel in a clockwise direction. They shall have machined flanges with facilities for locking in the closed and open positions. Every valve shall be provided with an indicator to clearly show the position of the valve and each hand-wheel shall be fitted with a brass nameplate indicating the purpose of the valve.

8.3.7 Earthing

Two 13mm diameter holes (or connectors) for connection of earth wires copper lug shall be provided on the transformer under frame. Those holes shall be located one on each lower side of the transformer.

8.3.8 Network surge arresters

AVR top tanks or covers shall be fitted with specific supports for installing surge arresters (not supplied).

8.4 Electrical design

8.4.1 Electrical characteristics

Nominal input voltage	22kV
Minimal input voltage	18.7kV
Maximum input voltage	23.1kV
Nominal output voltage	22kV
Short circuit withstand 1 second	16kA
Rated current	150, 200, 250, 300, 400A
Rated frequency	50Hz
Power frequency impulse withstand voltage 50Hz/1min.	50kV rms
Power impulse withstand voltage (1.2/50µs)	125kV

8.4.2 Magnetic circuit

Core shall be made of low loss, high permeability material and the core construction shall avoid static discharge and development of short-circuit paths within itself or to the ground. The core design shall ensure no hot sections due to over fluxing or circulating currents. The flux density at any point shall not exceed 1.65T.

All metal parts of the Voltage Regulator apart from the individual core laminations, core bolts and associated individual clamping plates etc. shall be earthed at one point with suitable size of tinned copper strip of area not less than 0.8cm.

8.4.3 Winding

Windings shall be made with high conductivity copper or aluminum and shall be designed and manufactured to resist, without suffering damage, the thermal and mechanical effects caused by external short-circuit. The insulation material of windings shall be suitable for the specified temperature rise and shall be thermally stabilized.

Winding (electrical circuit) shall be designed to not generate a hot spots. For this purpose sufficient cooling duct axial/radial shall be provided, size of duct shall be such that easy flow of oil is not blocked, and can easily take away the generated heat.

The temperature of the conductor material in the windings of voltage regulators under the short-circuit condition shall not exceed 250°C.

8.4.4 Reactor

The AVR shall be supplied with a reactor(s) for the purpose of maintaining continuity while the tap-changer is changing position.

The reactor shall be isolated from ground to provide protection from lightning and switching surges. Construction of the reactor shall minimize no-load losses and leakage current.

8.4.5 Potential transformer

The AVR shall include a potential transformer for auxiliary supply (Control, OLTC, etc..)

The secondary voltage of the potential transformer shall be 120VAC.

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8.4.6 Harmonic suppression

The Voltage Regulator shall be designed in such a way that in the output contains minimum amount of harmonics. The sum of 3rd, 5th, 7th harmonics shall not be more than 3% of RMS rated value and the individual value shall not be more than 2%. For this purpose, composite low pass filters may be added in order to get nearly sine wave output. Voltage Regulator supplier shall demonstrate the output wave shape.

8.5 Bushings

The voltage regulator shall be fitted with Porcelain bushings conforming to latest relevant international standards IEC 60137 and IEC 60815. The bushings shall be compatible with the service conditions and system parameters. The bushings shall be terminated by tinned copper alloy flat pad terminals with four holes and stainless steel bolts to accept vertical connection with overhead line AAAC covered conductors of cross-sectional area starting from $70mm^2$ up to $240mm^2$.

Bushings shall have the following characteristics:

Rated Voltage	24kV
Minimum Creepage distance	600mm
1 minute dry (kV RMS) voltage withstand	60kV
10 second wet (kV RMS) voltage withstand	50kV
Basic Impulse full-wave dry withstand (1.2 / 50µs)	125kV

All bushings shall be identical and fully interchangeable.

The bushing shall be permanently marked near their location.

8.6 Noise level

The maximum noise level shall be:

- 55dB for each one phase AVR
- 60dB for 3 phases AVR

8.7 Voltage control

The Voltage Regulator shall have an automatic voltage control device (relay) to control the on load tap changing type sector switch for varying the effective transformation ratio.

The auxiliary supply for the automatic voltage control relay and the OLTC shall be provided by an auxiliary winding incorporated in the Regulator main winding.

OLTC shall comply with IEC 60214 and shall be suitable for power flow in both directions. Only designs which have been type tested in accordance with this standard shall be accepted.

A counter shall be included with the tap changing mechanism to indicate the number of operations completed by the equipment.

All terminals shall be clearly and permanently marked with numbers corresponding to the cables connected thereto.

Tap changers shall be suitable for load flow through the Voltage Regulator as stipulated in the technical requirements.

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8.8 On Load Tap Changer (OLTC)

The voltage regulation range shall be ± 10% in 32 steps for 3 phase AVR and ± 15% in 32 steps for 3 single phase AVR installed in close-delta connections (3 phases, 3 wires).

The tap-changing mechanism shall be completely oil-immersed. The time of the tap-changer to operate from neutral to maximum position should not exceed one minute.

On-load tap changer shall have minimum **32 steps** with automatic control system.

The minimum number of mechanical operations of the OLTC shall exceed 500,000 operations. Anyway, maintenance could be required before reaching this number of operations.

OLTC shall be contained in separate tanks mounted in an accessible position in or on the sides of the Voltage Regulator main tank. Designs having the on-load tap changer contained within the main Voltage Regulator tank are also acceptable.

The tap selectors shall be arranged to permit easy access for maintenance and repair of the equipment thereon, preferably without the necessity of lowering the oil level in the main Voltage Regulator tank.

Current making and breaking switches, integral with the tap selector equipment shall be contained in a separate tank designed in a manner to make it impossible for the oil therein to mix with oil in the tap selector and main Voltage Regulator. The head of oil in this tank may be maintained by a separate compartment.

The OLTC motor shall operate on 120VAC normal auxiliary supply. A suitable 2 x 12V & 60Ah Min. (or equivalent) re-chargeable battery bank with inverter to obtain 120V 50Hz normal AC supply shall also be provided as a backup to operate OLTC operating mechanism.

Automatic changeover shall be provided to switch supply from the former to the latter. The latter shall **bring back the tap changer to the zero position automatically during power failure**. When the supply is restored, the changeover shall automatically switch to the normal auxiliary supply. The battery charger shall be provided with automatic trickle charge, float charge, and boost charge with proper protection like overcharge trip, low voltage trip, etc. The battery bank and a battery charger for the above purpose shall be supplied and housed in a suitable weather, vermin, and insect proof cubicle with locking facilities.

When the gas and oil actuated relay operates, it shall send a signal to block the operation of the OLTC after bringing back the OLTC to the zero position.

Auto - Local - Manual selector switch shall be provided for the operation of motor and the operating mechanism. Provision shall also be made available to operate the tap changer manually without the motor using a manual operating handle. The manual operating handle shall be provided and housed in the tap changer operating mechanism cubicle.

An approved means shall be provided to safeguard the Voltage Regulator when the tap changer mechanism fails to perform a complete tap changing operation and the indication " Tap change incomplete" shall be initiated.

A glass window shall be provided in the tap changer operating mechanism cubicle to view the following Tap position Tap change incomplete indication.

The following operating conditions are to apply to the on-load tap selector controls:

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- It shall not be possible to operate the electric drive when the manual operating gear is in use. Operation from the local control switch shall cause one tap movement only unless the control switch is returned to the off position between successive operations.
- All electrical control switches (auto- local - manual) and manual (hand) operating gear shall be clearly labeled in an approved manner to indicate the direction of tap changing.

8.8.1 OLTC position indicator

AVR shall be fitted with a visual position indicator.

It (they) shall be made of polymer and located on:

- The front face of the AVR (near the control cabinet) in case of 3 phases AVR.
- Top of AVR (above oil level) above the control cabinet and stands downward at a 45-degree angle for single phase AVR for ease of reading from ground level if pole mounted installed.

8.9 AVR control Cabinet

The control cabinet envelop shall be of:

- IP56D: Dust protected, powerful water jetting and against penetration of a wire
- IK10: can withstand an impact energy of 20 joules, which is equivalent to a 5kg hammer falling from a height of 40cm

The door of the control unit cabinet shall be lockable with a standard Diameter 8mm lock.

The voltage regulator control shall be of Microprocessor-based type and modular in design to allow easy installation and removal of accessory hardware to enable the addition of features and functions.

The microprocessor-based control unit which provides the function of continuously monitoring AVR's output voltage and automatically adjusts tap changers in AVR until the desired voltage is obtained.

The unit shall include a keyboard for programming all operations and setting the parameters. It is allowed that programming being performed by portable personal computer.

Users access to the control unit shall be protected by several password levels depending on the operations to be done with the control unit (programming, setting, etc...).

8.9.1 Front face

In addition to the keyboard, the front face of the control unit shall include:

- An LCD screen for displaying relevant information during programming, setting, etc.... The display shall have an adjustment for contrast.
- A six-digit (or more) electronic operations counter, which counts every tap change.
- 2 USB ports
- Motor fuse support for OLTC motor
- Switches and LED indicators

8.9.2 Communication/control protocols

As a minimum, the following communication/control protocols shall be made available:

- DNP 3,
- IEC60870-5-(101) (104),
- DATA 2179,
- MODBUS,
- IEC 61850

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The AVR shall be connected to the EDC's SCADA system.

8.9.3 Metering functions

The following metering functions shall be included in the control box:

a) Instantaneous metering
- Load voltage, secondary
- Source voltage, secondary
- Load voltage, primary [kV]
- Source voltage, primary [kV]
- Power factor
- Line frequency
- Load current, primary [A]
- kVA load
- kW load
- kVAr load
- Tap position and percent regulation.
- Voltage harmonic (3,5,7,9,11,13), percent
- Current harmonic (3,5,7,9,11,13), percent.

b) Demand metering (time interval 3-60 minutes) Time sampling interval [minute] 1 minute to 1 day:
- Source voltage, primary [kV]
- Load voltage, secondary
- Load current, primary [A]
- Power factor at Max. kVA demand
- Power factor at Min. kVA demand
- kVA load
- kW load
- kVAr load
- Max. tap position
- Min. tap position

8.9.4 Tap changer diagnostic and preventive maintenance.

The control unit shall include all necessary functions for OLTC diagnostic and preventive maintenance.

8.9.4.1 Duty Cycle Monitor

The control shall have a "Duty Cycle Monitor" that will calculate the life used for all contacts of the tap-changer based upon actual service conditions and the regulator design.

8.9.4.2 Preventive Maintenance Tapping

The control shall be able to perform preventive maintenance tapping, which is the ability for the control to exercise the tap changer based upon user-defined conditions on a routine basis to prevent the build-up of carbon deposits on the contacts. Two modes shall be available allowing for various degrees of configurability and the ability to exercise all stationary and moveable contacts.

8.9.4.3 Time on tap

The control shall have a TIME ON TAP feature that provides specific information about the amount of time that the regulator has spent on each tap position.

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8.9.4.4 Histograms

The control shall store user configurable data for histograms (graphs that show voltage regulator performance at a glance).

8.10 Accessories

8.10.1 Buchholz relay for breathing type AVR

The tap changer compartment of the Voltage Regulator shall be fitted with gas and oil-actuated relay equipment having contacts which close on collection of gas / following oil surge or low oil level conditions in the tap changer compartment. The closing of contacts shall send signal to block the operation of the OLTC after bringing back the OLTC to the zero position. The gas and oil-actuated relay shall be provided with a test cock to collect gas sample. The gas and oil-actuated relay shall be mounted in such a way so that all gas arising from the tap changer compartment will pass into the gas and oil-actuated relay.

8.10.2 Oil temperature and alarm device

The thermometer installed shall be of 2 resettable pointers with the maximum temperature indicator of resettable type with horizontal reading scale graduated in °C.

The technical characteristics of the thermometer shall be as follows:

Mounting	Top mount
Range (°C)	0 to 130
Accuracy	± 2%
Ambient operating temperature (°C)	-10 to 60
Protective index (IEC 60529)	IP 55

The thermometer shall be suitably protected or self-protected against corrosion.

The lens of the thermometer shall be made of UV resistant polycarbonate.

In addition, a pointer to register the highest temperature reached shall also be provided. When the pointer reached a temperature of 90°C it shall close a contact to send signal to block the operation of the OLTC after bringing back the OLTC to the zero position

8.11 Oil

All AVR shall be filled to the required level with new, unused, clean, standard mineral oil in compliance with IEC 60296 and shall be free from all traces of polychlorinated biphenyl (PCB) compounds.

The oil shall be PCB free; EDC will refuse the delivery of the AVR that is not proved to comply with this requirement.

Oil suppliers' coordinates, oil type, reference, and detailed characteristics shall be provided in the offer.

8.12 Marking

The marking shall be strictly conformed to the requirement of IEC 60076.

The plate shall be indelible and made of stainless steel or aluminum.

It shall mention the following information:

- Manufacturer's Name

- Reference
- Cooling class
- Serial number
- Month and year of manufacturing (in clear)
- Number of phases
- Rated kVA
- Rated current
- Supplementary continuous-current ratings
- Rated voltage
- Voltage transformer ratio
- Rated range of regulation
- Rated frequency;
- Impulse level, full wave in kilovolts (kV)
- Un-tanking weight
- Total weight
- Insulating liquid type
- Volume of insulating liquid (weight of insulating liquid when specified in place of volume)
- Conductor material
- Average winding rise in degrees Celsius (°C)
- Complete diagrams showing the leads and internal connections and their markings, including polarity markings, and the voltage obtainable with the various connections
- Installation and operating instructions reference
- Symmetrical short-circuit withstand ampere rating with time duration
- Asymmetrical short-circuit withstand, first peak ampere rating (when specified)
- On-load tap-changer model number and maximum through-current rating
- Tap-changer motor capacitor rating
- Purchase order Number (P.O. Number)
- "ELECTRICITE du CAMBODGE" and "កម្មសិទ្ធិអគ្គិសនីកម្ពុជា"
- EDC's LOGO

9 Technical data sheets

No.	Description	Unit	Requirements	Supplier's Offer
9.1	**22kV Automatic Voltage regulator**			
1	Manufacturer country		To be specified	
2	Manufacturer		To be specified	
3	Manufacturer's reference of offered product		To be specified	
4	Product country of origin		To be specified	
5	Applicable standards		IEC 60076 and IEC 602141 or equivalent to be mentioned	
5a	Full copies of type test reports submitted within the bid		Mandatory	
6	Mechanical design		☐ 3 phases AVR ☐ 3 single phase AVR	
Tank				
7a	Oil preservation system		☐ Hermetically sealed-tank AVR ☐ Breathing type AVR	
7b	Oil preservation system shall be strictly conformed to § 6.3.1 chapter.		Mandatory	
8	ONAN cooling		Mandatory	
9a	The tank fabrication shall be done with low carbon steel.		Yes	
9b	The tank shall be mounted on skid or suitable frame to be installed on concrete basement (3 phases AVR or U beams on poles for 3 single phase AVR).		Yes	
9c	Tanks shall be designed in such a way that no rainwater is retained at the cover of the tanks.		Yes	
9d	Lifting lugs shall be provided to lift the complete voltage regulator ready for service.		Mandatory	

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10	Radiator(s), if provided, shall be designed so that all painted surfaces can be thoroughly cleaned and easily painted in site with brush or spray gun.		To be specified	
10a	If detachable type radiators are provided, they shall be connected directly to the tank and shall be provided with machined flanged inlet and outlet branches. Plugs shall be fitted at the top and bottom of each radiator for filling and draining.		To be specified	
11a	Transformers and smaller parts such as brackets, etc. are powder painting with Dark Grey colour-RAL 7033 or 7036.		To be specified	
11b	The inner surfaces of the tank and radiators (if any) are coated by an oil resistant paint.		Mandatory	
11c	Tank conforms to the requirements of paragraph 8.3.5.		Yes	
12a	Complete set of valves is provided for draining, sampling, filtering, air release, and isolation purposes.		Yes	
12b	Valves are of the sluice type, have non-rising spindles and shall be closed by turning the hand-wheel in a clockwise direction.		Mandatory	
12c	Valves are machined flanges with facilities for locking in the closed and open positions.		Mandatory	
12d	Every valve is provided with an indicator to clearly show the position of the valve and each hand-wheel are fitted with a brass nameplate indicating the purpose of the valve.		Mandatory	

13	Two 13 mm diameter holes (or connectors) for the connection of earth wire copper lugs are provided on the transformer under frame.		Mandatory	
14	AVR top tanks are fitted with specific supports for installing surge arresters (not supplied).		Mandatory	
Electrical Characteristics				
15	Nominal input voltage Minimal input voltage Maximum input voltage Nominal output voltage Short circuit withstand 1 s Rated current Rated frequency Power frequency impulse withstand voltage 50Hz/1min. Power impulse withstand voltage (1.2/50μs)	kV kV kV kV kA A Hz kV rms kV	22 18.7 23.1 22 16 □ 150 □ 200 □ 250 □ 300 □ 400 or □ 50 50 125	
Magnetic circuit				
16a	Core are made of low loss, high permeability material and the core construction avoids static discharge and development of short-circuit paths within itself or to the ground.		Mandatory	
16b	The core design ensures no hot sections due to over fluxing or circulating currents. The flux density at any point shall not exceed 1.65T.		Yes	

16c	All metal parts of the Voltage Regulator apart from the individual core laminations, core bolts, and associated individual clamping plates, etc. are earthed at one point with suitable size of tinned copper strip of area not less than 0.8 cm.		Yes	
Winding				
17	Windings are made with high conductivity copper or aluminum and are designed and manufactured to resist, without suffering damage, the thermal and mechanical effects caused by external short-circuit.		Mandatory	Copper ☐ Aluminum ☐
18	The insulation material of windings shall be suitable for the specified temperature rise and shall be thermally stabilized.		Yes	
19	Winding (electrical circuit) shall be designed not to generate hot spot.		Yes	
20	The temperature of the conductor material in the windings of voltage regulators under the short-circuit condition shall not exceed 250°C.		Yes	
Reactor				
21	The AVR is supplied with a reactor(s) for the purpose of maintaining continuity while the tap-changer is changing position.		Mandatory	
22	The reactor is isolated from ground to provide protection from lightning and switching surges.		Yes	
23a	The AVR includes a potential transformer for auxiliary supply (Control, OLTC, etc.)		Mandatory	

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23b	The secondary voltage of the potential transformer is:	VAC	120	
24a	The Voltage Regulator is designed in such a way that in the output contains minimum amount of harmonics.		Mandatory	
24b	The sum of 3rd, 5th, 7th harmonics shall not be more than 3% of RMS rated value and the individual value shall not be more than 2%.		Mandatory	
Bushings				
25	The voltage regulator shall be fitted with Porcelain bushings conforming to latest relevant international standards IEC 60137 and IEC 60815.		Mandatory	
26	The bushings shall be terminated by tinned copper alloy flat pad terminals with four holes and stainless steel bolts to accept vertical connection with overhead line AAAC covered conductors of cross-sectional area starting from 70 mm^2 up to 240 mm^2 with lugs.		Mandatory	
27	Rated Voltage Minimum Creepage distance 1 minute dry (kV RMS) voltage withstand 10 second wet (kV RMS) voltage withstand Basic Impulse full-wave dry withstand (1.2 /50μs)	kV mm kV kV kV	24 600 60 50 125	
28	All bushings are identical and fully interchangeable.		Yes	
29	The bushing is permanently marked near their location.		Yes	

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Maximum Noise level				
30a	for each phase	dB	55	
30b	3 phases AVR	dB	60	
Voltage control				
31	The Voltage Regulator includes an automatic voltage control device (relay) to control the on-load tap changing type sector switch for varying the effective transformation ratio.		Yes	
32	The auxiliary supply for the automatic voltage control relay and the OLTC is provided by an auxiliary winding incorporated in the Regulator main winding.		Yes	
33	OLTC complies with IEC 60214 and shall be suitable for power flow in both directions. Only designs which have been type tested in accordance with this standard shall be accepted.		Yes	
34	A counter is included with the tap change mechanism to indicate the number of operations completed by the equipment.		Yes	
35	All terminals are clearly and permanently marked with numbers corresponding to the cables connected thereto.		Yes	
36	Tap changers are suitable for load flow through the Voltage Regulator as stipulated in the technical requirements.		Yes	
OLTC				
37	Voltage regulation range:		± 10% in 32 steps for 3 phases AVR ± 15% in 32 steps for 3 single phase AVR installed in close-delta connection (3 phases, 3 wires)	
38	The tap-changing mechanism is		oil-immersed	

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39	The time of the tap-changer to operate from neutral to maximum position.	mn	≤ 1	
40	Minimum number of mechanical operations: of the OLTC shall exceed operations.		≥ 500 000	
41	The tap selectors shall be arranged to permit easy access for maintenance and repair of the equipment.		Yes	
42	The OLTC motor shall operate on normal auxiliary supply.		120VAC	
43	A suitable 2 X 12 volt & 60Ah (Min.) (or equivalent) re-chargeable battery bank with inverter to obtain 120V 50Hz normal AC supply shall also be provided as a backup to operate OLTC operating mechanism.		Yes	
44	OLTC strictly conforms to Chapter 8.8		Mandatory	
45	OLTC position indicator conforms to requirements of clause 8.8.1		Yes	
Control cabinet				
46	IP56D and IK10 indices		Yes	
47	The door of the control unit cabinet shall be lockable with a standard Diameter 8 mm lock.		Yes	
48	The voltage regulator control shall be of Microprocessor-based type and modular in design to allow easy installation and removal of accessory hardware to enable the addition of features and functions.		Yes	
49	The microprocessor-based control unit which provides the function of continuously monitoring AVR's output voltage and automatically adjusts tap changers in AVR until the desired voltage is obtained.		Yes	

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50	The unit shall include a keyboard for programming all operations and setting the parameters. It is allowed that programming being performed by portable personal computers.		Yes	
51	Users access to the control unit shall be protected by several password levels depending on the operations to be done with the control unit (programming, setting, etc...).		Yes	
52	In addition to the keyboard, the front face of the control unit shall include: •ALCD screen for displaying relevant information during programming, setting, etc.... The display shall have an adjustment for contrast. •A six-digit (or more) electronic operations counter, which counts every tap change. •2 USB ports •Motor fuse support for OLTC motor •Switches and LED indicators		Yes	
53	As a minimum, the following communication/control protocols shall be made available: •DNP 3, •IEC60870-5-(101) (104), •DATA 2179, •MODBUS, •IEC 61850		Yes Yes	

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54	The AVR shall be connected to the EDC's SCADA system.		Yes	
Instantaneous Metering functions				
55	Load voltage, secondary	kV	Yes	
56	Source voltage, secondary	kV	Yes	
57	Load voltage, primary	kV	Yes	
58	Source voltage, primary	kV	Yes	
59	Power factor		Yes	
60	Line frequency	Hz	Yes	
61	Load current, primary [A]	A	Yes	
62	kVA load	kVA	Yes	
63	kW load	kW	Yes	
64	kVAr load	kVAr	Yes	
65	Tap position and percent regulation.		Yes	
66	Voltage harmonic (3,5,7,9,11,13), percent	%	Yes	
67	Current harmonic (3,5,7,9,11,13), percent.	%	Yes	
Demand metering functions (time interval 3-60 minutes) Time sampling interval [minute] 1 minute to 1 day:				
68	Source voltage, primary	kV	Yes	
69	Load voltage, secondary	kV	Yes	
70	Load current, primary	A	Yes	
71	Power factor at Max. kVA demand		Yes	
72	Power factor at Min. kVA demand		Yes	
73	kVA load	kVA	Yes	
74	kW load	kW	Yes	
75	kVAr load	kVAr	Yes	
76	Max. tap position		Yes	
77	Min. tap position		Yes	

Fonctions				
78	The control unit shall include all necessary functions for OLTC diagnostic and preventive maintenance.		Yes	
79	The control shall have a "Duty Cycle Monitor" that will calculate the life used for all contacts of the tap- changer based on actual service conditions and the regulator design.		Yes	
80	The control shall be able to perform preventive maintenance tapping, which is the ability for the control to exercise the tap changer based upon user-defined conditions on a routine basis to prevent the build-up of carbon deposits on the contacts.		Yes	
81	The control shall have a TIME ON TAP feature that provides specific information about the amount of time that the regulator has spent on each tap position.		Yes	
82	The control shall store user configurable data for histograms (graphs that show voltage regulator performance at a glance).		Yes	
Accessories				
83	Buchholz relay for breathing type AVR only		Mandatory	
84	Oil temperature and alarm device		To be specified	
Oil				
85	New, unused, clean, standard mineral oil		Mandatory	
86	Oil in compliance with		IEC 60296	

87	Oil free from all traces of polychlorinated biphenyl (PCB) compounds		Mandatory	
Marking				
88	STRICTLY in accordance with		IEC 60076	
89	STRICTLY in accordance with Clause 8.12		Mandatory	
The offer shall include all drawings and dimensions as well as all technical catalogues. If not, the offer shall be rejected.				
If the required type tests are missing, the offer shall be rejected				
Supplier's offer column must be properly filled with the right figures. "Compliant, Yes, ",√, etc.... "are not accepted.				

Deviation from the technical specification:

The bidder shall list point after point and explain here in after all deviation from the requested technical specification.

1/

2/

3/

Full technical information shall be supplied within the bid. If not, the offer shall not be considered

Bidder signature: