

CEB STANDARD 024 : 1998

Specification

for

36KV VOLTAGE REGULATORS

CEYLON ELECTRICITY BOARD

SRI LANKA

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SPECIFICATION FOR 36KV VOLTAGE REGULATORS

1.0 SCOPE

This specification covers the general requirements of design, manufacture and testing of 36kV Three Phase Automatic Voltage Regulators.

2.0 SYSTEM PARAMETERS

(a)	Nominal Voltage	-	33kV
(b)	System highest voltage	-	36kV
(c)	System frequency	-	50Hz
(d)	Number of phases	-	03
(e)	Method of earthing	-	Non effectively earthed
(f)	System fault current (symmetrical rms)	-	13.1 kA

3.0 SERVICE CONDITIONS

(a)	Annual average ambient Temperature	-	30 ^o C
(b)	Maximum ambient temperature	-	40 ^o C
(c)	Maximum relative humidity	-	90%
(d)	Environmental conditions	-	Humid tropical climate withheavily polluted atmosphere.
(e)	Operational altitude	-	From MSL to 2000m above MSL

4.0 APPLICABLE STANDARDS

The equipment and the components supplied shall be in accordance with the standards specified below or later editions and/or amendments thereof.

a)	IEC 76 (1990)	-	Power Transformer
b)	IEC 354 (1990)	-	Loading Guide for Oil immersed power T/F
c)	IEC 137 (1990)	-	Bushing for alternating voltage above 1000V
d)	IEC 214 (1990)	-	On-load Tap-changers.
e)	IEC 542 (1976)	-	Application guide for on load tap changer
f)	BS 4360 (1990)	-	Weldable structural steel.
g)	BS 729 (1971)	-	Hot dip galvanised coatings on iron and steel articles.
h)	IEC 296 (1990)	-	Inspection for unused mineral insulating oil for transformers and switchgears.
i)	IEC 529 (1990)	-	Degree of protection provided by enclosures.

5.0 BASIC FEATURES

5.1 General

The 33KV three phase automatic voltage regulators will be used in long overhead Radial / Open-Ring Feeders to improve the down stream network supply performance.

5.2 Type of Voltage Regulators and Operating Conditions

The Voltage Regulators shall be mineral insulating oil immersed with ONAN cooling and suitable for outdoor installation.

5.3 Continuous Maximum Rating

The voltage regulators shall have the rating stated in the Schedule of Technical Requirements and shall comply with the requirements of IEC 76 and IEC 354 with regard to temperature rise on all tapplings and over loading.

5.4 Voltage Ratio

The Nominal Input and output Voltage shall be 33:33 kV, minimum input voltage shall be 28KV and the maximum input voltage shall be 34.5 kV. The output voltage shall be 33 KV

5.5 Electrical Connections

Voltage Regulator windings shall be of three phase auto star connection type, star point unearthed.

5.6 Duty Under Fault Conditions

The Voltage Regulator shall be capable of withstanding for 3 seconds without damage against external short circuit between phases or between phase to earth, with the short circuit level limited to 4KA rms for 3 seconds.

Evidence shall be submitted with the offer as to the extent to which the manufacturer has proved or is able to prove either by calculation or test the ability of the specified voltage regulator to withstand short circuit. The Purchaser reserves the right to require calculations to prove that the design of voltage regulator offered will satisfactorily comply with this Clause.

5.7 Losses and Evaluation of Losses

The following shall be specified by the Bidder;

- a) No Load Losses at rated voltage and rated frequency.
- b) Load losses at rated MVA rating at 75 Deg. C.
- c) Zero phase sequence/Phase in ohms.
- d) No load current and power factor.

For the purpose of Bid assessment, the Bid price in Sri Lanka Rupees and the cost of Voltage regulator losses will be taken into account, the basis of comparison of losses being as follows:-

The "Present Worth" of the cost of losses of each Voltage Regulators equals

SLR (300,000 Fe + 100,000 Cu)

Where Fe = No load loss expressed in kW.
and Cu = Full load copper loss expressed in kW.

5.8 Magnetic Circuit and Windings

- a) Reasonable low flux density shall be taken for economical design of magnetic circuit. Care shall be taken to avoid static discharges. Magnetic circuit shall be designed with mitered joint so as to get good performance out of magnetic circuit.
- b) Core bolts shall not pass through limbs of the magnetic circuit, however if any core bolts passes through yoke shall be suitably insulated. Core bolts through yoke shall be tested at 2000 volts RMS for 60 seconds withstand test.
- c) Magnetic circuit shall be suitably clamped so that no HUM is experienced and the average surface noise level shall not exceed 71 dB ,when measured in accordance with BS 6056 (1981).
- d) Magnetic circuit shall be designed with utmost care that flux density is not more than 1.8 tesla when the supply is 33kV + 12.5% and frequency 50 Hz is connected on input terminals. Bidders shall demonstrate the maximum flux density by way of design calculation, taking into account the effect of V/F.
- e) All metal parts of the Voltage regulator with the exception of 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 0.8 cm² potential.
- f) Winding (Electrical circuit) shall be designed so that no hot spot is generated, 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.
- g) Winding Terminations and connections leads shall be rigidly supported with the core frame.

5.9 Harmonic Suppression

The voltage regulator shall be designed in such a way that in the output least harmonics effect are there. 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, so as to get nearly Sine wave output. Voltage regulator supplier shall demonstrate the output wave shape.

5.10 Earthing of Magnetic Circuit

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position just beneath the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be

tested at voltages up to 2.5 kV for the purpose of checking deterioration during service. The connection to the link shall be on the same side of the core as the main earth connection. These requirements are compulsory.

5.11 Tank Fabrication for Regulators

- a) The tank fabrication shall be done with low carbon steel conforming to BS 4360. Tank construction shall be sufficiently strong. Suitable sizes of stiffeners both vertical & horizontal shall be provided. The tank shall be mounted on skid.
- b) Tanks will be tested for 1 kg/Cms for pressure and vacuum test, there should not be permanent deflection of more than 6 MM for upto 1500 Length of tank and 10 MM for upto 2000 MM tank length.
- c) Tanks shall be designed in such a way that no rain water is retained at cover of the tanks, for this purpose tanks covers shall be sloped both sides.
- d) Lifting lugs shall be provided to lift the complete regulator ready for service.

5.12 Breather

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.

5.13 Terminal Bushings

The voltage regulator shall be provided with outdoor type 36kV bushing insulators. All bushing shall comply with IEC 137. The minimum creepage distance shall be 900mm and the minimum protected creepage distances shall be 315mm.

The bushing shall be of the oil filled type or sealed construction suitable for service under the very humid conditions. Typical section of bushing insulators showing the internal construction, method of securing the top cap and method of sealing shall be submitted with the offer

Minimum phase to phase clearance shall not be less than 900mm

5.14 Valves

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

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

5.15 Radiators

Radiators if provided, shall be designed so that all painted surface 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.

5.16 Earthing Terminals

Two earthing terminals, each capable of carrying the stipulated maximum earth fault current 4kA for 3 sec. shall be provided close to the base and on opposite side of the tank structure.

5.17 Voltage Control

5.17.1 General

- a) 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. On Load Tap changer (OLTC) of " **Machinenfabrik Reinhausen**" type design shall be provided with the voltage regulator.
- b) 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.
- c) OLTC shall comply with IEC 214 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.
- d) A counter shall be included with the tap change mechanism to indicate the number of operations completed by the equipment.
- e) 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.

5.17.2 On-Load Tap Changers (OLTC)

- a) On-load tap changer shall have 16 steps (17 positions) with automatic control system. 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 is also acceptable.
- b) The tap selectors shall be so arranged as 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.

- c) 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.
- d) The OLTC motor shall operate on 230V AC normal auxiliary supply . A suitable 2 X 12 volt & 60 AH (Min.) re- chargeable battery bank with inverter to obtain 230V 50Hz normal AC supply shall also be provided as a back up to operate OLTC operating mechanism. Automatic change over 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 change over 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 over charge trip, low voltage trip etc.. The battery Bank and a battery charger for the above purpose shall be supplied housed in a suitable weather, vermin and insect proof cubicle with locking facilities.
- e) During power failure the tap changer shall return to the zero position to prevent voltage rise in the down stream. The tap changer mechanism shall be inoperative when the voltage regulators are fed in the reverse direction, as this situation will arise when the voltage regulators are installed in the Open-Ring Feeders (there will be emergency back feeding requirement).
- f) When the gas and oil actuated relay operates it shall send a signal to block the operation of the OLTC after bring back the OLTC to the zero position.
- g) Auto - Local - Manual selector switch shall be provided for operation of motor and the operating mechanism. Provision shall also be made available to operate the tapchanger manually without the motor using a manual operating handle. The manual operating handle shall be provided and housed in the tapchanger operating mechanism cubicle.
- h) An approved means shall be provided to safe guard the voltage regulator when the tap changer mechanism fail to perform a complete tap changing operation and an indication " Tap change incomplete" shall be initiated.
- i) A glass window shall be provided in the tapchanger operating mechanism cubicle to view following;
 - i) Tap position
 - ii) Tap change incomplete indication
- j) The following operating conditions are to apply to the on-load tap selector controls:-
 - (i) It shall not be possible to operate the electric drive when the manual operating gear is in use.
 - (ii) Operation from Local control switch shall cause one tap movement only unless the control switch is returned to the off position between successive operations.
 - (iii) All electrical control switches (Auto- Local - Manual) and manual (hand) operating gear shall be clearly labelled in an approved manner to indicate the direction of tap changing.

5.18 Oil Temperature Indicating Devices

The Oil temperature indicating device shall have a dial type indicator to indicate the oil temperature of the voltage regulator and 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 bring back the OLTC to the zero position.

5.19 Gas and Oil-Actuated Relays (Buchholz Relay)

- a) 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 bring back the OLTC to the zero position.
- b) The gas and oil-actuated relay shall be provided with a test cock to collect gas sample.
- c) 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.

5.20 Technical Requirements

- | | | | |
|----|---------------------------------------|---|--|
| a) | Line Capacity | - | 4 MVA |
| b) | Over loading | - | As per IEC 354 |
| c) | Short time withstand current/duration | - | 4KA /3 seconds |
| d) | Input voltage | - | 33KV Nominal
- 28KV Minimum
- 34.5 Maximum |
| e) | Output voltage | - | 33 ± 0.3 KV |
| f) | Number of phases | - | 3 |
| g) | Frequency | - | 50Hz |
| h) | Type of Cooling | - | ONAN |
| i) | Oil Temperature Rise | - | 45°C |
| j) | Winding Temperature Rise | - | 55°C |
| k) | Connection | - | Auto 3 phase, star connected |

- | | | | |
|----|--------------------------------|--|--|
| l) | Insulation level | | |
| | i) | Impulse withstand voltage
(1.2/50 μ s) kV peak | - 200kV |
| | ii) | Power frequency withstand
voltage (wet 1min.) | - 70kV |
| m) | Bushings | | |
| | i) | Total Creepage Distance | - 900mm |
| | ii) | Protected Creepage Distance | - 300mm |
| n) | Percentage regulation | | - Less than 1% |
| o) | Duty cycle and Installation | | - Continuous & Outdoor |
| p) | Winding material | | - Copper |
| q) | Oil | | - Mineral oil -Transformer Oil to BS144 |
| r) | Core material | | - Cold rolled grain oriented Silicon Steel. |
| s) | On Load Tap Changer | 3 phase 200 Amps for 15% boost and 5%buck with 16 steps (17 position) and automatic control system, IP-54 enclosures suitable for outdoor installation | |
| t) | Stand by supply source | | - 1000VA (invertor 1 phase 50Hz 230V), With 2 X 12V, 60AH battery back up bank suitable for 30 minutes |
| u) | Oil temperature Max. indicator | | - provided as per Clause 5.18. |
| v) | Marshalling box | | - IP-54 enclosure |
| w) | Bucholz relay | | - provided as per Clause 5.19 |

6.0 Quality Assurance

The Bidder/manufacturer shall furnish documentary proof that the manufacturer possesses the Quality Assurance certification conforming to ISO 9001 for the manufacture of 33KV Transformers for the particular plant where manufacture is carried out. The Bidder shall certify all the documents as true copies of the originals.

7.0 ADDITIONAL REQUIREMENTS

7.1 Spares

A list of recommended spare parts (along with the detailed prices) for five years trouble free operation shall be furnished with the offer.

7.2 Rating Plate

The Rating Plate shall be made of stainless steel and shall provide the ratings and data of the voltage regulator as per IEC 76. The rating plate shall be positioned on the tank at a height of 1.5 m from the base.

7.3 Packing

Each item shall be packed properly and protected for shipment and transport from the place of manufacture to purchaser's site. The purchaser may require to inspect and approve the packing before the items are despatched but the bidder shall be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not exonerate the Bidder from any loss or damage to faulty packing.

7.4 Warranty

The Bidder shall guarantee the efficient good working of the voltage regulators supplied and guarantee the voltage regulators to be free of defects for a period of twelve months from the date on which the purchaser takes over the voltage regulators.

8.0 INFORMATION TO BE SUPPLIED WITH THE OFFER

8.1 The following shall be furnished with the offer.

- a) Particulars requested in annexure - A.
- b) Constructional features and materials used for components
- c) Separate explanatory drawings and dimensions of operation of on load tap changing mechanisms etc.
- d) Overall dimensional drawings
- e) Drawing of Rating plate to scale incorporating the particulars called for.
- f) Quality Assurance Certification conforming to ISO 9001.
- g) The following Certificate of Type Tests carried out on 33kV transformers of same capacity, and in accordance with the specified standard. Copies of all the test certificates shall be certified by the manufacturer as true copies of the originals;
 - i) Measurement of winding resistance (as per Clause No.10.2 of IEC 76)

- i) Measurement of voltage ratio and check of phase displacement (as per Clause No. 10.3 of IEC 76)
- iii) Measurement of short circuit impedance and load loss (as per Clause No. 10.4 of IEC 76)
- iv) Measurement of No Load loss (as per Clause No. 10.5 of IEC 76)
- v) Temperature rise test (as per IEC 76-2)
- vi) Dielectric test (as per IEC 76-3)

8.2 Test Certificates, Performance Curves etc., furnished shall be based on the Type Tests conforming to the relevant standard .The Test Certificates shall clearly identify the equipment concerned, showing the manufacturer's identity, Type No. and basic technical parameters, and shall be from a **recognised Testing Authority acceptable to the Purchaser.**

Copies of the Type & Routine Test Certificates shall be certified by the Bidder as the true copies of the originals.

8.3 Failure to furnish the particulars requested in clause 8.1 and 8.2 will result in the offer being rejected.

9.0 INSPECTION AND TESTING

9.1 General requirements

The Regulator shall be subject to inspection and test by the Purchaser during manufacture and before despatch.The costs of all tests including the provision of the necessary test equipment shall be borne by the Contractor and shall be deemed to be included in the Bid Price.

At least 21 working days notice shall be given when the plant is ready for inspection & tests and every facility shall be provided by the manufacturer to enable the Purchaser to carry out the necessary inspection and witnessing of tests.

9.2 Routine Tests

The following Routine Tests shall be carried out on the Voltage regulators by the manufacturer and the test report shall be supplied with the regulator

- a) Measurement of winding resistance (as per Clause No.10.2 of IEC 76)
- b) Measurement of voltage ratio and check of phase displacement (as per Clause No. 10.3 of IEC 76)
- c) Measurement of short circuit impedance and load loss (as per Clause No. 10.4 of IEC 76)
- d) Measurement of No Load loss (as per Clause No. 10.5 of IEC 76)

- e) Dielectric routine test (as per IEC 76-3)
 - i) High voltage power frequency test
 - ii) Induced over voltage test at 125 Hz.
 - iii) Characteristic of transformer oil (Break down value ,tan-delta and resistivity)

9.2.1 Voltage Control Equipment

The completely assembled switching apparatus is to be operated forty times through a complete tap changing cycle in the normal manner with the transformer unexcited followed by ten similar operations in the normal manner with the transformer alive at normal voltage on open circuit.

NOTE: A complete tap changing cycle is to comprise movement from minimum, to maximum and return to minimum tap, or equivalent.

9.2.2 Magnetic Circuit

Each core completely assembled is to be tested for one minute at 2,500 volts A.C. between core bolts, side plates, structural steel work and core at the core and coils stage. After the voltage regulator is tanked and completely assembled, a further test is to be applied between the core and the earthed structural steel work to prove that the core is earthed, through the removable link, at one point only.

9.2.3 Gas and Oil-Actuated Relays

- (a) Oil Leakage - Gas and Oil actuated relays are to be subjected to an internal oil pressure of 207kN/m² (30 p.s.i.g.) for 15 minutes. No leakage shall occur.
- (b) Gas Collection
- (c) Oil Surge.
- (d) Voltage - 2 kV for one minute between electrical circuits and casings.

9.2.4 LV Equipment

Insulation tests shall be carried out on all LV equipment at 2 kV for one minute.

9.3 Acceptance Test

The following acceptance test shall be carried out on one voltage regulator of each size and type and the tests shall be witnessed by the Inspector appointed by the purchaser.

- a) Measurement of winding resistance (as per Clause No.10.2 of IEC 76)
- b) Measurement of voltage ratio and check of phase displacement (as per Clause No. 10.3 of IEC 76)
- c) Measurement of short circuit impedance and load loss (as per Clause No. 10.4 of IEC 76)
- d) Measurement of No Load loss (as per Clause No. 10.5 of IEC 76)

- e) Dielectric routine test (as per IEC 76-3)
 - i) High voltage power frequency test
 - ii) Induced over voltage test at 125 Hz.
 - iii) Impulse withstand test.
- f) Temperature rise test (as per IEC 76-2, to be conducted on the tapping corresponding to the maximum losses).
- g) On-Load-Tap-Changer (To check the OLTC operation as per Clause 5.17, 5.18 and 5.19)

10.0 TECHNICAL LITERATURE & DRAWINGS

The selected Bidder shall supply along with the equipment the routine test report, all relevant drawings with dimensions, technical literature, hand books etc., in order to carry out the erection and commissioning of the regulators and to facilitate faultless operation and maintenance.

11.0 ANNEXURE :

ANNEXURE - A Guaranteed Technical particulars to be furnished by the manufacturer.

ANNEXURE - A**GUARANTEED TECHNICAL PARTICULARS
TO BE FURNISHED BY THE MANUFACTURER FOR 33KV VOLTAGE REGULATOR**

1.	Manufacturer's Name & Country of origin		-
2.	Line Capacity	kVA	-
3.	Rated Capacity	kVA	-
4.	Rated Voltage Input		
	i) Nominal	kV	-
	ii) Maximum	kV	-
	iii) Minimum	kV	-
5.	Rated Voltage Output	kV	-
6.	No. of phases		-
7.	Frequency	Hz	-
8.	Connections		-
9.	Vector Group		-
10.	Cooling		-
11.	Temperature rise of oil(Top layer by thermometer)	Deg. C	-
12.	Temperature rise in winding	Deg. C	-
13.	Hot spot temperature	Deg. C	-
14.	Insulation Level		
	i) Power frequency withstand voltage(Wet 1 min.) (Wet 1 min.)	kV	-
	ii) Impulse withstand voltage(1.2 /50 μ s) kV peak)	kV	-
15.	No load loss	kW	-
16.	Load loss	kW	-
17.	Total losses	kW	-

18.	Efficiencies at UPF & 0.8 PF		
	a) At 100% full load	%	-
	b) At 75% full load	%	-
	c) At 50 % full load	%	-
19.	i) Regulation at UPF	%	-
	ii) Regulation at 0.8 PF	%	-
20.	Overall dimensions	MM	-
	a) Length	MM	-
	b) Width	MM	-
	c) Height	MM	-
21.	Weights		
	a) Core & Windings	Kg.	-
	b) Tank & Fittings	Kg.	-
	c) Oil	Kg.	-
	d) Total weight	Kg.	-
22.	Quantity of oil for first filling	Ltrs.	-
23.	OLTC Specification		
	a) Name of Manufacturer		-
	b) Rated Voltage	kV	-
	c) Rated Current	Amp.	-
	d) BIL	KV	-
	e) Number of Steps		-
	i) Number of steps	Boost	-
	ii) Number of steps	Buck	-
	iii) Step No.(for normal/Nominal rated voltage)		-
24.	Winding material		-
25.	Core material		-
26.	Applicable Standard for Insulating Oil	BS/IEC-	
27.	Schedule of fittings (List of fittings to be provided with the complete regulator)		-
28.	Auxiliary winding supply voltage	Volts	-
29.	Stand by supply source		
	i) No. of batteries & type		-
	ii) Voltage & Amp-Hour of the battery		-
	ii) Inverter output voltage/frequency	V/Hz	-

30.	Whether the battery charger is provided with;	
	i) Automatic trickle charge	Yes/no -
	ii) float charge	Yes/No-
	iii) Boost charge	Yes.No-
	iv) Over charge Trip	Yes/No-
	v) Low voltage trip	Yes/No-
31.	Whether the Oil temperature gauge provided with maximum oil temperature indicator.	Yes/No-
32.	Whether the OLTC becomes inoperative when the oil temperature exceeds 90°C.	Yes/No-
33.	Whether the Buchholz relay provided with contact.	Yes/No-
34.	Whether the OLTC becomes inoperative when the Buchholz relay operates.	Yes/No-
35.	IP protection class of Marshalling box	-
36.	Type of galvanising	-
37.	The impedance Voltage at Continuous Maximum Rating (CMR) of the voltage regulator at 75°C	-
38.	Noise level as per BS 6056	dB -

SEAL AND SIGNATURE OF MANUFACTURER / DATE

2volreg