Technical Data **225-10**

Effective February 2014
Supersedes June 1998

Single-phase step voltage regulators

General

Eaton's Cooper Power Systems VR-32 single-phase step voltage regulators are tap-changing autotransformers. They regulate distribution line voltages from 10% raise (boost) to 10% lower (buck) in thirty-two steps of approximately 5/8% each. Voltage ratings are available from 2400 volts (60 kV BIL) to 34,500 volts (200 kV BIL) for 60 Hz and 50 Hz systems.

Internal potential winding taps and an external ratio correction transformer are provided on all ratings so that each regulator may be applied to more than one system voltage.

Smaller kVA sizes are supplied with support lugs for pole mounting and with substation or platform tie down provisions. Larger sizes are provided with substation bases with pad-mounting provisions.

Voltage is maintained within desired limits by controls that feature superior accuracy, reliability, and serviceability. Continuity of service is assured by rugged, service-proven tap-changers and core-and-coil assemblies functioning with the control.

Eaton's Cooper Power Systems voltage regulators are available with a full complement of standard features for routine applications, as well as a full line of optional accessories for unique applications. In addition, the regulator offers desirable features that enhance operation and service.

Cooper Power Systems
by EATON

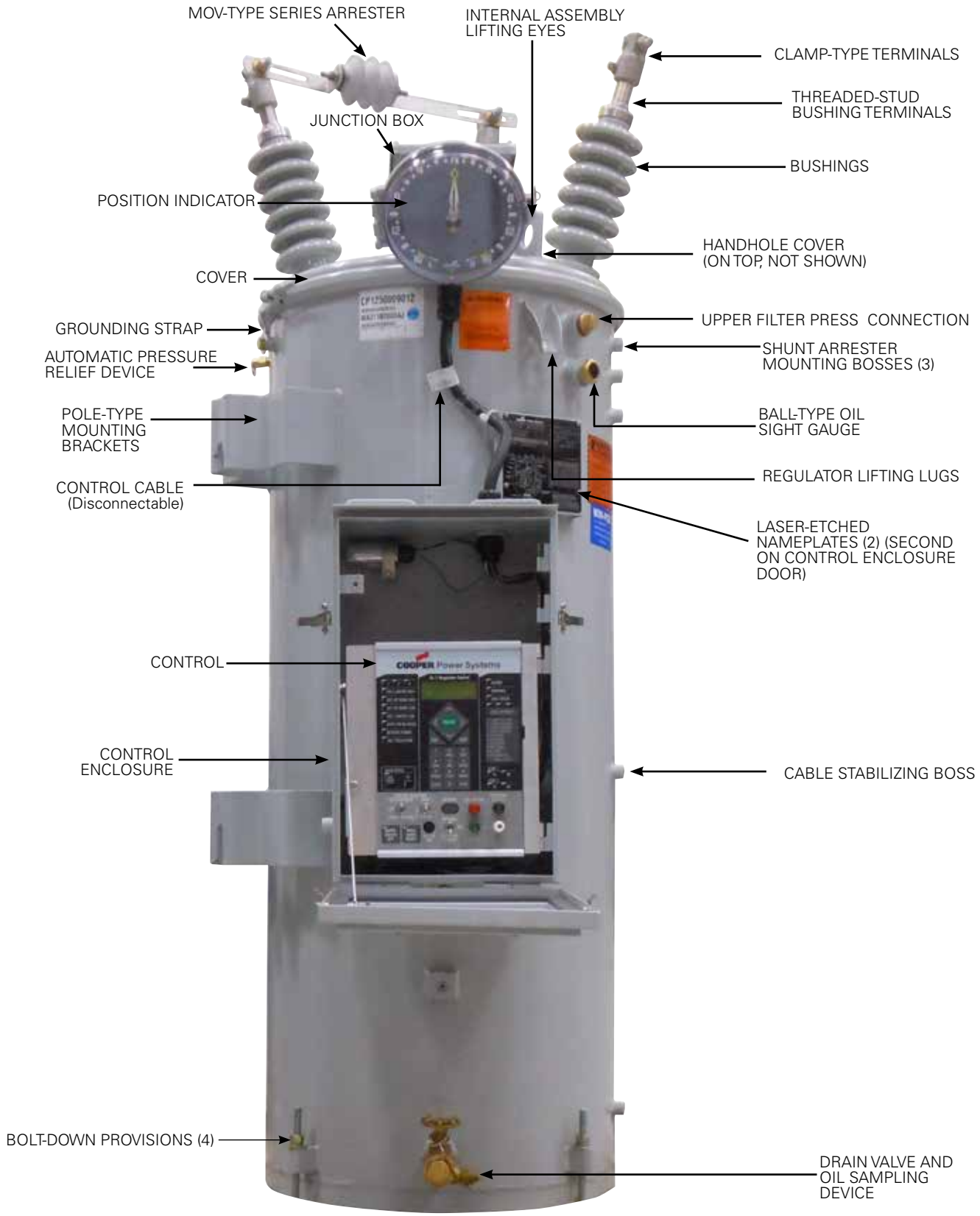

Figure 1. External features on the VR-32 voltage regulator.

Standard features

A sealed-tank construction allows the use of 65 °C rise insulation system in 55 °C rise rated designs to provide an additional 12% capacity above the nameplate rating without loss of normal insulation life. Additional load capacity is stated on the nameplate, this ADD-AMP™ feature is available as long as the tap-changer's maximum current rating is not exceeded.

The unit construction cover suspends the internal assembly consisting of the core-and-coil assembly, tap-changer, and the reactor for ease of inspection and maintenance.

All Eaton's Cooper Power Systems voltage regulators are manufactured and tested to the IEEE Std C57.15™-2009 standard.

- CL-7 control
- Tap changer with motor and power supply
- Position indicator with ADD-AMP adjustment
- Two laser-etched nameplates
- Lifting lugs
- Oil drain valve and sampling device
- Upper filter press connection
- Oil sight gauge
- Mounting provisions for shunt arresters
- High-creep bushings with clamp-type connectors
- Bolt-down provisions (overhead units)
- Pole-type mounting brackets (overhead units)
- Substation base (substation units)
- External series arrester
- Automatic pressure relief device
- Handhole
- Control cabinet with removable front panel
- Ratio correction transformer
- Conformally coated circuit boards

Optional Accessories

- Shunt arresters
- Extra-length control cables
- Elevating structure
- 4-hole NEMA® H-spades
- Cooling fans
- Nameplates in alternate languages or metric units
- Internal differential potential transformer for complete reverse power flow w/metering
- CL-7 control accessories
  - Multi-phase functionality
  - Front panel overlays in alternate languages
  - Serial communications interfaces:
    - RS232
    - Fiber Optic - ST
    - RS485
  - Ethernet communications interfaces:
    - Fiber Optic - LC, MTRJ, ST, and SC
    - Copper - RJ45
  - Communications protocols:
    - DNP
    - IEC 61850
    - IEC 60870-5
    - 2179
    - MODBUS
  - 8input/8output universal contacts
  - 13.5 Vdc radio power supply
  - 13A-Hr control power battery backup
  - 48/125 Vdc substation battery power
  - 240 V external source

Arresters

Series surge arresters

All VR-32 voltage regulators are equipped with a bypass arrester connected across the series winding between the source (S) and load (L) bushings. This bypass arrester limits the voltage developed across the series winding during lightning strikes, switching surges and line faults. A MOV type series surge arrester of 3 kV offers series winding protection on all regulators except those rated 22 kV and above, which have a 6 kV MOV-type series surge arrester.

Shunt arresters

A shunt arrester is a recommended accessory on the VR-32 voltage regulator for protection of the shunt winding. The shunt arrester is a direct connected arrester mounted on the tank and is connected between the load bushing and ground. For additional protection, a shunt arrester may also be installed between the source bushing and ground. It is recommended that arresters be applied to all non-grounded bushings. Shunt arrester application data is listed in Table 1.

Table 1. Shunt Arrester Application Data

Regulator Voltage Rating	Nominal System Voltages (volts)		Recommended MOV Shunt Arrester Ratings (kV)
	Delta or Single-phase	Multi-grounded Wye	
2500/4330Y	2400	2400/4160	3
	2500	2500/4300	
5000/8660Y	4160	4160/7200	6
	4330	4330/7500	
	4800	4800/8320	
	5000	5000/8660	
7620/13200Y	6900	6900/11950	10
	7200	7200/12470	
	7620	7620/13200	
	7970	7970/13800	
11000	11000		15
13800	12000		15
	12470		
	13200		
	13800		
14400/24940Y		13800/23900	18
		14400/24940	
19920/34500GrdY		19920/34500	27
22000	22000		27
33000	33000		36

CL-7 control

- Source-side voltage calculated from tap position
- Internal-external voltage source switch
- Automatic/manual control switch
- Manual raise/lower toggle switch
- Position indicator drag hand reset switch
- Supervisory ON-OFF switch (for use with SCADA)
- Cell phone-style full numeric keypad
- 4x20 character display
- Multilingual display
- Three date formats
- Six-digit operations counter
- Voltage test terminals
- External voltage source terminals
- Neutral indicating dual LEDS
- Panel-mounted motor fuse
- Metering-PLUS™ one-touch,grouped-data display feature
- Tap-position tracking
- Voltage limiting ("First House Protection")
- Line drop compensation settings
- SOFT-ADD-AMP feature with adaptive functionality
- Duty Cycle Monitor (DCM)
- TIME-ON-TAP™ tap position tracking feature
- PMT™ Preventative Maintenance Tapping feature
- Tap-to-Neutral
- Security override
- Voltage reduction with three modes
- Digital metering package (including instantaneous, demand and time-tagged demand)
- Data profiler
- Configurable status alarms
- Configurable data alarms
- Event record
- Histograms
- Local data retrieval (USB Front Port)
- USB data port
- Resident communications protocol (DNP 3.0 and IEC 61850)
- CL-5D or CL-5E communications emulation
- Programmable I/P (Using logical equations)
- Alternate configuration settings
- Multi-phase operation

Figure 2. CL-7 Control.

Construction

Core and coil assembly

Ease of service is provided by the design of the core-and-coil, tap-changer, and reactor assembly. The entire assembly is cover suspended for ease of removal from the tank for inspection or maintenance.

The coil assembly features an aluminum strip in the series winding that achieves the optimum in ampere turn balance for exceptional strength under through-fault conditions.

Grain-oriented steel is used in the core, with a low reluctance lap joint. The rugged core clamp assembly secures the coil effectively and positions the core for the optimum in quiet operation and low core loss.

With sealed-tank construction, the external oxygen supply is eliminated from the tank environment. With the use of a 65 °C rise insulation system and designs with a nameplate rating of 55 °C, an additional 12% capacity is available from Eaton's Cooper Power Systems 32-step regulator without any loss of insulation life.

Quik-Drive™ tap-changers

The load tap-changer product offering consists of three Quik-Drive™ tap-changers, the most advanced tap-changers in the industry. Each device is sized for a specific range of current and voltage applications and share many similarities in their construction. The primary benefits of Quik-Drive tap-changers are: direct motor drive for simplicity and reliability; high-speed tap selection for quicker serviceability; and proven mechanical life (one million operations). Common Quik-Drive tap-changer features include: neutral light switch; position indicator drive; safety switches; and logic switches (back-off switches). Quik-Drive load tap-changers meet IEEE® and IEC standards for mechanical, electrical and thermal performance.

Figure 3. QD3 Quik-Drive tap-changer

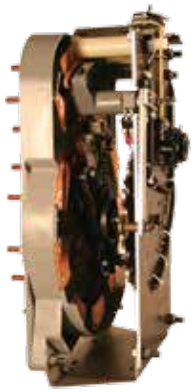

Figure 4. DDD Quik-Drive tap-changer

Figure 5. QD8 Quik-Drive tap-changer

Position indicator and ADD-AMP capability

Exclusive to Eaton's Cooper Power Systems, the uniquely designed position indicator offers corrosion resistant materials, an oversized viewing area and a reset solenoid that is replaceable using a single thumbscrew. It is mounted on a junction box on the cover of the regulator, and is directly connected to the tap-changer by a flexible drive shaft passing through the junction box and terminal board via a sealing gland.

The indicator face is graduated in steps, numbered 1 through 16 on each side of zero. Zero designates neutral. Drag hands indicate the maximum and minimum positions attained during raise and lower operations. The drag hands are reset around the position indicator hand by operating the drag hand reset switch on the control front panel.

The ADD-AMP feature of VR-32 regulators allows increased current capacity by reducing the regulation range. This is accomplished by either setting limit switches in the position indicator (HARD-ADD-AMP feature) or enabling the SOFT-ADD-AMP feature to prevent the tap-changer from traveling beyond a set position in either raise or lower directions. The limit switches have scales graduated in percent regulation, and are adjustable to specific values of 5, 6-1/4, 7-1/2, 8-3/4, and 10% regulation to alter the regulation range. The CL-7 control also allows for an Adaptive ADD-AMP feature which will automatically change the SOFT ADD-AMP setting based upon the current readings of the control.

The five possible load current ratings associated with the reduced regulation ranges are summarized in Tables 4 and 5. At each setting, a detent stop provides positive adjustment. Settings other than those with stops are not recommended. The raise and lower limits need not be the same value except for locations where reverse power flow is possible.

Figure 6. Position Indicator.

Table 2. ADD-AMP Capabilities of 50 Hz Ratings

Rated Volts	Rated kVA	Load Current Ratings (Amperes)[1] Regulation Range ±10%[1]	±8 3/4%	±7 1/2%	±6 1/4%	±5%
6600	33	50	55	60	68	80
	66	100	110	120	135	160
	99	150	165	180	203	240
	132	200	220	240	270	320
	198	300	330	360	405	480
	264	400	440	480	540	640
	330	500	550	600	668	668
	396	600	660	668	668	668
11000	55	50	55	60	68	80
	110	100	110	120	135	160
	165	150	165	180	203	240
	220	200	220	240	270	320
	330	300	330	360	405	480
	440	400	440	480	540	640
	550	500	550	600	668	668
	660	600	660	668	668	668
15000	75	50	55	60	68	80
	150	100	110	120	135	160
	225	150	165	180	203	240
	300	200	220	240	270	320
	450	300	330	360	405	480
	600	400	440	480	540	640
	750	500	550	600	668	668
22000	110	50	55	60	68	80
	220	100	110	120	135	160
	330	150	165	180	203	240
	440	200	220	240	270	320
	660	300	330	360	405	480
33000	165	50	55	60	68	80
	330	100	110	120	135	160
	495	150	165	180	203	240
	660	200	220	240	270	320

[1] Additional 12% increase in capacity is available due to the use of 65 °C winding rise insulation if the tap-changer's maximum current rating has not been exceeded. For loading in excess of the above values please your Eaton's Cooper Power Systems representative.

Table 3. ADD-AMP Capabilities of 60 Hz Ratings

Rated Volts	Rated kVA	Load Current Ratings (Amperes)[1] Regulation Range ±10%	±8 3/4%	±7 1/2%	±6 1/4%	±5%
2500	25	100	110	120	135	160
	50	200	220	240	270	320
	75	300	330	360	405	480
	100	400	440	480	540	640
	125	500	550	600	668	668
	167	668	668	668	668	668
	250	1000	1000	1000	1000	1000
	333	1332	1332	1332	1332	1332
	416.3	1665	1665	1665	1665	1665
5000	25	50	55	60	68	80
	50	100	110	120	135	160
	100	200	220	240	270	320
	125	250	275	300	336	400
	167	334	367	401	451	534
	250	500	550	600	668	668
	333	668	668	668	668	668
	416.3	833	833	833	833	833
7620	38.1	50	55	60	68	80
	57.2	75	83	90	101	120
	76.2	100	110	120	135	160
	114.3	150	165	180	203	240
	167[2]	219/232	241/255	263/278	296/313	350/370
	250[2]	328/347	361/382	394/417	443/469	525/556
	333[2]	438/464	482/510	526/557	591/625	668
	416.3[2]	548/580	603/638	658/668	668	668
	500[2]	656/668	668	668	668	668
	667[2]	875/926	875/926	875/926	875/926	875/926
	833[2]	1093/1157	1093/1157	1093/1157	1093/1157	1093/1157
13800	69	50	55	60	68	80
	138	100	110	120	135	160
	207	150	165	180	203	240
	276	200	220	240	270	320
	414	300	330	360	405	480
	500	362	398	434	489	579
	552	400	440	480	540	640
	667	483	531	580	652	668
	833	604	664	668	668	668
14400	72	50	55	60	68	80
	144	100	110	120	135	160
	288	200	220	240	270	320
	333	231	254	277	312	370
	416	289	318	347	390	462
	432	300	330	360	405	480
	500	347	382	416	468	555
	576	400	440	480	540	640
	667	463	509	556	625	668
	720	500	550	600	668	668
	833	578	636	668	668	668
19920	50	25.1	28	30	34	40
	100	50.2	55	60	68	80
	200	100.4	110	120	135	160
	333	167	184	200	225	267
	400	200.8	220	240	270	320
	500	250	275	300	338	400
	667	335	369	402	452	536
	833	418	460	502	564	668
34500	50	50	55	60	68	80
	100	100	110	120	135	160
	150	150	165	180	203	240
	200	200	220	240	270	320

1 Additional 12% increase in capacity is available due to the use of 65 °C winding rise insulation if the tap-changer's maximum current rating has not been exceeded. For loading in excess of the above values please contact your Eaton's Cooper Power Systems representative.

2 Regulators are capable of carrying current corresponding to rated kVA when operated at 7200 volts.