

# Single-phase step voltage regulators



## Product description

Eaton's Cooper Power™ series 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 32 steps of approximately 5/8% each. Voltage ratings are available from 2400 V (60 kV BIL) to 34,500 V (200 kV BIL) for 60 Hz and 50 Hz systems.

An internal potential transformer or control winding with 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.

Units are also equipped with an internal differential potential transformer (IDPT) to provide a source-load differential voltage. The differential voltage is used to provide a measured source-bushing voltage for reverse power voltage regulation. The differential voltage also enhances safety in conjunction with the CL-7 series voltage regulator control safe-to-bypass feature.

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 series voltage regulators are available with a full complement of standard features for routine applications, as well as a full line of optional accessories to solve most any voltage regulation challenge.

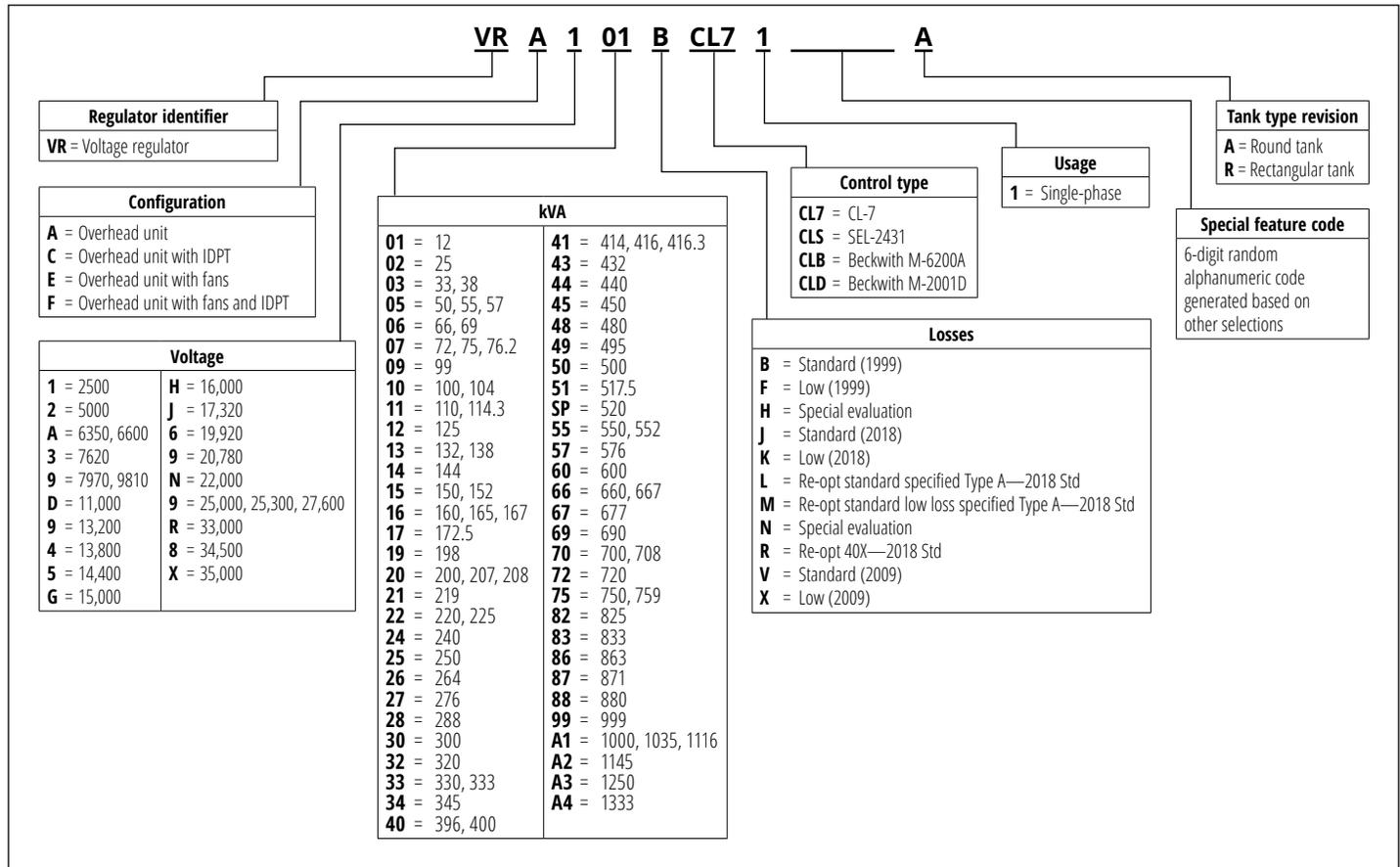
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### Catalog numbering information

Use **Table 1** as a guide when ordering voltage regulators or to interpret a voltage regulator catalog number.

**Table 1. Voltage regulator catalog numbering system**



**Regulator identifier**  
VR = Voltage regulator

**Configuration**  
A = Overhead unit  
C = Overhead unit with IDPT  
E = Overhead unit with fans  
F = Overhead unit with fans and IDPT

Voltage	
1 = 2500	H = 16,000
2 = 5000	J = 17,320
A = 6350, 6600	6 = 19,920
3 = 7620	9 = 20,780
9 = 7970, 9810	N = 22,000
D = 11,000	9 = 25,000, 25,300, 27,600
9 = 13,200	R = 33,000
4 = 13,800	8 = 34,500
5 = 14,400	X = 35,000
G = 15,000	

kVA	
01 = 12	41 = 414, 416, 416.3
02 = 25	43 = 432
03 = 33, 38	44 = 440
05 = 50, 55, 57	45 = 450
06 = 66, 69	48 = 480
07 = 72, 75, 76.2	49 = 495
09 = 99	50 = 500
10 = 100, 104	51 = 517.5
11 = 110, 114.3	SP = 520
12 = 125	55 = 550, 552
13 = 132, 138	57 = 576
14 = 144	60 = 600
15 = 150, 152	66 = 660, 667
16 = 160, 165, 167	67 = 677
17 = 172.5	69 = 690
19 = 198	70 = 700, 708
20 = 200, 207, 208	72 = 720
21 = 219	75 = 750, 759
22 = 220, 225	82 = 825
24 = 240	83 = 833
25 = 250	86 = 863
26 = 264	87 = 871
27 = 276	88 = 880
28 = 288	99 = 999
30 = 300	A1 = 1000, 1035, 1116
32 = 320	A2 = 1145
33 = 330, 333	A3 = 1250
34 = 345	A4 = 1333
40 = 396, 400	

**Control type**  
CL7 = CL-7  
CLS = SEL-2431  
CLB = Beckwith M-6200A  
CLD = Beckwith M-2001D

**Usage**  
1 = Single-phase

**Losses**  
B = Standard (1999)  
F = Low (1999)  
H = Special evaluation  
J = Standard (2018)  
K = Low (2018)  
L = Re-opt standard specified Type A—2018 Std  
M = Re-opt standard low loss specified Type A—2018 Std  
N = Special evaluation  
R = Re-opt 40X—2018 Std  
V = Standard (2009)  
X = Low (2009)

**Tank type revision**  
A = Round tank  
R = Rectangular tank

**Special feature code**  
6-digit random alphanumeric code generated based on other selections

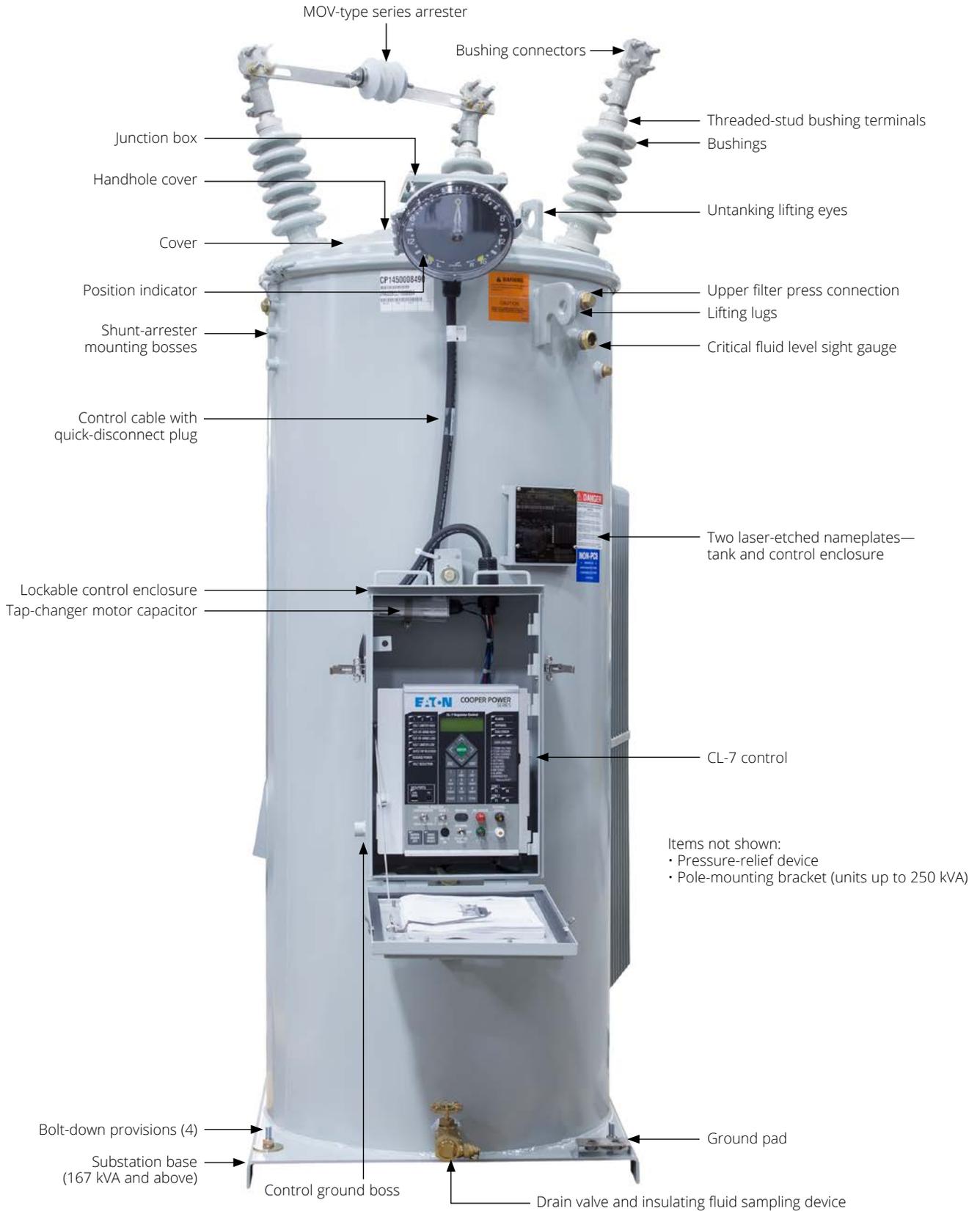


Figure 1. External features on the VR-32 voltage regulator

## Standard features

A sealed-tank construction allows the use of a 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 series voltage regulators are manufactured and tested to the latest version of IEEE® Std C57.15™.

- CL-7 series voltage regulator control
- Quik-Drive™ tap changer
- Position indicator with ADD-AMP adjustment
- Two laser-etched nameplates
- Lifting lugs
- Oil drain valve and sampling device
- Upper filter press connection
- Critical level fluid 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
- NEMA® 3R mild steel control enclosure
- Ratio correction transformer
- Conformally coated circuit boards
- Internal differential potential transformer for safe-to-bypass and measured source voltage

## Optional accessories

- Shunt arresters
- Control cable options:
  - Lengths up to 120 feet
  - Armored
  - Shielded
  - IEEE/IEC standard 19-pin interface
- Elevating structure, galvanized steel and adjustable
- 4-hole NEMA H-spades
- Cooling fans
- Nameplates—alternate languages and metric units
- Insulating-fluid thermometer with or without alarm contacts
- Insulating-fluid level gauge with alarm contacts
- Pressure and vacuum gauges with or without alarm contacts
- Gauges with 0–20 mA output for analog display
- Rapid pressure-rise relay
- Stainless-steel tank and cover
- Envirotemp™ FR3™ insulating fluid
- Tank and control enclosure ground connectors
- Alternate top-coat color
- External stainless-steel hardware
- Control enclosure:
  - Stainless steel
  - NEMA 3
  - Long box
  - 2X box
- Stainless-steel nameplates
- Substation base, below 167 kVA
- Pole-mounting brackets, on 333 kVA
- Wildlife guards

## 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 2**.

**Table 2. Shunt arrester application data**

Regulator voltage rating	Nominal system voltages		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	
7620/13,200Y	6900	6900/11,950	10
	7200	7200/12,470	
	7620	7620/13,200	
	7970	7970/13,800	
11,000	11,000		15
13,800	12,000		15
	12,470		
	13,200		
	13,800		
14,400/24,940Y		13,800/23,900	18
		14,400/24,940	
19,920/34,500GrdY		19,920/34,500	27
22,000	22,000		27
33,000	33,000		36

## CL-7 series control

### Standard features

- Safe-to-bypass safety feature
- Alphanumeric keypad for password entry
- 4x20 character easy-to-understand display
- Internal/external power switch
- Control function switch (auto-remote/off/local manual)
- Manual raise/lower toggle switch
- Drag hand reset switch
- Supervisory OFF switch (for use with SCADA)
- Control box heater built-in
- Six-digit operations counter
- Voltmeter terminals
- External source terminals
- Neutral light with dual LEDs
- Panel-mounted motor fuse
- Metering-PLUS™ one-touch, grouped-data display feature
- Tap-position tracking enhanced with IDPT
- Voltage limiter
- Line-drop compensation
- SOFT-ADD-AMP feature with adaptive functionality
- Duty cycle monitor (DCM)
- PMT™ Preventive Maintenance Tapping feature
- Tap-to-neutral and tap-to-target
- Role-based access control password system
- Factory-assisted secure password reset
- Voltage reduction
- Digital metering package (instantaneous and demand)
- Data profiler
- Configurable status and data alarms
- Sequence of events recording
- Tap-changer sequence of events recording
- Cybersecurity audit trail
- DNP3 communications log
- USB drive data port
- USB PC port
- Resident communications protocol (DNP 3.0, IEC 60870-5, Serial and TCP/IP Modbus®, 2179)
- Configurable logic
- Alternate configuration settings
- Multi-phase DeltaCalc™ advanced feature
- Cybersecurity enhancements
- Conformally coated circuit boards



Figure 2. CL-7 series voltage regulator control

### Options and accessories

- Multi-phase control for two or three regulators
- Alternate overlay languages (Spanish, French Canadian, Portuguese)
- Serial communications interfaces:
  - RS-232
  - Fiber optic—ST
  - RS-485
- Ethernet communications interfaces:
  - Fiber optic—LC, MTRJ, ST, and SC
  - Copper—RJ45
- Communications protocols:
  - DNP 3.0 (serial and TCP/IP)
  - IEC 60870-5
  - Modbus (serial and TCP/IP)
  - 2179
- Discrete I/O contacts (four or eight sets)
- 13.5 Vdc radio power supply
- 13 Ahr control power battery backup
- 48/125 Vdc substation battery power
- 240 V external source powering
- Auxiliary analog input contacts (12 inputs 4–20 mA, four inputs 4 A CT, two outputs Type A relay)
- Control enclosure auxiliary power (120 V or 230 V)

## Construction

### Core and coil assembly

Ease of service is provided by the design of the core-and-coil, Quik-Drive 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 series 32-step regulator without any loss of insulation life.

### Quik-Drive tap-changers

The load tap-changer product offering from Eaton's Cooper Power series 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 the devices 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.

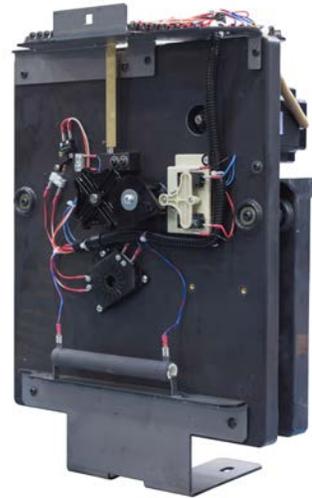


Figure 3. QD3 Quik-Drive tap-changer



Figure 4. QD5 Quik-Drive tap-changer



Figure 5. QD8 Quik-Drive tap-changer

**Position indicator and ADD-AMP capability**

Exclusive to Eaton, 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 control feature to prevent the tap-changer from traveling beyond a set position in either the 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 series control also allows for an Adaptive ADD-AMP feature that 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 **Table 3**. 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 3. Standard available voltages**

Nominal voltage	Standard available voltages ①							
<b>50 Hz</b>								
6600	6930	6600	6350	6000	5500	—	—	—
11000	11600	11000	10000	6930	6600	6350	6000	5500
15000	15000	14400	13800	13200	12000	11000	10000	6600
16000	16000	14400	13800	—	—	—	—	—
22000	22000	20000	19100	15000	12700	1000	10000	—
33000	33000	30000	22000	20000	11600	11000	10000	—
35000	35000	34500	33000	30000	22000	20000	11600	11000
<b>60 Hz</b>								
2500	2500	2400	—	—	—	—	—	—
5000	5000	4800	4160	2400	—	—	—	—
7620	8000	7970	7620	7200	6930	4800	4160	2400
13800	13800	13200	12470	12000	7970	7620	7200	6930
14400	14400	13800	13200	12000	7970	7620	7200	6930
19920	19920	17200	16000	15242	14400	7970	7620	7200
34500	34500	19920	—	—	—	—	—	—

① Standard voltages will be shown as pinned voltage options on the voltage regulator nameplate.

Table 4. ADD-AMP capabilities of 50 Hz ratings

Rated volts	Rated kVA	Load current ratings (amperes) <sup>①</sup>				
		Regulation range				
		±10%	±8 3/4%	±7 1/2%	±6 1/4%	±5%
6600 95 kV BIL	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
11,000 95 kV BIL	440	668	668	668	668	668
	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
15,000 150 kV BIL	660	600	660	668	668	668
	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
16,000 150 kV BIL	160	100	110	120	135	160
	320	200	220	240	270	320
	480	300	330	360	405	480
22,000 150 kV BIL	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
	880	400	440	480	540	640
	999 <sup>②</sup>	454	454	454	454	454
33,000 200 kV BIL	165	50	55	60	68	80
	330	100	110	120	135	160
	495	150	165	180	203	240
	660	200	220	240	270	320
	825	250	275	300	337	373
35,000 200 kV BIL	175	50	55	60	67.5	80
	350	100	110	120	135	160
	525	150	165	180	202.5	240
	700	200	220	240	270	320

<sup>①</sup> 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, contact your Eaton product representative.

<sup>②</sup> Additional capacity available when unit is equipped with cooling fans. For information on loading in excess of the values listed, contact your Eaton product representative.

**Table 5. ADD-AMP capabilities of 60 Hz ratings**

		Load current ratings (amperes) ①				
		Regulation range				
Rated volts	Rated kVA	±10%	±8 3/4%	±7 1/2%	±6 1/4%	±5%
2500 60 kV BIL	25	100	110	120	135	160
	50	200	220	240	270	320
	75	300	330	360	405	480
	100	400	440	480	540	640
	167	668	668	668	668	668
	219	875	875	875	875	875
	250	1000	1000	1000	1000	1000
	333	1332	1332	1332	1332	1332
	416	1665	1665	1665	1665	1665
	700 ②	2800	2800	2800	2800	2800
5000 75 kV BIL	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	833	833	833	833	833
	576 ②	1152	1152	1152	1152	1152
	660 ②	1320	1320	1320	1320	1320
7620 95 kV BIL	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
	152	200	220	240	270	320
	167 ③	219/232	241/255	263/278	296/313	350/370
	250 ③	328/347	361/382	394/417	443/469	525/556
	333 ③	438/464	482/510	526/557	591/625	668
	416 ③	548/580	603/638	658/668	668	668
	500 ③	656/668	668	668	668	668
	667 ③	875	875	875	875	875
	833 ③	1093/1157	1093/1157	1093/1157	1093/1157	1093/1157
	1145 ②	1503	1503	1503	1503	1503
13,800 95 kV BIL	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

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 information on loading in excess of the values listed, contact your Eaton product representative.

② Additional capacity available when unit is equipped with cooling fans. For information on loading in excess of the values listed, contact your Eaton product representative.

③ Regulators are capable of carrying current corresponding to rated kVA when operated at 7200 volts.

Table 5. ADD-AMP capabilities of 60 Hz ratings, continued

Rated volts	Rated kVA	Load current ratings (amperes) <sup>①</sup>				
		Regulation range				
		±10%	±8 3/4%	±7 1/2%	±6 1/4%	±5%
14,400 150 kV BIL	72	50	55	60	68	80
	144	100	110	120	135	160
	288	200	220	240	270	320
	332	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
19,920 150 kV BIL	833	578	636	668	668	668
	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
34,500 200 kV BIL	1000	502	552	602	668	803
	172.5	50	55	60	68	80
	345	100	110	120	135	160
	518	150	165	180	203	240
	690	200	220	240	270	320
	863	250	275	300	337	373

<sup>①</sup> 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 information on loading in excess of the values listed, contact your Eaton product representative.

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