

Smart Grid solution

COOPER POWER
SERIES

Smarter voltage regulation

Integrated intelligence made simple
by the voltage regulator experts

EATON

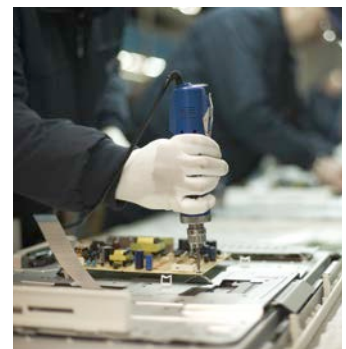
Powering Business Worldwide

Building Smart Grid infrastructure begins with advanced apparatus and integrated communications



Smart Grid complexity

- Eaton integrates proven reliability, continuous innovation, user-friendly interface and exceptional distribution system performance.
- Voltage management is critical to users of electrical equipment and sensitive electronics. Commercial, industrial and residential applications require a consistent voltage despite load current variations caused by expanding system demand and load profile fluctuations.
- While demands on the power grid expand, budgets remain tight. Often, the purchase of new equipment and the cost associated with installation and maintenance of the equipment must be justified by projected savings.
- Implementation of Smart Grid advancements and new technologies for power grid control and data acquisition require specialized expertise. Solutions are needed that are easy to implement and provide results without a lot of complication.



Voltage regulation solutions

Eaton's Cooper Power™ series voltage regulators

- Industry leader in voltage regulator technology and innovation
- Most advanced voltage regulator control in the industry
- Secure communications integration with grid-wide line of advanced controls
- More advanced solutions packaged to meet the needs of power suppliers
- Quickest responding single-phase step-voltage regulator tap changer in the industry
- Product support and expertise that is unmatched in the industry



Eaton's Cooper Power series CL-7 regulator control is specifically designed to meet the need for Smart Grid-ready equipment with an array of communications options. These options easily integrate with Eaton's Yukon™ enterprise software and other advanced controls to meet system control and data acquisition requirements.

Power saving Smart Grid advancements such as Integrated Volt/VAR Control (IVVC) and Conservation Voltage Reduction (CVR) are easily implemented with our industry-leading voltage regulating apparatus, control and communication interfaces.

The speed of the patented Quik-Drive™ tap-changer along with the unique Voltage Limiter capabilities of the control enable the fastest response available for extreme voltage swings.

Because Eaton's Cooper Power series voltage regulator apparatus and control are designed to operate together, exclusive features such as Duty Cycle Monitor (DCM), Preventive Maintenance Tapping (PMT™) and motor trouble diagnostics are available to alert users to a need for maintenance. Proactive maintenance and quick alerts to impending issues will minimize maintenance costs and system downtimes.

Eaton's Cooper Power series CL-7 multi-phase control, another major advancement from the industry's leader in innovation, enables operation of up to three voltage regulators with a single control. New multi-phase control options include true three-phase metering, innovative gang-operation strategies and enhanced delta system regulation.

Eaton offers CYME™ engineering analysis software to assist with the proper coordination of voltage regulators and capacitors on your distribution system. This will help minimize losses, improve voltage profiles and balance loads between feeders.

Optimize energy savings, power quality and asset management while minimizing power interruptions. Eaton's Cooper Power series voltage regulators are part of a comprehensive power management portfolio, an integral element in your Smarter Grid operation, and backed by expert technical support.

Widest range of voltage regulator product offerings

Pole-mount, platform-mount, substation and underground pad-mount and substation models

Single-phase, 32-step voltage regulators

Our line of voltage regulators combines all of the advantages Eaton has to offer into a complete regulator package. Nowhere else can you get a single-phase regulator with the innovative CL-7 control and complementary Quik-Drive tap-changer technology that is decades ahead of the competition. Combine these with more than a half-century of experience and expertise.

Substation voltage regulators (SVR)

Eaton leads the industry in the application of single-phase voltage regulators into substations regulating loads up to 60 MVA. With features such as fan cooling and insulating fluid filtration, SVRs provide a viable option superior to the use of On-Load Tap-Changers (OLTC) with the added flexibility of regulation separate from the power transformer. The CL-7 multi-phase control offers additional advanced features such as true three-phase metering and phase-voltage averaging ganged operation.

Voltage ratings are available from 2.4 kV (60 kV BIL) to 34.5 kV (200 kV BIL) for 60 Hz and 50 Hz systems.

Pad-mounted voltage regulators

Designed for use in public and commercial areas with underground distribution lines, pad-mounted regulators are available in single-phase, 2-in-1, and 3-in-1 configurations. The multi-unit designs offer 2 or 3 single-phase regulators in one tank for space-saving flexibility. These regulators are compatible with underground power distribution systems, and offer a safe, tamper-resistant cabinet built to the same standards of security as our traditional pad-mounted transformers. With a lower profile footprint than traditional overhead installations, they can be discretely installed in sensitive residential and commercial areas.

Modular integrated transportable substation (MITS)

Voltage regulator products can be combined with other power distribution equipment into an MITS for mobile, temporary or emergency needs. These unique, cost-effective, turnkey installations are fully integrated and factory pre-engineered. An electrical power substation or any other grouping of electrical equipment is assembled on a self-supporting structural base, or mounted on a Department of Transportation (DOT) compliant trailer. The mobile mounting is particularly suitable for temporary use during construction or disaster relief.



Substation class regulators



Distribution class regulator



Modular integrated transportable substations



Pad-mounted regulator

History of innovative design

1954

- Single-phase step-voltage regulators introduced

1959

- Step-voltage regulator with direct drive tap-changer

1984

- Microprocessor-based control for voltage regulators

1988

- Microprocessor-based CL-4 voltage regulator control



Eaton is the global leader in single-phase voltage regulators and controls, whether measured by market share or innovation. We continuously invest to improve power quality and delivery efficiency, reduce maintenance costs and extend the life of the regulator apparatus and control.

Designed with experience

Eaton's Cooper Power series regulator designs provide superior dielectric and short-circuit strength, higher efficiency and extended life:

- Unique reactor design consisting of a ground isolated shell type structure minimizes the effect of through-faults and ensures longer life under severe operating conditions. The dual-coil reactor design with interlaced windings minimizes voltage drop and no-load losses.

- Coil strength is improved through the use of hot pressed, thermally upgraded, epoxy-coated insulating paper.
- Voltage regulator tanks have fully welded external components to eliminate water entrapment leading to premature corrosion.

Industry-leading product development is proven by the most comprehensive and fully automated manufacturing test line in the industry. Routine production tests are conducted at full-rated voltage up to 35 kV.

1997

- Pad-mounted, single-phase voltage regulator—improves safety and environmental impact, and reduces costs

1997

- Dual cable disconnects with electronic CT protector improve safety and flexibility

1999

- QD8 Quik-Drive tap-changer provides longer life and enhanced power quality



The CL-7 control steps into the future with exclusive features such as:

Modularity

Install only the features that you need such as integrated communication interface boards, expanded input/output points, DC power supply and battery backup. Spare parts management is simplified; keep modular parts on the shelf for easy installation when needed.

Multi-phase regulation option

The CL-7 control leads the industry with the multi-phase option that allows the operation of two or three regulators with the use of a single control. The multi-phase option offers benefits such as a single communications point, less hardware to program and maintain, true three-phase metering, advance gang-operation modes and improved delta system voltage regulation.

Communications interface

The CL-7 control offers eight different integrated interface options including: serial RS-232, serial RS-485, Ethernet copper, three versions of Ethernet multi-mode fiber Ethernet single-mode fiber, and multi-mode serial fiber. Native communications protocols include DNP3 (serial and IP), IEC 60870-5-101 and -104, Cooper 2179, Modbus® RTU and Modbus TCP.

ProView™ NXG software

A single software program interfaces with the CL-7 control and other Eaton control products including the CL-6 voltage regulator control, Form 4D recloser control, the SPEAR™ recloser control, CBC-8000 capacitor bank control, and the GridAdvisor™ smart sensor.

The CL-7 is the next generation in the line of trusted Eaton CL controls. The CL-7 control continues the look, feel and functionality of a trusted line of controls while taking voltage regulation into the future with industry-leading features.

History of innovative design

2003

- DNP Class data reduction provides efficient communications and ease of use
- QD5 Quik-Drive tap-changer provides longer life and enhanced power quality

- Poly position indicator is corrosion free for extended life

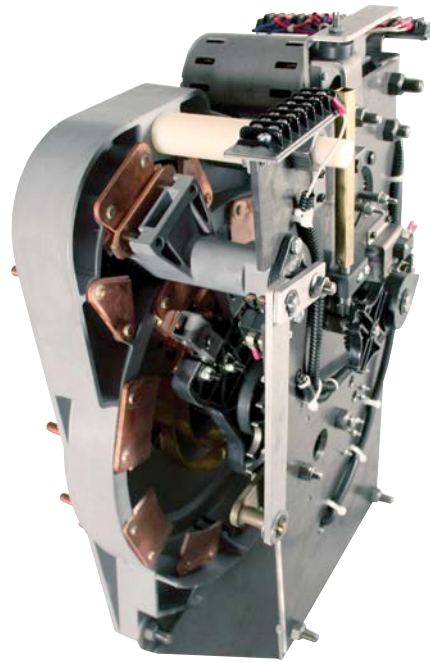
2004

- CL-6 control with programmable I/O increases programming flexibility, ease of use and longer life

- CL-6A control programmable from flash memory—easy to use, easy to program

Quik-Drive tap-changer

Eaton leads the industry with advancements to the SVR tap-changer mechanism. The Quik-Drive tap-changer rotates through all 33 positions in less than 10 seconds—providing the quickest response for superior voltage regulation. Other manufacturer’s regulators still use 80+ year-old spring-driven technology requiring 5 seconds per step.



The Quik-Drive offers:

Speed

- Quickest response to large voltage excursions
- Taps eight steps (5%) in just over 2 seconds

Accuracy

- The tap-changer Geneva Gear drive ensures accurate steps without calibrated springs
- Electrical feedback circuit ensures accurate tap position tracking and operations count by the control

Simplicity

- No springs reduces maintenance and provides faster response
- Fewer moving parts by 20% means greater durability and easier maintenance

Tap-changer integration with the CL-7 control

Since Eaton developed the control, the tap-changer and the rest of the voltage regulator apparatus, full integration of all components is realized.

Advantages of this integration include:

Duty Cycle Monitor (DCM)

Predictive maintenance feature eliminates unnecessary maintenance—reducing downtime and lowering costs. Valuable operational maintenance information, used in conjunction with control configurable logic and SCADA communications, can alert your control center to impending maintenance requirements. DCM calculates the life used for each arcing contact on the tap-changer. The control uses advanced algorithms, proprietary design information and measured power conditions during tap changes to estimate contact erosion.

Preventive Maintenance Tapping (PMT™) and Motor Trouble diagnostics

PMT performs user-scheduled automatic operations to prevent contact coking and provide periodic operations checks. Coking can occur in heavily loaded, under-oil contacts and can be seen in the reversing switch when a regulator rarely taps through neutral. Set the control to initiate operations using criteria such as time of day, maximum steps from neutral, or when the regulator is lightly loaded. PMT can be used in conjunction with the Motor Trouble diagnostics and SCADA communications to send an alert regarding operational issues. This can eliminate the need for regular function checks and reduce downtime.

- Duty Cycle Monitor (DCM) and Preventive Maintenance Tapping (PMT) improves equipment reliability

2005

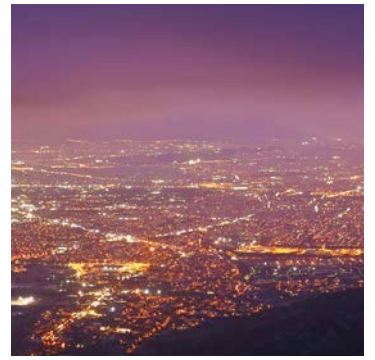
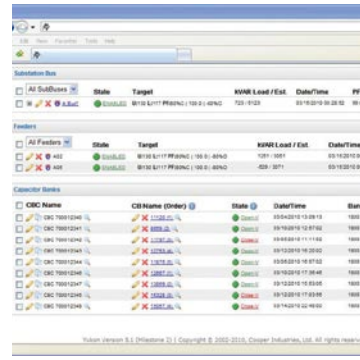
- 3-in-1 pad-mounted design improves application flexibility and safety, and reduces footprint and costs

2007

- QD5 Quik-Drive tap-changer polymer insulating board improves contact alignment, providing the quickest voltage regulation response

2008

- Junction box redesign improves quality and ease of maintenance



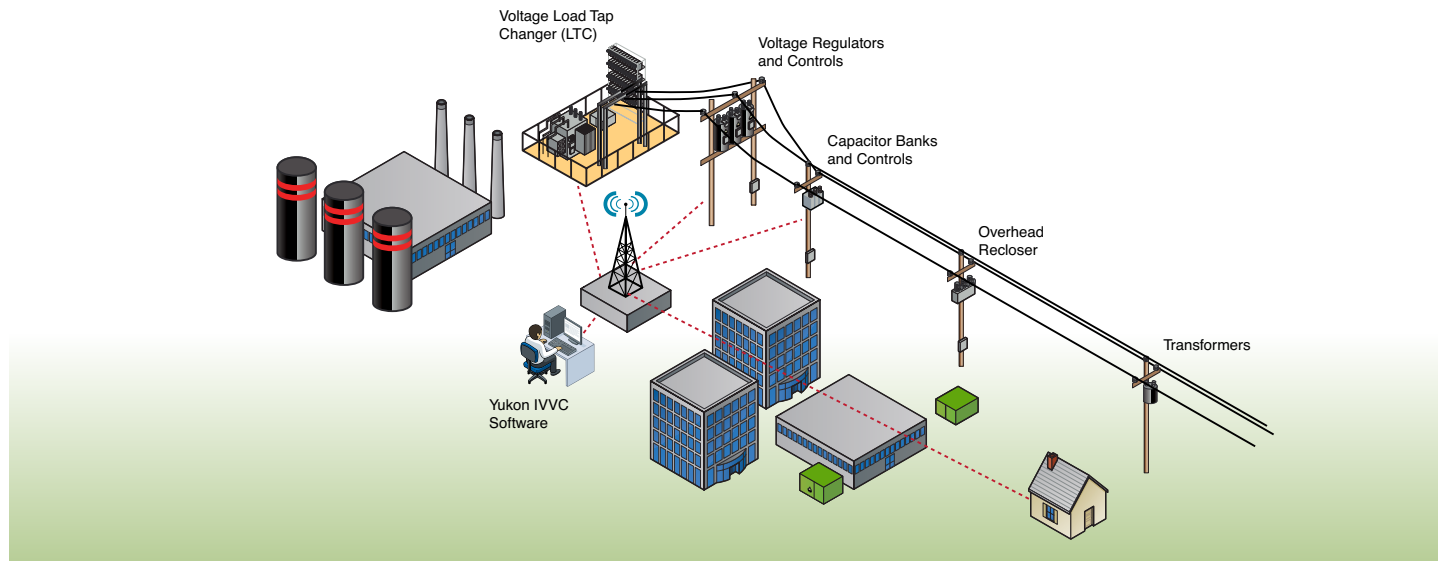
Smarter Grid solutions: IVVC improves power quality and system efficiency

Integrated Volt/VAR Control (IVVC) software communicates, analyzes and controls all voltage regulators, capacitors and OLTCs on a system to maintain voltage within acceptable levels as load increases or decreases. This allows leveling of each feeder's voltage profile and lowering of average voltages, often resulting in significant energy savings. IVVC software uses all of the built-in capabilities of Eaton's voltage regulator package: the regulator with the CL-7 control, and innovative tap changer.

Distribution automation solution

Eaton offers a full suite of power quality software and apparatus to support your Volt/VAR management solution. With unparalleled expertise to make your automation seamless, we offer:

- Single and multi-phase voltage regulators
- CL-7 voltage regulator controls
- Capacitor banks
- CBC-8000 capacitor bank control
- Yukon™ Volt/VAR management automation software
- CYME™ power engineering software



History of innovative design

- CL-6 control redesign delivers a smaller, more flexible package to fit inside the voltage regulator control box of any manufacturer

2009

- CL-6 firmware upgrades support Leader/Follower schemes and Auto-Restore Local
- Ethernet interface

2010

- CL-6 firmware upgrades introduce Alternate Settings and Adaptive Add-Amp



Key to your Smart Grid is smart apparatus

Optimal feeder voltage

Yukon IVVC software synchronizes with capacitors and voltage regulators leveling and lowering the feeder voltage profile. The voltage regulator works in conjunction with the capacitor, delivering the optimal feeder voltage profile. Graph 1 below represents the Yukon IVVC software altering the voltage profile—resulting in a reduction of the average feeder voltage from 122 to 118 volts.

Power factor correction is a crucial element in improving energy efficiency and reducing losses. Graph 2 below represents before and after effective implementation of Yukon Volt/VAR management software.

Power system studies for optimized results

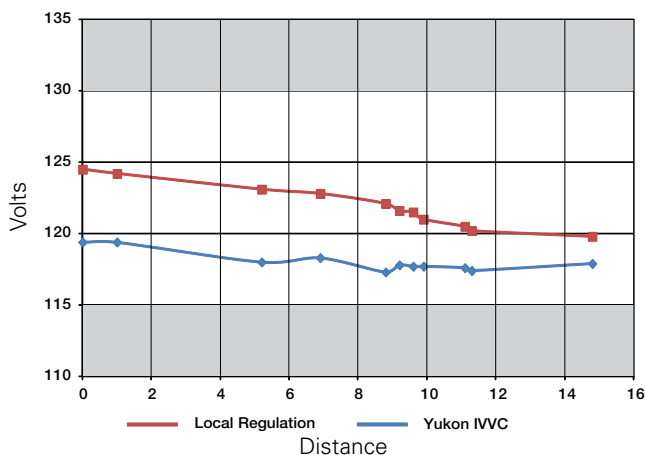
Maximize the benefits from implementing a Volt/VAR management solution using Eaton CYME engineering team.

Power system studies are offered to identify the best combination of voltage regulation equipment to optimize feeder voltage profiles and substation VAR management.

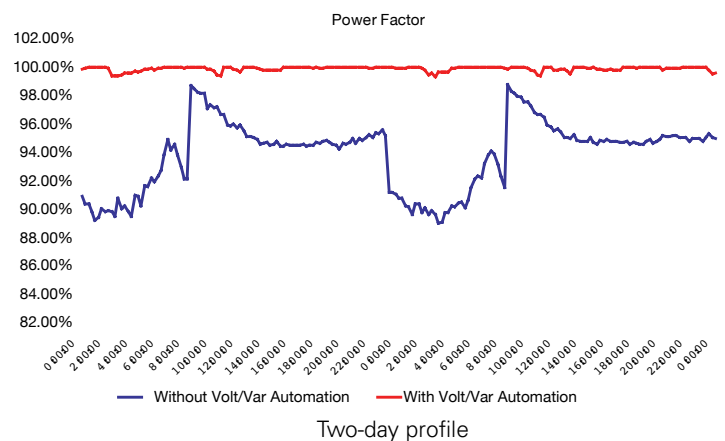
Energy efficiency

Eaton's Cooper Power series voltage regulators improve the efficiency of the system reducing costs:

- As a critical component of CVR and IVVC solutions
- When feeder automation alternates loading and power flow direction



Graph 1. Voltage Profile: Local regulation vs. Yukon IVVC



Graph 2. Yukon IVVC management software

2011

- Pioneers in development of Volt/VAR management system

- CL-6 adjusts automatically to load changes to increasing capacity and automating CVR or IVVC maintaining superior power quality and extending product life

2013

- Single- and multi-phase voltage CL-7 regulator control launched

DESIGN

BUILD

INTEGRATE

SUPPORT

Technical expertise before and after purchase

Eaton has the technical expertise to provide products best suited for a wide range of applications. Rely on our experienced Engineered-To-Order staff to create a voltage regulator design meeting your specifications and expectations. After the sale, technical support is available by phone and email, and in the field by Eaton's Electrical Services & Systems team and Field Application Engineers. Authorized Service Centers are located around the globe.

Our factory and traveling voltage regulator, control, IVVC and capacitor workshops qualify for Continuing Education Units (CEUs). For more than 35 years, Eaton's schools have trained more linemen, technicians and engineers on the proper installation, operation and programming of voltage regulators and controls than any other manufacturer in the industry.

CASE STUDY 1.

Utility IVVC software application

Utilities typically create operational plans for delivery of power within an acceptable voltage range at a planned power factor. One large utility evaluated Eaton's technology to take a big-picture view of voltage regulators and capacitors to better optimize voltage levels and vars. The business case for conservation voltage reduction (CVR) is complex. Factors include projected cost of fuel, emissions mitigation and added generation capacity with a goal of reduced expenditures and lower utility bills for customers.

This large utility built the business case for technology investment through the use of Eaton's CymDIST™ distribution planning power flow software.

After justifying the business case, they deployed voltage regulators, capacitor banks and Yukon Volt/VAR management software—including Integrated Volt/VAR Control—supporting peak load reduction through voltage and 24/7 load reduction. An additional benefit included remote identification of capacitor bank problems. The result was achievement of the financial and operational benefits identified in the CymDIST planning studies.

Utilities save on the cost of fuel and emissions mitigation, as well as a reduced need for additional peak capacity. Customers see smaller utility bills.

CASE STUDY 2.

Commercial and industrial application

Industrial expansion in a small Mexican city had placed a heavy load on the city's aging power grid that had not kept pace with growing energy demands. A cardboard manufacturer in the city faced morning startup with 10% voltage drops; it also was not uncommon to have intermittent voltage surges of 12–15%. The extreme voltage swings were causing damage to high-efficiency motors, electronics, drives and programmable logic controls common in paper processing.

During a site visit to discuss the voltage problems, the Eaton technical representative also recognized the limited space availability and that the substation was located inside the plant—an electrical equipment room with limited access. The ideal solution for this type of installation was

Eaton's Cooper Power series unique pad-mounted regulators with their complete deadfront construction, tamper-resistant cabinet and low profile. The electrical ratings of the three regulators in this installation were:

- 150 A
- 7.62 kV
- 114 kVA
- 60 Hz

With Eaton's Cooper Power series voltage regulators and controls in operation, used in conjunction with capacitors, power factor improved from 0.94 to 0.98.

History of innovative design

2014

- Voltage sag monitoring provides expanded CL-7 control capabilities

2015

- Polymer version of the QD8 tap changer improves an already great design
- Bias co-generation mode expands CL-7 functionally to solve modern grid problems

2016

- Fault detector functionally added to CL-7 control



CASE STUDY 3.

Military application

Eaton supplied three pad-mounted voltage regulators and a power transformer without an on-load tap-changer (OLTC) to replace the aging OLTC equipment in a substation on a military base. Pad-mounted voltage regulators with tamper-resistant cabinets and underground system compatibility ideally suited the application in which space inside the substation enclosure was at a premium and installation of additional fencing would be costly.

After installation, the customer requested the addition of three-phase ganged operation of the single-phase voltage regulators. The additional functionality was field installed with communications boards and fiber-optic cables added to enable the Leader/Follower control scheme. The inexpensive, easy-to-install solution not only met a customer need, but also illustrates the flexibility of Eaton's Cooper Power series CL-series voltage regulator controls.

CASE STUDY 4.

Modular Integrated Transportable Substation (MITS)

When Hurricane Sandy hit Rockaway Beach, NY, the storm surge left the 53rd Street substation under 5½ feet of water, according to the local utility spokesman. The substation was an air-insulated metal-clad design, which was particularly vulnerable to the salt water of the storm surge.

A nearby contractor had recently purchased an Eaton MITS to replace an aging substation for upstate New York. In the aftermath of the storm and with restoration of power a priority, he realized the MITS was the ideal solution to the problem at Rockaway Beach. The MITS is well suited for this type of application.

The MITS is:

- Prewired, tested and ready to install upon leaving the factory. This saves significant installation time during the critical early hours of the disaster recovery effort.
- Compact in design. All substation components fit neatly onto a single skid, making transportation manageable, even in a disaster area.
- Designed using shield-grounded cable that is much less susceptible to storm surges.

This particular MITS was designed with:

- A bank of three single-phase pad-mounted voltage regulators to provide superior power quality.
- A 5 MVA power transformer to convert voltage from 34.5 kV to 13.2 kV.

- A pad-mounted recloser for feeder protection.
- A small single-phase power transformer supplying 120 V power to the control systems integrated into the unit.
- Extra features such as built-in spill containment, telescoping flood lights and in-cabinet door lights that are helpful for crews restoring power at night.

Once the MITS arrived on site, the line crew, engineers and operation personnel immediately made the final connections between the damaged system and the MITS and restored power.

The MITS was the ideal solution to restore power quickly at Rockaway Beach.

2017

- DeltaCalc features improves delta system regulation using CL-7 multi-phase capabilities
- Modbus serial and TCP protocols become native to CL-7 control

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