



## ELCON Voltage Regulators

- ELCON'S voltage regulators for diesel locomotives, either "black box" or "module", look like OEM VRs, but they're really different! ELCON VRs excel in PERFORMANCE!
- What look like reproductions of "60's" and "70's" technology are not the same "old" thing!
- ELCON makes the **REAL** difference.!
- We have built our voltage regulation systems with current technology to provide more precise regulation and greater output stability under the full range of operating conditions.
- We have designed our VR systems to be more efficient, streamlined, and reliable in the long run.
- And, we have packaged our design in both the familiar "module" and "black box" configurations for application to any EMD locomotive, regardless of year of manufacture!
- Our VR UNIVERSAL module is built to work with all Dash-2 or later EMD locomotives, so you need to choose and stock only ONE ELCON product for future replacements.
- ELCON voltage regulators perform the way you want them to, and the way they need to...both for the short run and the long haul!
- ELCON's high-performance VR systems help you extend the life of your locomotive batteries - by helping you to reduce battery maintenance and replacement!



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**Choose and use ELCON VRs for improved performance overall!**

- **VR Improvements**
- Over the years, there has been little change in the voltage regulation systems used on EMD locomotives. While the systems currently used by the OEM are physically well built and very reliable, their performance is less than optimal in all operating conditions, and electrical reliability is still a problem.

Configuration	"Black Box"		"Module" (With Overvoltage Protection)			
<b>ELCON Model#:</b>	3-Terminal	4-Terminal	VR10E	VR13E	VR15E*	VR Universal
<b>ELCON Part #:</b>	13893	13892	13964	13851	13979	13847
<b>Application:</b>	Pre Dash-2 Systems	Pre Dash-2 Systems	DC Aux. Gen.	AC Aux. Gen.	AC Aux. Gen.	DC or AC Aux. Gen.
<b>EMD Model:</b>	3 Terminal	4-Terminal	VR10	VR11 & VR13	VR15*	ANY VR10, 11 or 13
<b>EMD Part #:</b>	8330790	8351980	8412927 & 8440256	8457997 & 9528276	9548067	ANY VR10, 11 or 13

**Whether "black box" or "module", ELCON VR systems offer greater stability, reliability, and versatility than their OEM counterparts!**

### ELCON Design Improvements

- As a specialist in the manufacture and repair of voltage regulation systems for EMD locomotives, ELCON has pursued its goal of building the best systems available,
- using the latest, proven technologies. Our efforts have resulted in design improvements that you should know about and benefit from by installing our VR products throughout your locomotive fleet. If you do, you are sure to realize two overall benefits:
  - (1) minimal downtime and expense due to longer locomotive battery life; and
  - (2) a smaller inventory of VR replacement parts due to the application versatility of ELCON's universal VR.
- Compare our ELCON VR systems with the current OEM voltage regulation systems (as we did), and then consider the ELCON product advantages described herein.



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### More Precise and Stable Regulation Over Entire Engine Speed, Load, and Temperature Range

ELCON VR systems provide stable voltage regulation of  $74 \pm 0.2$  volts for proper battery charging over the entire engine speed and auxiliary generator load range. Also, ELCON VR systems maintain stable regulation during ambient temperature variations in the locomotive's high-voltage cabinet.

The OEM VR13 module, through the same range of conditions, can regulate only to within  $\pm 1.5$  volts D.C. The OEM VR11 and OEM "Black Box" regulate only to within  $\pm 3$  volts under the same conditions (See "See Test Results Page 4")

### Higher Charging Voltage Produced At Idle, with Heavy Auxiliary Loading

At engine idle, with heavy auxiliary loads applied, such as cab heating or air conditioning, ELCON VR systems deliver more auxiliary generator field current, and so produce a higher charging voltage than any of the OEM VR systems.

ELCON VR units will regulate voltage typically to  $74 \pm 0.2$  volts until ALL auxiliary loads are applied.

OEM VR systems typically react with voltage decreases of almost a volt as each component of auxiliary load is applied incrementally.

### No Voltage Overshoot Upon Engine Start

Each ELCON VR product regulates properly at 74 volts DC immediately following engine start without voltage overshoot.

OEM VR systems typically overshoot to between 78 and 80 volts for about four (4) seconds immediately following engine start.

This can cause problems for some equipment connected to the PA (local control) and 13T (control) circuits. Add-on electronic equipment is not designed to withstand excessively high voltage inputs.

### Overvoltage Protection to Prevent Damage

All ELCON VR modules have a separate over-voltage shutdown circuit.

This circuit will sense if auxiliary generator voltage exceeds a predetermined level, typically 80 to 85 volts. The circuit will force the field circuit breaker to open and shut down the regulator before the excessive voltage can damage any locomotive equipment connected to the PA and 13T circuits.

If any current-design OEM VR module experiences a short-circuit failure, the voltage typically will increase to 115 volts or more for several seconds before the circuit breaker trips.

### ELCON VR15 Temperature Compensation To Adjust Battery Charging Voltage

The ELCON VR15 module includes a special temperature compensation circuit and battery electrolyte temperature probe that will adjust the battery charging voltage linearly for 72 volts when the electrolyte is at 120 degrees F and to 78 volts when the electrolyte temperature drops to 32 degrees F. This adjustment feature will decrease maintenance and extend battery life.

ELCON's Battery Electrolyte Temperature Probe is designed to replace any manufacturer's single-cell battery fill cap. Replacement positions the probe inside the battery. ONLY an internal type of temperature probe will measure the electrolyte properly so the regulator circuitry will produce the correct battery charging rates, even when a battery is equipped with an internal heater or an external battery heater.



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This ELCON VR15 circuitry is COMPATIBLE WITH EITHER the EMD battery-box probe OR the ELCON battery electrolyte probe. (This is not meant to infer, of course, that these two probe types are equivalent.)

- Silicon Controlled Switch (SCS)
- Selenium Rectifier
- Thermistors
- Silicon Controlled Rectifiers (SCRs)

ELCON's circuitry will sense which type of probe is installed, and will regulate appropriately according to the existing conditions. However optimum performance can be obtained only by measuring electrolyte temperature.

The use of such components for the OEM VR system requires unique specifications and special screening.

If a probe fails, the ELCON VR will default to  $74 \pm 0.2$  volts regulation until the condition is corrected. Failure of an electrolyte probe is indicated by the glowing of a RED LED.

Also, electrolytic capacitors and resistors greater than two (2) watts have been excluded from ELCON's module design. These are inherently low-reliability components.

If a probe fails in the OEM VR system, the module regulates at 78 volts. This can cause water loss and early battery failure. Also, the VR15 OEM system has no probe-failure indicator.

### Universal Design For Versatile Use and Minimal Parts Inventory

### Exceptional Reliability By Design

All ELCON VR products have been built with the same current technology and contain the same voltage regulation circuitry, whether they are designed for use with DC or AC auxiliary generators.

ELCON VR systems offer exceptional reliability because they are carefully designed with 60% fewer electrical components than their OEM counterparts, and are manufactured and assembled according to strict quality control procedures.

As a result, the only difference between ELCON's VR10 and VR13 modules made for use in Dash-2 locomotives is in how the field current wiring is connected internally - pins 5 and 6 for DC machines and pin 8 for AC machines. This should be good news to those railroads which have both DC and AC auxiliary generator types on their locomotives - because, when they use ELCON universal regulators, they need to stock only one replacement model.

The semi-conductors used in the OEM design are current, but not quite "state-of-the-art" in terms of design technology.

ELCON's "black-box" models also have been built with the same current technology and contain circuitry similar to ELCON's modules; however, the black-box components have been "packaged" differently for use in Pre Dash-2 locomotives. Because ELCON's "black boxes" employ the same modern circuit design, ELCON customers can upgrade their Pre-Dash 2 locomotives with AC auxiliary generators. This can open up a range of possibilities for electric cab heat and low idle to help save fuel.

All components used in the ELCON design are "off-the-shelf, state-of-the-art" devices with proven reliability. Also, ELCON components do not require special screening as do older OEM VR system components.

ELCON designers have specifically avoided using certain components which are included in OEM VR designs. Some components purposely avoided by ELCON include:



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## Test Results Show Performance Advantages

In a series of lab and "field" tests, engineers at ELCON, Inc. compared the performance of ELCON voltage regulators with the OEM standard VR13, VR11, VR10, and "Black Box" regulators.

The products were compared for proper voltage regulation in three areas of performance:  
 (1) over the entire engine speed and load range;  
 (2) at idle, with heavy auxiliary loading; and  
 (3) with changing ambient temperature.

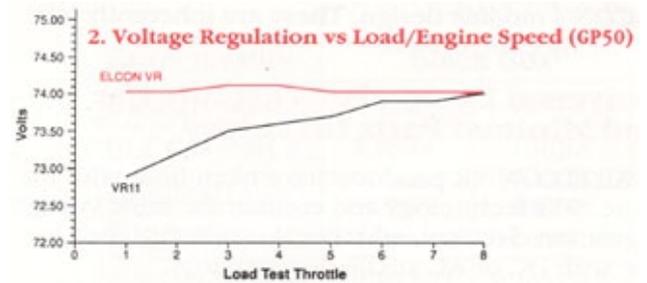
### (1) Engine Speed vs Load

ELCON's VR design has considerable advantages over the OEM VR11 and "Black Box" regulators in controlling voltage over the entire engine speed and load range for all locomotive models, and is equivalent in performance to the VR13 in this area.

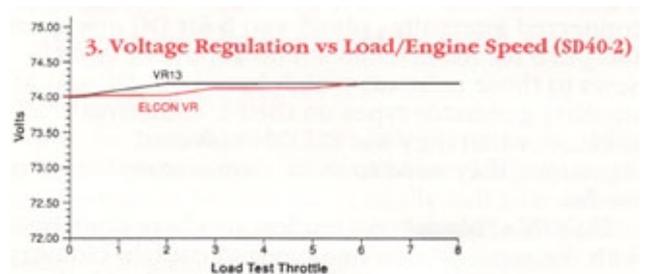
### Test Results

On typical SD40-2, SD45, and GP50 locomotives, test results demonstrated that the ELCON VR will regulate the auxiliary voltage to  $74 \pm 0.2$  volts. See Chart 1.

- On a typical SD45 and GP50 locomotives, it was demonstrated that the VR11 and "Black Box" VR can regulate voltage only to  $74 \pm 1.5$  volts. See Chart 2.

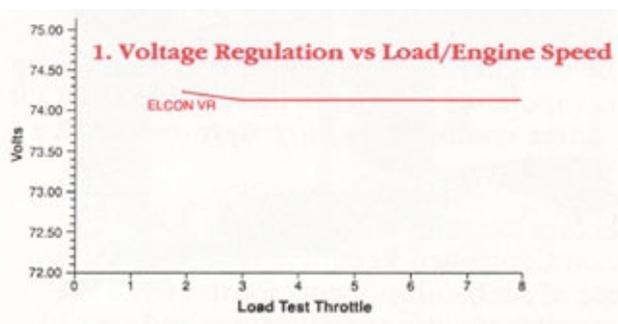


- On a typical SD40-2 locomotive, it was demonstrated that the VR13 will regulate voltage to  $74 \pm 0.2$  volts. See Chart 3.



### (2) Idle Speed - Heavy Auxiliary Loading

With the locomotive in idle and with considerable load applied to the auxiliary generator, the ELCON VR will deliver more field current and more consistent regulation of auxiliary voltage than the OEM VR13, VR11, or "Black Box" regulator.



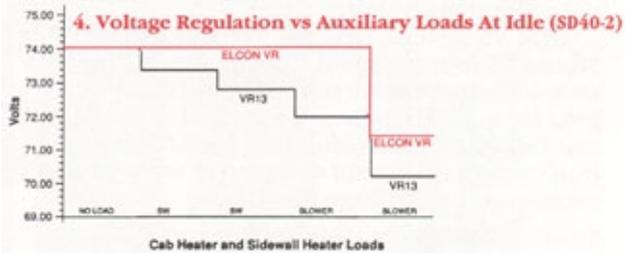
### Test Results

However when the OEM "Black Box" VR was tested under the same conditions on an SD45, the regulated voltage dropped approximately 1.0 volt to  $69.6 \pm 0.3$  volts, while operating in full current saturation.

On a typical SD40-2 locomotive, test results demonstrated that the ELCON VR will regulate auxiliary voltage properly to  $74 \pm 0.2$  volts until the final (fourth) cab heater load is applied. At idle, the auxiliary generator will be at maximum output, and the module will be operating at full current saturation. At this point, the voltage will drop to  $71.4 \pm 0.2$  volts, and the auxiliary generator will be limiting output.

Under the same conditions, it was demonstrated that voltage regulated by the OEM VR13 on an SD40-2 decreases by approximately 0.8 volts as each cab heater was added to the auxiliary load.

During the VR13 test, regulated voltage decreased to 73.4, 72.8, 72.0 and  $70.3 \pm 0.3$  volts as each cab heater was added to the load at idle. With all four cab heater operating the final voltage measured  $74 \pm 0.3$  volts. See Chart 4.



On typical GP50 locomotive, with all auxiliary loads applied, the ELCON VR demonstrated that it will regulate the auxiliary voltage properly to  $74 \pm 0.3$  volts.

However, when the OEM VR11 was tested under the same conditions on a GP50, the regulated voltage dropped approximately 1.0 volt to  $73.0 \pm 0.3$  volts.

On a typical SD45 locomotive, with all auxiliary loads applied, the ELCON VR demonstrated it will regulate the auxiliary voltage to  $70.6 \pm 0.3$  volts, operating in full current saturation.

However when the OEM "Black Box" VR was tested under the same conditions on an SD45, the regulated voltage dropped approximately 1.0 volt to  $69.6 \pm 0.3$  volts, while operating in full current saturation.

### (3) Voltage Regulation vs Temperature

Various climatic and operating conditions encountered by the locomotive will affect the temperature within the module compartment, but not the performance of the ELCON VR.

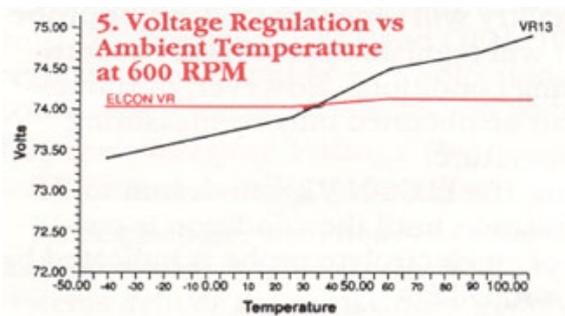
#### Test Results

#### The Elcon VR vs The OEM Vr13

The ELCON VR - Test results, as indicated in Chart 5, demonstrated that the ELCON VR will maintain  $74 \pm 0.1$  volts regulation under constant load and generator-speed conditions, whether the temperature within the compartment is  $-40$  degrees C or  $+100$  degrees C.

The OEM VR13, when tested, indicated that its regulation will change by 1.5 volts as the temperature varies between  $-40$  degrees C and  $+100$  degrees C. That is, the voltage it supplies will decrease as the temperature increases. See Chart 5.

Such voltage variation does not favor good battery charging and gassing conditions. On the contrary, according to the theory behind the VR15 temperature-varying regulator, an effective regulator should provide increased charging at lower ambient temperatures and reduced charging at bigger ambient temperatures.



**Both in the "field" and in the lab, the ELCON VR provides overall performance advantages over OEM VR products. ELCON VR design is clearly the star Performer!**

**Choose and use ELCON VRs for optimum performance, extended battery life, and reduced maintenance.**



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