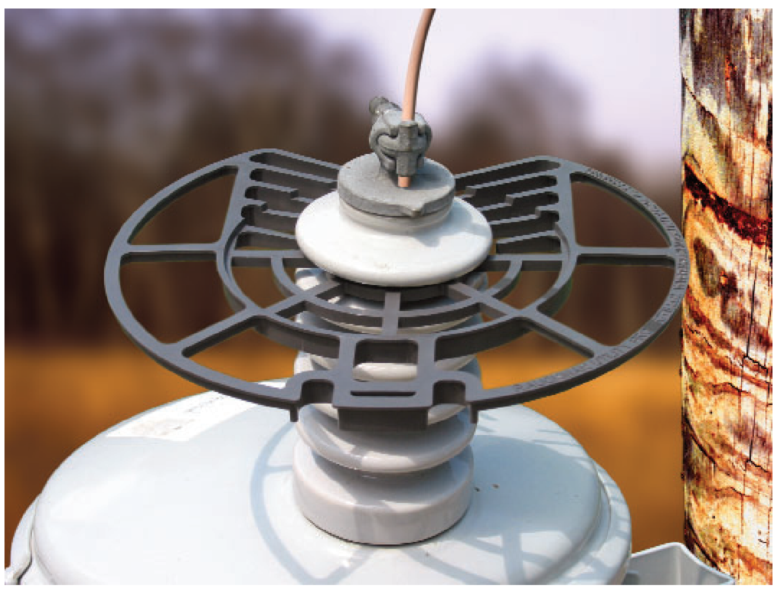
Rauckman Utility Products

Rauckman ZAPSHIELD™

Application Guide



ZAPSHIELD Model W-1525G

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About Rauckman ZAPSHIELD

The ZAPSHIELD is an active animal barrier designed to be installed on live distribution and sub-station bushings and insulators. While in the ever-present electric field of an energized circuit the ZAPSHIELD builds and stores an electric charge. Once touched by animals such as squirrels or snakes, the ZAPSHIELD will dissipate its stored energy in the form of an electrostatic discharge to scare the animals away.

Figure 1: ZAPSHIELD Model W-1525R

Theory of Operation

Effective Discharge Energy:

For a capacitive discharge to be effective, the discharged energy needs to be above the perception point and below the fatal point.

According to studies* performed, for a human body resistance of 1000 ohms a **1 second** continuous 60-Hz current of:

5 mA causes a tingling sensation.

10-20 mA would cause the beginning of sustained muscular contraction.

100-300 mA causes ventricular fibrillation, and can be fatal if continued over 1 second.

Let's calculate the 1 Sec. energy for these:

Voltage = R x I = 1000 x I
Time = 1 Sec
Power = V x I
Energy = Watt per Sec = Joules

For 5 mA
Voltage = **5 V**
Energy = **.025 Joules**

For 10 mA
Voltage = **10 V**
Energy = **0.1 Joules**

For 100 mA
Voltage = **100 V**
Energy = **10 Joules**

So would a 10 volt source be sufficient to scare squirrels away? **No not, quite**.

A squirrel has lots of hair and a tough hide. So the resistance of the squirrel would be more likely 50,000 to 100,000 ohms.

* Nave & Nave, Physics For the Health Sciences, 3rd Ed, W. B. Saunders, 1985

If we do the same calculations for 5 mA current for higher resistance then we see:

Voltage = **50k** x 5 mA = **250 Volts**
Energy = 1.25 Joules
Voltage = **100k** x 5 mA = **500 Volts**
Energy = 2.5 Joules

So do we need that much voltage? **YES**.

Do we need that much energy? **NO**.

What we need is an initial **Voltage high enough** (**250 to 500 Volts**) to overcome high skin resistance, and then **reduce the voltage very quickly** (Figure 2) so that after the skin resistance breakdown it would not harm the animal with high currents.

So the key is the duration of the applied voltage / current. To be effective, the discharge voltage and current should be high but occur for a very short time (i.e. μseconds).

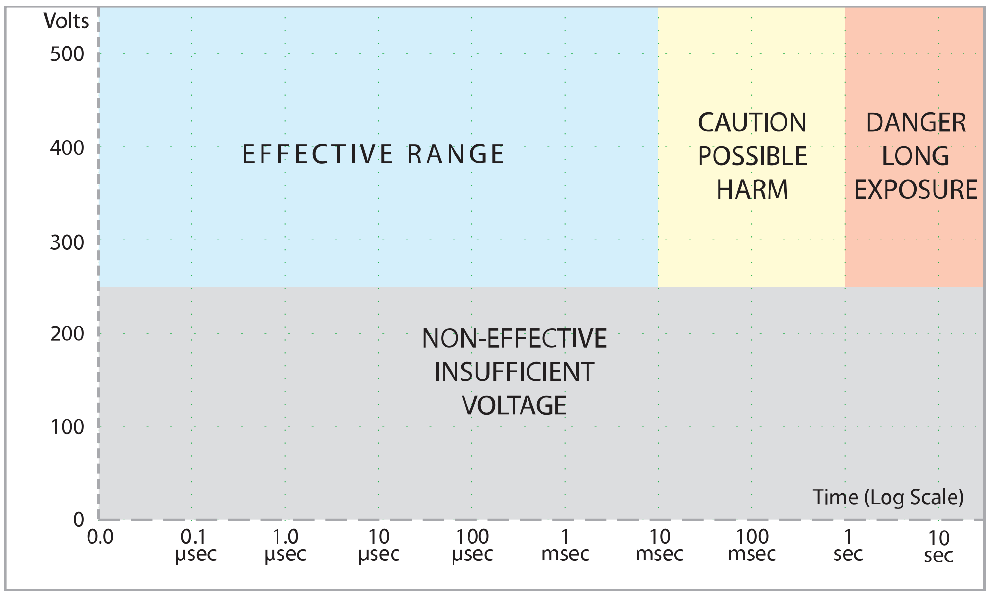


Figure 2: Effective Range of Voltage vs. Time for 50k to 100k Ohm Resistance

Product Design Objectives

The objectives were to design a product that:

1 - Delivers enough shock to scare the animals and conditions them to stay away from live electrical equipment.

2 - Keeps the shock level below lethal point.

3 - Keep the energy discharge far below any level that would affect system protection and coordination.

Electrical Tests

Purpose of Tests:

60-Hz capacitive discharge tests were conducted to determine and verify the working parameters of the Rauckman ZAPSHIELD for use by electrical utilities in substations and on distribution circuits.

To simulate working conditions and measure the voltage peaks and discharge current values of the product.

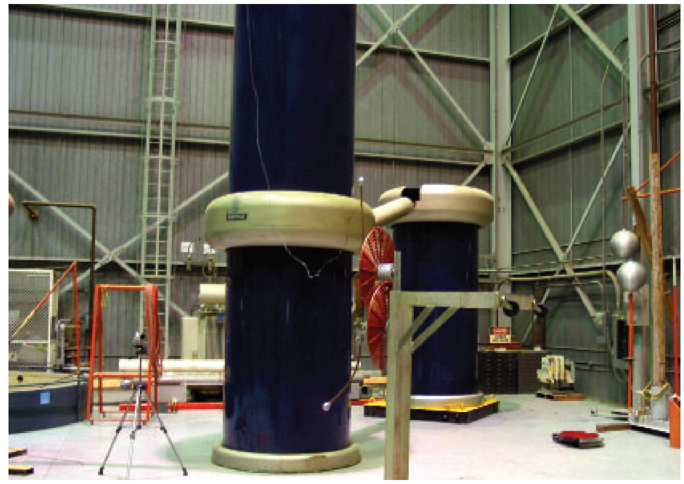


Figure 3: High Voltage Test Labs.

ZAPSHIELD Models Tested/Applicable:

Model	Description
W-1525R	10” Diameter, Red (tested)
W-1525G	10” Diameter, Gray

Testing Laboratory:

High voltage test lab at F. Gano Chance Research Center in Centralia, Missouri, USA (Figure 3).

TEST 1 - TRANSFORMER BUSHING

Test Setup / Procedure:

A 7.2 kV, 10 kVA single phase, pole mounted transformer was secured on a 10-inch aluminum beam (Figure 4) and the tank of the transformer was grounded. Tests were conducted and data recorded with the ZAPSHIELD mounted between bushing’s skirts 1 & 2, 3 & 4, and 5 & 6 (from top).

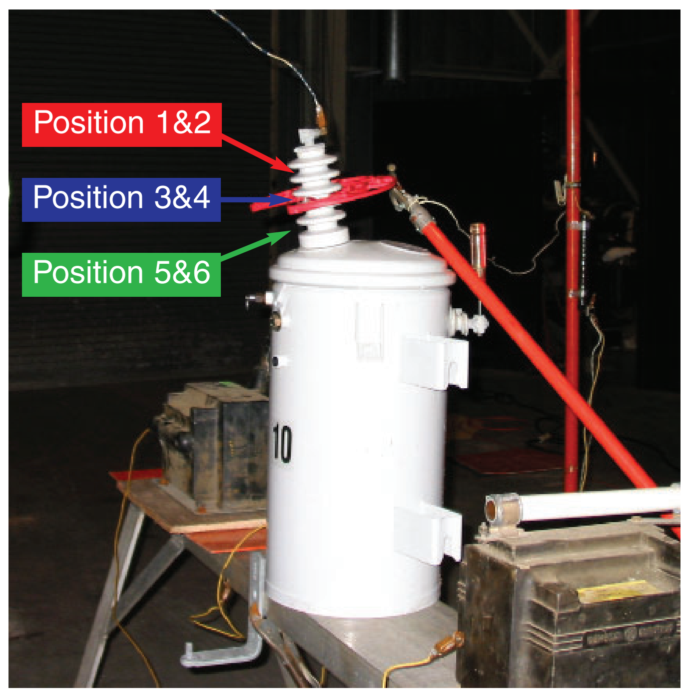


Figure 4: Test Setup with ZAPSHIELD Mounted Between Skirts 3 and 4 (from top).

Voltage was applied to the primary bushing of the transformer at 7.2 kV RMS L-G. The current discharged from the edge of the ZAPSHIELD was measured by using a hotstick with a fitting wired to a 1000-ohm resistor. The 1000-ohm resistor represented the animal's body resistance.

Attached in series with this resistor was a 100-ohm measurement resistor connected to ground (Figure 5).

The voltage drop across the 100-ohm resistor was measured and from that discharge current and voltage drop was calculated across the 1000-ohm resistor.

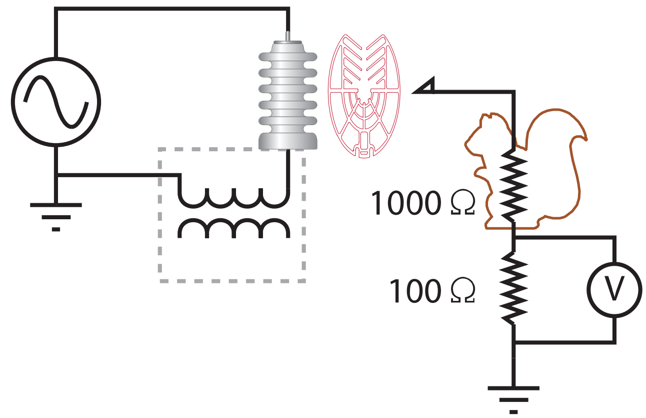


Figure 5: Test Setup Schematic

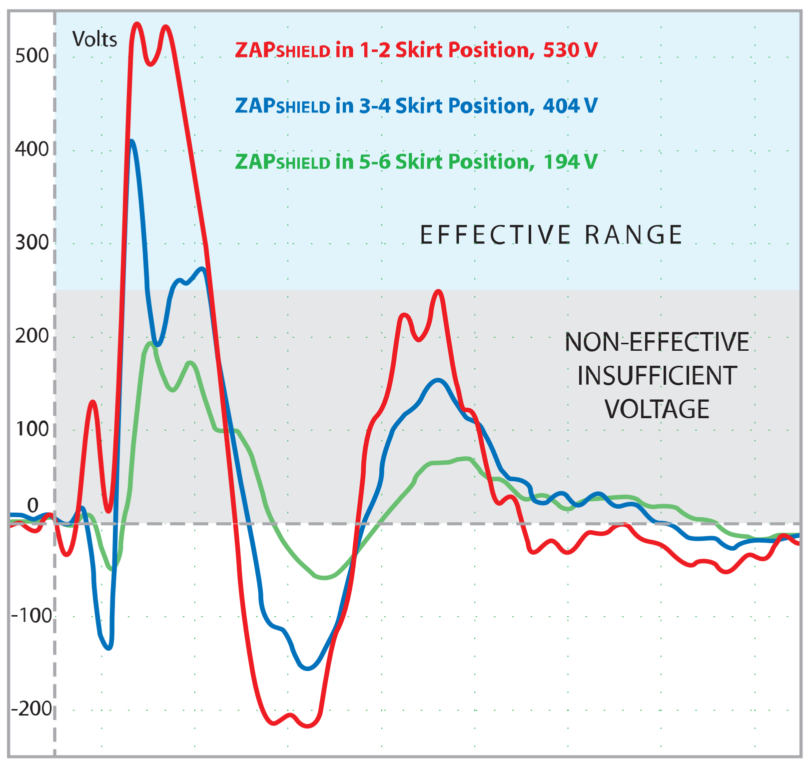


Figure 6: ZAPSHIELD's Voltage Curves for 3 Transformer Bushing Positions

ZAPSHIELD Test Data:

Figure 6 shows the voltage curve graphs (oscilloscope screen captures) for the ZAPSHIELD mounted at the 3 positions on the transformer's insulator. At the highest point (between 1-2 skirt position) the discharge is at **530 mA and 530 Volts at 1.028 µsec**.

Figure 7: ZAPSHIELD Mounted Under 1st Major Diameter Skirt of a station post Insulator

TEST 2 - STATION POST INSULATOR

Test Setup / Procedure:

A LAPP post insulator (cat. # 315210-70) was mounted on a 10-inch aluminum beam (Figure 7). Tests were conducted and data recorded with the ZAPSHIELD mounted under the 1st and the 3rd (from top) major diameter skirt of the insulator.

Test voltage of 19.9 kV RMS L-G was applied to top of the insulator. The current discharged from the edge of the ZAPSHIELD was measured similar to test performed on the transformer.

ZAPSHIELD Test Data:

Figure 8 shows the graphs of the oscilloscope screen captures of the voltage curves for the ZAPSHIELD mounted under the 1st and 3rd (from top) major diameter skirts of the insulator. At the highest point (under 1st skirt) the discharge is at **1 A and 1000 Volts at 1.128 µsec**.

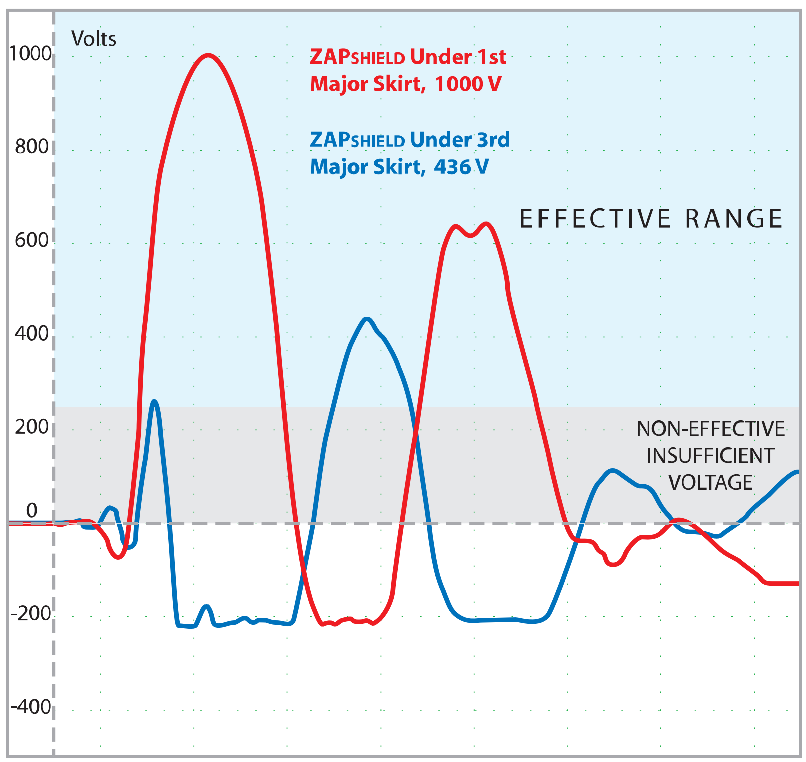


Figure 8: Voltage Curves with ZAPSHIELD Mounted Under 1st & 3rd Major Diameter Skirts of the Insulator.

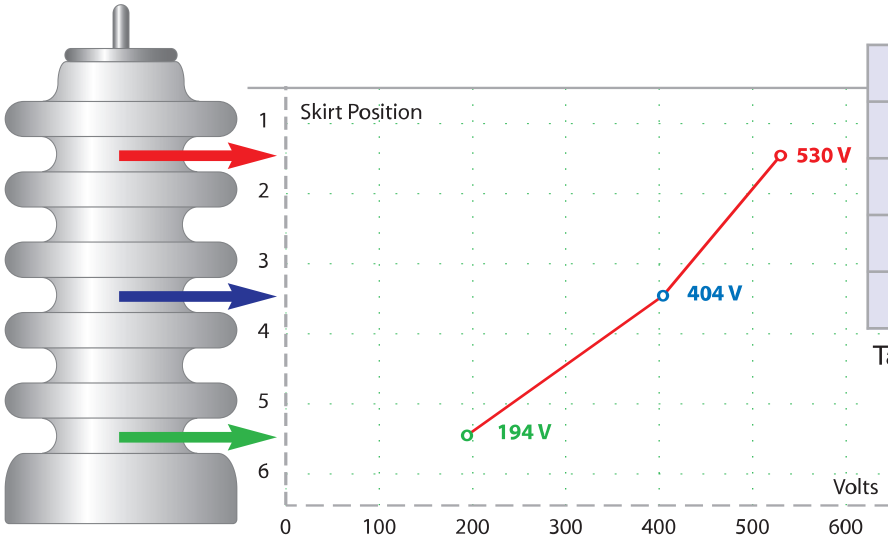


Figure 9: Comparison of Skirt Position vs. Voltage Peak on the ZAPSHIELD Mounted on the 7.2 kV Transformer Bushing.

Voltage Class >>	15 kV	27 kV	35 kV
L-G Voltage >>	7.2 kV	14.4 kV	19.9 kV
1&2 Skirt Position	YES	NO	CONSULT FACTORY
2&3 Skirt Position	YES	YES	
3&4 Skirt Position	NO	YES	

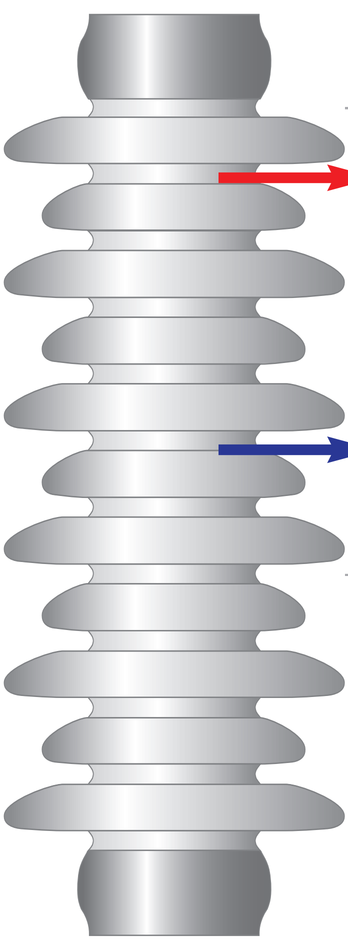
Table 1: Placement on Transformer Bushing based on System Voltage

Application

Figures 9 and 10 show the voltage peak for the ZAPSHIELD located on different positions of the transformer bushing and the station post insulator.

Voltage peak generated is directly affected by placement of the ZAPSHIELD.

Based on the graphs, tables 1 and 2 show the recommended placement of the ZAPSHIELD for different kV class equipment to create effective voltages.



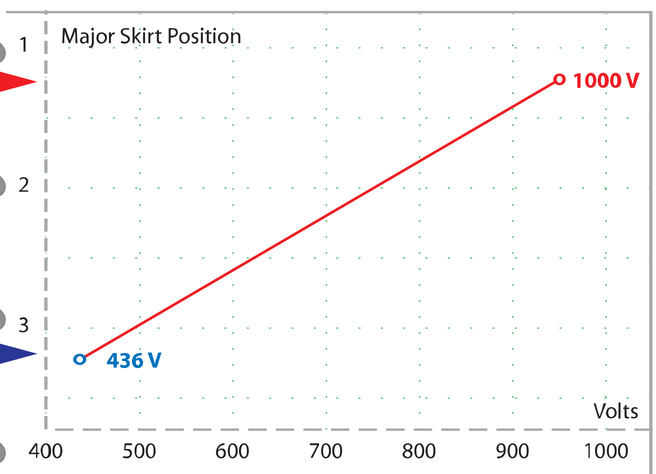


Figure 10: Comparison of Major Skirt Position vs. Voltage Peak on the ZAPSHIELD Mounted on the Station Post Insulator

Voltage Class >>	15 kV	27 kV	35 kV*
L-G Voltage >>	7.2 kV	14.4 kV	19.9 kV
Under 1st Major Skirt	YES	NO	NO
Under 2nd Major Skirt	YES	YES	NO
Under 3rd Major Skirt	NO	YES	YES

Table 2: Placement on Station Post Insulator based on System Voltage

* For higher voltages consult factory.

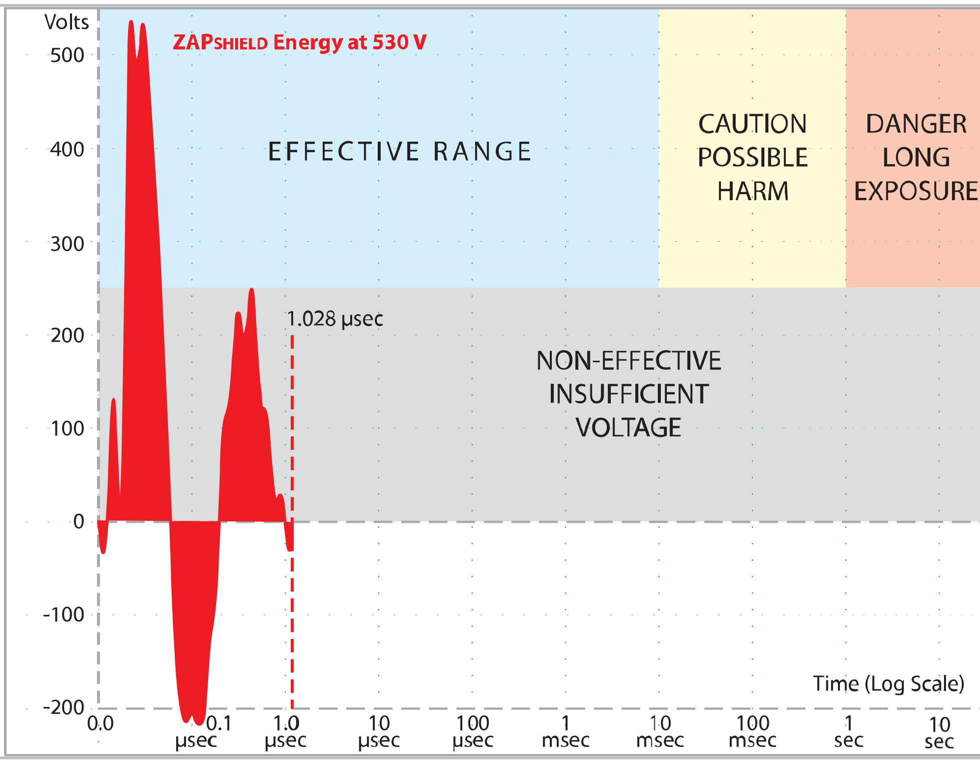


Figure 11: Discharge Energy of ZAPSHIELD on 1&2 Skirt Position of 7.2 kV Transformer

Conclusion

As discussed earlier, for a capacitive discharge to be effective, its discharged energy should be above the perception point and below the fatal point.

The Voltage and currents must be high enough to overcome the initial high resistance of the animal and must last only a fraction of a second.

Looking at the Figure 11 curve for ZAPSHIELD on 1-2 skirt position you would see:

Voltage = **530 Volts**
Current = **530 mA**
Time = 1.028 µSec
Watt = 530 x (530/1000) = 281

ZAPSHIELD Energy = 281 x (1.028 µsec)
= **0.000289 Joules**
= 289 µJoules

ZAPSHIELD delivers the right amount of voltage and current in the very short time of 1.028 µsec that effectively scares the animal away without harm. The ZAPSHIELD uses negative response conditioning to train the animal to stay away from energized utility equipment.

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