

# **Design and Equipment Issues for Overhead Distribution Systems**

*Test Results and Application Guidelines*

**1016043**

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Technical Update, December 2008

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# PRODUCT DESCRIPTION

Animal-related outages on electric power distribution systems have plagued utilities since distribution facilities were first installed. Today, mammals, birds, and snakes cause a significant number of electric outages throughout North America; and recent studies show animal-caused outages are increasingly common in both urban and residential areas.

Wildlife guards are commonly applied on electric power distribution circuits to reduce the frequency of wildlife-caused interruptions. Utilities often have questions regarding how the wildlife guards will perform on their system and how different wildlife guard products compare with one another. This work endeavors to provide utility personnel with pertinent information that they can use to make informed decisions about applying wildlife guards on their distribution system. This information can help utilities better evaluate their wildlife guard choices and enhance their understanding about the performance of the wildlife guard products that they already use.

## Results and Findings

Of the eleven wildlife guards tested in this project, only two samples (H and M) passed both the power frequency withstand and power frequency flashover tests. One of those samples (H) tested in the middle of the group for time to flame ignition during flammability testing, and it should be noted that the guard did not support combustion after the flame source was removed. Sample H is a boot-type guard, and M is an electrostatic guard.

## Challenges and Objective

Simply *using* wildlife guards is not enough. To yield the greatest possible benefit, wildlife guard applications need to be considered carefully. The guards must be properly specified and installed. A quick survey of distribution circuits in many locations can yield numerous instances of improperly applied wildlife guards. A primary factor in improper applications is a lack of understanding of how the guard is designed to function and how it will interact with the other components on the structure. The guidelines presented in this report are intended to provide a fundamental overview of proper guard application to mitigate wildlife interactions to the greatest extent possible. This information will benefit utility distribution engineers as well as line workers.

## Applications, Values, and Use

The information found in this report can be used by utility personnel to enhance wildlife guard applications and reduce detrimental animal interactions.

## EPRI Perspective

By taking a proactive approach to mitigating outages, utilities can address service reliability and environmental concerns in an appropriate manner while at the same time avoiding increased scrutiny from regulatory agencies. Reducing outages in today's competitive environment also represents an opportunity to gain a competitive edge through increased reliability and reduced operations and maintenance costs.

## **Approach**

Seven contributing utilities provided a total of eleven wildlife guard samples for testing. The eleven wildlife guard samples represent nine different commercial manufacturers and one set of shop-made guards that are produced by the utility that applies them. The project team subjected the wildlife guard samples to a battery of laboratory tests including: workability, power frequency withstand, power frequency flashover, lightning impulse withstand, flammability, and multi-stress aging chamber testing. This test regimen is based on IEEE P1656/D8 - *Draft Guide for Testing the Electrical, Mechanical, and Durability Performance of Wildlife Protective Devices on Overhead Power Distribution Systems Rated Up to 38kV* with additional testing added in many of the areas.

## **Keywords**

Wildlife Guard

Animal Guard

Distribution

Reliability

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# 1

## INTRODUCTION

Animal-related outages on electric power distribution systems have plagued utilities since distribution facilities were first installed. Today, mammals, birds and snakes cause a significant number of electric outages throughout North America and recent studies show animal-caused outages are increasingly common in both urban and residential areas<sup>1</sup>.

Wildlife guards are commonly applied on electric power distribution circuits to reduce the frequency of wildlife-caused interruptions. Utilities often have questions regarding how the wildlife guards will perform on their system and how different wildlife guard products compare with one another. This work endeavors to provide utility personnel with pertinent information that they can use to make informed decisions about applying wildlife guards on their distribution system. This information can help utilities better evaluate their wildlife guard choices and enhance their understanding about the performance of the wildlife guard products that they already use.

### Laboratory Testing

Seven contributing utilities provided a total of eleven wildlife guard samples for testing. The eleven wildlife guard samples represent nine different commercial manufacturers and one set of shop-made guards that are produced by the utility that applies them. The wildlife guard samples were subjected to a battery of laboratory tests including: workability, power frequency withstand, power frequency flashover, lightning impulse withstand, flammability, and multi-stress aging chamber testing. This test regimen is based on IEEE P1656/D8 - *Draft Guide for Testing the Electrical, Mechanical, and Durability Performance of Wildlife Protective Devices on Overhead Power Distribution Systems Rated Up to 38kV* with additional testing added in many of the areas. Test results are presented including numerous photographs.

The test regimen included the following components:

- *Power frequency testing* – 60-hertz withstand and flashover testing.
- *Lightning impulse withstand testing* – positive and negative polarity impulse testing at the BIL of the test fixture.
- *Multi-stress aging chamber testing* – the chamber is capable of providing electrical, thermal, ultraviolet light, and rain stresses for tests running into the thousands of hours.
- *Practical Issues* – this testing includes informal “ease of installation” and flammability testing.

### Guidelines for Wildlife Guard Application

By taking a proactive approach to mitigating outages, utilities can address reliability and environment concerns in an appropriate manner while at the same time avoiding increased

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<sup>1</sup> *Distribution Wildlife and Pest Control*. EPRI, Palo Alto, CA: 2001. 1001883.

scrutiny from regulatory agencies. Reducing outages in today's competitive environment also represents an opportunity to gain a competitive edge through increased reliability and reduced operations and maintenance costs.

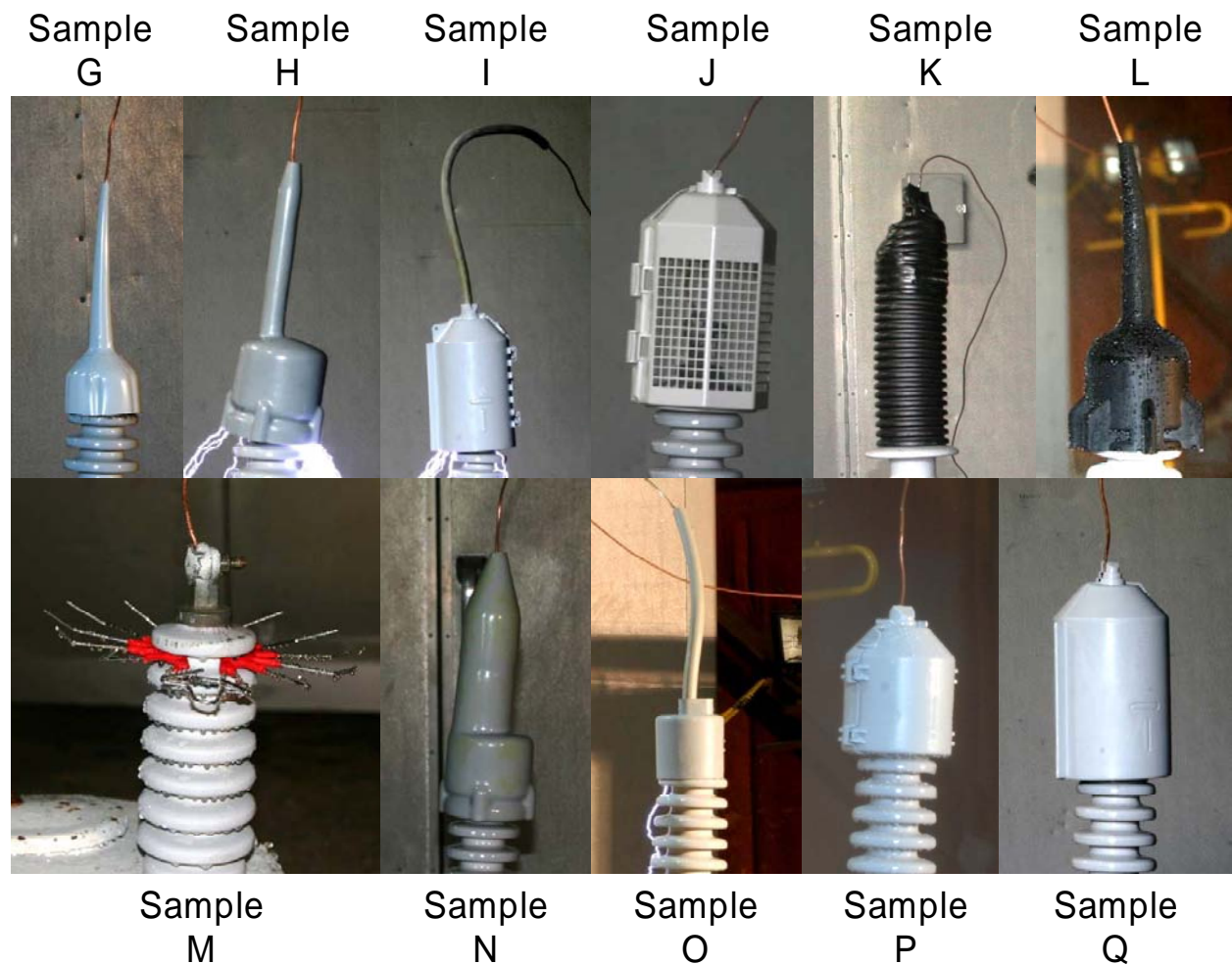
Simply *using* wildlife guards is not enough however. To yield the greatest possible benefit, wildlife guard applications need to be considered carefully. The guards must be properly specified and installed. A quick survey of distribution circuits in many locations can yield numerous instances of improperly applied wildlife guards. A primary factor in improper applications is a lack of understanding of how the guard is designed to function and how it will interact with the other components on the structure. The guidelines presented in this report are intended to provide a fundamental overview of proper guard application to mitigate wildlife interactions to the greatest extent possible.

# 2

## SUMMARY OF TEST RESULTS

### Test Samples

Eleven different wildlife guard models were tested. The samples are produced by nine different manufacturers including one set of shop-made wildlife guards which are produced in-house by the utility. As Figure 2-1 shows, the samples included both “clamshell” and “boot” designs and are made from a variety of base materials.



**Figure 2-1**  
**Composite Image Showing the Eleven Wildlife Guard Models Tested**

The samples are referred to by letter designation throughout this document rather than by manufacturer or model information. A wildlife guard set of one make and model usually consists of ten to twelve individual guard samples that are used for testing. Upon arrival at EPRI, the wildlife guard set is given a letter designation that is unique to the manufacturer and model combination. Each sample in the set is then inspected inside-and-out and given a unique sample code identification consisting of the sample letter followed by the date and sequence number of its inspection. For example, fictitious sample A-20070502-4 would be the fourth sample inspected on May 2, 2007 from the manufacturer and model combination designated A.

The test samples were sent directly to EPRI from the storeroom stock of utilities participating in the project. They were handled in the same manner as any wildlife guard headed for service in the field. The test samples were not handled roughly but they also did not receive any significant surface cleaning or other special preparations. The goal of this work was to test samples as they would appear in the field. Commonly available lineman's tools were used to make any required modifications to the samples during installation on the test fixture. For example, several of the wildlife guards required a conductor exit hole to be cut in the tip of the sample and lineman's pliers were employed for this task.

## **2007 Test Results – Tests on Virgin Samples**

For greater detail about each test performed for all samples, including pictures of sample damage, the reader is directed to the 2007 report<sup>2</sup>.

### ***Power Frequency Withstand Testing***

Each sample set was tested for power frequency withstand performance using the pass/fail criteria defined in IEEE P1656/D8. The IEEE Guide calls for a total of three wet withstand tests, 60-seconds in duration each, to be performed for each sample set. The sample set passes if all individual samples pass the test. The EPRI testing applied this same pass/fail criteria but also added additional testing including extending the withstand test time to 10 minutes, adding a single dry withstand test, and adding wet and dry withstand tests without the copper mesh installed. The additional tests provided a baseline for sample performance but were not factored into the pass/fail criteria for the samples.

Table 2-1 shows the overall power frequency withstand test results. Sample set G was notable for its poor performance as all three samples failed the wet power frequency withstand testing. A sample from set G also failed the dry withstand test. All failures for G samples were the result of punctures through the guard body.

Two samples from set O also suffered damage during withstand testing but the damage occurred after the 60-second mark in the test, so they passed IEEE P1656/D8 test criteria.

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<sup>2</sup> *Optimal Design of Overhead Distribution Systems: Laboratory Testing of Wildlife Guards*. EPRI, Palo Alto, CA: 2007. 1013963.

**Table 2-1  
Power Frequency Withstand Test Results**

Sample Set	IEEE P1656/D8 Pass/Fail	Reason for Failure	Comments
G	Fail	3 samples failed	Additional sample also failed dry withstand testing.
H	Pass		
I	Pass		
J	Pass		
K	Pass		
L	Fail	1 sample failed	Sample L-20070426-4 failed 45 seconds into test.
M	Pass		Possible surface crazing on sample M-20070426-7
N	Pass		
O	Pass		Two samples sustained damage after the 60-second mark.
P	Pass		
Q	Pass		Small area of carbonization inside after no-mesh wet withstand test.

***Power Frequency Flashover Test Results***

Each sample set was tested for power frequency flashover performance using the pass/fail criteria put forth in IEEE P1656/D8. The Guide specifies wet flashover testing only, but the EPRI test protocol adds dry flashover testing as well. The dry flashovers are judged based on the IEEE P1656/D8 pass/fail criteria and although any dry failures are noted, they do not contribute to the sample failing to meet IEEE P1656/D8 criteria.

Table 2-2 shows the overall performance of each sample set tested. Many of the samples did not meet IEEE P1656/D8 criteria, often with one of the three samples failing the test. One surprising finding from this testing is that sample set M actually increases the flashover value of the test fixture. While this may initially seem like a beneficial attribute, it can also lead to problems. The test fixture suffered an internal flashover during one wet test of an M sample. The flashover did not cause any permanent damage to the test fixture but it does indicate that these wildlife guards should be applied with caution on transformers that are not protected by a surge arrester.

**Table 2-2  
Power Frequency Withstand Test Results**

Sample Set	IEEE P1656/D8 Pass/Fail	Reason for Failure	Comments
G	Pass		
H	Pass		
I	Fail	1 sample failed wet	A different sample also failed dry flashover testing.
J	Fail	1 sample failed wet	
K	Fail	1 sample failed wet	
L	Fail	2 samples failed wet	
M	Pass		Increases test fixture flashover value.
N	Fail	1 sample failed wet	
O	Fail	2 samples failed wet	
P	Fail	1 sample failed wet	
Q	Fail	1 sample failed wet	

### ***Lightning Impulse Withstand Test Results***

All sample sets were tested for lightning impulse withstand performance in accordance with the testing procedure prescribed in IEEE P1656/D8. Three samples from each sample set were tested with both positive and negative polarity impulses with a peak voltage equal to the basic lightning impulse level (BIL) of the test fixture.

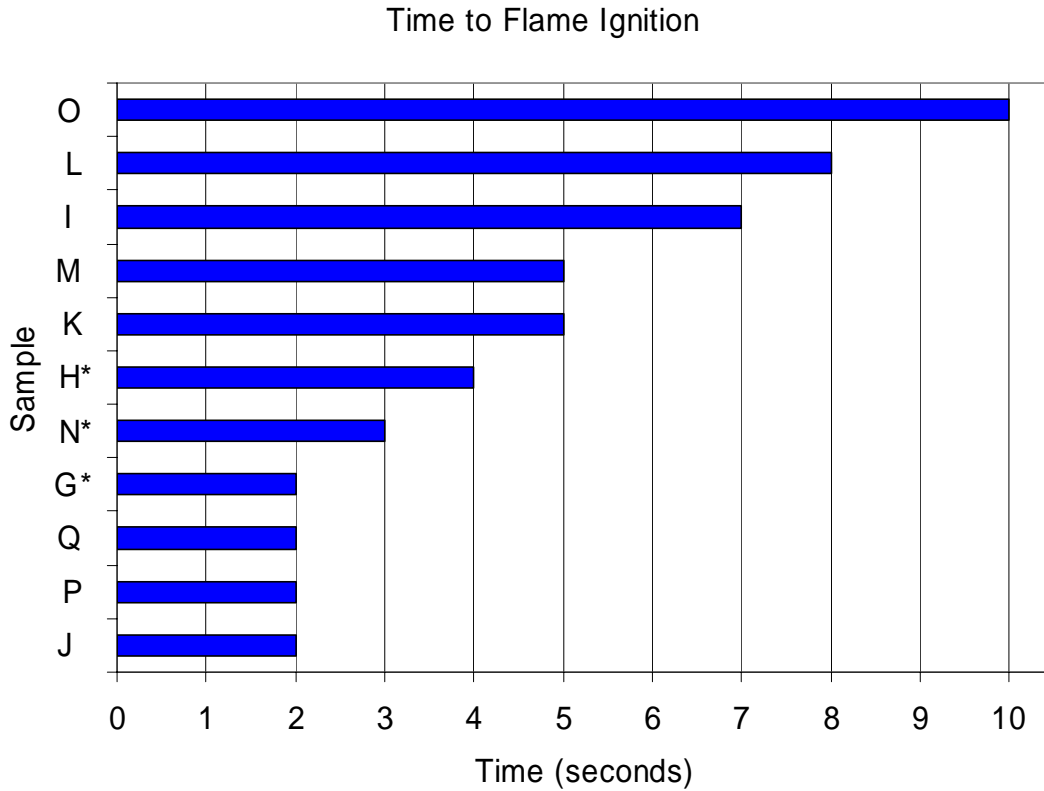
All sample sets passed the lightning impulse withstand test. Furthermore, all individual samples also passed the test and no samples exhibited a disruptive discharge (flashover).

Although this test yielded little information to help differentiate the different samples from one another, it did verify that the samples tested do not significantly degrade the lightning flashover performance of the distribution transformer on which they are installed.

### ***Results of Flammability Investigation***

The wildlife guards tested during the flammability investigation exhibited varying flame ignition and self-extinguishing characteristics. Figure 2-2 shows the time to flame ignition for each sample tested. The time to flame ignition represents how much time elapsed between when the flame source was applied and when the sample began to burn. Times range from two to ten seconds with five of the eleven samples going five seconds or longer before flame ignition. It should also be noted that three of the samples did not sustain combustion. Samples H, N, and G ceased burning within a few seconds after the flame source was removed.

The time to flame ignition metric is an indicator of the total amount of thermal energy needed to create combustion of the wildlife guard body. The flammability testing used a propane torch as the thermal energy source. In the field, the thermal energy can come from a variety of sources including wildlife-caused arcs, surface tracking, and expulsion fuse operation.



**Figure 2-2**  
**Time to Flame Ignition for Each Sample**  
(samples with a \* self-extinguished once the flame source was removed)

When considering the flammability characteristics of the wildlife guard samples, it is important to consider both the time to flame ignition and whether or not the guard sustains combustion. Clearly, the most favorable combination would be a long time to flame ignition on a product that does not support combustion. However, this performance combination is not always available. When considering the alternatives, it may be desirable to trade-off a slower time to flame initiation for a guard that does not support combustion.

Other observations from the flammability investigation include:

- *Sample G* – although the surface of the guard deforms almost immediately upon contact with the flame source, the guard did not sustain combustion.
- *Sample J* – flame progression across the sample is slowed by the lattice structure but the guard does support combustion.

- *Sample K* – the splicing tape used to seal the top of the guard does not support combustion but the sample body burned in its entirety.
- *Molded fingers are particularly susceptible to fire* – the molded “fingers” that cover the openings on several of the wildlife guards are susceptible to fire due to their long thin nature. These fingers also tend to be located in areas where tracking is more likely to occur meaning that they have a greater likelihood of being exposed to a heat source. The test flame was applied to the molded fingers (on all samples using the “finger” design) during the flammability investigation and spread from the fingers to fully consume the samples.
- *Dripping flaming material* – is a serious concern for a burning wildlife guard. Fire can spread from the wildlife guard to other equipment or the ground below via burning material dripping from the sample. All of the samples that sustained combustion exhibited this dripping to varying degrees. In the most severe cases, the drippings accumulated in a small burning pile under the sample causing a secondary ground fire.

## **2008 Test Results – Tests on Samples Aged via Multi-Stress Chamber**

### ***Multi-Stress Aging***

The multi-stress test chamber subjects test samples to multiple stresses for extended time periods to induce accelerated aging. Figure 2-3 shows the interior of the multi-stress aging chamber with the samples installed for testing and Figure 2-4 shows the interior during the ultraviolet light portion of the test cycle. Much consideration was given to the layout of the subsystems and sample orientation in an effort to keep the local environment around each sample as free of unintended influences as possible. These considerations include avoiding thermal, UV, or rain spray shadows, keeping the samples out of drip paths, and ensuring that the heating and rain spray system are not blowing directly on the samples.

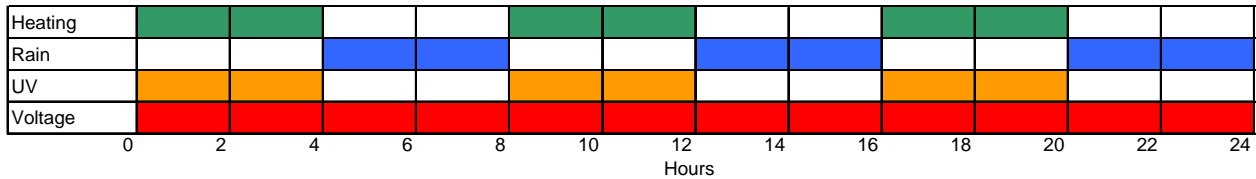


**Figure 2-3**  
**Interior of the Multi-Stress Aging Chamber Showing Samples Installed for Testing**



**Figure 2-4**  
**Interior of the Multi-Stress Aging Chamber during the Ultraviolet Light Exposure Portion of the Test Cycle**

The EPRI distribution-class multi-stress chamber produces four stresses over a 24-hour cycle as shown in Figure 2-5. White rectangles indicate that the stress is “off” while color in the rectangle represents that the stress is “on.” The x-axis units are hours representing one 24-hour chamber cycle. This cycle is repeated every 24 hours for the duration of the test.



**Figure 2-5**  
**Multi-Stress Aging Chamber 24-hour Cycle**

Several existing aging cycles by EPRI and others were consulted when designing the test cycle used for this test<sup>3,4,5</sup>. Based on comparison with the existing cycles as well as field aged samples, it is estimated that this cycle represents a southeastern United States locale and provides an acceleration factor of 15 to 20.

At least one sample from each sample set was included in the chamber for aging. After a pre-test inspection, the samples were mounted in the chamber and exposed for 2,176.9 hours. The samples included in the accelerated aging test are listed in Table 2-3. Mounting locations 1 through 8 correspond to bushing mounts in the test chamber. The number system starts with bushing 1 on far left when facing the samples with the door to the right. Correspondingly, bushing number 8 is the far right using this same orientation; bushing 8 is the closest to the camera in Figure 2-3. Mounting locations labeled with an “a” suffix, 1a through 7a, correspond to locations in between the bushings with the samples resting on the support table (also evident in Figure 2-3). These locations do not permit the sample to be exposed to electrical stress. It was decided that it was worth placing samples in these locations for the test, even if they don’t receive electrical stress, in order to accommodate as many samples as possible in the chamber.

The test samples were periodically inspected for damage or signs of aging. Inspections took place prior to the start of the test, at 500 hours, at 1,200 hours, and upon completion of the test at 2,176.9 hours. None of the samples exhibited any significant tracking or erosion during the multi-stress aging test. Even if the acceleration factor of the chamber is taken at its most aggressive estimate of 20, a total of 2,176.9 hours equates to approximately 5 years of field service. Since wildlife guards are intended to last much longer than 5 years in the field it is a positive result to see that this amount of aging caused few changes in the outward appearance of the test samples.

<sup>3</sup> H.M.H.M. Schneider, et al., *Accelerated Aging Chamber for Nonceramic Insulators*, 7th ISH, Dresden, 199 1

<sup>4</sup> R. Sundararajan, et al., *MultiStress Aging of Polymeric Insulators*, IEEE Conference on Electrical Insulation and Dielectric Phenomena, 2000.

<sup>5</sup> R. Sundararajan, et al., *MultiStress Accelerated Aging of Polymer Housed Surge Arresters under Simulated Coastal Florida Conditions*, IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 13, No. 1, February, 2006.

**Table 2-3  
Samples Tested and their Mounting Locations in the Multi-Stress Aging Chamber**

Sample Location	Sample	Comments
1	H-070419-8	Energized
2	I-070419-9	Energized
3	O-070426-8	Energized
4	L-070426-8	Energized
5	M-070426-2	Energized
6	G-070419-7	Energized
7	J-070420-4	Energized
8	K-070420-2	Energized
1A	N-070426-3	No electrical stress
2A	Q-070705-12	No electrical stress
3A	P-070427-1	No electrical stress
4A	L-070426-10	No electrical stress
5A	empty	Shaded by support bracket
6A	Q-070705-3	No electrical stress
7A	J-070420-5	No electrical stress

### ***2008 Electrical Testing***

At the completion of the aging test, the samples were removed from the chamber and re-tested according to the 2007 test protocols. The performance of the samples did not appreciably change from their virgin state. It appears that the aging test was not sufficiently long to cause the sample's electrical performance to deteriorate noticeably. As previously mentioned, this is an encouraging finding since wildlife guards are intended to last much longer than 5 years in the field.

### **Summary of 2007 and 2008 Testing**

Only sample sets H and M passed both the power frequency withstand and power frequency flashover tests. Sample H tested in the middle of the group for time to flame ignition during flammability testing and it should be noted that the guard did not support combustion after the flame source was removed. Samples H and M are a boot type and an electrostatic type guard respectively. This is not to say that the other guards performed poorly as several of them are

commonly used in the industry and appear to performing adequately. The test data presented in this report provides a good basis for judging different guard models against each other and can be used when considering applying new wildlife guards or in evaluating the need to switch to a different guard design.

# 3

## GUIDELINES FOR SPECIFYING AND APPLYING WILDLIFE GUARDS

Animal-related outages on electric power distribution systems have plagued utilities since distribution facilities were first installed. Today, mammals, birds and snakes cause a significant number of electric outages throughout North America and recent studies show animal-caused outages are increasingly common in both urban and residential areas<sup>6</sup>.

By taking a proactive approach to mitigating outages, utilities can address reliability and environmental concerns in an appropriate manner while at the same time avoiding increased scrutiny from regulatory agencies. Reducing outages in today's competitive environment also represents an opportunity to gain a competitive edge through increased reliability and reduced operations and maintenance costs.

Simply *using* wildlife guards is not enough however. To yield the greatest possible benefit, wildlife guard applications need to be considered carefully. The guards must be properly specified and installed. Applying guards haphazardly or without fully considering their interaction with the other line hardware can lead to very undesirable results. In some cases, misapplied guards may not offer any additional protection meaning that the cost to apply the guards was wasted. In more drastic cases, using the wrong guard or improperly installing guards can actually increase outage rates and make outages more damaging than they would have otherwise been.

### Considerations for Specifying Wildlife Guards

There are a number of factors that should be considered before specifying use of a particular guard. Due diligence in the specification process will reduce the likelihood of problems arising later on by ensuring that the right guard is installed and in the proper manner.

#### Ensure that the Wildlife Guard Fits the Intended Application

Ill-fitting wildlife guards offer little or no protection. It is essential to make sure that the correct guard is used in all applications. Figure 3-1 provides an example of improperly applied wildlife guards that do not properly fit the intended application. These guards do not sufficiently encapsulate the top of the bushing. Unfortunately, this particular application allowed a squirrel to short one of the bushings causing a flashover that spread to multiple phases.

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<sup>6</sup> *Distribution Wildlife and Pest Control*. EPRI, Palo Alto, CA: 2001. 1001883.



**Figure 3-1**  
**Poorly Fitting Wildlife Guards Do Not Mitigate Wildlife Interactions**

### Use Hardware-Specific Guards

It is best to use wildlife guards that are designed for use on specific hardware. Universal-fit or one-size-fits-all products rarely fit well. A guard that is designed for a specific application, cut-out cover-ups for example, are more likely to fit properly and offer better protection from wildlife and less likelihood of dislodgement due to wind, precipitation, or animal contact. For some hardware that are available in different sizes, such as lightning arresters, it is best to specify a guard that is molded for that specific make and model of equipment.

Also consider if the wildlife guard has enough ports for running multiple conductors in and out. Transformer bushing covers are one common application that frequently require at least two conductors to pass through the guard – the lead to the bushing and the lead to the lightning arrester. Also consider the application of the guard with gapped arresters. It is best to use a guard that fits correctly rather than have crews modify guards in the field.

### Workability

How easy are the guards to work with? Do they apply and remove easily using your current work practices? One of the best ways to answer these questions is to procure a few dozen of the wildlife guards being considered and give them to a few line crews for evaluation. It only takes a few minutes of handling a guard to determine if it is easy to work with. A good (and safer)

option for initial testing is to apply a new guard to a de-energized transformer on the ground at a storage yard. A few key characteristics to look for are:

- *Latches* – are they too tight? Too loose? The ideal latch closes snugly with moderate effort and latches tightly enough that you are sure it is closed properly. Some latches loosen-up after several open-close cycles which can be a remedy for overly stiff latches.
- *Hotstick application* – most guards are difficult to apply with a hotstick (even if the manufacturer says their product can be hotstick applied).
- *Field modifications required* – some guards are designed with a one-size-fits-all approach and are intended to be modified by the utility. For example, there are certain boot-type bushing guards that come with a deep boot that is intended to be trimmed for each application. This requires a good deal of time on the part of the line crew and leads to roughly cut edges and a poor seal around the bushing. Guard modification should be avoided to the greatest extent possible.

The bottom line is that wildlife guards that are easy to work with will be applied correctly more often, are safer to work with, and can be applied faster than difficult guards.

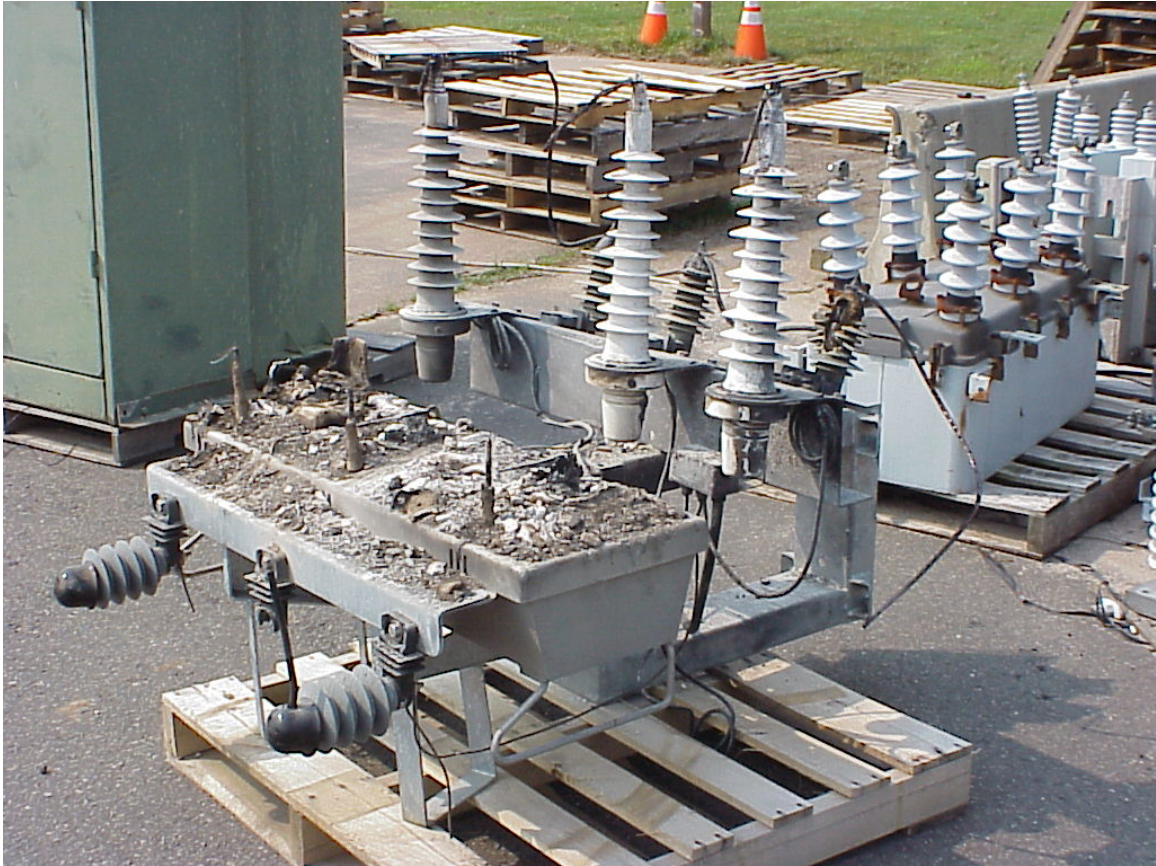
### Flammability

It is highly recommended to use wildlife guards that do not easily support combustion. There are two factors to consider with flammability - ignition temperature and combustion sustainment. Clearly, the most favorable combination would be a very high ignition temperature on a product that does not support combustion.

There are multiple sources which can cause a wildlife guard to burn. One common heat source comes from leakage current and dry-band arcing associated with tracking. This is most common on guards which are improperly applied (installed too low on bushings) but can also occur on properly applied guards, especially in heavy contamination environments. A second heat source comes from a flashover in the vicinity of the guard. Some of the more common ways a guard may be exposed to a flashover are: the guard is overcome by an animal, there is an animal contact somewhere else on the same structure, or lightning initiates a flashover. No matter what the source of the heat, it is desirable for the wildlife guard not to support combustion.

Figure 3-2 shows the aftermath of an event involving a recloser which was exacerbated, and possibly initiated, by burning wildlife guards. Once the wildlife guards caught fire, they continued to burn and dripped burning material causing the fire to spread.

For clamshell-type bushing guards, the molded fingers that cover the guard openings can be particularly problematic. These fingers can act as kindling wood does for a campfire. The long and thin characteristics of the fingers make them susceptible to combustion which then spreads to the rest of the guard. This problem can be aggravated when critters, especially birds, attempt to build nests in this region of the guard. The nesting material causes tracking which generates heat and can eventually lead to failure of the guard.



**Figure 3-2**  
**Recloser Event Exacerbated by Burning Wildlife Guards**

### **Guidelines for Applying Wildlife Guards**

There are numerous products available to help mitigate wildlife-initiated outages on distribution lines. While most of these products will deter unwanted wildlife interaction with distribution circuits, they must be properly applied to achieve this goal. Not all wildlife guards are suited for all applications. For example, just because a particular guard is made for bushing cover-up does not mean that it can be satisfactorily applied to all bushings. The guard must be the right size to properly encapsulate the top of the bushing. Once the right guard is specified then it must also be properly installed.

### ***Improper Installation Practices***

Unfortunately, improper wildlife guard installation is not uncommon. Seemingly minor deviations from construction standards can negate the effect of adding wildlife guards or even increase the outage risk on a circuit.

## Improper Wildlife Guard Placement

Bushing covers are the most commonly utilized animal outage-mitigating product used throughout the United States<sup>7</sup>. Unfortunately, bushing covers are also one of the most often improperly applied guards. A recent EPRI survey of utility wildlife mitigation practices found that 20% of responding utilities reported problems due to improper bushing cover installation<sup>8</sup>.

Most bushing covers are designed to fit just under the top skirt on the bushing. Installing bushing covers below the top insulator skirt places the cover too close to the grounded equipment tank and increases the likelihood of tracking and flashover. Figure 3-3 provides an example of improperly installed bushing covers while Figure 3-4 shows a side-by-side comparison of correct and incorrect installation.



**Figure 3-3**  
**Example of Improperly Installed Bushing Covers**

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<sup>7</sup> *Distribution Wildlife and Pest Control*. EPRI, Palo Alto, CA: 2001. 1001883.

<sup>8</sup> *Current Issues and Concerns on the Impact of Wildlife and Vegetation on Overhead Distribution Lines*. EPRI, Palo Alto, CA: 2006. 1012437.



**Figure 3-4**  
**Comparison of Correct and Incorrect Bushing Cover Installation**

### Cutting and Puncturing Wildlife Guards

Common wildlife guard field modifications include cutting the guard in half and cutting new conductor holes through the guard. For applications where clamshell guards don't quite close around a bushing the guard is often cut in half, placed around the bushing, and secured in place with a few wraps of tape or nylon ties. This is problematic for a few reasons including the fact that the guard now has fully exposed slits down each side and that a few wraps of tape (or nylon ties) are the only thing holding the guard in place. The tape may degrade over time or be chewed allowing the guard to fall away from the bushing.

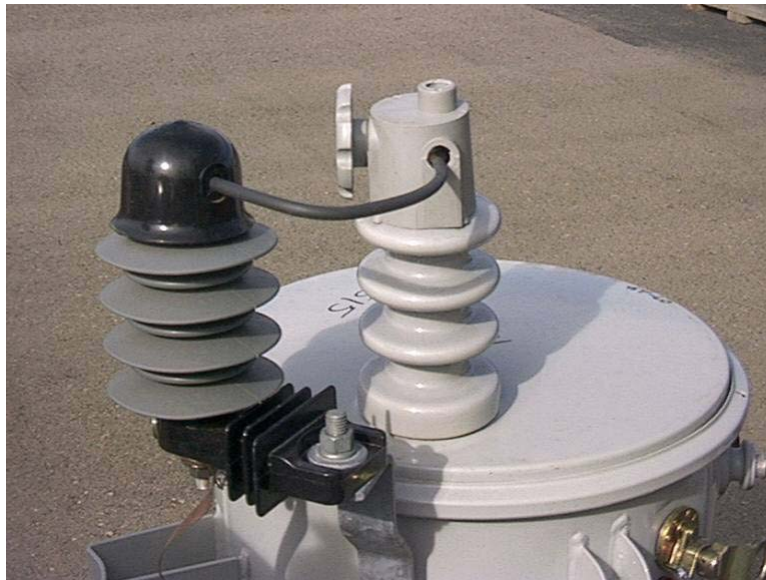
The problem with cutting new conductor exit holes in a guard is that every hole introduces a new weakness in the guard that can be exploited by a critter. Additionally, each conductor that passes through the guard presents a new risk for animal contact. This is especially dangerous for conductors that exit on the side of the guard as they are closer to the grounded equipment tank. Many manufacturers produce guards with multiple conductor ports and use of these guards is suggested when additional conductor exit holes are required.

### ***Transformer Poles and Arresters***

Transformer poles are problematic because of their exposed bushing contacts and because they include other problematic devices such as cutouts, surge arresters, and uninsulated jumper wires. Outages often occur when an animal on a grounded transformer tank touches an energized conductor or bridges the distance between two energized jumper wires. Bushing covers, arrester caps, and 600V-rated insulated jumpers should be used to reduce the risk of wildlife-induced outages.

In general, all new arresters, on transformer poles or otherwise, should be ordered and installed with manufacturer-supplied wildlife caps. 600V-rated insulated covering also should be used for arrester hot leads. No exposed wire should extend beyond the wildlife cap, and leads should be kept as short as possible.

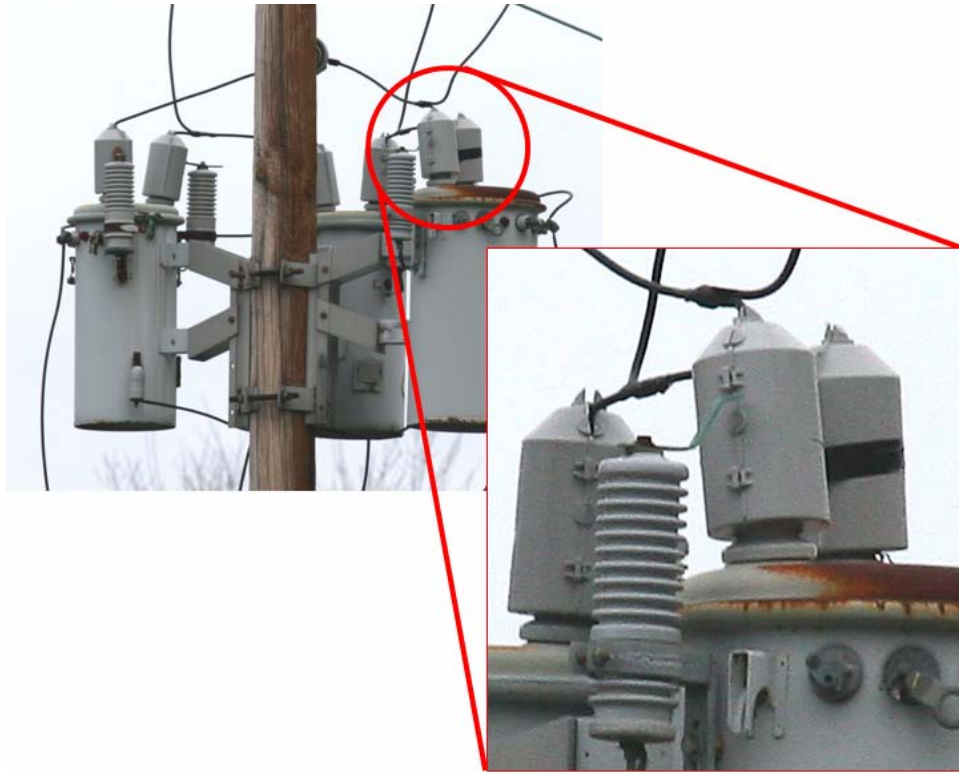
Transformer mounted arresters, like those shown in Figure 3-5 and Figure 3-6, should also be installed with manufacturer supplied wildlife caps and 600V-rated insulated covering. A variety of arrester caps are also available for retrofitting existing equipment.



**Figure 3-5**  
**Arrester Cap and Bushing Guard Installation on a Distribution Transformer**

Older gapped arresters, such as those shown in Figure 3-6, can cause problems if small birds, climbing animals, or even insects span the open gap. When gapped arresters are used, a combination bushing and arrester cover is recommended (Figure 3-7). Otherwise, a transformer bushing cover with a side knockout must be used to provide an adequate opening for the spark gap rod. It is also important to properly align the opening in the bushing cover with the spark gap rod to allow proper arrester operation.

The installation shown in Figure 3-6 does not make a provision for the arrester spark gap which practically negates any protection from the arrester. If this bushing experiences a surge, the arrester will probably still discharge eventually but the wildlife guard material must be punctured first. This scenario is likely to allow enough energy into the transformer that the surge causes an internal failure. Figure 3-6 actually shows a multitude of installation errors on one structure: the guards are applied too low on the bushings, there is no accommodation for the spark gap on the arresters, and a clamshell guard is being held closed with tape.



**Figure 3-6**  
**A Multitude of Installation Errors – Guards Installed too Low, Taped Clamshell-Type Bushing Guard**



**Figure 3-7**  
**Combination Bushing and Arrester Cap**

Figure 3-8 shows a better attempt at accommodating the arrester's spark gap but this installation is still insufficient. Although there is a clear air path between the top of the bushing and the arc gap rod, the distance between the two points is probably too big to allow for adequate protection. That particular guard has a radius of 2.5 inches (63.5 mm). A gap this size will allow a significant voltage spike to impact the transformer before the arrester begins to conduct. This situation is made even worse when considering that a lightning surge presents an intense voltage spike that imposes a very high rate of voltage rise on the transformer and arrester. The transformer internals are more susceptible to this surge than the air gap which means the transformer is likely to suffer an internal failure before the spark gap begins to fully conduct. It is necessary to ensure that the gap distance is set and maintained correctly whenever applying wildlife guards to gapped arresters.

Another consideration is that if this arc gap does fire, the intense heat of the arc could ignite the wildlife guard causing a fire at the pole top.

A better, more reliable choice for this pole would have been to replace the gapped arrester with a polymer body MOV arrester. The use of gapped arresters should be discontinued as much as possible.



**Figure 3-8**  
**It is Unlikely that this Arrester is providing Adequate Protection Given the Length of the Spark Gap**

## **Cutouts**

Cutouts are problematic because they are often mounted near a grounded surface or near other energized equipment so there are many possible paths for a critter to cause a fault. There are two ways to prevent cutout problems: isolation and insulation. Isolation entails mounting cutouts in a manner that makes an animal contact more difficult, such as on insulated fiberglass brackets. Insulation requires covering the potential phase-to-phase or phase-to-ground points which animals and birds may contact.

Cutouts are often installed with metal brackets. If the metal bracket is grounded, it can easily allow for an animal to bridge the distance between a cutout and ground. Therefore, non-conductive brackets are recommended for circuits with high animal exposure. Covered conductor jumper wires are also suggested for cut-outs on circuits prone to wildlife-induced outages.

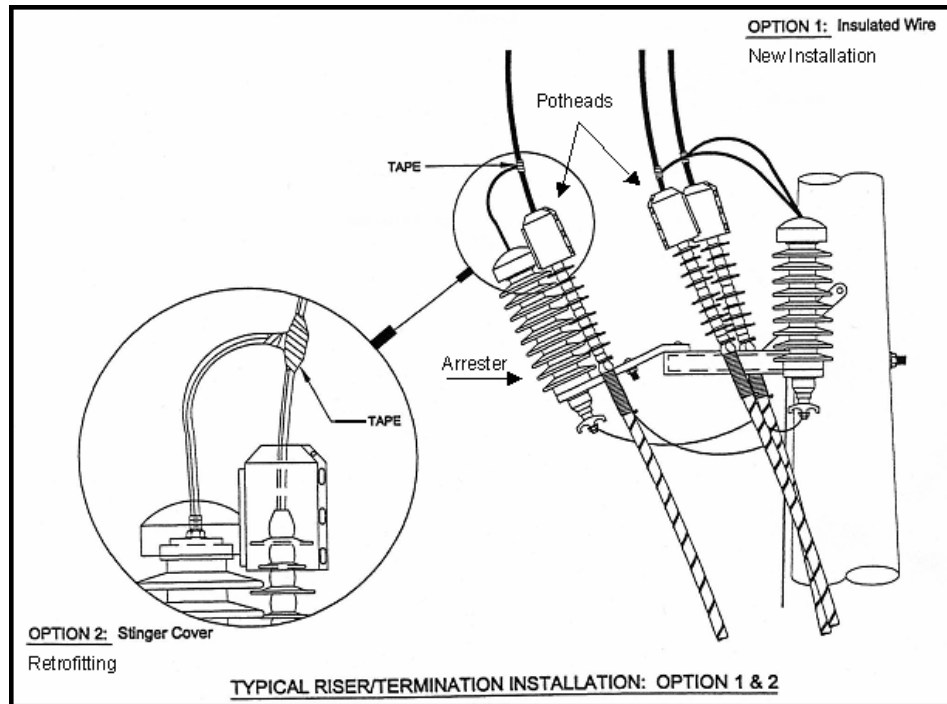
Cutouts also can be covered if they cannot be effectively isolated. Several manufacturers produce cutout covers (Figure 3-9). Cutout covers should always be used in tandem with 600V-rated insulated jumpers. Any conductors that cannot be covered should be wrapped with insulating tape.



**Figure 3-9**  
**Example of Cutout Wildlife Guard and Arrester Cap**

## ***Riser Poles***

Rise poles are problematic due to the large number of devices and connections that are often found on the pole. Cutouts and arresters on rise poles should be covered as previously described. All equipment should be mounted on non-conductive brackets or crossarms. The riser pothead should be fitted with a snap-on clamshell type cover as illustrated in Figure 3-10. Any conductors that cannot be covered should be wrapped with insulating tape. No exposed conductor should extend beyond the bushing cover and leads should be kept as short as possible.



**Figure 3-10**  
**Pothead and Arrester Guard Application for Riser Poles**

## ***Regulators, Reclosers, and Capacitors***

Regulators, reclosers, and capacitors can be lethal to animals due to exposed bushings and jumpers. Reclosers and regulators should include bushing covers, arrester caps, and 600V-rated insulated covering (Figure 3-11) as previously discussed. Groundwires in close proximity to energized items also should be either isolated or insulated. No bare portion of the insulated leads should extend beyond the bushing covers or arrester caps.

Reclosers may mask detection of animal electrocutions by clearing an interruption. If an animal is killed in a remote location it may then go undetected.



**Figure 3-11**  
**Wildlife Guard Application for Reclosers – Bushing Covers, Arrester Caps, Covered Leads, and Non-Conductive Brackets**

Capacitors should always be purchased with animal protection already installed. The animal protection consists of custom-fitted bushing covers and covered jumpers (Figure 3-12). Stinger wires and all capacitor protective devices also should be animal guarded. Capacitors without animal protection can be retrofitted with aftermarket bushing covers and stinger wire cover.



**Figure 3-12**  
**Capacitor Bank with Factory-Installed Wildlife Guards**

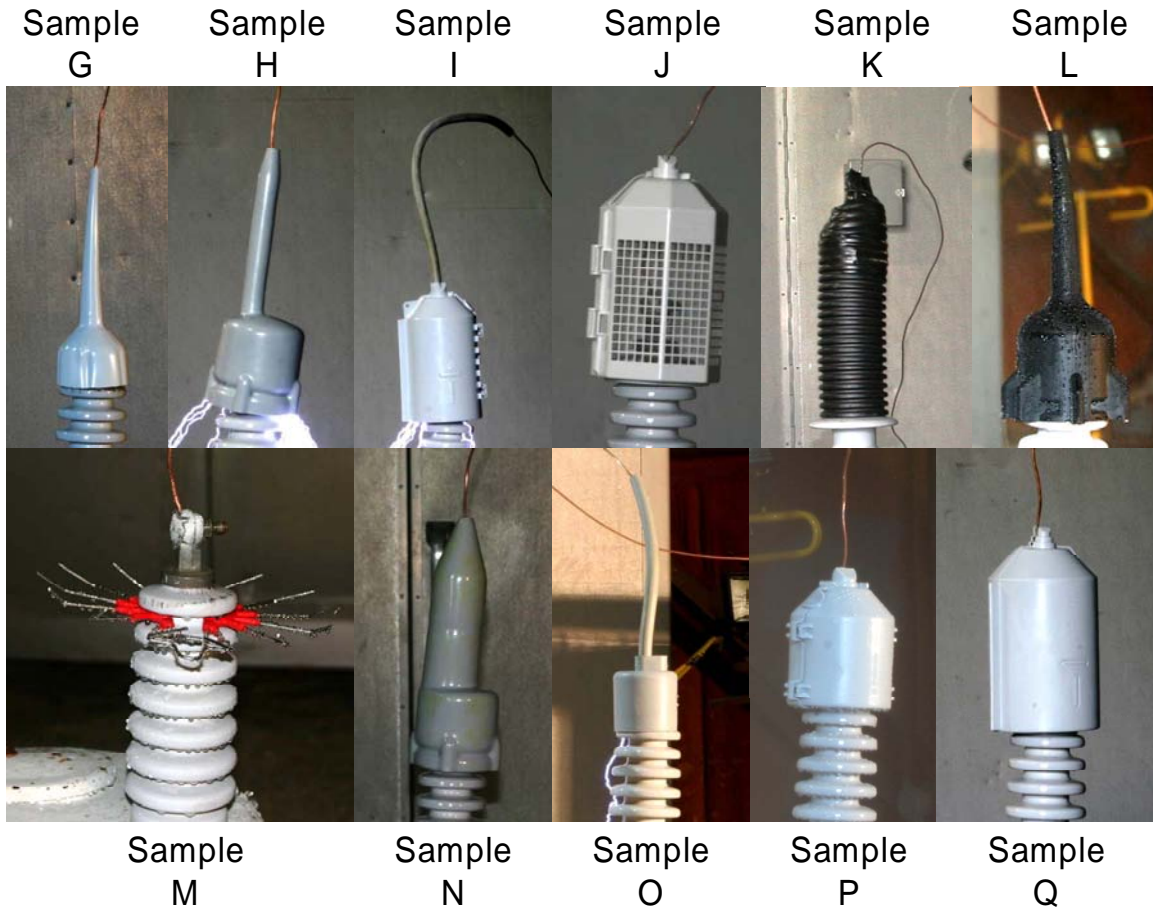
# A

## SUMMARY OF WILDLIFE GUARD SAMPLES

Eleven different wildlife guard models were tested. The samples are produced by nine different manufacturers including one set of shop-made wildlife guards which are produced in-house by the utility. As Figure A-1 shows, the samples included both “clamshell” and “boot” designs and are made from a variety of base materials.

The samples are referred to by letter designation throughout this document rather than by manufacturer or model information. A wildlife guard set of one make and model usually consists of ten to twelve individual guard samples that are used for testing. Upon arrival at EPRI, the wildlife guard set is given a letter designation that is unique to the manufacturer and model combination. Each sample in the set is then inspected inside-and-out and given a unique sample code identification consisting of the sample letter followed by the date and sequence number of its inspection. For example, fictitious sample A-20070502-4 would be the fourth sample inspected on May 2, 2007 from the manufacturer and model combination designated A.

The test samples were sent directly to EPRI from the storeroom stock of utilities participating in the project. They were handled in the same manner as any wildlife guard headed for service in the field. The test samples were not handled roughly but they also did not receive any significant surface cleaning or other special preparations. The goal of this work was to test samples as they would appear in the field. Commonly available lineman’s tools were used to make any required modifications to the samples during installation on the test fixture. For example, several of the wildlife guards required a conductor exit hole to be cut in the tip of the sample and lineman’s pliers were employed for this task.



**Figure A-1**  
**Composite Image Showing the Eleven Wildlife Guard Models Tested**

## **Sample G**

According to the manufacturer's literature, wildlife guard G (Figure A-2) has the following attributes:

*Molded of gray, semi-rigid, poly vinyl chloride (PVC), approximately .080 thick. The gray color allows it to blend in with the sky and the color of the transformer housing. This material is highly resistant to arc tracking and damage from ultraviolet attack, weather extremes, salt spray, industrial corrosives and air-borne abrasives such as sand. It will not support combustion. It remains flexible up to -20°F and withstand up to 212°F without sagging.*



**Figure A-2**  
**Wildlife Guard from Sample Set G Installed on a Test Fixture**

### **Sample H**

According to the manufacturer's literature, wildlife guard H (Figure A-3) has the following attributes:

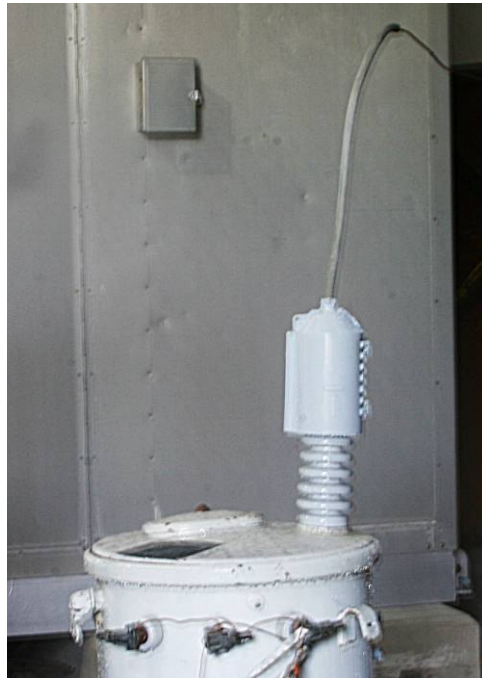
*... the wildlife protectors are made from a light gray, high voltage, plastisol compound that is a minimum of 100 mils thick. This material contains ultraviolet stabilizers and fungicides and has a dielectric strength of 240 V/mil.*



**Figure A-3**  
**Wildlife Guard from Sample Set H**

### ***Sample I***

The Wildlife guards in sample set I are a clamshell design (Figure A-4) with a conductor exit hole on top and a hole on the bottom to fit around the neck of a bushing. The entrance and exit holes are protected by molded “fingers.” Further product information for this wildlife guard is not available.



**Figure A-4**  
**Wildlife Guard from Sample Set I Installed on a Test Fixture**

### **Sample J**

According to the manufacturer's literature, wildlife guard sample H (Figure A-5) is made of an HDPE resin. The guards are a hinged clamshell design.



**Figure A-5**  
**Wildlife Guard from Sample Set J Installed on a Test Fixture**

### **Sample K**

The wildlife guards in sample set K are shop-made by the utility that uses them. The main body of the guard appears to consist of corrugated black polyethylene pipe cut to length. The pipe has an approximate diameter of four inches. Two relief cuts are made at the top to allow the pipe to be “closed” around the conductor and the opening is sealed with linerless rubber splicing tape. These guards are applied on the bushings of substation breakers and “sit” on top of the top shed of the bushing, similar to the test installation shown in Figure A-6.



**Figure A-6**  
**Wildlife Guard from Sample Set K Installed on a Test Fixture**

### **Sample L**

The wildlife guards in sample set L are an injection molded boot design. According to the manufacturer's literature, the guard is molded from a thermoplastic elastomer (TPE) material and is pigmented black to help enhance the material's resistance to UV degradation. Figure A-7 shows one of the guard samples installed on the test fixture.



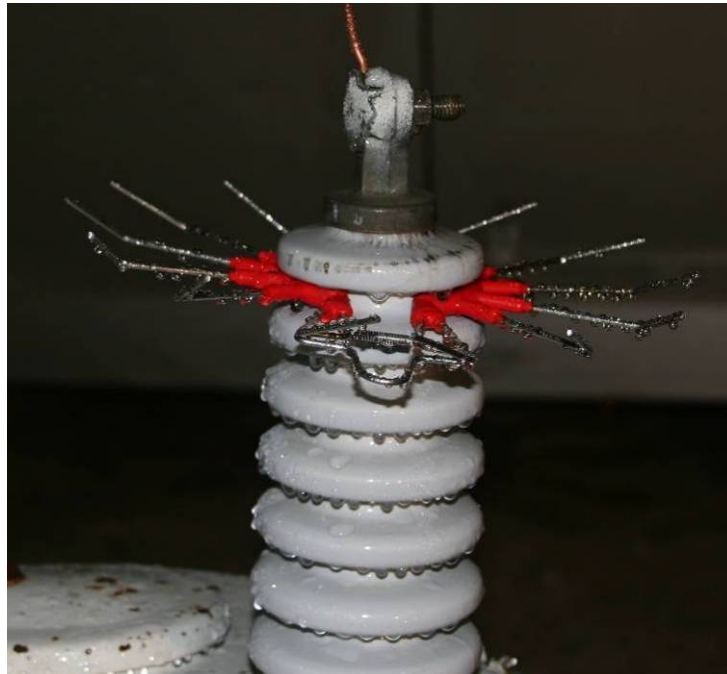
**Figure A-7**  
**Wildlife Guard from Sample Set L Installed on a Test Fixture**

### **Sample M**

The wildlife guards in sample set M use an electric shock to deter wildlife contacts with energized components. The shocking potential is generated by the guard's placement in the electric field near the top of the bushing. According to the manufacturer's literature, the electrostatic guard is intended to function as follows:

*...animal guard consists of rugged plastic with metal spokes radiating outward. When an animal touches the spokes, it receives an electric shock, similar to those generated by electrified livestock fences. The animal is not injured and power service is not interrupted.*

Figure A-8 shows one of the guards installed on the test fixture. According to the manufacturer's instructions, the guard should be installed in the "tines-up" position but it can also be installed "tines-down" if sufficient clearances can't be achieved with the tines pointing upward.



**Figure A-8**  
**Wildlife Guard from Sample Set M Installed on a Test Fixture**

### **Sample N**

The wildlife guards in sample set N are boot-type guards that require de-energized installation since the transformer hot lead is passed through the guard. Manufacturer's literature could not be located for this particular model of guard so the product material and other key characteristics could not be verified. Figure A-9 shows a guard from sample set N installed on the test fixture.



**Figure A-9**  
**Wildlife Guard from Sample Set N Installed on a Test Fixture**

## **Sample O**

The manufacturer's literature for the guards in sample set O states the following:

*All of these insulating caps are manufactured from "Nordel" as produced by Du Pont. Nordel is an ethylene propylene based hydro carbon rubber with outstanding temperature, insulating, and weathering qualities.*

These guards have an overall length of fifteen inches with a three-inch inner diameter cup opening where the guard rests on the bushing. Figure A-10 shows one of the guard samples installed on the test fixture.



**Figure A-10**  
**Wildlife Guard from Sample Set O Installed on a Test Fixture**

### **Sample P**

The wildlife guards in sample set P use a two-piece design in which each half is fitted around the bushing during installation and closed together with interlocking tabs as shown Figure A-11.

According to the manufacturer's literature, the wildlife guard is made from a UV enhanced high-density polyethylene resin. The wildlife guard features multiple conductor entrances with one entrance on the center top and one on each beveled side located just down from the top. All entrance holes are covered by flexible fingers.



**Figure A-11**  
**Wildlife Guard from Sample Set P**

### **Sample Q**

The wildlife guards in sample set Q utilize a one-piece hinged clamshell design with a conductor exit hole on top and a hole on the bottom to fit around the neck of a bushing. The entrance and exit holes are protected by molded “fingers” which can be seen at the top of the protector in Figure A-12. According to the manufacturer’s literature, the wildlife guard is made from UV stabilized polypropylene.



**Figure A-12**  
**Wildlife Guard from Sample Set Q Installed on a Test Fixture**



# **B**

## **TEST PROCEDURES**

### **EPRI Test Procedure Based on IEEE P1656/D8**

At the time of testing in 2007, the IEEE is working towards ratifying IEEE P1656/D8 - *Draft Guide for Testing the Electrical, Mechanical, and Durability Performance of Wildlife Protective Devices on Overhead Power Distribution Systems Rated Up to 38kV*. The tests outlined in the Draft Guide are focused on ensuring that wildlife protective devices do not compromise the electrical performance of the apparatus on which they are applied. IEEE P1656/D8 outlines several different test types including the wet withstand and wet power frequency flashover tests summarized in this report (IEEE P1656/D8 2007).

### **Workability Testing**

An attempt was made to provide a subjective estimation of the workability related issues with the test samples. Expert linemen and high voltage technicians examined the following issues during ease of installation testing:

- Ease of barehanded guard installation and removal
- Ease of guard installation and removal wearing primary gloves
- Ease of guard installation and removal using one or more hotsticks

Installation tests were graded as one of three categories: easy, hard, or not possible. Many samples are configured such that they are not well suited for hotstick installation as the primary lead to the transformer must be disconnected and passed through the guard. These guards are likely to be applied through live-line working techniques using primary gloves. Hotstick tests were therefore marked “NA” for these guards.

The test procedure also called for recording comments on the technician’s general impression of the sample’s durability and how firmly the sample attached to the transformer bushing. The test procedure for the installation portion of the testing is shown in the full EPRI test procedure in Appendix A – Test Procedures.

### **Wet Withstand Testing**

The wet withstand test set forth in IEEE P1656/D8 has two options. The first option involves a moving grounded electrode and the second option utilizes a fixed grounded electrode. Both options require that the test sample be installed in typical fashion with bare No. 6 AWG copper wire. The samples are then soaked with a de-ionized water rain spray that conforms to IEEE Std. 4 requirements (IEEE Std. 4-1995).

The fixed electrode option was chosen because it appears to be a more rigorous test. The fixed electrode method is also inherently safer for the testing technician since the moving electrode method requires the technician to use a hotstick to move a grounded conductor over the surface

of the energized wildlife guard. For the fixed electrode tests, IEEE P1656/D8 dictates that the sample is wrapped in solidly grounded copper mesh. However, there is some room for interpretation within the Guide for how to apply and trim the mesh. The standard reads:

*Wrap solidly grounded copper mesh across all surfaces of the sample, approaching to within 5 cm (-0, +2cm) of the exposed, energized conductor at the end of the sample.*

The above statement makes no mention of how to attach the copper mesh to the sample, how the edges should be trimmed, or how to make the ground connection to the mesh. For the purposes of this testing, these issues were addressed by using solid copper wire wrapped over the copper mesh to hold the mesh on the sample. The copper wire also provides a convenient attachment point for a ground conductor via a large copper spring clip to ground the mesh. The edges of the copper mesh were rolled back upon themselves to eliminate any sharp cut-ends of the copper mesh from sticking out. Every attempt was made to achieve 100% surface contact with the copper mesh although this was not always possible for certain guard geometries.

### **Withstand Test Voltage**

IEEE P1656/D8 states that the test voltage should be 120% of the nominal voltage of the system for which the sample is rated. A system voltage of 14.4-kV was assumed thus requiring a test voltage of 9.9 kV as shown below:

$$V_{\text{Test}} = \frac{14.4 \text{ kV}}{\sqrt{3}} \bullet 120\% = 9.9 \text{ kV}$$

This appears to be a reasonable test voltage as it proved to be challenging for many of the wildlife guards being tested.

### **Withstand Test Procedure**

The withstand test involves mounting the sample on the test fixture (a distribution transformer with the internals removed), covering the sample with solidly grounded copper mesh, and soaking the sample with an IEEE Std. 4 compliant rain spray. After a 5-minute pre-soak period, the rain spray continues to run and the test setup is energized to the test voltage of 9.9-kV line-to-ground. The test duration defined in IEEE P1656/D8 is 60 seconds when using the IEEE Std. 4 precipitation rate of 1-2 mm/minute. However, the EPRI test plan differs from this value in that the test progresses for 10 minutes or until the sample fails, whichever comes first. The withstand test is repeated for a total of three samples and pass/fail is defined in IEEE P1656/D8 as:

*The wildlife protective device passes the wet withstand test if all three samples do not puncture or flashover.*

The results section of this report indicates time to failure and whether or not the sample passed IEEE P1656/D8 withstand criteria for all samples.

The EPRI test plan went beyond the basic IEEE P1656/D8 requirements by adding several other tests to provide a baseline of performance as well as greater detail of the sample performance. In addition to the three required wet withstand tests, the EPRI test plan also requires:

- An initial dry 60-second withstand test without mesh
- An initial wet 10-minute withstand test without mesh
- A dry 10-minute withstand with mesh

These tests provide an indication if discharge activity or damage is likely to result from less severe conditions than those present during the wet grounded-mesh withstand test.

The sample is viewed and recorded with a DayCor camera and UE Ear during all withstand tests. The DayCor camera provides a visual indication of corona discharges on the sample's surface and the UE Ear provides an audio indication of corona. The sample is inspected and any signs of damage are recorded upon completion of each phase of withstand testing and removal from the test fixture. Numerous images are also recorded with a digital SLR camera during all stages of testing.

The full EPRI test procedure is shown in Appendix A – Test Procedures.

### **Wet Power Frequency Flashover Testing**

Wet power frequency tests are performed on a total of three samples of the design under consideration. Wetting is achieved via an IEEE Std. 4 compliant rain spray and the test fixture is a distribution transformer with the internals removed.

The test begins by assessing the dry and wet flashover performance of the test fixture without a sample installed. Five dry and five wet flashovers are recorded and the dry and wet flashover averages are calculated to provide baseline values against which the test object's performance can be compared. IEEE P1656/D8 defines pass/fail criteria for this test as follows:

*The device passes the wet power frequency flashover test if the average flashover value of all three samples is not less than 90% of the value obtained on the test fixture alone.*

Once the test fixture baseline is established, the first sample is installed and tested dry. Five consecutive dry flashovers are recorded to complete the dry portion of testing on the sample. The rain spray system is then turned on and the sample is soaked for 5 minutes. After the soak period, the rain spray system continues to operate and five consecutive wet flashovers are performed. That concludes a full cycle (dry and wet flashovers) for one sample. The sample is inspected and any signs of damage are recorded upon removal from the test fixture. The test fixture top and bushing are then dried and a new sample is installed and the test cycle begins again. This cycle is completed for a total of three samples. Each stage of the process as well as any resulting damage are recorded and photographed.

The results section of this report details sample performance and whether or not the sample passed IEEE P1656/D8 flashover criteria for all samples. The full EPRI test procedure is shown in Appendix A – Test Procedures.

### **Lightning Impulse Withstand Testing**

Lightning impulse withstand tests are performed on a total of three samples of the design under consideration. The test is performed with a peak voltage equal to the basic lightning impulse level (BIL) of the test fixture and tests are performed with both positive and negative polarity.

The test fixture's BIL was determined to be 130 kV so impulse testing of the samples was carried out a 130 kV. IEEE P1656/D8 references IEEE Std. 4™-1995 Section 7.8.2.3 to define pass/fail criteria for this test as follows:

*If no disruptive discharge occurs, the test object has passed the test. If more than one disruptive discharge occurs, the test object has failed to pass the test. If one disruptive discharge occurs in the self-restoring part of the insulation, then nine additional impulses are applied and, if no disruptive discharge occurs, the test object has passed the test.*

*If any evidence of failure in a non self-restoring part of the insulation is observed with the detection methods specified by the appropriate apparatus standard during any part of the test, the test object has failed to pass the test.*

All three test samples must meet these test criteria for the wildlife protective device to pass the lightning impulse withstand test.

The results section of this report details sample performance and whether or not the sample passed IEEE P1656/D8 criteria for all samples. The full EPRI test procedure is shown in Appendix A – Test Procedures.

### **Flammability Investigation**

Basic flammability testing is performed on one sample from each type of wildlife protective device. The testing is intended to assess each sample's flammability characteristics including whether or not the sample ignites when exposed to a heat source and if so, whether or not the sample self-extinguishes once the heat source is removed. This testing does not follow a specific testing standard.

Flammability testing is performed by using a propane torch to apply a flame to each wildlife protector. The flame is applied until the sample begins to burn at which point the flame is removed. The time to ignition and time to self extinguish are recorded along with digital images and video of the testing process.



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