Avian Protection Plan
Lostwood National Wildlife Refuge

March 15, 2003

Prepared by:

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Table of Contents

List of Acronyms and Abbreviations

APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
cm	centimeter
EDM	EDM International, Inc.
EPA	Eagle Protection Act
ESA	Endangered Species Act
GOABS	gang operated air break switch
GPS	Global Positioning System
km	kilometer
kV	kilovolts
LNWR	Lostwood National Wildlife Refuge
MBTA	Migratory Bird Treaty Act
mi	mile
MLEA	Moon Lake Electrical Association
NESC	National Electrical Safety Code
NRECA	National Rural Electric Cooperative Association
REA	Rural Electrification Administration
ROW	right-of-way
ROWs	rights-of-way
RUS	Rural Utilities Service
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
UV	ultraviolet
v	volt

1.0 INTRODUCTION

Lostwood National Wildlife Refuge (LNWR) initiated this Avian Protection Plan (APP) in 2003 to protect birds from potential electrocution hazards on the installation's existing distribution grid. This is part of a larger program initiated by the U.S. Fish and Wildlife Service (USFWS)

The purpose of this APP is to identify the relative level of electrocution risks to raptors and other large birds that may use power poles for perching. Use of these structures is common by both resident and migratory birds, particularly for foraging. Many raptor species hunt from stationary perches, migratory birds will use power poles for resting during migration, and some species of birds may select certain pole configurations for nesting. All of these uses increase the vulnerability of larger birds for potential electrocution.

As part of the APP effort, EDM International, Inc. (EDM) examined distribution structures to identify pole configurations that may present a risk to perching raptors and other large birds that may move through the LNWR. These field examinations documented low-, medium-, and high-risk structures based on the specific electrical configuration relative to the pole location, associated habitat types, topography, and bird use. These data were compiled to identify the appropriate retrofitting options and to develop a prioritization list for the LNWR, in order to provide both short-term and long-term plans for bird protection.

The following report presents the findings from EDM's field surveys. These variables and APP report objectives include:

- Identification of areas exhibiting an increased risk for bird electrocution and potential electrical outages.

- Appropriate retrofit recommendations.

- Bird-friendly standards for new construction.

The overall goal of collecting these data is to identify potential problem areas for retrofitting within the LNWR.

2.0 LEGAL PROTECTION

The Migratory Bird Treaty Act (MBTA) protects the vast majority of birds in the U.S., with the exception of a few species, such as the introduced house sparrow, European starling, and rock dove (pigeon). The purpose of the MBTA is to afford protection to migratory birds, their parts, nests, and eggs. See 50 CFR § 10.13 for a full list of federally covered species.

The MBTA states that, unless permitted by regulation, it is unlawful to pursue, hunt, "take," capture, kill, possess, sell, barter, purchase, ship, export, or import any migratory birds, or any part, nests, eggs, or products thereof. Culpability is strict liability (i.e., no degree of knowledge need be proven).

For misdemeanors, the penalties include fines up to $5,000 per individual and $15,000 per organization and up to 6 months imprisonment. Migratory bird electrocutions violate the misdemeanor provisions of the MBTA. The USFWS has stated that electrical utilities fall under the provisions of the MBTA, as their utility structures and lines are causing a "take" when electrocutions occur.

Bald and golden eagles, eggs, and their nests are protected under both the MBTA and Eagle Protection Act (EPA). The EPA was first signed into law June 8, 1940, affording protection to bald eagles. On October 24, 1962, the EPA was amended to afford protection to the golden eagle, based on the similarity of appearance of golden eagles to immature bald eagles. The law states no person shall "take," possess, sell, purchase, barter, offer for sale, purchase or barter, transport, export, or import any bald or golden eagle alive or dead, or any part, nests or eggs, thereof without a valid permit to do so. The EPA expands protection beyond the MBTA to define molest or disturb as a "take." Culpability for EPA violations is knowingly or with wanton disregard for the consequences of their act. Maximum criminal penalties for misdemeanor violations of the EPA include fines up to $100,000 per individual and $200,000 per organization and up to 1 year of imprisonment. Vehicles and equipment also can be forfeited for violations.

Additional protection is afforded to threatened and endangered bird species under the federal Endangered Species Act (ESA) (50 CFR 17). The ESA was signed into law on December 28, 1973. The law affords protection to fish, wildlife, and plants listed as federally endangered or threatened. The ESA makes it unlawful to import, export, "take," transport, sell, purchase, or receive in interstate or foreign commerce any species listed as endangered or threatened. "Take" under the ESA means an act that kills, injures, or harms a listed species. Violations may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Maximum penalties (misdemeanor) for violations include fines up to $100,000 per individual and $200,000 per organization, as well as up to 1 year of imprisonment. Vehicles and equipment also can be confiscated. The ESA increases protection to habitat and prohibits the harassment of threatened and endangered birds.

The USFWS has begun to increase enforcement of the MBTA, the EPA, and the ESA. The first utility cited for violation of the MBTA was Pacific Gas and Electric of California. In 1993, the utility was fined $1,500 for violations and agreed to retrofit lines to safer standards. On April 16, 2001, the USFWS issued another notice of violation to the same utility. In an April 2002 settlement agreement, Pacific Gas and Electric Company agreed to inspect a minimum of 200 line miles each year for 5 years. Raptor electrocution mitigating devices must be placed on a minimum of 2,000 poles annually.

In 1998, Sand Point Electric of Alaska was fined $500 and was likewise compelled to retrofit dangerous structures. More recently, however, a plea agreement between the United States Department of Justice and the USFWS with Moon Lake Electrical Association (MLEA) of Utah ushered in an entirely new era of enforcement . Under the agreement, MLEA was given 3 years of probation, ordered to pay $100,000 in fines and restitution, and was required to retrofit structures dangerous to migratory birds. MLEA also was required to enter into a Memorandum of Understanding with the USFWS and to develop an APP.

3.0 CONTRIBUTING FACTORS TO RAPTOR ELECTROCUTION

Power lines situated in areas with low vegetation and flat terrain are particularly attractive to raptors in the western U.S., because they provide structures from which to hunt and roost (Boeker 1972; Benson 1981). Eagles and buteos (soaring hawks) actively use pole structures, particularly in areas where prey is abundant and few other perch sites exist (Olendorff et al. 1981). Pole perches give raptors a wide range of vision and greater attack speed when hunting. Poles also provide a place for raptors to broadcast territory boundaries and find either sun or shade (Colson and Associates 1995). Twelve North American raptor species have been documented nesting on utility structures (Blue 1996). Some raptors, particularly osprey, frequently nest on utility structures (Nelson and Nelson 1976; Blue 1996). Smith (1985) observed that eagles and hawks often perch on outer and upper utility tower sections during the day and roost on inner and lower sections during the night.

Some raptors, such as the red-tailed hawk, actively seek power line corridors (Ansell and Smith 1980) (Photo 1). However, forest dwelling accipiters, such as the northern goshawk, Cooper's hawk, and sharp-shinned hawk *(Accipiter striatus)* rarely perch on power poles as they prefer the seclusion and shelter of trees (Olendorff et al. 1981).

Photo 1 Red-tailed Hawk Using a Communication Pole as a Hunting Perch

Historically, the North American raptor most commonly electrocuted has been the golden eagle. Golden eagles are electrocuted more frequently than bald eagles, and juveniles are more frequently electrocuted than adults (Benson 1981). The most common hawk electrocuted is the red-tailed hawk and the most common owl is the great horned owl (Harness 1997).

Bird dimensions are important when considering bird protection. Table 1 provides average bird sizes and weights for common species that may occur on the LNWR. The

Raptor Research Foundation recommends a minimum of 60-inch spacing between phases and phase-to-ground to minimize bird (specifically eagle) electrocutions (APLIC 1996). A large female eagle may have a 90-inch wingspan (54 inches between wrists); however, the 60-inch spacing was selected based on the fleshy wrist-to-wrist distance. The distribution line spacing recommendations also were developed specifically to minimize electrocutions of immature eagles when they begin or terminate a flight, as this is when these younger birds are the most vulnerable to electrocution.

Table 1 Average Size and Weight of Nine Bird Species that May Occur In and Near the Project Area

Species	Length (Inches)	Wingspan (Inches)	Weight (Pounds)
Golden Eagle	30	79	10
Bald Eagle	31	80	9.5
Ferruginous Hawk	23	56	3.5
Swainson's Hawk	19	51	1.9
Red-tailed Hawk	19	49	2.4
Rough-legged Hawk	21	53	2.2
Osprey	22	63	3.5
Great Horned Owl	22	50	5.5
Great Blue Heron	47	84	6.5

Adapted from Wheeler and Clark 1995 and Terres 1991

Numerous factors in addition to bird size and conductor separation contribute to electrocutions. Inclement weather, particularly wet snows, is a major contributing factor to many eagle electrocutions (Benson 1981). Feathers are good insulators unless they become wet. Raptors with wet feathers are 10 times as vulnerable to electrocution above 5,000 volts (Nelson 1979a; Olendorff et al. 1981). Dry birds contacting live wires with their beak and foot, however, can still be killed at voltages below 5,000 (Olendorff et al. 1981). Wet birds also may have greater difficulty navigating around energized conductors when flying to and from poles.

Wind direction relative to utility crossarm orientation also affects the probability of electrocution (Boeker 1972; Nelson and Nelson 1976; Nelson 1977; Benson 1981). Crossarms mounted perpendicular to the wind allow raptors to soar away from the structure and attached wires. Raptors taking off from crossarms mounted parallel to prevailing winds can more easily be blown into energized conductors. Wind orientation presumably places inexperienced fledgling birds at greatest risk.

Raptor electrocutions often fluctuate seasonally. In the winter, power line poles are valuable sit-and-wait hunting sites, allowing raptors to seek prey without expending energy on active flight hunting (Benson 1981). During the spring, raptors may increase their exposure to electrocution by utilizing pole structures as nesting sites. Seasonal fluctuations of prey abundance also may influence the number of raptors electrocuted in a particular area (Olendorff et al. 1981; Benson 1981).

Age is a significant factor in golden eagle electrocutions. Adults feed the immature eagles during the first few months after fledging. During this period the young eagles gain flight experience by short perch-to-perch flights. As these birds begin to hunt for themselves they generally still rely on stationary perches. The young eagles are inexperienced in takeoffs and landings and less adept at maneuvering than adults (Nelson and Nelson 1976; Nelson 1979a, 1979b). Short flights from perch-to-perch, hunting from the perch and takeoff and landing experience all place young eagles at a high risk for electrocution (Olendorff 1993).

4.0 METHODS

4.1 Field Surveys

EDM initiated field surveys in order to document high-risk structures, examining the specific electrical configuration relative to the pole location, associated habitat types, topography, and bird use. Rights-of-way (ROWs) in bird concentration areas were examined and, when applicable, field data were recorded. Sites of historic mortality also were examined.

Field data included:

- Pole location
- Photograph number (when applicable)
- Primary voltage
- Configuration of the primary unit(s)
- Equipment associated with each pole
- Any indications of previous bird mortalities associated with a structure (including species identification and approximate age, if known)
- Sign of bird use (e.g., whitewash, castings, prey remains, feathers, and bones)
- Topography
- Associated habitat type(s)
- Bird species observed in and near the structure, and the behavior of these birds (e.g., perched, flying, foraging)
- Any unusual field observation or anomaly

The resulting field data were recorded on standard data sheets (Appendix A) and then transferred into a spreadsheet (Appendix B). Applicable photos were taken of pole configurations, representative habitats, and any mortalities observed during the surveys. Avian mortalities were identified to species, when feasible, and genus or family when insufficient bird remains were available. Cause of death also was recorded, when known.

When retrofitting measures were recommended, a pole number was assigned to the structure, and retrofitting options were identified. The poles were also recorded with a GPS unit so that retrofitting crews can located the poles. The GPS data points are included in the report appendix and as an attached data file.

4.2 Habitat Classification

In rugged, uneven terrain, not all utility poles are at equal risk. Since the purpose of still-hunting is to perch on the highest point to get the best view of the countryside, raptors will select certain poles for perching over others. These “preferred perches” offer the best vantage point and these poles, if unprotected, are more likely involved in electrocutions (APLIC 1996).

An overall habitat ranking of “High,” “Medium,” or “Low” was calculated in the spreadsheet, based on the variables of habitat, bird use (e.g., whitewash, castings, prey remains, feathers, and bones), and topography. Numerical values were assigned relative to these variables to determine a risk value for each pole surveyed. The highest value was given to poles located in rural areas with native vegetation, signs of raptor use, and poles located higher than surrounding poles. The lowest value was given to poles in more disturbed habitats without native vegetation. This strategy to rank habitats was used because geographic location and habitat setting are as important as the technical utility pole design in determining the actual risk of electrocution (Mañosa 2001). This information was combined with the pole configuration risk to prioritize retrofitting, as described below.

The results of the field surveys are included in Appendix B. Habitats classified as “High” are more likely to be used by eagles. Poles classified as “Medium” are more likely to be used by medium-sized raptors such as red-tailed hawks, although eagles also may be present. “Low” areas are less likely to be used by large raptors.

4.3 <u>Pole Risk Classification</u>

The field surveys recorded pole configurations. Starting at the top of each pole, a unit configuration was recorded for each structure along with the presence of transformers, cutouts, surge arresters, and other equipment. The presence of existing animal protection products also was noted. Although a variety of distribution line construction techniques and configurations were observed during the surveys, the existing distribution grid is constructed to standards established by the Rural Utilities Service (RUS).

Research on raptor electrocutions has shown certain structures are more lethal to birds of prey than others. This is especially true when mortality rates are adjusted for structure frequency (Harness 1997). For example, three-phase tangent structures may be responsible for the same number of electrocutions as three-phase transformer banks. However, because three-phase transformer banks occur less frequently in rural areas than tangent structures, their adjusted lethality is significantly higher. Based upon historical problems in the western U.S., the following ranking was used for utility configurations:

High Configuration Risk

- Three-phase transformer banks and other three-phase equipment poles
- Tangent structures with all primary wires supported on a crossarm (RUS C9-1 unit)
- Three-phase deadend and angle poles
- Three-phase riser poles
- Poles with pole-top groundwires

Medium Configuration Risk

- Single-phase transformer banks and other single-phase equipment poles
- Single-phase risers

Low Configuration Risk

- Three-phase tangent structures with the center phase on the pole top (RUS C1 unit)
- Two-phase tangent structures
- Single-phase structures

4.4 <u>Retrofitting</u>

When retrofitting measures were recommended they were recorded on the field data sheets during the pole inspection. Retrofitting measures and the codes used to record them included:

AC	Arrester Cap
BC	Bushing Cover
BS	Bird Spike
CG	Conductor Guard for Primary Conductor
COC	Cutout Cover
EP	Elevated Perch
IJ	Insulated Jumper
RG	Remove/Gap Pole Top Groundwire
TA	Tape
TRI	Triangle (Anti-Perching Device)

When raptor protection devices were already present, they were noted. The proposed retrofitting measures were recorded on standard data sheets and then transferred into a spreadsheet (Appendix B).

The individual number of pieces required to retrofit a pole were recorded on the data sheets to assist with future material ordering. Individual jumper pieces requiring insulation also were noted. For example, a single-phase transformer was frequently recorded as requiring three insulation pieces; one to the cutout, one to the arrester, and a remaining piece from the cutout to the transformer bushing. The proper approach to install retrofitting measures is provided in Chapter 5.0–Structure Configurations and Recommended Retrofitting Measures.

4.5 <u>Retrofitting Prioritization</u>

A pole retrofitting prioritization list was developed to provide both short-term and long-term plans for bird protection (Table 2). Recommendations were prioritized based on both the habitat and pole risk classification system discussed in the previous paragraphs.

Table 2 Retrofitting Prioritization Determined by Habitat Use and Pole Configuration

Categories of Electrocution Risk			
	Pole Risk Configuration		
Habitat Classification	**Low Risk Config.**	**Medium Risk Config.**	**High Risk Config.**
Low Quality	**3**	**3**	**2**
Medium Quality	**3**	**2**	**1**
High Quality/Preferred Perch	**2**	**1**	**1**

Retrofitting Priority **1** – High Risk Pole
Retrofitting Priority **2** – Medium Risk Pole
Retrofitting Priority **3** – Low Risk Pole

The highest priority was placed on high-risk equipment and deadend poles located in areas with high-quality habitat for birds and their associated prey base or near known raptor roost/nest sites. A retrofitting priority of "High" also was assigned to structures with carcasses/bones (i.e., mortalities) at the pole base or preferred perch poles with inadequate spacing.

Structures with reduced clearances located in lower quality habitat were assigned a "Medium" retrofitting priority. Although these structure types are potentially lethal, they did not show signs of heavy raptor usage and were typically located near roads or other human-related areas. Low-risk structures in high-quality habitat also were assigned a medium retrofitting priority due to the potential frequency of bird use.

A "Low" priority was assigned to potential hazardous structure types located in more disturbed areas with low raptor use (e.g., parking lots, urban areas). The retrofitting prioritization is included in the field data spreadsheet located in Appendix B.

The 1981 version of APLIC's *Suggested Practices* states that "correcting 2 percent of all structures can eliminate 95 percent of all eagle electrocutions." Even though the authors of this statement acknowledge this is probably overly optimistic, it does illustrate the importance of a habitat/pole configuration approach to optimize retrofitting. This APP provides an approach to identify potentially hazardous pole configurations within the LNWR.

5.0 STRUCTURE CONFIGURATIONS AND RECOMMENDED RETROFITTING MEASURES

The following is a discussion of typical structure configurations and recommended new construction and retrofitting measures. Retrofitting measures were selected that are both effective and economical to install. An emphasis was placed on specifying products that can be safely installed “hot” to minimize labor costs. For simplicity the unit drawings shown are 7.2/12.47kV.

5.1 Single-Phase Tangent Structures

The most common distribution unit types located in rural areas are tangent structures. Figure 1 illustrates a typical single-phase tangent structure constructed on a wood pole. Single-phase lines are usually constructed without crossarms and support a single energized phase conductor on a pole-top insulator. Single-phase structures without pole-top grounds or pole-mounted equipment generally provide adequate separation for all animals.

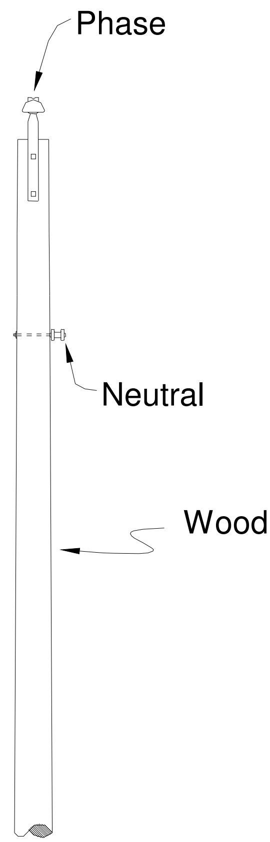

Figure 1 Typical Rural Distribution Single-Phase Pole Configuration, 7.2kV

5.2 Three-Phase Tangent Structures

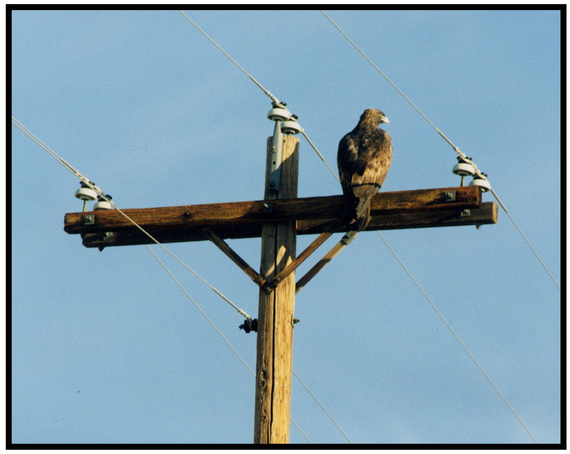

Photo 2 Golden Eagle and a Typical Three-Phase Tangent Structure

Another common distribution unit located in rural areas is a three-phase tangent structure. Figure 2 illustrates a typical three-phase tangent structure constructed on a wood pole. Three-phase power lines are usually constructed with an 8-foot crossarm supporting two conductors. A single energized phase conductor typically sits on a pole-top insulator. Distribution three-phase tangent structures, without pole-top grounds or pole-mounted equipment, generally provide adequate separation for all but the largest raptors since 44 inches of phase separation is provided. There also is a 20-degree angle between the outer and center phase wires. This separation is appropriate in areas where large raptors are less likely to occur. In areas where eagles use these poles as preferred perches (Photo 2), additional protection to minimize the electrocution risk would be recommended. Retrofitting is also appropriate on older REA three-phase tangent structures where the crossarm is mounted on the lower pole-top pin through bolt. These older type units have decreased outer to center phase separation because the crossarm is mounted closer to the pole top.

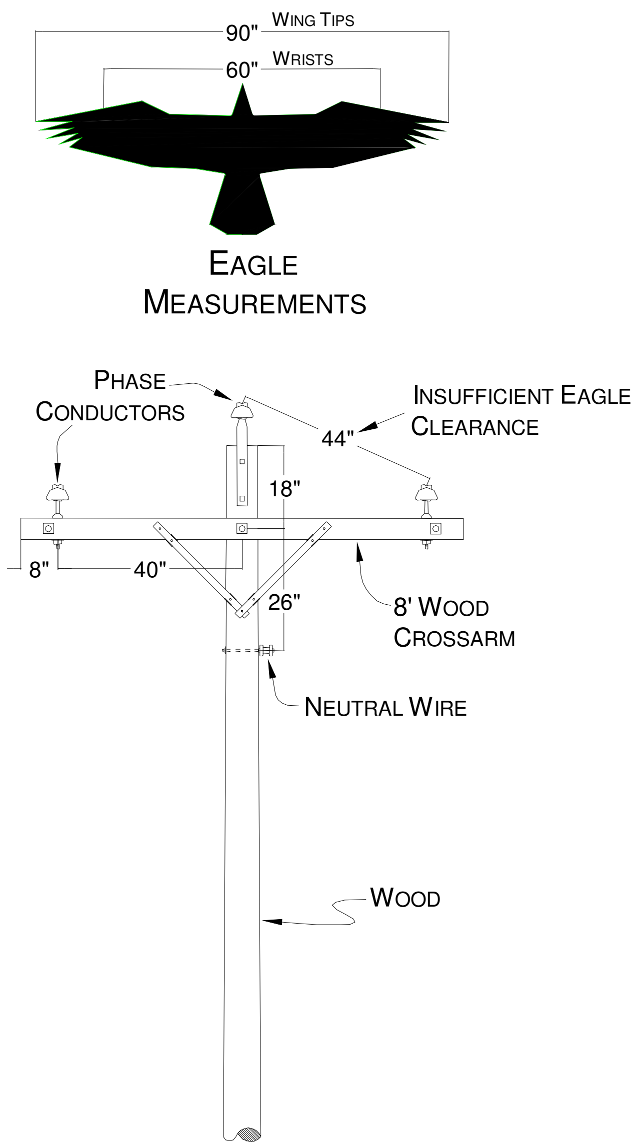

Figure 2 Typical Rural Distribution Three-Phase Pole Configuration, 7.2/12.47kV

In rural areas, new three-phase tangent structures with 8-foot crossarms should be framed to provide an additional 16 inches of clearance, bringing the total phase-to-phase separation to 60 inches as recommended in *Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996* (APLIC 1996). This additional clearance required for eagles can be obtained by lowering the crossarm 27 inches on new poles (Figure 3).

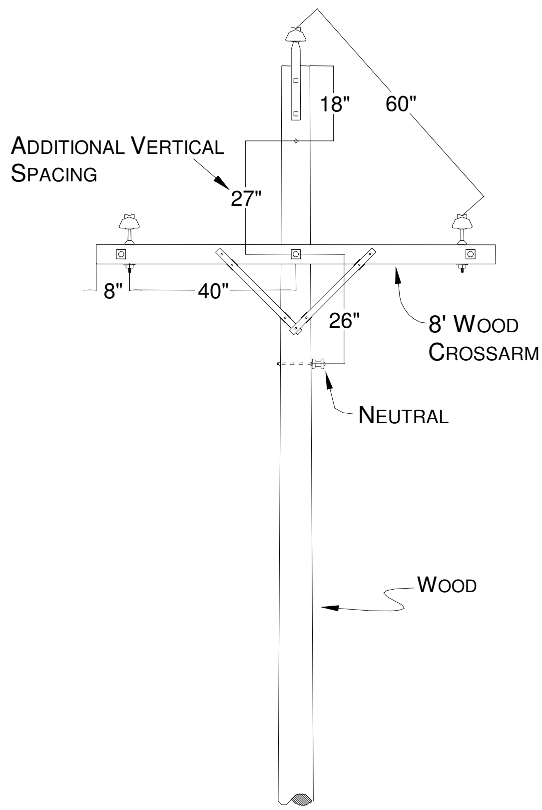

Figure 3 Eagle-Safe Three-Phase Pole Configuration Using an 8-foot Dropped Crossarm, 7.2/12.47kV

Dropping a crossarm an additional 27 inches may require shorter spans or taller poles to maintain safety clearances, adding to the structure cost. A common alternative to dropping the arm is to use a 10-foot crossarm and lowering the arm only an additional 12 inches (Figure 4). This provides the recommended 60 inches of separation without using taller poles and is the most economical method to raptor-proof a structure.

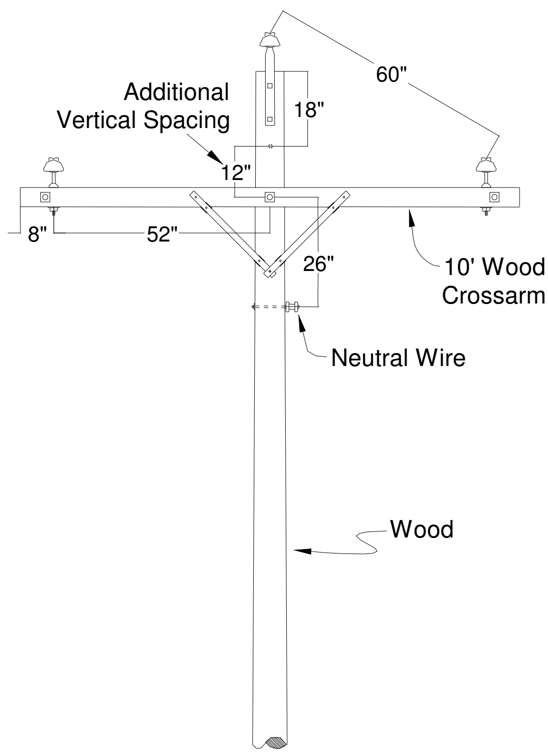

Figure 4 Eagle-Safe Three-Phase Pole Configuration Using a 10-Foot Crossarm, 7.2/12.47kV

If large conductors are used, mounted 8 inches from the crossarm end, the crossarm will need to be dropped to maintain 60 inches of separation.

Retrofitting options applicable to three-phase tangent structures, if warranted, include installing devices to discourage bird perching or covering energized components to prevent a phase-to-phase or phase-to-ground fault. Anti-perching triangles and newly available bird spikes provide suitable retrofitting deterrents to keep large birds from landing on conventional wood crossarms where spacing is less than 60 inches (see Section 5.15, Perch Management). Unfortunately perch deterrents may simply shift the problem to other structures. At preferred perching sites a more effective retrofitting solution is to install conductor guards (Photo 3) on exposed tangent phase wires. Table 3 provides manufacturer options for three different conductor guards. The retrofitting recommendation data in Appendix B use code **CG** to specify conductor guards.

Table 3 Conductor Guards

Manufacturer	Material	Web Site
DMX Industries	Polymer	None: (314) 385-9396
EcoElectrical	PVC w/Silicone Coating	http://www.ecoelectrical.com/
Kaddas	ABS Plastic	http://www.kaddas.com/

Conductor guards can be installed with hotline sticks and will accommodate small line angles. The most widely used cover is the Kaddas *Bird Guard*. The ends of the Kaddas covers must be trimmed for a proper fit to the conductor. Failure to properly trim the ends may result in the covers coming off in strong winds. Some utilities also fit armor rods over the conductor prior to fitting conductor covers, due to wind abrasion and vibration concerns. In areas where airborne contamination is a concern, a conductor cover with a silicone coating may be preferable.

Photo 3 Kaddas Bird Guard Mounted on a Preferred Perch Structure

5.3 <u>Deadend Structures</u>

A deadend is a point on a distribution line where conductors terminate. A double deadend has conductors terminating from two directions. Jumpers are used to connect these two sets of conductors. The arrangement of primary jumpers can be the difference between a safe and lethal structure. For example, a three-phase double deadend structure can either jumper the outer phase jumpers over (Photo 4) or under (Photo 5) the crossarms. Placing jumpers under the arms during new construction precludes large animals from making a phase-to-phase contact with the center phase jumper and is the preferred method. Where safety concerns may prevent the reconfiguration of the jumpers below the crossarm, insulating all three primary jumpers with 600V insulation (see Section 5.11, Primary Jumpers) would be a retrofit option.

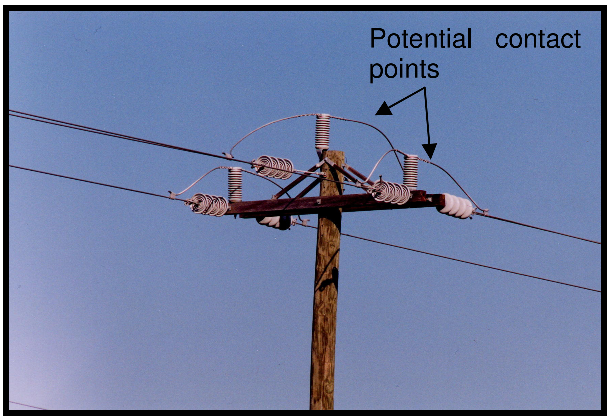

Photo 4 Three-Phase Double Deadend with Exposed Jumpers over the Crossarms

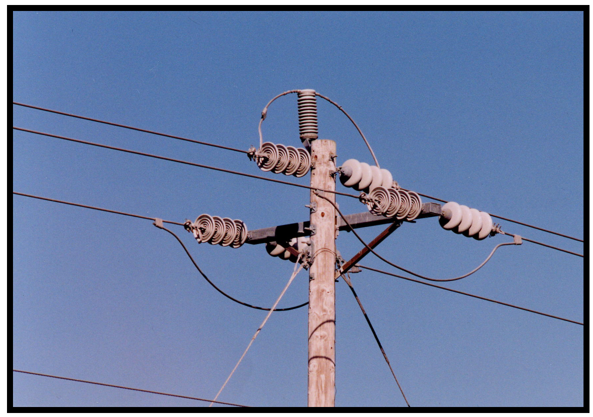

Photo 5 Three-Phase Double Deadend with Jumpers Safely Passing under the Crossarm

Deadend tap structures also can be problematic due to exposed jumper wires. Sixty inches of separation should be maintained or jumpers should be insulated with 600V insulation (see Section 5.11, Primary Jumpers). The center phase also can be fitted with a 26-inch insulated extension clevis to provide additional raptor protection when birds are taking off or landing (Photo 6). Jumpers that are unnecessarily long can increase electrocution problems and should be formed with minimal slack. Vertical construction (Photo 7) is preferred at corners to eliminate jumper issues. Placing the neutral on the pole is preferable to terminating it on the crossarm.

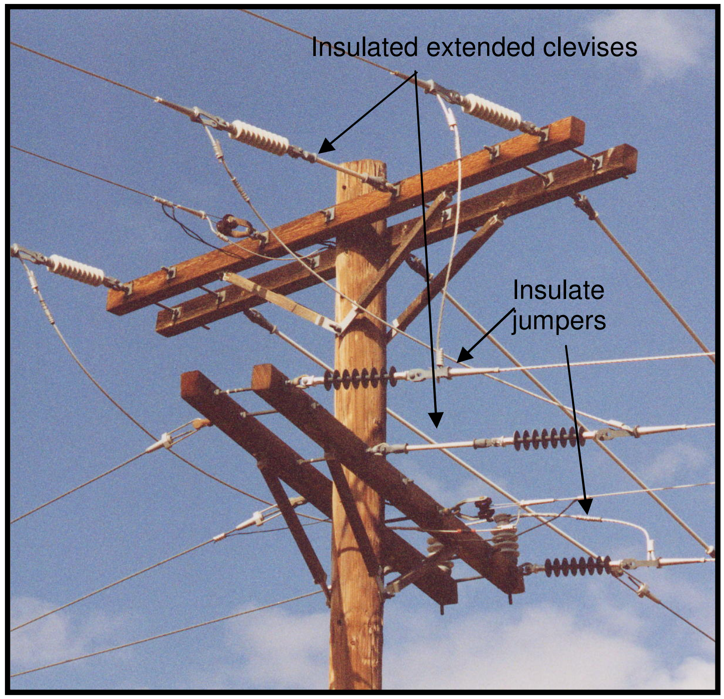

Photo 6 Three-Phase Tap Structure Fitted with Insulated Extended Clevises

Photo 7 Three-Phase Vertical Bird-Friendly Angle Structure

Deadend poles sometimes require insulated jumpers to allow safe perching. Where this is not practical and 60 inches of separation is lacking, perch management is an option (see Section 5.15, Perch Management). However, perch management is most successful when other parts of the structure are still safely accessible to birds.

For single deadend units, anti-perching devices should be placed on only the front crossarm (Photo 8). This placement allows raptors to continue to utilize a safe portion of the structure.

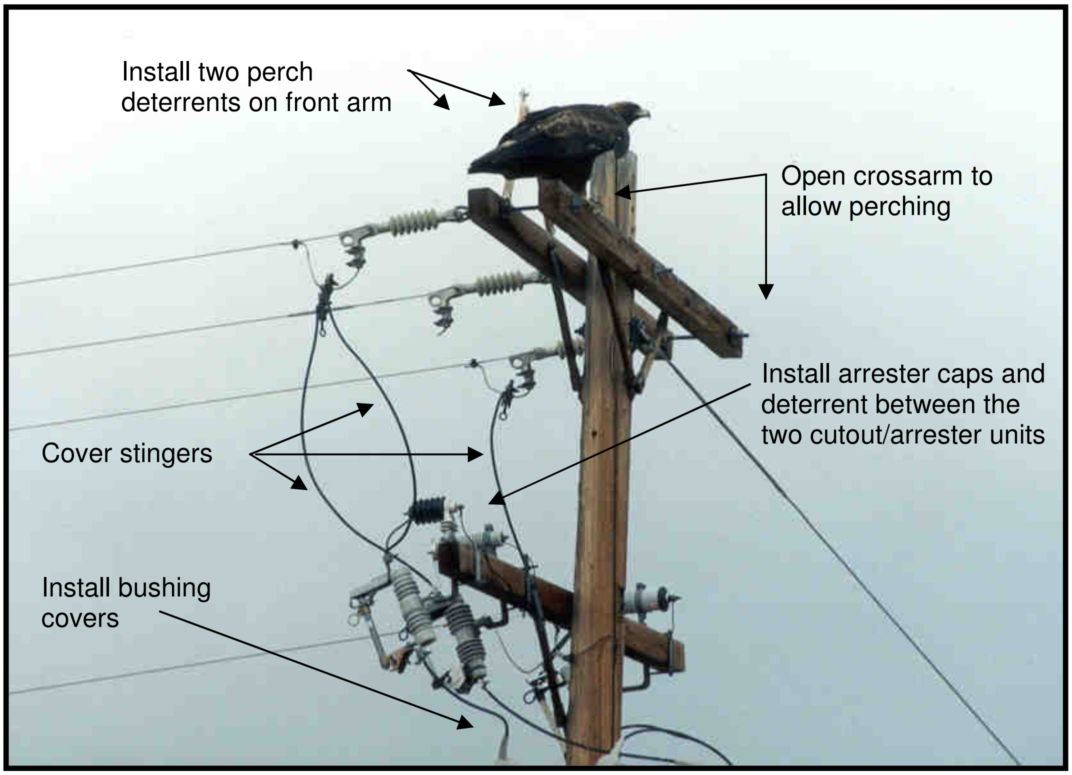

Photo 8 Deadend Structure with Perch Deterrents on the Front of the Structure to Allow Perching on the Safer Structure Portion

Retrofitting deadend tap structures often requires a combination of perch deterrents and insulated jumpers. Where jumpers are in close proximity to other jumpers or grounded hardware, insulation can be used to mitigate problems. Insulated jumpers will not, however, address narrow phase separation terminating on deadend crossarms. Perch deterrents are recommended to prevent birds from trying to land between narrowly spaced wires. For example, at angle structures, anti-perching devices should be placed on the top and lower crossarms between exposed phase jumpers (Photo 9). If the neutral wire also terminates on the crossarms, additional perch deterrents should be placed on the front face of each crossarm to prevent phase-to-neutral contacts when birds are either taking off or landing.

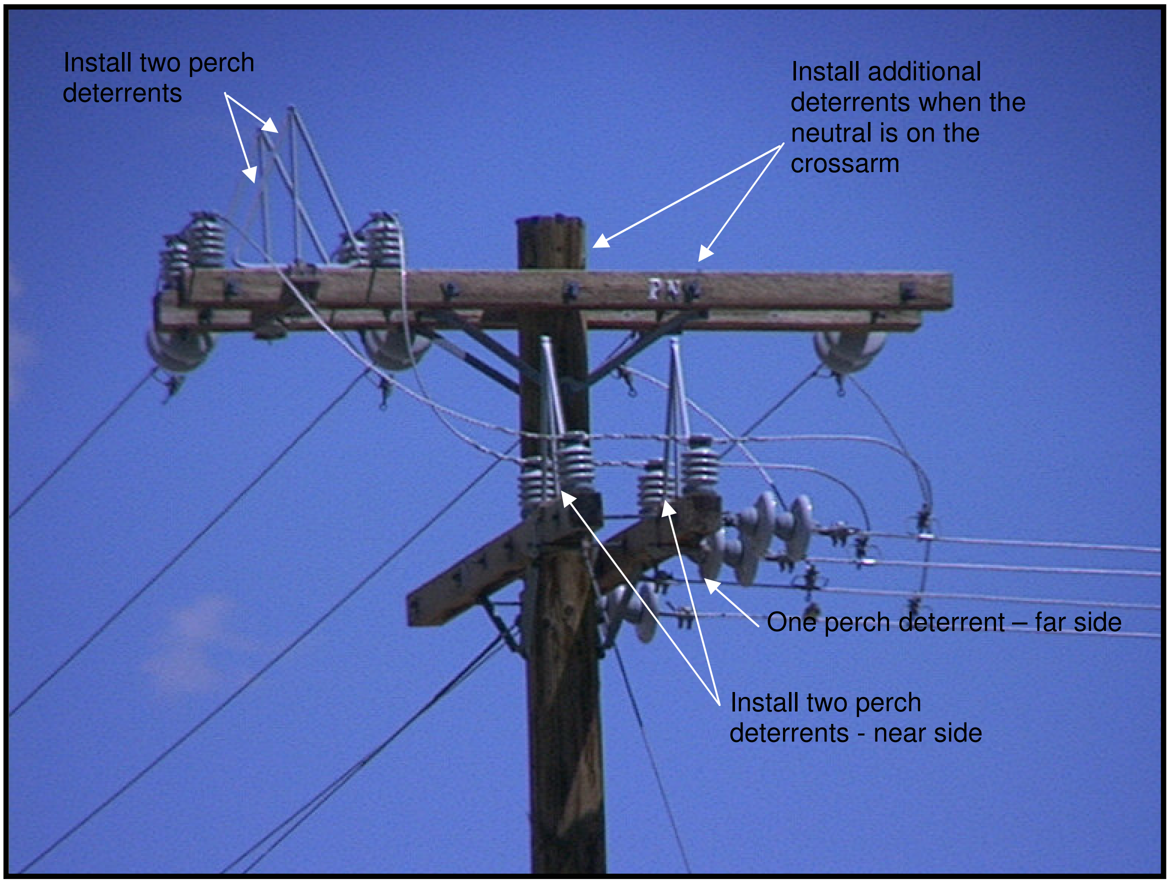

Photo 9 Angle Deadend Structure with Neutral on Crossarm

If the neutral terminates on the pole (below the crossarm) and the center phase is jumpered under the crossarm, perch deterrents are only required on the lower crossarm (Photo 10). This configuration will provide adequate separation for hawks and owls. However, if eagles are present, additional perch deterrents should be placed on the front face of each crossarm to prevent potential phase-to-phase contacts when birds are either taking off or landing.

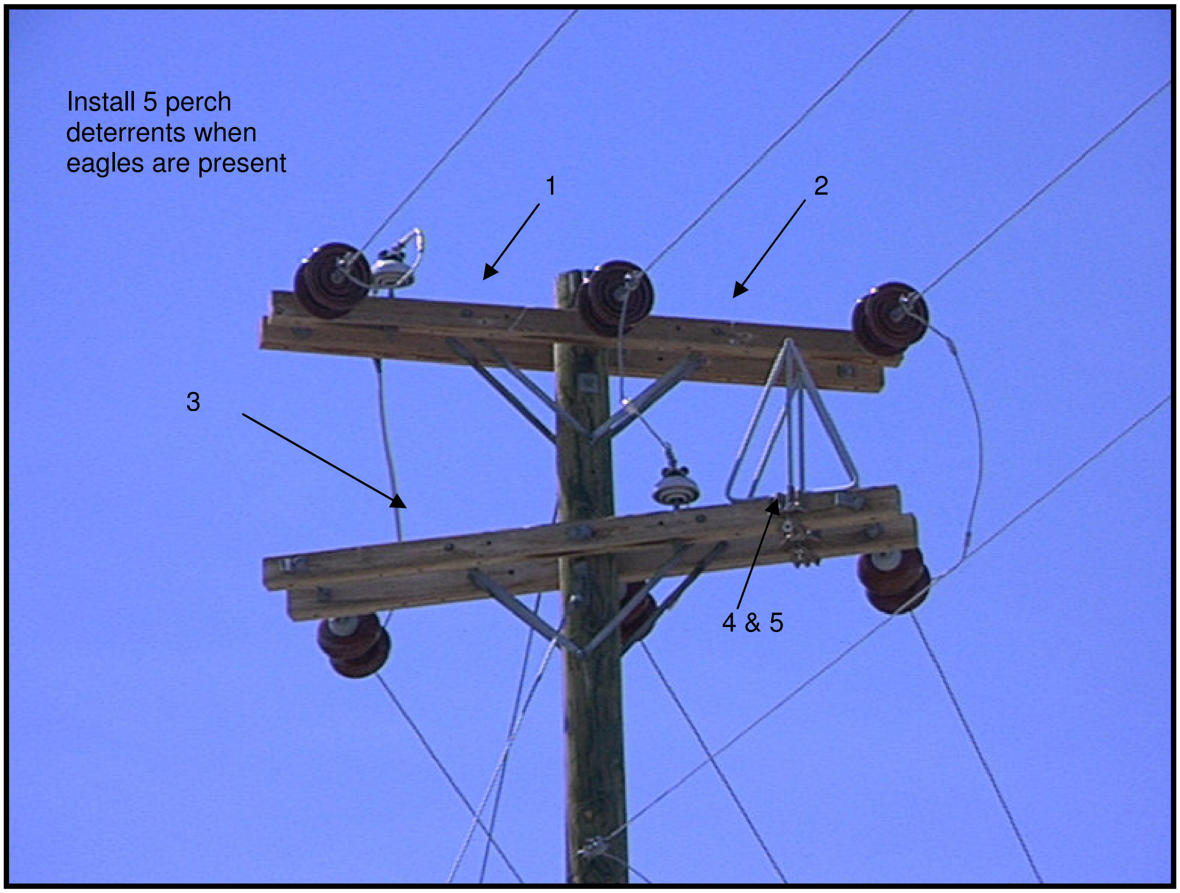

Photo 10 Angle Deadend Structure with Neutral on the Pole

If jumper wires are near groundwires or grounded guying attachments, the grounds also should be covered with protective molding (see Section 5.13, Pole-Top Grounds).

5.4 Crossarms

North American distribution utilities have historically selected wood as the material of choice for poles and crossarms. Accordingly, most animal-proofing techniques are designed for use on wood pole structures. Recently other materials, such as concrete and steel, are being used in distribution line construction. Sometimes non-wood crossarms are used because they are not susceptible to woodpecker damage. In some regions of the U.S., woodpecker damage to wood poles is the most significant cause of pole deterioration. When steel crossarms are substituted for wood, the critical clearance for animals often becomes the phase-to-crossarm separation (i.e., phase-to-ground) (Photo 11).

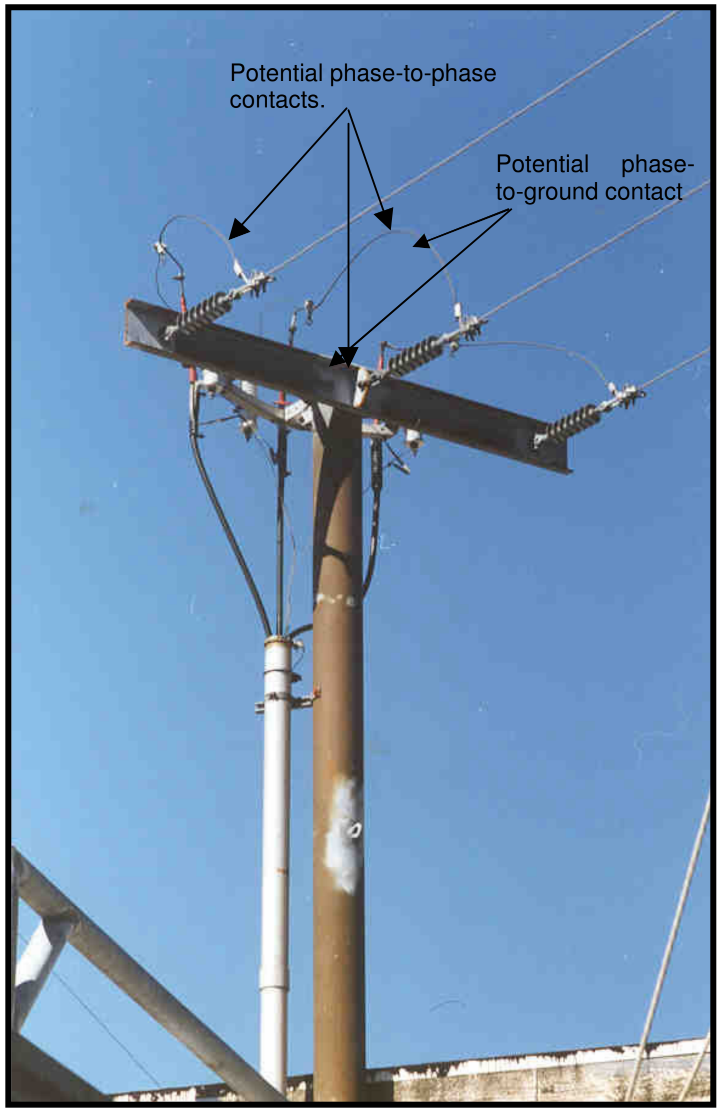

Photo 11 Metal Crossarm Posing a Significant Phase-to-Ground Electrocution Risk

Non-wood crossarms are commonly used in distribution line construction in Europe and other parts of the world and there are differences in electrocution rates of birds on wooden versus metal structures. Sometimes distribution steel crossarms are used in the U.S. as an underbuild on steel transmission poles. LNWR is not using conductive crossarms, but if they are employed in the future, alternative framing such as using suspension insulators instead of pin-type insulators or the use of cover-up material should be considered to eliminate potential animal contacts.

5.5 <u>Crossarm Braces</u>

Prior to 1972, it was common to employ grounded metal crossarm braces. These braces were attached with lag bolts to the pole and crossarm front (Photo 12). Birds perching on crossarms were able to simultaneously touch one energized conductor and a grounded brace. The Rural Electric Association abandoned metal braces in 1972 because grounded braces were contributing to raptor electrocutions. The metal braces were replaced with nonconductive wood braces. All new construction should employ nonconductive braces to minimize animal contacts. In addition, existing metal braces should not be grounded.

Photo 12 Swainson's Hawk Perching on a Crossarm Supported by an Ungrounded Metal Crossarm Brace

5.6 Risers

Risers are poles where an overhead and underground system are connected. Riser poles include protective surge arresters and fused cutouts or switches. The riser pothead is the point where overhead electrical conductors come together and continue down the pole as an underground cable. Potheads are typically supported on either metal brackets or wooden crossarms. The spacing of all of these components can be a risk to perching birds and climbing mammals (Photo 13).

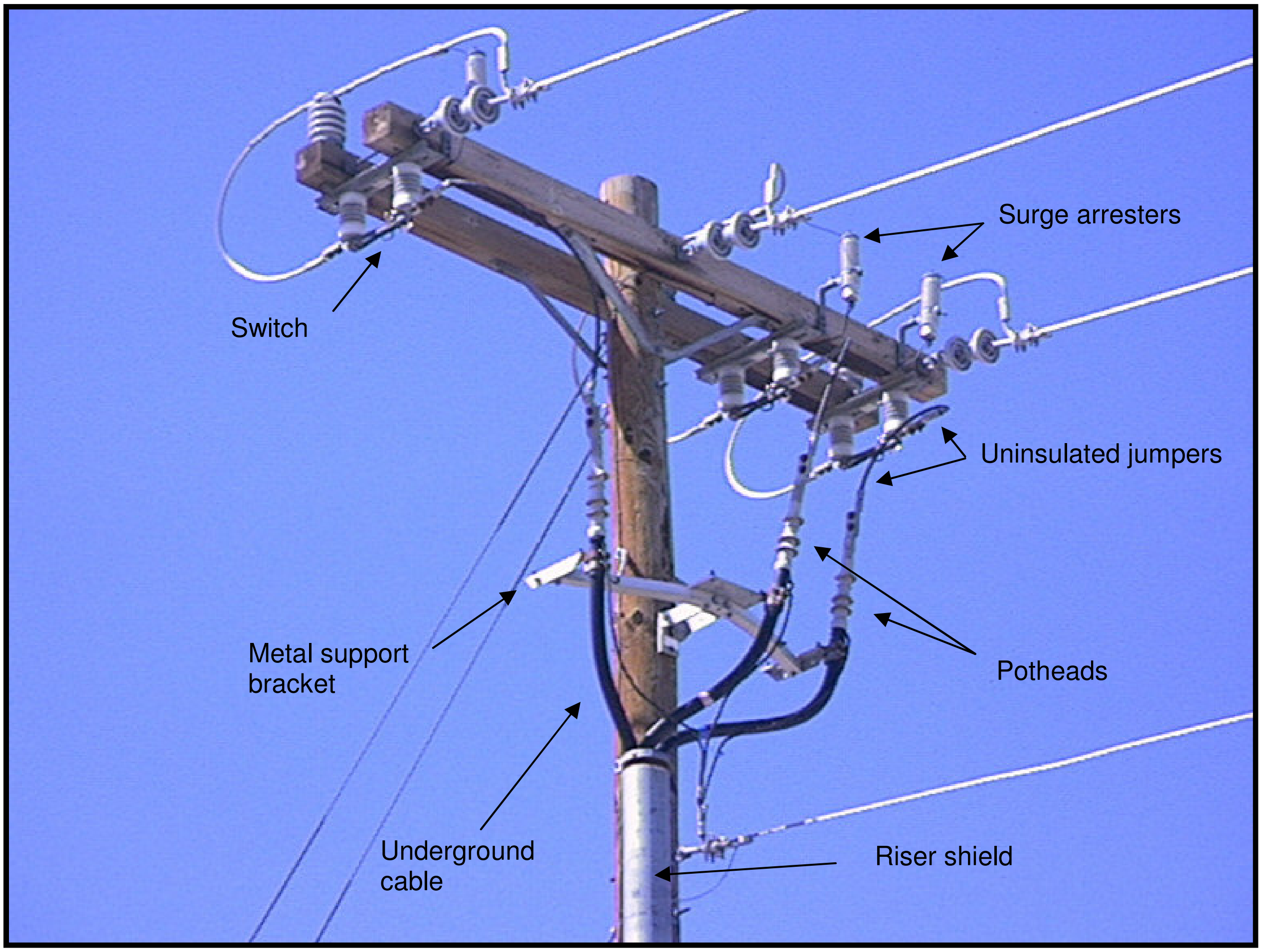

Photo 13 Unprotected Riser Pole

Riser protective equipment and all jumpers should be animal proofed as discussed in Sections 5.9 and 5.12, Cutouts and Stinger Wires, respectively. The riser pothead should be fitted with a snap-on "clamshell" type cover (Figure 5). 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.

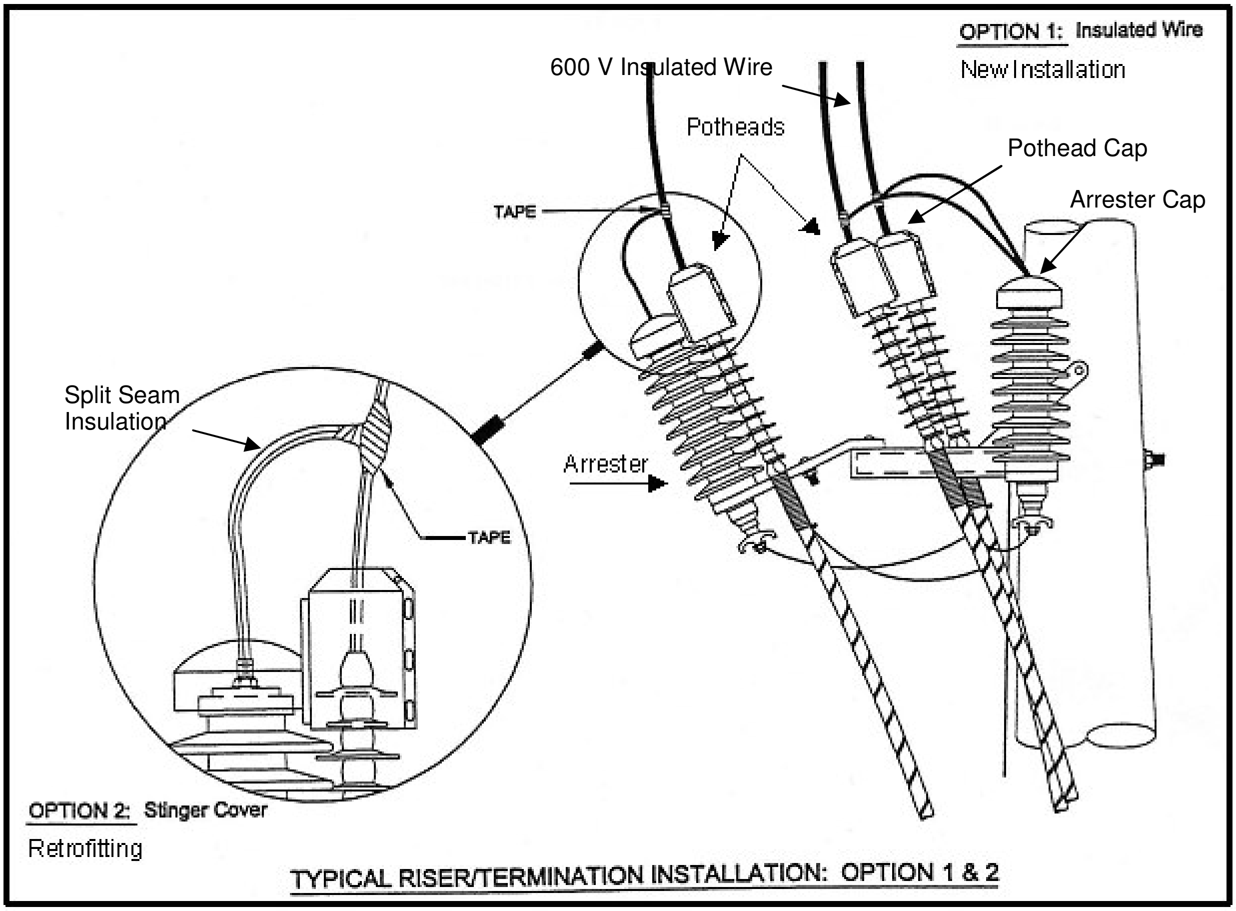

Figure 5 Protected Riser Pole with Pothead Covers

5.7 Transformers

Most overhead distribution line animal-caused outages occur on transformer poles. Equipment 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.

Photo 14 "Wheel-Type" Bushing Cover Delivered with the Transformer

Bushing covers and 600V-insulated wire are a protective system that can provide the necessary insulation level to minimize animal-caused outages. New transformers can be ordered with a "wheel-type" wildlife protector (Photo 14) installed by the transformer manufacturer (Table 4). Porcelain protector models also are available from Porcelain Products Company that will have limited deterioration from exposure to ultraviolet rays, moisture, and temperature extremes. The porcelain protectors are available in either a top entry or side-cable entry.

Table 4 "Wheel-Type" Transformer Protector Manufacturers

Manufacturer	Material	Web Site
Central Moloney, Inc.	Polypropylene	http://centralmoloneyinc.com/
Cooper Power Systems	Polypropylene	http://www.cooperpower.com/
Howard Industries, Inc.	Polymer	http://www.howard-ind.com/
Porcelain Products Company	Porcelain	http://www.porcelainproductsco.com/

All bushing covers should be installed with 600V-insulated stinger wire for additional animal protection (see Section 5.12, Stinger Wires).

A variety of after-market bushing covers are available for retrofitting (Photo 15). These covers are generally made of track-resistant, high-density polymers that either snap on or slide over bushings. Snap-on covers allow installation without removing the transformer stinger wire. Slide-over units require the stinger wire to be temporarily removed in order to slide the cover over the transformer bushing. For retrofitting purposes the "clamshell" type may be preferable (Table 5). The covers can be ordered with a fire-resistant material. If they are struck by lightning the material will not burn and drip to the ground.

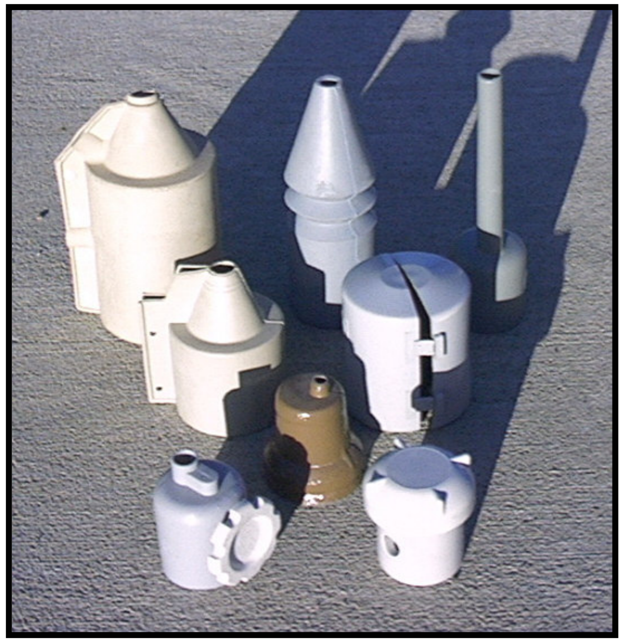

Photo 15 After-Market Bushing Covers

No uniform standards exist for bushing covers, and some are more resistant to ultraviolet (UV) and environmental degradation than others. This degradation can lead to tracking problems. When bushing covers are selected, their properties should be thoroughly reviewed and line crews instructed on the proper method of installation. The retrofitting recommendation data in Appendix B use code **BC** to specify bushing covers.

Table 5 "Clamshell-Type" Bushing Cover Manufacturers

Manufacturer	Material	Web Site
Central Moloney, Inc.	Polypropylene	http://centralmoloneyinc.com/
DMX Industries	Polymer	None: (314) 385-9396
H.J. Arnett Industries	Polypropylene	http://www.arnettindustries.com/
Hendrix Wire and Cable	Polypropylene	http://www.hendrix-wc.com/
Howard Industries, Inc.	Polymer	http://www.howard-ind.com/
Hubbell	Polypropylene	http://www.hubbellpowersystems.com/
Kaddas	Polymer	http://www.kaddas.com/
Preformed Line Products	Plastisol	http://www.preformed.com/
Raychem	BCAC	http://www.tyco.com
W.H. Salisbury & Co.	SALCOR	http://www.whsalisbury.com/
Warco, Inc.	Ethylene Propylene	http://www.warcoinc.com/

It is not uncommon for bushing covers to be placed improperly. Installing bushing covers below the first insulator skirt can eventually result in flashovers. Photo 16 depicts the proper and improper way to install bushing covers.

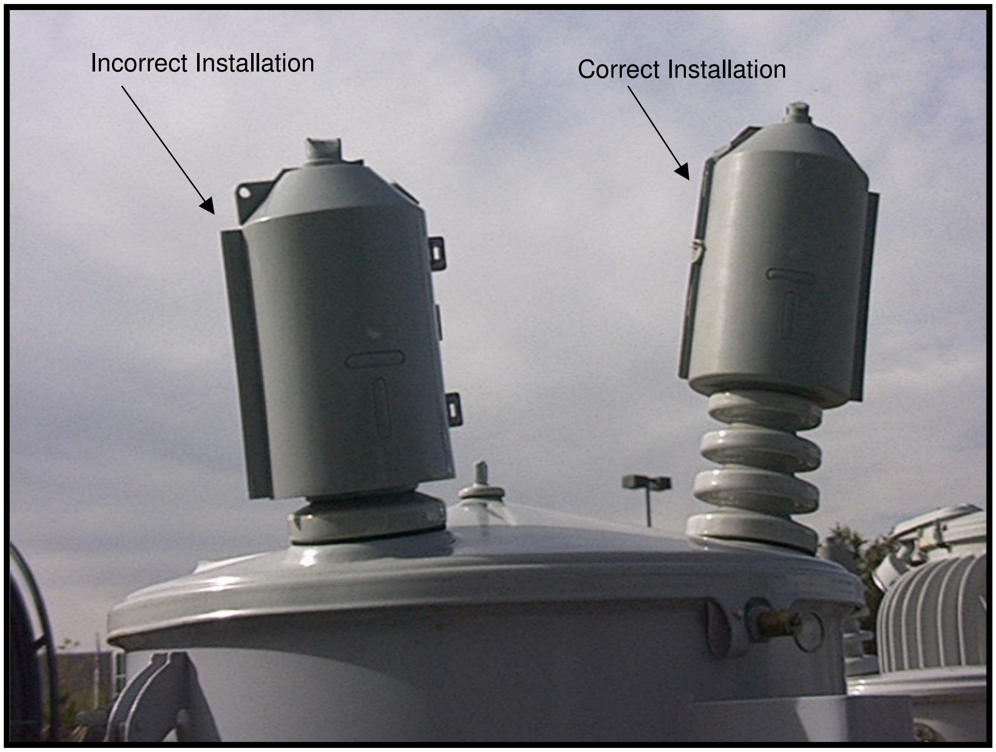

Photo 16 Fargo Bushing Covers Installed Incorrectly (Left) and Correctly (Right) over Transformer Bushings

The Hendrix bushing cover has an internal ridge to ensure their product is correctly installed on the top bushing shed. Covers also can be ordered to cover both the transformer bushing and gapped arrester (Photo 17).

Transformer manufacturers also sell pole-type distribution transformers with a protective insulated cover rated at 15kV dielectric strength. The quoted insulation values may deteriorate over time due to exposure to ultraviolet light, contamination, and other aging factors. However, insulated covers on pole-type distribution transformers will help to mitigate the electrocution of raptors and small animals on the top of transformers. RUS borrowers do not need any special approval from RUS to buy transformers with this feature if the basic transformer is RUS accepted (i.e., included in the RUS List of Materials).

Photo 17 Combination Arrester/ Bushing Cover

5.8 Other Equipment

Regulators, reclosers, and capacitors can be lethal to animals due to exposed bushings and jumpers. Regulators maintain the level of voltage within a prescribed range in order to maintain efficient equipment operation or to prevent equipment damage. Reclosers are pole-mounted devices attached to overhead lines sensitive to interruptions of current flow in the overhead wires. When a recloser senses an interruption it automatically opens and immediately re-closes. If current problems persist after a number of reclosings or "shots" the recloser will remain open; this will cut off power until the recloser is reset manually. Most reclosers are set to remain open after three shots. Reclosers may mask detection of bird electrocutions by clearing an interruption. If a bird is killed in a remote location it may then go undetected.

Reclosers and regulators should include bushing covers and 600V-insulated wire (Figure 6) as discussed in Section 5.7, Transformers. Groundwires in proximity to energized items also should be either isolated or insulated. No bare portion of the insulated leads should extend beyond the bushing covers.

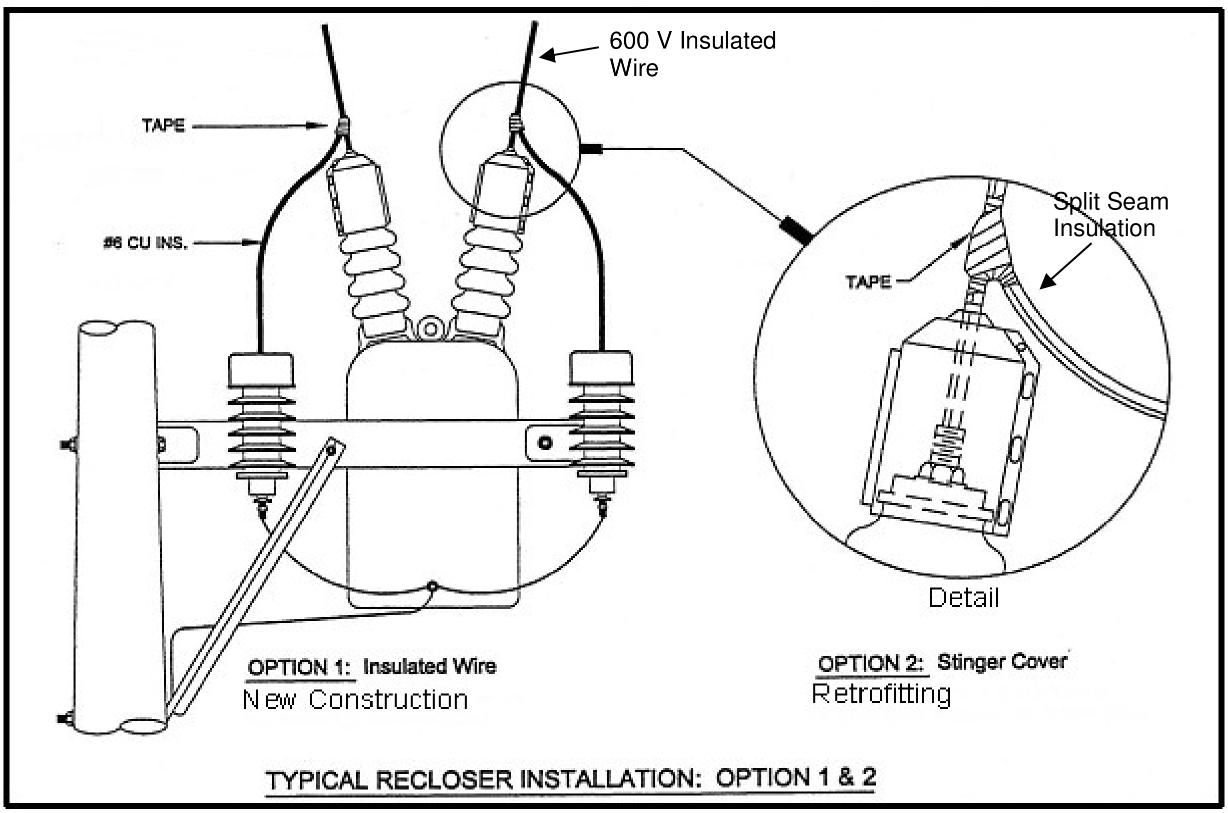

Figure 6 Recloser Fitted with Animal Protection

A capacitor is an electrical device for storing a charge of electricity and returning it to the line. It is used to balance the inductance of a circuit. Capacitors always should be purchased with animal protection already installed (Photo 18). The animal protection consists of custom-fitted bushing covers and covered jumpers. Stinger wires and all capacitor protective devices also should be animal guarded. Capacitors without animal protection can be retrofitted with after-market bushing covers and stinger wire cover.

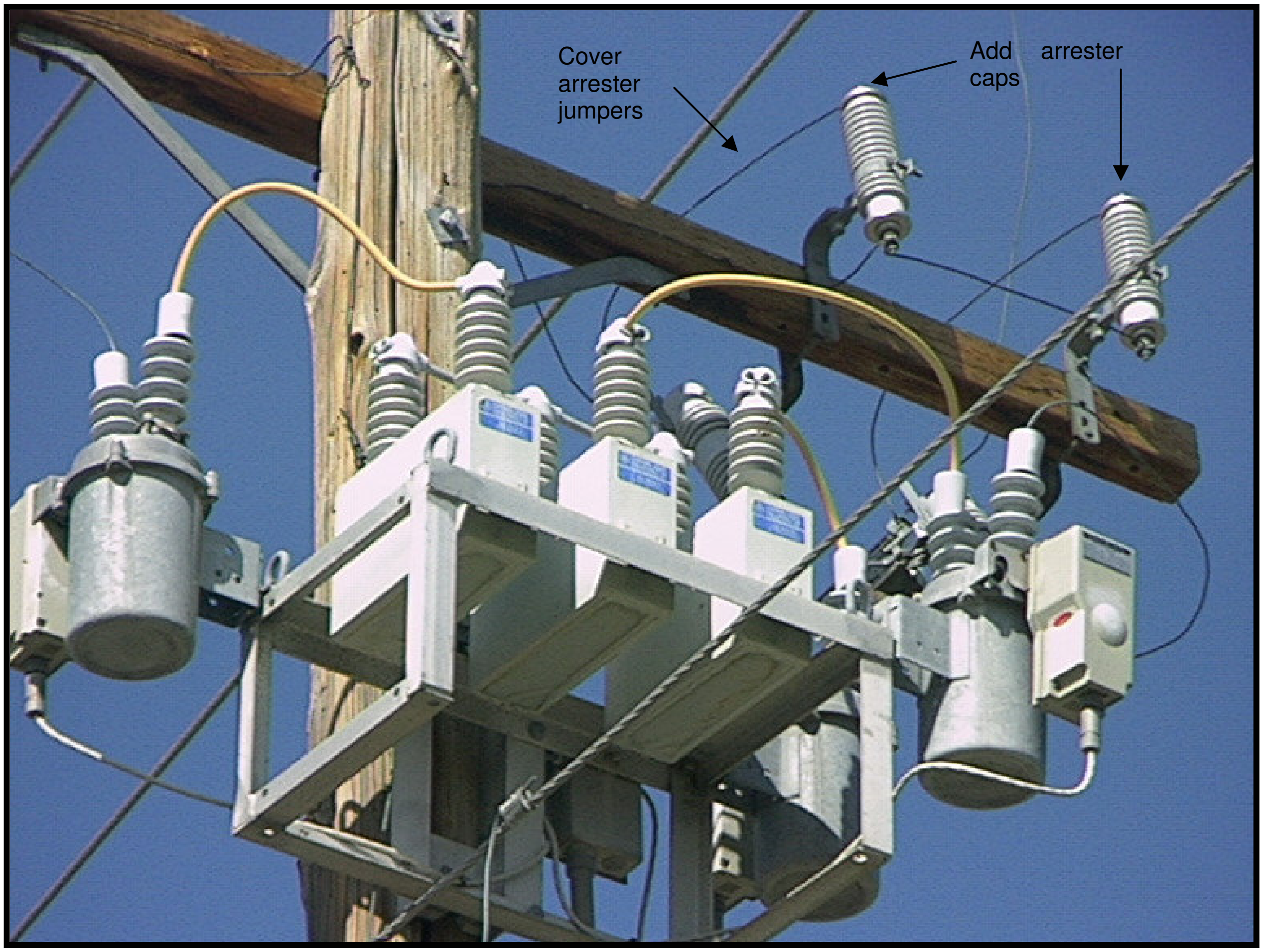

Photo 18 Capacitor Bank Factory Ordered with Animal Protection

5.9 Cutouts/Switches

5.9.1 Cutouts

A cutout is a device used to make a fused connection between primary conductors; this device is often called a "fused cutout." If the fuse fails, this mechanism provides a visible open, which can be seen from the ground. The top plate of the cutout is energized and can be problematic to animals if they are mounted near a grounded surface. 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 (Photo 19)

Cutouts are often installed with metal L-brackets (see Section 5.14, Brackets). If the metal bracket is grounded it can easily allow for an animal to bridge the distance between a cutout and ground (Photo 20).

Photo 19 Cutout Mounted on an Insulated Fiberglass Bracket to Isolate Animal Contacts

Photo 20 Damaged Cutout Resulting from an Animal Contact

If cutouts are in close proximity to each other, perch deterrents can be placed between the devices to minimize the chance of phase-to-phase contact (Photo 21) (see Section 5.15, Perch Management). Whenever cutout leads are in proximity to a grounded plane or another phase conductor and the potential exists for an animal to bridge the gap, the cutout jumpers should be insulated with 600V insulation (see Section 5.12, Stinger Wires).

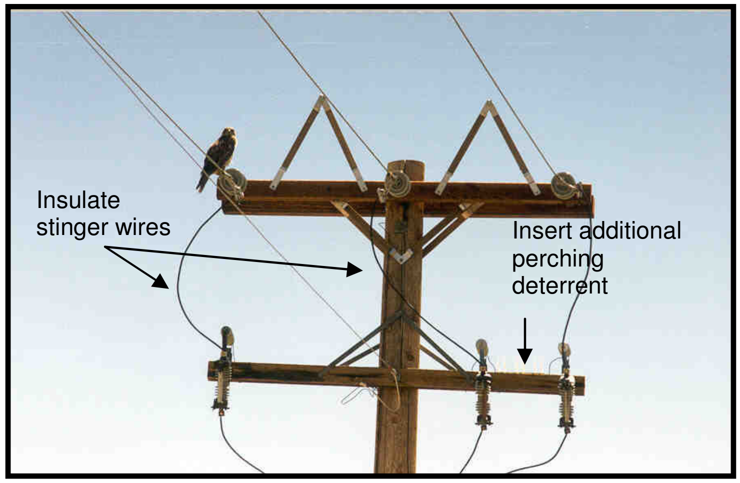

Photo 21 Three Cutouts Mounted on a Three-Phase Transformer Bank

Cutouts also can be insulated if they cannot be effectively isolated. Kaddas manufactures several cutout covers (Photo 22) to insulate the top of various cutouts. This is a new product and no information is available on its performance. The Kaddas cutout cover should always be used in tandem with 600V-insulated jumpers. Any conductors that cannot be covered should be wrapped with insulating tape. Presently there are no covers available for load break cutouts. The retrofitting recommendation data in Appendix B use code **COC** to specify cutout covers.

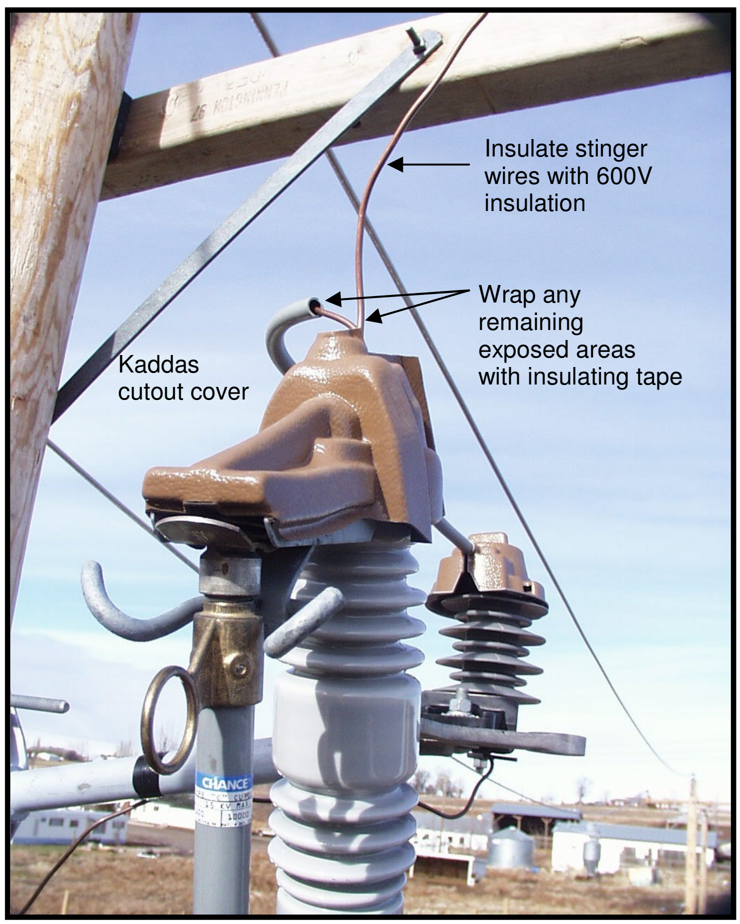

Photo 22 Cutout with an Insulating Cover

5.9.2 Switches

Switchgear is used to energize or de-energize three phases at one time. Existing gang operated air break switches (GOABS) are very problematic to animal proof because they typically have minimal separation, and traditional retrofitting measures (e.g., perch guards, spikes) interfere with the operation of the switch. If a switch needs retrofitting it is best to install an elevated perch above the switch to encourage birds to use the higher location (Refer to Section 5.15.1, Elevated Perches). New switches can be purchased with fiberglass support arms versus steel arms. At least one switch manufacturer, S&C, produces a unit with wildlife protection on the interrupter. It also may be possible to order and mount new switchgear upside-down to prevent animal contacts. However, this would need to be coordinated with the manufacturers.

5.10 Surge Arresters

Arresters clear over-voltage problems such as lightning strikes. Arresters have a groundwire attached to one end leading to earth and another end either attached or in proximity (gapped) to an energized wire. Arresters are used on all equipment poles and underground riser locations and can be mounted on crossarms or directly on a transformer. All new arresters should be ordered and installed with manufacturer-supplied wildlife caps. 600V-insulated wire also should be used for arrester hot leads (Figure 7). No exposed wire should extend beyond the wildlife cap, and leads should be kept as short as possible. The retrofitting recommendation data in Appendix B use code **AC** to specify arrester caps.

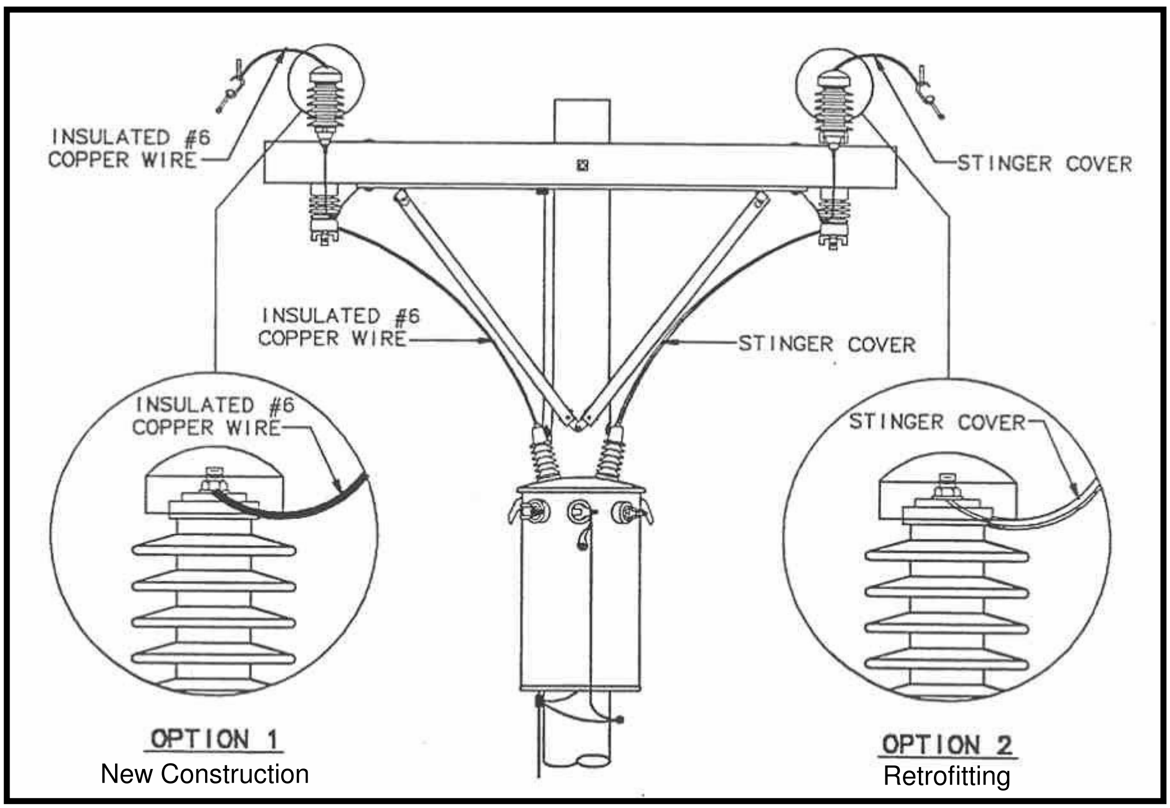

Figure 7 Installing New and Retrofitting Surge Arresters

Transformer mounted arresters also should be installed with manufacturer supplied wildlife caps and 600V-insulated wire (Photo 23).

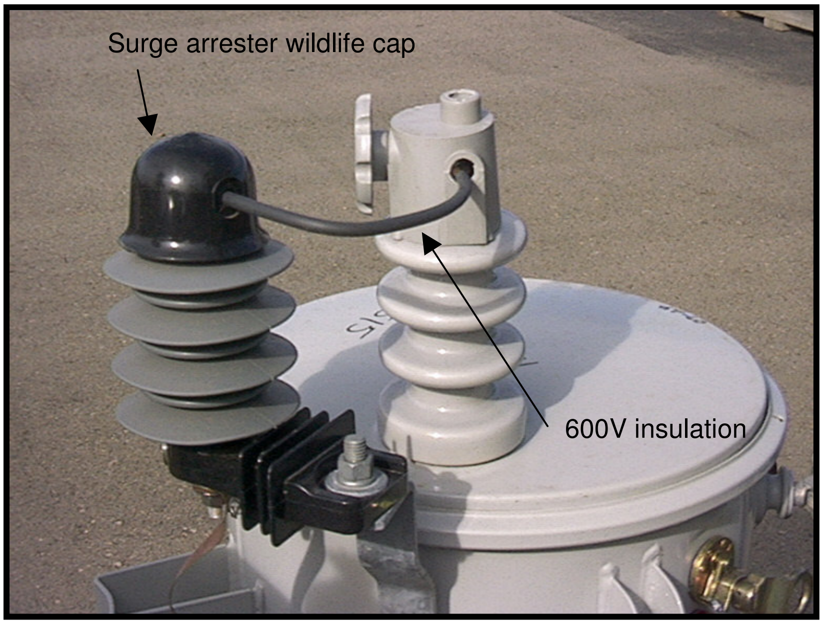

Photo 23 Transformer Mounted Surge Arrester with Wildlife Cap

Older gapped arresters (Photo 24) can cause problems if small birds, climbing animals, or even insects span the open gap. Gapped arresters should continue to be phased out of a system. When gapped arresters are used, a transformer bushing cover with a side knockout must be used to provide an adequate opening for the spark gap rod, and the bushing cover opening must be aligned with the spark gap rod. Groundwires associated with surge arresters should be routed under crossarms to avoid potential phase-to-ground contacts (Photo 25).

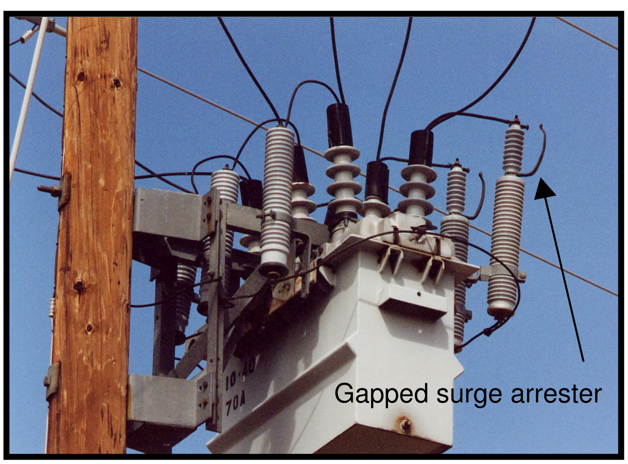

Photo 24 Gapped Surge Arrester

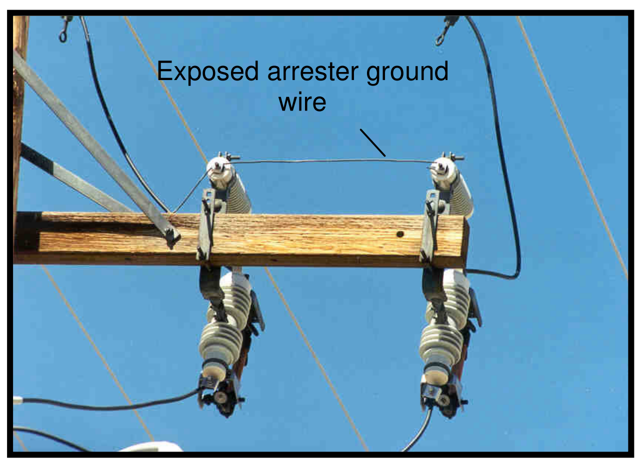

Photo 25 Exposed Arrester Ground

The position of an arrester can be modified to reduce potential contacts. Installing arresters in a horizontal fashion with insulated leads reduces exposure to animals (Photo 26). This installation also should include an insulated cap. Attention should be placed on the groundwire exiting the bottom of the arrester. If the groundwire is in proximity to any energized hardware, it too should be insulated (Photo 27). Any conductors that cannot be covered should be wrapped with insulating tape.

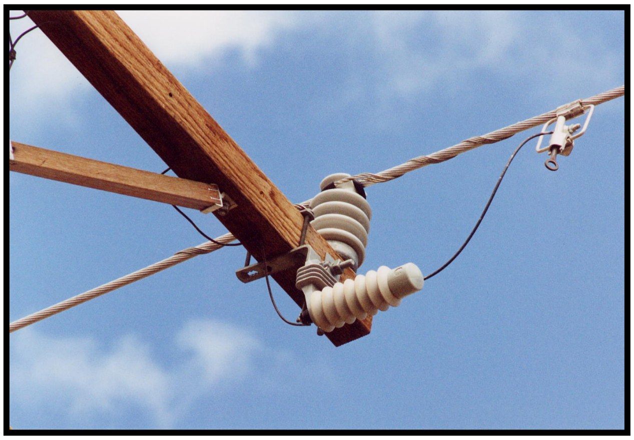

Photo 26 Horizontally Mounted Surge Arrester to Reduce Animal Exposure

Photo 27 Insulated Surge Arrester Ground to Eliminate Phase-to-Ground Animal Contacts

5.11 Primary Jumpers

When an energized primary jumper is in proximity to a grounded plane or another phase conductor and the potential exists for an animal to bridge the gap, the jumper should be insulated. New jumper construction should minimally include 600V-insulated wire (Photo 28). Although 600V insulation does not protect for the full line voltage, it does provide enough insulation to allow brief animal contact without causing a flashover. Prolonged contact with protected parts may still cause insulation failure and allow for a short-circuit.

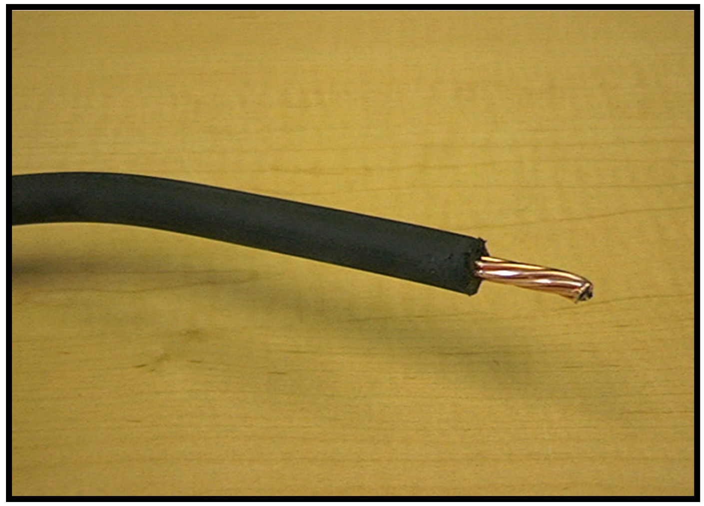

Photo 28 Insulated Jumper Wire for New Installations

When retrofitting it may not be practical to install 600V insulated wire on deadends and tap units. In these situations W.H. Salisbury & Co. insulating SALCOR cover material can be employed. This insulation has a split seam and can be installed over existing wire without disconnecting the lead wire from the bushing, which is very useful when retrofitting (see Section 5.12, Stinger Wires). The retrofitting recommendation data in Appendix B uses code **IJ** to specify insulated jumper pieces.

SALCOR stinger cover is made from an ozone and UV-resistant EPDM elastomeric compound designed to provide years of track resistant reliable service. For conductor sizes up to 2/0, use a 3/8-inch-diameter cover; for conductors up to 266.8 ACSR, use a 5/8-inch-diameter cover; and for larger conductors up to 336.4 ACSR, use a 3/4-inch-diameter cover.

Primary jumpers are regularly fastened to pin-type insulators for support. Distribution ties manufactured of aluminum covered steel secure jumpers in the top groove of interchangeable head-style insulators. Distribution ties supplied with a pad, provide superior abrasion protection for the conductor under all types of motion, including low frequency sway oscillation, high frequency aeolian vibration, and galloping. The pad component is recommended because it surrounds bare conductor with a resilient cushion where the conductor would come into contact with the insulator and with the center section of the tie. In the case of distribution ties applied over insulated jumpers, the ties can be furnished without pads because the jacketing itself prevents contact with the bare conductor. PREFORMED™ Plastic Line Ties also are offered as an alternate to metal ties applied over insulated jumpers.

5.12 Stinger Wires

Equipment such as transformers, regulators, capacitors, and reclosers are fed with a primary "stinger" wire off the main power line. When an energized transformer stinger is in proximity to a grounded plane or another phase conductor and the potential exists for an animal to bridge the gap, the stinger should be insulated. New equipment construction should minimally include 600V-insulated stinger wire. As discussed in Section 5.11, Primary Jumpers, 600V insulation does not protect for the full line voltage on distribution class transformers. However, it does provide enough insulation to allow brief animal contact without causing a flashover. Prolonged contact with protected parts may still cause insulation failure, resulting in a line short-circuit.

As stated for jumper wires, when it is not practical to reinstall 600V-insulated wire, the W.H. Salisbury & Co. insulating SALCOR cover material should be employed. This insulation has a split seam and can be installed over existing wire without disconnecting the lead wire from the bushing (Photo 29). The same recommended sizes for the stinger cover-up material would apply, as presented in Section 5.11, Primary Jumpers.

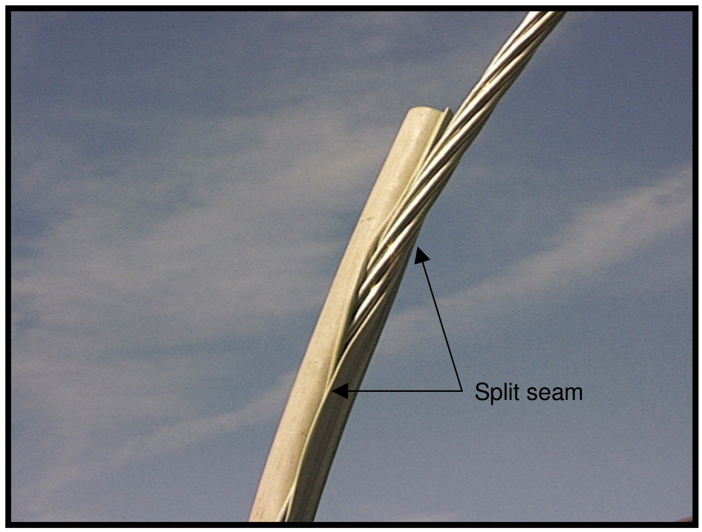

Photo 29 Stinger Retrofitted with W.H. Salisbury & Co. Insulating Salcor Cover Material

A properly animal-protected equipment unit includes 600V-insulated stingers and properly mounted bushing covers. No bare portion of the insulated leads should extend beyond the wildlife caps.

5.13 Pole-Top Grounds

Poles located in wide-open areas are attractive to raptors. These same conditions also make utility poles vulnerable to lightning strikes. Lightning can cause extensive damage to utility structures and equipment. Early construction practices attempted to limit lightning damage by running groundwires to the pole tops (Photo 30). A copper wire was placed all the way down the pole and bonded to a ground rod/plate buried at the pole base. The downwire also was tied into the neutral conductor. The groundwires provided a path for lightning strikes allowing lightning to travel down the wire to earth, instead of passing through equipment or traveling down the pole, destroying it in the process.

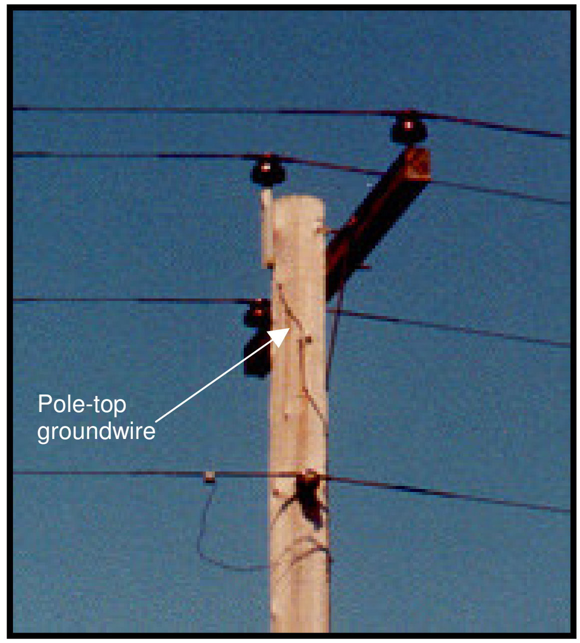

Photo 30 Pole with a Pole-Top Groundwire

Sometimes metal hardware, such as crossarm braces and guy wires, also was bonded to these overhead groundwires. This was done to eliminate leakage currents. Unfortunately these grounding practices resulted in reduced phase-to-ground distances for large perching birds and were often lethal. Birds perching on top of the pole were too frequently electrocuted when perching on an insulator and touching their tail to the pole-top groundwire. Pole-top grounds extending above the pole (Photo 31) continue to be particularly problematic.

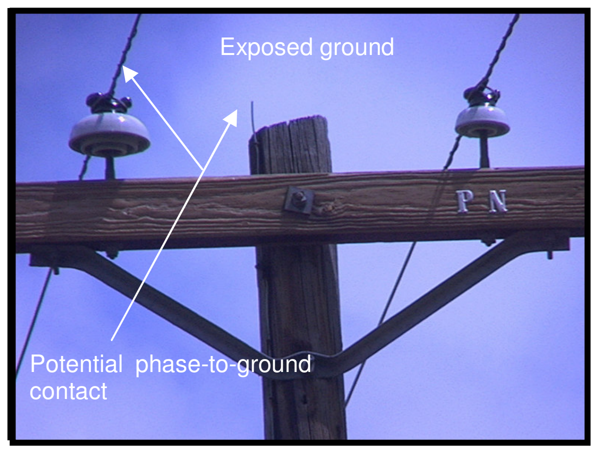

Photo 31 Pole with Groundwire Extending above the Pole Top

The REA changed their overhead grounding practices in 1972 in response to raptor electrocutions. It was determined that existing pole-top grounds could be gapped and still provide adequate lightning protection. The gaps break the pathway to earth, thereby reducing the risk for perching birds of prey. This can be accomplished by placing two 4-inch gaps in the pole groundwire (Photo 32). Lightning will spark over the gaps while still allowing raptors to perch safely on the pole top. Since an eagle's tail feathers can reach 10 inches below a perch, the end of the pole groundwire should be at least 12 inches from the pole top.

An alternative solution is to simply remove the pole-top grounds above the neutral.

Although use of pole-top grounds is no longer a construction practice, they still exist on a number of structures. For structures located with pole-top grounds, the groundwire should either be gapped system wide or removed. The retrofitting recommendation data in Appendix B use code **RG** to specify either removing or gapping existing pole-top grounds.

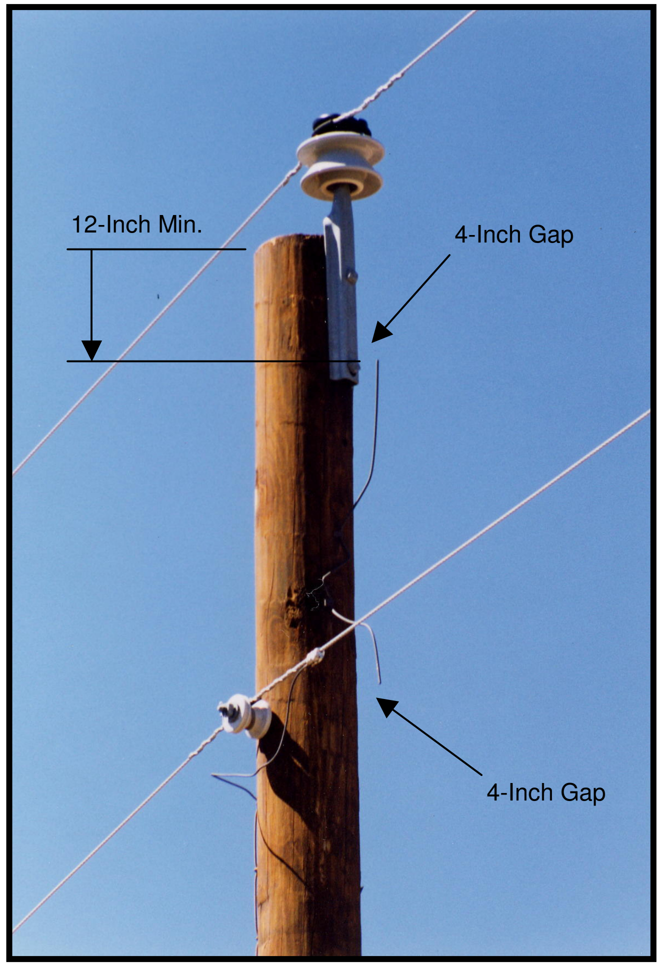

Photo 32 Pole with a Pole-Top Ground Properly Gapped to Prevent Raptor Electrocutions

5.14 Brackets

Metal riser/cutout/arrester brackets can pose a risk to animals when they are bonded to earth through groundwires (Photo 33 and Photo 34). An animal on a conductive bracket needs only to touch one energized jumper wire to complete a pathway to ground.

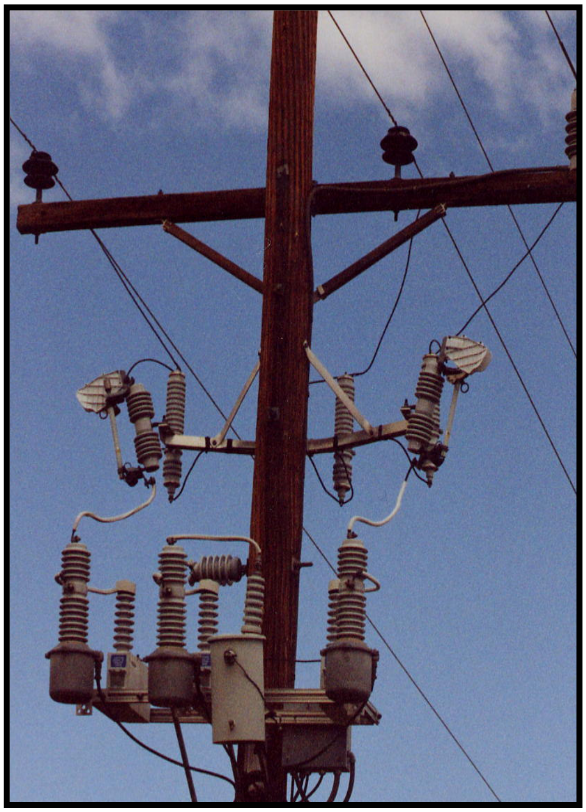

Photo 33 Three-Phase Metal Cutout/Arrester Bracket

Photo 34 Single-Phase Metal Cutout/Arrester and Pothead Bracket

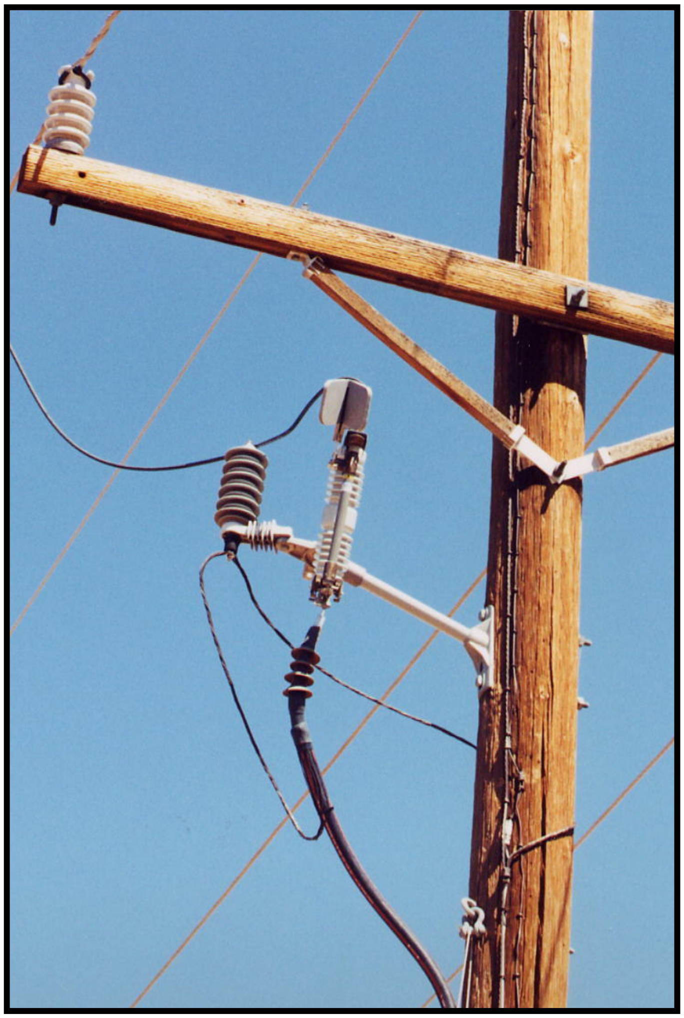

Photo 35 Single-Phase Fiberglass Cutout/Arrester Bracket

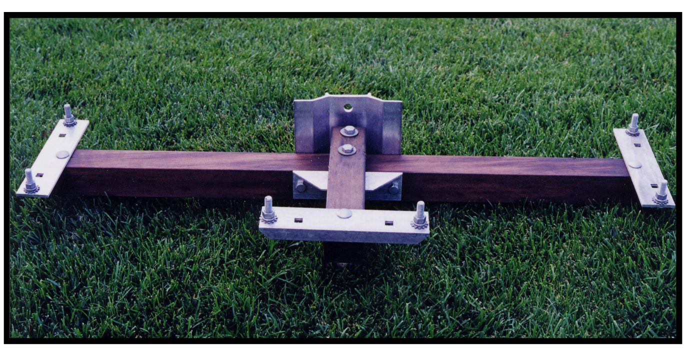

Photo 36 Three-Phase Wood Bracket

In new construction, metal brackets can either be replaced with nonconductive fiberglass (Photo 35) or wooden (Photo 36) standoff brackets. Either of these brackets is preferable because they are insulated. It is important to note the metal ends of the brackets should not be bonded to ground.

During retrofitting it may not be economical to replace brackets. In these situations it may be more practical to cover exposed wires with 600V insulation and install wildlife protectors on exposed cutouts, bushings, potheads, and arresters, as discussed in previous sections. Conductive and nonconductive brackets supporting multiple phases should still employ insulated jumper wires if there is not adequate separation between jumpers.

5.15 Perch Management

Perch management is designed to either encourage perching in safer areas of a structure or to deter birds from perching in dangerous or high-risk areas when adequate separation is not provided (Figure 8).

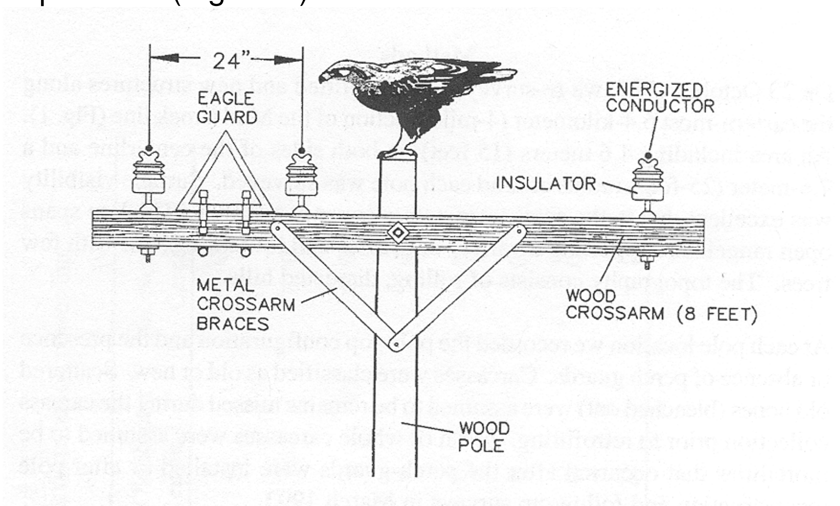

Figure 8 Golden Eagle on a Three-Phase Tangent Structure with Inadequate Separation

5.15.1 Elevated Perches

Perch encouragement is typically achieved with elevated perches designed to attract birds to the highest point on the structure. When elevated perches are constructed they should be designed so birds cannot get under the perch during the heat of the day or during inclement weather.

Eagle perches should be approximately 8 to 12 inches above a crossarm to prevent birds from sitting under the perch (Photo 37). Installation of perches also must adhere to National Electrical Safety Code (NESC) and all other pertinent safety requirements. Elevated perches are particularly important on structures located at topographical high points near a prey base. The support arms should also be used as perching deterrents between closely spaced phases.

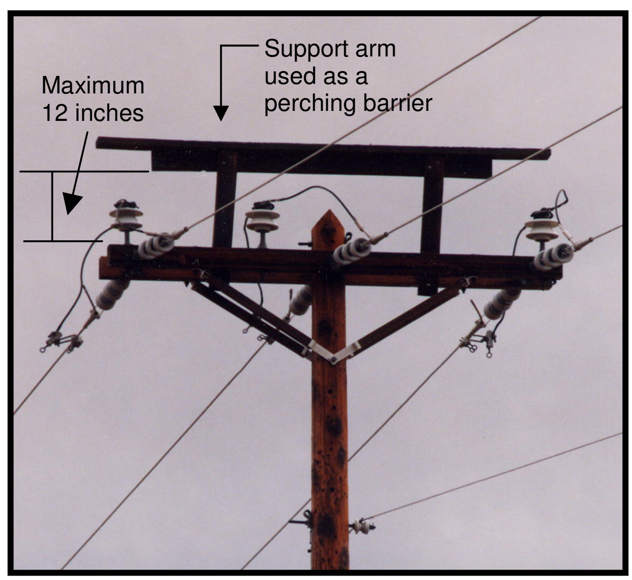

Photo 37 Elevated Perch on a Three-Phase Tangent Structure

Perch deterrents can be successfully used in tandem with elevated perches. As with all devices, they should be installed properly so that they do not create future operational problems. Manufactured perches are available from Aluma-Form and Hughes Brothers. The retrofitting recommendation data in Appendix B use code **EP** to specify elevated perches.

5.15.2 Perch Guards

Perch guards are designed to discourage birds from landing at dangerous structure locations. They also may be used to keep birds from defecating on suspension insulators and equipment. Perch guards are typically triangular and are commercially available from several manufacturers made out of different materials (Table 6). Some can be installed "hot" with hotline sticks; others must be bolted to the structure. In general, perch guards that can be installed "hot" cost more than guards requiring more labor to install. One unique Kaddas design has a center strut to preclude perching under the perch guard (Photo 38).

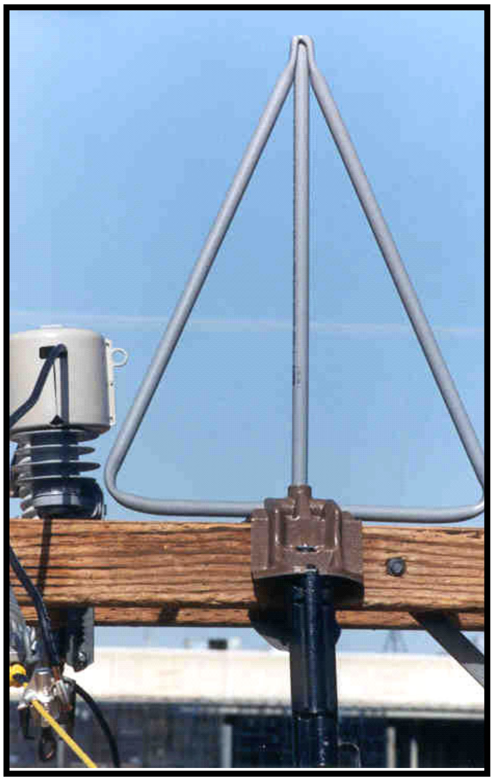

Photo 38 Kaddas Perch Guard with a Center Strut to Prevent Perching within the Triangle

Several guards require the horizontal crossarm surface for mounting. This may not be possible when cutouts, arresters, and other items are present. In those situations a unit that mounts into the vertical crossarm surface is required (Photo 39).

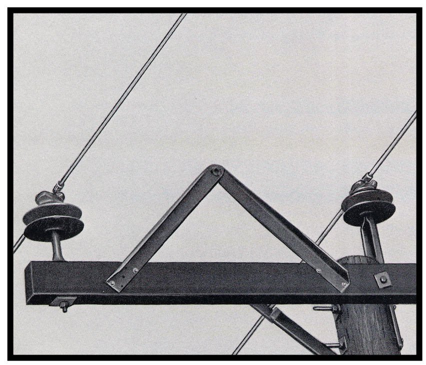

Photo 39 Hendrix Perch Guard that is Adjustable and Mounts on the Vertical Crossarm Surface

Table 6 Perch Guards

Manufacturer	Material	Web Site
Coyote Enterprise	PVC	None: (970) 878-5041
EcoElectrical	PVC w/Silicone Coating	http://www.ecoelectrical.com/
Hendrix Wire and Cable	Polypropylene	http://www.hendrix-wc.com/
Hughes Brothers	Fiberglass	http://www.hughesbros.com/
Kaddas	PVC	http://www.kaddas.com/
Mission Engineering	HDPE	httt://www.mission-eng.co.za/
Pacer Industries	PVC	None: (208)733-8074

It is important to note that perch guards do not always keep birds off structures (Photo 40). The goal of a perch guard is to discourage a bird from roosting in a certain area. This is most successful if safer portions of the pole are still available to the bird. Perch guards are simply a tool to manage where birds can land on a structure (Photo 41).

Photo 40 Bird Perching on a Triangle Perch Guard

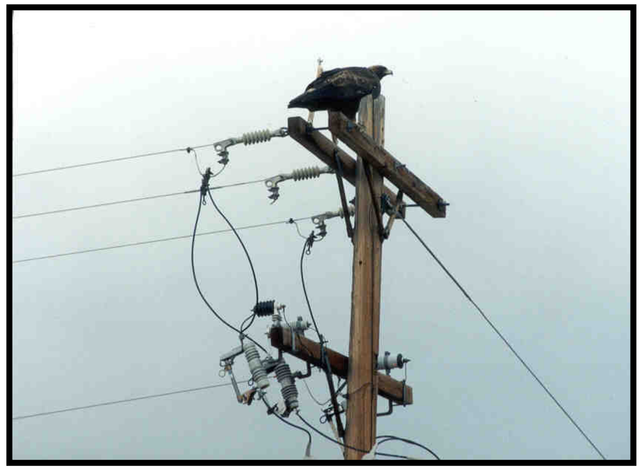

Photo 41 Perch Guard Shifting an Eagle Toward the Safe Side of a Deadend Unit

In new construction it is preferable to provide adequate separation of conductors for birds rather than to use perch guards. Placing perch guards on the top of some poles can even contribute to electrocutions, since birds may choose to roost lower on the pole near energized equipment. Perch guards also can simply shift problems onto other dangerous line segments (Photo 42). The retrofitting recommendation data in Appendix B use code **TRI** to specify perch guards.

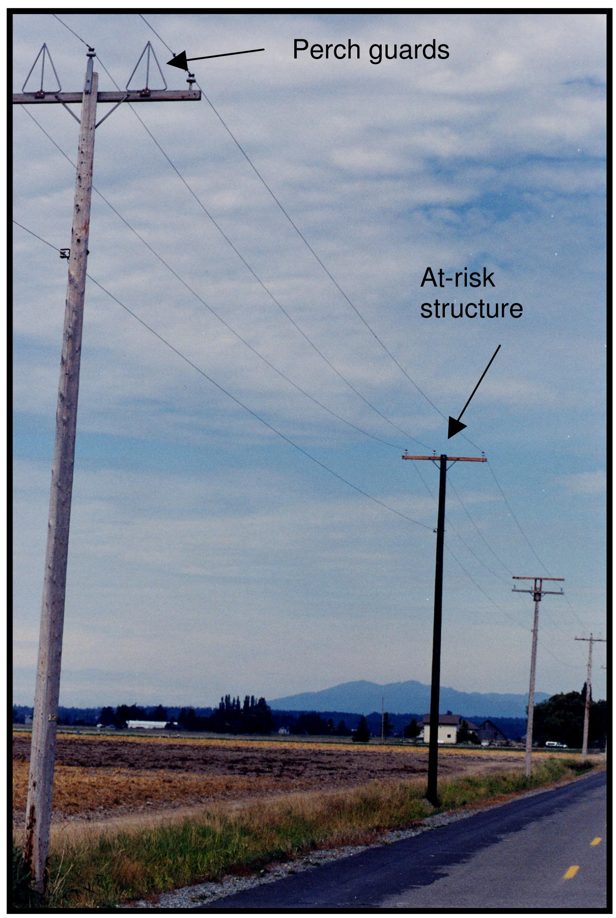

Photo 42 Perch Guards may Shift Birds Toward more Problematic Structures

Perch guards should be sized properly to discourage birds from perching under or adjacent to the guards (Photo 43), and purchased with a protective coating to prevent UV deterioration. Home-made guards without UV protection will often prematurely deteriorate, becoming ineffective (Photo 44).

Photo 43 Raptor Perching under a Perch Guard

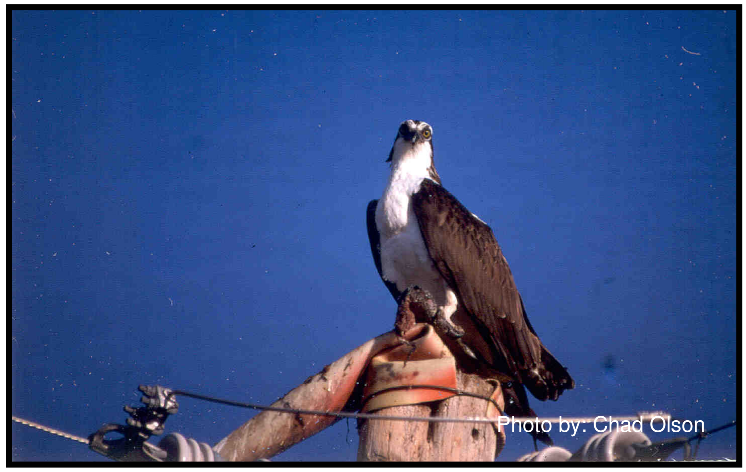

Photo 44 Deteriorated Traffic Cone used as a Perch Guard

Like all utility components, guards should be installed according to the manufacturers' specifications using NESC clearances to avoid potential electrical problems. Guards placed too close to conductors can lead to flashover problems under certain environmental conditions. On the other hand, providing too much separation, may allow birds to land next to guards.

Captive bird tests reveal hawks require 6 inches of separation before they will attempt to land between an insulator and a perch guard (Photo 45). Eagles will attempt to land when there is a minimum of 10 inches between a guard and insulator. Accordingly, utilities should not increase their separation beyond 5 inches, if the goal is to keep eagles and hawks off their structures.

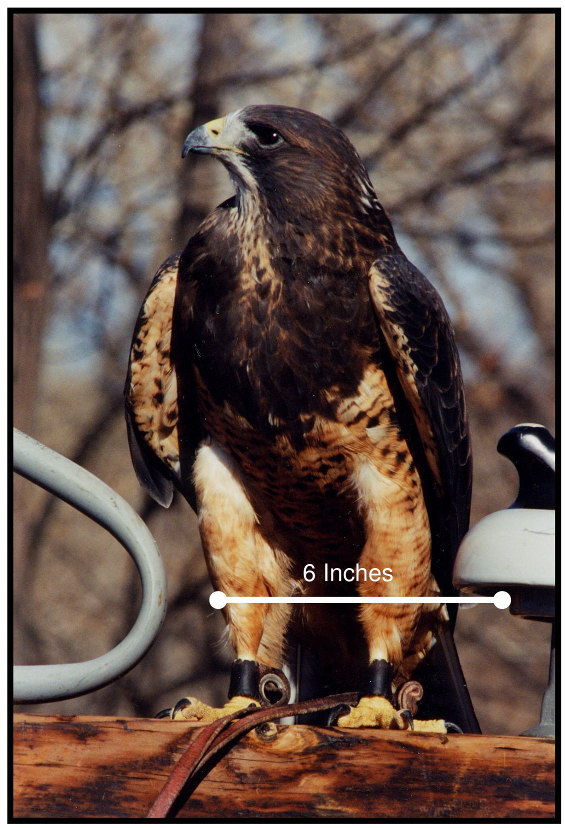

Photo 45 Providing 6 Inches of Separation will allow a Swainson's Hawk to Perch between the Insulator and Guard

5.15.3 Bird Spikes

Bird spikes can be an effective perching deterrent. Spikes can be placed in hard to reach areas and come in a variety of materials (e.g., metal, plastic polymers) and sizes to deter a wide range of bird species. However, the spikes must be sized properly and installed in the right location on the structure in order to effectively deter birds. Small spikes will not deter large birds and small birds may nest in them (Photo 46). Small plastic-type spikes become brittle and break easily, reducing their effectiveness. The potential risks to employees climbing and working around sharp spikes also can be significant.

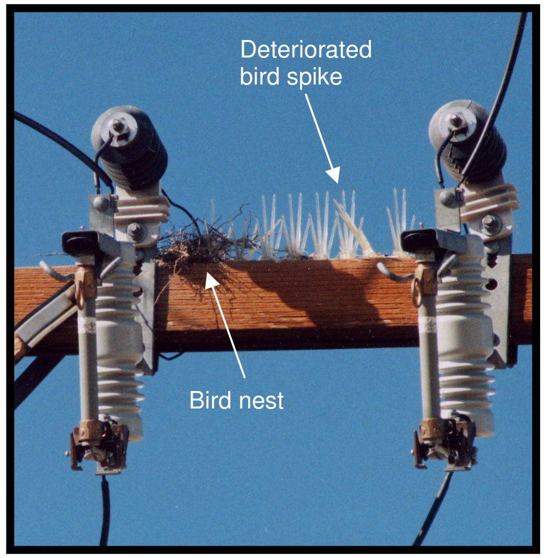

Photo 46 Bird Nesting in Small Plastic Spikes

Specialized Mission Engineering HDPE bird guards developed to eliminate bird streamer faults have shown to be useful in deterring raptor perching (Photo 47). In captive testing, the bird guards were successful at all perching attempts and did not harm the birds. These modular guards can be linked together to form chains that can be angled, they are easy to work around during line maintenance activities, and they are furnished with a UV coating to prevent deterioration. These new bird spikes are attached to the pole with either a UV-resistant strap or they may be screwed on the structure. Contact Mission Engineering at www.mission-eng.co.za for more information on the bird spikes or email supern@mission-eng.co.za. The retrofitting recommendation data in Appendix B use code **BS** to specify bird spikes.

Photo 47 Golden Eagle Perched next to a Mission Engineering Bird Guard

6.0 COLLISIONS

Birds face collision threats from power lines, television towers, radio and cellular telephone towers and related wires, wire fences, wind turbines, cars, aircraft, trains, etc. Although birds often exist near power lines without significant collision risks, problems occur in localized areas where certain factors exist.

The following information on bird collisions is provided to better understand why birds may collide with power lines, and what applicable mitigation may minimize those risks.

6.1 Risk

Size and maneuverability are important factors in evaluating species' vulnerability to colliding with overhead wires. Soaring and slow-flying species are less vulnerable to collision hazards than fast, strong flyers (i.e., species with high wing loading). For example, many species of ducks are vulnerable to collisions when flying at low altitudes because of their high flight speed. Flying in flocks also restricts maneuverability and increases collision risk.

Generally, raptors are infrequently involved in collisions although they spend extensive periods of time in the air relative to ground-dwelling species. However, some raptor species such as the peregrine falcon (*Falco peregrinus)* can be vulnerable to collisions because of their hunting behavior (attaining high speeds when following prey near the ground) (Olendorff and Lehman 1985). These collisions usually occur on distribution lines employing small conductors. Raptor collisions with larger transmission conductors are less documented. Some large, heavy-bodied birds such as herons, cranes, swans, and pelicans are frequently reported casualties of transmission line collisions because of their large wingspans and lack of agility.

The probability of collisions occurring is influenced by how birds use habitat near power lines. Collisions with power lines can occur during daily flights within a daily use area. In general, ecologically sensitive areas such as wetlands, where birds congregate to nest, feed, roost, migrate or overwinter, should be avoided if possible. Intermittent wetlands are another good example of habitat that also should be avoided but is not always obvious. A power line located between a feeding area and a roosting site of wetland birds can be problematic, especially when only a short distance separates them, resulting in birds making a short flight at the critical height. Birds crossing power lines at low altitudes several times a day makes them more susceptible to collision.

6.2 Overhead Static Wires

Overhead static wires are frequently located above transmission conductors. These wires are grounded and are used to shield lightning from striking the transmission conductors. Overhead static wires are typically smaller than transmission conductors, and several collision reports have stressed that reduced or smaller static wires are particularly likely to cause bird collisions (APLIC 1994). There are also eyewitness accounts of swans that have managed to avoid phase conductors in time, only to crash into the overhead static wires, which were thinner and less visible.

6.3 Wire Marking

One of the most effective ways to reduce avian mortality is to mark wires to make them more visible (Beaulaurier 1981). However, from an engineering point of view, wire marking is not always a good solution. Devices, which physically enlarge the wire commonly act as wind-catching objects, encouraging icing in winter and increasing the risk of wire breaks and power outages due to line tension and stress loads. The attachment of devices also may cause physical damage to the conductors from abrasion. Wire marking also has not proved to be the perfect solution and there is no broad agreement among biologists on the success of line marking. However, the effectiveness of some marking methods that target specific species can hardly be questioned, and marking is justified if spans are determined to be dangerous to endangered and vulnerable species.

Although several products are available to mark power lines, there have been very few rigorous experimental designs to test their effectiveness. Also, very few studies comparing products have been completed. Following is a discussion of the various products available to mark wires and their advantages and disadvantages. Table 7 lists vendor product information.

Table 7 Bird Collision Devices and Manufacturers

Manufacturer	Device	Description	Web Site
Kaddas	Flapper	Swinging Plate	http://www.kaddas.com/
BirdMARK	Bird Flight Diverter	Swinging Plate	http://www.pr-tech.com/products/birds/birdsigns.htm
MidSUN	Collision Guard	Swinging Mat	http://www.midsungroup.com/
Mission Engineering	Bird Collision Diverter	Swinging Plate	http://www.mission-eng.co.za
Dulmison	Bird Flight Diverter - BFD	Coiled Solid PVC Wire Marker	http://catalog.tycoelectronics.com
Preformed Line Company	Bird Flight Diverter - BFD	Coiled Solid PVC Wire Marker	http://www.preformed.com
Dulmison	Swan Flight Diverter - SFD	Coiled Solid PVC Wire Marker	http://catalog.tycoelectronics.com
Dulmison	Spiral Vibration Dampers -SVD	Vibration Dampers	http://catalog.tycoelectronics.com

6.3.1 Flapper

The Flapper (Photo 48) was designed in South Africa in partnership with Preformed Line Products, ESKOM, and the Endangered Wildlife Trust (EWT). The Flapper is distributed by Kaddas and is designed to securely grip wires up to a diameter of 0.75 inch with a locking plastic jaw. The Flapper can be installed and removed from the ground (Photo 49); has been UV stabilized; and is available in red, white, and black. Black and white flappers provide maximum contrast.

Photo 48 White Flapper

The Flapper is used in Africa and is effective at reducing collisions. However, ESKOM has experienced problems with the device shifting in some of the earlier versions (van Rooyen 2000).

Photo 49 Flapper Installation

A new Flapper version was released this year. According to the distributor, this unit when properly applied will not shift and move on the line. The manufacturer also recommends using silicone adhesive on the clamp (Klein part number 51138). There are two versions of the Flapper, one is attached with a ratcheted clamp, and the other is installed with a breakaway composite screw using a hotline stick. The Flapper is available with a luminescent paint that will glow in low light situations. The color of devices plays an important role in reducing collisions (Kreithen 1996).

The advantage of the Flapper is the movement of the swinging plate helps make a line more visible than simply increasing the line profile. The effectiveness of the Flapper has been scientifically tested in South Africa, and preliminary data show that the Flapper is effective in reducing bustard and crane collisions (van Rooyen 2000; Mark Anderson 2001). However, in areas of vandalism to overhead power lines, a marking system resembling a target might create problems. The potential for devices slipping on hard to access overhead transmission static wires also is a significant concern.

6.3.2 BirdMARK Bird Flight Diverter

The BirdMARK (Photo 50) is distributed by P&R Industries and is designed to securely grip wires up to a diameter of 2.5 inches with a strong spring-loaded clamping jaw. The clamping jaw also is used with several other P&R products designed specifically for power lines. The BirdMARK is presently being used in England and Ireland.

Photo 50 BirdMARK Bird Flight Diverter

The BirdMARK can be installed and removed from the ground without interrupting power. The manufacturer claims the BirdMARK will stay in position even in a Force 8 gale. The swinging roundel is available in either orange or red-and-white.

As discussed for the Flapper, the advantage of the BirdMARK is the movement of the swinging plate makes a line more visible than simply increasing the line profile. However, vandalism can be a problem. Unfortunately, no studies on the effectiveness of the BirdMARK were found in the scientific literature although it would appear the device should be similarly effective as the Flapper.

Mission Engineering and MIDSUN Company have recently introduced their own versions of swinging devices to prevent collisions (Photo 51). No data are available on their effectiveness.

Photo 51 Mission Engineering (left) and MIDSUN (right) Bird Diverters

6.3.3 Bird Flight Diverter

The Bird Flight Diverter (BFD) was developed in Europe during the 1970's (Figure 9). The BFD is made from a high-impact, standard gray PVC and is UV stabilized.

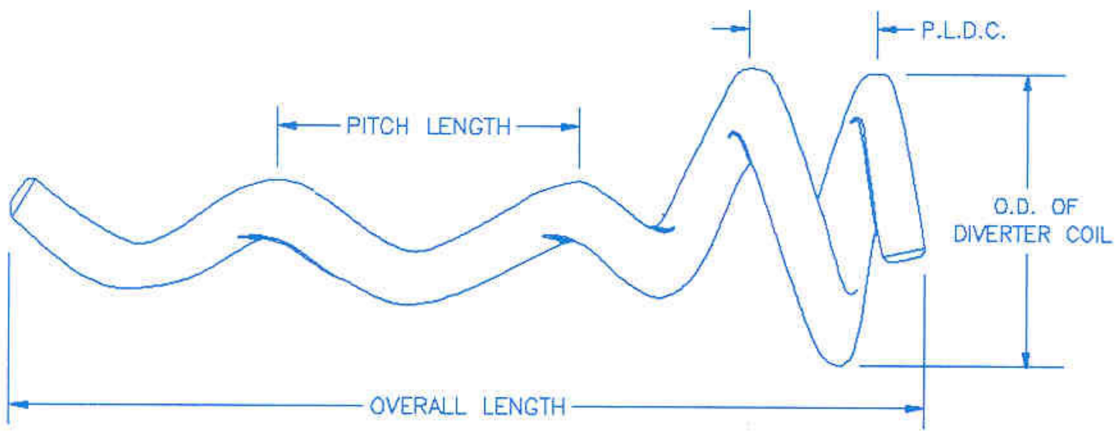

Figure 9 Bird Flight Diverter Manufactured by Dulmison. Made from High Impact PVC and UV Stabilized.

The Dulmison BFD is available in a variety of colors and different sizes to accommodate a conductor ranging from 0.175 to 1.212 inches (Photo 52).

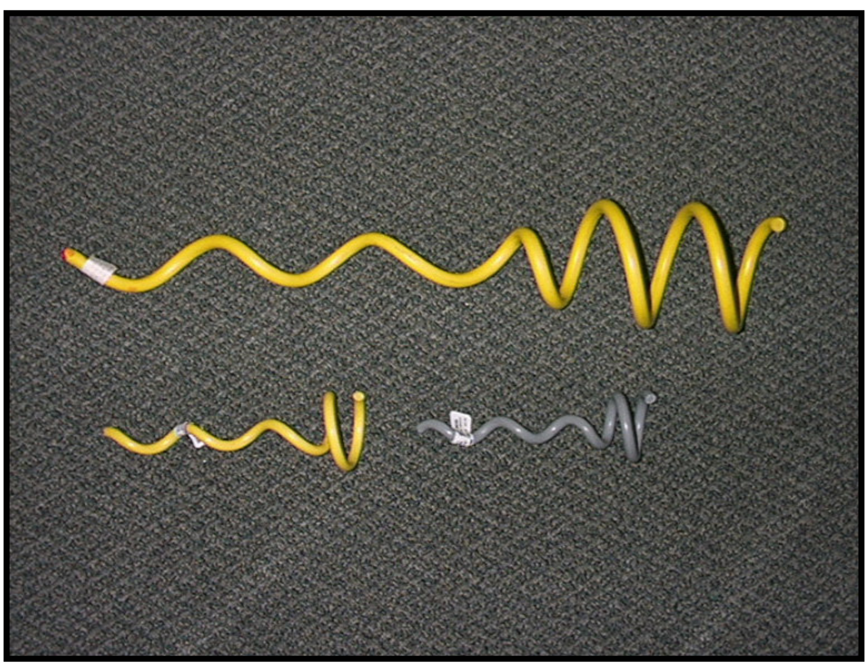

Photo 52 Bird Flight Diverters for Small and Larger Wires

The BFD has been effective when installed on transmission overhead static wires in Europe, where typical spacing ranges from 16 to 33 feet. In North America, the BFD also has recently shown to be effective in reducing waterfowl collisions with overhead static wires (Crowder 2000). The spacing of the BFDs in Crowder's 1998-2000 study was 20 feet apart. The BFD is believed to be effective because its profile increases line visibility.

However, the BFD cannot be installed on electrically energized conductors with a voltage more than 230kV because of ozone deterioration. The ozone destroys the chemical properties, making the BFD brittle and reducing the service life. BFDs also can create radio and television interference when installed on higher voltage conductors but are appropriate on overhead static wires and on lines below 230kV. The BFD colors may fade after long periods of exposure but should not become brittle or lose their elastic properties. ESKOM has used the Preformed Line Products, Bird Flight Diverter in South Africa for years with no reports of mechanical failure (van Rooyen 2000) although some red PVC devices have faded.

6.3.4 Swan Flight Diverter

The Swan Flight Diverter (SFD) is similar to the BFD but includes four 7-inch spirals (Photo 53). The SFD also is made from a high-impact, standard gray PVC and is UV stabilized. The Dulmison SFD is available in a variety of colors and sizes to accommodate conductors ranging from 0.175 to 1.212 inches.

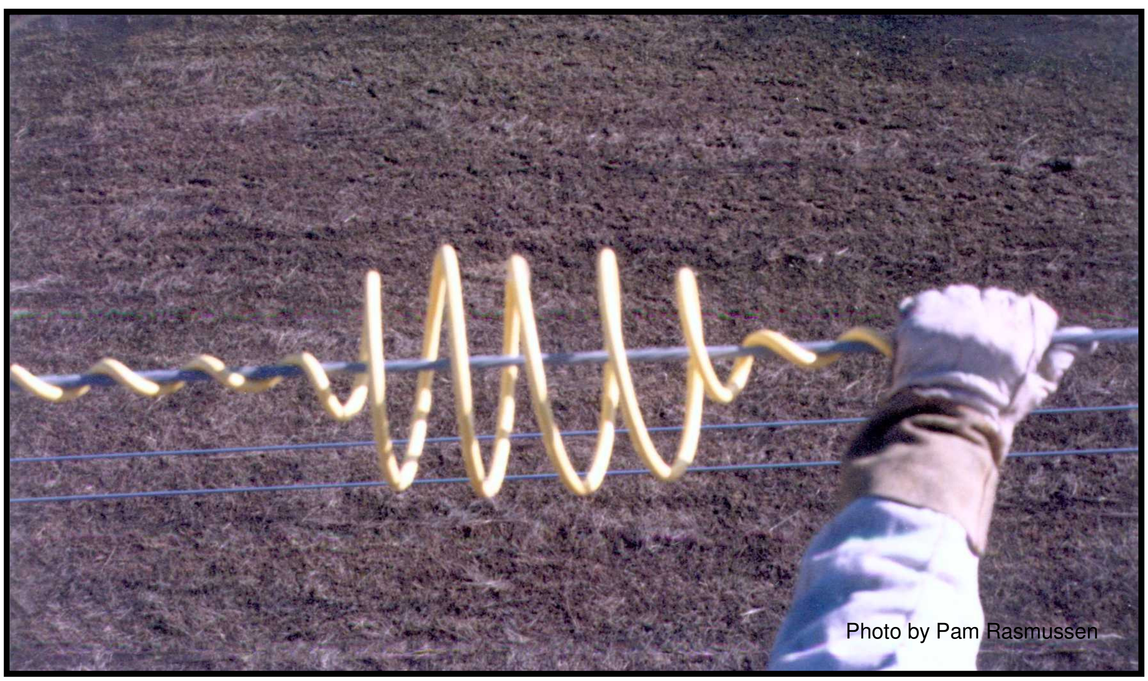

Photo 53 Swan Flight Diverters Being Placed on a Static Wire

The SFD has been shown to be effective when installed on transmission overhead static wires in North America. In the early 1990's Northern States Power Company addressed a problem where endangered trumpeter swans (*Cygnus buccinator*) were colliding with a power line during the winter months in a small bay on the St. Croix River in Hudson, Wisconsin. Yellow SFDs were installed to increase the shield wires' visibility in low light conditions. The SFDs were installed May of 1996, using a 50-foot spacing staggered on each parallel shield wire, resulting in an appearance of a 25-foot spacing.

In this example, a lineman was placed in a line cart on the shield wire and pulled himself across the shield wire by hand to install the diverters (Photo 54). It took a three-man crew 2 hours of setup time for each wire crossing and 30 minutes for the lineman in the cart to install the SFDs. To date no additional collisions or deaths have been documented (Rasmussen 2001).

Photo 54 Lineman Iinstalling SFDs from a Suspended Pull Cart

In Indiana, the SFD has also recently shown to be effective in reducing waterfowl collisions with overhead static wires (Crowder 2000). The spacing of the SFDs in Crowder's 1998-2000 study was 20 feet apart (Photo 55). The close spacing was required to compare the effectiveness of the SFD to the BFD.

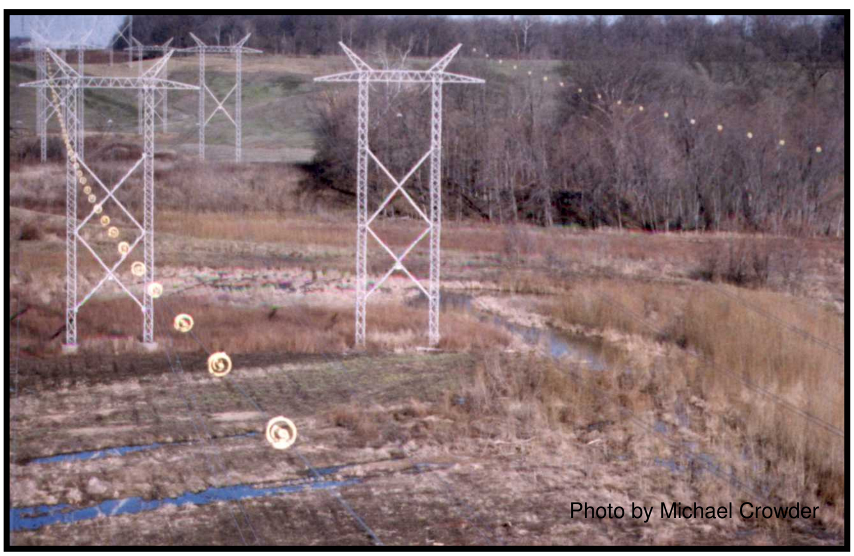

Photo 55 Swan Flight Diverters Installed at a 20-foot Interval in Indiana

Like the BFD, the SFD cannot be installed on electrically energized conductors with a voltage more than 230kV because of ozone deterioration. The ozone destroys the chemical properties and makes the SFD brittle, reducing the service life. SFDs also can create radio and television interference when installed on higher voltage conductors, but these devices are appropriate on overhead static wires and on lines below 230kV. As discussed for BFDs, the SFD colors may fade after long periods of UV exposure but should not become brittle or lose their elastic properties.

6.3.5 Spiral Vibration Damper

Spiral Vibration Dampers (SVDs) are manufactured from solid PVC into a helix (Figure 10). The purpose of the damper is to reduce high-frequency aeolian vibration. The SVD is designed to provide the action/reaction motion to oppose the natural vibration of cable by gripping a conductor tight at one end; loosely on the opposite end. The vibration is often inducted by low velocity winds of 3 to 8 mph.

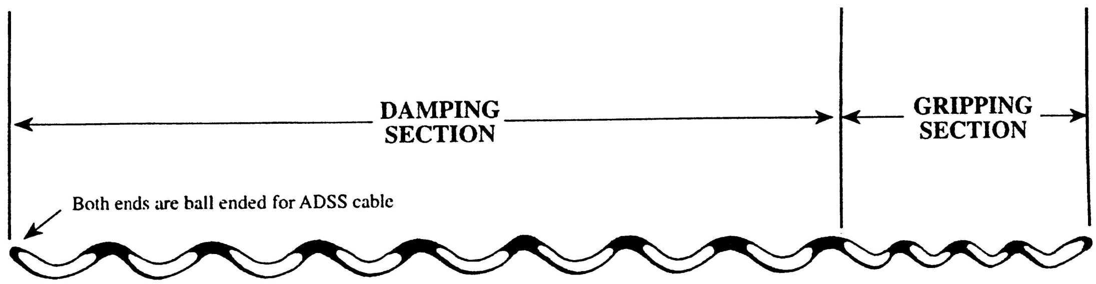

Figure 10 Spiral Vibration Damper

The Dulmison SVD is made from a high-impact, standard UV-stabilized PVC. The SVD also is available in a variety of colors, and there are different sizes available to accommodate a conductor ranging from 0.175 to .76 inch.

SVDs have been used in the San Luis Valley in Colorado to mitigate crane collisions. Coverage of the wires was 27.5% per span, reducing collisions by 61%. As discussed for BFDs and SFDs, the SVD cannot be installed on electrically energized conductors with a voltage more than 230kV because of ozone deterioration. Radio and television interference can be a problem when installed on higher voltage conductors. The SVD colors also may fade after long periods of UV exposure but should not become brittle or lose their elastic properties, making them appropriate for overhead static wires and lines below 230kV.

Tri-State Generation and Transmission Association has used the Dulmison and Preformed spiral vibration dampers for approximately 16 years without any failures (Dille 2001). The dampers are easy to install; however, after several years they do become brittle and will break if they need to be removed.

6.4 <u>Conclusion</u>

6.4.1 Marker Type

There are very few comparative studies testing the effectiveness of various marker devices to minimize bird collisions with power lines. One study by Crowder (2000) compared the SFD and BFD in their effectiveness to reduce waterfowl collisions at an Indiana wetland. Another study in South Africa by the EWT (in review) tested the effectiveness of the Flapper and BFD to reduce bustard and crane collisions. Both studies showed all devices to be effective in reducing, but not eliminating collisions. In Crowder's study there was no significant difference between the SFD and BFD based upon the number of dead birds per search. Comparisons between the Flapper and BFD are not yet available from South Africa.

The circumstantial nature of existing data and the lack of analysis of known instances of collisions, compounds the difficulty of selecting appropriate mitigating devices. There are no studies on which marker is most effective for raptors. However it is very likely that swinging plates will show to be more effective than static measures. Unfortunately although an experimental swinging plate used in the San Luis Valley was effective in reducing collisions, the aerodynamic instability of the plate proved to be destructive to conductors. It is important to select mitigating measures that will need minimal maintenance to reduce the potential for future disturbance. Until test data are available demonstrating the Flapper, BirdMARK, Mission Engineering, and MIDSUN plates are aerodynamically stable and that the devices will stay in place during high winds, other passive devices should be sought in hard to access areas. Swinging plate systems hold great promise for reducing collisions, but they should be tested on less critical lines with easy access.

Passive marking devices include the SVD, BFD, and SFD have all been demonstrated to reduce collisions with waterfowl, cranes, bustards, and swans. They are all manufactured from a high-impact PVC that possesses excellent strength and durability properties. Although these devices are available in a variety of colors, there is a general consensus that these devices work because they increase the profile of the line, not because of their color. Because the SFD has the largest profile, it is preferred over the SVD and BFD. In areas with heavy ice loading, the larger profile might not be preferable. Passive markers can be ordered in yellow to maximize contrast with the horizon during low-light conditions.

6.4.2 Marker Spacing

The space between wire markers varies depending upon a number of factors including the size of marker, bird species, and extent of the concentration areas. The optimal way to install markers is to stagger them to minimize the number of devices required. In the collision studies documented in *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994,*

- The BFD reduced collisions from 86% to 89% when spaced 16 feet apart and 57% to 58% when spaced 33 feet apart.

- The larger BFD (Catalog BFD-7) reduced collisions 65% to 74% when spaced 50 feet apart.

- The SVD reduced collisions 61% when 27.5% on the span was covered.

In the only published study on the SFD, Northern States Power Company eliminated swan collisions using yellow SFDs at a staggered 50-foot spacing, resulting in an appearance of a 25-foot spacing.

It is important to note the reported collision reduction levels are complied from a variety of sources and are not directly comparable due to varying methodologies, environments, and bird species. Also, none of the studies specifically addressed raptor collisions.

The optimal diverter placement is to stagger the devices midway between each other on alternating lines to reduce the number of markers required. A significant portion of the cost associated with installing any marker is achieving the proper device placement. When stringing the conductors it is important to mark where the diverter is to be placed rather than to perform measurements when the wires are in the air. This is more critical when installing markers with a helicopter or tall crane than when using a pull cart.

Given today's pressures to ensure electrical reliability, it is imperative that utilities exercise due diligence when seeking to implement solutions to such problems. Care must be used in solving potential collision problems to avoid creating additional operational problems that could lead to degradation of facility availability by promoting either forced or scheduled outages. Thus, utilities should exercise caution by using solutions with a proven track record or by thoroughly testing potential solutions before implementing them on critical facilities.

Although active devices have been shown to effectively reduce collisions, passive PVC devices have proven to be effective in the long term. Tri-State has used spiral vibration dampers for approximately 16 years without any failures, and Northern States Power has successfully used the SFDs since 1996 with no maintenance problems. Likewise Montana Power has used the BFD's for over 5 years with no shifting or other maintenance problems.

7.0 RESULTS AND CONCLUSIONS

7.1 Survey Results

The field surveys identified 46 structures in need of retrofitting (Chart 1). Retrofitting options were developed for each structure type and are included on the data summary sheets (see Appendix B). Measures include stinger and jumper covers, transformer bushing covers, arrester caps, ground wire gapping, and perch deterrents. Refer to the columns labeled "Retrofit for Faunal Safety" for specific recommendations for each pole. The latitude and longitude for each pole is recorded on the sheets to locate poles for retrofitting. The enclosed CD also includes the latitude and longitude waypoint files and copies of the structure photos referred to in the data summary. Refer to Chapter 5 for general electrocution retrofitting recommendations and Chapter 6 for collision recommendations.

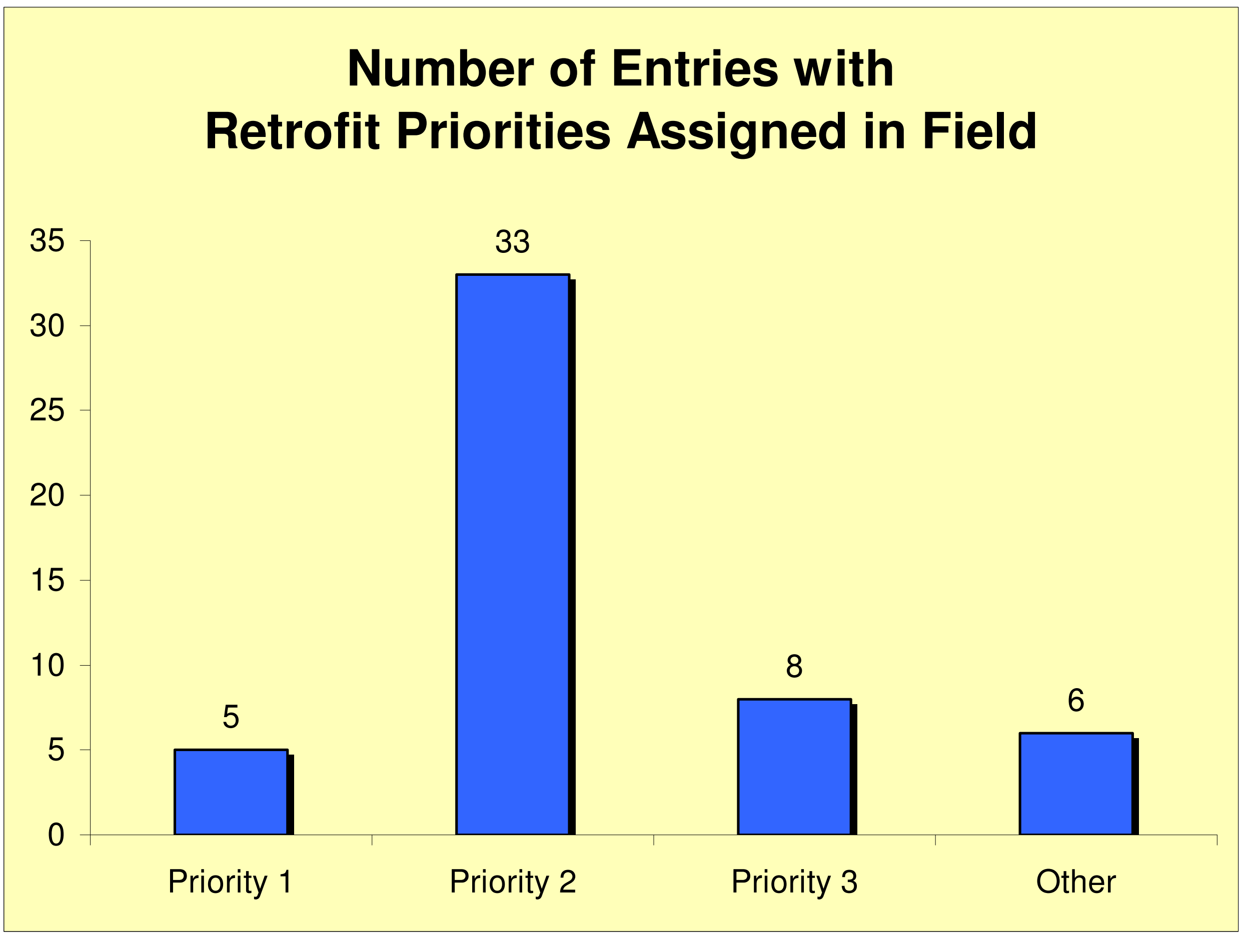

Chart 1 Retrofitting Priority Assigned in the Field

Certain structures are known to pose an increased electrocution risk to birds. The level of risk depends on a combination of factors including pole configuration, proximity of pole to nests, bird species inhabiting the area, feeding areas or other important habitat features. On the LNWR the only lethal structure identified was a transformer pole with two single-phase risers. Two great horned owls have been electrocuted at this structure near a refuge residence (refer to pole A01).

7.1.1 Transformers

Transformers are historically associated with more avian mortalities than any other structure type (Harness 1997). This survey identified 24 structures with transformers in need of retrofitting. Some of the refuge transformers are electrically protected using fuse links between the tank mounted arrester and transformer bushing. The use of fuse links makes it very difficult to animal/raptor proof because there are no commercially available products designed to cover exposed fuse links. Phasing out fuse links and substituting cutouts and insulated jumper wires (600 Volt class insulation) will allow for bushing covers and better animal protection.

7.1.2 Three-phase Tangent Units

Thirteen old-type REA C1 configurations were recorded. These units do not have adequate phase-to-phase separation for eagles. Accordingly, perch deterrents are recommended. It is best to use a deterrent that will not allow birds to perch under the guards (Refer to Section 5.15 – Perch Management).

7.1.3 Lightning Arrestors

Twenty-six structures were identified with unprotected lightning arresters. Many of these units are gapped. Lightning arrestors and their unprotected jumpers can be problematic and insulated jumpers and insulating caps should be placed on these units. Gapped arresters should continue to be replaced with nongapped types. When bushing covers are to be placed on equipment poles with gapped arresters, a bushing cover with a side knockout like the Raychem BCAC can be used (Photo 56).

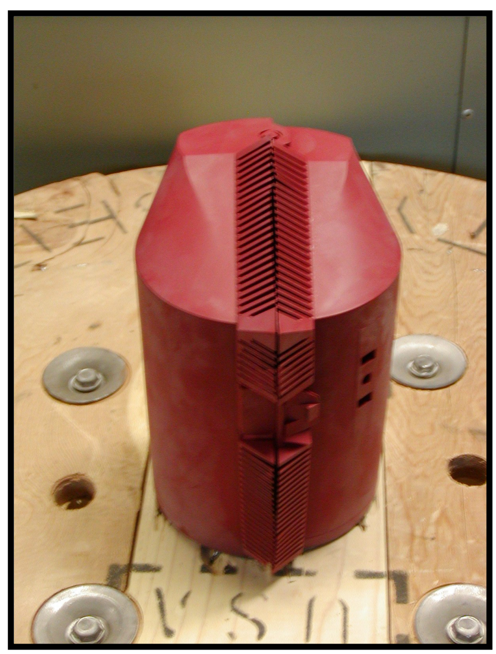

Photo 56 Raychem BCAC Bushing Cover with a Side Knockout

7.1.4 Riser Poles

Grounded steel pothead brackets associated with riser poles are common. The brackets offer an attractive perch platform for birds. Pothead covers should be installed and remaining exposed areas covered with fusing tape.

7.1.5 Metal Cutout and Arrestor Brackets

Grounded steel cutout and arrestor brackets are common and pose an electrocution risk. As with pothead brackets, uninsulated jumpers and arrestors may facilitate phase-ground contact if a bird perches on a grounded bracket. For retrofitting, all leads to the cutouts and arresters should be covered. Caps should also be used on arresters. Fiberglass brackets should be increased throughout the system in new construction.

7.1.6 Pole top ground wires

Although most utilities have not used pole top ground wires for approximately 30 years, they do persist on older lines. The removal or gapping of ground wires should be a high priority for raptor protection.

7.1.7 Collisions

Avian collisions can occur on lines, especially those crossing high value bird habitat, such as over waterways. Spans D06 and E01 were identified as areas for an increased risk of collision. These spans should be fitted with bird Flappers with a 5-m spacing.

7.2 <u>New Construction</u>

As discussed in Chapter 5.0, all new construction should include the following to minimize risks of avian electrocutions:

- All new equipment should be installed with bushing covers and covered jumpers.
- 60 inches of phase-to-phase and phase-to-neutral/ground separation should be provided.
- Down guys should include insulating links to eliminate a potential path to earth when they are in proximity to energized wires.
- Crossarm braces should continue to be nonconducting wood.
- Nonconductive cutout/pothead brackets should be considered instead of metal brackets.

- Deadends should employ insulating links at the center phase and insulated jumpers when needed.
- Primary jumpers with less than adequate separation for either eagles or hawks should be covered with a minimum of 600v rated insulation.

7.3 Monitoring and Reporting

A key component of any APP is treating potential electrocutions as an incident requiring prompt reporting. It is important to continue to collect detailed information on these events to direct future retrofitting efforts. It also is important to follow up on retrofitting measures to gauge their performance. When dead or injured birds are found, employees should be instructed to report them, and an Avian Reporting Form should be completed. It is important to completely fill out forms, because effective retrofitting requires detailed knowledge on both the devices contacted and the bird species affected. It also is important to note any bird band, marker, or neck collar discovered.

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Appendix A
STANDARDIZED FIELD DATA SHEETS - SAMPLE

Appendix B
FIELD DATA SPREADSHEET