STEEL/CONCRETE POLES

Steel/Concrete Pole Construction Worldwide

Most distribution power poles in the United States are made of wood, a nonconductive material.[30] In contrast, steel and concrete poles are commonly used in distribution line construction in Europe and other parts of the world. In Western Europe, it is estimated over 90% of the distribution poles are metal with grounded metal crossarms (Janss and Ferrer 1999). On such configurations, electrocutions can occur from phase conductor to pole or phase conductor to metal crossarm, placing both large and small birds at risk (Bayle 1999; Negro 1999; Janss and Ferrer 1999). Accordingly, European electrocution mitigation methods differ from those of the United States because measures effective on wooden power poles have not solved electrocution problems on conductive poles (Janss and Ferrer 1999). However, covering conductors with a dielectric material appropriate for avian protection is typically more effective in preventing electrocutions than is perch management, regardless of whether the pole is wooden, steel, or concrete (Negro 1999). Covering conductors is the preferred method on new or retrofitted steel and concrete poles in Europe (Janss and Ferrer 1999).

Concrete poles, with their internal metal rebar support structure, pose similar electrocution risks to metal poles. Concrete poles also provide a pathway to ground, further increasing their electrocution risk, especially when wet or when fitted with conductive crossarms. The largest remaining black-tailed prairie dog *(Cynomys ludovicianus)* colony complex in North America is in northwestern Chihuahua, Mexico (Ceballos et al. 1993). This complex supports a high density of raptors and nearby power lines are constructed with reinforced concrete poles with steel crossarms. In 2000, 1,826 power poles were surveyed and 49 electrocuted birds were found, including Chihuahuan ravens *(Corvus cryptoleucus)*, ferruginous hawks *(Buteo regalis)*, red-tailed hawks *(B. jamaicensis)*, prairie falcons *(Falco mexicanus)*, American kestrels *(F. sparverius)*, and golden eagles. The number of electrocutions led researchers to conclude that these poles represent a serious risk for wintering raptors (Cartron et al. 2000). The subsequent replacement of steel crossarms with wooden arms on over 200 poles in this area significantly reduced the electrocution risk of these structures (Cartron et al. 2005).

Steel/Concrete Pole Construction in the United States

Historically, utilities in the United States have primarily used wood for distribution poles and crossarms. Accordingly, many avian retrofitting techniques today are designed for use on wood structures. Fiberglass, concrete, and steel poles are now being used more in distribution line construction for a variety of reasons. Sometimes non-wood poles are used because they are not susceptible to damage by woodpeckers. In some regions of the United States, woodpecker damage is the most significant cause of pole deterioration (Abbey et al. 1997). Steel poles and concrete poles are harder for animals such as squirrels, raccoons, and cats to climb. By keeping these animals off structures, utilities can help reduce outages. Non-wood poles may also be used because they are not susceptible to fungal, bacterial, or insect damage.

Distribution power lines constructed with steel or concrete poles using standard utility configurations can significantly reduce phase-to-ground separations. Fiberglass poles have a higher insulation resistance than steel, concrete, and wood poles.

Single-phase lines are usually constructed without crossarms and support a single energized phase conductor on a pole-top insulator.

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[30] The insulation value of wood poles and crossarms is variable based on age, condition, contamination, and wetness.

Wood or fiberglass distribution structures, without pole-top grounds or pole-mounted equipment, generally provide adequate separation for birds (Figure 5.26).

When steel or concrete poles are used (Figure 5.27), a bird perched on the pole top can touch its body to the conductor while simultaneously contacting the grounded pole

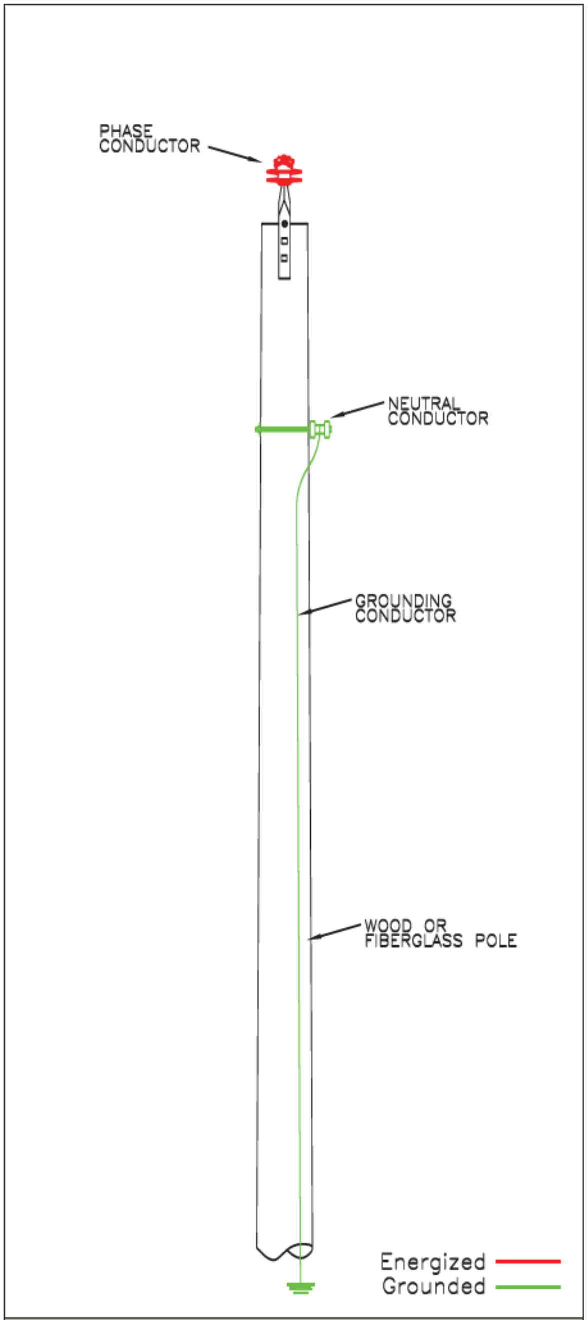

FIGURE 5.26. Typical single-phase distribution configuration on a wood or fiberglass pole.

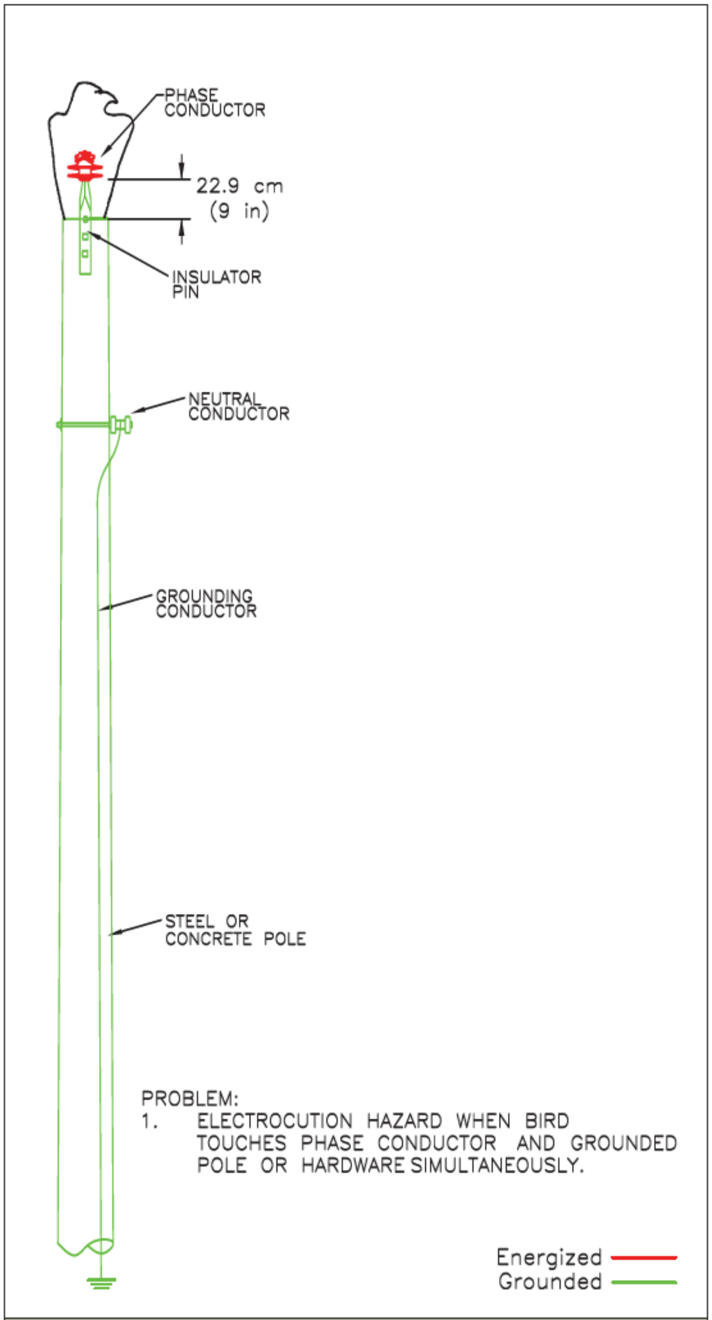

FIGURE 5.27: Problem single-phase configuration on a steel or reinforced concrete pole.

top or hardware with its feet, resulting in electrocution. One solution to this problem is to install a phase cover (Figure 5.28, Solution 1). Another solution is a two-step process: (1) place the phase conductor on an insulator installed on an extended fiberglass-reinforced pole-top pin to increase the separation between the phase conductor and the pole top, (2) install a pole cap to deter birds from perching on top of the pole (Figure 5.28, Solution 2). In tests with captive raptors at the Rocky Mountain Raptor Program, a pole cap's slick surface discouraged birds from perching (Harness 1998).

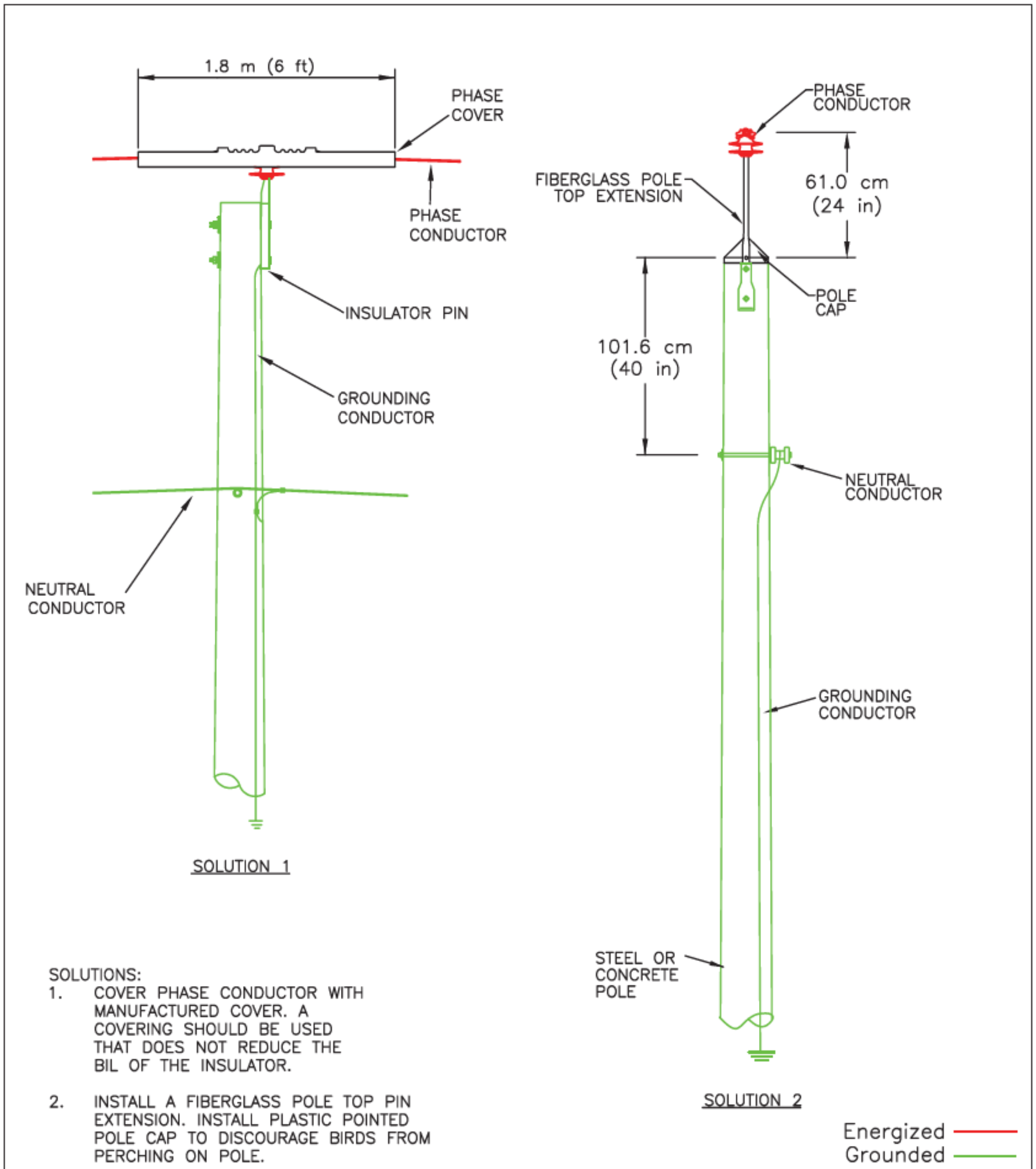

FIGURE 5.28: Solutions for single-phase configuration on a steel or reinforced concrete pole.

When steel or concrete poles are used for multi-phase structures, the critical separations for birds are both the phase-to-phase and the phase-to-pole (i.e., phase-to-ground) separation (Figure 5.29). Although the phase-to-phase issues are the same as encountered on wood poles, the phase-to-pole issue is not.

As on the single-phase structure (Figure 5.28, Solution 2), additional separation should be provided for the center pole-top phase conductor by placing it on an extended fiberglass reinforced pole-top pin and adding a pole cap to discourage perching. Additionally, wood or fiberglass crossarms should be used. Steel crossarms mounted on steel poles should be avoided because their minimal phase-to-ground separations make them extremely hazardous. Birds landing on grounded steel arms become grounded and need only touch one energized conductor or piece of hardware to be electrocuted.

The reduced phase-to-ground separations found on existing steel or concrete poles can be mitigated in several ways. One method is

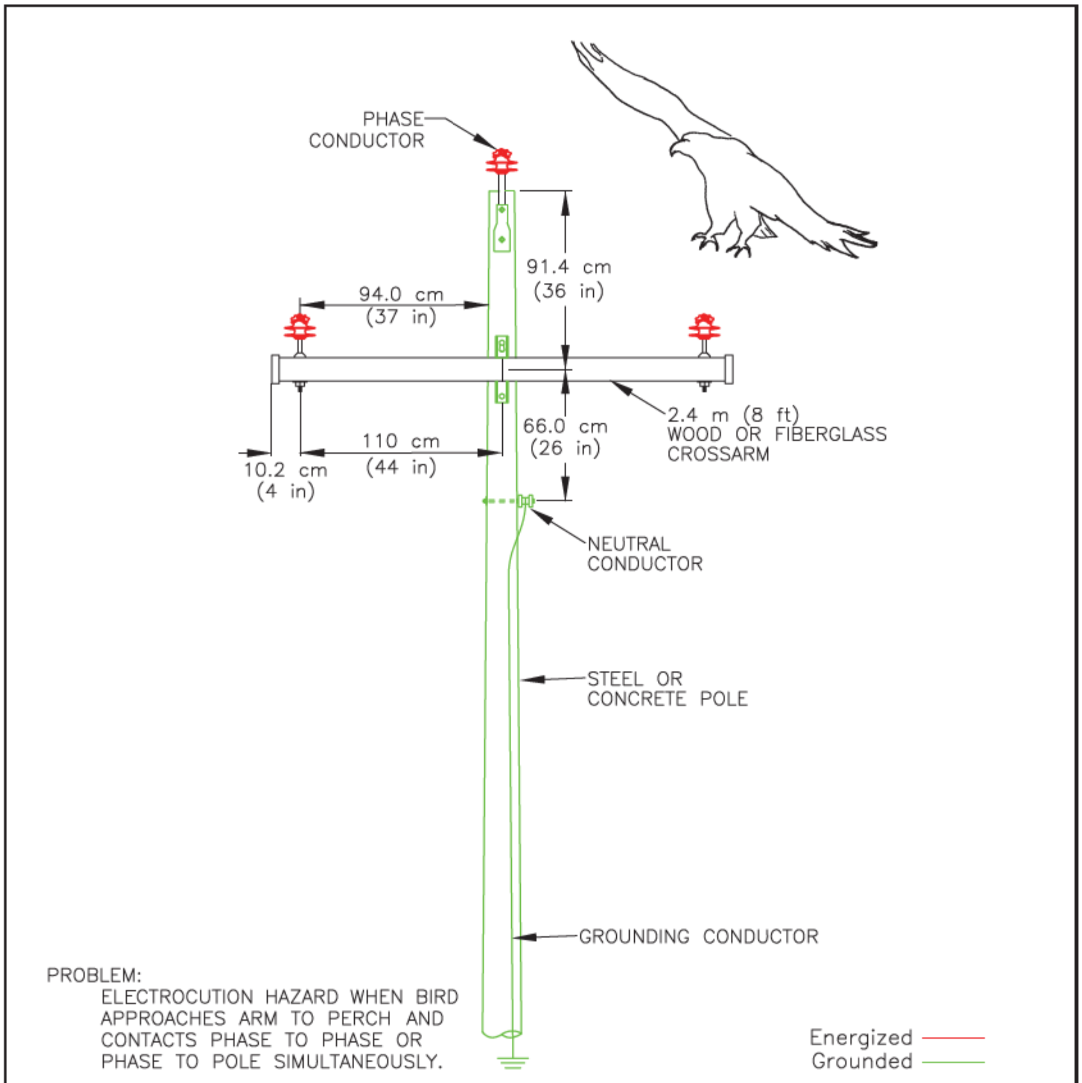

FIGURE 5.29: Problem three-phase configuration on a steel or reinforced concrete pole.

to cover the pole from the crossarm to the pole top with a material designed for this purpose (Figure 5.30). This can be achieved by wrapping a band of 40-mil thermoplastic polymer membrane backed with a pressure-sensitive adhesive around the pole from the crossarm up to and including the top of the pole, or by spraying the same area with a protective coating that has sufficient dielectric strength. A utility performed a dielectric test of a thermoplastic wrap, and determined that a 46 x 167-cm (18 x 66-in) piece allows no appreciable current leakage at 35 kV for a three-minute duration. The thermoplastic wrap also can effectively increase phase-to-ground separations on narrow profile configurations.

As an alternative to wrapping the pole top, perch discouragers can be mounted on the crossarm to deter birds from perching on the crossarm (Figure 5.31). Crossarms fitted with perch discouragers are effective in reducing

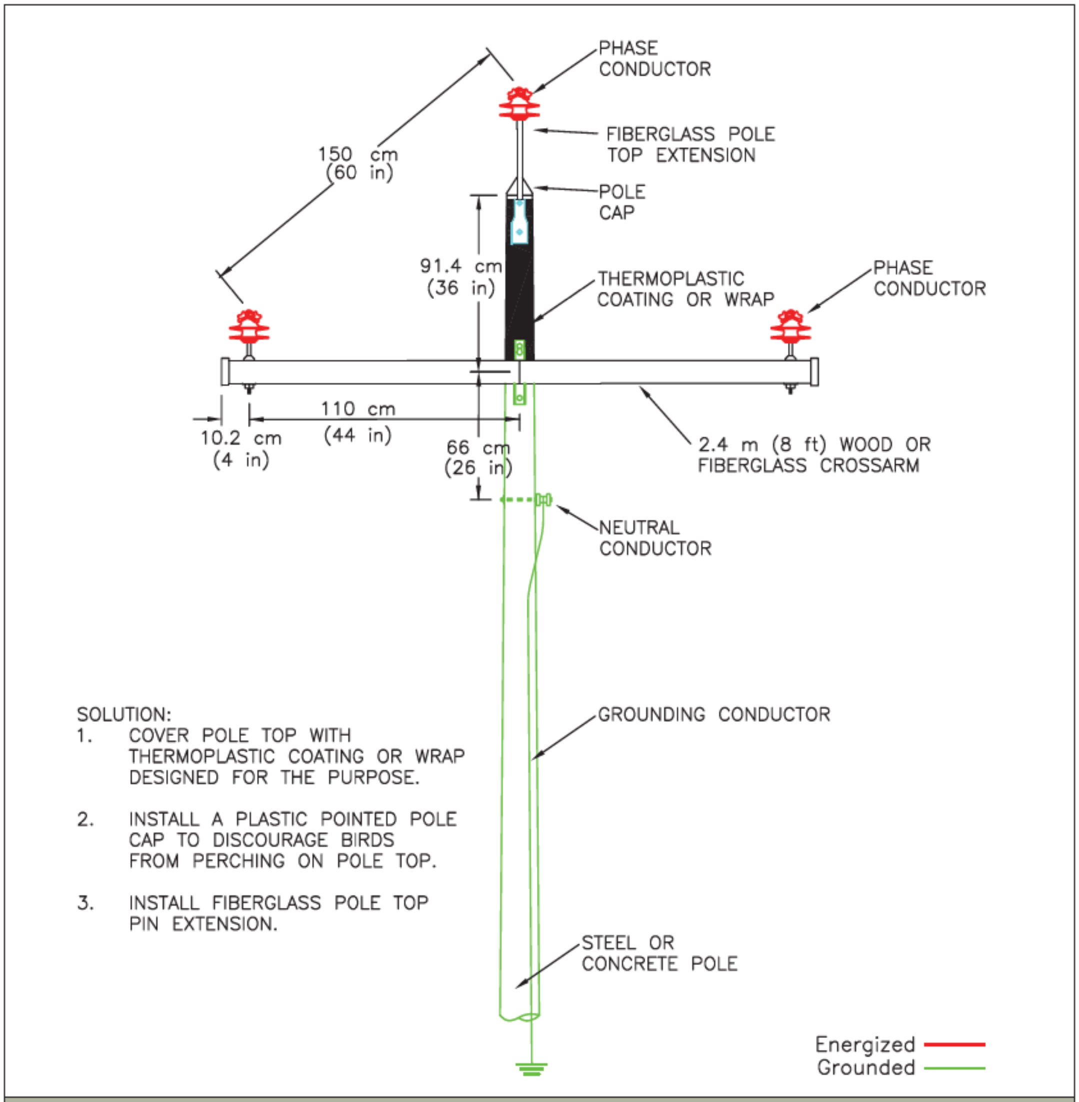

FIGURE 5.30: Solution for three-phase configuration on a steel or reinforced concrete pole using thermoplastic wrap.

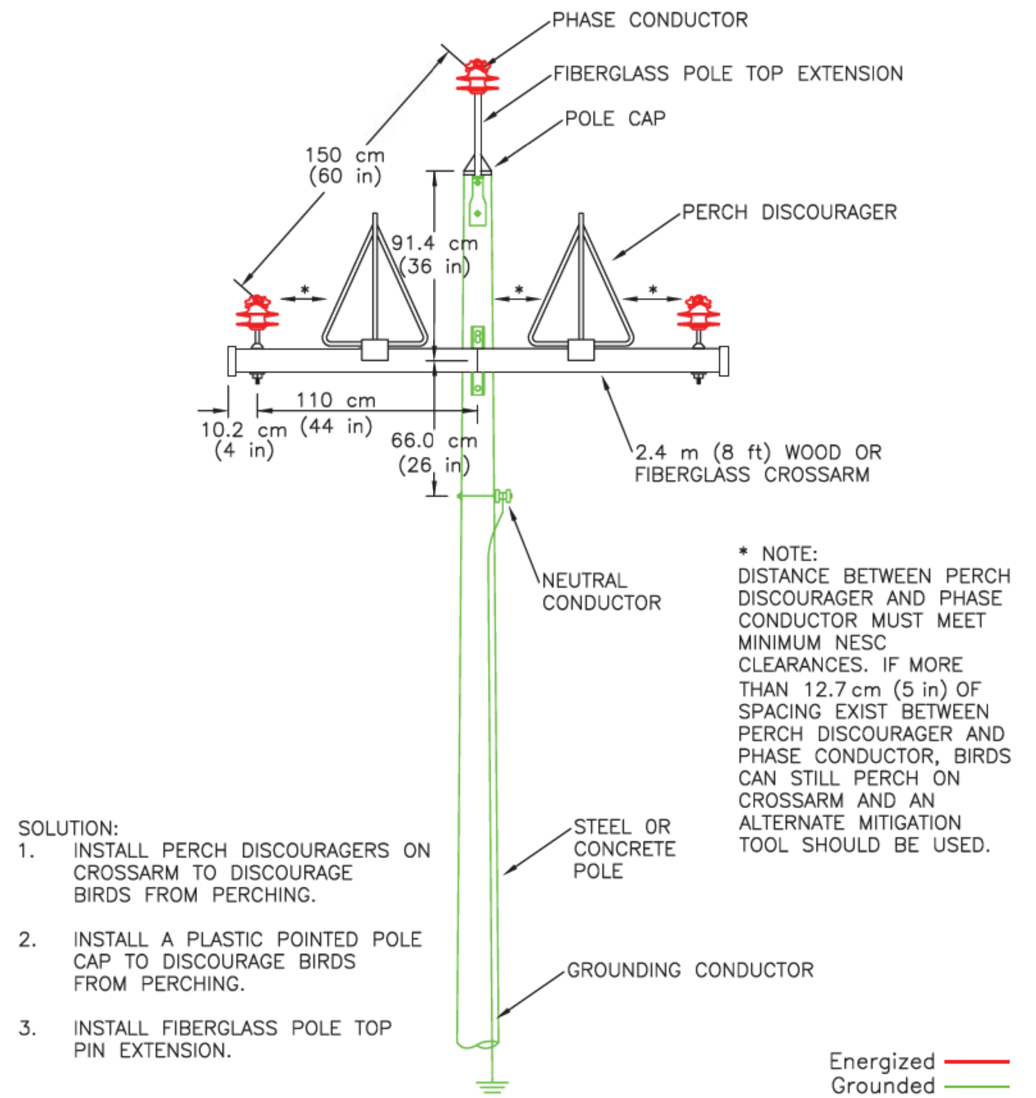

FIGURE 5.31: Solution for three-phase configuration on a steel or reinforced concrete pole using perch discouragers.

some but may not eliminate all avian mortality (Harness and Garrett 1999). Perch discouragers also may shift birds to other nearby poles that might not be any safer. For guidance on the use of perch discouragers from both biological and engineering perspectives, see page 17 and page 68.

Another suitable method for reducing avian electrocution risk is covering the outer two phase conductors to prevent phase-to-pole (i.e., phase-to-ground) contacts (Figure 5.32). On the center phase, a phase cover or a pole cap with extension pin should also be installed.

Another option is to suspend two of the energized conductors from the crossarm, instead of supporting them on the arm (Figure 5.33). Suspending the conductors allows birds to perch on the crossarm without contacting energized conductors. A pole cap and extended fiberglass reinforced insulator pin should still be used to discourage perching on the pole top to prevent contact with the center phase. Suspending the insulators and conductors will also allow utilities to achieve 150-cm (60-in) separation with 1.8 or 2.4-m (6 or 8-ft) crossarms (as shown in Figure 5.33). If vertical construction is used with steel or reinforced concrete poles, phase covers should be installed on all three conductors.

Avian-safe separation can be achieved on steel and reinforced concrete dead-end or corner poles by installing fiberglass extension links or adding additional insulators between the primary dead-end suspension insulators and the pole. This solution is similar to those recommended for three-phase distribution dead-end and corner configurations using wooden poles and crossarms (Figures 5.16 and 5.23). Bare jumper wires are commonly used to connect incoming conductors to the

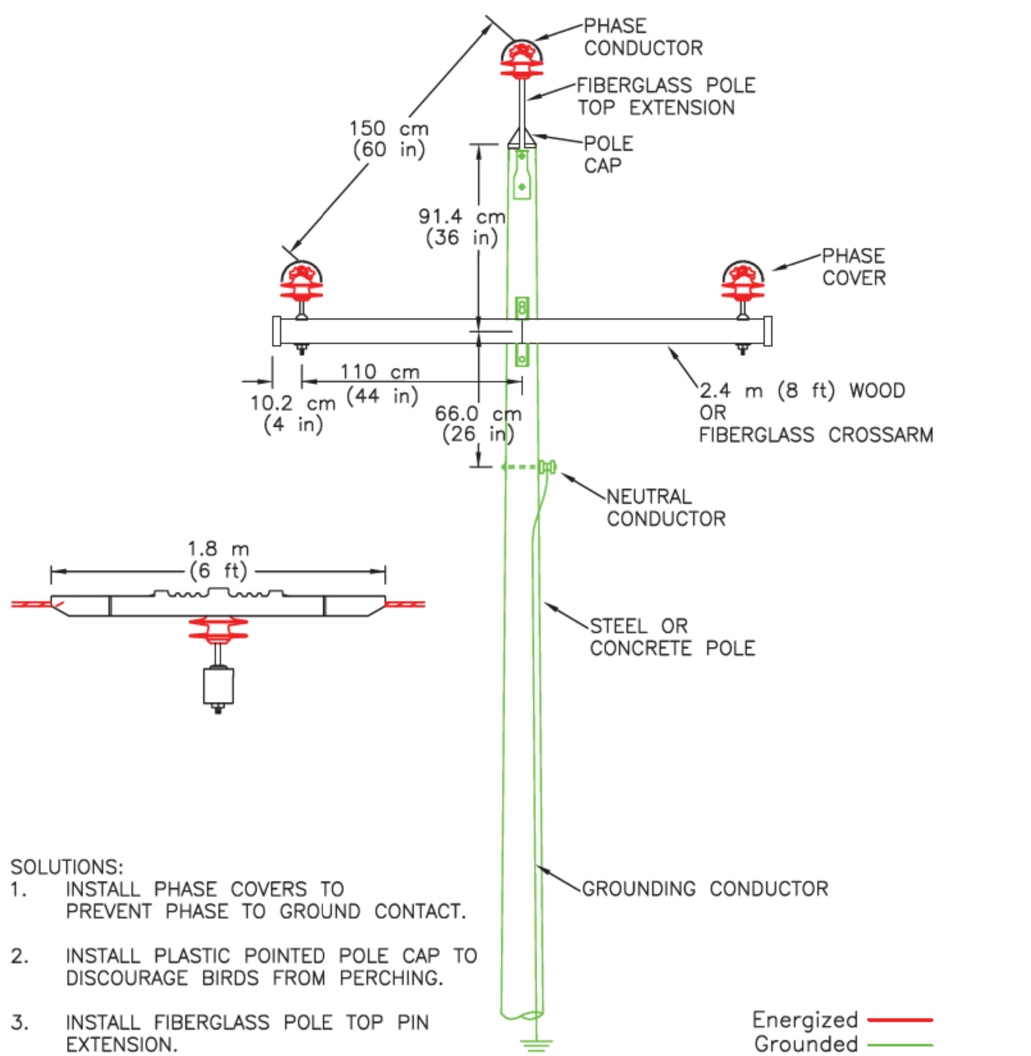

FIGURE 5.32: Solution for three-phase configuration on a steel or reinforced concrete pole using phase covers.

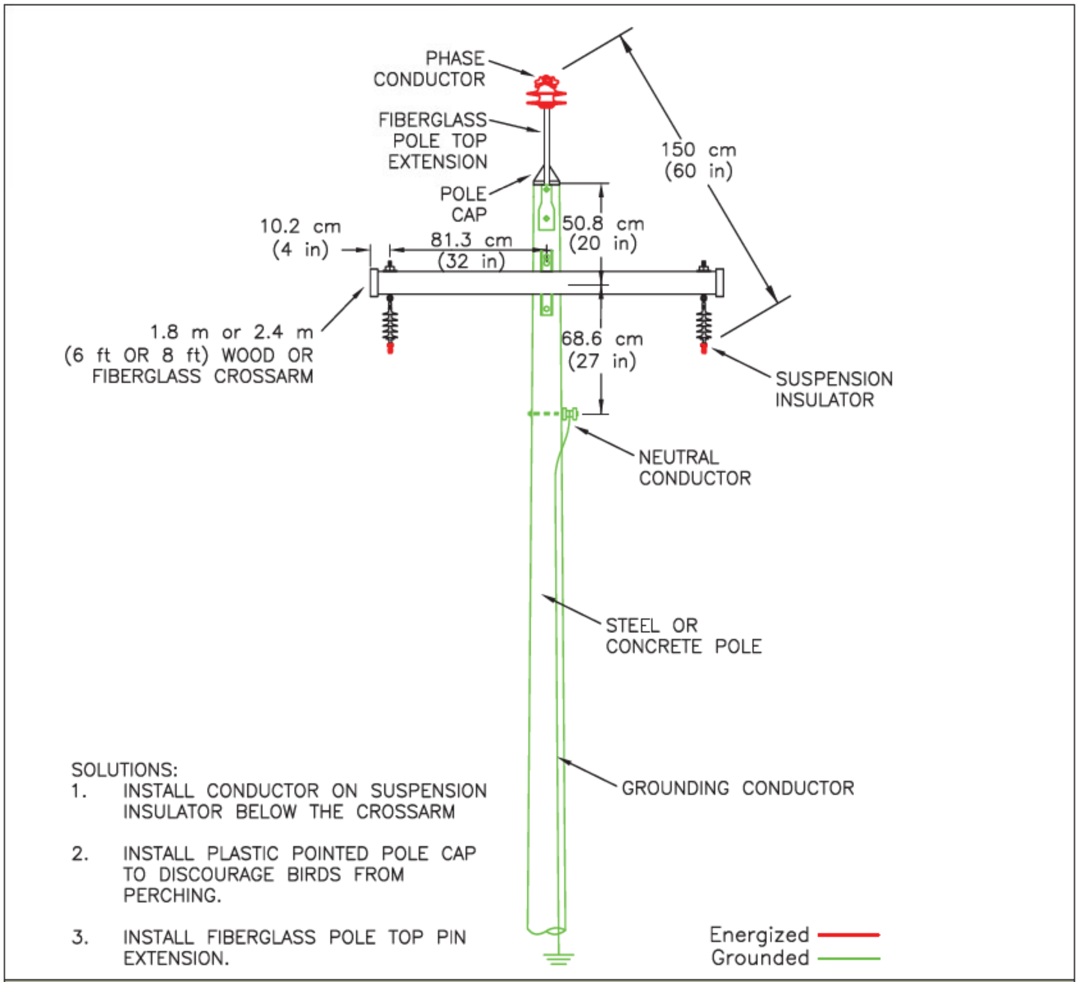

FIGURE 5.33: Three-phase configuration on a steel or reinforced concrete pole with suspended insulators.

outgoing conductors, making the line turn or tapping off the main circuit. Covering the jumper wires with a material suitable for avian protection or replacing them with covered conductor will reduce electrocution risk.

Problem Transmission Designs

Although transmission lines rarely electrocute birds, there are a few exceptions, particularly on lower voltage transmission lines (i.e., 60 kV or 69 kV).[31] The armless configuration, in which conductors are mounted on horizontal post insulators, commonly used for distribution lines (see Figures 5.20 and 5.21), may also be used for some transmission lines below 115 kV (Figure 5.34). In areas subject to high lightning levels, lightning protection may include an overhead static wire that must be grounded. On installations with wood poles, utilities, particularly in salt spray or other contaminated areas, may bond the bases of the post insulators to the grounding conductor to prevent pole fires. A bird perched on the insulator can be electrocuted if it comes in

[31] If distribution underbuild is present on a transmission structure, the recommendations shown previously for distribution configurations should be used to make the underbuild avian-safe.

contact with the energized conductor and either the grounded insulator base or the bonding conductor. From 1991 through 1993, more than 30 golden eagles were electrocuted along approximately 32 km (20 mi) of a 69-kV line with this configuration in central Wyoming (PacifiCorp, unpubl. data).

This configuration was once thought to be avian-safe because it was anticipated that birds would perch on the pole top rather than on the insulators. The 1996 edition of *Suggested Practices* recommended installing perch discouragers on the insulators to prevent electrocutions. However, because birds were still able to fit between the perch discourager and the conductor, the use of perch discouragers alone has been determined ineffective (PacifiCorp, unpubl. data).

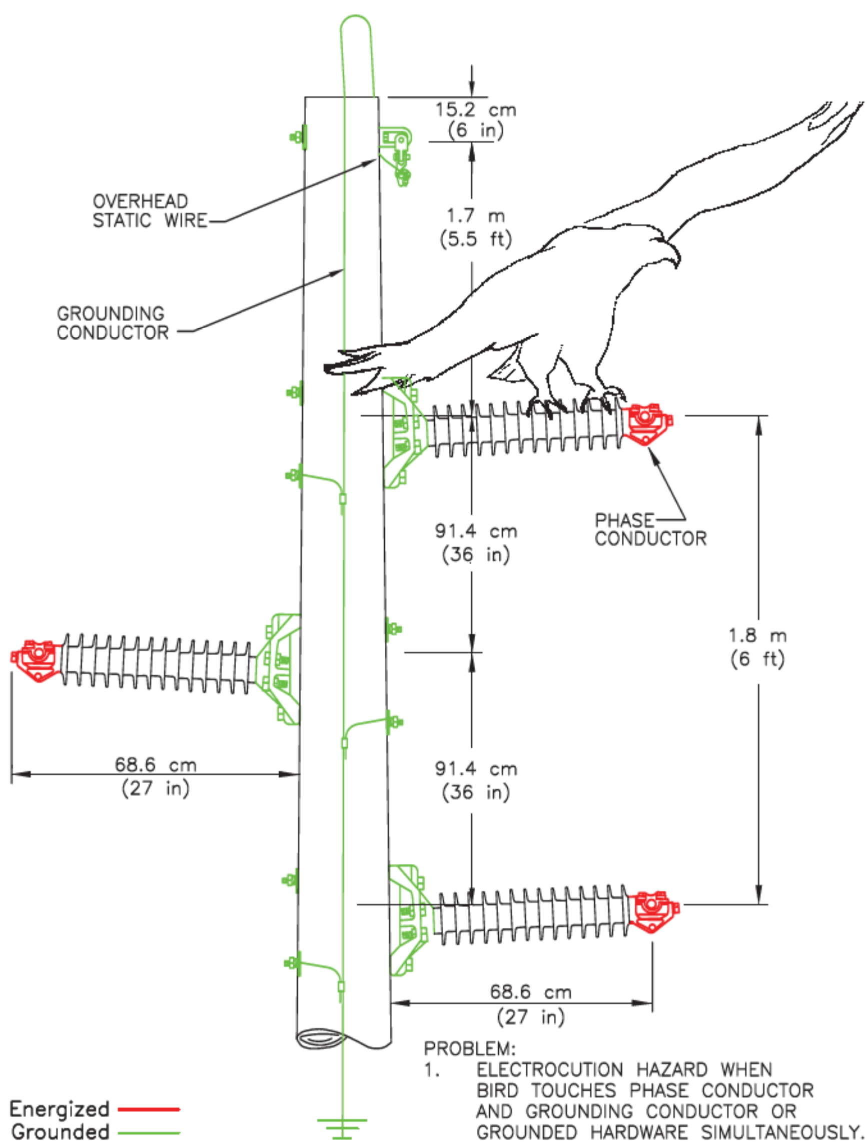

FIGURE 5.34: Problem 69-kV horizontal post insulator design.

Utilities are testing different options (Figure 5.35) for reducing electrocution risk on horizontal post construction. These options include:

- Covering the insulator bases and bolts with cover-up material designed for this purpose.

Installing an insulated pole grounding conductor or covering the pole grounding conductor with appropriate cover-up material, or wood or plastic moldings. The grounding conductor should be covered at least 30.5 cm (12 in) below the lowest energized conductor.

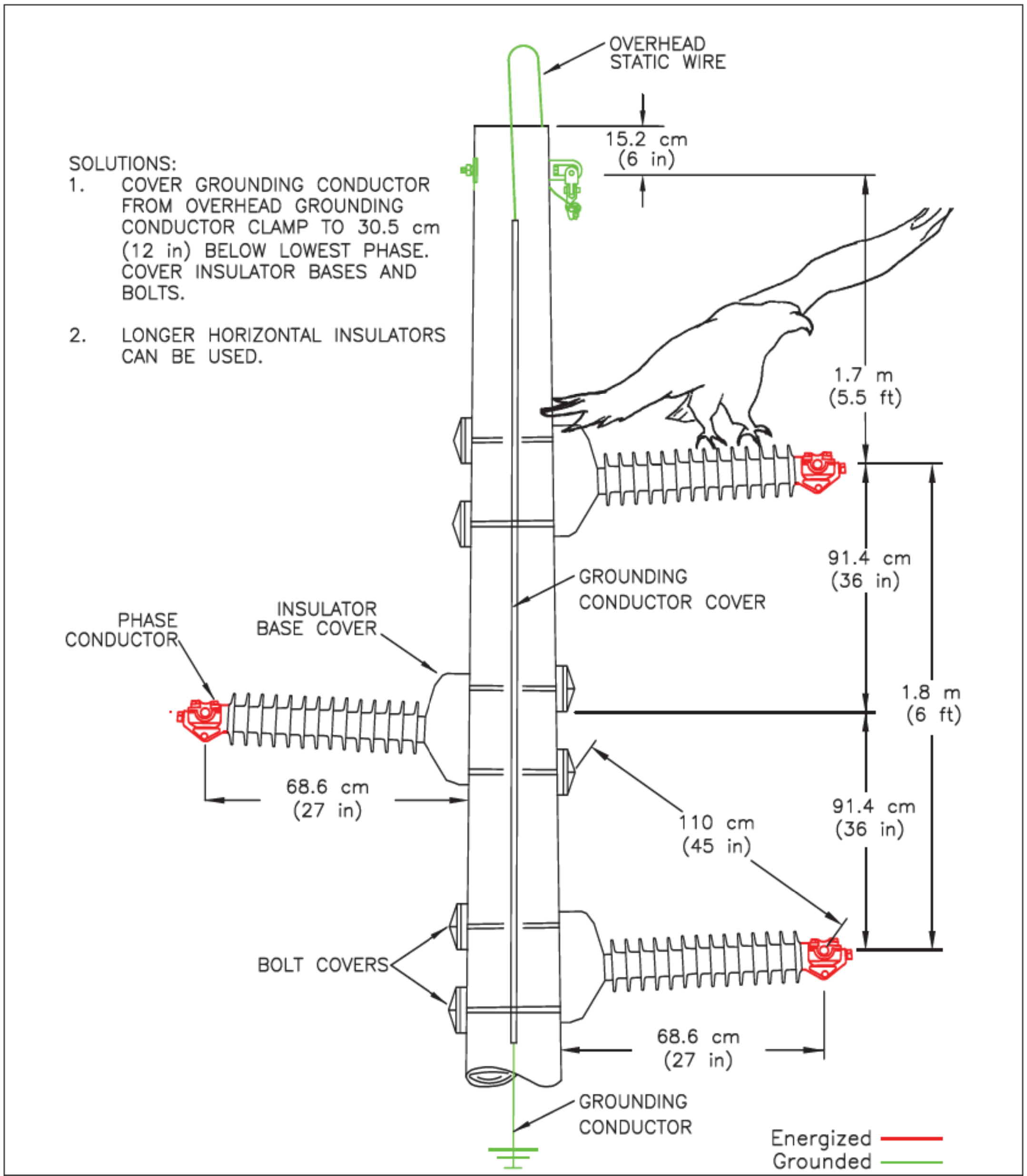

FIGURE 5.35. Solutions for 69-kV horizontal post insulator design.

- Replacing 60-kV or 69-kV post insulators with longer insulators (i.e., 115 or 138 kV) to provide the necessary 150-cm (60-in) separation. Although this may be a costly retrofit option, it can be used for new construction.

The wishbone configuration (Figure 5.36) is commonly used for 34-kV to 69-kV lines. The distance from the top phase to the lower arm can be less than 1 m (3.3 ft), which presents an electrocution hazard when large birds such as eagles or waders touch their heads to the energized conductor while

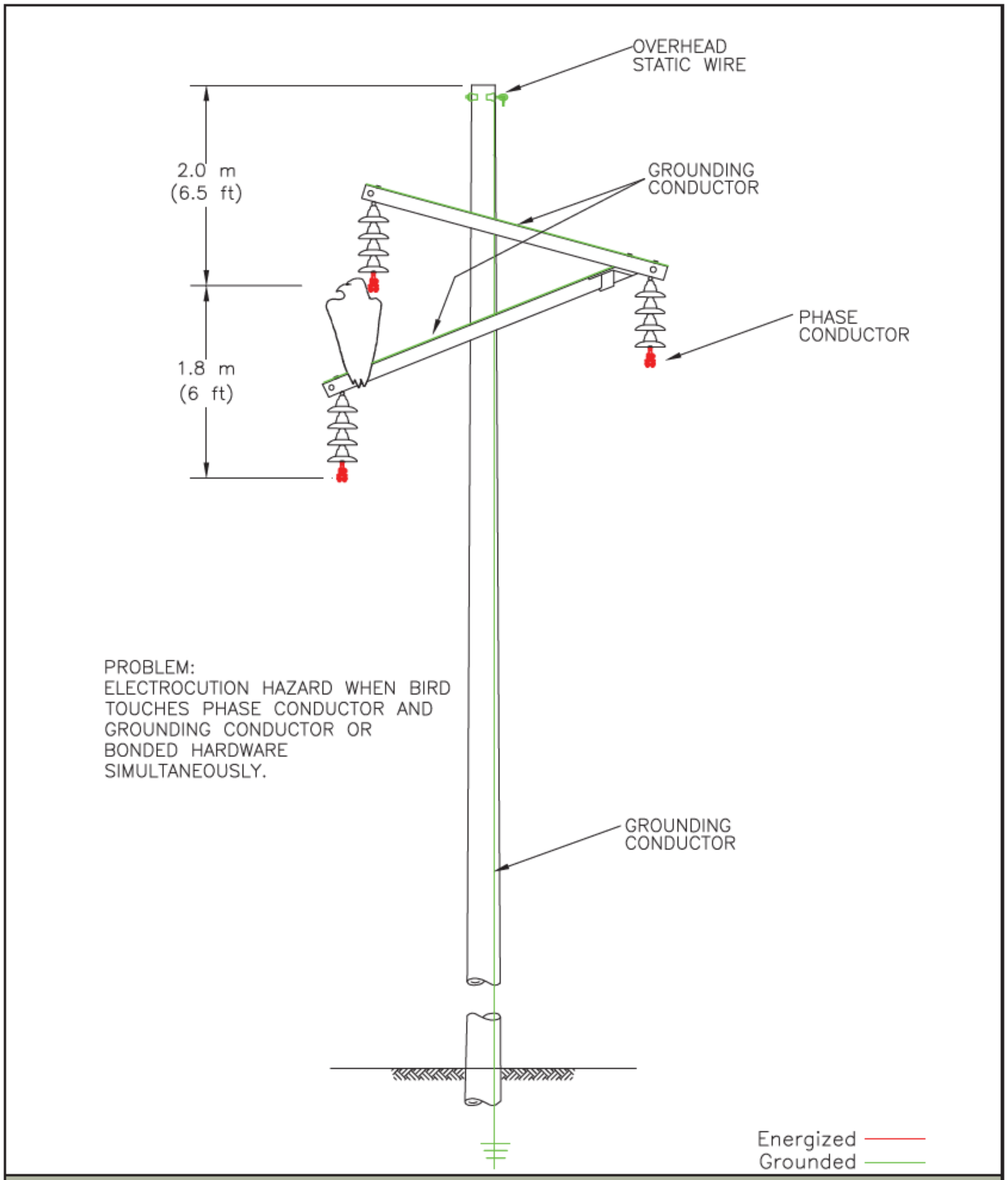

FIGURE 5.36: Problem wishbone design.

perched on the grounding conductor or bonded hardware on the crossarm.

To prevent phase-to-ground contact on the wishbone design, the grounding conductor and bonded hardware should be covered. This can be accomplished by:

- installing a dielectric cover on the lower crossarm (Figure 5.37), and
- covering the grounding conductor with plastic or wood molding or plastic tubing. A covered ground wire may also be used. The grounding conductor should be

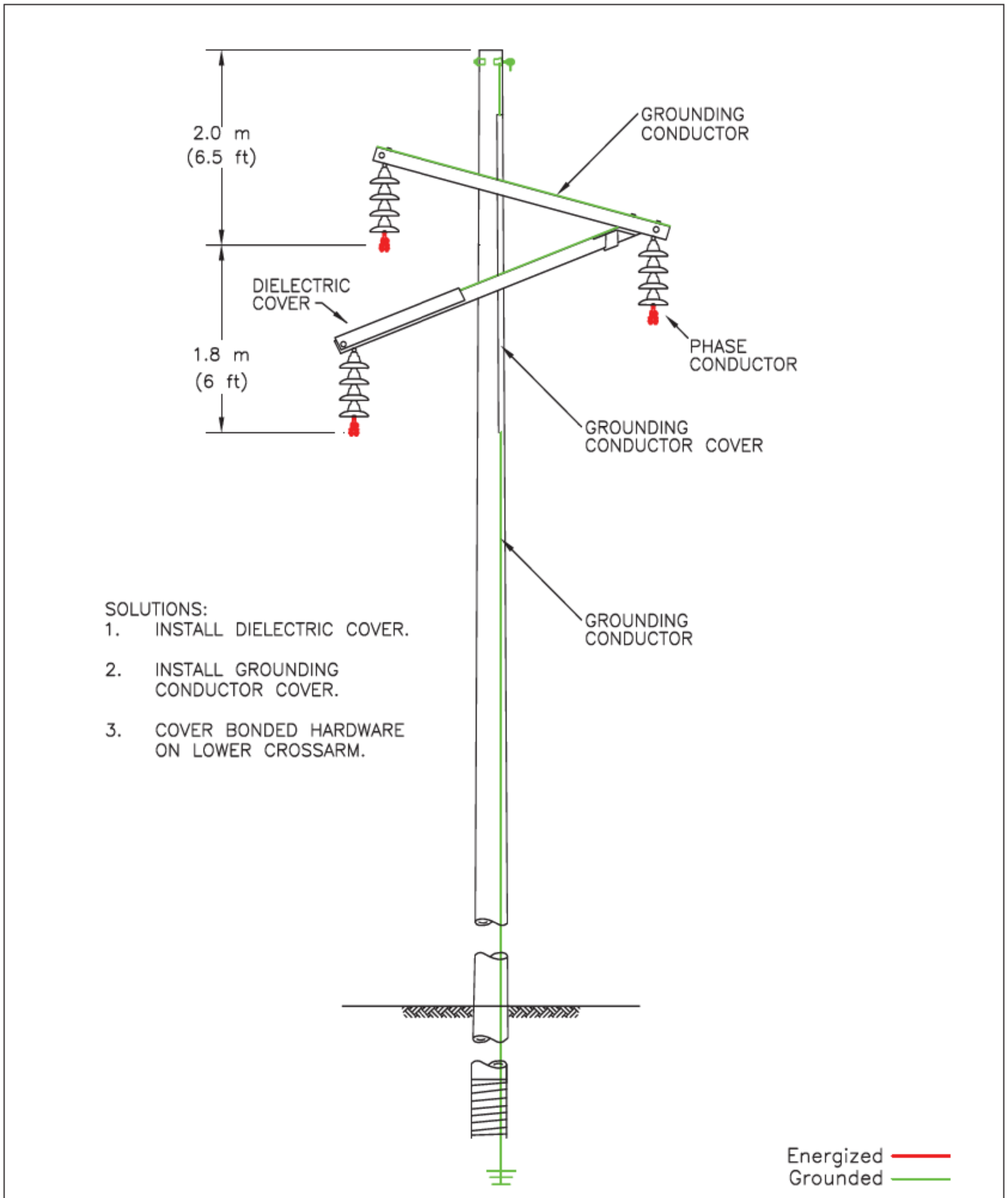

FIGURE 5.37: Solution for the wishbone design.

covered at least 30.5 cm (12 in) below the lowest energized conductor. Bonded hardware on the lower crossarm should also be covered with a material appropriate for avian protection.

For new construction, a wishbone design that provides adequate separation for large birds can be used (Figure 5.38). An avian-safe suspension configuration (Figure 5.39) can also be used for new construction as an

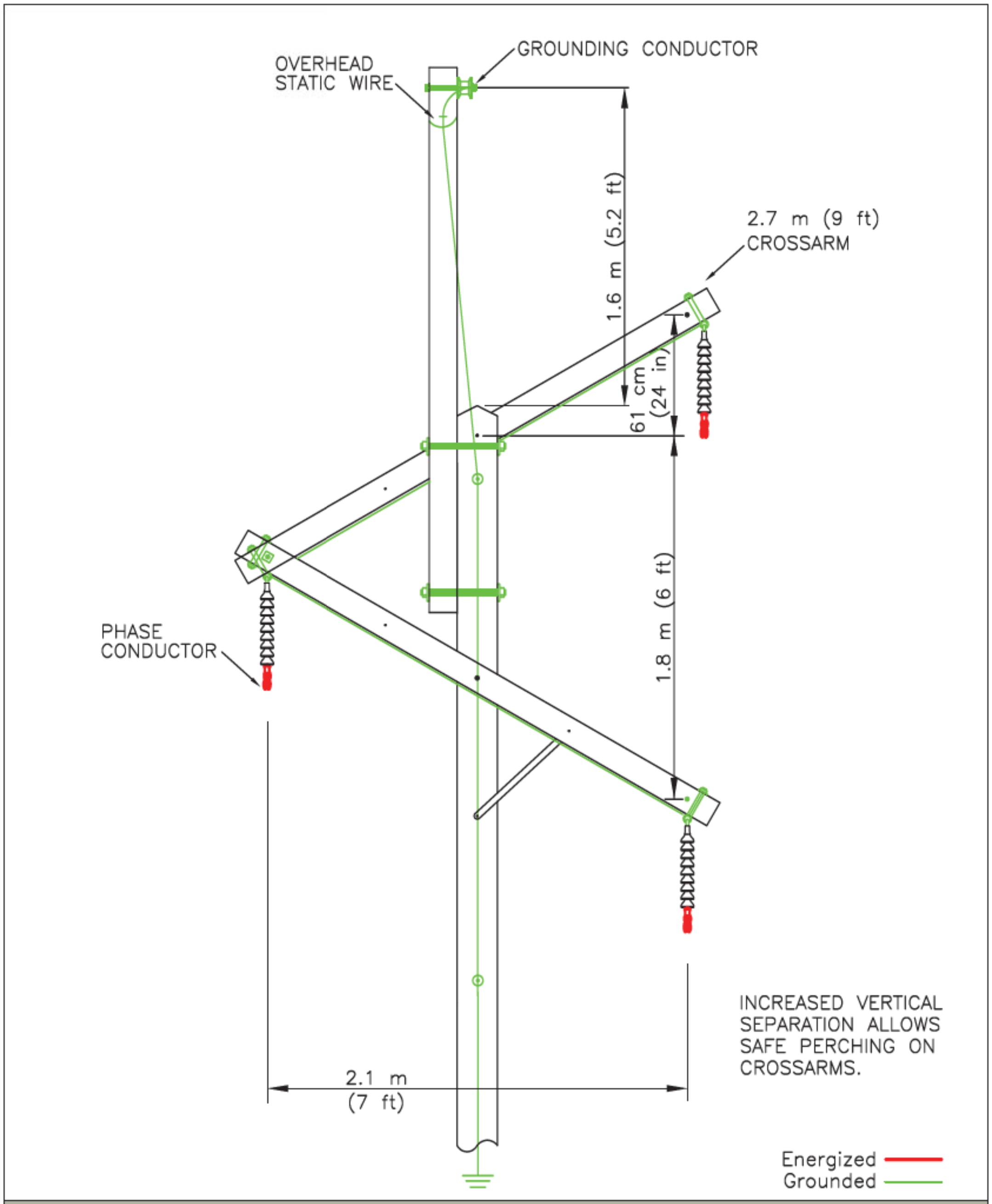

FIGURE 5.38: Avian-safe wishbone construction.

alternative to the wishbone or horizontal post designs. This suspension configuration provides adequate separation between phases and accommodates perching on the davit arms. The ridge pin overhead-grounding conductor attachment may also be replaced with a side-mounted suspension arrangement so the pole top is also available for perching. Although this construction can reduce electrocutions, it may contribute to streamer problems from

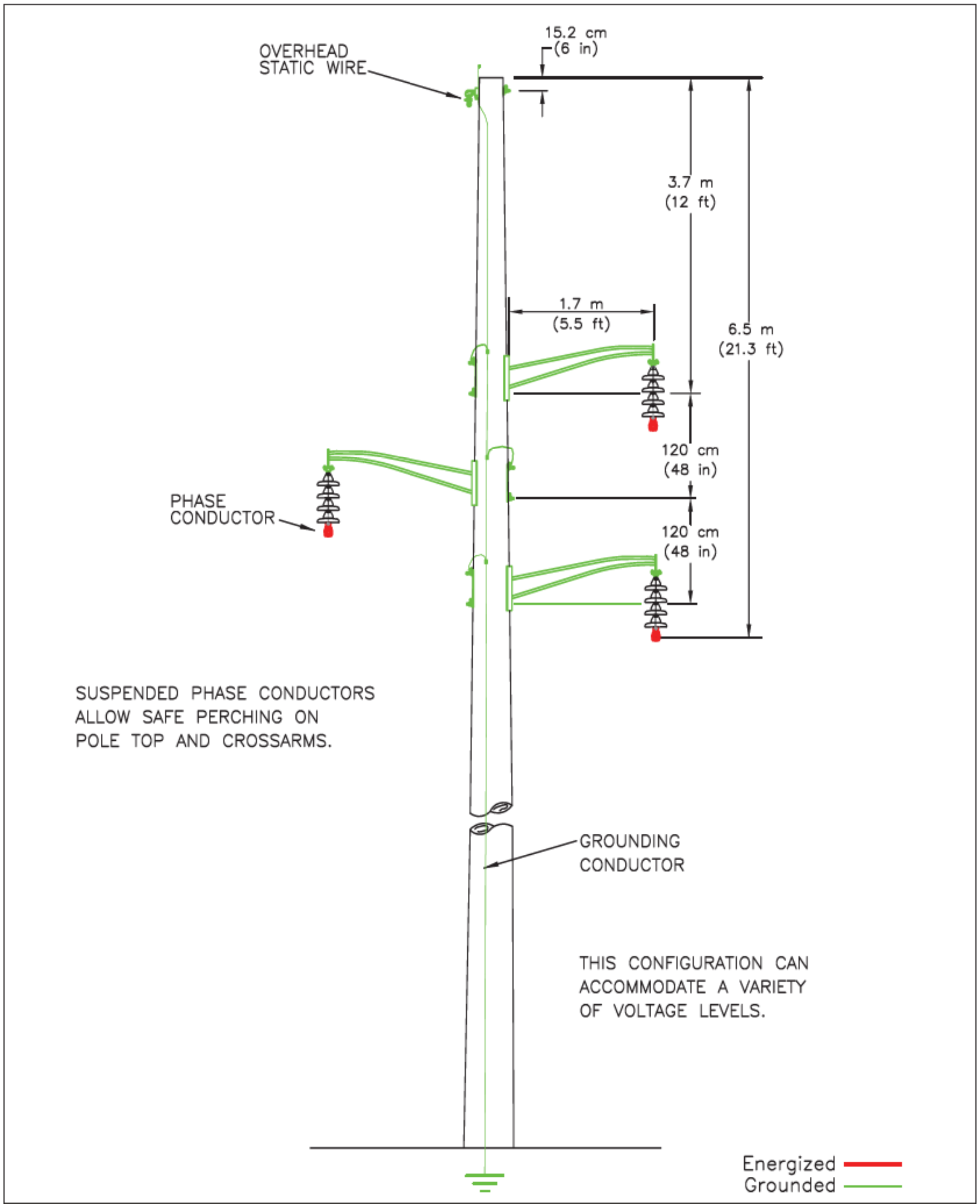

FIGURE 5.39: Avian-safe suspension configuration.

birds perching on a davit arm and defecating on the conductor or insulator below.

Figure 5.40 depicts a 69-kV design with a steel bayonet added as a lightning rod. This rod is grounded and significantly reduces separation between energized hardware and itself. This configuration can pose a phase-to-ground electrocution risk for birds that attempt to land or perch on the crossarms. In one year, 69 raptor carcasses were recovered from under a line of this configuration in southern Idaho (Idaho Power Co., unpubl. data). If

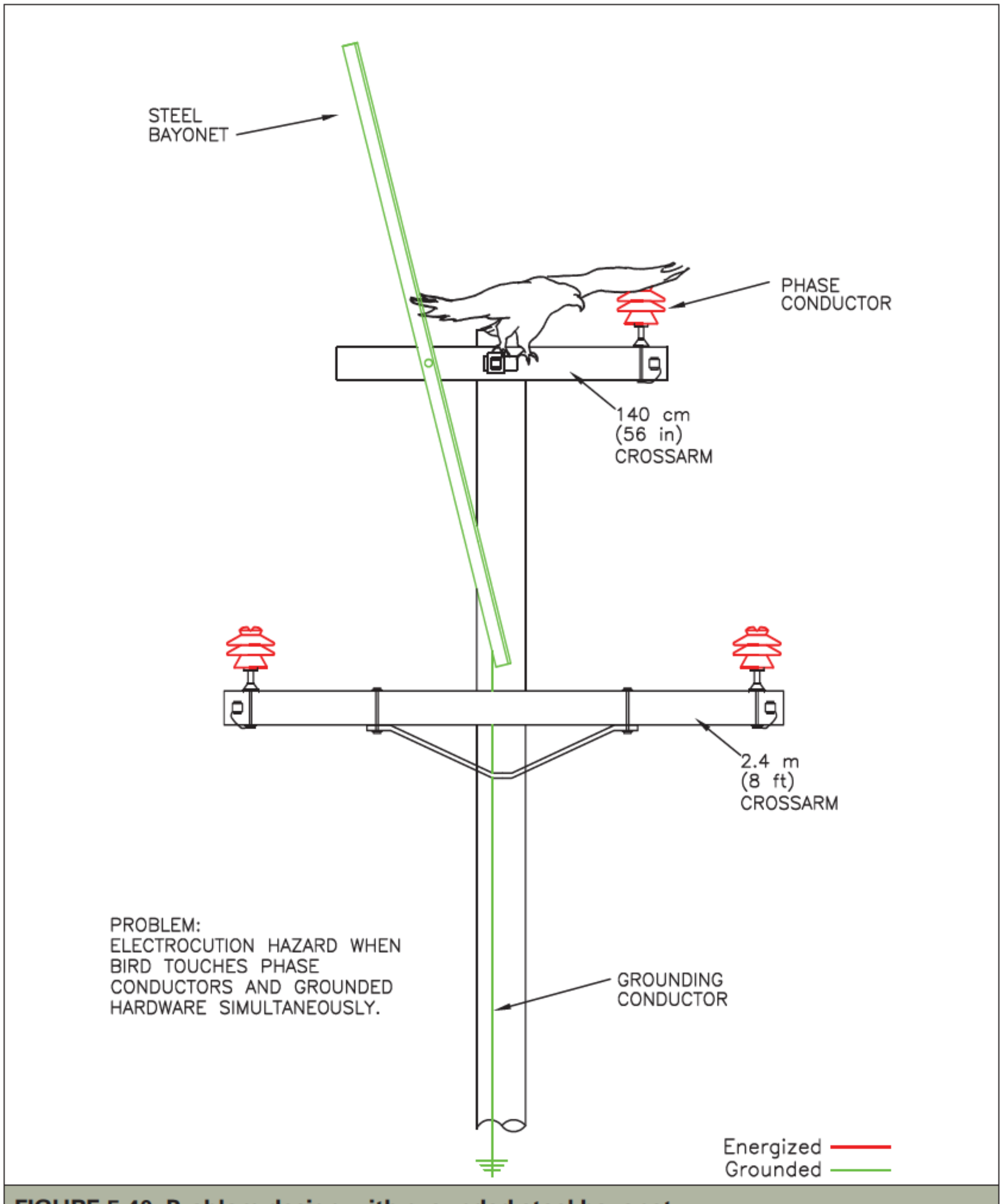

FIGURE 5.40: Problem design with grounded steel bayonet.

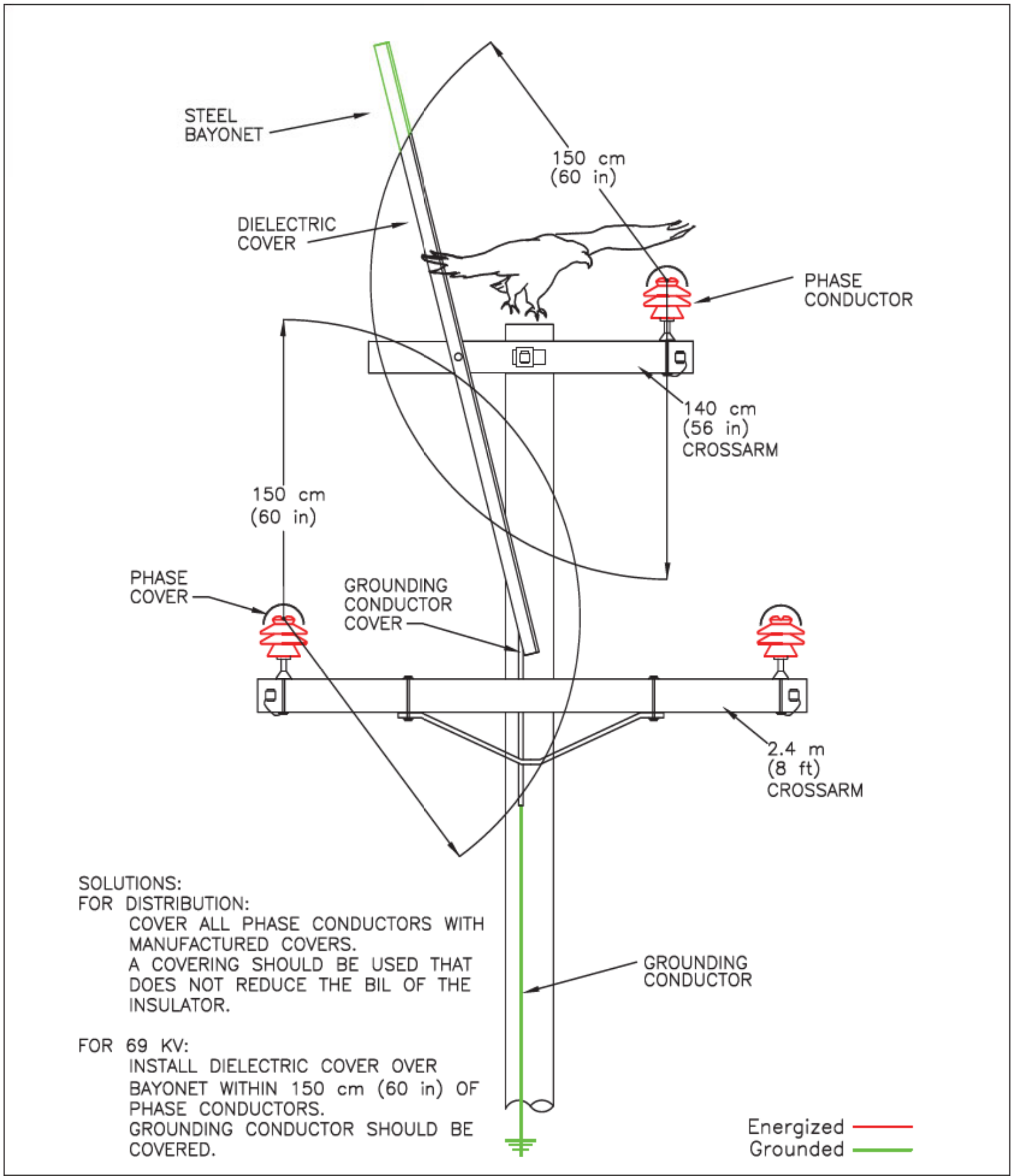

FIGURE 5.41: Solutions for design with grounded steel bayonet.

this configuration is used for a distribution line, phase covers can be installed on all three phases to prevent electrocutions (Figure 5.41). If mitigating a transmission line of this configuration, the bayonet should be covered with a dielectric cover within 150 cm (60 in) of the phase conductors. The grounding conductor should also be covered.

On the corner structure shown in Figure 5.42 (Problem 1), large birds may be electrocuted by making simultaneous contact with uncovered phase jumpers and the grounded structure. A solution to this problem is to install horizontal post insulators to move the phase jumpers further from ground (Figure 5.43, Solution 1).

Raptor mortalities have occurred on double-circuit transmission tower designs with insufficient clearance for perching raptors from the grounded center crossarm brace (also called grounded tension member or wind brace) to the top phase (E. Colson, Colson and Associates, pers. comm. in APLIC 1996) (Figure 5.42, Problem 2). Electrocutions on this configuration may be remedied by covering grounded tension members with dielectric material (Figure 5.43, Solution 2). It may also be possible to replace the tension

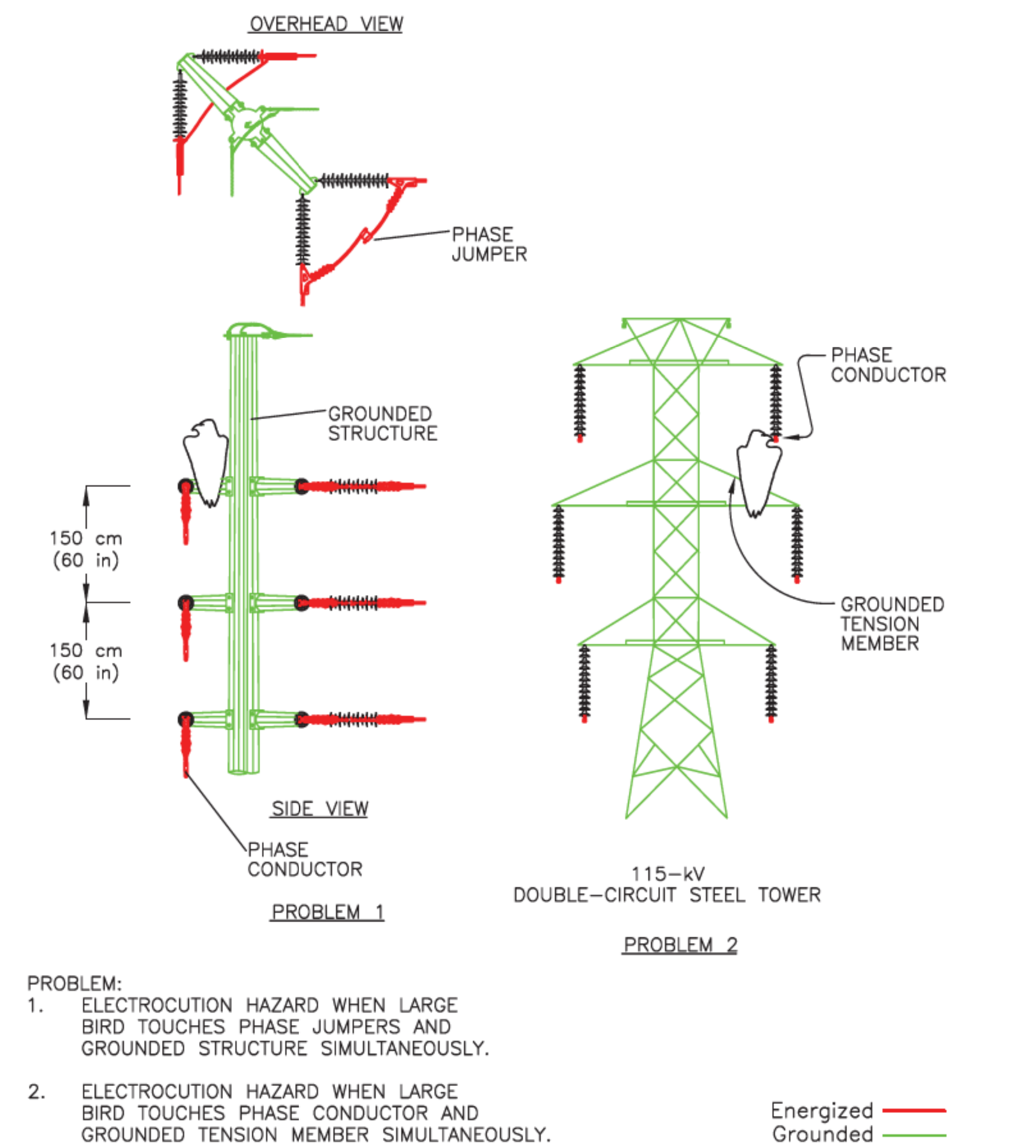

FIGURE 5.42: Problem transmission designs.

member with a non-conducting material (e.g., fiberglass) that meets structural requirements.

Transmission lines may produce arcing, where current jumps, or arcs, from a conductor to a bird on the structure. Though the conductor separation on higher voltage lines is sufficient to avoid this, it can occur on the more closely spaced lower voltage transmission lines. To prevent bird-induced arcing on more closely spaced transmission lines, conductor separation should be increased from 152 cm (60 in) by 0.5 cm (0.2 in) for each kV over 60 kV (see Table 5.3).

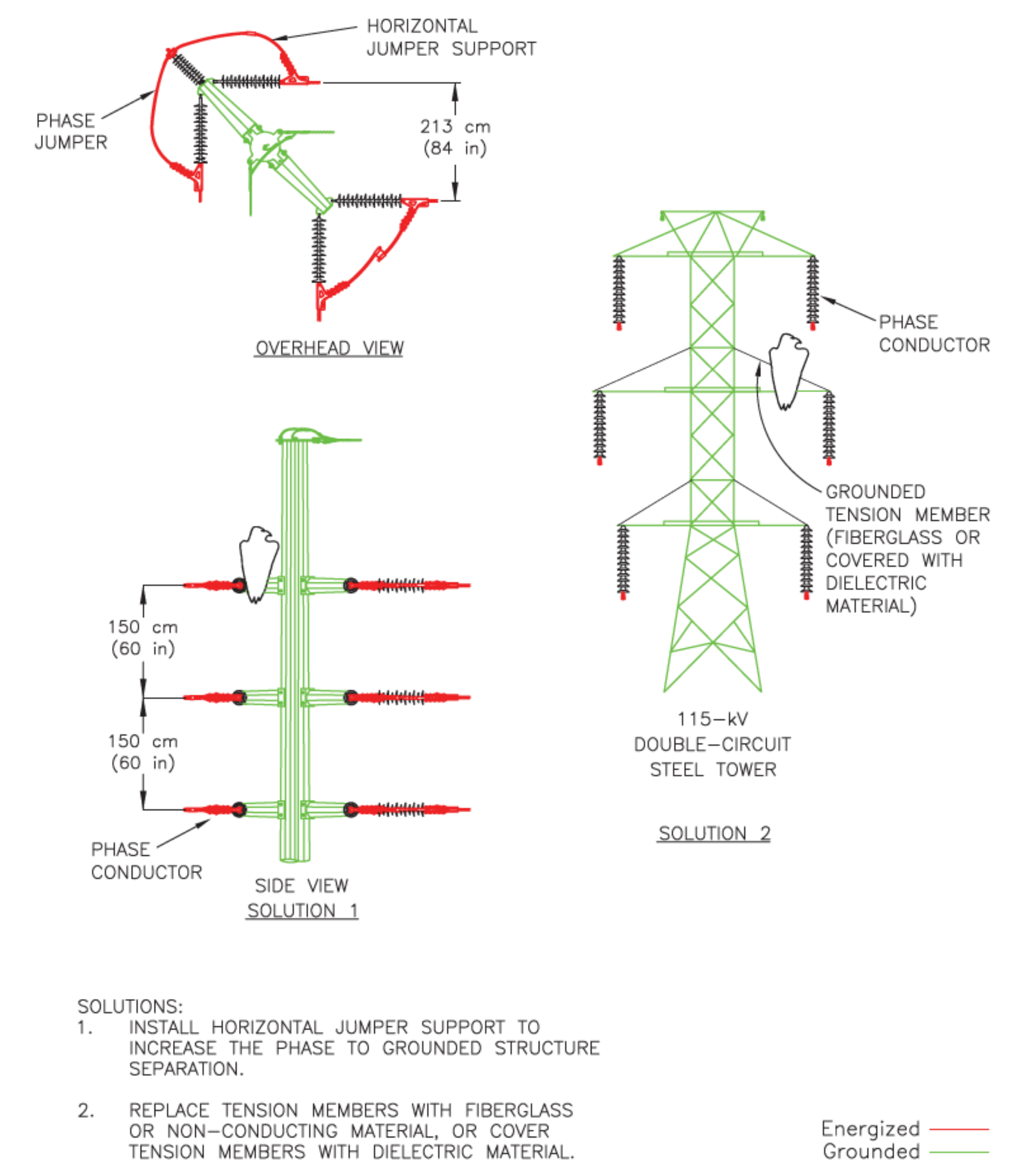

FIGURE 5.43: Solutions for transmission designs.

TABLE 5.3: Recommended conductor separation for transmission lines >60 kV.

kV	Horizontal Spacing	Vertical Spacing
69 kV	157 cm (62 in)	106 cm (42 in)
115 kV	180 cm (71 in)	130 cm (51 in)
138 kV	192 cm (76 in)	141 cm (56 in)

Equipment Poles

TRANSFORMERS AND OTHER EQUIPMENT

Equipment poles are poles that have transformers, capacitor banks, reclosers, regulators, disconnect switches, cutouts, arresters, or overhead-to-underground transitions (often referred to as *riser poles*). Equipment poles pose increased electrocution risks to birds of all sizes because of close separations between both phase-to-phase and phase-to-ground (Figures 5.44, 5.45).

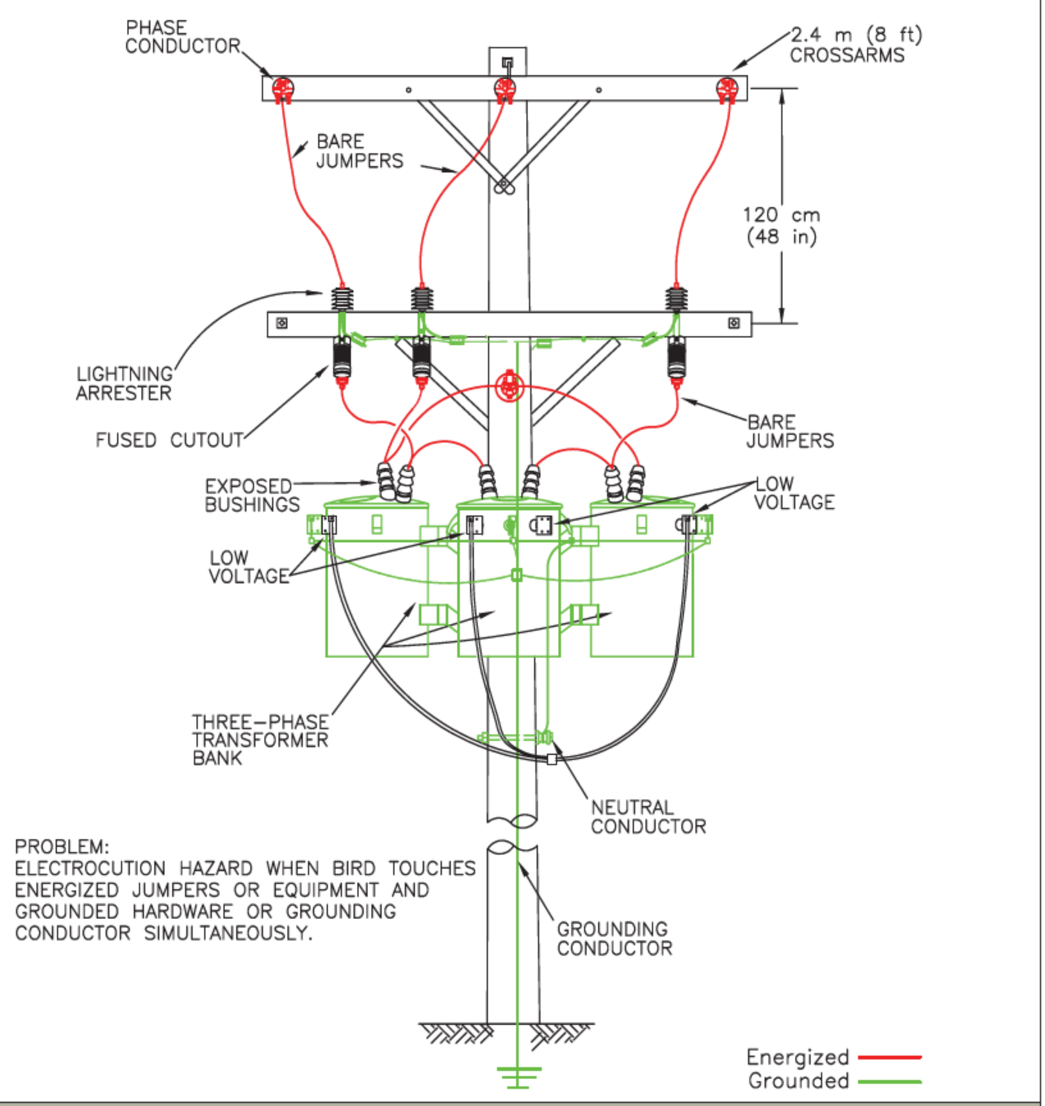

FIGURE 5.44: Problem three-phase transformer bank.

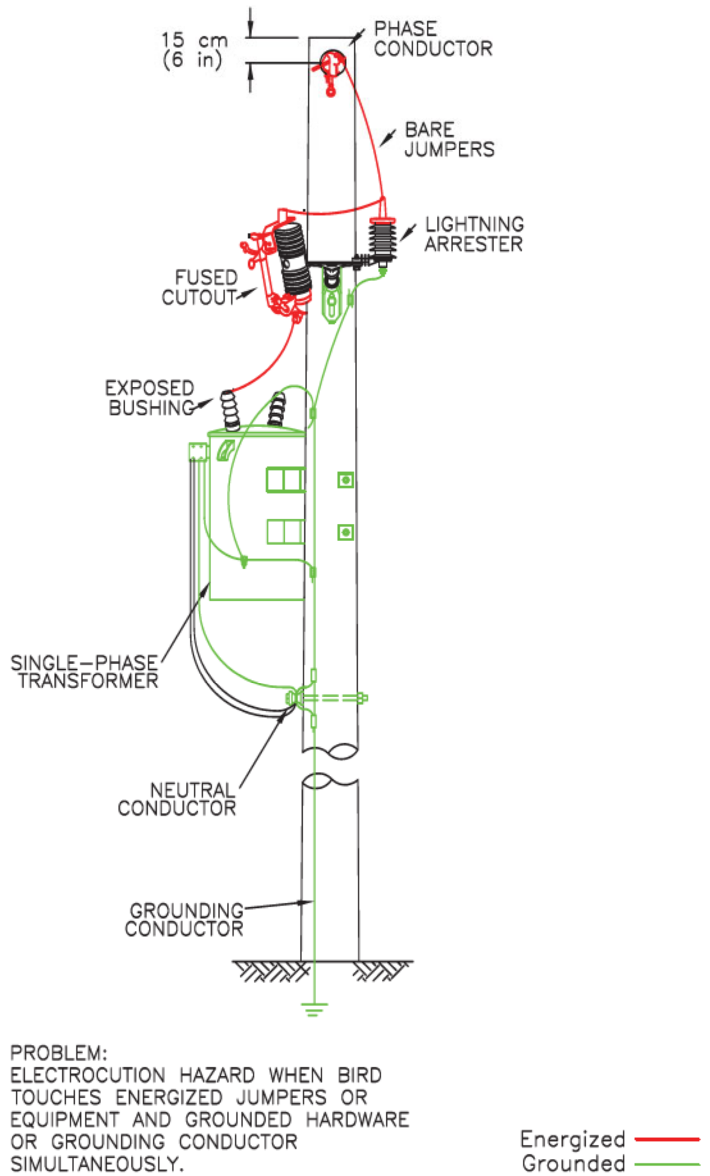

FIGURE 5.45: Problem single-phase transformer bank.

If a line is located in an area of high lightning activity, some utilities may install an overhead (grounded) static wire, requiring the installation of a grounding conductor all the way to the top of some or all structures. To assure the safety of line personnel and the general public, the NESC requires that all electrical equipment such as transformers, switches, lightning arresters, etc., must also be grounded. This grounding usually reduces the separation between energized and grounded parts of the system.

In a review of raptor electrocutions from 58 utilities in the western United States between 1986 and 1996, more than half were associated with transformers (Harness and Wilson 2001). Fifty-three percent of confirmed electrocutions (*n*=421) were associated with transformers, yet only one-quarter of the poles in these areas were transformer poles. Single or three-phase transformer banks were associated with 41% of eagle mortalities (*n*=748), 59% of hawk mortalities (*n*=278), and 52% of owl mortalities (*n*=344). In Utah and Wyoming, poles with exposed equipment accounted for only 32% of all structures surveyed (*n*=74,020), yet 53% of poles with mortalities (*n*=457) had exposed equipment (Liguori and Burruss 2003). In particular, transformers were present on 16% of structures surveyed, yet were found on 36% of poles with mortalities. Small birds (including starlings, magpies, and songbirds), ravens, and owls were more frequently electrocuted at poles with transformers or other equipment than at poles without equipment.

Utilities should be sure to address electrocution risk on the entire pole when retrofitting or designing equipment poles. Electrocution risk on new or retrofitted equipment poles can be reduced by using a variety of cover-up materials including covered conductors, moldings, covered jumper wires, arrester covers, bushing covers, cutout covers, phase covers, and other covers to prevent birds from making simultaneous contact between grounded and energized conductors or hardware (Figures 5.46, 5.47). See the *Precautions* section (below) for a discussion of cover-up materials. When lightning arresters are installed on a wooden crossarm in combination with fused cutouts, the arrester ground wire is normally attached beneath the arm connecting the base of the arresters to ground without bonding or contacting the arrester brackets.

The use of perch discouragers alone on or near equipment poles is not recommended, as perch discouragers may deter birds from landing on the crossarm, leaving equipment arms or transformers as perching alternatives. However, perch discouragers may be used if an alternative perch is provided and exposed equipment is covered with appropriate avian protection devices.

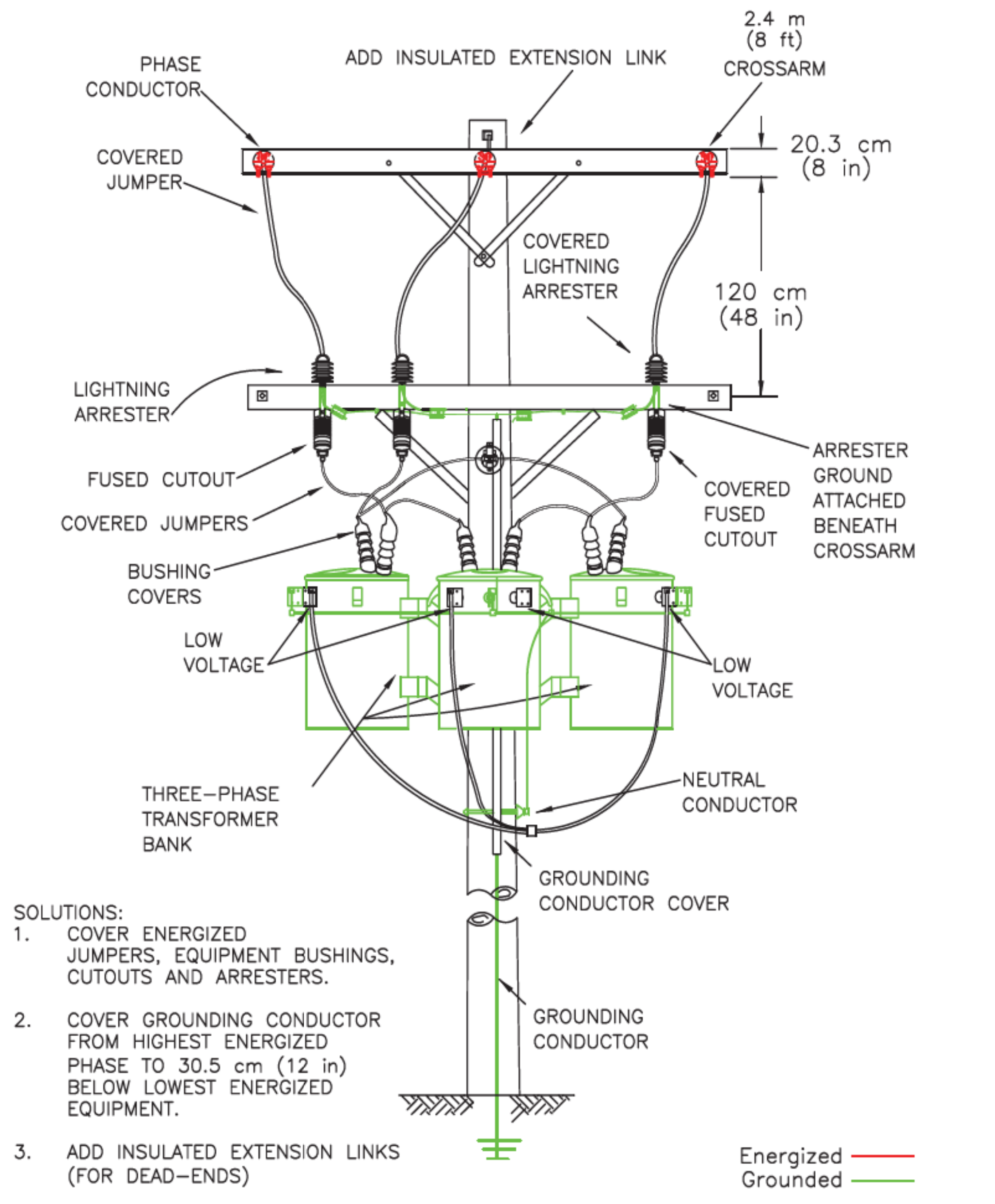

FIGURE 5.46: Solution for three-phase transformer bank.

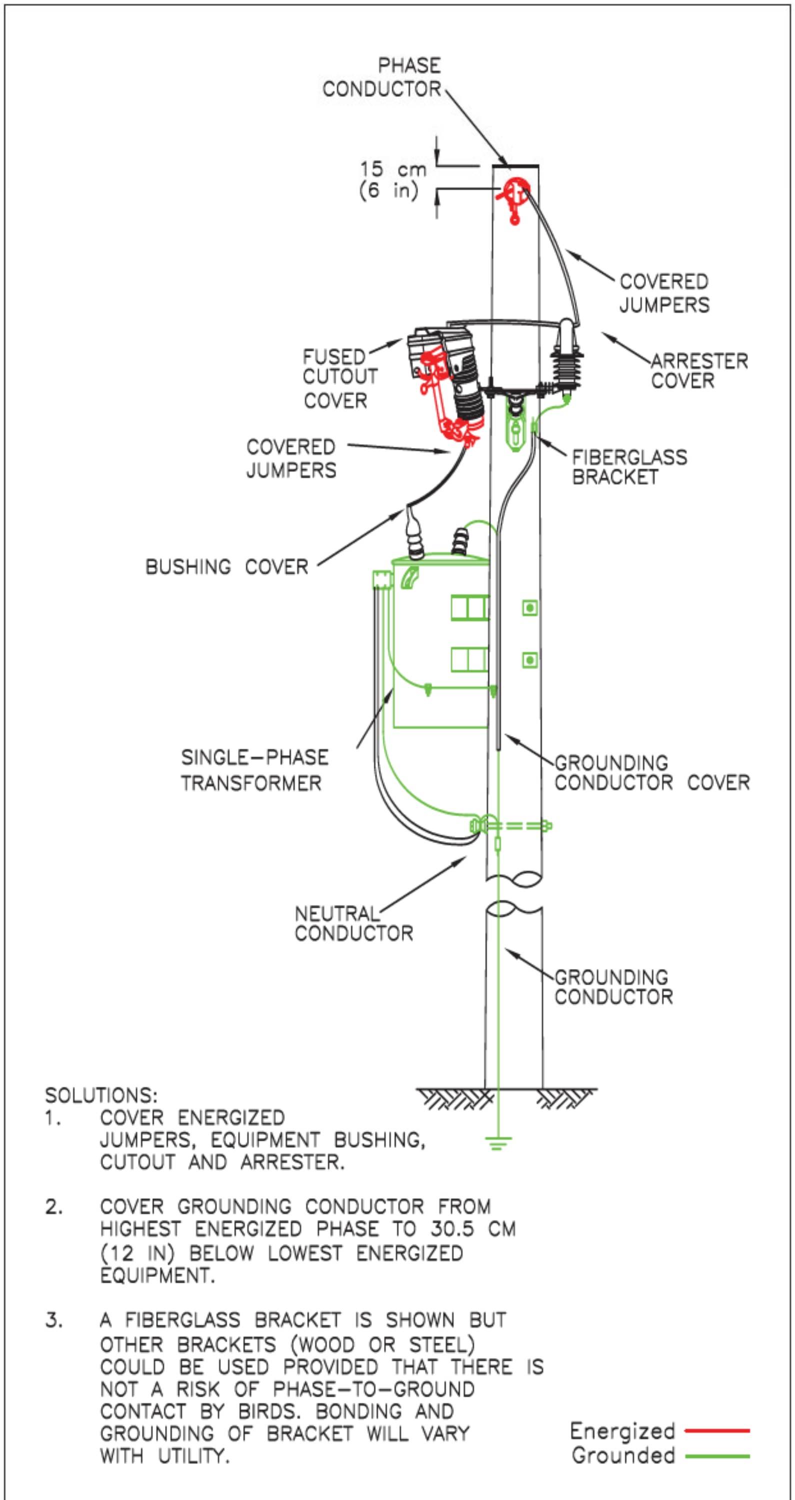

FIGURE 5.47: Solution for single-phase transformer bank.

PRECAUTIONS

When using cover-up products on equipment, a utility should be aware of several important points. First, these products are intended only for wildlife protection; **they are not intended for human protection**. Second, there are currently no standard protocols for testing such products (see page 51 for further information on testing). Utilities are advised to evaluate the products that they select for durability, effectiveness, ease of installation, etc. Finally, wildlife protection products may not be effective or can cause problems if installed improperly. Bushing covers and arrester covers should fit between the first and second skirts of the bushing or arrester. Likewise, phase covers should sit on the top skirt of the insulator and not extend to the crossarm. If covers are pushed down too far, they can cause tracking, outages, or fires. Cutout covers should also be evaluated to ensure that they will not interfere with the operation of the cutouts or the use of a load-break tool. Coverings on jumper wires should cover the entire jumper, because exposed gaps can pose an electrocution risk. See the APLIC website (www.aplic.org) for a current list of avian protection product manufacturers.

SWITCHES

Many types of switches are used to isolate circuits or redirect current for the operation and maintenance of a distribution system. Several examples are shown in Figures 5.48, 5.49, and 5.50. Because of the close separation, it may be difficult to mitigate electrocutions on switch poles. Efforts can be made to either provide birds with safe perch sites on adjacent poles or to make switch poles less hazardous to birds. The installation of unprotected switch poles is discouraged in raptor use areas due to the electrocution risk and difficulty of making these poles avian-safe. Where switches are installed, offset or staggered vertical switch configurations with an

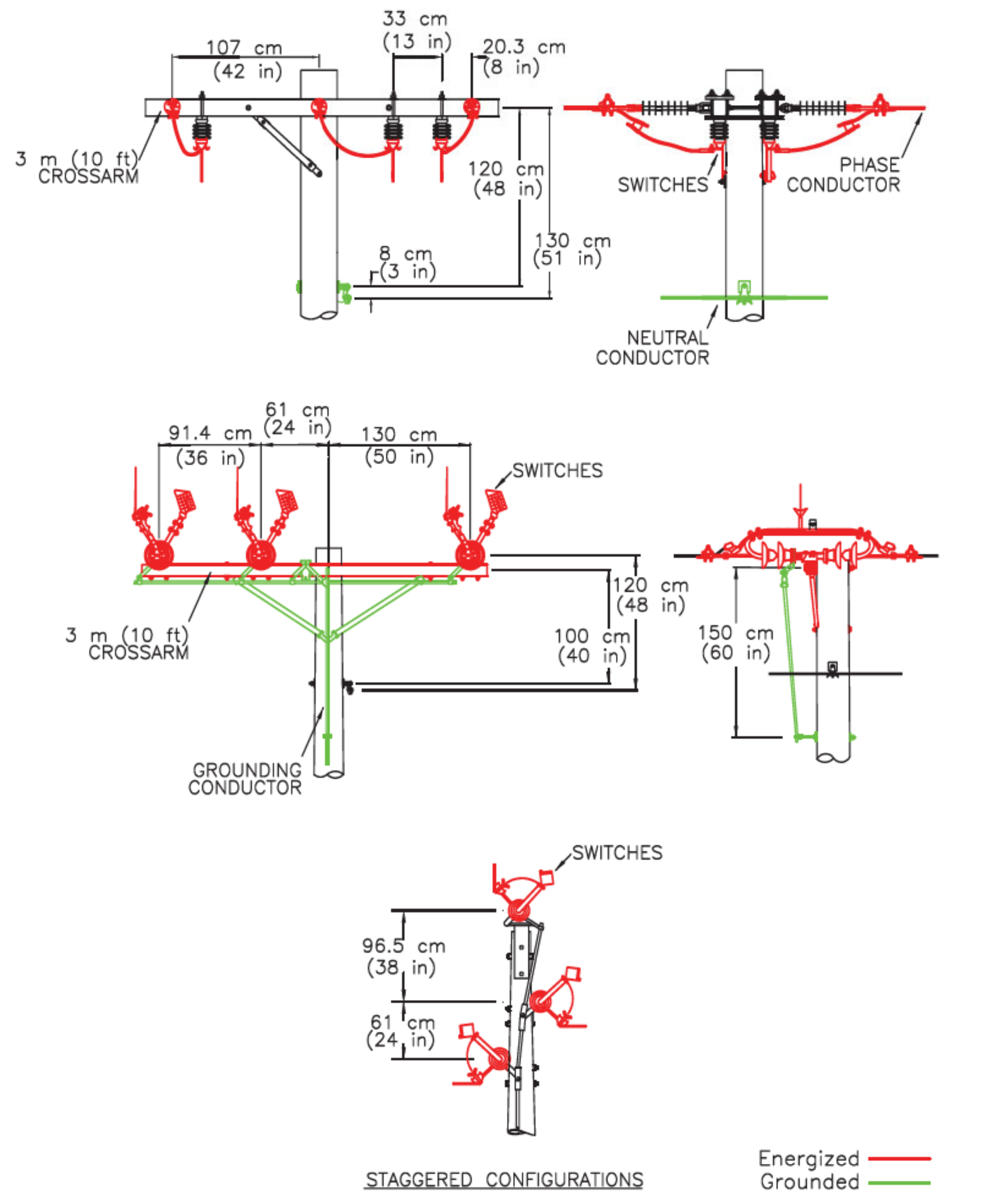

FIGURE 5.48: Pole-mounted switches.

alternate perch above the top switch may provide a safer perching site (see Figure 5.49). Separation is key to making these structures safer for birds. Coverings designed for the purpose should be used on as many of the energized components as possible. Using fiberglass arms for switches may also help reduce electrocutions.

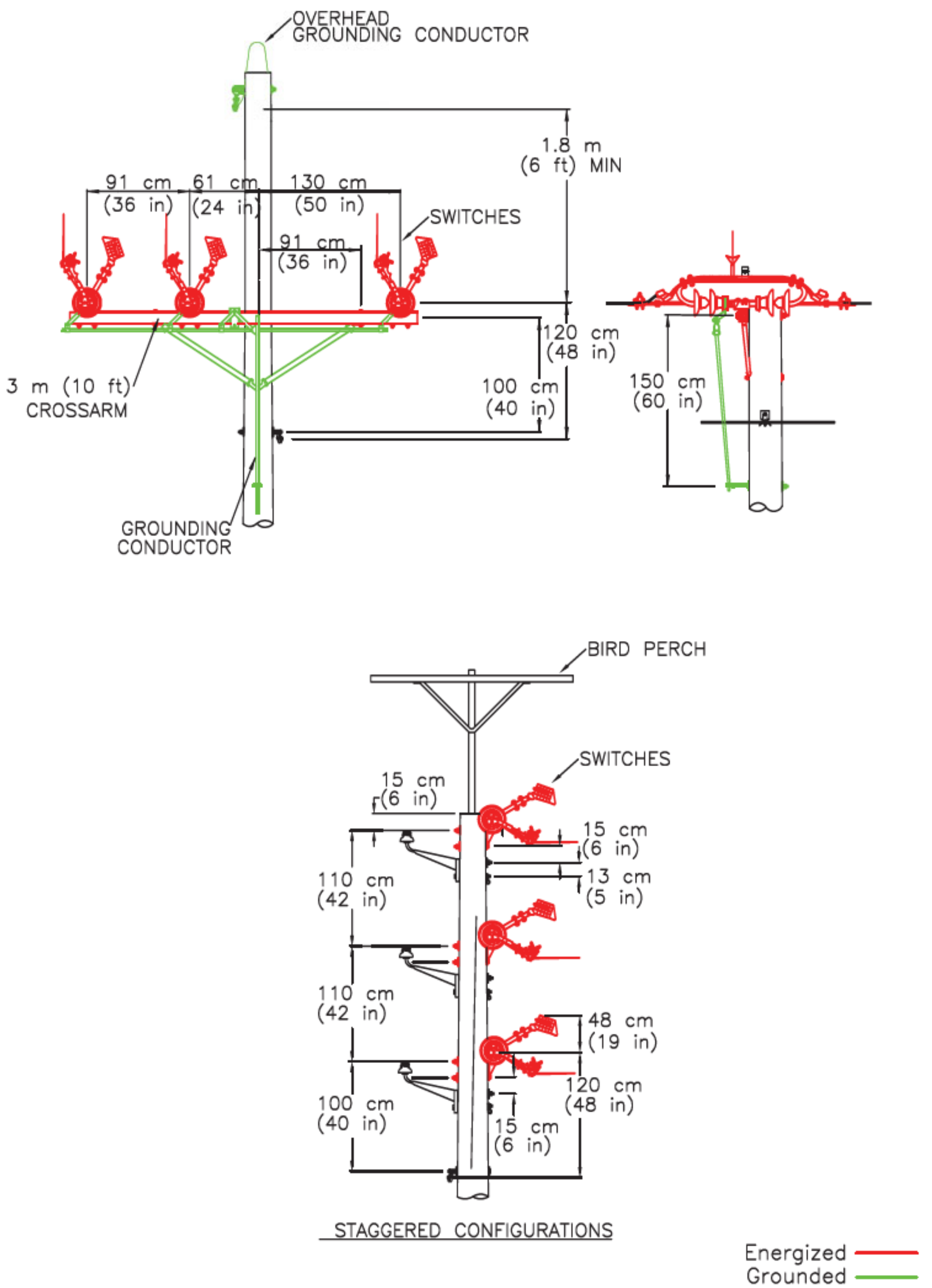

FIGURE 5.49: Pole-mounted switches.

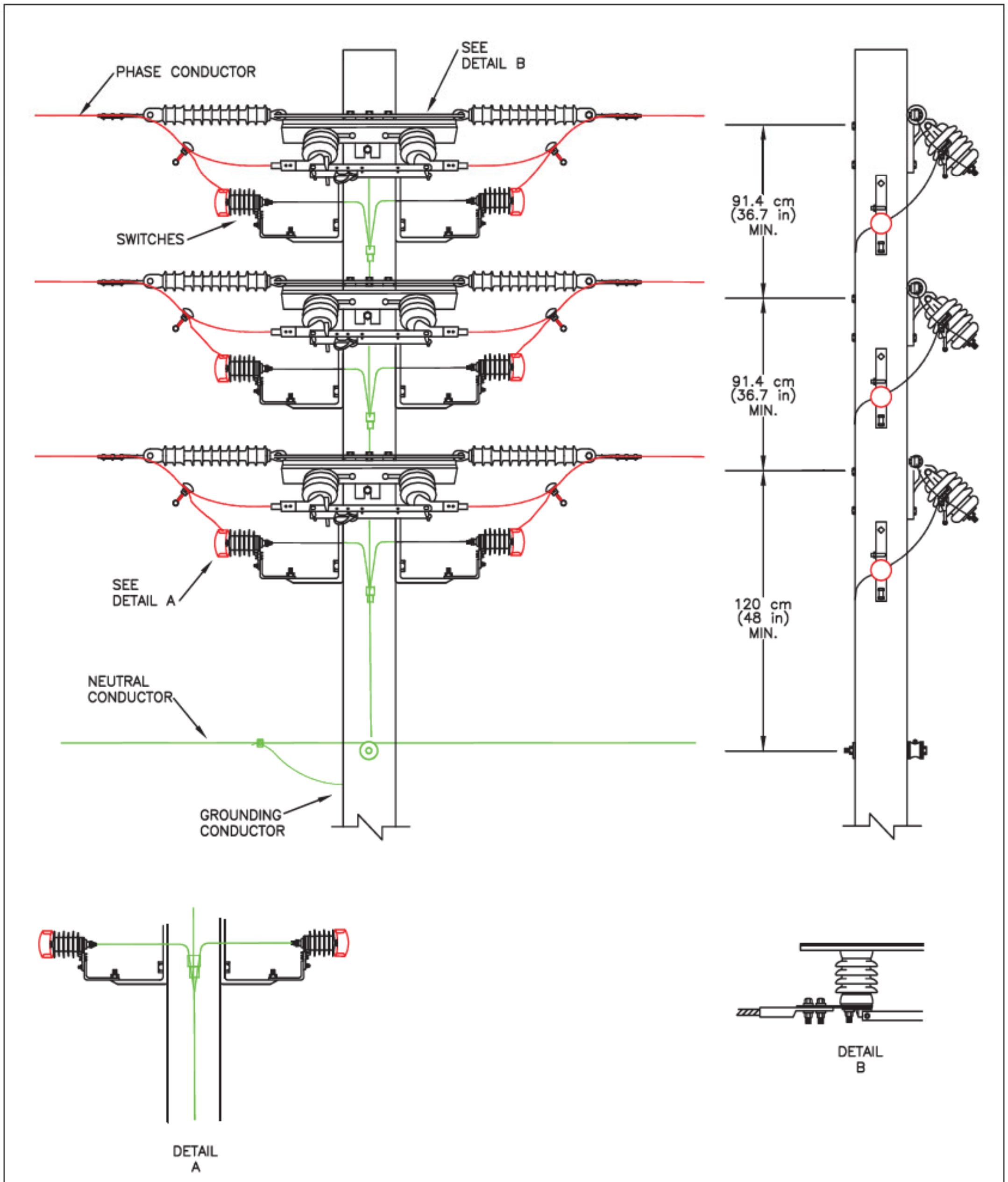

FIGURE 5.50: Pole-mounted switches.

SUBSTATION MODIFICATION AND DESIGN

Substations are transitional points in the transmission and distribution system. While raptor electrocutions at substations are uncommon, smaller birds such as songbirds and corvids may perch, roost, or nest in substations, causing electrocution and outage risks. Numerous bird species have caused substation outages, including great horned owl *(Bubo virginianus)*, American kestrel, black-billed magpie *(Pica hudsonia)*, European starling

(Sturnus vulgaris), golden eagle, and monk parakeet *(Myiopsitta monachus)* (PacifiCorp, unpubl. data; Florida Power and Light, unpubl. data). Over an 18-month period, 18 bird-caused outages were documented in substations in six western states, which affected over 50,000 customers (PacifiCorp, unpubl. data).

Over the years, numerous techniques have been used to prevent bird and animal contacts in substations. Such techniques include habitat modification, physical barriers, auditory, visual, olfactory, and pyrotechnic discouragers, and physically removing animals. Many of these practices have had limited success, or are cost-prohibitive or impractical. The most effective method for preventing bird contacts in substations employs the practices used for distribution and transmission structures, "insulate" or isolate (see page 59). For new substations, a combination of framing and covering can prevent contacts by birds and other animals. For existing substations, cover-up materials designed for the purpose can be installed to make substations avian-safe.

SUMMARY

Power line structures can present electrocution hazards to birds when less than adequate separation exists between energized conductors or between energized conductors/hardware and grounded conductors/hardware. This document recommends 150-cm (60-in) separation for eagles. Other separations may be used based upon the species impacted. Avian-safe facilities can be provided by one or more of the following:

- increasing separations to achieve adequate separation for the species involved
- covering energized parts and/or covering grounded parts with materials appropriate for providing incidental contact protection to birds
- applying perch management techniques.

A utility's Avian Protection Plan (see Chapter 7) should identify new construction designs, retrofitting options, approved avian protection devices, proper installation techniques, and other procedures related to avian protection.

CHAPTER 6

Perching, Roosting, and Nesting of Birds on Power Line Structures

IN THIS CHAPTER

- Avian Use of Power Lines
- Nest Management
- Reliability Concerns

This chapter examines how birds use power line structures. It considers the advantages and disadvantages that utility structures present to birds as well as the effects birds have on power reliability.

Power line structures provide perching, roosting, and nesting substrates for some avian species. This is particularly true of raptors that inhabit open areas where natural substrates are limited. Nest management, including platforms installed on or near power structures, can provide nesting sites for several protected species while minimizing the risks of electrocution, equipment damage, or outages. Nest management might also include the control of the monk parakeet (*Myiopsitta monachus*), a species introduced from South America, which constructs large, communal nests, often on power line structures, causing significant reliability problems.

AVIAN USE OF POWER LINES

RAPTORS

Perching

Power line structures in relatively treeless areas have made millions of kilometers of suitable habitat available to perch-hunting raptors (Olendoff et al. 1980). Power poles offer raptors an expansive view of the surrounding terrain while they inconspicuously watch for prey below (see Figure 4.9). Perch-hunting also allows raptors to conserve energy by minimizing flight activity (Figure 6.1). Ospreys (*Pandion haliaetus*) readily perch-hunt from power poles that have been placed near treeless wetlands or other water bodies.

FIGURE 6.1: Peregrine falcon with prey on distribution pole.

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There is a strong association between raptor activity and utility rights-of-way (Williams and Colson 1989). Following the 1974 construction of a 230-kV transmission line in Colorado, raptor density near the line increased from 4 to 13 raptors per square kilometer (km^2) (10 to 34 per square mile [mi^2]) to 21 to 32 raptors/km^2 (54 to 83/mi^2) after construction (Stahlecker 1978).

Although transmission towers comprised only 1.5% of available perches in this area, 81% of raptors seen during surveys used them as perches. Rough-legged hawks *(Buteo lagopus)*, golden eagles *(Aquila chrysaetos)*, and prairie falcons *(Falco mexicanus)* used towers more than any of the other available perches (e.g., distribution poles, fence posts, trees, windmills, etc.). Craig (1978) noted that almost 78% of all raptors perched along a 187-km (116-mi) survey route in Idaho were perched on power poles or wires. During a three-year study in southern New Mexico, Kimsey and Conley (1988) found that open terrain traversed by transmission towers received more use by raptors than similar areas without towers. In Wyoming, golden eagles and other raptors perched on distribution poles during winter to exploit a locally abundant food source (Harness and Garrett 1999).

Roosting

Raptors also use power line structures for roosting. Roosts may be selected for protection from predators and inclement weather, or for their proximity to food sources. Raptors that nest on utility structures often use those nests as nocturnal roosts as well. They can roost singly (e.g., osprey or buteos), or communally (e.g., Harris' hawks *[Parabuteo unicinctus]* or wintering bald eagles *[Haliaeetus leucocephalus]*). When perched side-by-side, birds can span the distance between phases or phase and ground, which increases the risk of an electrocution as well as an outage. Excrement from multiple birds can also create outage risks by contaminating equipment.

Craig and Craig (1984) found that golden eagles wintering in Idaho often roosted communally on several types of power line structures. These structures allowed eagles to exploit local populations of jackrabbits, and provided shelter from inclement weather. Eagles and hawks may use the lower portions of transmission towers, which provide some degree of cover for night roosting in barren areas (Smith 1985). In Spain, transmission substations serve as summer roost sites for congregations of lesser kestrels *(Falco naumanni)*. These sites may play an important role in the conservation of this declining species (Arevalo et al. 2004).

Nesting

Casual observation attests, and many studies have documented, that raptors nest on distribution and transmission structures (see Table 6.1). Although most species that nest on power line structures inhabit open, arid areas, one notable exception is the osprey (Figure 6.2). Ospreys use utility structures for nesting more than any other North American raptor. They typically select poles that are located near or over waters where fish are abundant. To protect ospreys and the power system, nest platforms have been installed on or near transmission towers and distribution poles so nest material and excrement will not contaminate lines. In addition, power poles that are left standing when lines are decommissioned can provide both nest and perch sites. During an 11-year period in Michigan, an average of 55% of the osprey platforms available were occupied (Postupalsky 1978). On Lake Huron in Canada, 82% of artificial platforms were occupied within one year of installation (Ewins 1996). In 1995, nearly 46% of osprey nests studied in Finland (*n*=951) were located on artificial structures and, in southern Finland, up to 90% of occupied nests (*n*=79) were on artificial platforms (Saurola 1997).

TABLE 6.1: Accounts of raptor species nesting on transmission structures (T), distribution poles (D), and substations (S).*

Species	Reference
African hawk-eagle *(Hieraaetus faciatus)*	Tarboton and Allan 1984 (T); Allan 1988 (T)
American kestrel *(Falco sparverius)*	Illinois Power Company 1972 (T); Blue 1996 (P); Georgia Power Company, unpubl. data (T)
Aplomado falcon *(Falco femoralis)*	The Peregrine Fund 1995 (T); D. Bouchard, pers. comm. (T)
Bald eagle *(Haliaeetus leucocephalus)*	Keran 1986 (T); Bohm 1988 (T); Hanson 1988 (T); Marion et al. 1992 (T); J. Swan, pers. comm. (T)
Black-breasted snake eagle *(Circaetus gallicus)*	Brown and Lawson 1989 (T)
Black eagle *(Aquila verreauxii)*	Boshoff and Fabricus 1986 (T); Ledger et al. 1987 (T); Jenkins et al. 2005 (T)
Brown snake eagle *(Circaetus cinereus)*	Brown and Lawson 1989 (T)
Crested caracara *(Caracara cheriway)*	J. Lindsay, pers. comm. (S)
Eurasian kestrel *(Falco tinnunculus)*	Boshoff et al. 1983 (T)
Ferruginous hawk *(Buteo regalis)*	Nelson and Nelson 1976 (T); Gilbertson 1982 (T); Gilmer and Stewart 1983 (T); Gaines 1985 (T); Bridges and McConnon 1987 (T); Electric Power Research Institute 1988 (T); Fitzner and Newell 1989 (T); Steenhof et al. 1993 (T); Olendorff 1993a (T); Bechard and Schmutz 1995 (P); Blue 1996 (T); Erickson et al. 2004 (T)
Golden eagle *(Aquila chrysaetos)*	Anderson 1975 (T); Nelson and Nelson 1976 (T); Herron et al. 1980 (T); Electric Power Research Institute 1988 (T); Steenhof et al. 1993 (T); Blue 1996 (P); Kochert et al. 2002 (T); PacifiCorp, unpubl. data (S, T)
Great horned owl *(Bubo virginianus)*	Gilmer and Wiehe 1977 (T); Steenhof et al. 1993 (T); Blue 1996 (P); PacifiCorp, unpubl. data (D, S)
Greater kestrel *(Falco rupicoloides)*	Kemp 1984 (T); Hartley et al. 1996 (P)
Harris' hawk *(Parabuteo unicinctus)*	Ellis et al. 1978 (D); Whaley 1986 (T); Bednarz 1995 (T); Blue 1996 (P)
Lanner falcon *(Falco biarmicus)*	Tarboton and Allan 1984 (T); Hartley et al. 1996 (P)
Martial eagle *(Polemaetus bellicosus)*	Dean 1975 (T); Boshoff and Fabricus 1986 (T); Hobbs and Ledger 1986 (T); Boshoff 1993 (T); Jenkins et al. 2005 (T)
Mountain caracara *(Phalcoboenus megalopterus)*	White and Boyce 1987 (P)
** Note that some studies refer only to nesting on power line structures (P).*	

Continued

TABLE 6.1: Accounts of raptor species nesting on transmission structures (T), distribution poles (D), and substations (S).* (cont.)

Species	Reference
Osprey *(Pandion haliaetus)*	Melquist 1974 (D); Detrich 1978 (T); Henny et al. 1978 (T, D); Prevost et al. 1978 (T); Henny and Anderson 1979 (D); van Daele et al. 1980 (D); Jamieson et al. 1982 (D); Austin-Smith and Rhodenizer 1983 (T); Fulton 1984 (T); Keran 1986 (T); Hanson 1988 (T); Vanderburgh 1993 (D); Blue 1996 (P); Ewins 1996 (T, D); Henny and Kaiser 1996 (T, D); Meyburg et al. 1996 (P); Poole et al. 2002 (P); Henny et al. 2003 (T, D); Henny and Anderson 2004 (D)
Pale chanting goshawk *(Melierax canorus)*	Brown and Lawson 1989 (T)
Peregrine falcon *(Falco peregrinus)*	Bunnell et al. 1997 (T); White et al. 2002 (T); PacifiCorp, unpubl. data (T)
Prairie falcon *(Falco mexicanus)*	Roppe et al. 1989 (T); Blue 1996 (P); Bunnell et al. 1997 (T)
Red-tailed hawk *(Buteo jamaicensis)*	Nelson and Nelson 1976 (T); Ellis et al. 1978 (T); Fitzner 1980a (T); Gilbertson 1982 (T); Brett 1987 (T); Electric Power Research Institute 1988 (T); Fitzner and Newell 1989 (T); Steenhof et al. 1993 (T); Knight and Kawashima 1993 (P); Blue 1996 (T); Stout et al. 1996 (D); Brubaker et al. 2003 (P)
Rough-legged hawk *(Buteo lagopus)*	Bechard and Swen 2002 (P)
Swainson's hawk *(Buteo swainsoni)*	Olendorff and Stoddart 1974 (D); Fitzner 1978 (D); Fitzner and Newell 1989 (T); Blue 1996 (P); England et al. 1997 (P, T)
Tawny eagle *(Aquila rapax)*	Dean 1975 (T); Tarboton and Allan 1984 (T); Jenkins et al. 2005 (T)
White-backed vulture *(Gyps africanus)*	Ledger and Hobbs 1985 (T)
Zone-tailed hawk *(Buteo albonotatus)*	Blue 1996 (P)

** Note that some studies refer only to nesting on power line structures (P).*

Nest location on a power structure can vary by species and structure type. On natural substrates, ospreys typically nest on the flat tops of dead trees and broken tops of live trees. Likewise, on power structures, ospreys prefer the upper portions of transmission towers or the tops of distribution poles. Red-tailed, Swainson's *(Buteo swainsoni)*, and ferruginous hawks *(B. regalis)* generally prefer nest heights that are relatively high, moderate, and low, respectively. Tower sections where steel latticework is relatively dense are generally preferred, as this provides more support for nests (Figure 6.3). The configuration of two poles supporting four paired sets of crossarms was most often used by raptors in New Mexico (Brubaker et al. 2003). Double dead-end and dead-end distribution poles (see Figures 5.15, 5.16, 6.2, 6.23, 6.24, 6.25, and 6.26 for examples) are the distribution configurations most commonly used by osprey and some other raptors throughout North America.

Steenhof et al. (1993) reported an 89% success rate for ferruginous hawk nests on

FIGURE 6.2: Osprey nest on double crossarm of non-energized pole.

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FIGURE 6.3: Red-tailed hawk nest on steel lattice transmission tower.

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platforms (*n*=19), which was higher than nesting success on cliffs (58%, *n*=38) or other natural substrates (20%, *n*=5). Likewise, ferruginous hawk nesting success was higher on artificial platforms in Wyoming than on natural substrates (Tigner et al. 1996). Bechard and Schmutz (1995) stated that nesting platforms could be beneficial for ferruginous hawks, especially in previously occupied habitats where the number of natural nest sites is in decline. They recommend spacing nest platforms out-of-sight of other buteo nests.

Nest platforms for bald eagles provide support for weak or collapsed nests, attract birds searching for a breeding site, encourage the reuse of historic sites, and support nests moved from areas of pending human activity or development (Postupalsky 1978; Hunter et al. 1997). In Florida an increased number of bald eagle nests on man-made structures has been reported. In 2003, there were 24 bald eagle nests on man-made structures with

46% on transmission towers (J. Swan, pers. comm.). In 2004 and 2005, the number of nests on towers increased due to the loss of nesting trees to hurricanes in 2004 (S. Nesbitt, pers. comm.).

ADVANTAGES TO RAPTORS NESTING ON UTILITY STRUCTURES

Utility structures can provide nesting substrates in habitats where natural sites are scarce, facilitate the range expansion of some species, increase the local density of some species, and offer some protection from the elements. In addition, some raptors have increased their nest success and productivity on power line structures.

In New Mexico, decommissioned telephone poles and energized electrical poles were used by nesting raptors (Brubaker et al. 2003). Thirty-two of 338 poles were used by nesting raptors, including 27 pairs of Swainson's hawks, 3 pairs of red-tailed hawks, and 2 pairs of great horned owls *(Bubo virginianus)*. In Wisconsin, red-tailed hawks nested on artificial structures, including transmission towers, as the availability of natural nest sites declined in human-altered landscapes (Stout et al. 1996). New 230-kV and 500-kV lines on the Hanford Reservation in Washington were monitored between 1979 and 1988 (Fitzner and Newell 1989). After construction of the lines in 1979, only one red-tailed hawk nest appeared on these structures. By 1988, 19 Swainson's, ferruginous, and red-tailed hawks' nests were found on the structures. Red-tailed hawks and common ravens *(Corvus corax)* in southern California nested on utility structures in greater numbers than expected based on the availability of potential nest substrates (Knight and Kawashima 1993). In 1980 and 1981, the PacifiCorp Malin-to-Midpoint 500-kV transmission line was constructed across eastern Oregon and southern Idaho (Steenhof et al. 1993). In cooperation with the BLM, PacifiCorp installed 37 nesting platforms designed by Morley Nelson (Figure 6.4) (Nelson and Nelson 1976; Olendorff et al. 1981; Nelson 1982). Within one year, raptors and ravens began nesting on these platforms. Although only 2% of the towers had platforms, 72% (n=29) of the golden eagle and 48% (n=52) of the ferruginous hawk nesting attempts were made on the artificial platforms. Nineteen (51%) of the platforms were used at least once. Steenhof et al. (1993) suggested that the needs of nesting raptors should be considered and assistance encouraged during the construction of transmission lines, especially when the line traverses treeless habitat and the disturbance of a sensitive prey species is not an issue.

The construction of artificial nesting platforms, including those on power poles, has contributed to the ospreys' population growth and range expansion in North America (Houston and Scott 2001; Henny and Anderson 2004). Although the number of ospreys nesting on natural substrates remained constant in the Willamette Valley, Oregon, from the 1970s to 1990s, the number of active nests on power line structures increased from 1 in 1977 to 66 in 1993 (Henny and Kaiser 1996). In 2001, 234 osprey pairs were nesting in this area, with 74% of the nests located on power poles or platforms erected by electric utilities (Henny et al. 2003).

Power line structures may also help local raptor populations increase (Olendorff et al. 1981). Within ten years after construction of a 500-kV transmission line across eastern Oregon and southern Idaho, 53 pairs of raptors and ravens nested on line structures while their nesting densities on nearby natural substrates remained at pre-construction levels (Steenhof et al. 1993). In South Africa as well, raptor nests are not removed unless they pose a threat to the power supply. Consequently, many raptor species regularly nest on transmission towers (Ledger et al. 1993).

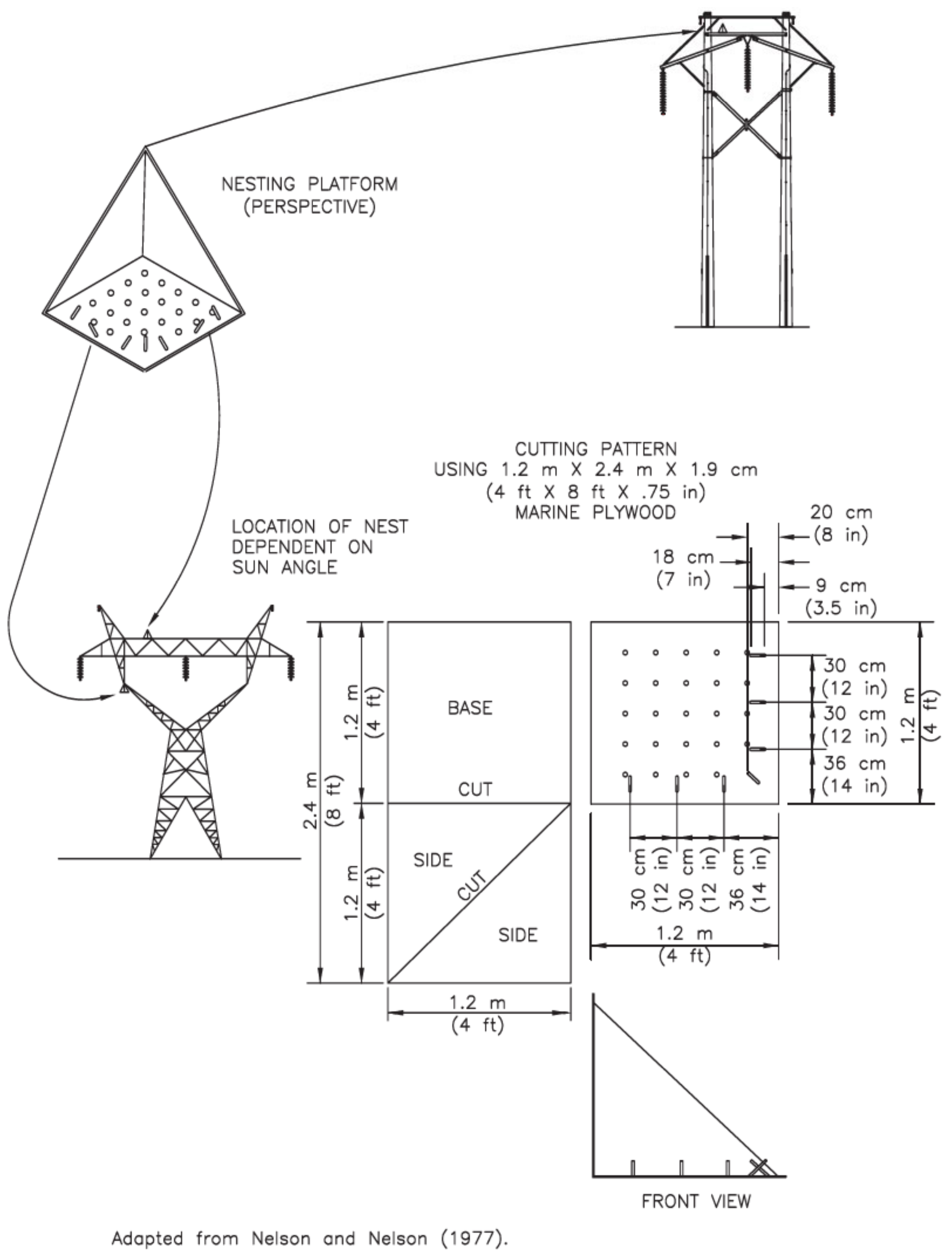

FIGURE 6.4: The Morley Nelson raptor nest platform.