IEEE Guide for Animal Deterrents for Electric Power Supply Substations

Sponsor
Substations Committee
of the
IEEE Power Engineering Society

Reaffirmed 23 September 2004
Approved March 18, 1993
IEEE Standards Board

Abstract: Methods and designs to mitigate interruptions and equipment damage resulting from animal intrusions into electric power supply substations thereby improving reliability and minimizing the associated revenue loss are addressed.
Keywords: barrier, flashover, mitigation, phase-to-ground fault, phase-to-phase fault

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ISBN 1-55937-304-0

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Introduction

(This introduction is not a part of IEEE Std 1264-1993, IEEE Guide for Animal Deterrents for Electric Power Supply Substations.)

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IEEE Guide for Animal Deterrents for Electric Power Supply Substations

1. Overview

This guide is divided into seven clauses. Clause 1. provides the purpose and scope of this guide. Clause 2. lists references to other standards. Clause 3. provides definitions of terms that are used in the guide, but are listed here as a quick reference. Clause 4. discusses the various types of animals and the problems they may cause. Clause 5. recommends criteria for implementing a mitigation program. Clause 6. explains different mitigation methods. Clause 7. describes the effectiveness of the various mitigation methods.

1.1 Purpose

Intrusion by animals into electric supply substations has been a problem experienced by most of the electric utility industry. The costs associated with outages caused by animals continue to escalate. Although animal problems differ in nature geographically, the damage to equipment, interruption of or loss of service to customers, and safety problems encountered by operating personnel result in the same general concerns.

This guide identifies various animals, the problems they cause and mitigation methods. Further, it recommends criteria for applying mitigation methods, documents survey-reported effectiveness of various methods and recommends factors for evaluating effectiveness of methods once they are applied.

1.2 Scope

This guide documents methods and designs to mitigate interruptions and equipment damage resulting from animal intrusions into electric power supply substations, thereby improving reliability and minimizing the associated revenue loss.

2. References

This guide shall be used in conjunction with the following publication:

IEEE Std 100-1992 The New IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI)[1].

[1]IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1331, USA.

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3. Definitions

This clause contains key terms as they are used in this guide. For additional definitions, see IEEE Std 100-1992 [2].

3.1 barrier: Any product whose sole purpose is to act as an obstruction to the path of the animal. A barrier may have electrical insulating properties, but by design and application, its use is limited to blocking an animal's passage or an animal's contact with energized conductors or equipment.

3.2 coating: (as defined by the Steel Structures Painting Council)[3] Generic term for paints, lacquer, enamels, etc. A liquid, liquefiable, or mastic composition that has been converted to a solid protective, decorative, or functional adherent film after application as a thin layer.

3.3 grounded member: Any part in a substation that is normally connected to or in contact with earth.

3.4 insulating member: The part of the substation that isolates the energized conductor from a grounded member or other energized conductors.

4. Animal intrusions

There are many animals including birds, mammals, reptiles, and insects that can affect the operation of electric supply substations. The effect of these animals can be evaluated by the problems they cause, type of outages that result, equipment commonly damaged, and safety/health hazards that the animals present to personnel. In October and November 1990, an IEEE questionnaire was sent to 174 public utility companies (utilities) in the United States and Canada, requesting information on their experiences relating to animal outages. Of these utilities, 114 responded.

4.1 Types of animals

Listed below are those specific animals that have been identified by the survey as known or potential sources of animal-related outages. The majority of the survey responses identified squirrels, birds, raccoons, and snakes as the primary source of animal-related intrusions.

Percentage of Respondents

Animals	Utilities reporting this animal
Squirrels	90%
Birds	86%
Raccoons	57%
Snakes	46%
Cats	43%
Mice	30%
Rats	19%
Opossums	13%

Several other animals were identified as ones with which some utilities have experienced problems. These animals are not major contributors, as none were reported by more than 5% of the utilities. They are listed below in alphabetical order.

[2]Information on references can be found in clause 2.
[3]Steel Structures Painting Council publications are available from the Steel Structures Painting Council, 4400 5th Avenue, Pittsburgh, PA 15213, USA.

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a) Bats
b) Deer
c) Dogs
d) Foxes
e) Frogs
f) Gophers
g) Ground hogs
h) Insects
i) Lizards
j) Moles
k) Monkeys
l) Pikas
m) Rabbits
n) Ring-tailed cats
o) Skunks
p) Weasels

Consideration of several factors is important when addressing intrusions at specific substation locations. Also, the particular animals and the degree to which they pose problems will vary according to geographic location. The dominant animals, such as squirrels and birds, were reported by nearly every utility. While squirrels were the worst offenders overall, birds were a greater problem in farmland areas. Raccoons were identified most often in the cooler northern and midwestern climates, while problems with snakes were more commonly reported by utilities from the southwest and southeast. Activity levels and the number of intrusions also will vary with the season of year.

4.2 Problems

There are various reasons why animals enter substations. Cats enter substations for warmth, woodpeckers create holes for shelter and to store food, birds build nests on equipment and structures. Raccoons and snakes try to reach bird nests for young birds and eggs. Squirrels, especially during weaning cycles, migrate through unfamiliar territory. Predators, such as foxes, enter a substation looking for rodents and other nocturnal animals that make homes in vaults, equipment, and structures.

Animals in substations cause a variety of problems, such as faults, which can result in power outages, reduced equipment life, or severely damaged equipment. They may even pose a variety of safety and health hazards.

Squirrels, raccoons, snakes and other creatures that climb fences, structures and equipment may eventually come into contact with energized parts of equipment or conductors, thus causing outages and damage. Rodents chewing through power and control cable insulation can also cause outages and damage.

Birds build nests in substation structures and equipment, sometimes using conductive material such as wire or magnetic tape that can fall or be carried into contact with insulators or bushings. Some birds have wing spans that can bridge phase-to-phase distance and cause an outage. Bird droppings can also be a major problem. Being communal, many congregate in a relatively small area. Their droppings accumulate on electric hardware quickly, causing insulator or bushing flashovers and possible equipment damage.

4.2.1 Outages

Animal-related outages run the gamut from momentary disturbances to long-term outages. Major portions of substations can be tripped off line, including transmission circuits.

In addition to the inconvenience caused by an outage and the cost of repair, revenue could be lost until service has been restored. Outages, sustained or momentary, reduce the long-term confidence of all customers and could be a critical

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factor for commercial and industrial customers. These problems can become serious if they are recurring in a particular substation or class of substations.

The majority of animal-related faults start as phase-to-ground faults, which may become phase-to-phase faults. Due to reduced clearances, these faults typically occur at 15 kV and below, but are not uncommon at up to 46 kV Animal-related outages are less common at voltages above 46 kV.

4.2.2 Equipment damage

The equipment susceptible to animal-related damage includes power transformers, capacitors, breakers, reclosers, surge arresters, voltage and current transformers, regulators, switchgear, potheads, switches, bushings, insulators and bus conductors.

Flashovers cause costly damage, which in many cases is so severe that equipment or components must be replaced. The equipment most commonly damaged by animal intrusions are bushings and bus insulators. Damage to bus insulators usually requires replacement of the insulators. Damage can include burned glazing, tracking, chipping, and even total fracture. Besides the direct damage to the insulators, the fault can cause stress in other equipment, such as transformers, breakers, etc., which reduces the life of the equipment and sometimes results in complete equipment failure.

Animals on breakers usually cause phase-to-ground faults that can damage the bushings and internal parts, such as stationary and movable contacts. Although the initial contact is likely to cause a phase-to-ground fault, at 15 kV voltage level and below it is common that the fault escalates to a phase-to-phase event, many times involving all six bushings on a breaker. Equipment damage can be much more severe than burning, chipping, tracking, or breaking of the bushing. The flashovers and arcing can burn holes in the covers of the equipment, which can be catastrophic for oil-filled equipment due to the possibility of fire.

In addition to damage to equipment, rodents and other animals chew on cable insulation, damaging cables in troughs, control houses, switchgears, and vaults. Woodpeckers cause major damage as they create holes for food storage and sometimes for shelter, and many animals build nests that can be fire hazards or interfere with equipment operation.

4.2.3 Safety/health hazards

Animals in substations can be safety hazards for operations and maintenance personnel. Although direct encounter between personnel and the animals that invade substations is unlikely, any confrontation can be hazardous. Additionally, animals can cause health hazards, particularly due to accumulations of animal wastes.

Safety is a concern when personnel confront live animals. Snakes that climb onto equipment and structures may not be seen until a person is close. Bees or other insects that nest in the substation may attack, as may any animal that has been cornered in vaults, troughs, or any other enclosure.

Odorous emissions from animals, such as skunks can be quite unpleasant. Animal wastes can cause unsanitary conditions for workers. Bird droppings are the most common problem, especially where large flocks of pigeons, ravens, starlings, etc., have roosted within a substation.

5. Criteria

A mitigation program should be put in place after experiencing an unacceptable level of animal-related problems. Typical criteria for implementing animal deterrent programs are frequency and duration of occurrences, cost of occurrences, safety hazards, severity of damage, equipment type, customers served, substation location, design type, and quality of service.

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The point at which cost of occurrences and safety and health hazards justify implementing deterrent programs is often difficult to establish. However, frequency of occurrences is one criteria that is relatively easy to quantify. Survey results indicate that corrective measures are typically implemented when the annual outage rate reaches one to three outages per substation.

5.1 Operating history

Once the need for a program is identified, the specific causes of the problem need to be determined. Outage records, maintenance reports, and routine inspections of facilities will afford specific information as to the cause and extent of the problem.

In a typical report, each entry should include facility name, date, time, equipment affected, animal(s) involved, outage duration, number of customers affected, weather conditions, repairs or testing conducted, relays activated, and voltage level.

5.2 Application determination

The operating history should be reviewed and the mitigation options selected. The application determination process should include consideration of the solution’s cost-benefit ratio, applicable governmental regulations, and community acceptance.

5.2.1 Cost-benefit analysis

The anticipated cost of implementing the mitigating measures should be compared to the anticipated benefit. Sufficient justification should be provided to support cost of implementation. Certain levels of unacceptability are intangible and may be dictated by company policies, community acceptance, customer relations, etc.

5.2.2 Governmental regulations

Some methods described in this guide, such as the use of chemicals or trapping of certain species, may be in conflict with governmental regulations. Therefore, part of the determination of which method to use should include research into applicable laws and regulations.

5.2.3 Community acceptance

Community acceptance of animal deterrent methods should also be considered. The impact on adjacent property owners should be addressed and, if needed, a demonstration along with specific product safety information and performance experiences should be made available.

5.3 Performance monitoring

Some means should be put in place for evaluating the effectiveness of any mitigation measures that have been applied. Records should be kept for each substation to record the deterrent used, date of application, what type of animal and problem the deterrent is intended to mitigate, and the history of animal-related problems. This record is necessary to monitor the performance of the applied deterrent in order to evaluate the feasibility of future applications.

6. Mitigation methods

The main methods for mitigating the effects of animal-related problems in substations are physical barriers, increased insulation, and deterrents. Physical barrier methods are those that are designed to block or discourage the entrance of

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animals into substations or restrict their access to areas of energized conductors. Increased insulation methods are designed to prevent or reduce the problems animals cause by increasing the effective distance to be bridged. Deterrent methods seek to discourage or repel the animals from the area in and around the substation or specific equipment.

Each substation needs to be evaluated to determine the effectiveness of any given mitigation method. The substation layout, equipment design, geographical location, and the animal behavior should be evaluated before one or more methods are adopted. One method may not be the answer to preventing all animal-related problems. Often a trial and error approach is necessary to find an effective solution for each situation.

6.1 Physical barriers

Physical barriers can deny animal access to energized areas in a substation. These barriers can be implemented at the perimeter of the substation, or at the base of the structures and equipment located within the substation. Specific barrier methods can be categorized as follows: fence barriers, structure barriers, line barriers, electric fences, and enclosures.

6.1.1 Fence barriers

To deny animals access at the fence line for an outdoor substation requires consideration of possible access paths over, through, and under the fence.

A smooth polycarbonate [typically 1.5 mm–10 mm (1/16 in–3/8 in) thick], sheet metal, or aluminum barrier extending down 610 mm to 915 mm (24 in to 36 in) from the top of the fence can deny several animal types the toeholds necessary to climb over the fence (see figure 1). Use of transparent polycarbonate has been found to minimize the number of aesthetic objections from residents near the substation.

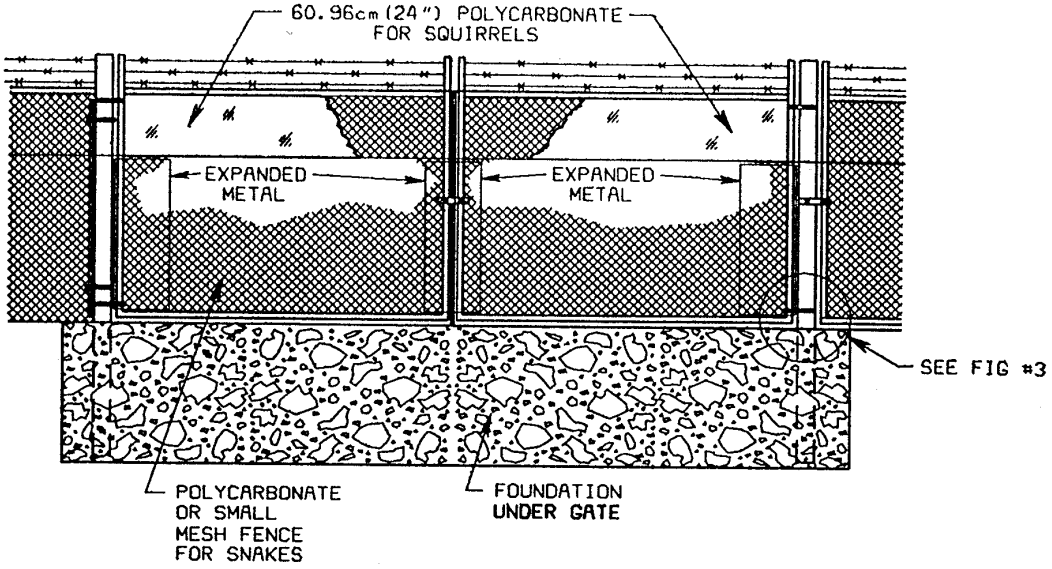


Figure 1— Fence and gate barriers

Access through the fence can be blocked by utilizing a smaller mesh fabric. For example, the standard 50 mm (2 in) diamond fence fabric can be replaced with a smaller mesh such as 25 mm (1 in) diamond. The size of the mesh required depends on the size of the animal of concern. The primary fence fabric should be galvanized or otherwise protected against rust and extend below the ground line to prevent burrowing under the fence. The fence fabric should be installed continuously around the corner fence posts (see figure 2).

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Vertical polycarbonate or metal strips can be installed to plug the gap between the fence post and the fence fabric. Examples of places where this is effective are: walkway or driveway gates, removable fence sections, and changes in fence height where use of continuous fabric is not possible. Flexible, expanded metal can be installed between the swinging gates and gate post. The expanded metal should be bent to prevent binding during gate operation (see figure 3). Expanded metal may also be installed at the gate closing point. Holes may be cut, as needed, to permit the padlock end of the latch assembly to protrude through the expanded metal.

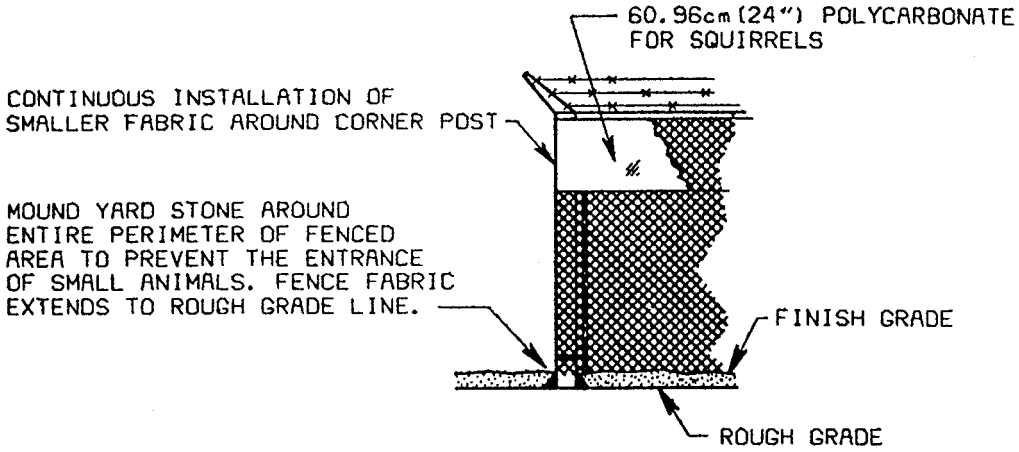


Figure 2— Corner post detail

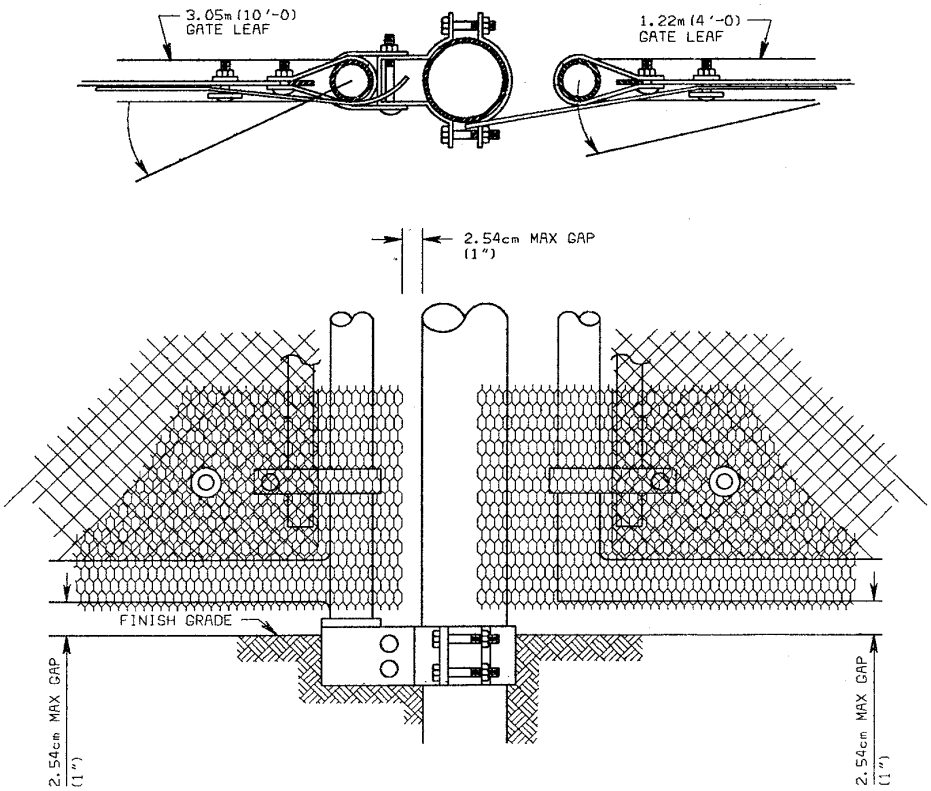


Figure 3— Gate post detail

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Where frost or other sources of ground heaving is a concern, the fence posts should be anchored in concrete to prevent gaps from developing over time between the bottom of the fence and the ground line. Special treatment at cantilevered gates is often required, including a gate foundation (see figure 1), in order to maintain a maximum gate frame-to-ground line gap of approximately 25 mm (1 in) or less.

Heavy rainfall or spring runoff could create gaps under the fence due to washout. Any gaps that develop should be filled. Runoff patterns should be redirected away from the substation fence to ensure proper drainage and to prevent reoccurrences. Drains which exit the substation and their associated sump manholes may need to be screened.

Where buildings are close by, adjacent roofs or walls may extend above the normal substation fence height and provide entrance paths. Taller fences may be required to block these paths. Another avenue over the substation fence can be provided by transmission line towers or wood poles and their associated guy and anchor wires where they are located at or near the fence line. Line barriers (see 6.1.3) can be installed on the guy and anchor wires. Polycarbonate or sheet metal climbing guards can be installed on the poles and towers, but should be located at the same height as the fence barrier.

Even the most comprehensive fence barrier can be quickly defeated if proper attention is not given to maintenance of the perimeter. Placement of climbable items (e.g., bushes, trees, boxes, pallets, poles, cable reels, etc.) near or against the fence should be avoided. Where this cannot be avoided, such as with landscape plantings, other mitigation methods may be needed.

6.1.2 Structure barriers

Where the number and type of substation structures economically allow, smooth polycarbonate or sheet metal barriers (see 6.1.1) can be installed inside the substation instead of on the fence. This approach allows animals access to the substation, but reduces their ability to climb to areas of energized conductors, bushings, etc. The smooth sheet barriers are required on every structure leg, pole, cable riser, or piece of equipment (e.g., transformer, circuit breaker, regulator, capacitor, etc.) that comes in contact with the ground line (see figure 4).

There are several disadvantages that may limit the success of structure barriers over those barriers installed along the perimeter. First, the structure legs are rarely “clean shaped.” The presence of conduits, switch operating rods, handles, ladders, etc., increases the number of nonstandard and odd-sized or odd-shaped polycarbonate or sheet metal pieces required. Second, the animal barriers can complicate access to equipment for maintenance and operating personnel. Safety concerns may arise as these nonstandard barriers can change personnel perceptions of safe areas. Third, the exceptional agility of the animals involved makes it difficult to identify and eliminate all possible paths.

6.1.3 Line barriers

Access for squirrels and similar small animals that can walk along wires can be blocked by installing ultraviolet (UV) stabilized polycarbonate discs on all overhead lines that enter the substation and on guy and anchor wires for poles adjacent to the substation fence. The discs are fabricated as split halves to facilitate assembly on existing lines (see figure 5). They should be located approximately 3 m (10 ft) beyond the fence line or at a distance deemed sufficient to prevent the animals from jumping off the wire and landing within the fenced area. The slotted dimension X varies to match the wire diameter and allows the disc to rotate.

6.1.4 Electric fences

Electrified substation fences may be installed to provide a shock sufficient to deter animals from entering the substation. Use of this method may be unacceptable or illegal in some areas. In addition, these installations can be maintenance intensive.

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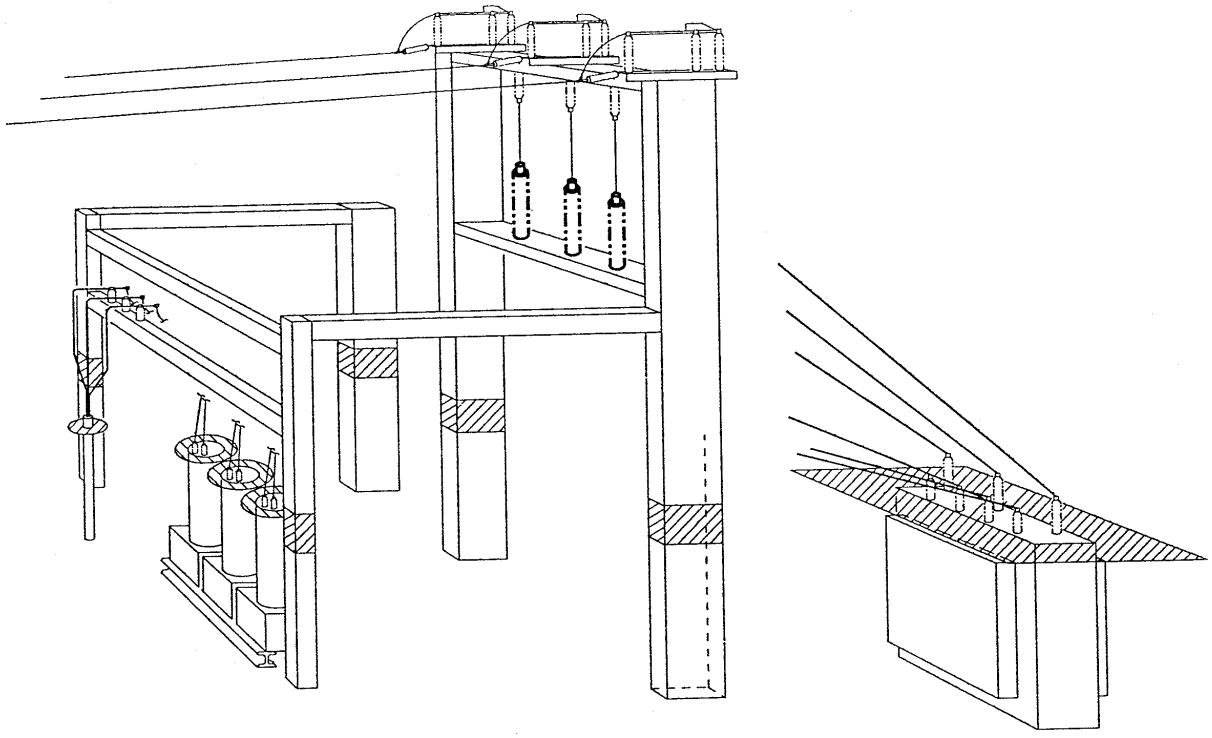


Figure 4— Structure barriers

6.1.5 Enclosures

A completely enclosed substation would seem to provide the ultimate barrier against animal intruders. However, experience with indoor substations, switchgear, and similar enclosures has proven this to be untrue. In addition, it is impractical to enclose a substation just to solve an animal intrusion problem. Conduits, cable trenches and tunnels, drains, doorways, and ventilation openings provide several access paths for animals into enclosures. Vaults give rise to similar problems. Netting or similar type screening applied over such openings can effectively block animal entrance while not restricting air flow. Metal or plastic barriers can be used to block trenches and tunnel ways; however, consideration should be given to loss of air flow and cooling requirements.

Duct sealant-type putty and spray foam materials can be used to seal conduit openings in substation power distribution panels and other control boxes (especially in buildings and other heated areas) where mice and other rodents have been known to build nests and chew through control cables.

6.2 Increased insulation

Increasing insulation levels can be an effective approach to mitigate animal-related problems once an animal has gained access to structures or equipment. This approach can consist of coverings, coatings, and increased clearances.

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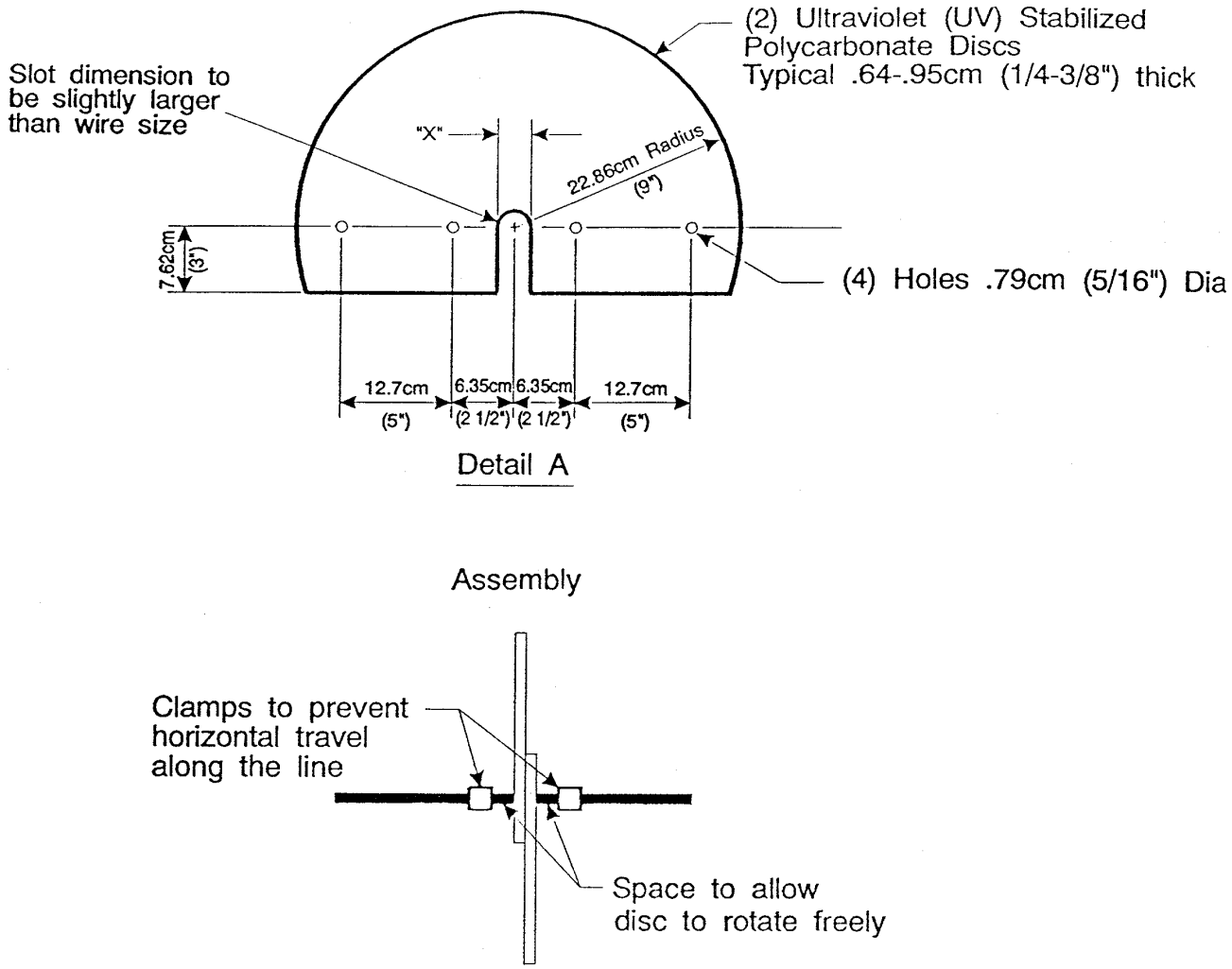


Figure 5— Polycarbonate line barriers

6.2.1 Coverings

An effective means of handling animal-related outages involves the use of insulating coverings on bushings and conductors to increase effective insulation levels. These coverings come in a variety of styles and can be used separately or in various combinations to deal with particular situations.

Equipment bushings can be protected from animal-related flashovers by installing protective boots. Equipment leads can be protected by wrapping bare leads with insulating tape or by using insulated conductor. Other means of increasing insulation levels include the use of wildlife guards, sheets of insulating material or heat-shrinkable insulation.

Wildlife guards are insulating covers added to the tops of bushings overlapping the first bushing petticoat. This effectively increases the phase-to-ground clearance of a bushing. Phase-to-phase clearance can be increased by making the center-phase cover sufficiently longer than the outside phases. Guards of this type are commercially available in a variety of shapes and configurations to accommodate a wide variety of circumstances. Some are fabricated from hard plastics, and may be hinged to allow ease of installation on energized equipment. Others are soft plastic and some are heat shrinkable. Guards can also be easily fabricated from readily available materials, such as PVC pipe.

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Sheets of insulating material can be added to the top of equipment, such as a breaker, with cutouts to allow for bushing exit. There are no commercially available products of this type that can be installed without any fabrication.

Where there is a danger of phase-to-ground contact, heat-shrinkable insulation can be applied to the conductor to increase the insulation level to ground. The material is placed around the conductor and heat is applied. The heat shrinks the material to conform to the shape of the conductor and form a tight fit. This product is commercially available in a variety of shapes and forms.

6.2.2 Coatings

Another method used to reduce the outages caused by animal contact is the application of an insulating coating to energized parts (e.g., bus) or nonenergized parts (e.g., tanks, enclosures, structural members) at the insulator or bushing attachments. This method is particularly suited for complicated areas where the placement of a guard is impractical.

Coatings are applied to increase the electrical insulation of a given area. The decision on where to apply a coating and to what extent and thickness should be based on the following parameters: the type of fault expected, the system voltage, and the offending animal.

An analysis of the type of fault expected (e.g., phase-to-phase or phase-to-ground) should give an indication as to whether the coating should be applied on the bus or the grounded member or both and how much of the member should be coated. The thickness of the coating should be determined by the system voltage and the offending animal. Manufacturers' recommendations should be followed to obtain the required dielectric strength, since the relationship between coating thickness and dielectric strength is not linear. Also, additional thickness beyond that which is required for dielectric strength may be desired if the offending animal has sharp claws that may penetrate a thin coating.

Coatings are typically applied by brushing, spraying, or dipping. The application method is based on the constraints of the particular installation. Care should be taken when applying coatings to vertical surfaces to obtain a uniform thickness.

Attention should be paid to the function of the equipment when coatings are applied to equipment, its energized parts, or both. For example, the current rating of a switch may be reduced if the current-carrying contacts are contaminated from overspray during the coating application. Also, coating the grounded member of a switch can cause safety and operational problems if the base of the insulating member and its supporting structure are completely insulated from ground. In this case, with the blade open and separated from the jaw end, a voltage surge could bridge the gap between the blade and jaw, since the phase-to-ground insulation level at the switch insulator has been increased.

To evaluate insulating coatings, performance criteria such as effectiveness, anticipated life, electrical properties, and adhesion and toughness characteristics should be considered. This evaluation in combination with material costs and application costs will assist in selecting or ranking alternatives.

6.2.3 Increased clearances

One method of mitigating animal-related problems is to increase clearances, that is, distances between phases and between phases and grounded parts. While it is probably impractical to redesign existing substations, future substations could be constructed with increased clearances where these problems are anticipated.

Components such as transformers, circuit breakers, reclosers, etc., are manufactured and built to international equipment standards. While the bushings can be specified for greater overall height, their placement for an increase in phase spacing is limited by the top surface area of the equipment. Design changes providing a custom-built piece of equipment may be cost prohibitive.

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6.3 Deterrent methods

Methods to discourage or repel the animals from the general substation area can be implemented anywhere on the property. Specific deterrent methods can be categorized as follows: fake predatory animals, disturbing noises, chemical repellents, perching and climbing deterrents, and screened nesting locations.

6.3.1 Fake predatory animals

Plastic owls, snakes, falcons or other objects can be placed conspicuously in the substation structure or on top of an enclosure. These practices have been found to be initially effective in driving off birds, rodents, and other small animals. However, long-term effectiveness of such devices is not common once the animals become accustomed to their presence.

6.3.2 Disturbing noises

Various types of disturbing noises can be generated to drive off animals. They consist of ultrasonic, loud, or danger signal noises. As with the fake predators, a high level of initial success is often followed by reduced long term effectiveness as the animals become accustomed to the pattern. In addition, where the noise is disturbing to humans, community acceptance can sometimes be difficult to obtain.

Ultrasonic sound wave methods for substation applications usually focus on rodents in indoor locations. The ultrasonic sound is inaudible to humans but can cause pain in the animals. When effective, the resulting stress on the animal is nontoxic yet drives them to seek other food sources and nesting areas.

Loud noises can be used to scare animals away from the substation. Rifles, shotguns, and cannons powered by compressed air, nitrogen, and propane can be used. In some areas, particularly, congested urban locations, local noise ordinances or other governmental regulations may prohibit the use of noise as a deterrent.

Danger signal noise generators attempt to scare off the animals by producing sounds that mimic animal danger signals. These sounds attempt to lead the entire herd or flock into sensing that danger is approaching. When effective, the animals become nervous and annoyed by the interference with the group defensive signals, or are deprived of their ability to detect other sounds required for safety in their normal environment.

6.3.3 Chemical repellents

Chemical repellents and additives can be used to treat the food supply, or as baits in traps to kill animals if they enter or live within the substation. Chemicals can be very effective. However, acceptance of this method is limited because of community, environmental, and governmental concerns and regulations. Typical repellents and additives, especially when added to food sources, can result in accidental poisonings of humans or nonthreatening animals. The chemicals can, through drainage and runoff, reach nearby rivers, streams, etc., and contaminate the water supply.

6.3.4 Perching and climbing deterrents

Several methods are available to make perching areas undesirable to birds. A common deterrent involves the use of a sticky gel. This gel can be applied as a deterrent, to surfaces where birds perch such as structures, incoming wires, and guy wires. The gel is applied directly to the surface where the birds perch. When the bird lands on the treated surface, there is no immediate effect. However, when it attempts to fly away or walk, its feet initially remain stuck. The bird is not harmed or permanently trapped, and with a struggle can get free. Feeling trapped, the frightened bird gives out a danger warning and then avoids the area. Other formulations of gels include a gritty substance that birds find unpleasant to stand in, or a chemical that produces a burning sensation in their feet. Personnel safety is a concern with these gels, as it is possible the slight stickiness could throw maintenance or operating personnel off balance when they walk onto the coated surfaces.

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Another means of deterring birds from perching is through the use of adhesive-backed, spined perch-deterring strips (see figure 6). These strips, sometimes called porcupine wire, have sharp metal spines protruding in an array of directions and can be attached to common perching and roosting areas to render it impossible for birds to land. Caution must be used to avoid reducing electrical clearances below acceptable levels.

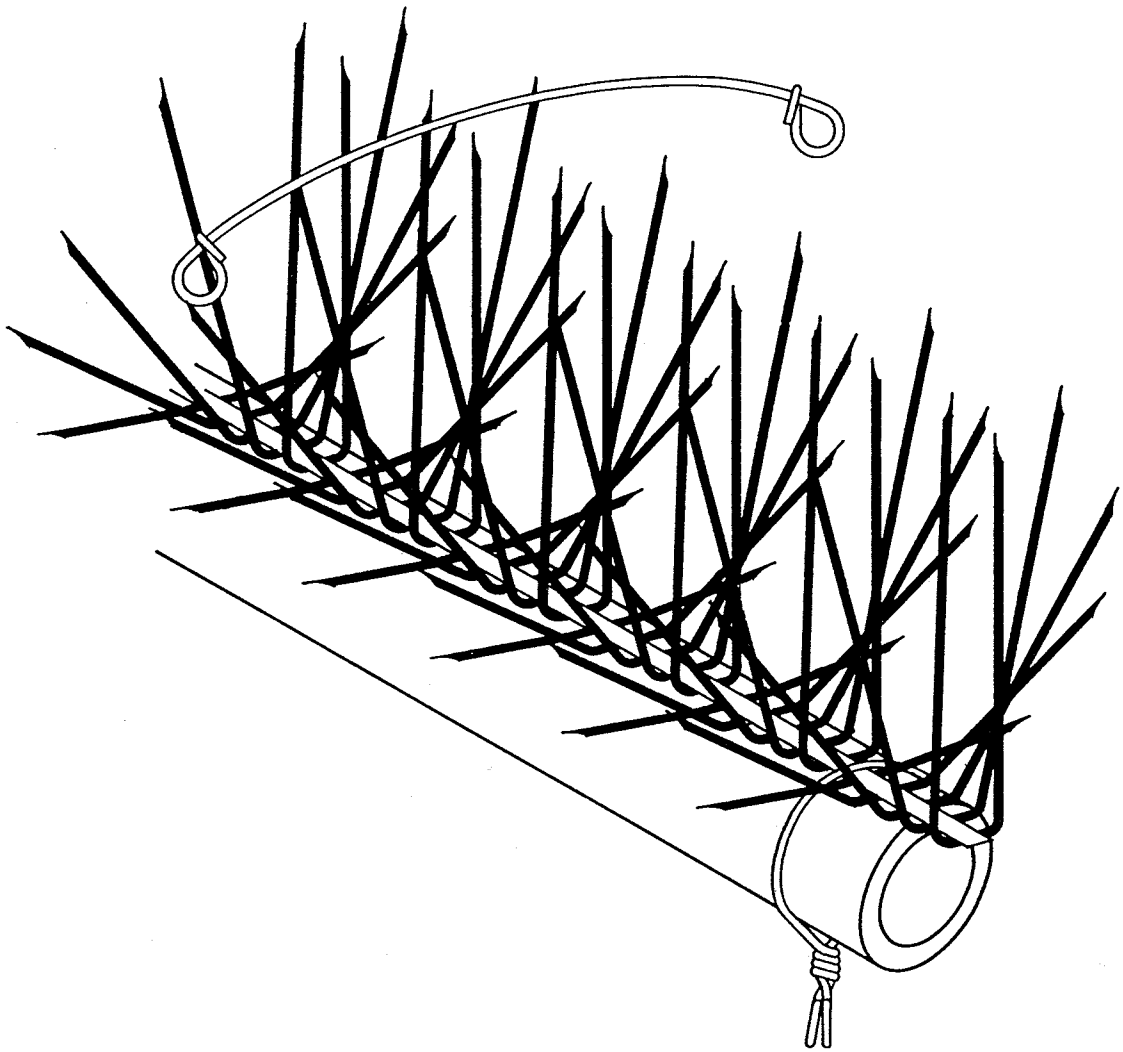


Figure 6— Spined perch-deterring strip

Climbing deterrents include lubricants, porcupine wire, and spiny cylinders. Coating the structure legs and other climbing surfaces with a slippery lubricant can be effective against snakes. However, over time, the lubricant will dry out, harden and become brittle, typically requiring recoating on a periodic basis. The presence of the lubricant can be annoying to maintenance personnel, as can the required recoating. The spined perch-inhibiting devices described previously can be applied on climbing surfaces to deter climbing. These spiny alternatives can represent a safety concern to maintenance personnel.

6.3.5 Screened nesting locations

Deterrence of birds and other animals from the general area can be accomplished if access to the preferred nesting sites within the substation is denied.

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Galvanized or other mesh screening can be installed around specific known nesting locations within the substation such as structure corners, switch bases and jaw assemblies, building eaves and rafters, reactor compartments, and over semi-enclosed transformers (usually open at the top). Netting, aluminum or polycarbonate barriers, and fiberglass panels are other possible screening materials. With any screening, consideration should be given to proper air flow and cooling of any screened equipment.

Other nesting deterrents include installing upright steel pegs in the structure at known nesting locations and the sealing of the open ends of tubing. An additional benefit to the prevention of nesting may be reduced intrusion by snakes, raccoons, and other predators seeking the eggs and young in the nests.

Depending on the species of animal involved, it may become necessary to relocate existing nests to remote locations before screening can be installed at existing substations. Such attempts may require permits from governmental agencies. In extreme cases the substation may be relocated to a non-nesting area. The design criteria for siting future substations may be modified to increase consideration of non-nesting locations.

6.4 Other methods

There are other methods for handling animal intrusions in addition to those described previously. These other methods can be categorized as follows: shields, selective landscaping and trapping.

6.4.1 Shields

Where bird droppings are a persistent problem, shields may be employed. Shields are usually made of sheet metal or some similar material and are installed between the perch and the equipment to be protected. The shields deflect or catch the droppings. Shields may need to be analyzed for their load contributions to the structure, and those that catch the droppings will require periodic cleaning.

6.4.2 Selective landscaping

Whenever possible, landscapers should use plants that are nonfruiting and do not provide a food source, such as seeds, fruits, or nuts. Landscaping should also be located carefully to avoid providing avenues of access for animals.

6.4.3 Trapping

Occasionally, it may become necessary to employ trapping as a means of control. Trapping may be employed within the substation or the surrounding area where governmental regulations allow.

7. Mitigation method effectiveness

The effectiveness of various methods used to minimize animal-related problems or damage at substations is primarily related to the type of animal for which mitigation is required. The success of these methods as reported in the survey (see clause 4.) is described below.

The reported percentage of effectiveness is based only on the respondents who have utilized the particular method. Effectiveness columns may not add to 100% because not all respondents indicated the degree of effectiveness and others indicated intermediate degrees of effectiveness.

7.1 Physical barriers

The following is a summary tabulation that provides an indication of the effectiveness of physical barriers.

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Table 1— Effectiveness of physical barriers

Physical barriers	Respondents that have tried method (%)	Of respondents that have tried method, those reporting long-term effectiveness (%)	Of respondents that have tried method, those reporting not effective (%)
Fence barriers	22	27	4
Smooth climbing guards	18	52	0
Smaller mesh fence	14	38	6
Electric fences	5	67	0

7.2 Increased insulation

The following is a summary tabulation that provides an indication of the effectiveness of increased insulation methods.

Table 2— Effectiveness of increased insulation methods

Increased insulation	Respondents that have tried method	Of respondents that have tried method, those reporting long-term effectiveness (%)	Of respondents that have tried method, those reporting not effective (%)
Bushing/insulator covers	65	71	1
Insulating tapes	25	62	0
Heat shrink insulation	25	83	0
Insulating coating	36	49	5
Increased clearances	2	100	0

7.3 Deterrents

The following is a summary tabulation that provides an indication of the effectiveness of deterrent methods.

Table 3— Effectiveness of deterrent methods

Deterrents	Respondents that have tried method (%)	Of respondents that have tried method, those reporting long-term effectiveness (%)	Of respondents that have tried method, those reporting not effective (%)
Plastic owls/snakes	56	2	38
Ultrasonics	30	3	31
Screening nesting locations	26	77	3
Loud noises	17	16	21
Chemical repellents	17	32	16
Sticky gels	9	10	40
Spined perching deterrents	3	100	0

7.4 Other methods

Use of shields, landscaping and trapping were reported by too few respondents to provide meaningful results. However, they are legitimate means to handle certain animal-related problems and it would be beneficial to consider them.

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