



IEEE Guide for Animal Mitigation for Electric Power Supply Substations

STANDARDS

IEEE Power and Energy Society

Developed by the
Substations Committee

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IEEE Guide for Animal Mitigation for Electric Power Supply Substations

Developed by the

Substations Committee
of the
IEEE Power and Energy Society

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IEEE SA Standards Board

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Abstract: Documented in this guide are methods and designs to mitigate interruptions, equipment damage, and personnel safety issues resulting from animal intrusions into electric power supply substations, thereby improving reliability and safety, and minimizing the associated revenue loss.

Keywords: Animal, barriers, coating, damage, deterrent, fencing, IEEE 1264™, insulation, intrusion, laser, materials, mitigation, netting, noise, optical gel, outages, performance, program, repellent, slide, survey, wire

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Introduction

This introduction is not part of IEEE Std 1264-2022, IEEE Guide for Animal Mitigation for Electric Power Supply Substations.

IEEE Std 1264™-2015 was revised by members of the IEEE Guide for Animal Mitigation for Electric Power Supply Substations Working Group and is under the sponsorship of the Transmission and Distribution Substations Operations Subcommittee of the Substations Committee of the IEEE Power and Energy Society.^{6,7} This guide provides guidance and information to substation engineers on the problems animals cause in electric power supply substations. 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.

For the 2015 revision, updates were made to several clauses to incorporate valuable industry feedback from members and balloters, in particular the clauses regarding line barriers and insulating coverings. The Working Group had originally planned to send out a new survey and incorporate updated findings in this revision, yet resources to accomplish this were not available.

For this 2022 revision, valuable additions are made by new and continuing members, resulting in clarified information in certain subclauses for animal intrusions and preventive methods, with additional new subclauses as well. In particular, physical sizing considerations are included, along with a new [Annex C](#). Focused concern is added for insects (such as Rasberry crazy ants), damage from large bird pecking behavior, and health issues from bird guano. The clause on criteria is expanded to be cautious not to compromise the performance of existing equipment when designing for potential mitigation improvements. The fencing subclause is expanded for both non-electric and electrified fencing, with insights for wind loading impacts, buried fabric corrosion, and improved animal blockage. The barrier disc descriptions are expanded and improved, and detail added for sealing of enclosures, including new sealing guidelines in [Annex B](#). The information for guards and coverings is improved, along with new subclauses for approaches using optical gel, cone-shaped perch deterrents, bird wire, slides, nettings, and lasers. Some caution is added regarding landscaping overhang of barriers, overall good housekeeping of the site, and bird behavior regarding nest reclaiming. Finally, two new subclauses are added describing materials properties for plastics and silicone, and differing aspects of performance testing.

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IEEE Guide for Animal Mitigation ~~Deterrents~~ for Electric Power Supply Substations

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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,⁷ 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 Scope

This guide documents methods and designs to mitigate interruptions, equipment damage, and personnel safety issues resulting from animal intrusions into electric power supply substations, thereby improving reliability and safety, and minimizing the associated revenue loss.²

1.2 Purpose

Intrusion by animals into electric power 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 [similar](#) ~~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.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{8,9}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

⁸The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁹The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

2. Normative references

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IEEE Std 1656™, IEEE Guide for Testing the Electrical, Mechanical, and Durability Performance of Wildlife Protective Devices on Overhead Power Distribution System Rated up to 38 kV. [10,11](#) ^{1,2}

3. Definitions

For the purposes of this document, the following terms and definitions apply. The IEEE Standards Dictionary Online should be consulted for terms not defined in this clause. [12](#) ³

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 entry to or contact with energized conductors or equipment.

[10](#) ¹ IEEE publications are available from The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<https://standards.ieee.org/>).

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coating: ~~(as defined by the Steel Structures Painting Council)~~ 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.^{13,14 4}

grounded member: Any conductive object (structure or equipment) ~~part in a substation that is normally~~ connected to a ground grid ~~or in contact with earth~~.

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

wildlife deterrent: A device designed to deter perching of birds or access by other animals to an area where high voltages are present.

wildlife guard: A device, guard, or structure that is intended to avert contact by wildlife by providing electrical isolation from high-voltage equipment.

4. Animal intrusions

There are many types of animals including birds, mammals, reptiles, and insects that can affect the operation of electric supply substations. The effect these animals have can be identified ~~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.

¹³Definition from the Steel Structures Painting Council.

^{14 4} Steel Structures Painting Council publications are available from the Steel Structures Painting Council, 4400 5th Avenue, Pittsburgh, PA 15213, USA.

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.

Table 1—Percentage of respondents

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

Several other animals were identified from the survey 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 as follows in alphabetical order:

- 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 the animal's physical and behavioral characteristics ~~several factors~~ is important when addressing intrusions at specific substation locations. The wingspan or tail length of a species of bird can identify a specific issue (see Annex C for some sample sizes). The size of hole a rodent can fit its body through or the mass congregation of ants that can accumulate in specific regions are all factors that need to be identified. The particular animals and the degree to which they pose problems varies ~~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 vary with the season of year.

4.2 Problems

There are various reasons why animals enter substations. For example, cats enter substations for warmth, woodpeckers create holes for shelter and to store food, and 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. [Insects such as Raspberry crazy ants swarm a device and create a fault. When an ant gets electrocuted, it releases a pheromone that communicates to the other ants that they are under attack, and to come and fight, which results in tens of thousands of dead electrocuted ants that create even more of a mess and/or fault. Animals and insects](#) ~~They~~ may even pose a variety of safety and health hazards due to [their](#) ~~animal~~ waste, and safety to personnel who come upon the animal unexpectedly.

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 [due to the buildup and corrosive nature of guano](#). 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 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 can also occur at higher voltages.~~

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. [Some large birds have been observed pecking at damaged polymer insulators on energized phases in excess of 138 kV.](#) Besides the direct damage to the insulators, the fault can cause stress in other equipment such as transformers [and](#) 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. [Mice have been observed creating nests between phases in breaker panels inside control houses. This has resulted in fires or phase-to-phase faults caused by either the mice or the snake bridging the gap between the phases trying to get to the mice.](#) 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 those animals that have been cornered in vaults, troughs, or any other enclosure.

Odorous emissions from animals, such as skunks, can be quite unpleasant. Animal [droppings and guano wastes](#) can cause unsanitary conditions for workers. Bird droppings are the most common problem, especially where large flocks of pigeons, ravens, starlings, [and other birds, have roosted within a substation. Bird guano can be conductive, acidic, and unhealthy to be around. Bird guano can accumulate in large piles, and during rain or humid conditions, becomes a conductive, acidic paste on the electrical equipment that causes corrosion and/ or flashover. Other hazards exist from other species, such as mice droppings. Hantavirus is a virus that lives inside mice feces, and when disturbed it can become airborne in the form of a harmful dust etc., have roosted within a substation.](#)

5. Criteria

A mitigation program should be put in place when experiencing an unacceptable level of animal-related problems. Typical criteria for implementing animal mitigation 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.~~

— [Frequency and duration of occurrences](#)

— [Cost of occurrences](#)

— [Safety hazards](#)

- [– Severity of damage](#)
- [– Equipment type](#)
- [– Customers served](#)
- [– Substation location](#)
- [– Design type](#)
- [– Quality of service](#)

The point at which cost of occurrences and safety and health hazards justify implementing mitigation programs can be difficult to establish. However, frequency of occurrences is one criterion 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, failure mode detail, 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 [added risk](#), cost-benefit ratio, applicable governmental regulations, and community acceptance.