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Regulations concerning predator-deterring electric fences

Laid down by the Directorate for Nature Management on xx xx xxxx pursuant to Act No. 100 of 19 June 2009 relating to the management of biological, geological and landscape diversity (Nature Diversity Act), Section 17a, cf. formal delegation resolution of 22 June 2012 No. 606.

§ 1. Purpose

These regulations are intended to specify a standard for predator-deterring electric fences.

§ 2. Definitions

The following definitions apply to the regulations:

Predator-deterring electric fence: An electric fence that prevents large carnivores from gaining access to areas with livestock or dogs, and which confers the right to kill such wild animals pursuant to Section 17a of the Nature Diversity Act

§ 3. Requirements for predator-deterring electric fences

The Directorate for Nature Management stipulates requirements for predator-deterring electric fences in the form of a standard. The standard is provided as an annex to these regulations.

§ 4. Entry into force

These regulations will enter into force on xx xx xxxx.

Standard

Measures to prevent large-carnivore damage

the Norwegian Environment Agency

Erecting and maintaining predator-deterring electric fences

Photo: Norwegian Wildlife Damage Centre, NIBIO Tjøtta/Lise Aanensen

Norwegian Wildlife Damage Centre
NIBIO Tjøtta

Standard for predator-deterring electric fences

This is the default standard to be followed unless otherwise specified in the grant award decision. The measure must be carried out in accordance with this standard before it can be approved and grant payment disbursed.

Principles regarding predator-deterring electric fences

Predator-deterring fences have to be constructed and maintained with attention to all components that are part of the fence system. Construction and maintenance requires knowledge of and information about agricultural and large carnivore conditions, which must be taken into consideration by the user in collaboration with the Office of the County Governor. The term "qualified personnel" is used in this document to denote persons with the competence required to document that a fence system meets the technical specifications of this standard, including that it complies with European Standard EN 60335-2-76, *Household and similar electrical appliances - Safety - Part 2-76: Particular requirements for electric fence energizers*, and Nemko supplement II.

Approved fence types

There are two main types of fences approved in Norway for safeguarding livestock and semi-domesticated reindeer from predation:

- 6-wire high-tensile electric fence
- Enhanced wire-mesh fence

The fence types are dimensioned to keep out most individuals of the relevant large carnivore species (Table 1). The fences must be tailored to the –large carnivore species in question. In areas with multiple large carnivore species present, the fence must be dimensioned in relation to the species that is most difficult to exclude.

The height of the fence is not the most critical factor, but rather the animal's experience of the encounter with the fence before it decides to jump it. In light of this, proper placement of the nose wire (the offset wire to deliver a shock to the carnivore's snout) of an enhanced wire-mesh fence or the bottommost wires of a 6-wire high-tensile electric fence is more important than the overall height.

Studies by the Swedish Wildlife Damage Centre show that an enhanced wire-mesh fence with a top wire and bottom wire can provide good protection against lynx, as long as the mesh size is small and cannot be easily stretched apart. Lynx are good climbers, so care must be taken not to run the fence line too close to trees.

To deter wolves the fence must be a minimum of 120 cm high, although fence height is seldom the critical factor for whether or not a large carnivore jumps over. When using 6-wire high-tensile electric fence, the space between the four lowest wires must not exceed 20 cm, or else the wolf will be able to crawl/jump between them. A fence with relatively taut bottom wires will also keep out stray dogs and foxes.

In areas where bears are a concern, both enhanced wire-mesh fences and 6-wire high-tensile electric fences have been used. A high-tensile electric fence is more suitable than an enhanced wire-mesh fence in areas with deep snow.

Electric fences have not been thoroughly tested specifically for wolverines but have proven an effective deterrent. An enhanced wire-mesh fence or a 6-wire high-tensile electric fence is therefore highly likely to adequately deter wolverines as well.

Results vary for the largest fences across uncultivated land. This is partly because such systems are more prone to malfunctions and the added difficulty of monitoring large carnivore damage when it

occurs within too large an enclosure. Smaller fence systems will also present less of an obstacle, making it easier for large carnivores to choose to go around rather than breach the fence. Thus, the recommended maximum enclosure area within a predator-deterring electric fence is 10 km^2.

Table 1. Approved spacing and height dimensions for electric fences, tailored to large carnivore species.

Large carnivore species	Fence type	Bottom-wire ground clearance (cm)
Bear, wolf (lynx, wolverine)	6-wire high-tensile electric fence	20, 40, 60, 80, 100–105, 125–130
Lynx, wolf (bear, wolverine)	Electrified wire-mesh fence	20 (nose wire), 120–125 (top wire)

Project management

Before erecting a predator-deterring electric fence, the area to be enclosed must be approved by the Office of the County Governor. Before erecting the fence system, permission must be obtained from landowners and, in areas with domesticated reindeer husbandry, from the reindeer husbandry industry and management authorities. The relevant provisions set out in the Nature Diversity Act of 19 June 2009 and the Planning and Building Act of 27 June 2008 must be met. The fence system must also satisfy the provisions under the Neighbouring Properties Act of 5 May 1961.

One prerequisite for the proper functioning of electric fences is the use of high-quality materials installed according to regulations. Wires, insulators, posts, power cables, and the energiser and earthing system must be adequately dimensioned for the system.

6-wire high-tensile electric fences
High-tensile electric fences must have six wires and be 125–130 cm high, and the bottom wire must have a maximum of 20 cm ground clearance. This bottom wire should be placed as low as possible to prevent large carnivores from crawling or digging under it (Figure 1).

Figure 1. High-tensile electric fence with six wires. (Photo: Norwegian Wildlife Damage Centre, NIBIO Tjøtta/ Inger Hansen).

End and corner posts must be sturdy (10–15 cm in diameter and approximately 2.5 m long), pressure-treated, and driven or dug down to extend below the frost line, a minimum of 1 m into the ground. The intermediate posts fixed in the ground may be more slender and can be placed up to 20 m apart. Between these, spacers are to be placed approximately 5 m apart, depending on the terrain. The post material must be pressure-treated in accordance with Norwegian standards relating to contact with the ground.

The electrified wires must be galvanised, have a minimum diameter of 2.5 mm, a certain degree of flex, and be of the high-tensile variety, which has a minimum conductivity of 30 to 35 Ω/1 000 m. Stainless wire is more brittle and breaks more easily under strain. Electric tape and rope are poorer conductors and must therefore not be used. Electrified barbed wire is not permitted in electric fences. Tensioners must be installed on all wires, and all splices must meet approved standards regarding wire splices or connectors (quick connectors are not permitted). Springs for tension regulation must be used for stretches over 50 m. The insulators must be durable and the distance between wires and uninsulated elements (creepage distance) must be at least 4 cm, measured along the insulator's surface (Figure 2).

Corners and other sharp angles exert heavy pressure on the insulators, so specialised insulators must be used (Figure 3).

Figure 2. The creepage distance between an electrified wire and any uninsulated element must be at least 4 cm (Photo: DeLaval).

Figure 3. Specialised insulators must be used where there are sharp angles in fence direction. (Photo: DeLaval/ Jan Pettersson).

In areas frequented by moose, it is best to make the fence more visible, e.g. by fastening a broad, white band of fibre or plastic (not necessarily conductive) over the top wire, or installing blinking lights along the top wire.

Enhanced wire-mesh fence

An enhanced wire-mesh fence consists of wire mesh with an additional electrified top wire and nose wire (Figure 4). In general, the same requirements apply for electrified wire-mesh fences as for 6-wire high-tensile electric fences. The top wire is to be installed 20 cm above the wire mesh, while the nose wire must be offset a minimum of 12.5 cm to the outer side of the enclosure (using a spacing insulator), 20 cm above ground. If the overall height of the fence is less than the minimum 120 cm, an additional top wire must be added (see Table 1).

Figure 4. Enhanced wire-mesh fence with electric top and nose wires. (Photo: Norwegian Wildlife Damage Centre, NIBIO Tjøtta/ Inger Hansen).

The electrified wires must be galvanised, have a minimum diameter of 2.5 mm, a certain degree of flex, and be of the high-tensile variety. The nose wire, which is to be offset on the outer side of the fence, must be attached to the wire mesh using insulators (25 cm) and/or screw-in spacing insulators (minimum 12.5 cm long). Steel wires must be tightened with tensioners. To avoid induction current, the wire mesh must be securely earthed. An enhanced wire-mesh fence is not recommended for use in areas with heavy snowfall.

Earthing system

The earthing system is vitally important for completing the circuit so that a shock is delivered when an animal comes into contact with the fence wires. For this purpose, earthing rods recommended for the specific fence system must be used. The rods must be at least 1 m long, spaced 1 to 2 m apart, and driven down into ground with a soil condition of constant dampness. The rods are attached to the same single cable that connects back to the energiser's earthing terminal. The number of rods needed depends on the energiser's output capacity, fence length and earthing conditions. If the fence is to be electrified when there is frost or snow, or erected in dry conditions or other poor earthing conditions, conductivity can become poor and resistance increased. In such poor conditions, an extra earth wire must be fitted to the fence, with earthing rods along the entire fence line. The earthing system must be set up according to the supplier's recommendations and guidelines for earthing to ensure optimal functionality.

The fence's earthing system must be placed a minimum of 10 m from any high-voltage system.

Erecting the fence

Select a fence line that is as straight and flat as possible. Long, straight stretches simplify the tasks of setup, maintenance and vegetation clearing (Figure 5). It is advantageous to use existing forest roads or other open pathways. End posts, corner posts, posts at angle points and gate posts must be fixed securely in the ground to ensure they do not topple. The intermediate posts of a stretch should always be aligned.

Figure 5. Always strive for a straight, wide, flat fence line. (Photo: Ronald Bjøru)

The fence must not be set up parallel to high-voltage lines. If an electric fence must be erected near suspended power lines, no fence wires or power cable must be higher than 3 m above ground. This applies to the area directly under a power line and 2 m to each side if the power line carries a nominal voltage of less than 1 kV, and 15 m to each side for higher voltage. The fence line must not be run along a high-voltage clearance zone. Crossing beneath suspended power lines should be avoided whenever possible. If not possible, the line of crossing should be as close to a right angle as possible, beneath the power line and with the clearances prescribed above. When power lines are to be crossed, the relevant electric company must be informed.

Fence wires and power cables must not be affixed to posts used for high-voltage, low-voltage, telephone or telegraph lines. A mains-powered energiser may be mounted to a post for low-voltage lines, provided that permission has been obtained from the relevant electric company.

Fence wires and power cables must be placed at least 2 m from suspended communication lines. Electric fences and energisers must not be installed where there is a fire risk, and flammable materials must be kept away from the fence wires and power cables (EN 60335-2-76 and Nemko supplement II).

Fence wires and power cables must not come in contact with metallic objects that are not components of the electric fence. Fence wires and power cables must be securely affixed to insulators made of electrically and mechanically sound material.

Parallel connection of fence wires is to be used in order to increase the cross-section and reduce resistance in the fence. Connectors are to be used to join the parallel wires together, ensuring a more uniform voltage.

The fence must be fitted with an extra top wire in any area where there are elevated terrain features within 1 m of the fence's outer side. In lynx areas, trees must not be used as fence posts or be located near the fence, since the lynx can climb them and jump the fence.

A fence must completely enclose all sides of the pasture, including sides facing water. Ditches, dips and streams must be fenced off, preferably with auxiliary electrified wires extended down from the main fence (Figure 6). If the fence crosses a stream prone to flooding, the stream should be redirected through a pipe to prevent water from shorting the circuit. A screen or grill must cover the pipe opening. A good alternative is to install switches at flood-prone streams so that electrified wires extending down into the ditch can be disconnected from the rest of the circuit in times of high water flow.

Gates must be equipped with a cable in underground protective tubing that allows water to drain so that there is always a current running through the entire fence, even when the gate is open (Figure 7). The electrified cable and earthed cable must not share the same tubing. Also, there must be at least one electrified wire in the gate itself, which can be opened with an insulated handle. A 20-m stretch of electric fencing along each side of the path or road approaching the gate is recommended as a corridor to prevent large carnivores from coming in contact with the actual gate. Any walking paths that traverse the enclosure must be accommodated with electrified gates.

Figure 6. Example of how to fence off a ditch using auxiliary wires. (Photo: Norwegian Wildlife Damage Centre, NIBIO Tjøtta/ Inger Hansen).

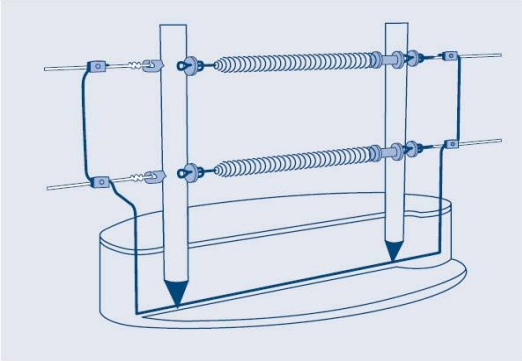

Figure 7. Schematic with gate electrified from only one side. A cable run underground carries the current past the gate. (Illustration: DeLaval.)

Electric cattle grids can be used where complete enclosure of a pasture is very disadvantageous, e.g. where a fence must cross a road and gates are not an option for reasons involving rightsholders. Electric cattle grids must be at least 3 m long, measured in the road direction. They must be installed on a stable foundation and very solidly constructed. A 20-m stretch of electric fencing must be erected on each side of the road approaching the grid to form a corridor to help to prevent large carnivores from coming in contact with the grid.

Where the fence system is installed near areas with extensive public traffic, measures must be taken to give due consideration to public needs.

Any electric fence, or parts thereof, installed along a road or path must be marked with warning signs that are securely fixed to posts or the actual fence wires, at intervals of no more than 100 m. The signs must measure 100 x 200 mm, with a yellow background on both sides. Both sides must show the symbol for dangerous voltage along with the text ADVARSEL ELEKTRISK GJERDE in black lettering at least 25 mm high (EN 60335-2-76 and Nemko supplement II).

Please also refer to European Standard EN 60335-2-76, *Household and similar electrical appliances - Safety - Part 2-76: Particular requirements for electric fence energizers*, and Nemko supplement II.

The energiser

The energiser must be installed by qualified personnel to ensure that it is in accordance with the applicable safety standard, EN 60335-2-76 and Nemko supplement II.

The energiser must have the capacity to compensate for a voltage drop in the fence system. Therefore, the energiser must be dimensioned with respect to the fence system's length, number of wires, wire conductivity, earthing conditions and height of the bottom wire. The system is required to maintain adequately high voltage throughout the entire fence, a minimum of 4 500 V at all points at all times. Therefore under optimal conditions the fence voltage is often 6 000 to 7 000 V. An alternative to mains power is a powerful battery-run energiser, which it may be beneficial to

supplement by solar panels. If the fence is not disassembled during winter, a mains-powered electric fence should be electrified year-round to prevent deer and moose from trampling down the wires.

For safety reasons it is prohibited to connect two or more energisers to the same electric fence, and the minimum distance between fencing using different energisers is 2.5 m (EN 60335-2-76).

The fence's power cables must be equipped with surge protection and lightning arrestors, as close as possible to the energiser.

An energiser should have additional functions for monitoring outgoing voltage (V), incoming voltage (V), the earthing system (V) and output (J). These monitoring functions should also be connected to an audible or flashing alarm that is triggered when any value falls outside the programmed value range. Alarm functions should be linked to the mobile telephone network.

Accessories
There are certain small, low-cost accessories that everyone should have, such as a device that can switch off fence voltage on-site, and a voltage indicator that also functions as a voltmeter. The voltage indicator has directional capacity to aid in locating faults. These accessories can save the user a great deal of labour when inspecting and maintaining the fence in the field.

Routines for approval, inspection and maintenance

Approval
When initially erecting a fence, the system must be checked and approved by the Office of the County Governor. In advance of this inspection, qualified personnel must provide documentation that the fence system meets the applicable safety standard (EN-60335-2-76 and Nemko supplement II). It is the user's responsibility to ensure that the fence system functions as intended and meets standard requirements at all times. Malfunctions in the system must be remedied immediately upon discovery. The Office of the County Governor or a representative designated by the County Governor may conduct spot checks of approved fence systems. It is recommended that qualified personnel inspect the fence system at least every three years.

Preparing high-tensile electric fences for winter
Certain pre-winter measures are necessary to safeguard cervids. All fence wires are to be slackened. The wires are to be unhooked from ground-fixed posts, while the spacers should be laid on the ground. This protects the fence from snow weight and passing cervids, and makes it easier to set up again in the spring.

Setting up the fence in spring
It is the user's responsibility to ensure that the fence system meets the standard requirements after set-up in the spring, and that the voltage is adequate throughout prior to releasing the livestock into the enclosure. When necessary, this must be conducted by qualified personnel. The wires must be retightened and top and bottom wire heights, wire spacing, connections, fence posts, and insulators must be checked. The enclosed area must be free of any large carnivores before the power is restored and the livestock released. Where necessary, the area should be searched and cleared by personnel using a dog.

Measuring voltage
Unless the energiser's monitoring functions are connected to an alarm system, the voltage must be checked daily. Outgoing and incoming voltage as well as the earthing system voltage and output should be read on the energiser's display. With older energisers, the voltage must be checked daily with a voltmeter at certain checkpoints along the fence in addition to the electrified wire and earth wire from the energiser. This can be performed at the same time one checks the fence line and attends to livestock. All values are to be logged in order to submit the necessary documentation as a basis for quality control of the fence. If the voltage in the fence measures less than 4 500 V and cannot be improved, qualified personnel must check the fence system.

Inspecting the fence line

The entire fence line must be inspected at least once a week. Check the bottom-wire ground clearance (maximum 20 cm), all connections, fence posts and insulators, and that the wires are taut and properly spaced. Clear away windfall and other vegetation touching the wires. It is the user's responsibility to perform the necessary maintenance to ensure the fence system functions as intended and meets standard requirements at all times.

Checking on grazing livestock
Grazing livestock within the enclosure must be checked more than the set minimum of once a week. Use a dog if possible. This will help to discover large carnivore damage more quickly.

Clearing vegetation
Vegetation must be cleared at regular intervals to prevent gradual voltage drop (Figure 8). During the grazing season it is necessary to clear growth multiple times.

Figure 8. Example of the need for clearing vegetation under the fence. (Photo: Norwegian Wildlife Damage Centre, NIBIO Tjøtta/ Inger Hansen).

Troubleshooting procedure
Troubleshooting often reveals that weak voltage is due to deficiencies in the earthing system. Other common system malfunctions are leaking current due to vegetation, conductivity problems (rusted wire, thin wire, and broken wire/circuit) and wire connectors/connections. Other common faults that cause voltage drop include electrified wires touching wire mesh or earth wires. Additional weak points are low-quality insulators, corner posts that are too weak or not driven deep enough, and a bottom wire with too much ground clearance.

Summary of requirements for predator-deterring electric fences

Project management

- Before erecting a predator-deterring electric fence, the area to be enclosed must be approved by the Office of the County Governor. Also, permission must be obtained from landowners and, in areas with domesticated reindeer husbandry, from the reindeer husbandry industry and management authorities. The fence system must satisfy the relevant provisions set out in the Nature Diversity Act, the Planning and Building Act, and the Neighbouring Properties Act.
- When initially erecting a fence, the system must be checked and approved by the Office of the County Governor. In advance of this inspection, qualified personnel must provide documentation that the fence system meets the applicable safety standard (EN-60335-2-76).

The fence system

- The energiser must be installed by qualified personnel to ensure that it complies with the applicable safety standard, EN 60335-2-76.
- The energiser must have the capacity to compensate for a voltage drop in the fence system, and must be dimensioned for the fence system.
- Fence voltage must maintain a minimum of 4 500 V at all points at all times.
- Wires, insulators, posts, power cables, and the energiser and earthing system must be adequately dimensioned for the system and meet the requirements of this standard.
- Parallel connection of fence wires is to be used to increase the cross-section and reduce resistance in the fence. Connectors are to be used to join the parallel wires together.
- The fence's power cables must be equipped with surge protection and lightning arrestors, as close as possible to the energiser.
- The earthing system must be set up according to the supplier's recommendations and guidelines for earthing to ensure optimal functionality.
- Mains-powered energisers should have functions for monitoring outgoing voltage (V), incoming voltage (V), the earthing system (V) and output (J). The monitoring functions should be connected to an alarm system, preferably via the mobile telephone network.
- A fence must completely enclose all sides of the pasture, including any sides facing water. Ditches and streams must be fenced off with auxiliary electrified wires extended down from the main fence. A flood-prone stream should be redirected through a pipe or the fence fitted with switches to disconnect these auxiliary wires.
- The fence must be fitted with an extra top wire in areas where there are elevated terrain features within 1 m of the fence's outer side.

  Gates must be equipped with a cable in underground protective tubing that allows water to drain. Also, there must be at least one electrified wire in the gate itself, which can be opened with an insulated handle. Any public paths that traverse the enclosure must be accommodated with electrified gates.
- Electric cattle grids must be at least 3 m long, measured in the road direction, installed on a stable foundation and very solidly constructed. A 20-m stretch of electric fencing must be erected on each side of the road approaching the grid to form a corridor.
- Where the fence system is installed near areas with extensive public traffic, measures must be taken to give due consideration to public needs.
- Electric fences installed along a road or path must be marked with warning signs in accordance with the applicable safety standard.
- The fence must not be set up parallel to high-voltage lines or along a high-voltage clearance zone. When power lines are to be crossed, the relevant electric company must be informed.
- Fence wires and power cables must not be affixed to posts used for high-voltage, low-voltage, telephone or telegraph lines.

Fence dimensions and approved wire spacing

- The fence must be tailored to the type of predator. In areas with multiple large carnivore species present, the fence must be dimensioned in relation to the species that is most difficult to exclude.
- The ground clearance of the bottom wire must not exceed 20 cm.
- The minimum height of an electrified wire-mesh fence is 120 cm, and 125–130 cm for a 6-wire high-tensile electric fence.
- The recommended maximum enclosure area within a predator-deterring electric fence is 10 km^2.

Large carnivore species	Fence type	Wire ground clearances (cm)
Bear, wolf (lynx, wolverine)	6-wire high-tensile electric fence	20, 40, 60, 80, 100–105, 125–130
Lynx, wolf (bear, wolverine)	Electrified wire-mesh fence	20 (nose wire), 120–125 (top wire)

Inspection and maintenance

- The enclosed area must be free of any large carnivores before the fence is electrified and the livestock released into the enclosure.
- Regular maintenance of the fence system must be carried out when setting up each spring and as needed otherwise. It is the user's responsibility to ensure that the fence system meets the standard requirements at all times.
- The entire fence line must be inspected at least once a week.
- Grazing livestock within the enclosure must be checked more than the set minimum of once a week.
- Vegetation must be cleared at regular intervals during the grazing season.
- Outgoing and incoming voltage as well as the earthing system voltage and fence output should be checked daily, whether via the alarm system, from the energiser's display, or using a manual voltmeter. All values are to be logged.
- Malfunctions in the system must be remedied immediately upon discovery.
- If the voltage in the fence measures less than 4 500 V and cannot be improved, qualified personnel must check the fence system.
- Certain pre-winter measures are required to safeguard cervids.