

# NATURAL RESOURCES CONSERVATION SERVICE CONSERVATION PRACTICE SPECIFICATION

## PERMANENT POWER FENCE

(Feet)

### CODE 382(e)

#### I. SCOPE

The work shall consist of furnishing electric fence materials and installing high-tensile smooth wire at the location(s) shown on the plan map and, if needed, on the drawings or as staked in the field.

Fencing includes brace assemblies, gates, cattle guards, and other components required to meet site conditions and achieve objectives for practice application.

#### II. CONSIDERATIONS

Fence design will be adequate to control the animal(s) of concern, and must be suited to the landscapes over which it will be installed and shall be adapted to the physical environment of the site.

Because of the potential hazards to humans, power fence is most appropriate for use in areas not frequented by the public.

Livestock must be trained to respect a power fence if it is to be effective, particularly if less than three line wires are used.

Boundary fences shall comply with Nevada state laws and fencing codes or standards for construction. Refer to the Nevada Revised Statutes Part 569.431 (1991) for the definition and requirements of a "Legal Fence".

#### WILDLIFE CONSIDERATIONS

##### SAGE GROUSE

Fences are an entanglement risk to large, ground nesting birds. Fences are especially dangerous for sage grouse near leks. When planning fences in known sage grouse habitat, consult with the NRCS State Biologist regarding the fence placement and lek locations.

Besides fence placement, there are a number of modifications that can be made to the fence to make it more visible to birds and other wildlife. To make a fence more visible, consider using the white tipped metal fence posts, securing flagging or reflectors to the top fence wires, or slide sections of PVC pipe over the top wire.

##### DEER AND ELK

Where antelope, elk calf or deer fawn movement is to be allowed for, the bottom line wire should be a ground

wire with subsequent wires alternately charged. A 20-inch ground clearance is recommended for the bottom line wire when it is charged and free antelope, calf or fawn movement is desired. To accommodate passage of mature elk and deer, maximum fence height is 40-inches (the top line wire should be a ground wire) and the top two line wires shall be set a minimum of 12-inches apart at the post location. The bottom wire will be set at a minimum of 18 inches above ground.

A "live" or charged top line wire can be encased within small diameter plastic pipe encouraging continued passage over a fence section having high deer or elk traffic while the remaining fence line is left with an exposed "live" top wire.

Deer normally jump with their hind legs forward and the distance between the two top wires is critical to adult deer. If the top two fence wires are loose or too close together, deer can entangle their hind legs in the fence which is often fatal or they can break the top wire(s) in their struggles, damaging the fence.

Elk drag their hind legs over the top of barriers as they jump them. For fence sections with heavy big game use, or when animal entanglement becomes a problem, consider replacing the top fence wire with wooden poles or rails to increase visibility of fencing.

Another alternative is to slide plastic pipe over the top line wire of the fence which will increase fence visibility.

##### ANTELOPE

In antelope country, the total fence height should be constructed as low as feasible and the bottom wire should be at least 18-inches from the ground. In areas recognized as antelope migration routes, the bottom wire should be smooth wire.

Conservation practice specifications are reviewed periodically and updated if needed. To obtain the current version of this specification contact the Natural Resources Conservation Service.

For big game migration routes, consider the use of "let-down" fence sections to aid movement of animals. See practice specifications for Let-Down Fencing and Other Fence Components, Practice Code 382(h).

**WILDLIFE FRIENDLY FENCE SPACING:**

Wire Description	Spacing Measured from Groundline (Inches)			
3- wire	16*	26	38	
4-wire	16*	22	28	40

\*IN AREAS OF BIG GAME MIGRATION, THE BOTTOM WIRE WILL BE SET AT 18 INCHES ABOVE GROUND AND BE SMOOTH WIRE.

For additional wildlife friendly fencing information, refer to *Fencing Guidelines for Wildlife* (Wyoming Game and Fish, 2004) or *A Landowner's Guide to Wildlife Friendly Fences* (Paige, 2008).

### III. SPECIFICATIONS

#### A) MATERIALS

All power fencing that is accessible to the public shall have signs securely attached to the top wire at intervals of no more than 250-feet to warn people that the fence is charged.

All fencing materials will be new unless otherwise specified.

The materials used in construction must be in accordance with, and equal or exceed, in strength and durability, the following specifications:

#### WIRE

High-tensile smooth wire is preferable for use with power fences as it is easier to handle and there is no barb damage to animals.

Fencing materials shall conform to the requirements of American Society for Testing and Materials (ASTM) ASTM A854 for high-tensile wire.

When the size of steel wire is designated, the diameter shall be defined for U.S. Steel Wire Gage.

- High-tensile, single strand, smooth wire shall be at least No. 12½-gauge, Class III galvanized or aluminum coated, steel wire.
- For 2-wire power fencing, a minimum strand tensile strength of 135,000-psi is required.
- For 3-wire (or more) power fencing, a minimum strand tensile strength of 170,000-psi is required

The American Society for Testing and Materials has graded metallic coated (galvanized), high tensile, steel fence wire as follows:

GRADE	MINIMUM TENSILE STRENGTH*	MINIMUM BREAKING POINT**
135	135,000	1,039
180	180,000	1,386
200	200,000	1,540
220	220,000	1,694

\*pounds per square inch (PSI)

\*\*pounds of direct pull for No. 12½-gauge wire

Wire connecting ground rods to the energizer and all underground wires shall be No. 12½-gauge, or larger, high-tensile steel wire having an insulating cover. Wire insulation shall be high density, polyethylene or polypropylene plastic, with ultraviolet stabilizer and capable of withstanding a minimum of 10,000 volts.

#### LINE POSTS

All line posts shall be of sufficient length to be driven at least 18-inches into the ground (24-inches deep in low-strength, sandy soils).

Above ground post length must be sufficient to allow for the required top wire height *plus* adequate space (normally about 3-inches) to firmly install wire fasteners, insulators, etc. Pre-drilled holes in posts (constructed of non-conducting material) allow situating the top wire closer to the top of a post.

Wooden in-line posts shall have a minimum 2-inch top diameter.

Wood posts need not be new material; however, all posts should be of the most durable wood type available (*i.e.*, juniper, cedar, eucalyptus, Australian ironwood, "insultimber", etc.).

All posts that come in contact with the soil shall be treated with an EPA-registered wood preservative. Wood posts shall be treated from the butt end of the post to a distance of at least 30 inches for line posts and 36 inches for all corner, gate, and bract posts. Steel posts shall conform to the requirements of ASTM A702. Standard T-section steel posts, weighing not less than 1-pound per foot of length, may be used when high-quality plastic or ceramic insulators are installed. Steel posts are to be studded, embossed or punched for the attachment of wire insulators and have an anchor plate near the bottom of the post. Steel line posts shall be rolled from high carbon steel and have a protective coating. The coating may be either galvanizing by the hot dip process, or painted using

one or more coats of high quality, weather resistant, paint or baked enamel.

Fiberglass posts are lighter than steel posts and withstand greater side-to-side stress. Polypropylene plastic posts have adequate strength but special clips are needed to attach wire to the posts. Fiberglass and plastic posts will not rot and are non-conductive.

Fiberglass posts shall be a composite of marble, fiberglass, and polymer resins that have been treated by thermosetting (heat treatment) and a ultra-violet (UV) protective agent.

"T"-shaped fiberglass posts shall be at least 1-inch in cross section with notches.

Round plastic posts should be at least 1-inch in diameter posts with notches on a 2-inch spacing.

#### **BRACE POSTS - WOODEN**

Wooden, upright, brace posts and anchor posts (pull posts) shall have a minimum top diameter of 6-inches.

Posts for brace units shall be of sufficient length to allow for the required top wire height *plus* 3-inches and to be set in the ground a minimum of 36-inches.

Wooden horizontal braces shall be a minimum of 6-feet in length and have a minimum diameter of 4-inches.

Unless otherwise specified, wood brace posts shall be of cedar, redwood, juniper, or other wood of equal life and strength. All wooden materials used in this practice that require preservative treatment will conform to National Standard Material Specification NSMS #585. Pine posts shall be treated with an EPA-registered wood preservative.

#### **BRACE POSTS - STEEL**

- All metal corner, gate and in-line brace unit posts shall be new pipe or angle iron at least 6½-feet in length.
- Steel pipe shall have a minimum diameter of 4-inches and angle iron shall have sectional dimensions of at least 2½ x 2½ x ¼-inch.
- Horizontal or diagonal cross braces will be new or used pipe at least 2-inches in diameter or angle iron a minimum of 2 x 2 x ¼-inch in dimension.
- Steel horizontal or diagonal cross braces will be a minimum of 6-feet in length.
- Steel brace posts and horizontal braces shall conform to the requirements of ASTM A702 for steel posts and ASTM A53 for bracing pipes.
- Steel posts and braces shall be permanently capped and have a protective coating; either galvanizing by the hot dip process, or painted using one or more coats of high grade, weather resistant, paint or baked enamel.

**OTHER:** Alternative types of materials and designs may be used for fence construction if: (1) they meet or exceed NRCS fence specifications; and, (2) they are

approved in advance by the State Resource Conservationist.

Locally accepted fencing materials and fence configurations not addressed in Nevada NRCS fence specifications should be incorporated into the Field Office Technical Guide with prior approval of the State Resource Conservationist.

#### **BRACING WIRE**

Brace wires (tension members or guy wires) shall be formed from two complete loops of No. 12½-gauge, high tensile, galvanized, wire, two complete loops of No. 9-gauge smooth wire, or two complete loops of No. 12½-gauge double strand smooth wire.

Tension wires shall have a tensile strength not less than 58,000-psi and shall have a minimum of Class 3 zinc coating as specified in ASTM A641.

#### **STAYS**

Stays and stay fasteners shall conform to the requirements of the appropriate ASTM for the fencing material specified, unless otherwise specified.

Fiberglass stays of thermosetting (heat treated) reinforced composite material consisting of marble fiberglass and high-polymer resins shall be used.

Wooden stays that are specifically manufactured for use in permanent electric fence designs are also acceptable.

#### **INSULATORS**

All metal posts and wooden brace posts require insulators. Wood line posts also require insulators unless specially fabricated posts are used which carry the manufacturer's recommendation that insulators are not needed.

Fiberglass posts are non-conductive and don't require insulators.

Insulators of porcelain ceramic or high quality, high-density, polypropylene or polyethylene plastic, with ultra-violet (UV) stabilizer, capable of withstanding a minimum of 10,000 volts must be used on steel or conventional wooden posts (Exhibits 2, 3, and 4).

#### **WIRE FASTENERS**

Fence fasteners or "clips" are to be galvanized and fastened to allow fence wire to slide past fiberglass (or specialty wood) line posts and stays.

An alternative to fasteners is to purchase pre-drilled fiberglass (or specialty wood) posts. The holes should be sized so that wires are free to move when tightened.

#### **ENERGIZER AND COMPONENTS**

Electronic energizers or power fence controllers are to meet the following attributes/specifications:

- Energizer must have high output and low impedance.
- Energizer must have a minimum output of at least 4000-volts (4kv) with all fencing charged under maximum anticipated load.
- Pulse rate of 35 to 65 pulses per minute.
- Each pulse is completed within 300-microseconds, or less.
- High impact, self-insulating, and weather resistant, cases.
- Solid state circuitry.
- Safety pace fuse to prevent over-pulsing.
- 110-volt/220-volt systems must be UL listed.
- Battery powered systems must be capable of operating 3 weeks without recharge.

The effective power of an energizer is determined by the "joule" rating of the unit. Joules measure the total amount of stored energy released by the energizer during each pulse. The higher the joule rating of the energizer, the greater the shock and the fence will be more effective.

In general, an energizer should supply 1-joule for every 6-miles of wire to be electrified.

For example, if 12-miles of electrified fence wires are installed (*i.e.*, 4-miles of fence running 3 "live", or "charged", wires), the energizer should have a rating of at least 2-joules.

Recommended joule ratings for energizers based on fence design:

MINIMUM JOULE RATING	MILES OF ELECTRIFIED FENCE WIRE
1	6
2	12
3	18
4	24

#### FENCE GROUND SYSTEM

Poor grounding is the most common cause of electric fence problems.

For an animal to receive a shock it must complete a circuit between the energizer by touching a "live" wire and simultaneously touching a fence ground wire leading back to the energizer; or, by touching a "live" wire while standing on mineral soil that can pass electrical current back to the energizer (through soil grounding rods).

Moist soil is a relatively good conductor of electricity and an electrical circuit can be established by installing a grounding system at the energizer location and running only "live" or "charged" line wires. Irrigated pastures usually do not require ground wires.

Dry soils are very poor conductors of electricity and have high resistance to electrical current. Electric fencing on dry, upland soils will not provide an effective shock to animals unless ground wires are included on the fence.

All grounding rods shall be galvanized steel rods ½-inch in diameter and a minimum of 6-feet in length.

If energizer terminals accept copper wire, then copper grounding rods, copper clamps and copper wire may be used in the energizer grounding system. Avoid mixing dissimilar metals to prevent electrolysis.

A lightning arrester or lightning choke is recommended.

The energizer manufacturer's requirements for lightning protection must be met or exceeded.

## B) CONSTRUCTION SPECIFICATIONS

### ALIGNMENT

Fences shall be reasonably straight and not deviate more than 12-inches from a straight line between corner and brace assemblies.

### FENCE HEIGHT AND WIRE SPACING

The number of line wires, fence height and wire spacing are determined by the kind and class of livestock to be controlled. The top line wire should be set no lower than two-thirds the shoulder height of the animals to be controlled.

*Permanent power fences will consist of at least two "live" or "charged" wires.*

The interval between line wires shall be set so that grazing animals will receive a facial shock if they attempt to extend their head through the constructed fencing.

Examples of fence heights and wire spacing (from the ground upward) for electric fencing to control different kinds of livestock under both wet and dry soil conditions are listed below. A charged or live wire is designated as + and a ground-return wire as –.

<b>WET SOIL/IRRIGATED PASTURE OR MEADOW</b>				
<b>MATURE CATTLE WITH/WITHOUT CALVES - NO SHEEP</b>				
2-wire Fence:	18"	-	32"	
	+		+	
<b>SHEEP WITH/WITHOUT MATURE CATTLE AND CALVES</b>				
4-wire Fence:	8"	-	16"	-
	+		+	24"
				+
				34"
				+
<b>DRY SOILS/RANGELAND</b>				
<b>MATURE CATTLE WITH CALVES - NO SHEEP</b>				
3-wire Fence:	12"	-	20"	-
	+		-	32"
				+
4-wire Fence:	16"	-	22"	-
	-		+	30"
				+
				36"
				+
<b>MATURE CATTLE WITH CALVES - SHEEP</b>				
4-wire Fence:	6"	-	13"	-
	-		+	23"
				+
				36"
				+
<b>SHEEP</b>				
5-wire Fence:	6"	-	13"	-
	-		+	21"
				+
				30"
				+
				40"
				+
<b>DEER AND ELK EXCLUSION FENCE</b>				
9-wire Fence:	8"	16"	24"	32"
	+	-	+	-
				40"
				+
				50"
				-
				60"
				+
				72"
				-
				84"
				+

#### LINE POST

Line posts serve simply to maintain the spacing between wires and to set fence height.

Wooden line posts shall be set solidly in the ground a minimum depth of 30-inches.

Wooden line posts can be driven.

Where post holes are dug for installing fence posts, the holes shall be at least 6-inches larger than the diameter or side dimension of the posts.

Post holes shall be back-filled with soil unless otherwise specified. Earth backfill around posts shall be thoroughly tamped in layers not thicker than 4-inches and shall completely fill the post hole up to the ground surface.

Steel or fiberglass line posts shall be driven solidly into the ground a minimum depth of 18-inches. For very loose, sandy soils, set posts 24-inches deep.

LINE POST SPACING is the same for all line post materials (fiberglass, metal, wood, etc.): Line post intervals shall be as follows:

- Spacing of line posts for a 2-wire cross fence will not exceed 100-feet with or without stays.
- Spacing of line posts for a 3-wire (or more) fence will not exceed 100-feet without stays.
- Spacing of line posts for a three (or more) wire fence may be up to 150-feet where two or more stays are evenly spaced between posts.

#### LINE WIRE INSTALLATION

Fence line wires shall be stretched and attached to posts as follows:

- The fencing wire shall be placed on the side of the post expected to receive the greatest pressure.
- Where fencing is installed to protect a specific area, wire shall be placed opposite the area being protected.
- Each strand of wire shall be attached to each post.
- The top line wire shall be set so that fence posts extend a minimum of 3-inches above the wire unless specially fabricated posts that allow a more narrow spacing are installed.
- The fencing wire shall be fastened to line posts by means of wire insulators manufactured for this purpose (Exhibits 2, 3, and 4).
- Line wires must be free to move back and forth through wire fasteners.
- All live wires and all ground wires shall be joined to themselves with a continuous jumper wire. These connections shall be made near the start and end of each line wire, and at gate posts. Jumper wires are to be insulated from each other (Exhibit 4).
- All line wires shall be dead-ended at the anchor post (pull post) of gate, corner, and in-line brace assemblies (Exhibits 3 and 4).

#### FENCE WIRE TENSION

As with non-electric fence, fence wires should be tensioned working from the top wire down.

Each line wire strand is stretched taut to over 200-pounds of tension per strand of wire depending on wire grade.

A tension indicator spring can be installed on one line wire and remaining wires tightened, according to feel, to same tension as the wire strand with the indicator spring.

In-line or end-post ratchet strainer devices shall be installed on each line wire to maintain correct tension between all brace assemblies (Exhibit 5).

- On short fence runs (less than 600-feet), in-line wire strainers (ratchet wire tighteners) shall be attached to one end of each line wire where it terminates at the brace post location.
- On long, straight, fence runs over 600-feet in length, wire tighteners should be located at the center point (friction center) between fence line ends.

#### GROUND SYSTEM

All electric fences must be grounded (Exhibit 1).

The energizer shall be grounded to a minimum of four galvanized steel or copper rods, ½-inch in diameter and a minimum of 6-feet in length, driven 5½-feet into the ground near the energizer and spaced at 10-foot intervals. The energizer shall be connected to each of the grounding rods with one continuous line of

No. 12½-gauge insulated wire attached with ground rod clamps.

The energizer grounding system must be set at least 35-feet away from ground rods of any other electrical circuit.

When possible, locate energizer ground rods in areas of water accumulation where the soil is always moist.

Ground wires in the fence must also be connected to a ground rod. The ground wire attached to the fence may be located anywhere along the fence that a 6-foot depth can be obtained for driving the grounding rod.

Ground wires along the fence line should be connected to ground posts:

- every 3000-feet in wet soil conditions, and
- every 1500-feet in dry soil conditions.

Additional grounding is required for large energizer systems (14-joules or more).

An additional set of four ground rods (6-foot in length and ½-inch in diameter) for arresting lightning are required to be installed not closer than 65-feet from the ground rods set at the energizer.

A lightning choke (lightning diverter) should also be installed.

#### STAYS

When required, stays shall be evenly spaced between line posts to ensure that the proper interval between line wire strands is maintained.

#### SPLICING

Proper wire splicing is critical to insure both adequate contact and minimum damage to wire coating.

When splicing line wires, the "Figure-8" knot or suitable splice sleeves applied with a tool designed for that purpose shall be used.

The "Figure-8" knot shall have no less than four (4) wraps of each end about the other. All wraps shall be tightly wound and closely spaced. See Exhibit 4.

Splices made with splice sleeves shall have a tensile strength no less than 80 percent of the strength of the wire being spliced.

#### CORNER, BRACE AND GATE POSTS

Braces are required at all corners, gates, and at all definite slope breaks and changes in alignment to the line fence.

- In straight sections on moderate terrain, in-line brace units are required at intervals not to exceed 4000 feet (250 rods).
- Corner brace assemblies shall be installed at all points where the fence alignment changes

15-degrees or more. Brace units are required at the beginning and end of each curved fence section.

- Brace units are required at any point where the vertical angle described by two adjacent reaches of wire is upward and exceeds 10-degrees.

All wooden corner, gate, and in-line brace unit posts shall be set a minimum of 4-feet in the ground - the deeper a post is set, the stronger it will be.

Anchor posts (pull-posts) shall be set with a one to 2-inch lean away from the direction of fence pull.

Wooden brace posts can be driven.

If post holes are dug for installing fence posts, the holes shall be at least 6-inches larger than the diameter or side dimension of the posts. Post holes are to be back-filled with soil or concrete. Earth backfill around posts shall be thoroughly tamped in layers not thicker than 4-inches and shall completely fill the post hole up to the ground surface. Concrete backfill around posts shall be rodded into place in layers not thicker than 12-inches and shall completely fill the post hole to the surface of the ground. Backfill, either soil or concrete, shall be crowned-up around posts at the ground surface. No stress shall be applied to posts set in concrete for a period of not less than 24-hours following the development of a firm set of the concrete. Wooden, horizontal, brace members (compression braces) shall be notched into the top part of the brace post and post being braced, at a location between the top two line wires. Steel dowels can be used, rather than notching, to attach a horizontal brace between the anchor post and brace post.

The elevated end of diagonal brace members shall be notched into post being braced at a location sited between the top two line wires.

#### BRACING WIRE

Brace wiring (tension member) shall consist of two (2) wire strands that extend from a point approximately 6-inches below the top of the brace post to about 4-inches above the ground level of the post being braced (anchor post or pull post). The brace wires should be double wrapped around each post, stapled, and spliced together. A stout stick, pipe, or metal rod, about 18 to 24-inches long, is placed mid-way along the brace wires, and all four wires are twisted together so the brace wires tightly secure the compression brace and provide needed rigidity. If a diagonal brace is used, the tightening stick is positioned below the diagonal to avoid hitting this brace member as the stick is turned. See Exhibit 2.

Also see practice specifications for Post and Standard Barbed Wire Fence, Practice Code 382(a) Exhibit 1.

#### GATES AND OTHER FENCE COMPONENTS

Live or charged line wires are best routed under a gateway using insulated wire, rather than overhead. Grounded line wires should also be directed under the gateway. Line wires strung over a gateway are susceptible to wind and vehicle damage. See Exhibits 6, 7, and 8.

Materials used in gate construction shall conform to the kinds, grades, and sizes specified for a new fence, and shall include the necessary fittings.

Panel gate fittings shall not be of a lesser quality than the gate manufacturer's standard.

Also see practice specifications for Let-Down Fencing, Water Gaps, Cattle Guards, and Other Fence Components, Practice Code 382(h).

#### **IV. INSTALLATION**

Installation of the fence shall conform to the specifications and exhibits or other drawings, as provided.

All posts shall be placed to the required depth and shall be firmly embedded so that there is less than 1-inch of horizontal movement at the top of post when a horizontal force of 80-pounds is applied.

The completed job shall be workmanlike and present a good appearance. The installer and other persons will conduct all work in accordance with proper safety procedures.

#### **V. BASIS OF ACCEPTANCE**

After the fence has been installed, a site inspection will be made to determine if fence construction, and the materials used, meet practice specification requirements, as specified on the conservation practice documentation worksheet.

#### **VI. MAINTENANCE**

This practice will require the performance of periodic maintenance.

Volt meters, used to determine voltage on line wires, are desirable for monitoring electrical systems.

Fence maintenance items to be alert to and corrected include:

- disconnected ground wires
- short across wires
- broken insulators
- deteriorated ground rods
- wire tension
- broken wires
- wire corrosion
- shorting due to vegetation
- pulled clips
- bent steel posts
- bent or broken stays
- post alignment
- post stability
- sagging gates

- ground rod clamps loose
- wildlife concerns
- electrical terminals corroded

#### **REFERENCES**

The following references provide excellent guidance for fence construction, selection of fencing materials, and the installation of fence components.

Gallagher Power Fence Manual.

<http://www.gallagherusa.com>

Henderson, G.E. 1966. Planning Farm Fences. American Association for Agricultural Engineering and Vocational Agriculture, Athens, GA. 54pp.

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