Irrigation
FACTSHEET

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Design and Operation of Irrigation Systems Near Electrical Transmission Lines

Striking electrical transmission lines with an irrigation water jet can cause current transfers that may be dangerous. Current transfers can occur by the following methods:

1. Direct contact of the irrigation system with the transmission line.
2. Leakage current – the result of an alternate path being provided for the conduction of electrical current. This situation can arise when concentrated jets of water from the irrigation system come into contact with transmission line conductors. (Current flows from the powerline to nozzle through the jet).
3. Flashovers – occur when the insulating qualities of the air are not great enough to overcome the potential difference between a conductor and objects at another potential. Flashovers can occur between conductor to tower, phase to phase and conductor to ground due to a water jet interacting with the powerline.

An irrigation jet striking a transmission line is a nuisance to the power utility because:

- The force exerted on the lines by the water jet can be many times the weight load or expected wind loading. Swaying of the conductors can result.
- A flashover can create power outages, which may interrupt service to thousands of customers.

Minimum Clearance Standards

To ensure safe operation of irrigation equipment near transmission lines, minimum separation distances are required. The clearance required between the water jet and the live conductors is a function of the voltage of the conductor. The values shown in Table 1 are the minimum clearances acceptable, provided by BC Hydro, for the various line voltages.

The total water spray height includes the working height of the nozzle plus the maximum stream height above the nozzle. Two irrigation system types that have working heights which interact with powerlines are centre pivots and gun systems.

Working heights of centre pivot systems range from 12 to 25 feet, however, most pivots are less than 14 feet. The working height of a travelling gun ranges from 6 to 11 feet. These heights are required to permit these systems to operate over crops providing good uniformity without damaging the crop.

TABLE 1 IRRIGATION WATER TO POWER LINE CLEARANCE STANDARDS					
Line Voltage, kV	**Phase Spacing *(s), m**	**Min. Mid-Span Height *(H), m**	**Conductor-to-Water Clearance*(Y), m**	**Allowable Total Water Spray Height,*(L)**	
				m	**ft**
69	1.52	5.5	0.6	4.9	16.1
138	4.3	6.9	0.9	6.0	19.7
230	5.5	7.4	1.5	5.9	19.4
287	6.7	7.8	1.9	5.9	19.4
345	10.6	8.7	2.3	6.4	21.0
500	13.7	10.0	3.2	6.8	22.3

******see Figure 1 for letter designations*** ***Table taken from BC Hydro***

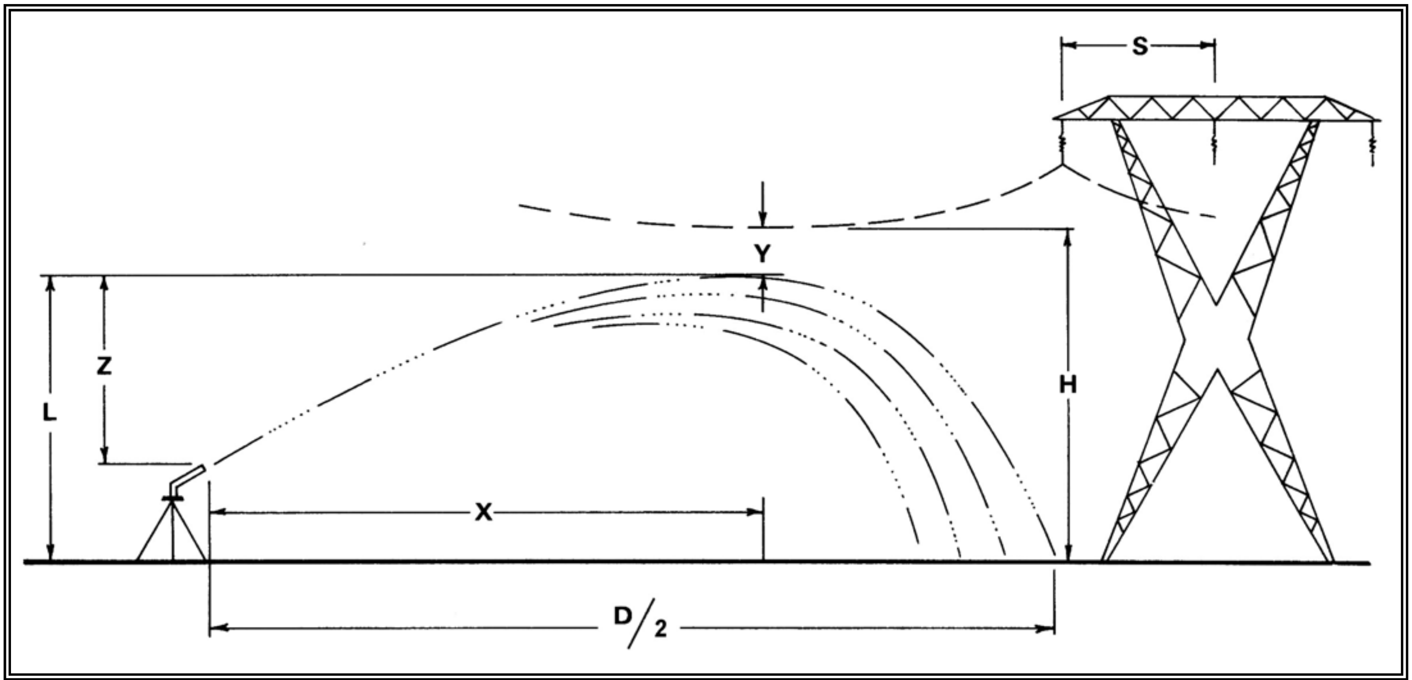

Figure 1 **Schematic Showing Distances**

Calculating Maximum Stream Height

While the working height of a nozzle can be measured easily, the maximum stream height is more difficult. The maximum spray height is a function of the type of sprinkler, angle of trajectory, nozzle size and operating pressure.

Manufacturers indicate maximum spray heights for various impact sprinklers but not for giant guns.

Nelson Irrigation Corporation has developed a formula for determining the maximum stream height and location of maximum stream height for gun systems based on the wetted diameter and pressure. (Assuming that the gun is operating on level ground.)

$Z = C \times D - K \times (D)^2$
$X = 0.3 \times D$

where:

Z = maximum stream height above sprinkler nozzle
X = horizontal distance from the nozzle at which maximum stream height occurs
D = wetted diameter
C = dimensionless factor dependent on barrel trajectory
K = dimensionless factor dependent on barrel trajectory and operating pressure

See Figure 1 for a graphic display of the various parameters. The dimensionless factors 'C' and 'K' can be determined from Table 2 and 3.

TABLE 2	**VALUES OF 'C'**				
Trajectory	15^0	18^0	21^0	24^0	27^0
'C'	C = 0.067	C = 0.081	C = 0.096	C = 0.111	C = 0.127

from Nelson Irrigation Corporation

TABLE 3	**VALUES OF 'K' (x 10^{-3})**				
psi	**Trajectory**				
	15^0	18^0	21^0	24^0	27^0
40	0.181	0.187	0.194	0.203	0.213
68	0.121	0.125	0.129	0.135	0.142
80	0.091	0.093	0.097	0.101	0.107
100	0.072	0.075	0.078	0.081	0.085

from Nelson Irrigation Corporation

An example showing the use of Tables 2 and 3 may be helpful.

What is the maximum stream height of a 1.0-inch taper bore nozzle operating at 80 psi with a 24^0 trajectory?

- Manufacturers specifications indicate a flow rate of 260 gpm with a wetted diameter of 355 feet for the above specifications.

D = 355 ft.

X = 0.3 x D = 0.3 x 355 ft. = 107 ft.

Z = C x D – K x $(D)^2$

from Table 2 C = 0.111

from Table 3 K = 0.101 x 10^{-3}

Z = (.111 x 355) – 0.101 x 10^{-3} x $(355)^2$ = 26.7 ft.

A maximum stream height of 26.7 ft occurs 107 ft. from the 1.0 inch taper bore nozzle operating at 80 psi with a 24° trajectory.

Table 4 provides data on maximum stream heights for various nozzles, trajectories and operating pressures. These values have been derived from the equations shown above.

Selecting an Irrigation System to Match Clearance Standards

The type of irrigation system selected will depend on field size, shape, topography and location of the transmission line. As mentioned earlier, the basic types of irrigation systems, which interact with powerlines are centre pivots, stationary and travelling gun systems.

Although a centre pivot system cannot cross powerlines, its closest approach will depend on the total water spray height and maximum stream height. Using a lower trajectory nozzle for the end gun will reduce stream height but may also significantly reduce the effective radius of the centre pivot. It may be more economical to shut the gun off when in close proximity to the powerline but have an increased radius for the remainder of the field.

Stationary and travelling gun systems may be designed to operate underneath the transmission lines in some instances. If this is not possible, the system must be designed to give access on either side of the powerline. **The closest point of approach should be calculated and marked in the field to prevent the irrigation operator from setting up the equipment any closer.**

An example of a gun system selection follows.

A farmer wishes to irrigate a 60 acre field that is bisected by a 345 kV transmission line. A travelling gun capable of 300 gpm is selected to do the job. The height of the nozzle on the gun cart is 7.0 ft.

From Table 1:

Total water spray height = 21.0 ft

Maximum stream height = 21.0 – 7.0 ft = 14.0 ft

TABLE 4 STREAM TRAJECTORY DATA FOR GIANT GUNS WITH *TAPER BORE NOZZLES*

Nozzle	Pressure psi	Flow Rate gpm	Nozzle Trajectory	Wetted Diameter	Radial Distance to Maximum Stream Height (x) ft	Maximum Stream Height (z) ft
.6”	60	81	18^0	229	69	12.0 ft
			21	233	70	15.4
			24	240	72	18.9
	80	94	18	251	75	14.5
			21	253	76	18.1
			24	260	78	22.0
.7”	60	110	18^0	252	76	12.5
			21	257	77	16.1
			24	265	80	19.9
	80	128	18	278	83	15.3
			21	281	84	19.3
			24	290	87	23.7
.8”	60	143	18	272	82	12.8
			21	276	83	16.7
			24	285	86	20.7
	80	165	18	302	91	16.0
			21	304	91	20.2
			24	310	93	24.7
.9”	60	182	18	287	86	13.0
			21	296	89	17.1
			24	305	92	21.3
	80	210	18	323	97	16.5
			21	328	98	21.0
			24	335	101	25.9
1.0”	60	225	21	315	95	17.4
			24	325	98	21.8
	80	260	21	344	103	21.5
			24	355	107	26.7
	100	290	21	364	109	24.6
			24	375	113	30.2
1.1”	80	330	21	375	113	22.4
			24	387	116	27.8
			27	395	119	33.5
	100	370	21	400	120	25.9
			24	412	124	32.0
			27	420	126	38.3
1.3”	80	445	21	409	123	23.0
			24	421	126	28.8
			27	430	129	34.8
	100	500	21	437	131	27.1
			24	451	135	33.6
			27	460	138	40.4
1.6”	80	675	21	470	141	23.7
			24	475	143	29.9
			27	485	146	36.4
	100	755	21	494	148	28.4
			24	510	153	35.5
			27	520	156	43.1

VALUES IN TABLE ARE APPROXIMATIONS ONLY

From Table 4:

A .8” nozzle, 18^0 trajectory, at 60 psi will deliver 145 gpm with a maximum stream height of 12.8 ft.

Operating two of these guns at the same time will provide 300 gpm and also maintain the maximum height limitation. Two drawbacks to this type of modification are immediately evident.

- the lower nozzle operating pressure may not provide the desired stream break-up
- the lower trajectory angle will reduce the wetted diameter thereby increasing the application rate. On some soils, compaction, puddling and runoff may result.

Similar methods can be used to reduce maximum stream heights for various flow rates. For gun systems less than 200 gpm, two low angle #85 sprinklers could be substituted. The maximum stream height is then reduced to 10 feet.

Summary

- The minimum mid-span heights shown in Table 1 are the absolute minimum conditions that will occur for the various line types shown. Actual mid-span heights may be higher in some areas. Consult BC Hydro if unsure about the span heights or powerline voltages in your area.
- Consult manufacturer specifications whenever possible to determine wetted diameters and maximum stream height.
- Ensure that the clearances shown in Table 1 are maintained at all times.
- Maximum stream heights can be reduced by utilizing two or possibly three smaller lower trajectory guns instead of one large gun. Application rates, however, will be increased due to the smaller wetted diameters.
- The maximum stream heights calculated in this report are for sprinklers operating on level ground. Uneven terrain may increase stream heights.
- For further information, consult BC Hydro factsheet F550.

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