Patterns of Resistance to a Pulsed Electric Current in Sound and Decayed Utility Poles

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Abstract

Patterns of electrical resistance measured at groundline were determined for 174 utility poles representing combinations of 7 species and 5 preservative treatments. Criteria developed from these patterns correctly indicated the internal condition of wood in 161 of 174 (93%) poles. Internal voids were detected during drilling prior to taking electrical measurements in 7 poles. A decrease of one or more readings to 75 percent of the highest reading generally indicated decayed wood. Sometimes no decayed wood was found when this criterion was applied, but no decayed wood escaped detection within the limits of our ability to see symptoms of decay. A problem in distinguishing between sound and decayed wood in some poles was caused by off-scale readings.

Decay is a major cause of damage to utility poles. For optimum service and reliability, poles must be inspected periodically to detect any evidence of deterioration. This permits timely application of supplementary preservative treatment to arrest further development of decay beyond safe limits.

Three basic types of decay occur in utility poles—external decay, shell rot (usually found in butt-treated cedar poles), and internal decay (often called hollow heart). External decay and shell rot are relatively easy to detect visually or by prodding the surface of the pole. Detection of internal decay is more complex because decay within the pole is hidden from view and is often below groundline. A method is needed for determining the internal condition of a pole quickly and accurately with a minimum of disturbance to the pole.

Although several methods are available for determining the internal condition of poles (2), the most commonly used are 1) sounding (by tapping) and 2) extracting increment cores. Nondestructive methods such as x-ray (1), ultrasonics (3), and needle-resistance pressure (2, 6), have not been generally accepted because of expense, lack of portable equipment, inaccuracy, or training required for personnel.

A method of using pulsed electrical current to detect discoloration and decay in living trees (5) appeared to be applicable for detecting decayed wood in utility poles as well as in trees (4).

The purpose of our study was to determine the patterns of electrical resistance to a pulsed current at groundline in utility poles of different tree species that had received different chemical preservative treatments.

Materials and Methods

We determined electrical resistance with a Shigometer® Model 7950. To use this device, a hole is drilled into the wood; and a wire probe, inserted into the hole, picks up the electrical impulses, which are registered on the meter. The meter registers electrical resistance up to 500 kilohms (kΩ).

Utility poles were examined at Chester, New Jersey (100 poles in October 1974), and at Orange Park, Florida (52 poles in December 1974 and 22 poles in December 1975). The poles were in plots maintained by Western Electric Company, Purchased Products Engineering, for evaluating effectiveness of various preservatives in poles of different tree species.

The poles studied were treated with one of the following preservatives: creosote, 2 percent pentachlorophenol in creosote (creo-penta), 5 percent pentachlorophenol in petroleum (penta-petroleum), pentachlorophenol in liquefied gas (penta-gas), and water-soluble mixtures of salts of chromium, copper, and arsenic.

The tree species studied were southern pine *(Pinus palustris* Mill., *P. taeda* L., and related species),

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Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco), ponderosa pine *(Pinus ponderosa* Laws.), jack pine *(Pinus banksiana* Lamb.), lodgepole pine *(Pinus contorta* Dougl.), western larch (*Larix occidentalis* Nutt.), and western redcedar *(Thuja plicata* D. Don). The poles were 7 to 11 inches in diameter and 8 to 10 feet long and were set 3 to 4 feet into the ground. Time of exposure ranged from 12 to 43 years.

The holes, 3/32 inch in diameter and 7 inches deep, were drilled at a downward angle of 45 degrees at groundline (Fig. 1). Before drilling, the surface of the pole was probed with a blunted ice pick to locate decayed wood on the surface and to facilitate starting the drill bit. Physical resistance of the wood to drilling was noted so that voids could be detected. If a sudden release in torque occurred, a second hole was drilled to the depth of release, and the drill bit was pushed into the hole without drilling to confirm the presence of a void.

Electrical resistance of the wood to a pulsed current was measured at 0.5-inch intervals from 1 inch in to a depth of 5-1/2 inches.

During the 1974 studies, increment cores were extracted from the same parts of the poles as those in which electrical readings were taken, and the condition of the wood was observed. A subsample of nine poles was taken in the New Jersey plots; the poles were pulled, and wedges were cut with a chainsaw (Fig. 2) to verify the condition of the wood as determined by increment cores and the meter. Condition of wood in poles measured in 1975 was determined by cutting 4-inch disks (Fig. 3) from 22 poles measured with the meter. The internal condition of 174 poles was determined, and the patterns of resistance were recorded. All determinations of wood condition were based on visual inspection.

Results

Seven of 174 poles had voids caused by advanced decay and the activity of ants or termites. These voids, 1 inch or more in width, were detected by probing the surface of the pole and by sensing abrupt releases in

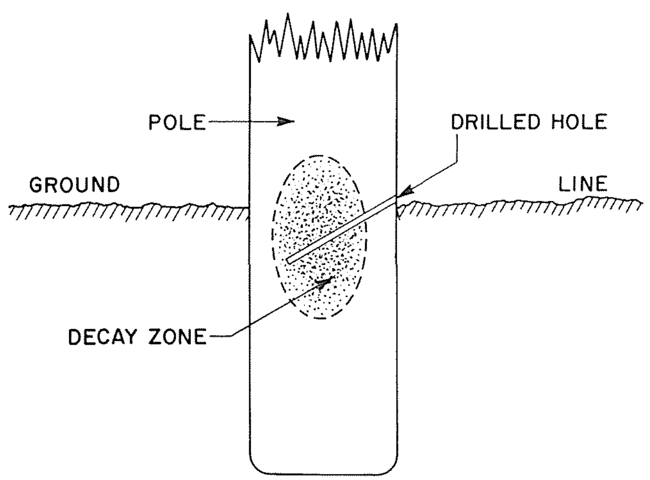

Figure 1. — The test hole is drilled at a downward angle of 45 degrees, from groundline.

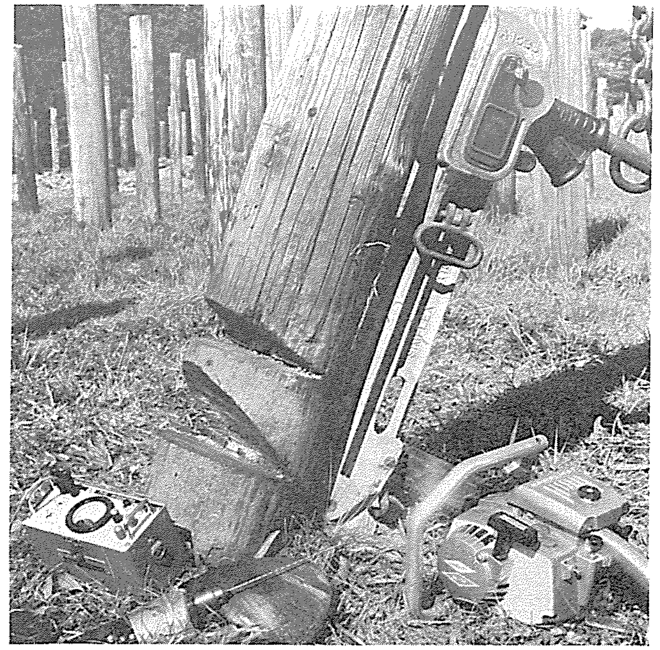

Figure 2. — Sample pole at New Jersey test plot, pulled and cut to check for decay.

Figure 3. — Closeup of same pole shown in Figure 2, revealing small pocket of internal decay.

torque as the drill bit entered the pole. The size of the void was determined by drilling a second hole to the depth of release and pushing the bit into the pole until it hit solid wood again. Another indication of the size of a void was given when the entire 11-inch probe was pushed into holes drilled only a few inches deep in 2 poles hollowed by ants.

Three basic patterns of electrical resistance were observed in the 167 poles where voids were not detected by physical probing and drilling (Table 1). In

Table 1. — VARIATION IN ELECTRICAL RESISTANCE AMONG 167 UTILITY POLES OF 13 DIFFERENT COMBINATIONS OF TREE SPECIES AND CHEMICAL PRESERVATIVES.

Species group and preservative	No. of poles: Total sample	Electrical resistance (kΩ)[a]: <500	Mixed	>500
Southern pine:				
Creosote[b]	62	27	22	13
Penta-petroleum	45	39	3	3
Creo-penta	12	6	4	2
Penta-gas	7	2	4	1
Salts	12	1	4	7
Douglas-fir:				
Creosote	1	0	0	1
Penta-petroleum	5	0	2	3
Penta-gas	7	1	0	6
Jack pine:				
Penta-petroleum	6	0	2	4
Ponderosa pine:				
Penta-gas	5	5	0	0
Lodgepole pine:				
Penta-petroleum	2	1	1	0
Western redcedar:				
Penta-petroleum	2	0	0	2
Western larch:				
Penta-petroleum	1	0	0	1
Total	167	82	42	43

[a]All 10 intervals read above 500 kΩ, below 500 kΩ, or a mixture of both above and below.
[b]One pole had a large void and no readings were taken.

43 poles all resistance readings were >500 kΩ, and therefore beyond the scale of the meter. These readings were found in most combinations of species and preservatives, but were more common (i.e., represented a higher proportion of sample) in Douglas-fir and jack pine than in southern pine (Table 1). They were also more common in southern pine treated with water-borne salts than in southern pine treated with any other preservative. In 42 poles, some readings were <500 kΩ and some >500 kΩ, mostly in southern pine.

Table 2. — ELECTRICAL RESISTANCE READINGS OF POLES WITH AND WITHOUT SYMPTOMS OF WOOD DECAY.

Electrical resistance readings (kΩ)	No. of poles: No decay	Decay	
All >500	43	—	
Some >500, none <250	20	—	
All <500, but lowest not less than 75% of highest	73	—	
Some >500, some <250, but none <125	7	4	
Some >500, some <125	4	7	
All <500, lowest less than 75% of highest	2	7	
Total	149	18	167

In 82 poles, all readings were <500 kΩ. This pattern was most common in southern pine treated with penta-petroleum and in ponderosa pine treated with penta in liquefied petroleum.

No symptoms of decay were observed in wood of poles having the following readings of electrical resistance (Table 2):

1. All >500 kΩ (Table 3, A).
2. Some >500, none <250 kΩ (Table 3, B,C).
3. All <500 kΩ, but lowest not less than 75 percent of highest (Table 3, D-H).

Symptoms of decay were observed in wood of poles having the following readings of electrical resistance (Table 2).

1. Some >500, some <250 kΩ (Table 3, L-M).
2. All <500 kΩ, lowest less than 75 percent of highest (Table 3, I-K).

Of those poles with some readings >500 and some <250 kΩ, poles with readings <125 kΩ (indicating that a drop of at least 75 percent has occurred) had decay more often than not (Table 2). Poles in which there

Table 3. — PATTERNS OF ELECTRICAL RESISTANCE OF WOOD IN UTILITY POLES.

	Species and preservative	Difference[a] (%)	Half-inch intervals[b]: 1	2	3	4	5	6	7	8	9	10
			kΩ									
	SOUND POLES											
A	Southern pine/creosote	([c])	>500	>500	>500	>500	>500	>500	>500	>50	>500	>500
B	Southern pine/creosote	—	>500	>500	>500	>500	>500	>500	350	320	>500	>500
C	Southern pine/creosote	—	>500	>500	>500	370	300	260	450	480	450	>500
D	Southern pine/creosote	45	400	310	310	270	270	290	300	490	420	380
E	Southern pine/creosote	50	150	100	100	100	160	140	110	100	80	100
F	Southern pine/penta petroleum	64	250	170	170	90	130	120	130	110	90	100
G	Southern pine/penta petroleum	55	70	50	60	70	70	110	110	80	50	50
H	Ponderosa pine/penta-gas	63	270	230	220	220	160	100	150	220	250	180
	DECAYED POLES											
I	Southern pine/creosote	89	370	230	180	180	130	80[d]	70	41	45	48
J	Southern pine/creosote	89	270	320	300	220	130	100	120	180	90	39
K	Southern pine/penta petroleum	83	140	160	150	110	180	70	50	80	38	30
L	Southern pine/creosote	—	>500	350	210	230	150	100	100	110	38	120
M	Douglas-fir/penta petroleum	—	>500	>500	>500	250	80	>500	450	>500	>500	180
N	Southern pine/salts	—	>500	>500	350	200	>500[e]	390	310	420	>500	240

[a]$\frac{\text{Maximum electrical resistance} - \text{minimum electrical resistance}}{\text{Maximum electrical resistance}} \times 100.$
[b]Intervals begin at depth of 1 inch.
[c]Difference cannot be calculated because maximum resistance not known.
[d]Underlined readings indicate symptoms of wood decay.
[e]Small void in decayed wood.

was no indication of the actual magnitude of decrease in electrical resistance (some >500, some <250, but none <125 kΩ) lacked decay more often than not.

Discussion

Results from other studies of a pulsed electric current to detect internal decay in trees (4) indicated that patterns of readings that show abrupt decreases indicate decay. The question is, how much of a decrease is necessary to indicate decay in utility poles that are made from a variety of tree species and preserved with a variety of materials? Data from our study give some answers but definitely not all. There were two weak factors in the study. First, the basis for the presence of decay was visual. Obvious decay could be detected this way, but incipient decay could not. Second, the meter measured resistance only to 500 kΩ yet many readings were beyond this. Because the true resistance corresponding to readings beyond 500 kΩ was not known, the percentage of decrease in the lower readings could not be calculated.

Within the above limitations criteria were established which accurately determined the presence or absence of wood with symptoms of decay in 161 of 174 poles. Advanced surface decay and internal voids were found by probing and drilling prior to taking electrical measurements. A decrease of one or more readings to 75 percent or less of the highest reading usually indicated decay (Table 2). If the highest reading was >500 kΩ, a reading <125 kΩ indicated at least a 75 percent decrease in resistance, which was also generally indicative of wood decay (Table 2).

If errors are made in using these criteria, they will be made in favor of calling a sound pole decayed, rather than a decayed pole sound. In actuality, some of the six poles that did not appear to have decay (Table 2) may contain wood that is in the early stages of decay.

Wood in poles having some readings >500, some <250, and none <125 kΩ was sometimes decayed (Table 2). For this reason, all such poles must be considered decayed. If poles with these characteristics make up a large percentage of poles to be inspected, further refinements of the method or the meter need to be developed.

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