PERFORMANCE OF WOOD POLES IN SERVICES

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1. INTRODUCTION

The work described in this paper was conducted by Morrison Hershfield Ltd. for the Canadian Electrical Association. It describes the condition and performance of 710 poles representing a number of pole species, preservative treatments, years in service and geographical locations. Data on the physical condition, surface preservative loading above and below ground and fungal population of each pole were collected to serve as a baseline for comparison with the results of future inspections of the same poles.

2. BACKGROUND

Wood poles are cost-effective and practical supports for conductors and accessories for the energy distribution and communications industries. They have significant advantages over competing materials and systems, including renewability of supply, low cost, low weight, ease of climbing and flexibility in framing and boring. However, as a natural organic material, wood is subject to biological deterioration in service, and to dimensional changes in response to ambient moisture changes.

It is essential that the owners of pole lines be able to predict the expected serviceability of all pole types in their pole plant so they can predict pole replacement requirements, schedule remedial treatments to extend the pole lives, define the most cost effective pole types and identify those that should not be installed in the future.

Wood poles are protected from decay and insect attack by treating the outer sapwood shell with a leach-resistant wood preservative. Pole treating standards such as CSA 080.4, define preservative retention and penetration requirements for several wood species and preservatives. It is fair to say that the standards reflect more what is practically feasible in the treating plant than what is desireable or necessary to ensure long term durability (Table 1).

We can hypothesize that the long term serviceability of different pole species will depend on such wood properties as sapwood thickness and permeability, heartwood natural durability and checking characteristics. Sapwood thickness essentially defines maximum radial penetration; natural durability and checking characteristics (a function of such properties as wood density, ratio of tangential to radial shrinkage and tension perpendicular to grain strength) influence the development of internal decay.

The physical service life of a pole also depends on the wood preservative, treating process, pretreatments and conditioning methods used, and climatic and geological conditions where the pole is installed. Mean annual temperature, number of days per year at or above certain temperatures and amount and distribution of precipitation affect the activity and distribution of wood degrading organisms and the depletion of preservatives from wood by leaching and bleeding. Local soil conditions and microclimate will also affect the durability of a pole.

We obviously need data from the field to check these assumptions and to provide more quantitative information on the expected performance of different pole types under different service conditions.

Normally, service record information is derived from periodic inspection and evaluation of the condition of poles in service (e.g. 2,3) or in field test plots established by pole owners (4) or by wood research organizations (5,6). Average physical life of the poles is given by their age when 50% of the poles have been removed because of deterioration. While there is considerable published service record information, most of it is based on experience in the USA or other countries.

Table 1
Preservative Treating and Durability Properties of Selected Wood Pole Species

		Western redcedar	Ponderosa Pine	Red Pine	Lodgepole Pine	White Pine	Coast Douglas-fir	Western Hemlock	Jack Pine	Amabilis Fir	Western Larch	Inland Douglas-fir	Spruce Sp
	Sapwood[1] Treatability	P	P	P	P	P	P	P	P	P	P	MR	MR
	Heartwood[2] Durability	D	ND	ND	ND	MD	MD	ND	ND	ND	MD	MD	ND
	Average Sapwood Depth (mm)	28	118	75	64	50	46	78	38	48	23	36	38
Tendency to Check	Specific Gravity	0.31	0.44	0.39	0.40	0.39	0.45	0.41	0.42	0.36	0.55	0.45	0.35
	ST/SR	2.14	1.28	1.70	1.45	2.52	1.58	1.57	1.48	2.12	1.75	1.82	2.16
	Tension ⊥ air dry (MPa)	1.46	3.47	3.54	3.78	2.64	3.06	2.93	3.65	3.06	3.62	2.70	3.0
	Predicted Checking Properties	POOR	EXCEL-LENT	MODERATE	GOOD	POOR	POOR	MODERATE	GOOD	MODERATE	POOR	POOR	POOR
CSA 080.4 Specifi-cation	Minimum Penetration (mm)	12.5 or 100% of sapwood	89 or 90% of sapwood	75 or 90% of sapwood	19 and 90% of sapwood	25 or 90% of sapwood	19 and 85% of sapwood	25	25 or 90% of sapwood	3 -	12.5 and 100% of sapwood	12.5 and 100% of sapwood	12.5 and 100% of sapwood
	Assay Zone (mm)	2.5-15	13-50	2.5-41	2.5-19	2.5-19	6-25	2.5-25	2.5-19	- 3	2.5-15	2.5-15	2.5-15
	Assay Retention	12.8	7.2	10.9	12.8	9.6	9.6	9.6	9.6	- 3	12.0	12.0	12.0
	Expected serviceability	BEST											WORST

1. P-Permeable; MR-Moderately Resistant; R-Resistant;
2. ND-Non Durable; MD-Moderately; D-Durable;
3. No CSA Standard at this time.

This method of establishing service performance data requires a long period of time to develop. Also, the pole survival curve tends to remain flat for a long period, then drops off rapidly as the average life is approached (Fig. 1).

As a consequence, inferior or inappropriate pole types are not detected or identified at an early stage. Because of the long time frame, records may not be consistent and may be lost so the reliability of the published results is often low.

The study described here was devised to provide rapid feedback on the performance of various wood pole species and treatments in different geographical locations in Canada. Pole species and treatments of interest, representing a range of age classes and geographical distribution were identified with the help of the Canadian Electrical Association member utilities.

The data collected on physical condition of the poles, surface preservative loadings, and fungal activity, provide a reference against which the condition of the same poles can be compared at some time (recommended five years) in the future. In this way, the change in physical, chemical and biological condition of the poles can be monitored and deterioration related problems anticipated early.

3. METHODS

Seven hundred and ten distribution poles, representing 76 combinations of wood species, preservative treatment, age in service and geographical location, were identified and inspected (Table 2). Where possible, ten poles were selected for each species, preservative, age and location combination; in some cases, fewer poles were available.

The pole locations were selected to represent four broad geographical areas: British Columbia (west), Prairies, central Canada and the Maritimes (east). They also represent a broad variation in climatic conditions as defined by the climate index for assessing above ground decay hazard, developed by T. Scheffer (7), (Fig. 2). The climate index is computed as follows:

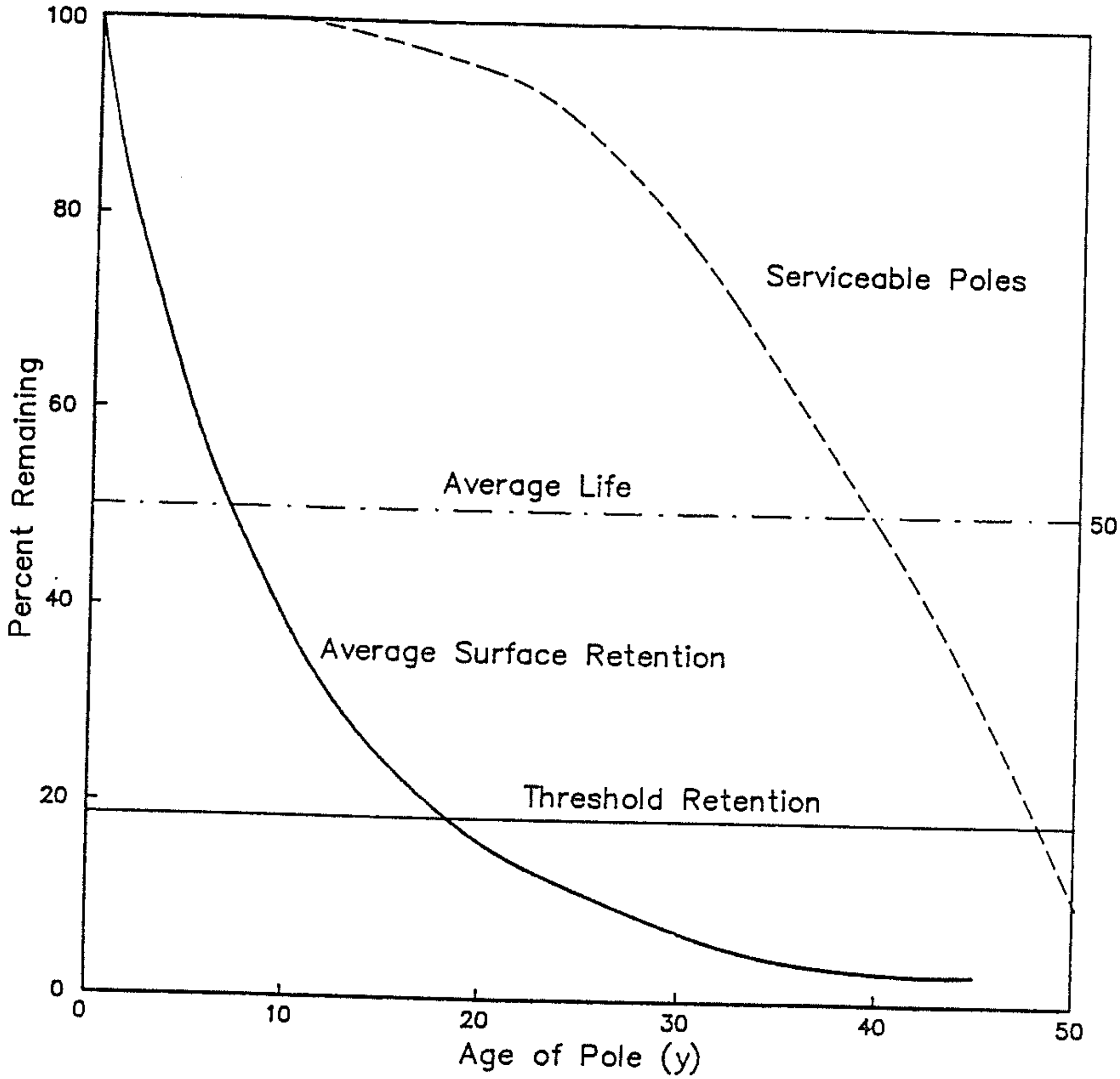

FIGURE 1 HYPOTHETICAL POLE SURVIVAL AND SURFACE PRESERVATIVE DEPLETION FOR A POLE POPULATION

Table 2

Summary of Pole Types Evaluated

Species	Preservative	Location	Age Classes
Western Cedar	PCP-FL	WEST	0-5, 6-10, 11-15, 16-20
Western Cedar	PCP-FL	PRAIRIE	0-5, 6-10, 11-15, 16-20
Western Cedar	PCP-FL	CENTRAL	0-5, 11-15
Western Cedar	PCP-FL	EAST	0-5, 6-10, 11-15, 16-20
Western Cedar	PCP-B	WEST	0-5, 6-10
Western Cedar	PCP-B	CENTRAL	6-10
Western Cedar	C-B	WEST	11-15, 16-20, 21-25, 26-30
Western Cedar	ACA-FL	WEST	0-5, 6-10
Lodgepole Pine	PCP-FL	WEST	0-5, 6-10, 11-15, 16-20
Lodgepole Pine	PCP-FL	PRAIRIE	0-5, 6-10, 11-15, 16-20
Lodgepole Pine	PCP-FL	CENTRAL	0-5
Jack Pine	PCP-FL	PRAIRIE	0-5, 6-10, 11-15, 16-20
Jack Pine	PCP-FL	CENTRAL	0-5, 6-10, 11-15, 16-20, 21-25
Jack Pine	CELLON	CENTRAL	16-20
Jack Pine	M-DOW	CENTRAL	11-15
Jack Pine	CCA	EAST	0-5
Red Pine	PCP-FL	CENTRAL	0-5, 6-10, 11-15, 16-20, 21-25
Red Pine	PCP-FL	EAST	0-5, 6-10, 11-15
Red Pine	CELLON	CENTRAL	16-20
Red Pine	CCA	CENTRAL	0-5
Red Pine	CCA	EAST	0-5, 6-10
Southern Pine	PCP-FL	PRAIRIE	0-5
Southern Pine	PCP-FL	CENTRAL	0-5, 6-10
Southern Pine	PCP-FL	EAST	6-10
Douglas Fir	PCP-FL	PRAIRIE	0-5, 6-10, 11-15, 16-20
Douglas Fir	PCP-FL	CENTRAL	0-5, 11-15
Douglas Fir	PCP-FL	EAST	0-5, 6-10
Western Larch	PCP-FL	CENTRAL	0-5
Spruce	PCP-FL (Inc.)	PRAIRIE	6-10
Spruce	M-DOW	CENTRAL	6-10
Spruce	ACA	CENTRAL	0-5
Spruce	ACA-KERFED	CENTRAL	0-5
Spruce	ACA	EAST	0-5
Spruce	CCA	EAST	0-5

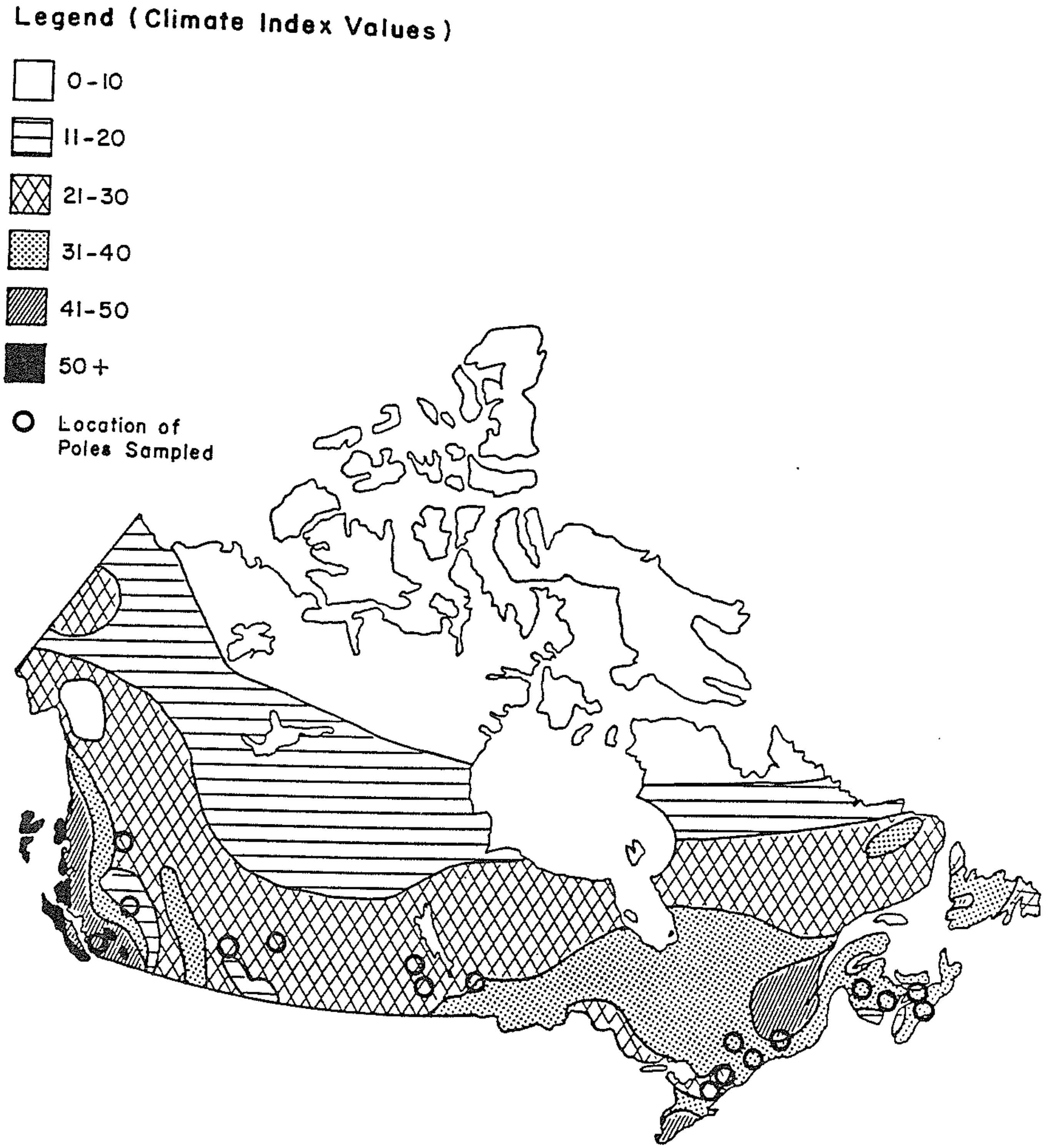

FIGURE 2 LOCATION OF POLES SAMPLED

$$\text{Climate index} = \sum_{\text{Jan}}^{\text{Dec}} \frac{(T-2)(D-3)}{17}$$

where T is the mean monthly temperature (°C)

D is the mean number of days per month with precipitation of 0.25mm or more and 17 is a factor that brings the index within the range 0 to 100.

Field inspection and sampling involved excavating around each pole and recording the features shown on the field record sheets (Fig. 3). Six millimeter deep samples of wood were removed from the pole surface, both above and below grade for measurement of preservative loading. In some cases, a second 6mm thick sample was taken from deeper in the pole to establish the preservative gradient. A five millimeter diameter core was taken with a sterile increment borer from approximately 15 cm below grade, near the largest check at or near the groundline. The cores were packed on ice and shipped to the laboratory for culturing.

Pentachlorophenol treated samples were analysed by the copper pyridine method (8); CCA and ACA treated samples were analysed by neutron activiation analysis, e.g. (9).

The increment cores were cut into 20 mm segments and examined by microscope for the presence of fungal hyphae. Segments containing hyphae were cultured on a malt-agar medium so the causal organism could be identified.

FIGURE 3

FIELD DATA SHEET

POLE NUMBER ____________
SPECIES ____________
TREATMENT ____________
TREATED BY ____________
POLE CLASS ____________
POLE HEIGHT ____________

UTILITY ____________
YEAR TREATED ________
YEAR INSTALLED ________
REMEDIAL TREATMENTS
TYPE ____________
____
YEAR ____________

INSPECTOR ____________
DATE ____________
POLE INFORMATION
TRANSFORMER - Yes/N
GUY WIRE - Yes/No
GROUND WIRE - Yes/No
OTHER ____________

CHECKING

DEGREE OF CHECKING - Light/Moderate/Heavy
WIDEST CHECK - 5 mm/ 5-10 mm/ > 10 mm
DEEPEST CHECK - 25 mm/ 25-75 mm/ > 75 mm
PENETRATES GROUNDLINE? - Yes/No

SLOPE OF GRAIN - Low/Medium/High

DAMAGE

SPUR - Light/Moderate/Heavy
WOODPECKER HOLES - Yes/No
CARPENTER ANTS - Yes/No
LIGHTNING - Yes/No
OTHER - Yes/No ____________

DECAY

SURFACE, ABOVE GRADE - Nil/Surface/ ≤ 25 mm/ > 25 mm
ASSOCIATED WITH - Checks/Spurs/Groundline/Other ________
EXPOSURE OF CORED FACE - N/NE/E/SE/S/SW/W/NW
SURFACE, BELOW GRADE-Nil/Surface/ ≤ 25 mm/ > 25 mm
LENGTH OF CORE EXTRACTED ________ mm
HOLLOW HEART - Yes/No
mm of Sound Wood ________

NOTES

____
____
____
____
____
____

MOISTURE CONTENT (%)

	SURFACE	25 mm	50 mm
ABOVE GRADE	______	______	______
BELOW GRADE	______	______	______

SITE

SOIL TYPE ____________
TOPOGRAPHY ____________
SITE DRAINAGE-Good/Moderate/Poo
SITE EXPOSURE-Open/Sheltered

PICTURE LOOKING	POLE LOCATION MAP
Picture of pole showing pole condition and surroundings.	Detailed map to tie pole location to permanent landmark.

4. RESULTS AND DISCUSSION

A large amount of information has been collected defining the surface preservative loadings and present physical and biological condition of the poles. While the information was developed as a basis for comparison with results of future inspections it provided additional data that may be useful to pole users and treaters.

4.1 Pentachlorophenol-in-oil full-length treatments

A comparison of pentachlorophenol retentions above and below grade (Table 3,4) suggests that initially, penta is depleted from the surface below grade faster than above grade. However, in older poles the penta concentration was often higher below grade, possibly due to preservative migration by gravity.

The retentions were generally lower in older poles than in newly installed poles; however, without knowledge of the initial retentions in the poles, it is impossible to predict preservative depletion rates. The results indicate that jack pine poles may warrant groundline remedial treatment earlier than other pole species, since the surface pentachlorophenol retention approached the generally accepted threshold retention of 0.20 pcf (10) in poles installed only 11-20 years. Shell decay was generally not significant in poles less than 16-20 years old suggesting that 15-20 years may be an appropriate time to apply groundline treatment to penta treated poles.

4.2 Pentachlorophenol in fugitive solvent systems - Cellon and Penta-Methylene Chloride

The pentachlorophenol distribution patterns were quite different for these treatments than for penta-in-oil treatments. Poles generally had significantly lower pentachlorophenol loadings below grade than above grade (Table 5). Surface or shell decay was noted in many of these poles, confirming the low chemical retention measured. This is attributed to the fact that gravitational migration of pentachlorophenol does not occur in fugitive solvent treated poles and to the effect of solvents on the stability of pentachlorophenol (10, 11).

Table 3

Average Retentions and Surface Decay
in Full-Length Penta Treated Poles
Western Cedar Douglas-Fir, Larch

Species and Treatment	Location	Age Class	Pentachlorophenol Retention					Surface Decay					
			Above Pcf	Grade kg/m^3	Below pcf	Grade kg/m^3	t	Above Grade A nil	Above Grade B surface	Above Grade C 25mm	Below Grade A nil	Below Grade B surface	Below Grade C 25mm
WRC	West	0-5	0.48	7.7	0.31	5.0	5.1**	10	0	0	10	0	0
		6-10	0.38	6.1	0.43	6.9	-1.3	10	0	0	10	0	0
		11-15	0.29	4.6	0.27	4.3	1.8	7	3	0	6	4	0
		16-20	0.39	6.2	0.35	5.6	0.9	5	5	0	7	3	0
WRC	Prairie	0-5	0.50	8.0	0.40	6.4	3.9**	10	0	0	8	2	0
		6-10	0.28	4.5	0.29	4.6	-0.2	0	5	0	1	4	0
		11-15	0.25	4.0	0.28	4.5	-1.2	3	7	0	4	6	0
		16-20	0.28	4.5	0.22	3.5	2.2*	0	10	0	0	9	1
		21-25	0.23	3.7	0.19	3.0	0.8	0	8	2	0	4	6
WRC	Central	0-5	0.57	9.1	0.49	7.8	1.8	7	2	1	10	0	0
		11-15	0.20	3.2	0.29	4.6	-2.3*	2	8	0	1	9	0
	Eastern	0-5	0.38	6.1	0.31	5.0	1.5	8	1	1	7	2	1
		6-10	0.36	5.8	0.34	5.4	0.4	4	5	1	3	5	2
		11-15	0.20	3.2	0.22	3.5	-1.4	1	8	1	1	7	2
		21-15	0.21	3.4	0.33	5.3	-2.4*	1	8	1	0	10	0
D.F.	Prairie	0-5	0.47	7.5	0.36	5.8	2.5*	4	0	0	4	0	0
		6-10	0.25	3.0	0.28	4.5	-1.4	10	0	0	10	0	0
		11-15	0.28	4.5	0.35	5.6	-2.8*	6	3	1	9	1	0
		25-30	0.20	3.2	0.18	2.9	0.8	1	8	1	3	7	0
	Central	0-5	0.35	5.6	0.31	5.0	1.0	5	0	0	5	0	0
		11-15	0.32	5.1	0.35	5.6	-0.9	7	6	2	14	1	0
	Eastern	0-5	0.55		0.45		+2.8*	9	1	0	9	0	1
		6-10	0.48		0.52		-0.5	2	0	0	2	0	0
W.L.	Central	0-5	0.58		0.46		1.3	4	1	0	5	0	0

Table 4
Average Retentions and Surface Decay
in Full-Length Penta Treated Poles
Pine Species

Species and Treatment	Location	Age Class	Pentachlorophenol Retention					Surface Decay					
			Above		Below		t	Above Grade			Below Grade		
			Pcf	Grade kg/m^3	pcf	Grade kg/m^3		A nil	B surface	C 25mm	A nil	B surface	C 25mm
L.P. Pine	West	0-5	0.62	9.9	0.49	7.8	3.2**	10	0	0	10	0	0
		6-10	0.24	3.8	0.31	5.0	-2.2*	10	0	0	10	0	0
		11-15	0.26	4.2	0.30	4.8	-3.0*	4	6	0	10	0	0
		16-20	0.28	4.5	0.30	4.8	-0.6	10	0	0	10	0	0
	Prairie	0-5	0.35	5.6	0.25	4.0	7.2	10	0	0	9	1	0
		6-10	0.29	4.6	0.27	4.3	0.8	6	4	0	6	4	0
		11-15	0.20	3.2	0.24	3.8	-1.6	2	8	0	7	3	0
		16-20	0.21	3.4	0.29	4.6	-3.2**	0	10	0	2	2	6
	Central	0-5	0.46	7.4	0.44	7.0	0.7	10	0	0	10	0	0
J. Pine	Prairie	0-5	0.36	5.8	0.44	7.0	-4.6**	10	-	-	7	3	-
		6-10	0.29	4.6	0.27	4.3	0.6	10	-	-	7	3	-
		11-15	0.15	2.4	0.14	2.2	0.5	-	10	-	4	6	-
		16-20	0.22	3.5	0.20	3.2	0.6	1	9	-	7	3	-
	Central	0-5	0.27	4.3	0.37	5.9	-2.3*	9	-	-	9	-	-
		6-10	0.36	5.8	0.20	3.2	3.5**	10	-	-	10	-	-
		11-15	0.31	5.0	0.30	4.8	0.1	4	5	1	10	-	-
		16-20	0.12	1.9	0.18	2.9	-4.5*	4	5	1	6	4	-
		21-25	0.18	2.9	0.14	2.2	3.3	9	1	-	8	2	-
S.Y. Pine	Prairie	0-5	0.35	5.6	0.26	4.2	3.7*	10	-	-	10	-	-
	Central	0-5	0.32	5.1	0.31	5.0	0.3	10	-	-	10	-	-
		6-10	0.36	5.8	0.44	7.0	-1.7	10	-	-	10	-	-
	Eastern	6-10	0.27	4.3	0.20	3.2	2.1*	8	2	-	10	-	-
Red pine	Central	0-5	0.46	7.4	0.43	6.9	1.1	10	-	-	10	-	-
		6-10	0.33	5.3	0.36	5.8	-0.8	7	3	-	10	-	-
		11-15	0.22	3.5	0.25	4.0	-0.8	10	-	-	10	-	-
		16-20	0.22	3.5	0.28	4.5	-1.5	5	5	-	9	-	1
		21-25	0.22	3.5	0.26	4.2	-1.1	10	-	-	10	-	-
	Eastern	0-5	0.55	8.8	0.48	7.7	2.1*	10	-	-	10	-	-
		6-10	0.30	4.8	0.32	5.1	0.5	5	-	-	5	-	-
		11-15	0.24	3.8	0.29	4.6	-2.5*	9	1	-	10	-	-

Table 5

Average Retentions and Surface Decay

in Penta-in-Fugitive Solvent Treated Poles

Species and Treatment	Location	Age Class	Pentachlorophenol Retention					Surface Decay					
			Above Pcf	Grade kg/m^3	Below pcf	Grade kg/m^3	t	Above Grade			Below Grade		
								A nil	B surface	C 25mm	A nil	B surface	C 25mm
J. Pine Cellon	Central	16-20	0.47	7.5	0.27	4.3	7.2**	7	3	-	1	7	2
R. Pine Cellon	Central	16-20	0.25	3.0	0.09	1.4	6.7**	6	4	-	1	1	8
Spruce M.C.	Central	6-10	0.55	8.8	0.41	6.6	1.6	10	-	-	5	4	1
J. Pine M.C.	Central	11-15	0.99	15.8	0.40	6.4	3.1**	8	2	-	4	1	5

Cellon and penta-MC systems used now incorporate co-solvents and other additives which promote penetration of pentachlorophenol into the wood cell wall, and help to bind pentachlorophenol in the wood. It is not known if these additives were incorporated in the poles studied.

Three of the penta-MC jackpine poles in service 11-15 years had very significantly lower retentions below grade than above grade (Table 6). These poles were located on poorly drained swampy sites, whereas the remaining seven poles were located on higher, better drained sites. This suggests that the performance of this treatment is highly dependent on site conditions.

Table 6
Effect of Site on Preservative Depletion
penta-Methylene Chloride
Retention (Pcf)

Pole No.	Above Grade	Below Grade	Site
21	0.91	0.05	Poorly drained, swampy
22	1.21	0.12	"
23	2.07	0.19	"
14-20	0.93	0.60	well drained

4.3 Waterborne preservative treatments - Ammoniacal copper arsenate (ACA) and Chromated Copper Arsentate (CCA)

Only recently installed ACA and CCA treated poles were included in this study. Three of the ACA treated pole lines had significantly lower preservative retentions below grade than above grade (Table 7). This was most evident in the poles located in the high rainfall western region (Vancouver, lower mainland). A comparison of the relative amounts of copper and arsenic present in the wood indicates that arsenic is preferentially lost from the poles,

Table 7

Average Retentions and Surface Decay

in ACA AND CCA Treated Poles

Species and Treatment	Location	Age Class	ACA or CCA Retention					Surface Decay					
			Above Pcf	Grade kg/m^3	Below pcf	Grade kg/m^3	t	Above Grade A nil	Above Grade B surface	Above Grade C 25mm	Below Grade A nil	Below Grade B surface	Below Grade C 25mm
WRC-ACA	West	0-5	0.98	15.7	0.53	8.5	3.4**	10	-	-	10	-	-
	West	6-10	1.03	16.5	0.42	6.7	3.7**	10	-	-	4	6	-
Spruce-ACA	Central	0-5	1.51	24.2	1.19	19.0	2.7*	14	-	-	9	5	-
ACA	Central	0-5	1.31	21.0	1.56	25.0	-2.0	5	-	-	3	2	-
ACA	East	0-5	1.14	18.2	1.06	17.0	0.63	10	-	-	8	2	-
Spruce-CCA (2 poles)	East	0-5	0.92	14.7	0.80	12.8	5.8	2	-	-	2	-	-
Jack Pine CCA (3 poles)	East	0-5	0.70	11.2	0.72	11.5	-0.1	3	-	-	3	-	-
Red Pine CCA	East	0-5	0.87	13.9	0.84	13.4	0.4	6	1	-	7	-	-
Red Pine CCA	East	6-10	0.86	13.8	0.78	12.5	1.5	9	1	-	8	1	1
Red Pine	Central	0-5	0.83	13.3	0.82	13.1	0.3	9	-	-	9	-	-

particularly below grade (Table 8). If it is assumed that the ACA treating solutions contained CuO and As2 O5 in the recommended ratio of 49.8 to 50.2, the expected ratio of Cu to As in the treated wood is about 55 to 45. In the western pole lines, the ratios of copper to arsenic were significantly higher for below grade samples, compared with above grade samples, indicating a higher proportion of arsenic leached below grade.

At this time, the ACA concentrations in the 0-5mm zone of the poles is still signficantly above the reported preservative toxic threshold level of about 0.1 pcf (12). Future inspections and analyses will determine if below grade leaching of ACA is a potential problem and will determine when remedial groundline treatments should be applied.

All CCA-treated poles were located in the Eastern and Central regions. Generally, preservative retentions were similar above and below grade (Table 7) indicating that any leaching that occurs is not greatly affected by soil contact.

A comparison of the ratios of copper, chromium and arsenic elements in the poles indicates that all were probably CCA Type C (Theoretical ratio Cu:Cr:As = 24:40:36). There were no consistent or signficant differences in the relative amounts of Cu, Cr, and As above grade and below grade.

Subsurface samples (5mm to 10mm below the surface) were analysed for some poles. The chrominum level is generally lower and the Cu and As levels are higher in the subsurface samples. This disproportioning effect has been reported by other authors, e.g. (13).

Table 8

Ratios of Cu, Cr and As in Surface Samples of ACA and CCA Treated Poles

Treatment	# Poles	Species	Location	Age	Ave. Ratio of Elements Above grade	Ave. Ratio of Elements Below grade	Level of Significance
ACA	10	WRC	West	0-5	58:0:41	68:0:31	.01
ACA	10	WRC	West	6-10	57:0:42	72:0:28	.01
ACA	14	Spruce	Central	0-5	59:0:41	60:0:40	N.S.
ACA	10	Spruce	East	0-5	59:0:41	61:0:39	N.S.
ACA-K	5	Spruce	Central	0-5	58:0:42	61:0:39	.01
CCA	2	Spruce	East	0-5	18:47:35	20:46:33	.05
CCA	3	Jack Pine	East	0-5	28:35:36	24:38:37	N.S.
CCA	9	Red Pine	Central	0-5	24:40:36	25:39:36	N.S.
CCA	7	Red Pine	East	0-5	23:39:38	25:40:34	N.S.
CCA	10	Red Pine	East	6-10	25:41:34	21:42:36	.05

Expected Ratios:	Cu:	Cr:	As
ACA	55:	0:	45
CCA-B	25:	29:	46
CCA-C	24:	40:	36

4.4 Checking Characteristics of Poles

4.4.1 Poles Species Effect

In theory, wood species with high shrinkage characteristics (high specifc gravity) low tension perpendicular-to-grain strength, or high ratios of tangential to radial shrinkage are expected to check badly. This was generally observed in this study (Table 9). Lodgepole pine, jackpine and southern yellow pine generally had the best checking characteristics. High density Douglas-fir and larch poles were rated moderate to heavy in checking. Western red cedar and red pine poles have high ratios of tangential to radial shrinkage, and were also rated moderate to heavy. Spruce poles checked severely, as reported by others (14, 15) as expected from its high ratio of tangential to radial shrinkage.

4.4.2 Wood Preservative Effects

Where possible, the checking characteristics for similar poles were compared for penta-in-oil treatments and waterborne treatments (Table 10). Although the data are limited, it appears that waterborne preservative treated poles check worse than oil borne preservative treated poles. Checks are generally wider, deeper and extend into the groundline more often with waterborne treatments. This is consistent with findings of other investigations (16, 17).

4.4.3 Kerfing Effect

Only limited data are available on this pretreatment on ACA treated spruce in service 0-5 years. Kerfing may have reduced checking slightly as checks were usually not as deep and fewer extended into the groundline with kerfed poles. However, the effect was marginal. These poles were only kerfed in the above ground portion to about two feet above the groundline. This may have contributed to its lack of effectiveness in controlling checking.

Table 9

Relationship Between Wood Properties and Observed Checking Characteristics

Species	ST/SR*	Basic Specific Gravity	Tension ⊥ Grain (PS2)	Observed Checking
Western Red Cedar	2.14	0.31	210	Moderate to heavy
Red Pine	1.70	0.39	510	Moderate to heavy
Jack Pine	1.48	0.42	530	Light to moderate
Lodgepole Pine	1.45	0.40	550	Light to moderate
Southern Yellow Pine	1.44	0.42-0.58	380-570	Light
Douglas-fir	1.58	0.45	440	Moderate to heavy
Western Larch	1.75	0.55	520	Moderate to heavy
White Spruce	2.16	0.35	480	Moderate to heavy

* ratio of tangential to radial shrinkage

Table 10

Effect of Preservative on Pole Checking

Species	Location	Preservative	Age	Checking Class % of Total Light	Mod.	Heavy	% of Poles with Checks 5mm wide	25mm deep	into groundline
Red Pine	East	CCA	0-5	25	75	0	62	88	0
		Penta	0-5	30	70	0	0	0	0
		CCA	6-10	0	100	0	30	90	10
		Penta	6-10	0	100	0	0	40	0
Red Pine	Central	CCA	0-5	40	60	-	90	90	30
		Penta	0-5	100	0	0	0	30	0
WRC	West	ACA	0-5	50	50	0	80	100	10
		Penta	0-5	90	10	0	20	90	0
		ACA	6-10	30	70	0	100	100	30
		Penta	6-10	70	30	0	70	80	10

5. FUNGAL ISOLATIONS

Fungi were isolated from more than half (366) of the 710 poles sampled. Most were fungi imperfecti which generally do not degrade wood significantly. Basidiomycete or true wood rotting fungi were identified in only five poles:

two Douglas-fir (penta) 25-30 years in service;
one white spruce (Penta-MC) 6-10 years in service;
one red pine pole (CCA) 0-5 years in service;
and one western red cedar pole (Creosote) 16-20 years in service.

Douglas-fir poles have long been recognized as susceptible to interior decay because of their thin sapwood, non durable heartwood and propensity to check. It is not surprising that a spruce pole had a wood rotter in the interior; it too has thin sapwood, low durability and a tendency to check. It is interesting that two of the other poles in this same line were infested with carpenter ants, the only two poles with carpenter ants identified in the entire study.

It is clear that if spruce and Douglas fir poles are used, internal treatments with fumigants will have to be considered.

The presence of a basidiomycete in the very young CCA-treated red pine pole suggests that it could have resulted from pretreatment infection which was not sterilized by the low temperature CCA treatment. This effect was noted by Zabel et al in a recent study in Eastern U.S.A. (14).

Non decay fungi, such as Fungi imperfecti occasionally were found in very young poles but generally increased in frequency with age of the poles. Future inspections and analysis of fungal populations will determine if these fungi are eventually succeeded by true wood rotting fungi or Basidiomycetes.

6. SUMMARY

710 poles representing 76 combinations of pole species, preservative treatment, pole age and geographical location were inspected and analysed for physical condition, surface preservative loading above and below grade and fungal population in the pole at the groundline.

These data provide a baseline against which the condition of the same poles can be compared at future inspections. It is hoped that new lines representing different combinations of pole species, treatement and location will be added to the data base in the future.

This preliminary study provided considerable information on effects of preservative, pole species and location on performance.

1. Preservative analyses suggests that preservative depletion depends on the preservative chemical and method of treatment and on the location of the pole lines. Pentachlorophenol levels at the surface of poles treated with penta-in-oil reach critical levels below grade in 15-25 years, with most rapid depletion in poles in the central region. Poles treated by the Cellon or penta-methylene chloride process were even more rapidly depleted below grade. Penta-MC poles located in swampy terrain had significantly greater penta losses below grade than poles located in well drained sites. ACA treated poles had significant below grade depletion, especially in poles placed in coastal B.C. areas. Arsenic was preferentially leached from the poles.

2. There was evidence that signficant migration of penta-in-oil down the pole occurs.

3. Pole species with high tangential to radial shrinkage factors tended to check wider and deeper. Spruce, Douglas-fir, cedar, larch and red pine had the worst checking characteristics.

4. Penta-in-oil treatments appeared to inhibit checking compared to CCA treatments.

5. Kerfing of ACA-treated spruce poles did not significantly improve their checking characteristics.

6. Non-decaying fungi were isolated in many poles, especially those that were in service several years. Decay fungi were isolated in only a few poles.

7. The isolation of a basidiomycete in a newly installed CCA-treated red pine pole suggests that pre-treatment infection was responsible for its presence.

7. REFERENCES

1. Canadian Standards Association. 1983. CSA 080-M1983 Wood Preservation. Standard 080.40M "Preservative treatments of poles by pressure process".

2. Doolittle, F.B. 1954. "Evaluation of service life justifies more desireable poles". Proc. AWPA. 50: 224-230.

3. Quayle, J.C. 1975. "Analysis of service life experiences of wood poles". Proc. AWPA 71:53-59.

4. Rural Electrification Administration. 1973. "Pole performance study" - Staff Report (Electric) USDA - REA.

5. Lumsden, G.Q. 1952. "A quarter century of evaluation of wood preservatives in poles and posts at the Golfport test plot". Proc. AWPA 48:27-47.

6. Walters, C.S. and R.D. Arsenault. 1971. "The concentration and distribution of pentachlorophenol in pressure-treated pine pole stubs after exposure". Proc. AWPA 67:149-169.

7. Scheffer, T.C. 1971. "A climate index for estimating potential for decay in wood structures above ground". Forest Prod. J. 21(10): 25-31.

8. American Wood-Preservers' Association. 1983. Book of Standards. Standard A5-83 "Analysis of Oil-borne Preservatives".

9. Meyer, J.A. and J.F. Siau. 1972. "Neutron activation analysis of copper, chromium and arsenic in wood". Wood Science. 5(2): 147-152.

10. Arsenault, R.D. 1973. "Factors influencing the effectiveness of preservative systems". Wood Deterioration and Its Prevention by Preservative Treatments. Ed. by D.D. Nicholas. Syracuse University Press, Syracuse, N.Y.

11. Davies, D.L. 1971. "Durability of poles treated with penta in LP gas system". Proc. AWPA 67:37-46.

12. Rak, J. and H.H. Unligil. 1978. "Fungicidal efficacy of ammoniacal copper and zinc arsenic preservatives tested by soil block cultures". Wood and Fiber 9(4).

13. Cech, M.Y., F. Pfaff and D.R. Huffman. 1974. "The CCA retention and disporportioning in white spruce". Forest Prod. J. 24(7): 26-32.

14. Hennig, W.M., 1981. Personal communication. Construction Standards Engineer, Alberta Power Ltd. Edmonton, Alberta.

15. Unligil, H.H. 1979. "Investigations of the treating characteristics and performance under subsequent service of eastern spruce poles preserved under plant conditions". Progress report presented to C.E.A. Forintek Canada Corp. Eastern Laboratory.

16. Gilfedder, J., W.G. Keating and I. Robertson. 1968. "Influence of certain preservatives on pole splitting". Forest Prod. J. 18(1) 28-30.

17. Selbo, M.L. 1964. "Ten-year exposure of laminated beam treated with oil-borne and waterborne preservatives". Forest Prod. J. 14(11): 517-520.

18. Zabel, R.A., A.M. Kenderes and F.F. Lombard. 1980. "Fungi associated with decay in treated Douglas-fir transmission poles in the Northeastern United States." Forest Prod. J. 30(4):51-56.