CCA-PEG POLE PRESERVATIVE RESEARCH

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MODIFICATION OF A WATERBORNE POLE PRESERVATIVE TREATMENT

ABSTRACT

This paper describes the research performed by Bell-Northern Research and Bell Canada in the modification of a 2.5% water solution of CCA-C (Chromated Copper Arsenic - type C) used in the pressure treatment of utility pole stock to mitigate the perceived hardening and checking tendencies of such treatment. Laboratory and field tests indicate that an additional of 4% polyethylene glycol (mol. wt 1000) reduces the checking of the treated sample poles (southern yellow pine, red pine and jack pine) and generally renders the treated pole surface less resistant to gaff insertion than the surface of the untreated pole. This modification of the pole surface is accomplished without alteration of the treated poles; corrosion, flammability, and electrical conductivity when compared to those same properties of the straight CCA-C treatment.

KEY WORDS

Chromated Copper Arsenic Preservative (CCA-C), Climbability, Moisture Content, Flammability, Smoke Generation, Electrical Resistance, Corrosivity to Metals, Fungus Resistance, Pilodyn Penetration, Polyethylene Glycol (PEG) 1000.

INTRODUCTION

In 1982, Bell Canada and Bell-Northern Research (BNR) designed and initiated a research program to investigate the modification of the CCA-C waterborne preservative treatment of poles. This activity was initiated in response to references in Bell Canada field reports describing the craftsmen's perceptions that CCA-C treated poles were more resistant to climbing gaff penetration than other preservative treated poles, such as penta-oil pressure-treated or butt-treated creosote poles. Bell Canada and BNR decided to investigate the modification of CCA-C solution rather than switch to other preservative treatments because the CCA-C treatment endowed these poles with property values that were most desired by Bell Canada (e.g. low corrosivity, good flammability and smoke generating properties, good electrical resistance, high fungicidal efficiency and longevity, and no "staining" and "leaching"). The purpose of this paper is to provide an overview of the research work that has been done by Bell Canada and BNR to overcome this perception of difficult gaff penetration on the part of craftsmen (climbers).

MATERIALS AND METHODS

All preservative experiments were performed on standard pole stock supplied by Bell Canada or other commercial suppliers. When four foot lengths of poles were used, the ends were sealed with an epoxy to minimize longitudinal penetration of the preservative. The poles were treated using a commercial concentrate of CCA-C diluted to 2.5% with water and appropriate concentrations of PEG 1000 or other modifiers. The preservative system was impregnated in the pole samples using a full cell pressure process at a pH of 1.9 or less and at a temperature of 75°F (23°C) or less.

Hardness or penetration tests were performed using a Pilodyn impact hammer with a 6 joule spring to exert the force on a 2.5 mm diameter blunt end probe. The other penetration test was performed on a MTS programmed mechanical property tester using a 2.5 mm diameter nail with a strain rate of 25 mm/min.

The other property tests (i.e. fungus resistance, flammability and smoke generation, electrical resistance and corrosivity) were performed by Eastern Forest Products Laboratory (Forintek). This facility is an acknowledged centre of excellence in North American in forest products research and so was utilized for their equipment and expertise to perform the tests according to accepted North Americans standards.

Wood Species Studied

Three pole species have been employed throughout this research program; namely: red pine (Pinus resinosa), jack pine (Pinus banksiana), and southern yellow pine (slash-Pinus elliotti, etc.). The first two species, red pine and jack pine are extensively grown in Central and Eastern Canada. Southern yellow pine is, of course, grown in the United States and has been included because of its excellent potential as pole stock.

Additives Studied

Modification of the pole to aid gaff insertion was examined and divided into three modes of approach. These modes were: (1) gaff lubricants, (2) retardation of the chemical reaction of the wood by the preservatives, and (3) plasticizing the wood matrix of the pole. Some of the chemical materials that relate to the modes are listed below:

1. Lubricants:
   - Silicones
   - Fluoropolymers ("Teflon type")
   - Waxes (Carnauba)
   - Fatty Acids
   - Fatty Alcohols
   - Soaps

2. Chemical Action Retarders:
   - Chelates
   - Chrome Fatty Acid Esters
   - Reduced Chrome CCA

3. Wood Plasticizers:
   - Polyhydric Alcohols
   - Fatty Acid Esters
   - Polyethylene Glycols

All additives, except those listed in Table 1, caused immediate precipitation of solids in the CCA-C working solution at all temperature and pH conditions within one hour of mixing. Those materials that demonstrated acceptable solution stability (24 hours in 2.5% CCA solution at 23°C) were used in the pressure treatment of 4 foot red pine bolts. The treatments are itemized in Table 1 long with a programmed Mechanical Testing System (MTS) and Pilodyn penetration results (test methods described in Section II). Pilodyn hardness and force to 25 mm penetration indicate why polyethylene glycol (PEG) 1000 and its homologs were designated for further research.

Optimization of PEG

Further research into the properties of polyethylene glycols of molecular weights other than 1000 indicated that glycols of lower weights (500, 750 etc.) tended to react at a faster rate with the CCA-C. They did not stay in the pole matrix as well with water leaching, although higher Pilodyn penetrations were obtained. Glycols with higher molecular weights did not penetrate into red pine as well as PEG 1000.

Measuring the amount of PEG 1000 in the treated poles and also in the residual solution in the pressure reactor demonstrated that a PEG construction of 4 to 5% was the most efficient. Further exploratory studies with southern yellow pine and jack pine indicated that a standard 2.5% CCA-C Working Solution with 4% PEG 1000 was the most appropriate combined chemical system for the wood species to be evaluated.

Fungicidal Properties

The standard soil block tests (AWPA M10 or ASTM D1413) were performed by Eastern Forest Products Laboratory of Canada (Forintek) to assess the effectiveness of the preservative in protecting the wood from various types of fungi. Both "leached" and unleached samples of CCA-C and CCA-C/PEG were exposed to the following fungi: Lenzites trabea, Poria monticola and Coniophora puteana.

Flammability and Smoke Generation

Flammability testing was conducted to evaluate several combustion properties of the CCA/PEG treated wood. The properties tested were the crib test for mass loss and heat generation (ASTM standard E-160), smoke generation (ASTM standard E-662) and flame spread tests using a fire tunnel.

Electrical Resistance

The DC electrical resistance was determined on fifteen sets of five end-matched 25.4 mm x 25.4 mm x 762 mm samples cut from the sapwood portion of each of the three species. Each test sample was fitted with a pair of stainless steel electrodes (11 gauge, 50 mm long, T316 alloy common nails) having a 660 mm span between electrodes. The DC electrical resistance of the samples was measured on three different occasions by subjecting them to a constant DC voltage and monitoring the resulting current flow.

The moisture content of the samples, shown on Figure 1, was measured in the 20 to 26% range. The test atmospheric condition was set at 70°F (23°C) and 90% RH.

Corrosivity to Metals

The corrosivity effects of the various wood treatments on metals typically associated with pole attachment hardware were determined in an accelerated manner. The corrosion test was conducted by sandwiching a sheet sample of the test material between two wetted blocks of wood that were untreated, treated with CCA or treated with CCA/PEG at different concentrations of PEG; another corrosion test was conducted by burying the metal samples in moisture laden wood particles also treated with varying concentrations of CCA/PEG which had been ground to 40 mesh. Both tests were conducted for 28 days at 50°C. The metal coupons tested consisted of: aluminum, copper, mild steel and galvanized steel.

ANALYSIS AND RESULTS

Fungicidal Properties

Bell and BNR contracted Forintek to conduct and interpret the soil block tests described above. Forintek concluded that the modification of the CCA-C by addition of polyethylene glycol did not affect the CCA-C fungicidal properties. Stake tests are now being installed to confirm this conclusion.

Flammability and Smoke Generation

Forintek also conducted these tests for BNR-Bell. The results of the tests described previously indicated that the addition of polyethylene glycol (PEG 1000) neither enhanced nor diminished the fire related properties of the CCA-C treated wood.

Electrical Resistance

The results of the electrical resistance tests described before performed by Forintek demonstrated the electrical resistance of the CCA/PEG treated wood at the recommended concentration of PEG (4.0%) to be slightly less than the electrical resistance of the sample of the respective species of untreated sapwood at 22% moisture content (see Figure 1). The scientists at Forintek could not determine if the decrease in electrical resistance was due to the PEG itself or the fact that CCA/PEG held more water in the sapwood than the unmodified CCA treatment. Tests determined that the average resistance range at 22% moisture content of wood treated with CCA-C was 20-25 megohms, of CCA/PEG was 10-15 megohms and untreated pine was 12-16 megohms. All three resistance ranges are typical of pine sapwood with moisture content of 22%.

Corrosivity to Metals

The addition of PEG to the CCA did not alter the corrosivity to galvanized steel or copper. There was some visual indication that the addition of PEG to CCA did increase the corrosivity to aluminum and mild steel; however, the visual change was barely detectable and there was no change of weight associated with the visual change. There was no consistent, defineable trend of corrosion associated to the PEG concentration or exposure time in the sample domain investigated. The researchers (Forintek, Bell and BNR) decided that results of the tests demonstrated that the corrosion effect by the addition of PEG was at worst (best) minimal). The mass loss data derived from this test is shown in Table 2.

<u>Penetration of CCA-PEG</u>

Analysis of laboratory pressure treated roundwood bolts demonstrated that the addition of PEG does not diminish the penetrability of the CCA-C into the wood matrix. Analysis of the treated wood also demonstrated that the addition of the PEG did not change the distribution of the chrome, copper and arsenic ions within the penetration domain from that of the distribution of CCA-C. The treatment (schedule, process and materials) was the same for the CCA-C and all CCA-C/PEG solutions and did not differ significantly from the treatment process used by the industry. The penetration of the PEG was determined on a cross sectional sample of red pine. Visual examination indicated that PEG penetration occurs only when the moisture content is below the fiber saturation concentration (preferred MC is 25%) and sapwood is available for penetration. Jack pine samples did not show penetration in all areas because the sapwood was completely removed in the tapering process. Whether the depth of penetration of PEG is regulated by wood porosity, moisture content or both will be determined in later experiments.

PILODYN DATA ANALYSIS

Pilodyn tests show favourable results in the ability of CCA/PEG to soften the outer shell of the poles.

Data collected in 1983 showed a definite increase in Pilodyn penetration for red pine and jack pine over standard CCA treated poles. With respect to southern yellow pine, no statistically significant softening was found. It should be mentioned, however, that few readings of southern yellow pine (SYP) CCA poles were available for comparison to CCA-PEG since Bell Canada has very few SYP-CCA poles in service.

1984 Pilodyn radings (N), taken from eight poles of each species "before" and "after" treatment, are summarized in Table 3. Three Pilodyn readings were taken at each pole location, 10 inches from the butt, mid-length, and 6 inches from the top.

Generally, the Pilodyn readings tend to follow the moisture content within the individual sample domain (untreated, CCA, CCA/PEG). It should be recognized that Pilodyn means of "well seasoned" CCA-C red pine, jack pine and southern yellow pine poles have been recorded at 13.9, 13.3 and 10.7 mm, respectively.[1]

Pilodyn testing and climbing trials of CCA-PEG poles confirmed our lab results; however, the sample sizes, especially those of southern yellow pine, were limited. Further tests, using a larger sample size and in climatic conditions other than Eastern Canada will be conducted to confirm the results of tests conducted so far by Bell Canada and BNR.

Soil block tests indicate that the addition of PEG to CCA does not significantly affect the fungicidal activity or permanence of the CCA preservative treatment. Additionally, stakes have been prepared, incorporating the PEG and the various CCA-C treatments for exposure in two Canadian and two U.S. sites to corroborate the lab tests.

1 BNR Technical Letter - TL-83-0487

ACKNOWLEDGEMENT

We have attempted, through this paper, to present an overview of the type of research that is continually being done by Bell Canada and Bell-Northern Research (BNR) on an outside plant structures problem that is plaguing all North American Utilities. We are grateful to have had this opportunity to present our program. We would like to thank all of the engineers and managers of Bell, BNR and TDL for their continued support of this research program. We especially thank Cheryl Maritan of BNR for her work in the product development, Jeff Harrott of Bell Canada for his work to complete the field trials and Clifford Ralph of Forintek for his assistance in preparing the first samples of the CCA-PEG system and the evaluation of the results.

TABLE 1

Assessment of Hardness Characteristics of Treated Wood Poles

MTS Loads at 25 mm Penetration vs. Penetration at 6 Joules (Pilodyn)

LOG # AND PRESERVATIVE	16% RH @ 23°C		23% RH @ 37°C		40% RH @ 16°C		32% RH @ 16°C		0% RH @ -20°C	
	MTS Kg LOAD	PM mm	MTS Kg LOAD	PM mm	MTS Kg LOAD	PM mm	MTS Kg LOAD	PM mm	MTS Kg LOAD	PM mm
38-CCA-C QUILON S	69.2	12	72.2	11	91.4	10	79.5	9	114.6	9
48-CCA-C QUILON M	66.6	11	84.3	10	92.3	9	79.4	9	104.5	10
6G-CCA-C 1/2 LESS CR	65.4	10	80.4	10	91.6	10	86.2	10	104.7	9
78-CCA-C 10% PEG 1000	45.8	16	44.8	15	46.8	14	48.7	15	56.3	12
9B-CCA TYPE C+2A1 DOWFAX	80.1	11	77.2	12	87.4	11	85.7	10	101.8	10
11B-CCA TYPE C	81.5	11	69.9	11	93.6	10	88.2	10	99.7	10
2B-UNTREATED	81.5	11	55.3	12	—	-	—	-	—	-
5B-UNTREATED	74.5	11	65.1	11	86.6	11	—	-	90.5	10
8B-UNTREATED	72.8	11	61.3	11	79.1	12	84.9	11	—	-

TABLE 2

Mass Loss due to Corrosion (%)

Material	Treatment %CCA	Treatment %PEG	Galvanized Steel block	Galvanized Steel particles	Aluminum block	Aluminum particles	Copper block	Copper particles	Steel block	Steel particles
Red Pine	0	0	0.9	0.6	+0.2*	0.6	0	0	1.7	2.0
	0	2.5	0.8	0.7	+0.2	0.4	+0.1	0.1	1.2	1.4
	0	4.0	1.1	0.7	+0.2	8.0	0.1	1.4	2.5	54.7
	0	10.0	1.3	0.6	+0.4	2.0	0.1	0	2.1	2.4
	1.0	0	0.9	1.5	2.2	0.3	0	0	3.6	1.1
	1.0	2.5	0.9	0.5	4.5	+4.0	0.1	0	2.7	1.1
	1.0	4.0	0.7	0.7	0.5	+4.1	0	0.4	2.8	1.0
	1.0	10.0	0.8	0.8	1.8	+0.9	0.2	0.2	2.1	1.0
	2.5	0	1.0	1.8	3.2	+4.2	+0.1	+0.1	5.5	3.3
	2.5	2.5	1.1	1.3	4.2	4.3	0	0.2	3.2	1.7
	2.5	4.0	1.5	2.2	4.8	7.0	0	0	4.7	2.1
	2.5	10.0	1.0	6.6	4.8	39.6	0	6.9	3.3	2.0
Jack Pine	0	0	0.6	0.4	0	0.7	0.1	0	7.6	1.0
	0	2.5	0.3	0.4	+0.1	1.1	0.1	0.1	+1.3	0.8
	0	4.0	0.3	0.7	+0.5	6.1	0.1	0	0.9	2.0
	0	10.0	0.3	0.5	+0.3	1.6	+0.1	0	1.0	1.2
	1.0	0	0.5	1.1	0.4	1.3	0	0.1	3.0	+0.2
	1.0	2.5	0.4	1.1	2.9	1.7	0.1	0.1	1.3	0.9
	1.0	4.0	0.5	1.2	3.2	0.1	0.2	0.9	1.1	1.1
	1.0	10.0	0.4	1.1	1.2	1.3	0	0.2	1.3	0
	2.5	0	0.9	1.1	1.1	+2.0	0	0	2.2	1.7
	2.5	2.5	0.4	1.5	2.9	0.5	0.2	0.1	1.3	1.4
	2.5	4.0	0.7	2.4	3.5	2.2	0	0.2	2.7	18.2
	2.5	10.0	0.6	1.7	2.9	1.0	0.3	0.2	3.3	1.5
Southern Yellow Pine	0	0	0.3	0.5	0.3	0.6	+0.5	0	1.1	1.1
	0	2.5	0.6	0.6	0.4	0.7	0.1	0	1.8	1.4
	0	4.0	0.5	0.6	+0.4	0.9	0.1	0.1	1.2	1.7
	0	10.0	0.4	0.5	+0.3	2.6	0.2	1.3	1.3	21.7
	1.0	0	0.6	1.3	1.0	+0.4	0	0.1	3.1	1.2
	1.0	2.5	0.6	1.2	3.7	2.2	0.3	5.2	2.3	0.9
	1.0	4.0	0.9	1.4	3.6	0.4	0.1	0.2	1.6	1.8
	1.0	10.0	0.8	1.2	2.9	0	0.1	0.3	1.5	0.3
	2.5	0	0.9	1.6	2.0	+1.9	0.1	0.2	2.5	2.0
	2.5	2.5	1.4	1.2	3.7	2.1	0.1	0.1	2.7	1.3
	2.5	4.0	0.8	1.7	3.4	0.6	0.1	0.1	2.0	1.5
	2.5	10.0	0.6	1.3	3.6	0.2	+0.6	0.2	3.5	1.2

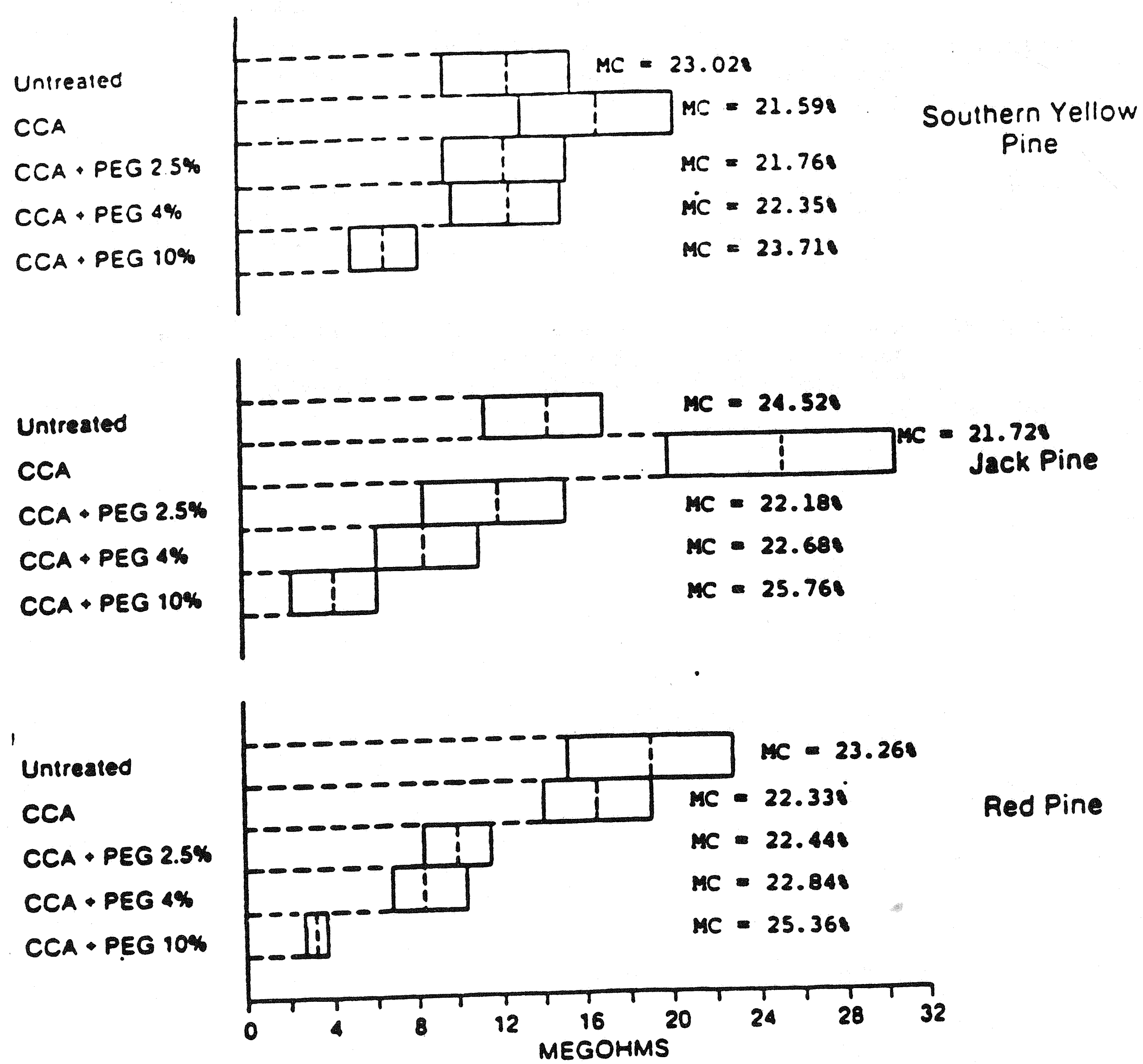
* Mass gain where + shown

TABLE 3

Pilodyn Data Analysis

Treatment	Species	N	Pilodyn Range	Mean	Moisture Content	No. of Poles
Untreated	Red Pine	72	14.8-18.1	16.1	30-50%	8
	Jack Pine	72	13.0-19.1	15.6	20-30%	8
	S.Y. Pine	72	10.9-15.9	13.3	30-50%	8
CCA-C	Red Pine	36	13.4-15.0	14.2	30-50%	4
	Jack Pine	36	11.4-14.2	13.2	20-30%	4
	S.Y. Pine	36	11.6-12.6	12.0	30-50%	4
CCA-C/PEG	Red Pine	36	14.6-18.9	17.2	40-50%	4
	Jack Pine	36	13.4-19.0	15.6	25-40%	4
	S.Y. Pine	36	10.1-12.2	11.4	35-45%	4

Figure 1: Average resistance of each treatment and each species



MC = Moisture Content

FIGURE 2 – CLIMBING TRIALS FEB.'84

SPECIES (All Companies)

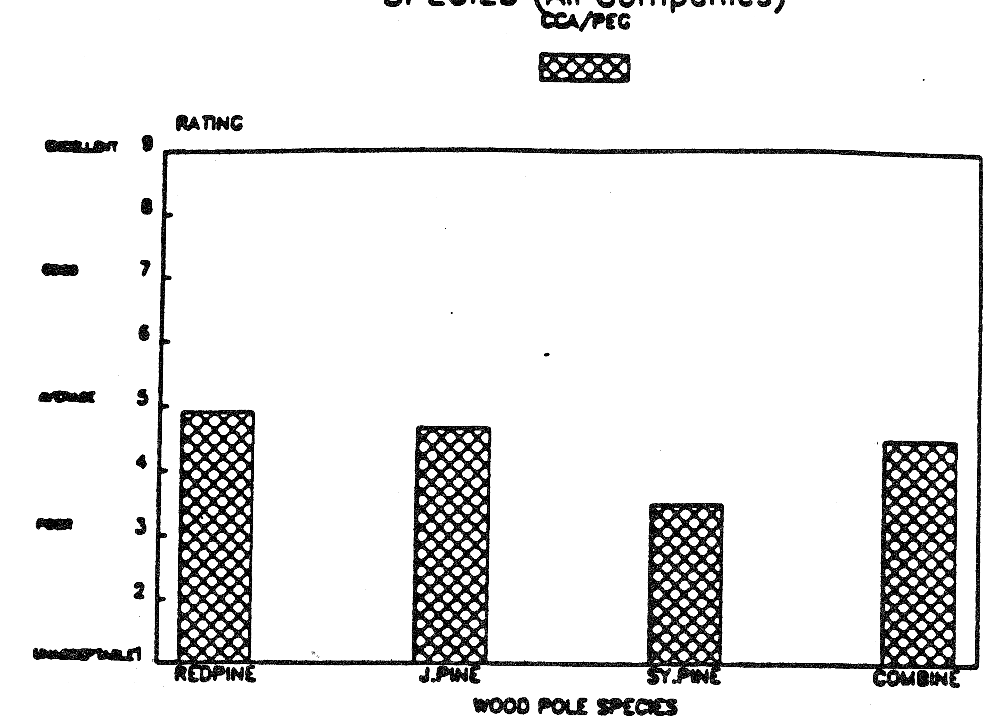


FIGURE 3 – CLIMBING TRIALS SEPT.'84

SPECIES & PRESERVATIVE (All Companies)