CCA/OIL FOR NORTHERN SPECIES

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INTRODUCTION

In recent years, Hickson Corporation introduced their newly developed CCA/OIL "Wolman^R ET^{TM}" treatment for wood utility poles[1-3]. Information was presented on the development and performance characteristics of CCA/OIL for southern yellow pine and since the introduction of ET, its use and acceptance in the United States has increased steadily.

Recently, Canadian utilities have shown interest in this product and some preliminary experimental work with a few northern species gave acceptable results. To broaden this work, pilot tests were done on lodgepole pine and Douglas-fir with a one-step process as well as lodgepole and jack pine with a two-step process. Red pine was treated with a two-step process in a commercial plant.

In addition, information is presented on current developments and product characteristics of CCA/OIL treated utility poles. This work has mainly been conducted on southern yellow pine poles but has direct implications for the northern wood species as well.

EXPERIMENTAL

Pilot Plant Trials - One Step

Experimental work was conducted using a computerized 1x3.7 m (3x12 ft) treating cylinder at Conley, GA. Samples of lodgepole pine and Douglas-fir were marked for end-matching and sawn in half. Before treatment, the end grain was sealed to minimize variability and penetration.

Initially, two charges were treated with 2% CCA solution to provide control matched samples. CCA/OIL charges were then treated using low (~0.5%), then medium (~0.75%), and finally high (~1%) oil concentrations.

The following treating cycle was used on all but the final charge where the pressure time was extended from two to three hours.

Task	Press/Vacuum	Time
Initial Vac.	533 mm/hg (21 in/hg)	30 min
Vacuum Fill	533 kPa (21 in/hg)	2 min
Raise Pressure	1100 kPa (160 psi)	1 min
Hold Pressure	1100 kPa (160 psi)	120 min
Rel. Pressure	100 kPa (15 psi)	15 min
Blow Back	----	3 min
Final Vac.	610 mm/hg (24 in/hg)	45 min

Injection data was collected using computerized data acquisition equipment adapted to the treating system computer. Curves were developed using a sapwood basis because of variation in heartwood content between charges.

After treatment each sample was sawn approximately 30 cm (12 in) from the end for penetration assessment. Each charge was assayed for oil content and retention data was obtained by weight measurements taken before and after treatment. Additionally, boring cores were taken from each charge for visual confirmation of oil penetration.

Pilot Plant Trials - Two Step

Test Procedure

Similarly, the treatability of jack pine and lodgepole pine pole stubs with CCA/OIL was determined using a two step process. Charges of jack pine and lodgepole pine were treated first with a modified full cell cycle for the CCA portion, then by a short full cell cycle with a high concentration of oil emulsion.

Task	Press/Vacuum	Time
TYPICAL JACK PINE		
CCA		
Initial Vacuum	381 mm/hg (15 in/hg)	10 min
Raise/Hold Pressure	1035 kPa (150 psi)	60 min
Release/Empty	100 kPa (to 15 psi)	10 min
Final Vacuum	685 mm/hg (27 in/hg)	90 min
OIL EMULSION		
Initial Vacuum	685 mm/hg (27 in/hg)	30 min
Raise/Hold Pressure	1035 kPa (150 psi)	30 min
Final Vacuum	508 mm/hg (20 in/hg)	30 min

TYPICAL LODGEPOLE

CCA

Initial Vacuum	457 mm/hg (18 in/hg)	40 min
Raise/Hold Pressure	965 kPa (140 psi)	120 min
Release/Empty	100 kPa (to 15 psi)	20 min
Final Vacuum	685 mm/hg (27 in/hg)	90 min

OIL EMULSION

Initial Vacuum	685 mm/hg (27 in/hg)	25 min
Raise/Hold Pressure	965 kPa (140 psi)	70 min
Release/Empty	100 kPa (to 15 psi)	10 min
Final Vacuum	533 mm/hg (21 in/hg)	25 min

Commercial Plant Trial - Two Step

The commercial plant trial of red pine poles with the CCA/OIL was done at Southern Wood Preserving of Hattiesburg, MS. The charge consisted of 36 poles with 33 being Class 4 and 3 being Class 3. The moisture contents of the Class 3 were over 28% in the 7.5-10 cm (3-4 in) zone (next to the heartwood), but the Class 4 were below 28%, in the 5.0-7.5 cm (2-3 in) zone (also next to the heartwood). The treating cycle was:

	Task	Press/Vacuum	Time
CCA			
	Initial Vacuum	381 mm/hg (15 in/hg)	15 min
	Vacuum Fill	---	15 min
	Raise/Hold Pressure	1100 kPa (160 psi)	30 min
	Release/Empty	---	25 min
	Final Vacuum	432 mm/hg (17 in/hg)	120 min
OIL EMULSION			
	Initial Vacuum	685 mm/hg (27 in/hg)	60 min
	Vacuum Fill	---	15 min
	Raise/Hold Pressure	1100 kPa (160 psi)	5 min
	Release/Empty	---	20 min
	Final Vacuum	500 mm/hg (20 in/hg)	60 min

RESULTS AND DISCUSSION

Pilot Plant Trials - One Step

The CCA/OIL treatments on lodgepole pine with low and medium oil had similar solution retentions and penetration in comparison to regular CCA (Table 1). For example, the average net solution retentions for the two charges of CCA were 398 kg/m^3 (24.7 pcf) and 372 kg/m^3 (23.1 pcf). In comparison, the low and medium CCA/OIL treatments were 353 kg/m^3 (21.9 pcf) and 314 kg/m^3 (19.5 pcf), respectively. If these retentions are adjusted based on the sapwood content of the poles, the retentions are 594 kg/m^3 (36.9 pcf) and 609 kg/m^3 (37.8 pcf) for CCA and 623 kg/m^3 (38.7 pcf) and 572 kg/m^3 (35.5 pcf) for the two oil retentions. In addition, the sapwood penetration for the lodgepole in all of these charges was 100% (Table 2).

In contrast to the lodgepole pine, the Douglas-fir samples had poor penetrations (Table 2) when treated with either CCA or CCA/OIL.

At the high CCA/OIL concentration, the solution retention and penetration was affected. Net solution retention on the first charge of this oil concentration was 354 kg/m^3 (22.0 pcf) or 507 kg/m^3 (31.5 pcf) when based on the sapwood portion of the poles sections. This amounts to about a 16% reduction in net injection. Penetration on 3 of the 4 pole sections met specifications. However, the penetration was lighter in areas and appeared somewhat spotty.

In contrast, the second charge of high oil was treated using an extended 3 hour press period. This charge had very good penetration and higher solution retentions (see Tables 1 and 2). This would indicate that concentration effects can be mitigated by cycle modifications.

Pilodyn readings were taken after treatment to measure the hardness of the poles. Initially, the pilodyn readings were slightly higher on the CCA/OIL treated poles (Table 3). As these poles aged and dried to 20-25%, the CCA/OIL maintained readings well over 13 mm.

The amount of oil in the poles were determined by the gauge retention and by assay (Table 4). Oil gauge retentions ranged from 1.3 to 4.2 kg/m^3 (0.08 to 0.26 pcf) based on the total cubic footage and 2.4 to 7.25 kg/m^3 (0.15 to 0.45 pcf) on a sapwood basis. Oil retentions in the outer 1.25 cm (1/2 in) zone of the poles were also determined by methylene chloride extraction. They ranged between 0.32 to 14.3 kg/m^3 (0.02 to 0.89 pcf), illustrating the heavier loading (or stacking) in this zone. Unfortunately, assays at the lower retentions are difficult to perform and these appear lower than expected. This may be an analytical error.

Boring cores were taken from each sample in every charge for visual verification of oil penetration. The penetrated portion of each boring was cut into 0.625 cm (1/4 in) segments and squeezed starting with the heartwood portion. When the segment produced oil, this was regarded as the depth of oil penetration (see Table 5).

The two high oil charges show good penetration depths of 2-5 cm (3/4-2 in). It is thought that the shallow penetration of the low and medium charges were due to the fact that 8 to 10 days passed between treatment and testing which allowed the pole sections to dry out making the emulsion hard to detect and also the lower concentrations make it difficult to "squeeze" out oil for detection.

Injection curves indicate that up to medium oil contents do not significantly affect solution uptake (Figure 1). However, at the high oil content, a drop off of about 20% occurred. However, as noted before, extra press time can compensate for the drop in rates when using higher oil levels.

Pilot Plant Tests - Two Step

For the two step treatment, pole stubs were first treated with CCA and then with oil emulsion. The average net CCA solution retention for the jack pine pole sections was 203 kg/m^3 (12.6 pcf) (Table 6). The oil pickups in the jack pine with a 17% oil solution ranged from 22.5 to 188 kg/m^3 (1.4 to 11.7 pcf) with a 78.9 kg/m^3 (4.9 pcf) average net oil solution retention. The variability was attributed to the differing amounts of sapwood in the pole sections.

The oil retention in the outer 1.5 cm (1/2 in) of the pole sections were determined by methylene chloride extraction. In jack pine, the oil retentions by assay ranged from 10.8 to 29.8 kg/m^3 (0.67 to 1.85 pcf).

Similarly, the lodgepole pine poles had a CCA net solution retention that averaged 48 kg/m^3 (9.2 pcf) (Table 6). The oil pickups had an average net solution retention of 27.4 kg/m^3 (1.7 pcf). The amount of oil in the outer 1.25 cm (1/2 in) of the lodgepole pine poles averaged 7.4 kg/m^3 (0.46 pcf) with little variation.

As a benchmark, one charge of lodgepole was treated just with the ET oil and no CCA. This pole had a net solution retention of 67.6 kg/m^3 (4.2 pcf) which translates to 18.5 kg/m^3 (1.15 pcf) oil by gauge. The assay was 26.6 kg/m^3 (1.65 pcf) oil in the outer 1.25 cm (1/2 in) of the pole. This represents the maximum amount of oil that could be expected in a lodgepole pine pole. Therefore, only about 1/2 of the possible oil is capable of being injected with a two step process.

The pilodyn readings for the jack pine poles averaged 15-16 mm and were consistent over time as the poles dried (Table 7). Pilodyn readings for the lodgepole pine were similar to the jack pine.

Commercial Plant Trial - Two Step

The results of the commercial test on red pine were a CCA gauge retention of 8.9 kg/m^3 (0.55 pcf) with a assay of 11.4 kg/m^3 (0.71 pcf) CCA. Penetration was 95% - 100% in the Class 4 poles and 85% - 90% in the Class 3 poles. These CCA results were achieved with a treating cycle similar to those for SYP. The oil results showed that red pine takes the emulsion rapidly and a gauge retention of 6.9 kg/m^3 (0.43 pcf) oil with an extraction value of 18.4 kg/m^3 (1.14 pcf) in the outer 1.25 cm (1/2 in).

NORTHERN-SOUTHERN ISSUES

In addition to the above treatment concerns, there are several issues that apply to both Northern and Southern species. These are discussed below.

SPECIFICATIONS

The SYP retention specifications for CCA/OIL are based on extensive climbing trials by various utilities on the 2000 plus poles treated in 1988. The recommended level of oil in the poles has been set at 16.1 kg/m^3 (1.0 pcf) oil in the outer 1.25 cm (1/2 in) of the pole with at least 2.5 cm (1.0 in) of oil penetration. This amount of oil and depth of penetration will ensure that the poles have been adequately treated and that the oil is in the outer portions of the wood where it is needed most for improved climbability. Obviously both the one-step and two-step treating cycles are designed to achieve the desired retention.

The CCA/OIL retentions for lodgepole, jack and red pine reported in this study should give good climbability as well. The red pine is the same as SYP and needs no further discussion. The lodgepole and jack pine retentions were somewhat reduced but should give good climbability considering these species are inherently softer than SYP. Also, the less dense Northern species have less wood fiber to coat than SYP (i.e., the specific gravity is less) and therefore less oil is required.

PATENT APPROVAL

The development of the Wolman® ET™ emulsion was unique because the chemistry of the oil and surfactants made the oil emulsion stable in CCA and provided improved climbing properties to the treated wood. A Canadian patent is pending[4] but U.S.[5] and other patents have been obtained. Hickson has made the technology available to several treaters.

INSTALLATIONS

Beginning in the spring of 1988, CCA/OIL poles have been installed by various utilities in many parts of the eastern United States. The initial 2000 plus poles treated by Koppers Industries and the more recently treated poles have been installed in locations from Florida to Eastern Canada.

The first complete line of CCA/OIL poles was installed by Southern Illinois Power Cooperative in the fall of 1991 near Golconda, Illinois[6]. The 69 KV transmission line stretches for 10.5 km (6.3 miles) and utilizes 110 Class 1 poles ranging in height from 17 to 23 m (55 to 75 ft). These poles were all treated using the CCA/OIL process.

The red pine poles treated by Southern Wood Preserving have since been shipped to Canada and have been installed in Quebec. Information on these poles will be presented as details are available

CLIMBING TRIALS

In our original paper on CCA/OIL we reported on the extensive climbing trials that were done by linemen from various utilities. In these trials, linemen overwhelmingly preferred the CCA/OIL treated poles over regular CCA. Since that time we have continued to conduct climbing trials on the CCA/OIL poles as they have been on exposure and weathered. In one such test, the CCA/OIL poles were climbed after 0, 6, 12, and 24 months exposure. Over the 2 year period several interesting observations were made:

1). Overall, the CCA/OIL poles were always preferred over regular CCA.

2). The grade evaluations of the poles after 2 years were basically the same as they were when the poles were first climbed which demonstrates the permanence and effectiveness of the oil.

A second climbing test or more appropriately a pole climbing survey involving 1400 poles was conducted by a large utility. The average age of the poles in these trials was 1.5 years. The results of this survey demonstrates the improved climbability of the CCA/OIL poles over CCA not only initially but over time. A report and presentation on this survey was given at this year's AWPA meeting in Washington, D.C.[7]

MIGRATION

The oil used in the CCA/OIL system is a high viscosity, lubricating type oil that over time has not shown any visual signs of migration. An analysis was conducted on some of the initial full size CCA/OIL poles that have been exposed vertically for almost 4 years to determine if any migration has taken place. Wood samples were taken from the 0-2.5 cm (0-1 in) zone of the 11 and 12 m (35 and 40 ft) poles at locations 2.5 m (8 ft) from the top, midway to the ground, and 0.6 m (2 ft) above the ground. At each location 4 samples were taken at 90 degree intervals around the pole and composited with samples from three other poles treated to the same oil retention. Three different oil retentions of poles were tested. The oil in the wood was determined by solvent extraction and the relative amounts of oil normalized to the top samples are as follows:

Low retention poles -	top	100 %
	middle	94 %
	bottom	89 %
Medium retention poles -	top	100 %
	middle	82 %
	bottom	100 %
High retention poles -	top	100 %
	middle	102 %
	bottom	99 %

The results of the analyses demonstrated that after 4 years of exposure the oil has not migrated down the pole. Also, the amount of oil obtained in the analysis was similar to what would be expected after the poles were originally treated. The lack of migration explains why the poles are still easier to climb over time as well as initially.

SOIL ANALYSIS

The lack of migration was also confirmed by analyzing the soil around several CCA/OIL poles. The results of total organic carbon analysis from soils near medium and high CCA/OIL poles compared to control soil from, 6 m (20 ft) away showed no oil movement.

	TOC mg/kg
Control	13710
Medium	5910
High	5070

Analysis for CCA components also showed no migration.

WEATHERABILITY

In addition to improving the climbability of poles, the CCA/OIL treated material has shown reduced checking. This property was reported by many early customers who have CCA/OIL poles in exposure. Since these reports, CCA/OIL treated lumber has been tested in outdoor exposure tests. After over one year of exposure the CCA/OIL treated lumber has shown reduced checking in comparison to the CCA control boards. Hickson Corporation will be reporting on the progress of these tests in the near future.

Similarly, poles in Florida are showing reduced checking. It will be interesting to see if the improved weatherability holds for CCA/OIL exposed in Canada.

CONCLUSIONS

These tests show that lodgepole pine treated with one-step CCA/OIL process will meet or exceed appropriate A.W.P.A. specifications. All charges treated would have passed the penetration specifications, but the use of a longer press is necessary in order to insure penetration at the higher emulsion concentration. Douglas-fir trials with either CCA or CCA/OIL gave poor results.

Using the two step process, the jack pine poles treated very readily while the lodgepole pine poles gave marginal results. Basically, the shallow sapwood in lodgepole did not allow sufficient latitude for successful two step, modified full-cell processing. Overall the jack pine poles had oil retentions in the outer 1.25 cm (1/2 in) that were 2 to 4 times higher than the lodgepole pine poles. The jack pine poles had adequate oil for climbability.

The commercial trial on red pine was very satisfactory and the material was acceptable on all properties.

In addition to the successful treating trials, the information on CCA/OIL poles in the U.S. such as oil migration data, climbing trials and other properties provide valuable information on the expected performance of CCA/OIL for Northern species.

Also, it does not appear as if there is any migration of CCA/OIL components either down the pole or into the soil around the pole.

REFERENCES

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TABLE 1

NET SOLUTION RETENTIONS

CCA/OIL LODGEPOLE PINE ONE STEP TREATMENTS

Treatment	Net Solution Ret. kg/m^3 (pcf) Total Cubes Basis	Net Solution Ret. kg/m^3(pcf) Sapwood Basis
CCA	398 (24.7)	594 (36.9)
CCA	372 (23.1)	609 (37.8)
Low OIL	353 (21.9)	623 (38.7)
Medium OIL	314 (19.5)	572 (35.5)
High OIL	354 (22.0)	507 (31.5)
High OIL*	375 (23.3)	639 (39.7)

* 3 Hr. Press Period

TABLE 2

DEPTH OF PENETRATION

CCA/OIL LODGEPOLE PINE ONE STEP TREATMENTS

	Sapwood, %	Sapwood Depth, cm (in)
Charge 1 CCA		
LP	100	2.5-8 (1-3.25)
DF	30-50	Douglas-fir
Charge 2 CCA		
LP	90-100	2.5-6 (1-2.5)
DF	15-20	Douglas-fir
Charge 3 Low Oil		
LP	100	2.5-7.5 (1-3)
DF	20-25	Douglas-fir
Charge 4 Medium Oil		
LP	100	2.5-6 (1-2.5)
DF	10	Douglas-fir
Charge 5 High Oil		
LP	80-100	2.5-7.5 (1-3)
DF	5-10	Douglas-fir
Charge 6 High Oil		
LP	95-100	3-5 (1.25-2)
DF	10	Douglas-fir

TABLE 3

PILODYN READINGS

CCA/OIL LODGEPOLE PINE ONE STEP TREATMENTS

Treatment	Initial Pilodyn (mm)*	20-40 Days	60-90 Days
CCA	18.4	13.7	14.0
CCA	18.5	13.7	13.4
Low	19.2	14.8	14.6
Medium	19.8	14.8	14.6
High	19.1	15.4	17.9
High	20.4	16.5	15.3

*Average of 12 Readings (3 Per Pole)

TABLE 4

OIL RETENTIONS GAUGE VS. ASSAY

CCA/OIL LODGEPOLE PINE ONE STEP TREATMENTS

Oil Concentrate	Oil Retention Gauge kg/m^3(pcf) Total Cubes Basis	Oil Retention Gauge kg/m^3(pcf) Sapwood Basis	Oil Retention Assay kg/m^3 (pcf) 0-1.25 cm (0-1/2 in)
Low	1.29 (0.08)	2.42 (0.15)	.32 (0.02)
Medium	2.42 (0.15)	4.35 (0.27)	3.54 (0.22)
High	4.03 (0.25)	6.44 (0.40)	11.43 (0.71)
High	4.19 (0.26)	7.25 (0.45)	14.33 (0.89)

TABLE 5

VISUAL OIL PENETRATION

CCA/OIL LODGEPOLE PINE ONE STEP TREATMENT

Oil Concentration	Boring No.	CCA, cm (in)	Oil, cm (in)
Low	1	8 (3.25)	1.25 (0.5)
Low	2	4.5 (1.75)	1.25 (0.5)
Low	3	2.8 (1.1)	1.25 (0.5)
Low	4	2.8 (1.1)	1.0 (0.375)
Medium	1	3.2 (1.25)	1.25 (0.5)
Medium	2	5 (2)	1.25 (0.5)
Medium	3	3.2 (1.25)	3.2 (1.25)
Medium	4	4.5 (1.75)	2.5 (1.0)
High	1	2.8 (1.125)	2.5 (1.0)
High	2	4.5 (1.75)	1.8 (.75)
High	3	5.3 (2.125)	1.8 (.75)
High	4	5.3 (2.125)	5.0 (2.0)
High	1	4.5 (1.75)	4.5 (1.75)
High	2	4.1 (1.625)	4.1 (1.625)
High	3	4.5 (1.75)	4.5 (1.625)
High	4	4.5 (1.75)	2.5 (1)
High	5	5.0 (2)	3.2 (1.25)

TABLE 6

JACK & LODGEPOLE PINE POLE SECTIONS

TWO STEP TREATING DATA

Sample	CCA Cycle Net Solution	Oil Cycle Net Solution	Oil Conc.(%)	Oil Retention Gauge kg/m^3(pcf)	Assay Oil Retention kg/m^3 (pcf) 0-1.25 cm (0-0.5 in)
Jack Pine					
Charge 1					
1A	175 (10.9)	54.7 (3.4)	17	9.3 (0.58)	13.9 (0.87)
1B	184 (11.4)	58.0 (3.6)	17	9.8 (0.61)	10.7 (0.67)
1C	214 (13.3)	188 (11.7*)	17	31.9 (1.98)	29.6 (1.85)
1D	171 (10.6)	53.1 (3.3)	17	9.0 (0.56)	14.9 (0.93)
Charge 2					
1E	166 (10.3)	113 (7.0)	17	19.0 (1.18)	19.4 (1.21)
1F	150 (9.3)	142 (8.8)	17	24.0 (1.49)	25.0 (1.56)
Charge 3					
2A	213 (13.2)	32.2 (2.0)	17	5.5 (0.34)	---
2B	207 (12.8)	22.5 (1.4)	17	3.7 (0.23)	---
2C	357 (22.2)	106 (6.6)	17	18.0 (1.12)	---
2D	200 (12.4)	24.2 (1.5)	17	4.2 (0.26)	---
JP Avg.	203 (12.6)	79.9 (4.9)		13.8 (0.86)	18.9 (1.18)
Lodgepole Pine					
Charge 1	--- ---	67.6 (4.2)	15	10.0 (0.62)**	18.4 (1.15)
Charge 2					
1	193 (12.0)	29.0 (1.8)	15	4.3 (0.27)	7.7 (0.48)
3	122 (7.6)	25.8 (1.6)	15	3.9 (0.24)	7.0 (0.44)
4	126 (7.8)	25.8 (1.6)	17	4.3 (0.27)	7.5 (0.47)
LP Avg.	148 (9.2)	27.4 (1.7)		12.2 (0.76)	7.4 (0.46)

* - 2.5 x Sapwood Than Other Samples In Charge

** - No CCA Treatment

TABLE 7

PILODYN READINGS

CCA/OIL TWO STEP TREATMENTS

	Initial Pilodyn (mm)	15 Days	60 Days
Jack Pine	16.2	16.8	16.4
Lodgepole Pine	16.0		16.0

FIGURE 1

CCA / OIL INJECTION RATES
LODGEPOLE PINE POLES - ONE-STEP PROCESS