**Report: WDL-2021-05a**

# Effect of Kopper's Pole Climbing Additive Technology on the Resistance To Gaff Penetration in Southern Pine Utility Poles

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## BACKGROUND

The Wood Durability Laboratory (WDL) at the LSU AgCenter became an ISO 17025 accredited laboratory through the International Accreditation Services (IAS) accreditation system on March 1, 2008. Additional test standards were added by IAS to the WDL approved scope of services on July 24, 2008, November 20, 2009, May 31, 2012, January 24, 2014, March 31, 2016, July 26th, 2016, and June 6th, 2018 (Table 1). The lab has been operating under ISO 17025 Guidelines for over ten years. This report is compliant with ICC-ES AC85. This report has not been reviewed by a licensed professional engineer nor a third party skilled in the art. Samples and information sheets on traceability of samples were provided by the sponsor and verified at the time of sample creation. The results from this test only relate to the items tested.

**Table 1**. Current scope and WDL test methods accredited by IAS.

| **IAS Accreditation Number:** | **TL-350** |
|---|---|
| Accredited Entity: | Wood Durability Laboratory |
| Address: | 227 Renewable Natural Resources<br>Louisiana State University<br>Baton Rouge, Louisiana 70803 |
| Contact Name: | Dr. Qinglin Wu, Director |
| Telephone: | (225) 578-8369 |
| Effective Date of Scope of Accreditation: | April 28th, 2020 |
| Accreditation Standard: | ISO/IEC Standard 17025:2017 |

| **Fields of Testing** | **Accredited Test Methods** |
|---|---|
| Wood testing | ASTM Standards D143[2], D1037[2] (Compression Parallel to surface, section 12 excluded), D2395[8], D3043[5] (Methods A & D only), D4442[8], and D5456[5] (Test methods referenced in Annex A3 & A4); AC257[3] test methods referenced in Section 4.0, excluding 4.3.1.1, 4.3.1.2, 4.3.1.4, & 4.3.2.2) |
| Wood preservatives | ASTM Standards D2481[3], D3273[5], D3345[1], D4442[8], D4445[3], & D5516[4]<br>AWPA Standards E1[1], E5[3], E7[1], E9[3], E10[1], E11[1], E12[1], E16[3], E18[3], E20[6], E21[4], E22[2], E23[2], E24[1], E26[4] and E29[5]<br>WDMA Standards TM-1[1] and TM-2[1]<br>WDL-SOP-25[6] – Field Evaluation of Termiticide against Subterranean Termites<br>AC380[7] test methods referenced in Sections 3, 4.1, 4.2 and 4.3, excluding 4.4.1 through 4.4.9) |

Approved: [1]March 1, 2008, [2]July 24, 2008, [3]November 20, 2009, [4]May 31, 2012, [5]January 24, 2014, [6]March 31, 2016, [7]July 26, 2016, [8]June 6, 2018, & [9]April 28, 2020

## OBJECTIVE

The objective of this study was to evaluate pilodyn and gaff hardness on treated poles provided by Koppers Performance Chemicals. A similar test was conducted in 2012 with results presented in Report # WDL-2011-14.

Surface hardness was assessed by means of gaff penetration testing using two different lineman gaffs. Gaffs used in this test were 9106A and 9206A. In addition to gaff hardness testing, surface hardness (penetration depth) was measured with a Pilodyn 6J and pole moisture content was also measured with a Delmhorst RDM-3 resistance type moisture meter.

## MATERIALS AND METHODS

A. Pole Sections

Twenty-one 3-foot-long pole sections were received from Koppers for gaff and Pilodyn hardness testing at the WDL. The pole sections and associated treatments are summarized in Table 2 below.

Table 2. A summary of the test pole identification.

| Koppers Gaff Testing | | | | |
|---|---|---|---|---|
| Pole Set / Treatment | % MC before Treating | Density of Pole calculated from Cut-offs (pcf)* | Gauge Retention (pcf) | IDs |
| Set 1 (CCA + 16% CLAW II – 2-Step Treatment) | 30.0% | Sections were cut from 5 – 8 foot poles and then randomized for treating. Density ranged from 33-42 pcf with an average of 37.2 pcf | CCA = 0.423 pcf<br>CLAW II = 0.450 pcf | 1-1, 1-2, 1-3 |
| Set 2 (CCA + 24% CLAW II – 2-Step Treatment) | 26.0% | | CCA = 0.455 pcf<br>CLAW II = 0.685 pcf | 2-1, 2-2, 2-3 |
| Set 3 (CCA + 2.5% CLAW II – 1-Step Treatment) | 33.0% | | CCA = 0.572 pcf<br>CLAW II = 0.533 pcf | 3-1, 3-2, 3-3 |
| Set 4 (CCA + 5.0% CLAW II – 1-Step Treatment) | 26.0% | | CCA = 0.490 pcf<br>CLAW II = 0.914 pcf | 4-1, 4-2, 4-3 |
| Set 5 (CCA + 7.5% CLAW II – 1-Step Treatment) | 32.5% | | CCA = 0.541 pcf<br>CLAW II = 1.515 pcf | 5-1, 5-2, 5-3 |
| Control Penta | NA | 40.0 | NA | 6-1, 6-2, 6-3 |
| Control CCA | NA | 41.0 | NA | 7-1, 7-2, 7-3 |

NA – Penta and CCA control poles was received by Koppers as treated and were cut to size for the test.

*The density of CCA / CLAW II poles was measured before treatment; the density for the penta and CCA control poles were measured as treated with chemical in the pole.

B. Conditioning and Drying

Upon receipt from Koppers, the pole sections were placed outdoors under an open-sided overhang for conditioning to constant moisture contents (MCs). This overhang was designed to protect the sections from the weather while allowing the maximum airflow. The sections were kept upright during this stage of drying. A Delmhorst RDM-3 resistance type moisture meter was used to measure the moisture content of each pole section at a depth of 1 inch prior to testing.

C. Moisture Content

Prior to physical testing, ten electronic moisture readings were taken from each pole section at a 1-inch depth, in the vicinity of the gaff hardness tests.

D. Pilodyn Hardness (Penetration Depth) Testing

Surface hardness (Penetration Depth) of the pole sections was measured with a 6 joule Pilodyn with a 2.5 mm diameter blunt end probe (Pilodyn 6 J, Proceq SA, Zurich, Switzerland) – Figure 1. Ten measurements were taken on each pole. The test consists of injecting a spring-loaded steel striker pin into the wood. The penetration of the pin depends on the hardness of the wood. A scale on the instrument gives the depth of penetration. Generally, the deeper the penetration, the softer the wood.


**Figure 1.** Pilodyn Testing of Treated Poles

E. <u>Gaff Hardness Testing</u>

Gaff hardness testing was performed using LSU's Instron Universal Testing machine (Model #5582) (Figure 2). The test setup used was designed to reproduce the principal movement of the gaff in penetrating a wood pole.

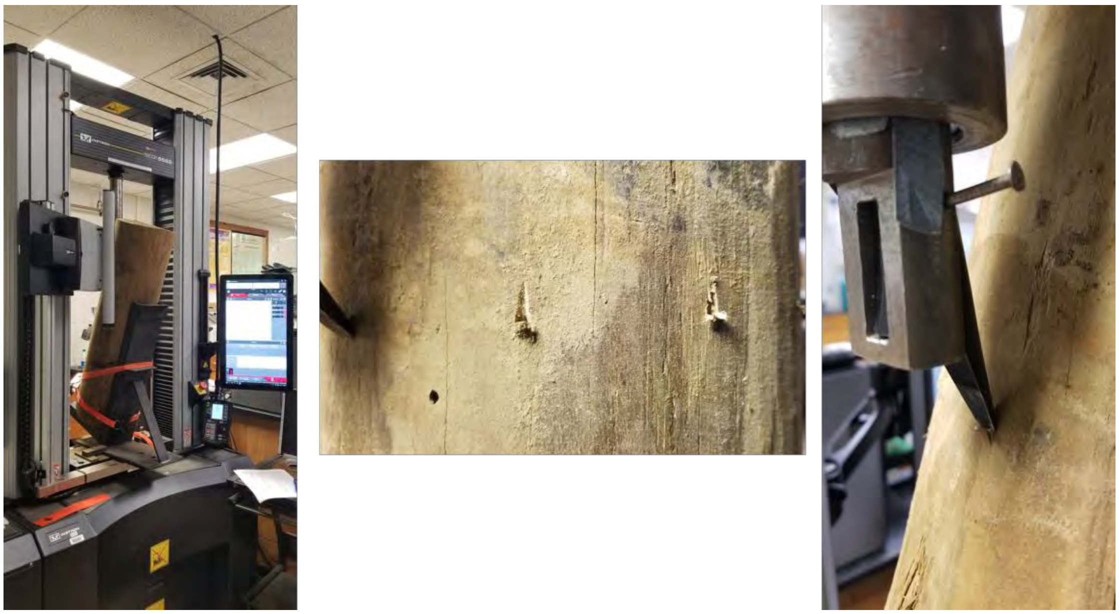

**Figure 2.** Gaff hardness testing with LSU's Instron Universal Testing machine

Two different lineman gaffs were used to evaluate the effectiveness of the Koppers poles. The T9106A gaff is designed to penetrate hard CCA poles, while the T9206A gaff is designed for general pole climbing and are identified as follows (Figure 3):

- Buckingham T9106A – Screw Style Replaceable CCA Pole Gaff.
- Buckingham T9206A – Screw Style Replaceable Pole Gaff.


**Figure 3.** Gaffs used in this test - 9106A and 9206A.

In addition to the pole sections being mounted at a 20 degree angle from vertical direction, both gaff styles used in this study were designed with a 16 degree angle between the upper and lower shafts of the gaff. The combination of these two angles resulted in a penetration angle of approximately 36 degrees to the central axis of the test specimens, which corresponds to the average angle measured on a lineman climbing the pole.

The pole stubs were carefully positioned on the test bench so as to avoid knots and other wood defects (e.g., split). Once the test stubs were mounted on the Instron machine, the load head was lowered until the gaff was in contact with the pole surface. A force of 5 pounds was applied to the pole sections prior to testing to ensure that the gaff was fully seated. The load head was then displaced 0.475 inches at a rate of 0.50 in./min. A load sensor/cell was used to measure the applied force in the axis of the gaff. A total of 10 replicate readings were taken for each treatment/gaff combination.

## RESULTS AND DISCUSSION

The following is a summary of the data presented in each.

### Moisture Content

The Penta (Set #6) and CCA (Set #7) control poles were received as treated by Koppers Utility and Industrial Products' plants and submitted as such. The % moisture content (MC) of these 2 groups indicate equilibration with the CCA control around 16% moisture content and the Penta control poles reading around 17% MC. The CCA/CLAW II poles had been recently treated by the Koppers Performance Chemicals' pilot plant in Griffin, GA. While these poles had over 2 months, after treatment to equilibrate, the moisture gradient was doubled of that of the CCA and Penta control poles with some of 1-step poles maxing out the moisture reader at 40+%. Since these poles contain the most CLAW, this may indicate that the CLAW II additive influences the measurement detected by the moisture meter giving a higher value. Another aspect is that this may be an indication that the CLAW II additive retards or slows drying after treatment. This data is presented in Table 3 and Figure 4.

Table 3 – Average percent moisture content for all three poles from each treatment set.

| Treatment | Average % MC* |
|---|---|
| Treatments Set 1 – 2-Step (16% CLAW) | 35.2 |
| Treatments Set 2 – 2-Step (24% CLAW) | 35.4 |
| Treatment Set 3 – 1-Step (2.5% CLAW) | 37.4 (1 pole over 40%) |
| Treatments Set 4 – 1-Step (5.0% CLAW) | 38.8 (1 pole over 40%) |
| Treatments Set 5 – 1-Step (7.5% CLAW) | 38.7 (2 poles over 40%) |
| Treatment Set 6 - Penta | 16.9 |
| Treatment Set 7 - CCA | 16.3 |

*Where pole exceed the moisture meter's range of 40%, 40% was used to calculate the average.

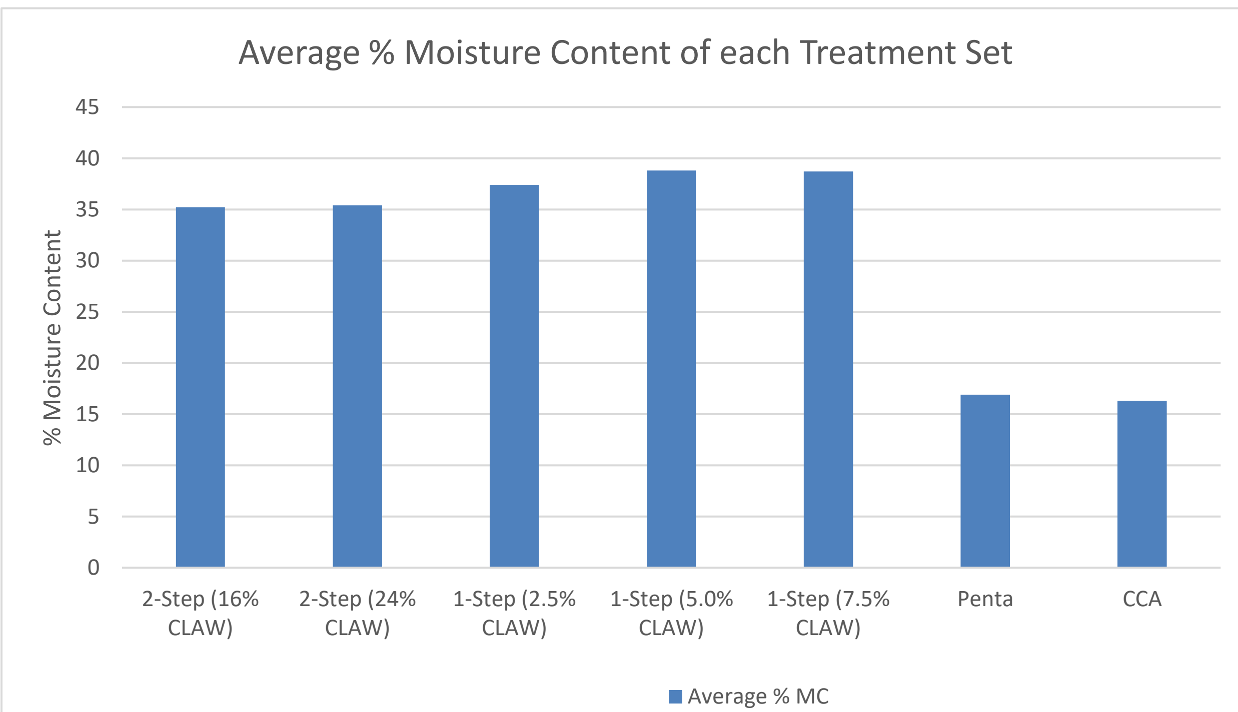


**Figure 4** – Moisture Content across all treatment sets.

<u>Pilodyn Hardness (</u>Penetration Depth)

When interpreting Pilodyn penetration data, it is important to note that the deeper the penetration of the striker pin, the softer the wood. On average, the CCA only poles were the hardest poles tested followed by the Penta pole sections. The hardness decreased throughout the experimental poles containing the CLAW II climbing additive at various levels. Pilodyn penetration data is summarized in **Table 4** and **Figure 5.**

Table 4 – Hardness Penetration Depth (mm) using a 6 joule Pilodyn.

| Set | ID | Pilodyn Hardness Penetration Depth (mm) | Average |
|---|---|---|---|
| 2-Step (16% CLAW) | 1-1 | 15.9 | 15.9 |
| | 1-2 | 15.9 | |
| | 1-3 | 15.9 | |
| 2-Step (24% CLAW) | 2-1 | 16.1 | 15.2 |
| | 2-2 | 14.7 | |
| | 2-3 | 14.8 | |
| 1-Step (2.5% CLAW) | 3-1 | 15.7 | 15.0 |
| | 3-2 | 16.2 | |
| | 3-3 | 13.0 | |
| 1-Step (5.0% CLAW) | 4-1 | 17.6 | 14.8 |
| | 4-2 | 13.2 | |
| | 4-3 | 13.6 | |
| 1-Step (7.5% CLAW) | 5-1 | 13.3 | 14.3 |
| | 5-2 | 13.1 | |
| | 5-3 | 16.4 | |
| Penta | 6-1 | 11.6 | 11.7 |
| | 6-2 | 11.7 | |
| | 6-3 | 11.9 | |
| Penta | 7-1 | 11.5 | 9.5 |
| | 7-2 | 8.7 | |
| | 7-3 | 8.4 | |

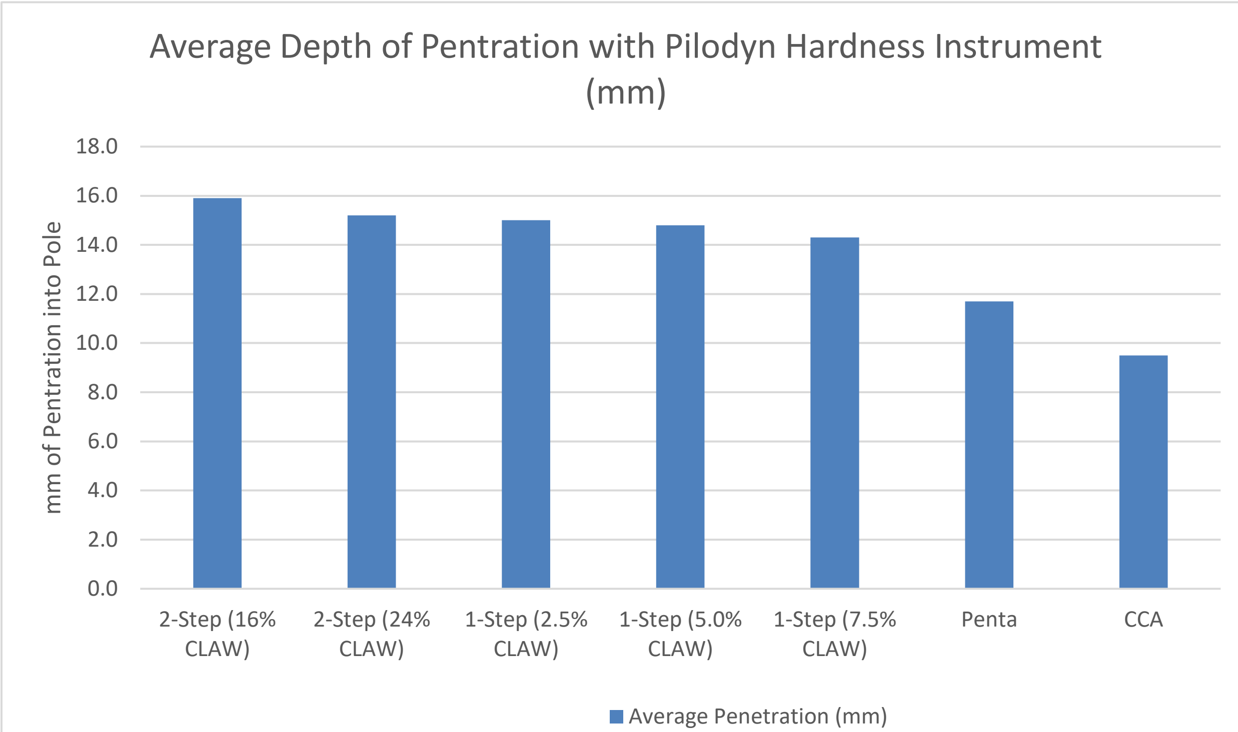


**Figure 5** – Average Pilodyn Hardness (penetration depth in mm) across all treatment sets.

<u>Gaff Hardness</u>

Gaff hardness data summarized in **Table 5** and associated **Figures 6-8** show that gaff hardness results. When interpreting this data, the lower the force to penetrate to the target depth of 0.475 inches, the softer the wood.

**Table 5** – Gaff Hardness Data of Buckingham 9106A CCA Pole Gaff & 9206A General-purpose Gaff.

| Gaff ID | | 9106A | | 9206A | |
|---|---|---|---|---|---|
| Treatments | ID | lbf. Avg | Overall Average | lbf. Avg | Overall Average |
| 2-Step (16% CLAW) | 1-1 | 150.6 | 165.8 | 215.4 | 245.8 |
| | 1-2 | 188.4 | | 272.3 | |
| | 1-3 | 158.4 | | 249.7 | |
| 2-Step (24% CLAW) | 2-1 | 142.5 | 143.0 | 238.2 | 212.9 |
| | 2-2 | 142.8 | | 231.8 | |
| | 2-3 | 143.6 | | 168.7 | |
| 1-Step (2.5% CLAW) | 3-1 | 143.1 | 179.7 | 193.4 | 214.7 |
| | 3-2 | 168.3 | | 191.7 | |
| | 3-3 | 227.6 | | 259.1 | |
| 1-Step (5.0% CLAW) | 4-1 | 159.7 | 197.5 | 208.1 | 265.8 |
| | 4-2 | 179.3 | | 277.3 | |
| | 4-3 | 253.4 | | 312 | |
| 1-Step (7.5% CLAW) | 5-1 | 299.6 | 238.6 | 351.2 | 298.3 |
| | 5-2 | 204.5 | | 235.4 | |
| | 5-3 | 211.6 | | 308.3 | |
| Penta | 6-1 | 217.4 | 215.7 | 387.4 | 370.3 |
| | 6-2 | 241.8 | | 358.4 | |
| | 6-3 | 187.9 | | 365.1 | |
| CCA | 7-1 | 259.9 | 382.1 | 250.7 | 382.6 |
| | 7-2 | 445.4 | | 451.8 | |
| | 7-3 | 441.1 | | 445.3 | |

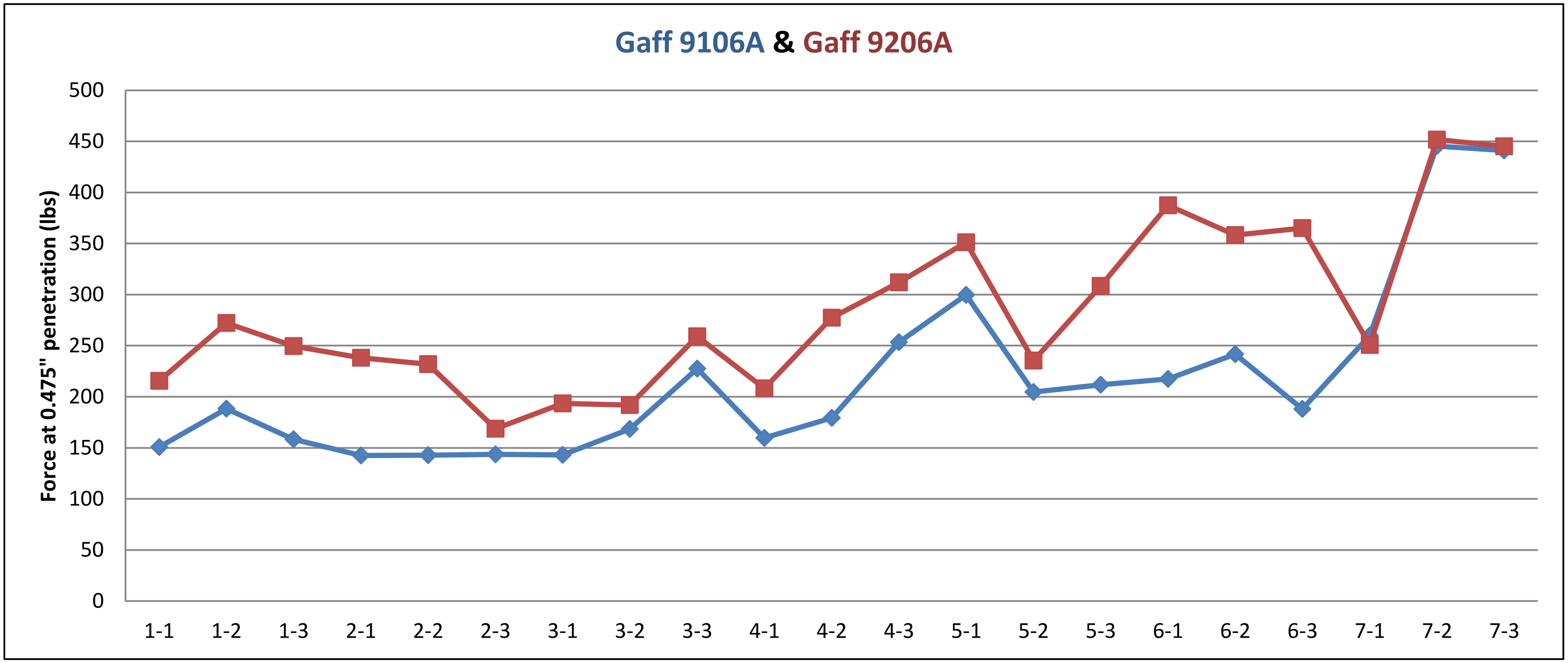


**Figure 6** – Gaff Hardness of Buckingham 9106A CCA Pole Gaff (blue line) & 9206A General-purpose Gaff (red line) for all poles.

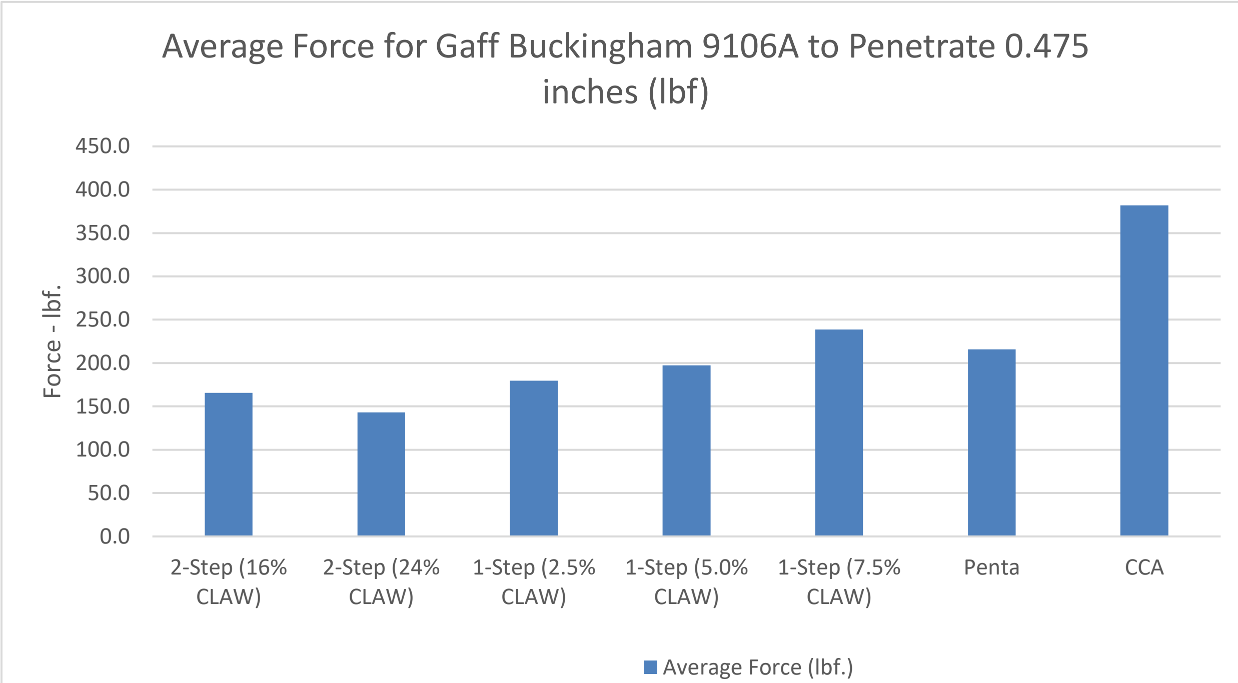


**Figure 7** –Gaff Hardness for Buckingham 9106A CCA Pole Gaff

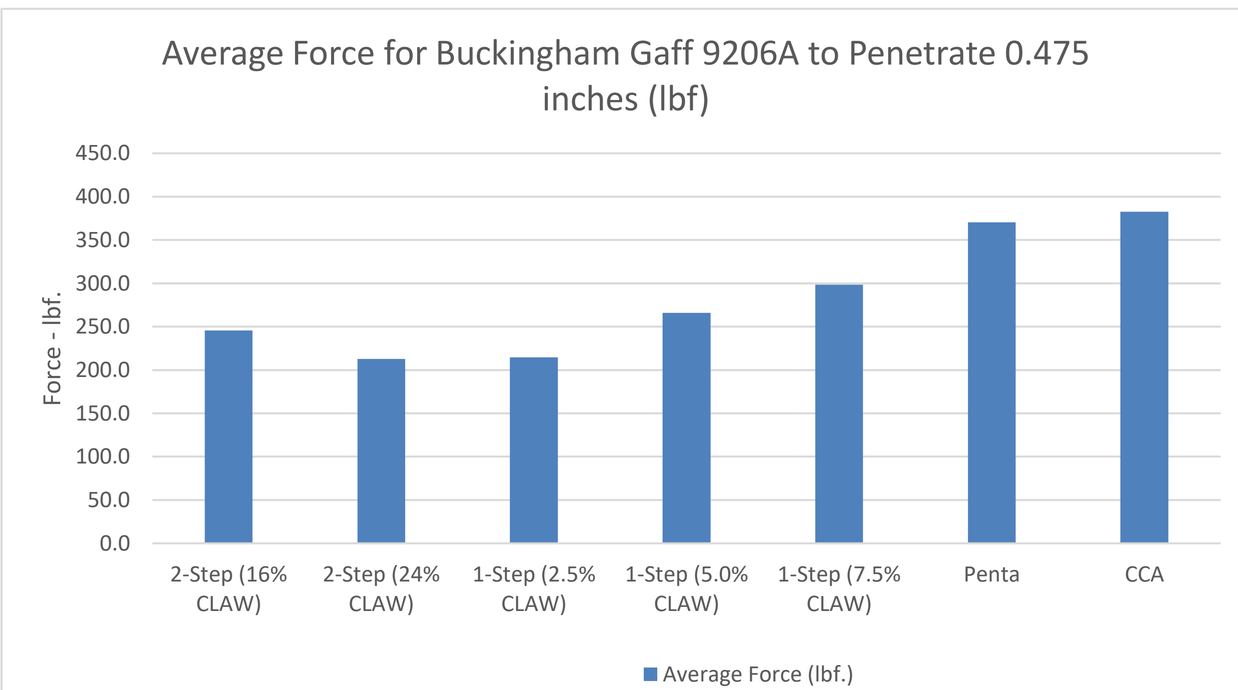


**Figure 8** –Gaff Hardness for Buckingham 9206A Pole Gaff

## SUMMARY OF RESULTS

Based on the overall data, the following can be seen:

- Based on the higher moisture contents of the CCA/CLAW II poles after two months of storage after treatment, this may indicate that the CLAW II additive influences the measurement detected by the moisture meter giving a higher value. This may also be an indication that the CLAW II additive retards or slows drying after treatment.
- Overall, the 9106A gaff took less force to penetrate to the 0.475 inch depth compared to the 9206A gaff for all sets except the CCA set which was similar for both gaffs. Since the 9106A gaff is designed to specifically penetrate hard CCA poles, it makes sense that it would penetrate into softer wood easier than the 9206A general gaff. Figure 6 shows, however, that the trends between the two gaffs is similar.
- All of the 1-step treatments produced more variable results between the three test poles compared to the 2-step treatment sets.
- With respect to the Pilodyn test, the CCA poles performed the worse followed by the Penta poles; the CCA/CLAW II poles overall were similar, but the 2-step treatment sets were slightly better with higher penetration depth measured compared to the 1-step treatment sets.
- With respect to the 9106A gaff, the following sets can be grouped together from the softest to the hardest based on the results:
  - Both of the 2-step treatments performed similarly with the lowest force needed.
  - Next followed the 1-step treatments with 2.5% and 5.0% CLAW II.
  - Next softest were Penta poles
  - The 1-step treatment with 7.5% CLAW II were next, worse than the Penta poles.
  - The CCA poles performed by far the worse.
- With respect to the 9206A gaff, the following sets can be grouped together from softest to hardest based on the results:
  - The 2-step treatment with 24% CLAW II and the 1-step treatment with 2.5% CLAW II appeared to be the best performers requiring the lowest amount of force.
  - Next followed closely the 2-step treatment with 16% CLAW II.
  - The 2-step with 5.0% CLAW II was next best in performance.
  - The 1-step treatment with 7.5% CLAW II was next
  - The Penta poles were next requiring on average an additional 70 lbf to achieve the target penetration.
  - The CCA poles performed the worse but only slightly worse than the Penta poles.
- Overall, considering the results of the pilodyn and both gaff tests, the trend suggests on average that the 2-step treatments produced softer wood than the 1-step treatments.
- Also, considering all three tests, with the exception of the 1-step 7.5% CLAW II set with the 9106A gaff, on average all the CLAW II treated poles were softer compared to the Penta poles and all CLAW II treated poles were much softer than the CCA only poles.

## REFERENCES CITED

SPSS 25 for Windows. 2021. Chicago, IL.

Steel, R.G.D. and J.H. Torrie. 1980. Principle and procedures of statistics – A biometrical approach. 2nd edition. McGraw Hill. New York. 633 p.

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# CERTIFICATE OF ACCREDITATION

*This is to attest that*

## WOOD DURABILITY LABORATORY

227 RENEWABLE NATURAL RESOURCES, LOUISIANA STATE UNIVERSITY
BATON ROUGE, LOUISIANA 70803, U.S.A.

**Testing Laboratory TL-350**

has met the requirements of AC89, *IAS Accreditation Criteria for Testing Laboratories*, and has demonstrated compliance with ISO/IEC Standard 17025:2017, *General requirements for the competence of testing and calibration laboratories*. This organization is accredited to provide the services specified in the scope of accreditation.

Effective Date July 9, 2020

IAS ACCREDITED

*President*

Visit www.iasonline.org for current accreditation information.

# SCOPE OF ACCREDITATION

International Accreditation Service, Inc.
3060 Saturn Street, Suite 100, Brea, California 92821, U.S.A. | www.iasonline.org

## WOOD DURABILITY LABORATORY

**Contact Name** Dr. Qinglin Wu **Contact Phone** +225 578-8369

*Accredited to ISO/IEC 17025:2017* *Effective Date July 9, 2020*

| **Physical** | |
|---|---|
| ASTM D143 | Standard test methods for small clear specimens of timber |
| ASTM D1037 | Standard test methods for evaluating properties of wood-base fiber and particle panel materials (compression parallel to surface, section 12, excluded) |
| ASTM D2395 | Standard Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials |
| ASTM D2481 | Standard test method for accelerated evaluation of wood preservatives for marine services by means of small size specimens |
| ASTM D3043 | Standard test methods for structural panels in flexure (methods A and D only) |
| ASTM D3273 | Standard test method for resistance to growth of mold on the surface of interior coatings in an environmental chamber |
| ASTM D3345 | Standard test method for laboratory evaluation of wood and other cellulosic materials for resistance to termites |
| ASTM D4442 | Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials |
| ASTM D4445 | Standard test method for fungicides for controlling sapstain and mold on unseasoned lumber (laboratory method) |
| ASTM D5456 | Standard specification for evaluation of structural composite lumber products (test methods referenced in annex A3 and A4 only) |
| ASTM D5516 | Standard test method for evaluating the flexural properties of fire-retardant treated softwood plywood exposed to elevated temperatures |
| AWPA E1 | Laboratory methods for evaluating the termite resistance of wood-based materials: choice and no-choice tests |
| AWPA E5 | Standard test method for evaluation of wood preservatives to be used in marine applications (UC5A, UC5B, UC5C); panel and block tests |
| AWPA E7 | Standard field test for evaluation of wood preservatives to be used in ground contact (UC4A, UC4B, UC4C); stake test |
| AWPA E9 | Standard field test for the evaluation of wood preservatives to be used above ground (UC3A and UC3B); L-joint test |

# SCOPE OF ACCREDITATION

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| | |
|---|---|
| AWPA E10 | Laboratory method for evaluating the decay resistance of wood-based materials against pure basidiomycete cultures: soil/block test |
| AWPA E11 | Standard method for accelerated evaluation of preservative leaching |
| AWPA E12 | Standard method of determining corrosion of metal in contact with treated wood |
| AWPA E16 | Standard field test for evaluation of wood preservatives to be used above ground (UC3B); horizontal lap-joint test |
| AWPA E18 | Standard field test for evaluation of wood preservatives to be used above ground (UC3B); ground proximity decay test |
| AWPA E20 | Standard method of determining the depletion of wood preservatives in soil contact |
| AWPA E21 | Standard field test method for the evaluation of wood preservatives to be used for interior applications (UC1 and UC2); full-size commodity termite test |
| AWPA E22 | Laboratory method for rapidly evaluating the decay resistance of wood-based materials against pure basidiomycete cultures using compression strength: soil/water test |
| AWPA E23 | Laboratory method for rapidly evaluating the decay resistance of wood-based materials in ground contact using static bending: soil jar test |
| AWPA E24 | Laboratory method for evaluating the mold resistance of wood-based materials: mold chamber test |
| AWPA E26 | Standard field test for evaluation of wood preservatives intended for interior applications (UC1 and UC2): ground proximity termite test |
| AWPA E29 | Antisapstain field test method for green lumber |
| ICC ES AC257 | Corrosion-resistant fasteners and evaluation of corrosion effects of wood treatment chemicals (test methods referenced in section 4.0, excluding sections 4.3.1.1, 4.3.1.2, 4.3.1.4 and 4.3.2.2) |
| ICC ES AC380 | Termite physical barrier systems (test methods referenced in sections 3, 4.1, 4.2 and 4.3, excluding 4.4.1 through 4.4.9) |
| WDL-SOP-25 | Field evaluation of termiticide against subterranean termites |
| WDMA T.M. 1 | Soil block test method |
| WDMA T.M. 2 | Swellometer test method |

*AWPA: American Wood Preservers' Association*

*WDMA: Window and Door Manufacturer Association*

**TL-350**
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END OF REPORT