Small-scale fire testing of DCOI-A treated utility poles

Xing Yang* and Kevin Archer

Viance LLC

Charlotte, North Carolina, USA

Abstract

The frequency and severity of wildfires has been increasing in the western United States over the past several years. Several electric utilities have significant financial investment in distribution and transmission pole infrastructure in fire prone areas and there are obvious concerns about the fire resistance of their installed poles. Despite significant effort by the utility industry and fire testing agencies, a standardized fire testing method for utility poles has not been agreed upon. Viance developed a simple in-house procedure based on the industry protocols under development so as to compare the fire performance of DCOI-A treated pole stubs with Penta treated pole stubs. Time to ignition, ignition temperature and char depth data were recorded for both preservative treatments under controlled conditions.

Introduction

Wildfires and brush fires are a major threat to electric utility infrastructure especially in the western United States. The high replacement costs of lost poles, downed lines, and associated power outages create major financial liabilities for electric utilities raising significant concerns about the fire resistance of their utility pole grid. Despite significant effort by the utility industry and fire testing agencies, a standardized fire testing method for utility poles has not been agreed upon. Gardner and White in 2009 reported a standard method called ENA pole fire test method to evaluate fire resistance of wood poles [1]. It is a modified version of the ASTM E1623 by replacing sample holder to a bracket to hold the pole stub and including a ring burner at the base of pole stub [2]. During testing, pole specimen is exposed to 60 kW/m_2 heat flux from the radiant heating panel (1.5m x 1.5m) for the full 10 minutes and flame contact from the ring burner for the last 5 minutes. The pole specimen was subjected to a simulated wind for up to 4 hours at 2m/s because wind can cause wooden poles to smolder even after fire has been abated. If maximum surface temperature was less than 200 $_oC$, the exposure would be terminated in advance. Time to ignition, ignition temperature, peak heat release rate, total heat release, and maximum surface temperature are reported. After wind exposure, the specimen is examined for damage including char depth. Since 2016, ASTM International's Fire Committee (E05) has been developing a standard ASTM WK52535 to test fire resistance of wooden utility poles [3]. The recent 2019 proposal described the testing methodology similar to ENA pole fire test method with some modifications. Heat flux from radiant panel is set as 50 kW/m_2 instead of 60 kW/m_2 in ENA method. Wind exposure would be terminated if surface temperature of pole specimen is lower than 50 $_o$C instead of 200 $_o$C. Before burning, specimen diameters are calculated from circumference measured at 5 locations vertically along the length. After testing, char depths and circumferences are measured at these 5 vertical location after removing chars. The proposal also presents two methods to calculate char depth. One is Uni-Directional that is maximum char depth from the side exposing radiant heating panel. The other is Concentric that is the difference of diameters calculated from circumferences before and after testing that considering significant char on unexposed side due to flaming or to flaming from ring burner. While this large-scale system is highly effective, it is also expensive to construct resulting in pricy testing cost. Therefore, a small-scale system would be very beneficial to evaluate the fire behavior of wooden poles treated with new preservatives or flame retardants. A simple method has been used by placing a measured amount of dry straw in a basket surrounding a pole and lighting the straw to burn pole specimen [4,5,6]. The test is stopped until the pole ceases to burn. The char depth and area are examined. However, testing results are very sensitive to weather conditions (temperature, relative humidity, wind) and even straw placement. Love and Morrell reported an improved method by using a gas burner to provide a specific flame size and temperature [6]. Konkler and Morrell further improved by using two infrared heating elements with the stainless-steel shields to contain the heat [7]. The set-up is simple and inexpensive; however, it has several drawbacks. The heating elements are powered by electricity reducing the mobility. Heat flux generated by these heating elements are limited. Comparing to large-scale system, lack of ring burner in this method impacts the burning intensity. To further improve the small-sale testing system and simulate large-scale system, we developed a small-scale in-house pole stub burn testing apparatus. Using this protocol the fire performance of DCOI-A treated red pine pole stubs were evaluated and compared with Penta treated Douglas fir pole stubs. Time to ignition, ignition temperature and char depth data were recorded for both preservative treatments under controlled conditions and reported below.

Material and Method

Two 5-foot long red pine pole stubs treated with DCOI-A were labeled as UP-1 and UP-2 and two 5-foot long Douglas fir pole stubs treated with Penta were labeled as PT-1 and PT-2. Starting from one end of each pole stub, five vertical locations at successive 6” intervals were marked. The circumference of each pole stub was measured at each 6” interval.

The small-scale fire test apparatus is shown in Fig. 1. The apparatus includes a radiant heating panel (10” wide x 19” long) powered by propane gas. The heat output is 32000 Btu/H. The bottom of heating panel is supported on a tripod 28” above the ground and placed 6” away from the pole stub surface during testing. A ring burner connected to propane gas is placed 2” below the bottom of the radiant panel. Gas flow during testing is 10 psi. The top of the pole stub is protected from flame with aluminum foil.

Fig. 1 Small-scale fire test apparatus for utility pole

The test begins with exposure of testing sample to radiant heating from the panel. When post stub ignites, time to ignition and temperature are recorded. After 5-min burning, ring burner is ignited and burning continues for another 5 min. Thereafter, post stub is exposed to a simulated wind for 30 min at 2m/s as shown in Fig. 2.

Fig. 2 wind exposure for post-burn utility pole

Char depth measurement

Char depth is the key parameter to evaluate burning behavior of poles. Similar to the description in ASTM WK52535 proposal, five vertical locations at successive 6” intervals from the top of post stub were marked as shown in Fig. 3. The maximum char depth at each location denoted as Uni-Directional was measured using rigid wire probe. Thereafter, char was removed by scraping and remaining circumference was measured. According to circumferences before and after burning, diameter change is calculated and denoted as Concentric char depth.

Fig. 3 Five marked locations for cha depth measurement

Results

Test results including time to ignition, ignition temperature and char depth are shown in Table 1. Diameters for each pole stub were calculated from the circumferences taken at 5 locations on the post stubs before burning. Overall, the difference in burning behavior between post stubs treated with DCOI-A and Penta is insignificant. Concentric char depth for sample UP-1 is relatively small because of wind direction change during burning. It results in the less char forming on the opposite side of pole compared to other samples. It is also obvious that Uni-Directional char depth is larger than Concentric char depth and due to different measurement methods used. Sample surfaces directly in front of the radiant panel were exposed to greater heat energy and flame exposure than the sides opposite the heating panel resulting in different char depth. Uni-Directional char depth is measured as maximum char depth at limited location while Concentric char depth considers the area around the pole.

The similar fire resistance characteristics of the two preservative treatments also suggest the burning behavior of pole stubs were majorly determined by oil content of treatment formulation rather than preservative type or pole stub species.

Table 1 Characteristics of treated pole stubs exposed to flame burning test

ID	Diameter (cm)	Time to ignition (min)	Ignition temp. (^{0}C)	Char depth (mm)	
				Uni-Directional (Average/STDEV)	Concentric (Average/STDEV)
UP-1	21.9	5.6	291	4.0/1.0	1.7/0.8
UP-2	20.1	6.1	320	4.0/1.0	2.8/0.4
PT-1	16.3	5.7	326	4.6/0.7	2.8/0.6
PT-2	16.9	6.1	332	4.4/1.5	3.4/0.5

Summary

A small-scale and inexpensive burn test was used to compare the fire resistance characteristics of DCOI-A and Penta treated pole stubs. The test shows promising as a screening tool for fire resistance properties. Based on measurements of time to ignition, ignition temperature, Uni-Directional and Concentric char depth by using the small-scale test, the fire resistance characteristics of the two preservative treatments appear to be equivalent.

References

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