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Evaluating Wood Pole Inspection Alternatives to Conventional Visual, Sound, and Bore Practices: Vendor B's Manufacturer Report

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ABSTRACT

The conventional methods used by electric utilities to inspect wood poles are visual-, sound-, and bore-based. As part of its commitment to advance the state of the art of overhead line transmission and supporting structures, the Electric Power Research Institute (EPRI) is sponsoring a multi-phase project to evaluate alternative technologies, including nondestructive evaluation (NDE). EPRI continues to build on past projects to identify opportunities to improve the reliability and cost-effectiveness of overhead line maintenance programs.

The first phase of the project identified commercially available tools capable of measuring a pole's compliance to code (that is, its remaining strength). After a review of existing resources, including manufacturer information, independent verification studies, and the knowledge of the project team, the team presented the identified best-use practices to EPRI utility sponsors. A list of six technologies and tools of particular interest and the respective manufacturers of each was developed. Of the six tools, two were later eliminated because of practical considerations unrelated to the devices themselves.

Subsequent to the delivery of Phase I results to project participants, a field trial was conducted on October 15–17, 2013, at a host utility to evaluate the fundamental elements for the shortlisted technologies. Four manufacturers representing four distinct NDE devices—ultrasonic tomography, sonic, mechanical testing, and resistance drilling—participated in the trial. The host utility selected three areas within its territory that represented differing service conditions, which provided valuable insights about the feasibility and limitations that might be encountered when implementing various tools. The host utility also applied its in-house practices (predominantly visual and sounding, followed by resistance drilling of suspect poles) to identify segments of line with varied pole conditions. In addition to this baseline information, the project team conducted a traditional sound/bore inspection, including partial excavation, of each pole. This information was not disclosed to project participants.

In Table 1-3, this report provides the findings of Vendor B, the manufacturer of a sonic tool, relative to traditional sound and bore practices. As part of the project requirements, results across each manufacturer were provided only to EPRI and the host utility. The relative findings can be compared across devices only in a general sense, and the basis to the findings might not be directly comparable because the threshold serviceability ratings differed among devices. The basis of operation was defined for each tool, and observations were offered to define the basis to threshold maintenance recommendations.

Keywords
Field trial
Nondestructive evaluation (NDE)
Remaining strength
Sonic technology
Wood poles

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Background

Continuing its commitment to advance the state-of-the-art in inspection and assessment of overhead lines for its member utilities, EPRI continues to build upon past projects to identify opportunities to improve the reliability and cost-effectiveness of maintenance programs. In an effort to provide EPRI members with first-hand knowledge of the capabilities of current inspection and assessment tools, EPRI has sponsored the project entitled, "Evaluating Wood Pole Inspection Alternatives to Conventional Visual, Sound and Bore Practices." The first phase of the project focused on identifying commercially available tools capable of identifying a pole's compliance to code (remaining strength). In addition, the project identifies best-use practices for existing technologies as a supplement to conventional practices.

Objectives

The primary objective of the project was to assess the application and considerations for use issues of various NDE technologies, represented by commercially available tools and devices, relative to "conventional" industry practices that principally apply sound-and-bore technologies to determine remaining sound wood and, in some cases, percent remaining section modulus or pole strength/capacity. Specifically, the focus of the project was to document the theory of operation and considerations for use for selected technologies. Through the review of existing resources, including manufacturer information, independent verification studies and existing knowledge of the Project Team, the identification of best-use practices were presented to EPRI utility sponsors.

Project Approach

The intent of this study was to research and provide information on the operation of existing technologies used to access the remaining strength of a pole. It is also important to recognize that while the *measurement* provided by the tool/device represents some measure of pole strength, the reliability of the *measurement* should be compared to actual destructive testing results (not part of this study) and compared to results obtained from a traditional sound-and-bore analysis to best judge enhancements to conventional practices. The *measurement* obtained from a sound-and-bore procedure is the derivation of *minimum* shell thickness in a given plane, usually obtained through an angular boring. This condition measurement can be either compared directly to utility-specific tabulated rule-of-thumb criteria to determine required maintenance actions or, in the case of this study, used as input information for software applications (such as the D-Calc™ program used herein) to calculate *percent remaining section modulus* (remaining strength).

At the request of the EPRI and member utilities, NDE products that can be used to enhance or replace traditional inspection methodologies were evaluated. Phase I efforts were limited to gathering information from the manufacturers. A questionnaire covering how these products work, the process for using these tools, training needed, and the cost of using and implementing these tools was received from each manufacturer and provided to EPRI member participants in a

summary table. The final report provides a succinct summary of the capabilities of four NDE technologies reviewed in the field trial and the two additional devices identified in Phase I as well as the Project Team's perspective regarding how they might be integrated into a pole inspection program.

Nondestructive Evaluation (NDE) Systems

The NDE strength assessment tools shortlisted for detailed evaluation by EPRI, host utility and Project Team representatives (Table 1-1) represent varying *technology types.* The final report included information on potential applications and limitations of these technologies. General descriptions of the technology category (theory of operation) and *product-specific* descriptions were also provided.

Table 1-1
Strength Evaluation Assessment Tools

Product	Technology Category
Vendor A	Ultrasonic Tomography
Vendor B	Sonic
Vendor C	Mechanical Testing
Vendor D	Resistance Drilling
Vendor E	Radiography
Vendor F	Mechanical Testing

Background Information

Subsequent to the delivery of Phase I results to project participants, a field trial was conducted at a host utility for the purposes of evaluating the fundamental elements for the shortlisted technologies. Specifically, the Field Trial objectives were as follows:

- Identify fundamental elements of these inspection tools
- Compare the tools with traditional techniques such as traditional sound-and-bore inspection
- Identify suitability for second-round testing on reject poles
- Identify considerations for use, such as application for all North American wood species, internal staff use, incorporation into existing field practices, etc.

While it was desirable to include each tool identified in Phase I, practical considerations unrelated to the devices themselves eliminated two manufacturers from the Field Trial: Vendor E and Vendor F's devices. Manufacturer information was included since significant interest continues for their technologies.

The following tools/manufacturers participated in the field trial (Table 1-2). Final deliverable data provided from each manufacturer was provided in an appendix to the final report.

Table 1-2
Participants in Field Trial

Product	Technology Category
Vendor A	Ultrasonic Tomography
Vendor B	Sonic
Vendor C	Mechanical Testing
Vendor D	Resistance Drilling

Field Trial Procedures

The Field Trial was conducted on October 15-17, 2013 with four manufacturer representatives as well as representatives from the host utility, EPRI and the Project Team. It is important to note that the representatives for each tool/device were considered to be experts in their use and application. Each representative conducted the Field Trial in a professional manner and was willing to share all information about their product to ensure proper use and incorporation into a utilities management program. Opportunities existed to purchase or have a third-party contractor provide the service for each tool/device. In all instances, each representative identified that on-site training for their tool/device is available.

The Project Team provided information regarding how the field activities would be performed. Specifically, the representatives were asked to conduct the trials as they would normally conduct activities and to ensure their reports detailed the elements of the procedure that would be required for the proper implementation of their tool. For example, noting if excavation of the pole is required to provide a thorough evaluation or if loading information would be a required element to provide a complete evaluation of serviceability. Each manufacturer provided the Project Team with daily uploads of their findings, provided a final data report and completed an updated questionnaire regarding the use of their tool.

Field Trial Results

The host utility selected three areas within their service territory that represented differing service conditions. This provided valuable insights as to the feasibility and limitations that may be encountered when implementing various tools. Additionally, the host utility utilized in-house practices, predominately visual and sounding, followed by resistance drilling of suspect poles, to identify segments of line within the various service areas where a variation of pole conditions were present. In addition to this baseline information, the Project Team conducted a traditional sound/bore, including partial excavation, inspection of each pole. This information was not disclosed to project participants in advance of this supplemental manufacturer's report. The exception was that project participants were asked to use particular caution around a few select poles that exhibited visually detectable *severe* degradation. This was a safety precaution; it should be noted that none of the poles were considered to be an immediate safety concern but this was done in an effort to ensure that caution should be used.

It should be expressly stated that the intent of the Field Trial was to evaluate fundamental elements related to implementing NDT technologies into existing inspection programs. The host utility reviewed previous studies (referenced herein) related to the accuracy of each tool in predicting remaining strength and chose the shortlist for either that reason or general interest in further understanding new enhancements to technologies. While Vendor B was not a participant in prior verification studies, general interest related to its use since coming into the market was considered in shortlisting the device for this study. Each of the other participants were identified as producing reasonable accuracy in predicting remaining strength and enhancements to the technologies was a key driver in their shortlisting. As previously mentioned, the Project Team conducted traditional sound/bore and partial excavation to identify a *baseline condition rating* for the pole. Percent remaining strength was also predicted by modeling the defect/degradation with the D-Calc™ program which identified percent remaining capacity in-line and transverse to the line direction based on pole size and defect dimensions. This information is only to be considered as a baseline for conventional practices. No part of this study identifies whether an individual tool accurately identifies the remaining strength as no verification of degradation extent through dissection or verification of strength through destructive testing was performed. The study was simply designed to *judge how the tool may be utilized to supplement existing practices and to validate repeatability and suitability for North American wood pole species*.

Table 1-3 provides findings specific to each manufacturer relative to traditional sound/bore practices. As part of the project requirements, results across each manufacturer were only provided to EPRI and the host utility. The final report cautioned that it is only in a general sense that relative findings can be compared across devices. It was also noted that the basis to the findings may not be *directly* comparable as the *threshold serviceability ratings* differed among devices. The basis of operation was defined for each tool and observations were offered to define the basis to threshold maintenance recommendations.

Table 1-3
Vendor B Results of Individual Product Findings Relative to Traditional Sound/Bore Practices

	Sound/Bore/Partial Excavation Results				Vendor B Results	
	Condition(s) Identified	**Defect Distance from Groundline (in.)**	**Percent Remaining Section Modulus Transverse/Inline**	**Pole Recommendation**	**Maintenance Grouping**	**Percent Remaining Strength**
1				OK	Good pole	45
2	Pocket Rot	-6	97/98	Monitor	Good pole	46
3	Heart Rot	-6	99/99	Monitor	Dangerous Pole	24
4	Shell Rot	-6	15/21	Replace	Good pole	48
5	Shell Rot	0	24/25	Replace	Excellent Pole	67
6	Shell Rot	-12	33/40	Replace	Good pole	39
7				OK	Good pole	50
8				OK	Good pole	43
9	Shell Rot	-6	74/74	Monitor	Good pole	41
10				OK	Excellent Pole	71
11				OK	Good pole	44
12				OK	Excellent Pole	81
13				OK	Excellent Pole	64
14				OK	Dangerous Pole	32
15				OK	Good pole	52
16				OK	No Signal	No
17	Pocket Rot	-12	99/100	Monitor	Dangerous Pole	35
18				OK	Excellent Pole	100
19				OK	Very Bad	13
20	Shell Rot	0	85/85	Monitor	Good pole	39
21	Shell Rot and Heart Rot	0	76/76	Monitor	Excellent Pole	78
22	Shell Rot	0	25/25	Replace	Good pole	35
23	Mechanical Damage	0	90/94	Monitor	Good pole	59
24				OK	Dangerous Pole	31
25				OK	Very Bad	13

Table 1-3 (continued)
Vendor B Results of Individual Product Findings Relative to Traditional Sound/Bore Practices

	Sound/Bore/Partial Excavation Results				Vendor B Results	
	Condition(s) Identified	**Defect Distance from Groundline (in.)**	**Percent Remaining Section Modulus Transverse/Inline**	**Pole Recommendation**	**Maintenance Grouping**	**Percent Remaining Strength**
26	Shell Rot and Heart Rot	0	32/37	Replace	Excellent Pole	63
27				OK	Excellent Pole	89
28				OK	Good pole	46
29	Mechanical Damage	6	98/87	Monitor	Good pole	53
30	Mechanical Damage	12	87/91	Monitor	Excellent Pole	62
31				OK	Excellent Pole	87
32	Pocket Rot	0	91/90	Monitor	Good pole	48
33				OK	Excellent Pole	66
34	Pocket Rot	-12	35/40	Replace	Dangerous Pole	31
35				OK	Good pole	42
36				OK	Good pole	38
37				OK	Good pole	56
38				OK	Excellent Pole	71
39				OK	good pole	50
40				OK	Excellent Pole	76
41				OK	Good pole	45
42				OK	Good pole	43
43	Shell Rot and Heart Rot	-12	66/66	Replace	Good pole	58
44	Heart Rot	-12	100/100	Monitor	Excellent Pole	100
45				OK	Excellent Pole	96

Manufacturer's Participation

EPRI, utility participants and the Project Team wish to thank each manufacturer for participation in this trial. EPRI and its members believe that an update to the capabilities of commercially available tools for the inspection and assessment of wood poles was warranted. The final report to EPRI details all of the information provided by each manufacturer and illustrates the relative improvements that each tool provides relative to conventional practices. The results only serve as a benchmarking exercise to conventional findings and are not intended to identify the accuracy or reliability of each device other than in a *relative* comparison. Conventional inspection practices, incorporating the D-Calc remaining section modulus calculation, provides only a relative indication of remaining strength and has not been validated through destructive verification testing. As future interest continues, a full study to incorporate either dissection of samples or full-scale destructive testing may be warranted to identify the reliability/accuracy of commercially-available tools. However, from time to time it is also important to ensure the industry is aware of enhancements that each manufacturer offers to improve their role in managing wood pole structure assets.

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