WOOD POLES NON-DESTRUCTIVE INSPECTIONS; THE GERMAN EXAMPLE

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ABSTRACT

Since 2010, the German telecom company has chosen a non-destructive technique to assess the quality of the 3 Mio wood poles installed in their networks, a technique called Polux.

Polux, thanks to two measurements per pole, gives an estimation of the residual strength in MPa (security index) and the delay before the next inspection within a scale from 0 to 9 years (maintenance index).

This technology, widely used in Europe and more especially in Austria, Scandinavia, Greece and Switzerland, and in the Americas, has been tested in Germany during three years through pilot projects before its official acceptance. Both comparative (decay inspection) and destructive tests have been performed on poles from different German regions.

This paper relates the pilot project process and the results obtained after the first measurement campaigns. Moreover, those results are compared to wood poles measured in other countries to observe the differences between each network, differences issued from different climates, species, maintenance policy and impregnations.

Thanks to GIS technologies, precise networks maps can be established. The maintenance is strongly optimized and the costs (interventions, changes…) highly reduced.

INTRODUCTION

CBS-CBT has developed in the 1990's a non-destructive technology for wood poles quality assessment: Polux [1].

Many utilities in Europe [2], but also in the Americas [3], have adopted this method to enhance networks reliability and to reduce maintenance costs [4].

Based on the Polux implementation success within Telekom Austria, Deutsche Telekom has decided to launch its own investigations on its networks throughout two pilot projects before deciding to choose Polux as the sole technology for their 3 Mio wood poles inspection.

This paper relates the pilot projects' steps and the results obtained after a one year full scale experiment.

POLUX TECHNOLOGY

The Polux technology has been developed in a large R&D project supported by EDF (Electricité de France), the Swiss Federal Institute of Technology located in Lausanne and CBS-CBT. The physical principle of the Polux device is the measurement of two physical basic wood properties at the pole's ground line (GL) level:

1. The GL local compression strength F, translating the residual wood density, directly correlated to the pole's residual Cantilever bending strength
2. The internal wood moisture content (MC) which relates the decay process (active or non-active) obtained through the wood bio-degradation equation (eq. 1) giving CO_2 and H_2O.

$$\text{Wood} + \text{micro-organisms} + O_2 \rightarrow CO_2 + H_2O \qquad (1)$$

Then, the Polux decision software gives the non-destructive evaluation (NDE) of the pole for both characteristics, the residual bending strength by pondering mainly the F value and the estimated next inspection date by analysing the associated MC to the residual strength.

A scale of four status informs the inspector:

1. The pole must be replaced as soon as possible
2. Next inspection in 3 years
3. Next inspection in 5 years
4. Next inspection in 8 years

This scale can be updated according to the inspection cycles commonly used by a specific company by adjusting the algorithm in the software.

In 2010, the fourth generation of device was born (figure 1)

Figure 1: Polux device, 4th generation. Non-destructive technology for wood pole quality assessment.

PILOT PROJECTS IN GERMANY

Before deciding to choose a new technology, Deutsche Telekom proceeds to pilot projects to evaluate its performances.

Concerning Polux, two pilot projects have been launched:

1. A preliminary one to confirm the technology accuracy
2. A second one to see if the technology is applicable within the company at its largest scale

Each pilot project has required one year in order to get the data and then to report them adequately.

Finally, the implementation is studied, especially concerning the data transfer within the Deutsche Telekom existing databases and the training to give to the in-field inspectors.

First pilot project: technology validation

The first pilot project started in 2007. The objective was to evaluate the technology accuracy on Deutsche Telekom wood poles.

Comparison of measurements at ground line level and at -30cm under the ground line level

A sampling of approximately 750 wood poles has been chosen in Bavaria. Those 750 wood poles have all been inspected with Polux. The impregnations were either salts or creosote and the mean age of the sampling was approximately 20 years old.

The Polux measurement is performed at the ground line level. To be sure to not forget some decay under the ground line level, some extra investigations have been required by Deutsche Telekom: Polux was used at the ground line level plus at -30cm (after digging). Both measurements have been compared (figure 2).

The first results show that all the decayed poles at -30cm under the ground line level have been rejected too by the measure at the ground line level, meaning that the measurement doesn't require an initial dig (Table 1).

This result is very important, because digging requires high costs.

Figure 2: Measurements at ground line level and at -30cm under the ground line level (after digging).

		At GL			
		R	FR	FG	G
Under the GL	R	**12**	0	0	0
	FR	1	**13**	16	1
	FG	1	6	**38**	23
	G	0	0	2	**11**

Table 1: Measurements comparison between ground line level (GL) and -30cm below the ground line level. All the decayed poles at -30cm from the GL have been rejected too by the measurement at the GL (R status).

Decay inspection

From the 750 inspected poles, a sampling has been removed from the field to be visually inspected: the poles were cut at ground line to observe any presence of decay under the ground line level (Figure 3).

The measurements were then compared to a micro-drilling method previously used by Deutsche Telekom.

Figure 3: Comparison between the Polux measurement, the decay presence and micro-drilling method. Decayed pole on the left, sane pole on the right.

The advantage of Polux is the numbered result: no interpretation is required, what is not the case for another method.

All the strongly decayed poles have been rejected by Polux, and many unjustified rejected poles by micro-drilling could have been saved by Polux.

Residual strength evaluation

After this successful test (decay inspection), the last one consisted in breaking some poles to evaluate their residual strength.

One advantage of Polux is its ability to evaluate the residual strength of the pole by giving a value in MPa.

Those tests were performed at a wood pole supplier: Fürstenberg Holz in southern Germany (Hüfingen). Figures 4 and 5 illustrate the tests and the results respectively.

Figure 4: Destructive tests and comparison with Polux residual strength evaluation. Tests in Hüfingen, Germany, Fürstenberg Holz.

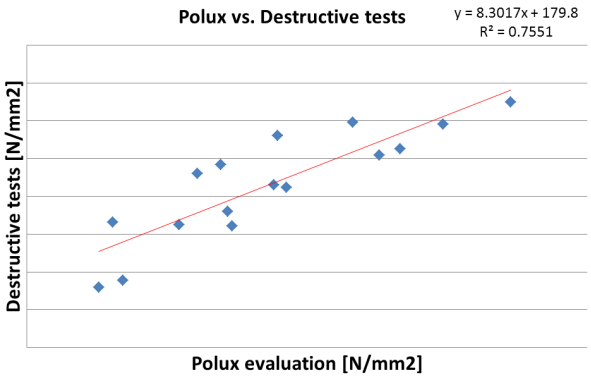

Figure 5: Destructive tests results vs. Polux evaluation. r^2=0.76, n=16 poles.

The correlation between Polux evaluation and the destructive tests presents a coefficient of determination r^2=0.76, a result similar to the other correlations in other countries and/or other species.

Conclusions after the first pilot project

The conclusions after the first Polux pilot project for Deutsche Telekom are:

- The measurement at the ground line level is available: digging is not required
- The results are objective (number): many poles can be saved as long as the most decayed ones are rejected thanks to Polux
- The destructive tests present high coefficient of determination (r^2=0.76)

Thanks to those positive results, Deutsche Telekom decided to launch the second phase of the development: the second pilot project.

Second pilot project: Technology large scale tests

The second pilot project had the following objective: is the Polux technology available for a large scale use, and what are the results on a large sampling?

Consequently, 12'000 wood poles have been measured in different regions of Germany during two months thanks to three to six inspectors.

In accordance with Deutsche Telekom current inspection cycle, the Polux scale has been modified with the following values: 0, 3, 6 and 9 years.

The maintenance results for the 2nd pilot project combining both Polux and visual inspection are given by the figure 6 and summarized as follow:

- Poles to be replaced: 6%
- Next inspection in 3 years: 18%
- Next inspection in 6 years: 34%
- Next inspection in 9 years: 42%

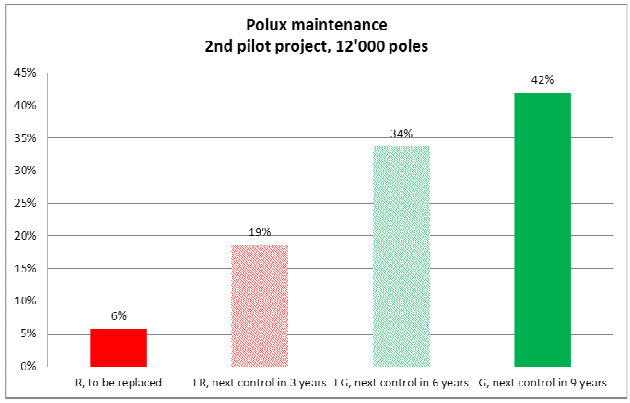

Figure 6: Polux maintenance results (including complementary visual inspection). 12'000 poles, 2nd pilot project for Deutsche Telekom. Salts and creosote poles mixed.

The Polux results reduce strongly the number of poles to be replaced (6% with Polux vs. 16% before) and extend the inspection cycle for the best ones. This has strong economic advantages.

In terms of poles residual strengths, the figure 7 presents the distribution obtained during the second pilot project with the following characteristics: mean: 35.1 MPa, Standard deviation: 10.0 MPa.

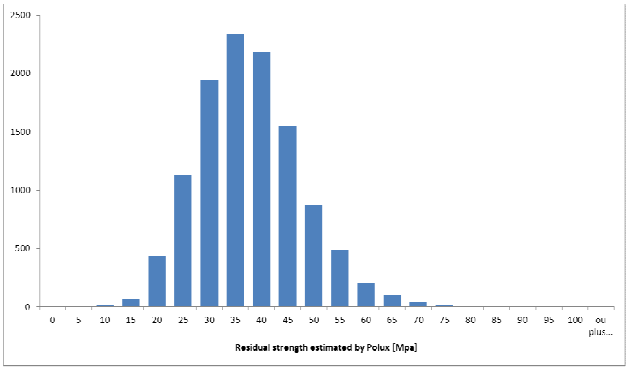

Figure 7: Poles residual strength evaluated by Polux [MPa]. 12'000 poles, 2nd pilot project for Deutsche Telekom. Mean age: 20 years old.

Thanks to the residual strength evaluation, the security index of each pole is given: this is the difference between the pole's residual strength and the limit set by the local standards.

COMPARISON WITH OTHER COUNTRIES

Based on the Polux large international database, the pilot project can be compared to other results from other countries.

Nevertheless, German wood poles must be compared to other countries where species and impregnation are similar.

Indeed, comparing Deutsche Telekom poles with the American networks would be irrelevant: species, impregnations and poles' dimensions are too different.

In Western Europe, where the comparison can be done, and where maintenance is performed, the average values for both strengths and inspection cycles are the following:

For utilities: Mean: 38.4 MPa, Std Dev.: 8.4 MPa, mean age: 26.3 years

- R, Poles to be replaced: 6%
- FR, Next inspection in 3 years: 10%
- FG, Next inspection in 5 years: 39%
- G, Next inspection in 8 years: 45%

For telecom: Mean: 40.2 MPa, Std. Dev.: 13.2 MPa, mean age: 26.5 years

- R, Poles to be replaced: 7%
- FR, Next inspection in 3 years: 10%
- FG, Next inspection in 5 years: 29%
- G, Next inspection in 8 years: 55%

In other terms, the results of strengths obtained during the second pilot project are right in the average of the database.

The percentage of "next inspection in 3 years" is higher for Deutsche Telekom (19% vs. 10% for the others) could be explained by the fact that the scale is longer for the other categories (5 to 6 years for FG and 8 to 9 years for G).

CONCLUSION

After the two successful pilot projects, Deutsche Telekom decided to implement Polux for the inspection of their wood poles.

Deutsche Telekom has approximately 3 Mio wood poles and the inspection cycle is 6 years (explaining the Polux 0-3-6-9 scale), meaning that 500'000 wood poles must be inspected yearly.

In 2010, after the first year of inspection with Polux, more than 500'000 poles have been checked.

If the results remain confidential, the trend confirms the results obtained during the pilot projects.

The maintenance costs could have been reduced drastically thanks to a drop of rejected poles and an extension of inspection cycle.

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