LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL

FIRE PROTECTION OF WOODEN POLES

Summary of results from different protection solutions

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Title

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FIRE PROTECTION OF WOODEN POLES

Summary of results from different protection solutions

Abstract

The present report regards activity 4 of project FusionPole dealing with the selection of suitable fire protection solutions to be applied to wooden poles for overhead lines decreasing their contribution for the propagation of forest fires. This study comprised fire tests conducted over four solutions: two intumescent paint systems; two protective wrap systems (a fabric protection applied mechanically to the surface of the pole and a glued system comprising a composite). All solutions showed to be effective in protecting the posts under the current test conditions. These results are, however, preliminary, and further tests are needed under conditions closer to those found in the field.

Keywords: FusionPole / Report / Wooden poles / Fire protection / Heat release

PROTEÇÃO AO FOGO DE POSTES DE MADEIRA

Resumo dos resultados para diferentes tipos de soluções

Resumo

O presente relatório diz respeito à atividade 4 do projeto FusionPole, relativa à seleção de soluções de proteção contra incêndio adequadas a serem aplicadas a postes de madeira para linhas aéreas, diminuindo a sua contribuição para a propagação de incêndios florestais. Este estudo compreendeu ensaios de fogo realizados sobre quatro soluções: dois sistemas de pintura intumescente; dois sistemas compreendendo o envolvimento exterior total dos postes (uma proteção de tecido aplicada mecanicamente na superfície do poste e um sistema de compósito colado à superfície). Todas as soluções apresentam-se como eficazes na proteção dos postes nas atuais condições de ensaio. Esses resultados são, no entanto, preliminares, sendo necessários mais ensaios em condições mais próximas às encontradas no campo.

Palavras-chave: FusionPole / Relatório / Postes de madeira / Proteção ao fogo / Libertação de calor

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1 | Introduction

Maritime pine (*Pinus pinaster* Aiton) utility poles for telecommunications overhead lines is a product with a low level of processing after cutting the tree in the forests, having low costs in terms of economy, energy and environment impact.

Considering that maritime pine takes between 30 and 40 years until reaching a proper dimension for cutting and the recent wildfires have decimated a large part of the Portuguese pine forest, it is expected that in the next decades there could be a lack of trees in quantity and quality to supply the market for telecommunications poles. This scenario will result in an increase of timber prices for this type of application and therefore the loss of competitiveness of wood poles versus other less environmentally friendly alternatives such as concrete and/or steel poles.

FusionPole project has two main objectives: a) to promote the reuse of the healthy parts of maritime pine poles removed from service through its connection to a new element that replaces the decayed part (prosthesis) – enhanced the partial re-use of material; b) to study fire protection measures that could prevent the contribution of wooden poles to the spreading of surface forest fires, following a recommendation made by ANACOM which is the Portuguese National Authority for Communications.

The project partners comprise four entities: the company Pedrosa & Irmãos Lda (Project Leader), the University of Coimbra (UC), the National Laboratory for Civil Engineering (LNEC) and the Forest Innovation and Competence Center (SerQ).

The present report describes the different fire retardant or fire protection solutions tested under the scope of task of 4.2 “Assessment of fire behavior” within activity 4 “Improvement of fire behavior” of the FusionPole project. The tests were conducted at the URF | Reaction to Fire Laboratory of LNEC.

The present report provides a summary of results obtained in order to support the selection from the technical point of view of the more advantageous to be used by the company Pedrosa & Irmãos Lda. The solutions selected by this company will be tested in a second step at the FIRELAB facilities at the University of Coimbra, under simulated fire conditions.

2 | Experimental program

Pedrosa & Irmãos Lda delivered to Fire Unit of the National Laboratory for Civil Engineering (LNEC) a total of fourteen maritime pine poles with a length of 1.5 m and a diameter ranging from 0.20 m±0.01 m, figure 2.1a. These poles were afterwards cut to a final length of 1.3 m given the dimensions of the fire testing chamber.

Regarding the solution of wooden poles protected by high tensile composite product (HTCP), pine wooden poles were delivered at LNEC already protected, figure 2.1b.

a)

b)

Figure 2.1 – Wooden poles delivered at LNEC from a) Pedrosa & Irmãos Lda; b) from the manufacturer of the fire protection (solution D)

The fire retardant protections comprised different solutions available in the market suitable for wood applied in outdoor conditions. Two of these solutions were applied by painting (solutions A and B), other solution comprised the wrap of the wood poles using a fire retardant fabric (solution C) and finally the last solution was the wooden pole involved in a composite (solution D), figure 2.1b.

For solutions A, B and C the protection was made after ensuring that the wooden poles showed a moisture content below 20 %. For that purpose, an electrical moisture meter was used.

Figure 2.2. shows the different fire protection solutions applied to the wooden poles before testing. Table 2.1 describes the characteristics of the different poles tested.

Solution A

Solution B

Solution C

Solution D

Figure 2.2 – Solutions applied to wooden poles delivered: a) at LNEC ;and b) from the manufacturer of the solution

Table 2.1 – Wooden poles tested

Wooden pole	**Details**
Nº 1	Untreated *Pinus pinaster* pole about 1.31 m long and ≈ 0.20 m in diameter; Painted with a coat of primer, followed by two coats of intumescent paint A and finally two coats of finishing paint.
Nº 2	Untreated *Pinus pinaster* pole about 1.31 m long and ≈ 0.20 m in diameter.
Nº 4	Untreated *Pinus pinaster* pole about 1.31 m long and ≈ 0.20 m in diameter. Painted with a coat of primer, followed by two coats of intumescent paint B and finally two coats of finishing paint.
Nº 5	*Pinus pinaster* pole treated with a water-based wood preservative containing copper, about 1.31 m long and ≈ 0.20 m in diameter. Painted with a coat of primer, followed by two coats of intumescent paint A and finally two coats of finishing paint.
Nº 6	*Pinus pinaster* pole treated with a water-based wood preservative containing copper, about 1.31 m long and ≈ 0.20 m in diameter.
Nº 7	*Pinus pinaster* pole treated with a water-based wood preservative containing copper, about 1.31 m long and ≈ 0.20 m in diameter. Painted with a coat of primer, followed by two coats of intumescent paint B and finally two coats of finishing paint.
Nº 8	*Pinus pinaster* pole treated with a water-based wood preservative containing copper, about 1.31 m long and ≈ 0.20 m in diameter. Protected with a fabric (solution C) measuring 1.22 m long and 0.70m wide and 0.4 mm thick.
Nº 13	Wooden pole coated with a composite (Solution D). The pole was cut to a length about 1.5 m long and ≈ 0.20 m in diameter.

The fire tests were based on the European test standard EN 13823:2020 – "Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item". The test standard consists in the evaluation of several aspects of the fire performance of a specimen of significant dimensions, which is subjected to the action of the flames of a gas burner with a nominal thermal power of 30 kW.

The following parameters were determined:

- FIGRA - Fire Growth Rate Index.
- SMOGRA - Smoke Growth Rate Index.
- THR_{600s} - Total Heat Released in the first 600s of exposure to the main burner flames.
- TSP_{600s} - Total Smoke Production in the first 600s of exposure to the main burner flames.
- HRR_{30s} – Average of the heat release rate, corresponding to a moving average of the heat released determined for each instant *t* considering the values recorded between *t*-15s and *t*+15s.
- SPR_{60s} – Smoke production rate, corresponding to a moving average of the heat released determined for each instant *t* considering the values recorded between *t*-30s and *t*+30s.

The determination of the FIGRA and THR_{600s} indices is based on the measurement and continuous recording of several parameters, namely temperature and the decrease in oxygen concentration.

The determination of SMOGRA and TSP_{600s} was based on the continuous measurement and recording of temperature, pressure difference and light attenuation.

In the test chamber the poles were place vertically slightly over the corner of the ignition source (burner), 8 cm from each side of the apex, figure 2.3.

Figure 2.3 – Pole placement in the test chamber and under testing

The bottom end of each pole was protected with a calcium silicate plate and a rock wool blanket with the same diameter as the post. This protection worked in a satisfactory manner in all cases, with exception of solution C, showing the poles only a slight superficial deterioration at the bottom end of the pole, which was disregard, in the final analysis of the results. In the field, this type of situation would not occur since the protection will be extend to a length of the pole under the soil.

3 | Results

3.1 Testing results

Table 3.1 showed the result of the tests carried out.

Table 3.1 – Summary of test results

Parameter	Poles tested							
	1	2	4	5	6	7	8	13
$FIGRA_{0.2MJ}$ (W/s)	—	46.2	—	—	48.6	—	—	—
$FIGRA_{0.4MJ}$ (W/s)	—	40.4	—	—	43.8	—	—	—
THR_{600s} (MJ)	0.5	3.1	0.7	0.6	2.9	0.6	0.3	0.4
SMOGRA (m^2/s^2)	—	—	—	—	—	—	—	—
TSP_{600s} (m^2)	12.9	11.7	17.9	14.3	24.4	13.3	12.1	9.7

The results showed the noticeable enhanced performance of the different fire protection solutions (poles 1, 4, 5, 7, 8, 13) versus the results obtained for wooden poles without protection (poles 2 and 6) in terms of heat released, figure 3.1, and total heat released, figure 3.2.

All solutions showed to be efficient, being the intumescent paint solution applied in pole number 4 the one that showed the highest heat released (figure 3.2) whereas as the fabric protection (pole number 8) showed the lowest heat released.

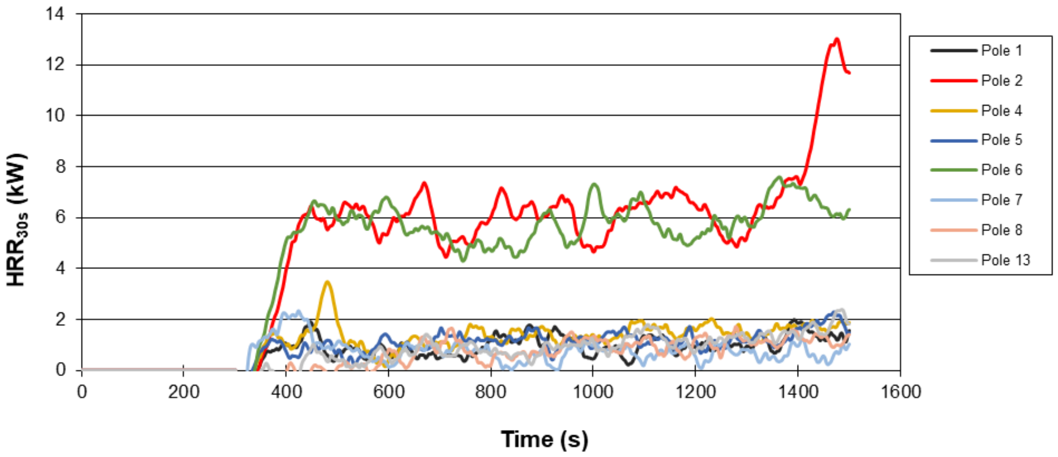

Figure 3.1 – Results regarding heat released considering an average time window of 30s – HRR_{30s}

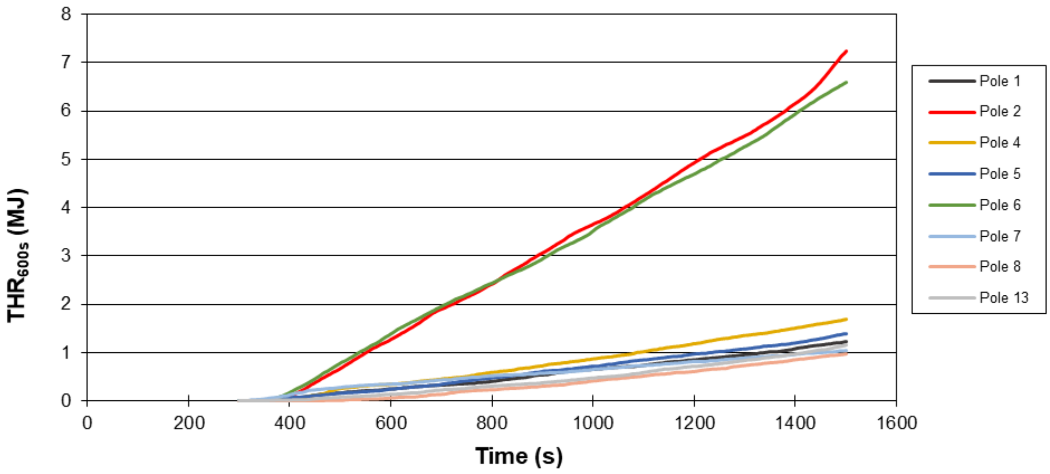

Figure 3.2 – Results regarding total heat released in the first 600s – THR_{600s}

Regarding fire development rate, figure 3.3, the same observation was made (significant lower performance showed by the poles not protected). Pole 4 protected by an intumescent paint (product B) showed a peak point which was after test verified to be due to deposit (contamination) existing at the surface of the pole.

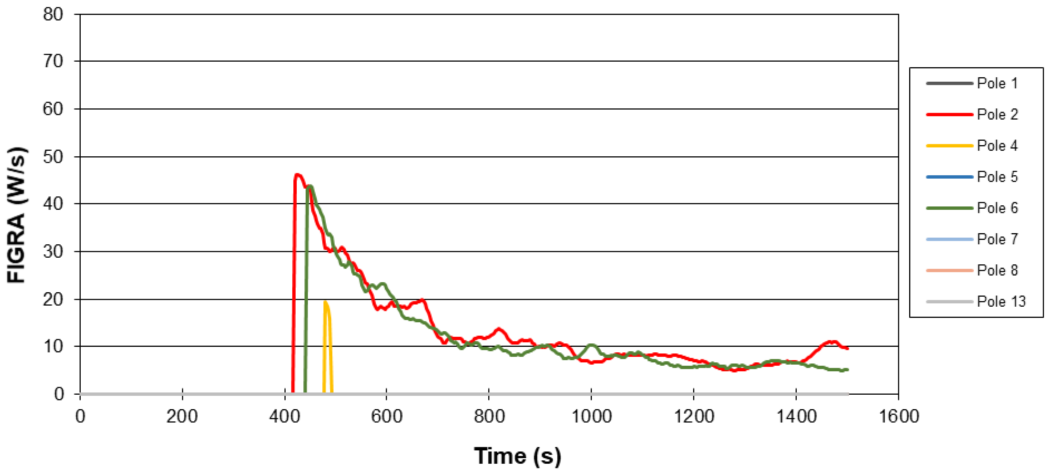

Figure 3.3 – Results regarding fire development rate

The pole treated with a solution of copper showed a higher smoke production rate, noticeable higher than the rest of the poles tested. In the case of the pole showing no treatment, it was observed a similar behavior with the poles protected against fire, figure 3.4. This same result was obtained for total smoke production, figure 3.5.

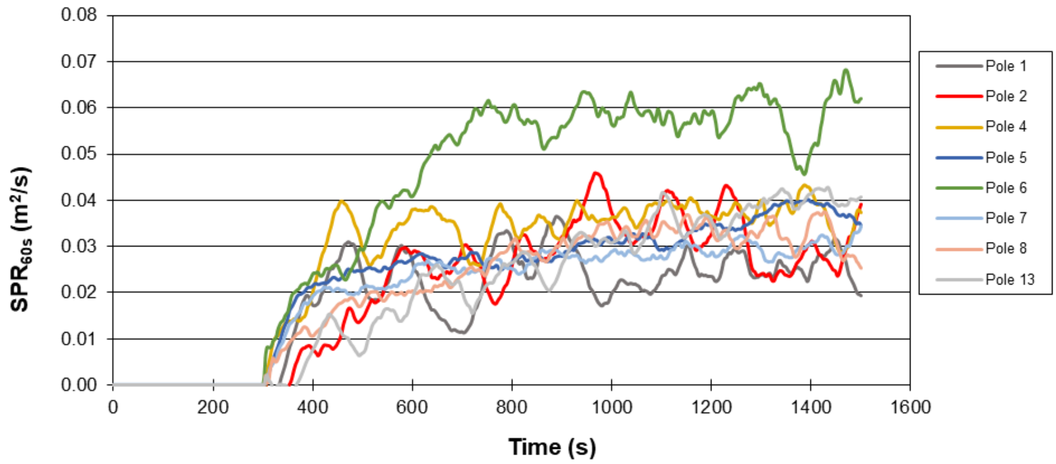

Figure 3.4 – Results smoke production rate average 60s (SPR_{60s})

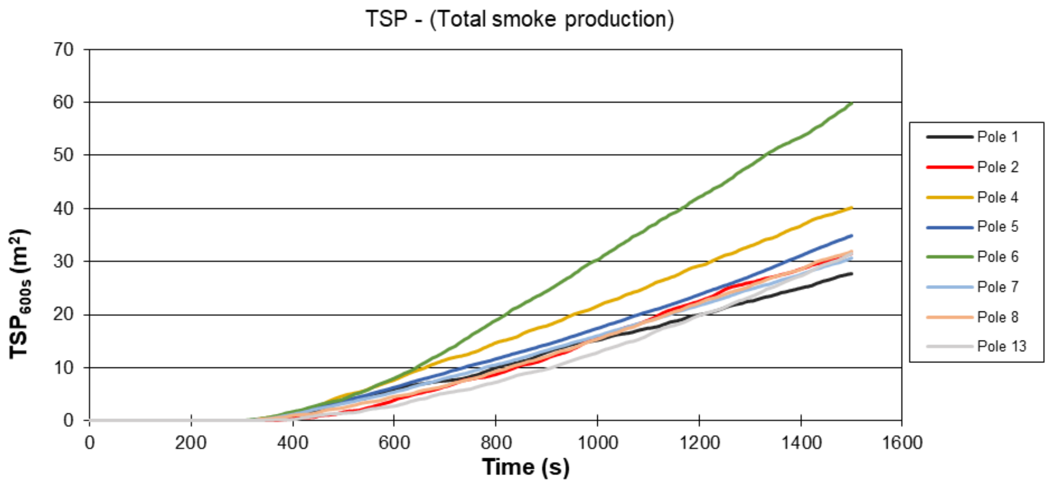

Figure 3.5 – Results for total smoke production in the first 600s – TSP_{600s}

3.2 Visual appraisal of the poles after testing

After testing, the poles were visually observed to assess the damage (loss of cross-section) at a distance of 10 cm and 30 cm from the bottom end of the pole. As expected the poles without protection showed a strong superficial degradation, figures 3.6 and 3.7, that could reach 4 cm in the face directly exposed to the fire.

The application of the intumescent paint A provided a good protection against fire not being noticed any severe deterioration of the superficial layers of the poles after testing, figures 3.8 and 3.9. The same conclusion can be taken from the application of the intumescent paint B, figures 3.10 and 3.11. In both cases, a small layer of charred wood is observable, figure 3.12.

Figure 3.6 – Bottom end of pole 2 – unprotected & untreated pole (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

Figure 3.7 – Bottom end of pole 6 – unprotected & treated pole (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

Figure 3.8 – Bottom end of pole 1 – Solution paint intumescent A & untreated pole (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

Figure 3.9 – Bottom end of pole 5 – Solution paint intumescent A & treated pole (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

Figure 3.10 – Bottom end of pole 4 – Solution paint intumescent B & untreated pole (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

Figure 3.11 – Bottom end of pole 7 – Solution paint intumescent B & treated pole (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

Figure 3.12 – Superficial degradation after testing (left – intumescent paint A; right – intumescent paint B)

The solution C comprised the wrapping of the wooden pole using a fire retardant fabric, figure 3.13. Unfortunately, in this case due to a defect of the wooden pole the protection to prevent the exposure of the bottom end of the pole was not sufficient. It was decided then to extend the test (subject the pole to the test) to verify if any deterioration of the fabric was observable. As result of this second test the integrity of the fabric was maintained showing however a more brittle behavior. For this solution only a treated pole was tested, since the sample provided by the manufacturer only turn possible one test.

Figure 3.13 – Bottom end of pole 8 – Solution fire retardant fabric & treated pole (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

The last solution tested was a wooden pole coated with a composite – solution D, figure 3.14. After testing, the pole was also cut in order to evaluate the degradation of the superficial layers of wood below the matrix. The results showed that, as for solution A and B, a small amount of charred is observable at 10 cm, figure 3.15, but the degradation at 30 cm of the bottom is insignificant. For the purpose of the test only the results at 30cm of the end are regarded as important since at this height eventual problems of insulation at the base of the pole does not affect the performance of the solution.

Figure 3.14 – Bottom end of pole 13 – Solution fire retardant fabric (left – bottom end of the pole; right up – Cross-section at 10cm of the end; right bottom – Cross-section at 30 cm of the end)

Figure 3.15 – Superficial degradation after testing (left – at 10cm of the bottom; right – at 30cm of the bottom)

Finally, it can be also concluded that there is no evidence that the wood preservative treatment based on water-based copper solution had any influence in the performance of the fire protection solutions tested.

4 | Conclusions

The aim of the study was to select possible fire protections that could prevent the contribution of wood poles for overhead lines for the propagation of forest fires (namely surface fires).

The solutions tested which included intumescent paints and protective wraps showed to be suitable solutions for the protection of wooden poles. In a second stage of the project the industrial feasibility (technical and financial) of the different solutions will be analysed and two solutions will be selected for tests to be made at the FIRELAB facilities at the University of Coimbra, under simulated fire conditions and considering exterior conditions (including ageing).

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APPROVED

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