LIGHTNING PROTECTION FIELD EXPERIMENT IN JAPAN ON A WIND TURBINE PLANT USING AN E.S.E. LIGHTNING CONDUCTOR

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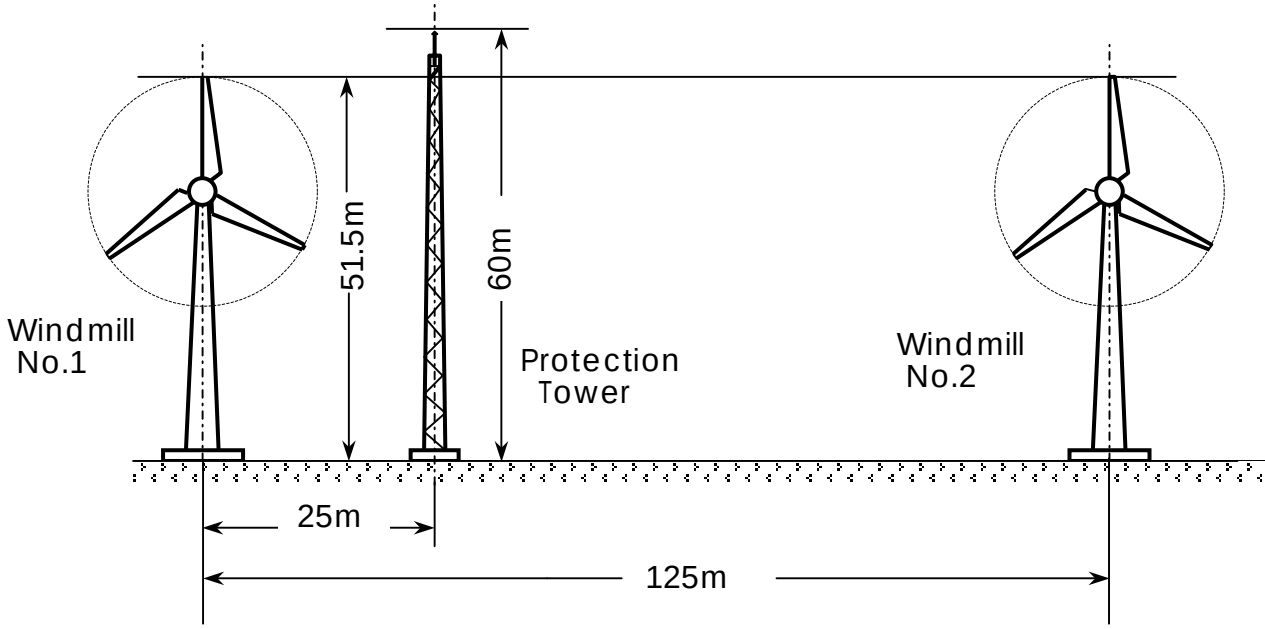
This experiment was carried out on the Nadachi wind turbine plant on the west coast of Japan and was designed to measure the effectiveness of lightning protection afforded by a PREVECTRON early streamer emission lightning conductor manufactured by Indelec.

1. INTRODUCTION OF THE SITE

The plant consists of two three-blade, horizontal-axis turbines, generating several hundred kilowatts of electricity and with a maximum height of 51.5 m. Each blade is approximately 10 m. long and is made of a composite material. When the site was inaugurated in December 1996, no specific provisions were included in the design for protection against direct lightning strikes.

The site is located in a region notorious for winter storms with a keraunic level of between 30 and 35. However, the storms specially occur during the few winter months and July / August. The lightning flash density is then very important during these months. Thus it was that in January 1997, the turbines sustained substantial damage from a series of violent thunderstorms : mechanical (broken blades), electrical (irreparable damage to electrical and telephone systems) and computer-related.

Configuration of Nadachi-windmill-Plant



2. THE LIGHTNING PROTECTION SYSTEM

In November 1997 a Prevectron–type ESE lightning protection system manufactured by INDELEC (France) was installed by CENTRAL LIGHTNING PROTECTION INC. (Japan) on a 60-meter mast, positioned between the tow turbines, 25 meters from one and 100 meters from the other, in order to take into account the fact that the winter T.storms come from the ocean and reach first the windmill #1 (see config. Drawing).
The Prevectron ESE device was set 8.5 meters higher than the highest point reached by the blades as they turn, or when at rest at their highest position.

3. INSTRUMENTION AND TESTING

At the same time, an automated monitoring station was positioned 1 km away. A special optical and mechanical twin-shutter camera allows the lightning to be photographed very quickly.
The twin-shutter is characterized by a photodiode sensor operation :

First : A mechanical shutter opening within 25 ms on a far weak luminous lightning.

Second : A liquid-crystal shutter opening within 5 µs with the first return stroke occurring in the filed of the lens.
An international clock is corrected every 30 minutes via the GPS satellite signal.

The 35 mm film used contains 700 exposures, giving an autonomy of approximately 3 months without maintenance. The films are time stamped with an accuracy of +- 100 µs, using a GPS satellite signal corrected every 30 minutes.

4. RESULTS

This report presents the results of two winter monitoring periods (1st quarter 1998 and

December 1998) with a total of 32 exposures showing cloud/ground flashes.

Among the 32 impacts – most of which were of the upward type – 29 were caught by the ESE protection, thereby avoiding considerable damage to the generators and auxiliary equipment. 2 impacted the turbine closest to the protection system and one impacted the turbine farther away. However, the three probably low intensity impacts that hit the generators only cause small traces at the surface of the blades, without structural damages to the turbines.

The figures were then analysed to find the correlation between the results of the experiment and the theoretical protection values.

5. CONCLUSION

These two monitoring campaigns, carried out on an industrial installation have clearly demonstrated the effectiveness of the protection afforded by a Prevectron ESE lightning conductor, and showed a good correlation with the theoretical model.

Assessment of a wind turbine's protection requirements indicates a level of protection I, thereby providing an efficiency of between 90 and 95%. In fact, where only one turbine is taken into account, the efficiency demonstrated during this experiment is 94%, while if both of the generators are considered, efficiency is 90%.
In both case, the efficiency of the LPS complies with the theoretical model.

Finally, it should be remembered that the electrogeometrical model of the standards CEI 61024-1 and NFC 17-102 is based on downward negative lightning strikes. It is interesting to note that the model of NFC 17-102 standard is also validated for upward (probably positive) strikes recorded during this experiment.
This experiment is still in process. The next step will consists to instrument the PREVECTRON tower, in terms of cloud/ground flashes characterization : upward streamer currents and return stroke amplitudes and polarity.

Furthermore an international experiment is conducted in BRAZIL (Sao Paulo state), from year 2000 to year 2005, around natural and triggered lightning. Among several objectives, one of them consists to establish competition between different instrumented single rod and Early Streamer Emission rod.
So the coming results will contribute to improve the understanding of the discharge mechanism, relative to single rods and Early Streamer Emission (ESE) lightning rod operation.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