21, rue d'Artois, F-75008 Paris
http://www.cigre.org

300-05

Symposium CAIRNS

RECOMMENDATIONS TO SOLVE CORROSION PROBLEM ON HV INSULATOR STRINGS IN TROPICAL ENVIRONMENT

by

O. L.S. PAIVA
R. SUASSUNA

Chesf

(Brazil)

D. DUMORA
R. PARRAUD *

Sediver

(France)

L.F. FERREIRA
M. NAMORA

Electrovidro

(Brazil)

ABSTRACT

In tropical areas, insulators are subjected to specific environmental conditions : an almost permanent high humidity (RH > 70 %), a high mean temperature, associated with periods without rainfall. The consequence is an increasing of the conductivity of insulator surface when they are lightly polluted. The frequent leakage currents associated with arcs and discharges are the cause of the corrosion of insulator metal end fittings.
The field experience of a new insulator design which is in operation since 5 years on 500 kV line in a severe typical tropical environment where the conventionnal insulators are submitted to corrosion problem is presented in this report.
On the base of the field experience and the analysis of the corrosion, recommendations to improve the corrosion performance of insulators based on the analysis of the corrosion mecanism [5] on HV insulator strings are presented in this report.

1. INTRODUCTION :

It is possible to distinguish two main corrosion mechanisms of insulator [2] :
The first corresponds to the electrolytic corrosion due to the passage of a frequent leakage current on each insulator of a string [3].
The second corresponds to the ''arc corrosion'' phenomenon [5] which concerns all the insulators of a string when the humidification of their surfaces is maximal, but also which increase the corrosion of the bottom units subjected to more arc activity duration than the other insulators during the pre-period of humidification and drying of the surface.

2. RECOMMENDED INSULATOR DESIGN FOR TROPICAL ENVIRONMENT

2.1 Insulator design

The insulator design corresponds to improvements of the insulator for tropical environment subjected to a natural contamination (dusts, salts, ashes of sugar canes, …) to reinforce the insulator corrosion resistance (electrolytic corrosion and arc corrosion).

2.2 Protection of the metal parts of the insulators

The cap and the pin of the insulator are protected by a continous zinc coating. A zinc protection with a very good bonding between the zinc layer and the pin forged steel or the cap cast iron, can be obtained by the hot dip galvanization process. A minimum zinc thickness of 110 µm can be obtained without risk of galvanization scaling due to a bad bonding.
In some wet conditions, the zinc coating (galvanization) can be subjected to a formation of zinc hydroxide. Its corresponds to a white deposit. It is a non soluble and non conductive material which does not affect the electrical performance of the insulators.
In tropical zones subjected to heavy contamination (areas close to the sea), the metal parts of the insulators must be protected against the effects of corrosion (atmospheric, electrical corrosion …), with reinforced galvanizing and sacrificial electrodes at the triple junction of the dielectric, metal parts and air.
The pin must be protected with a sacrificial electrode in pure zinc.
Even if the cap corrosion was never a serious problem from a mechanical point a view, in heavy polluted contamination, it is recommended, to avoid the formation of a rust deposit on the insulator dielectric surface.

* Sediver – 03270 SAINT-YORRE (FRANCE)

The figure 1 represents typical toughened glass optimised insulators used in tropical areas subjected to heavy contamination :

- to optimise the electrical stresses on the metal parts (cap and pin),
- to have a more uniform electrical field distribution on the insulator,
- to limit the effects of discharges around the metal parts during ''wetted'' periods.

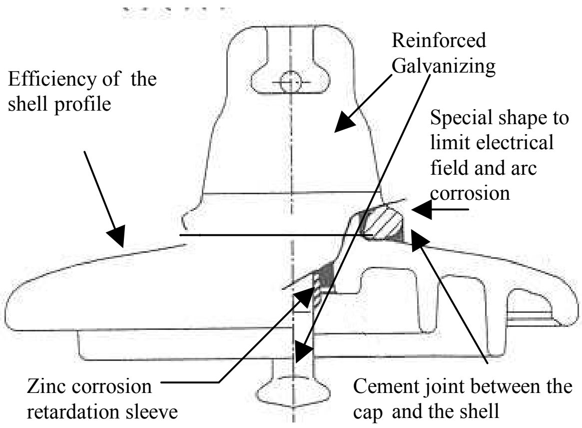

Fig. 1 : Toughened glass optimised insulator design

3. FIELD EXPERIENCE OF TOUGHENED GLASS INSULATOR FOR 500 KV TRANSMISSION LINES IN TROPICAL ENVIRONMENT

New optimised and conventional insulators were set up on a 500 kV transmission line built on the Nordeste area in Brazil. Insulators are tested as " I " and " V " strings composed of 26 units without protective devices on the same towers (Table 1).
Various corrosion degrees from A to D were defined to quantify the performance of the insulator after a comparative exposure time in the same towers (from 1994 to 1999) in areas where conventional insulators were subjected to early corrosion. (see table 1)
The various corrosion degrees are defined as indicated below :

Corrosion degree A) The galvanization protects always the metal, but some little superficial traces of oxidation are visible (modification of the visual aspect)
Corrosion degree B) Significant corrosion step with a rust formation ; Apparition of iron oxide which corresponds only to a partial attack of the galvanization
Corrosion degree C) Complete attack of the galvanization which is destroyed totaly. A rust deposit covers the metal.
Corrosion degree D) Heavy corrosion with a significant reduction of the metal thickness.

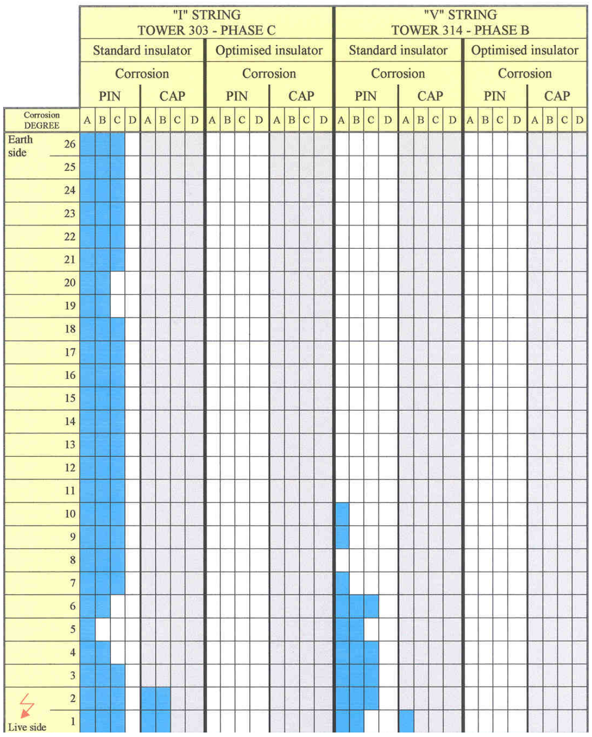

Table 1 : Comparative corrosion degree on ''I''and ''V'' strings after 50 months in severe tropical environment500 kV (tower 303) line Sobradinho-Itaparica

The table 1 shows:

a) For the optimised insulator design (see fig 1) with a cement joint between the cap and the dielectric and zinc retardation sleeve on the pin, no actual corrosion appears on the metal parts in comparison with standard insulator design
No pin corrosion and no cap corrosion have started on ''I'' and ''V'' strings. Only some points of white zinc hydoxide from the galvanisation which does not affect the efficiency of the galvanisation coating are visible on caps and pins.
The optimised insulators present an obvious corrosion improvement in comparison with the conventional insulators.
b) For the standard insulator, the pin corrosion is greater than the cap corrosion. The cap corrosion is starting on the live end units which are subjected to more arcs and discharges during the process of humidification and drying of the insulator surface.Corrosion is more important on ''I'' strings than on ''V'' strings. It can be explain by the fact that the pollution degree of ''I'' strings is higher than the pollution degree on ''V'' strings due to a better self cleaning of the insulator on inclined ''V'' strings.

4. GENERAL RECOMMENDATIONS FOR THE CHOICE OF INSULATOR FOR TROPICAL ENVIRONMENT

Tropical environment is characterised by an almost permanent high humidity (≥ 70 %), a mean high temperature and a long period without rainfall corresponding to the accumulation of a natural contamination.

We can distingued two main areas corresponding to different natural geographical zones :

- The inland areas which can be subjected to a natural contamination with dust from the ground
- The sea coast areas close to the sea which is subjected to a more conductive pollution (soluble salt), often associated with a solid contamination.

The table 2 below summarizes some recommendations for the choice of insulator to increase the life of the line with the prevention of corrosion damages, and to avoid other disturbances due to the flashover of the insulator strings

<table>
<tr><th rowspan="3">Contamination Level</th><th rowspan="3">Examples of Typical Contamination In tropical areas</th><th colspan="6">Recommanded insulators used on AC transmission lines for tropical areas</th></tr>
<tr><th rowspan="2">Insulator profile</th><th rowspan="2">Leakage distance (*) in mm/kV (Phase to phase)</th><th colspan="4">Corrosion protection</th></tr>
<tr><th>Galvanizing</th><th>Pin</th><th>Cap</th><th>Cap Assembling</th></tr>
<tr><td colspan="4"></td><td colspan="3">← Metal parts →</td><td></td></tr>
<tr><td>A – LIGHT : ESDD <0,07 mg/cm²</td><td><u>Inland areas</u> Clean zones at more than 10 km from a pollution source (sea, desert, industrial</td><td>Standard</td><td>16</td><td rowspan="3">REINFORCED GALVANIZING (110 µm min thickness)</td><td></td><td></td><td rowspan="3">CEMENT JOINT BETWEEN THE CAP AND THE DIELECTRIC SHELL</td></tr>
<tr><td>B – MEDIUM: ESDD <0,20 mg/cm²</td><td><u>Inland areas</u>
• conductive dusts from the ground
• agricultural areas with a possible use of fertilizer
• ashes resulting of the burning of sugar canes
• areas between 3 and 10 km from the sea</td><td>Long Leakage (antifog)</td><td>20</td><td rowspan="2">PIN EQUIPPED WITH ZINC CORROSION RETARDATION SLEEVE</td><td></td></tr>
<tr><td>C – HEAVY TO VERY HEAVY : ESDD >0,20 mg/cm²</td><td><u>Sea coast areas</u> (less from 3km from pollution sources)
• marine contamination + dust contamination
<u>Industrial zones</u> with conductive pollution</td><td>Long Leakage (antifog)</td><td>≥ 25/ to 40</td><td>SPECIAL CAP</td></tr>
</table>

(*) ratio of the leakage distance for the vertical strings, measured between phase and earth over the r.m.s. phase to phase value of the highest voltage for equipment (see IEC 60071.1)

Table 2 : Recommended insulators for tropical environment

5. CONCLUSION

In tropical areas, the long term performance of insulators under specific environmental stresses corresponding to a high humidity and high mean temperature can be increases with the use of toughened glass optimised design.

Field experience in Brazil on 500 kV lines confirms that toughened glass insulators equipped with zinc retardation sleeve on the pin, a cap with a cement joint between the cap and the dielectric shell, do have an excellent behaviour when used in tropical environment subject to contamination which causes not only a leakage current but also arcs and discharges during the cycle of humidification.

6. BIBLIOGRAPHY

[1] ''Isoladores tipo disco de vidro temperado - Analise de desempenho e vida util no sistema'' CHESF - UFPB - XI SNPTEE 1991 - SILVA R/BASTOS O/XAVIER G

[2] ''Corrosao de isoladores de disco EM LT's 500 kV da CHESF (Evolucao e solucao do problema) ROMERO O. SILVA/S.J. GUSMAO CAVALCANTI /R.PARRAUD/D. DE DECKER/F.KKEULER/RACHEL SUASSUNA/OSVALDO L.S. PAIVA

[3] CIGRE N° 22-203-Aging mechanisms of AC energised insulators CROUCH A/SWIFT D/PARRAUD R/DE DECKER D

[4] ISH 87 N°51-14 The DC component of leakage current on AC energized outdoor insulation : the effect of dry band discharges SWIFT D/FITTER C/LIS

[5] Cigre Symposium Cairns 2001 – Corrosion mecanism of insulators in tropical environment – R. PARRAUD – D. DUMORA

KEY WORDS : INSULATOR - CORROSION - POLLUTION - TROPICAL

RESUME

L'humidité très élevée rencontrée dans les pays tropicaux associée à une contamination qui se produit sur la surface des isolateurs en dehors des périodes de pluie entrainent la formation fréquente de courant de fuite, associée à des arcs et à des décharges qui corrodent les ferrures des isolateurs.

A la lumière de l'étude des mécanismes de la corrosion des isolateurs, un nouveau design d'isolateur en verre trempé à été developpé pour résoudre des problèmes de corrosion observés dans des zones tropicales sur des lignes de transmission 500 kV.

A la lumière d'essais comparatifs réalisés en vraie grandeur sur des chaines 500 kV, des recommandations sont faites pour les isolateurs afin de résoudre les problèmes de corrosion rencontrés précocément dans les zones tropicales.