

By Dr. Dong Wu



Outdoor Insulation for UHVDC



abb.com/hvdc



Outdoor insulation for ± 800 kVDC

- **Research activity started at ABB & STRI 1992**
 - With pollution test ability up to 1200 kV
 - Knowledge exchange (Cigré, IEC, other research institutes)
- **First paper published here in New Delhi**
 - Sept. 1993 on CIGRÉ 33 Colloquium
 - More results published in 94-98



Outdoor insulation for ± 800 kVDC

- **Pollution test, even and uneven rain test,...**
 - Station insulators up to 11 meters
 - Shed profile comparison
 - test with and without booster sheds
 - Bushings with hydrophobic surface
- **Significant operational experience reviewed and summarized**
 - 1250 pole-years, 80% of DC transmitted power
 - Published in Bangalore on NPSC-2000

Known to us

- **With the increasing of DC voltage**
 - No trend of using longer USCD, determined by pollution
 - No tendency of higher FO rate
 - Uneven wetting of wall bushing, eliminated by hydrophobic surface
 - Linearity applies except low pollution area
 - Linearity: pollution withstand voltage as function of insulator length (for a given shed profile)

Known to us

- **The design principle of DC outdoor insulation**
 - DC/AC: pollution accumulation, shed profile
 - Coordination of internal & external insulation
- **Good experience up to 600 kV**
- **Good experience with silicone rubber insulator**
 - In North America, in China
 - Shorter USCD used (75%)



Example: Silicone rubber insulator in application

■ USA, PI project

- Porcelain line insulator: 35.3 mm/kV, wash every 60 days
- Silicone line insulator: 27.1 mm/kV, no flashover
- Porcelain wall bushing: 23.2 mm/kV, hydrophobic coating
- Porcelain wall bushing: 500 kV, 40mm/kV, RTV coating
- Silicone wall bushing: 23.2 mm/kV, no flashover

■ China, in several 500 kV DC projects

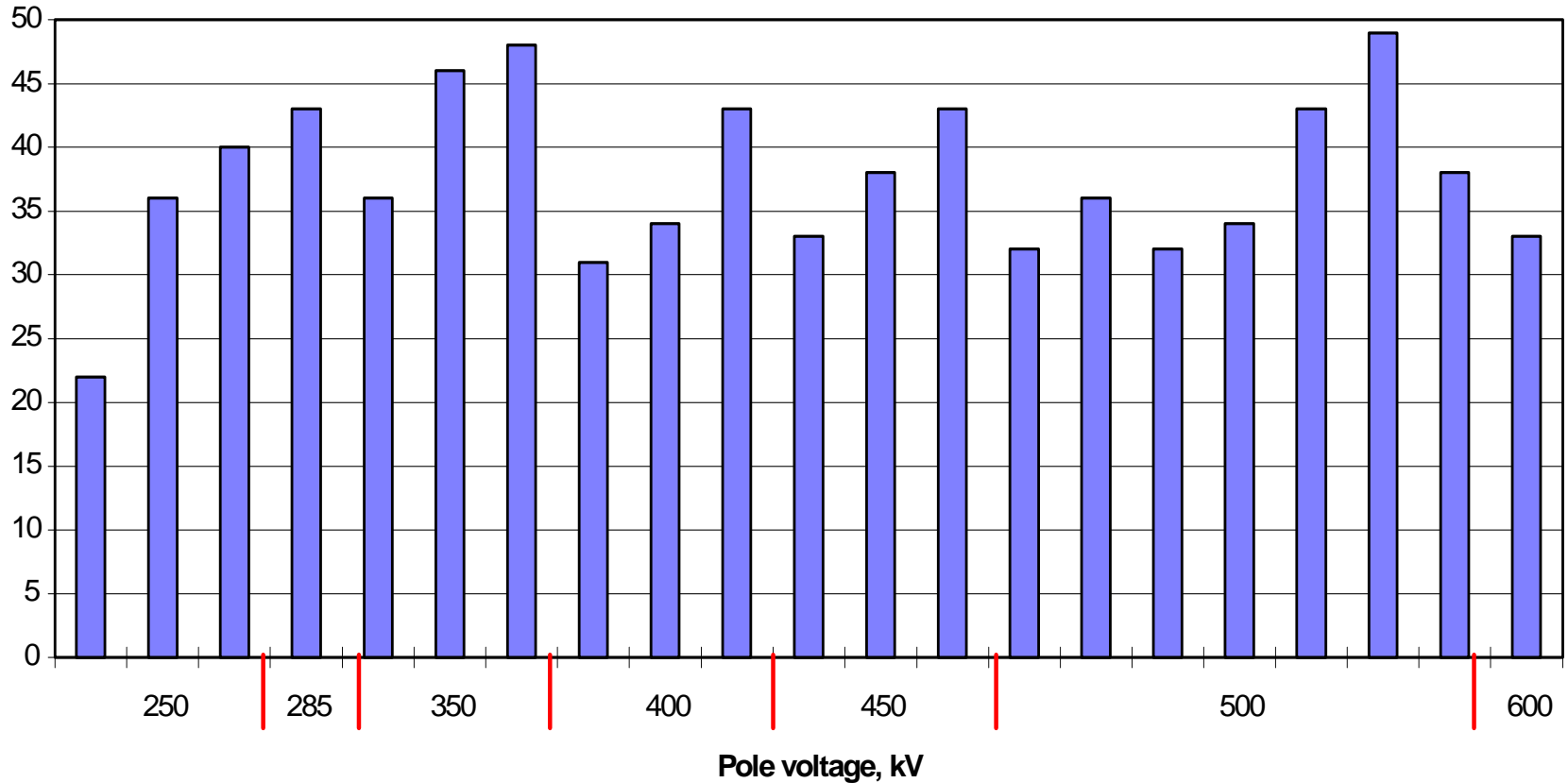
- Porcelain line insulator: ≥ 40 mm/kV, clean every year
- Silicone line insulator: 0.75 creepage, 10,000 in service, no flashover
- Silicone wall/reactor bushings: 0.75 creepage, no flashover

Known to us

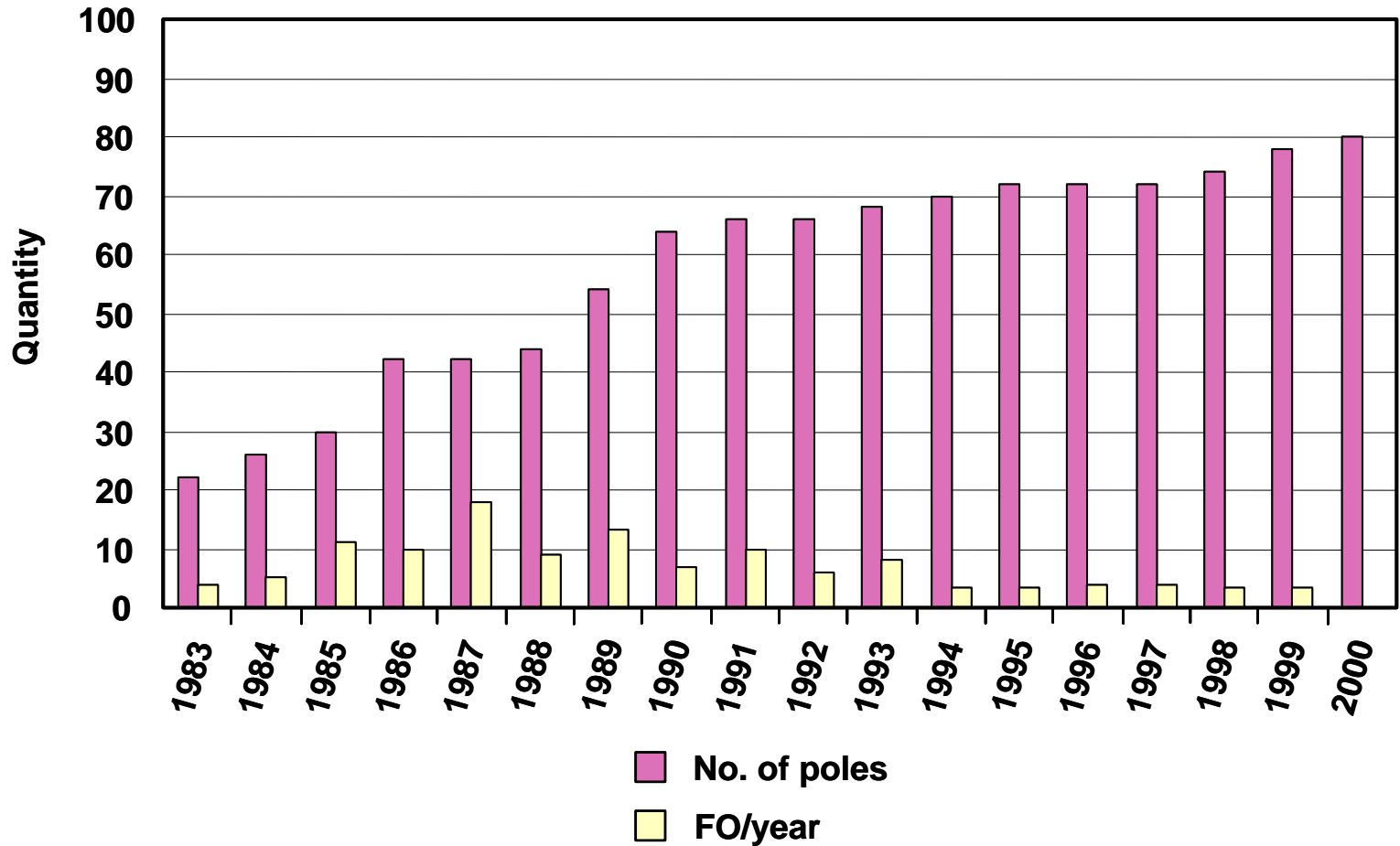
- **Alternative design and alternative solutions**
 - Reduced numbers of large insulator
 - Coatings, booster sheds,...
 - Indoor DC yard
- **Tools for site pollution severity measurement**
 - Mobile pollution test station
- **Tools for overall line performance estimation**
 - LPE program

No trend of using longer USCD

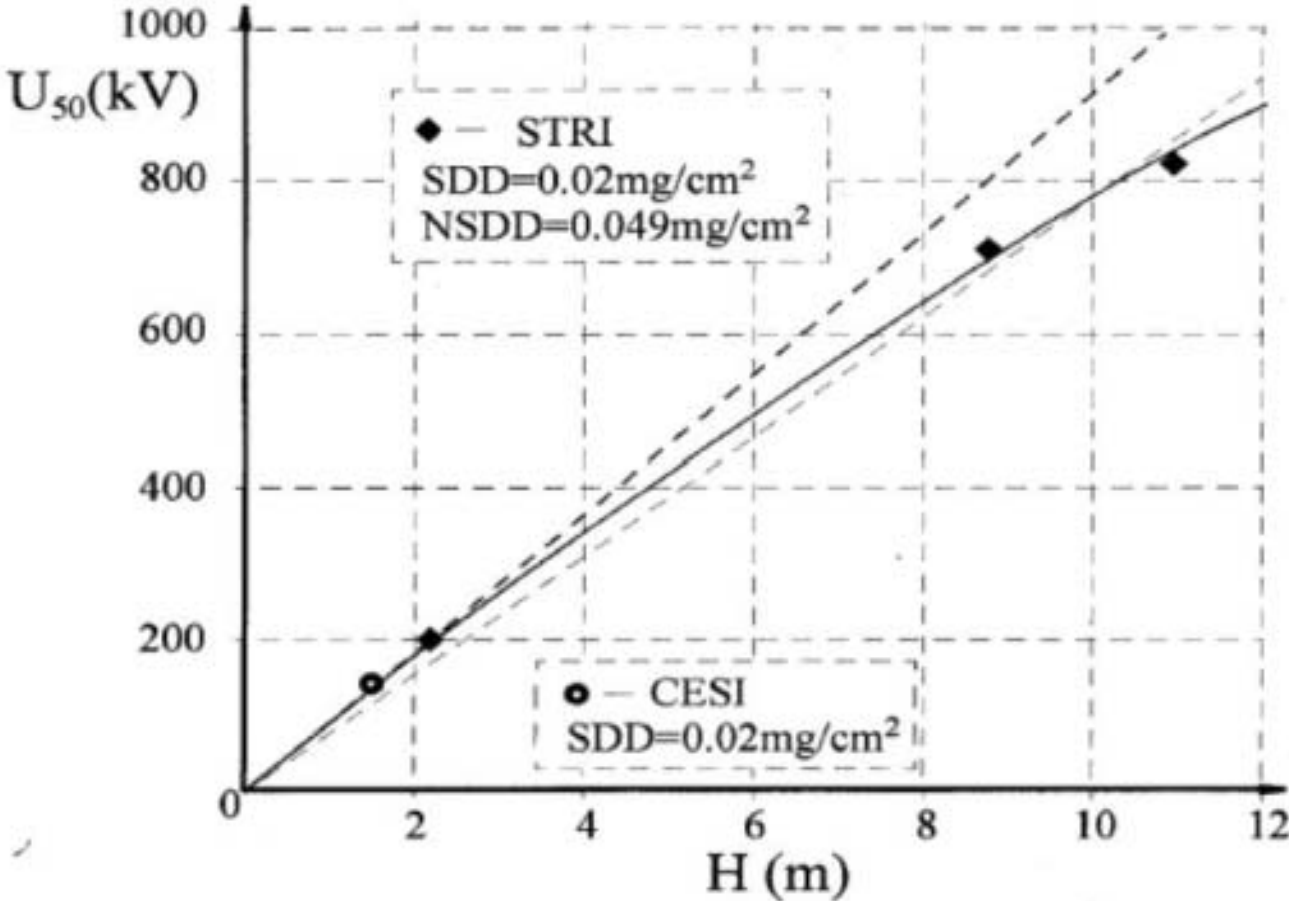
mm/kV



No tendency of higher FO rate



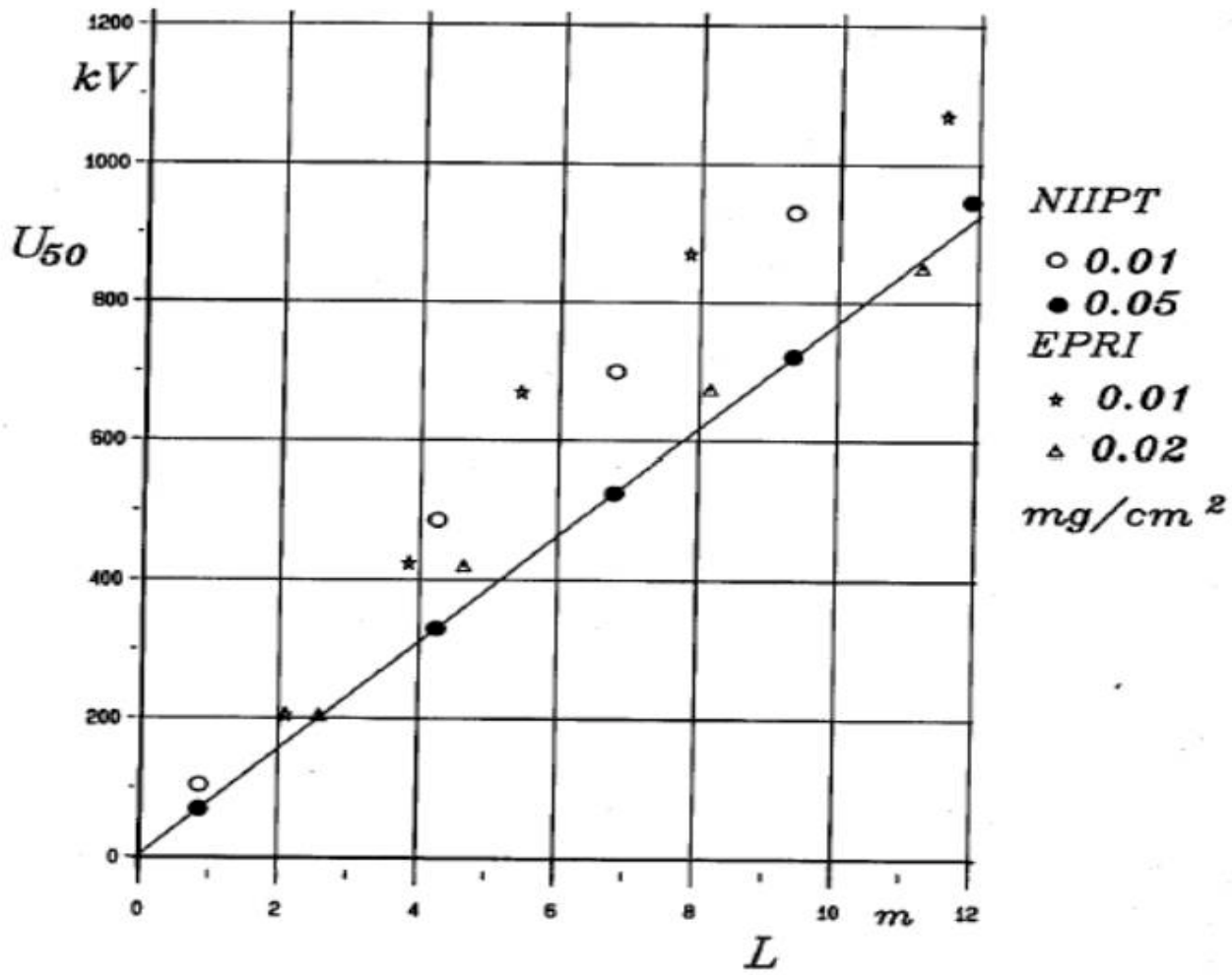
Linearity Applies



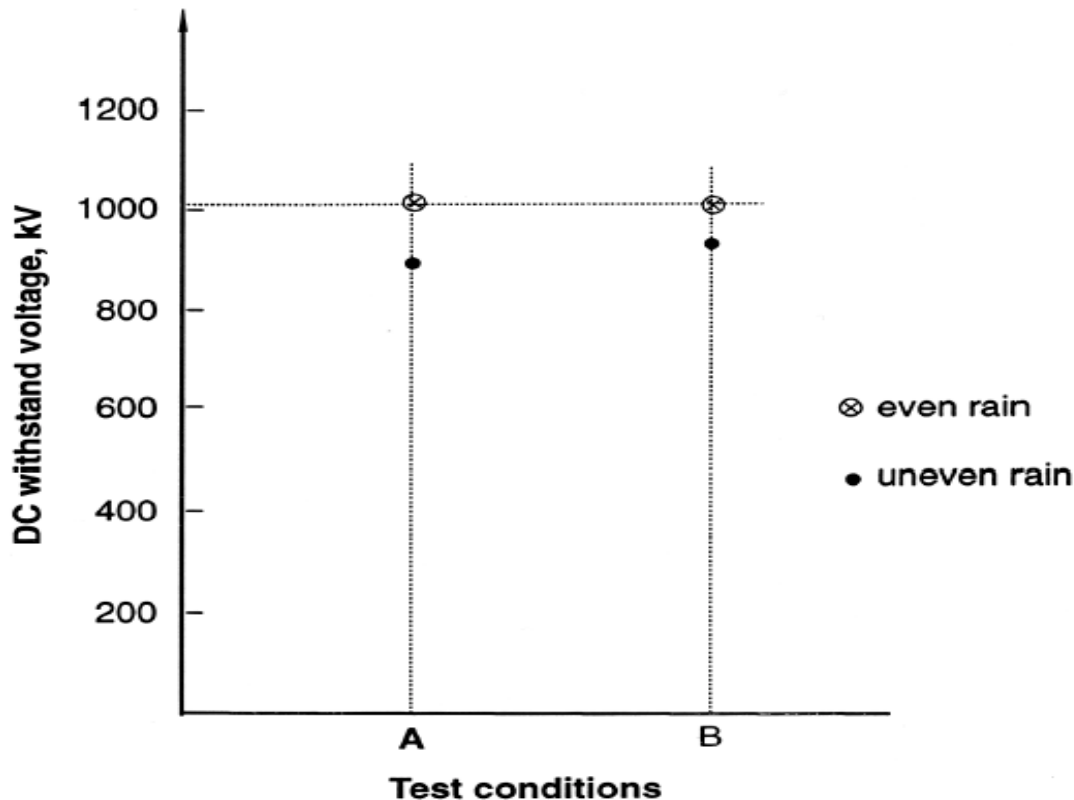
POLLUTION TEST RESULTS



Linearity Applies



Uneven rain on DC station post



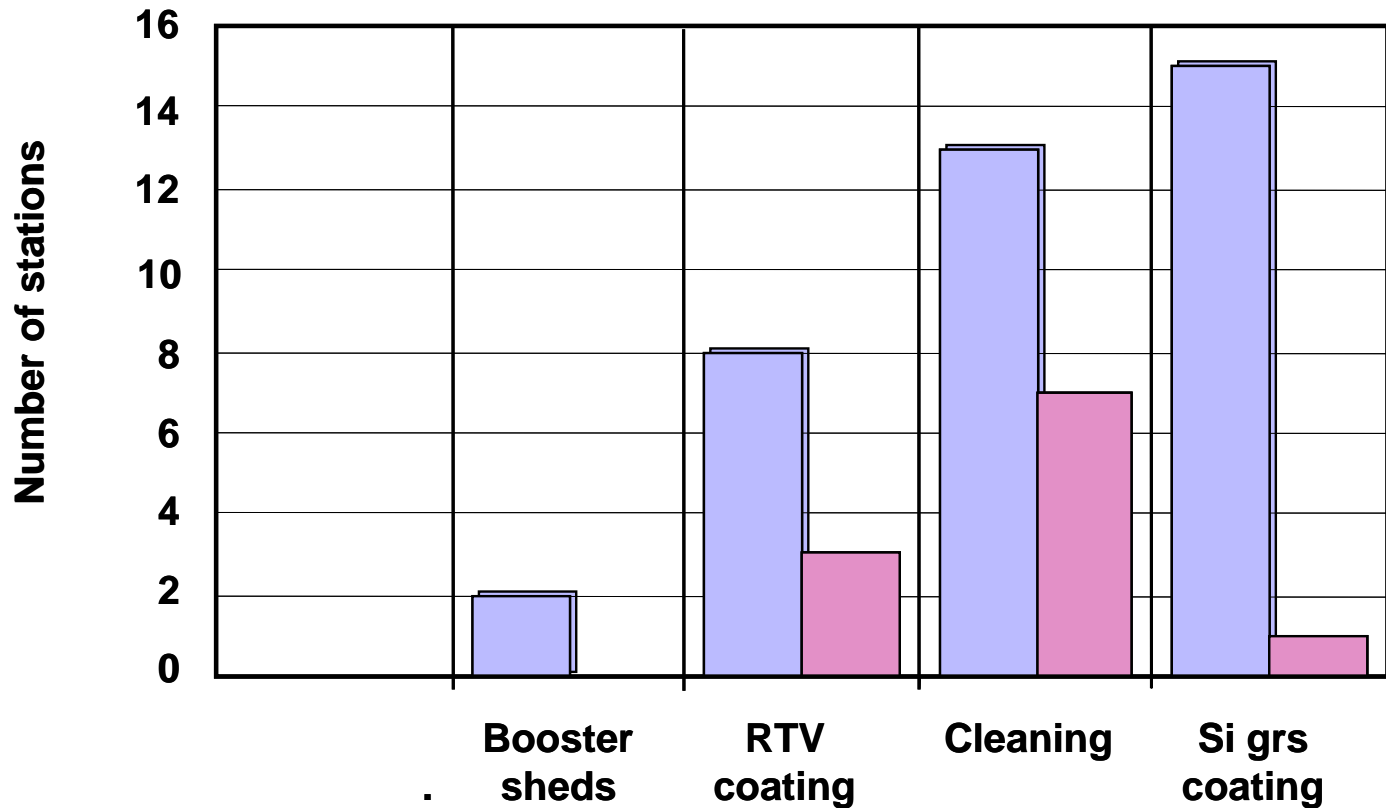
DC withstand voltage of a 5.25 meter station post insulator under even and uneven rain

A — 230 $\mu\text{S}/\text{cm}$, higher rain intensity (≈ 2.4 mm/min)

B — 485 $\mu\text{S}/\text{cm}$, standard rain intensity (≈ 1.4 mm/min)



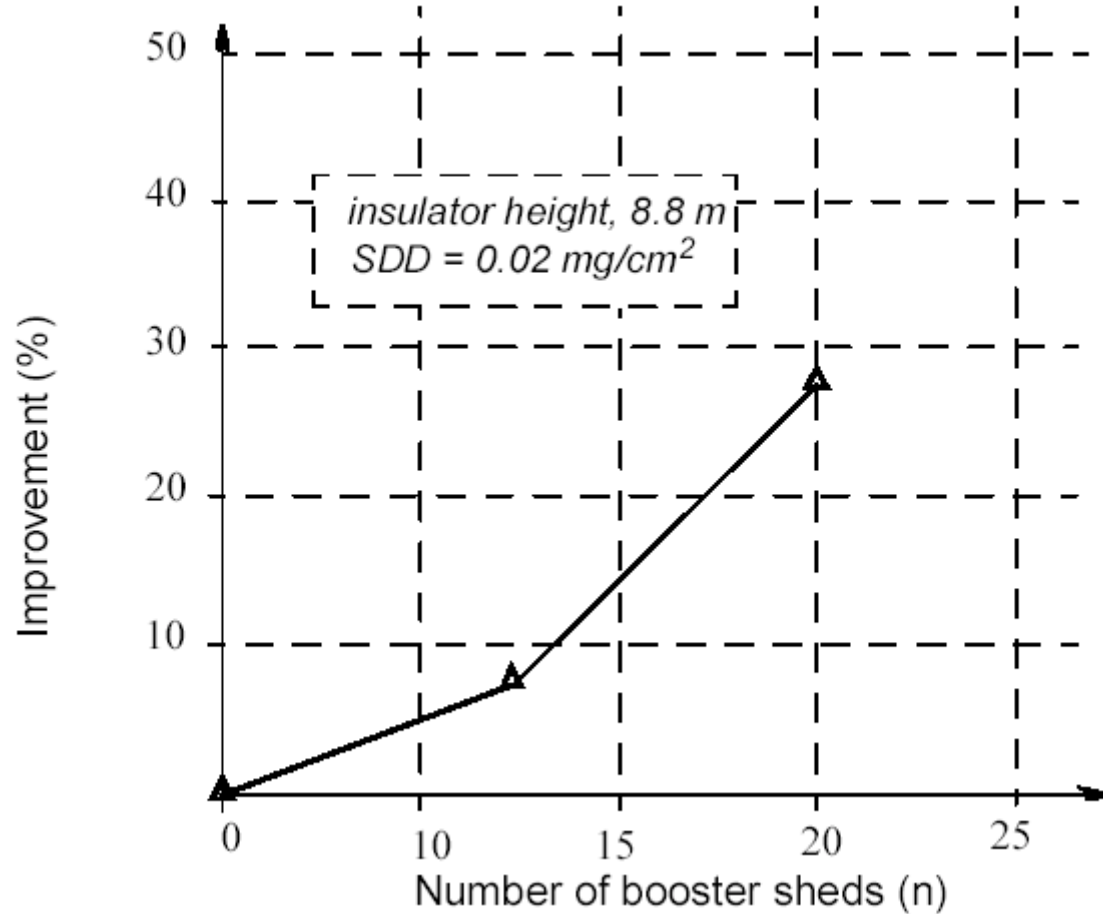
Alternative solutions



 No. of stations using the countermeasure

 No. of stations with flashovers in spite of the measure

800 kVDC pollution test: effect of booster sheds



Way to good design and performance

- **Accurate site condition specification;**
- **Making a reliable insulator selection and dimensioning;**
- **Use insulators with hydrophobic surface whenever applicable;**
- **Reduce the number of insulators with large diameters;**
- **Examine the co-ordination between the inner and outer voltage distribution for HVDC apparatus;**
- **Choose the suitable monitoring and maintenance methods when it is necessary;**
- **Indoor DC yard if necessary.**

A B B