Recent Trend of Metal Oxide Surge Arrester Technology

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1. High gradient technology of metal-oxide blocks
   1000V/mm class metal-oxide blocks

2. Application of External Gapped Line Arresters
   Consideration of cost-effective installation

3. D.C. use of Metal-oxide blocks
   Surge arresters for rolling stock

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History of High Gradient Technology

High gradient MO elements have been applied in GIS surge arresters

1000V/mm

600V/mm Ultra-high

400V/mm High gradient

200V/mm

1980 1990 2000 2010 2020

1975 world's first gapless MO surge arresters

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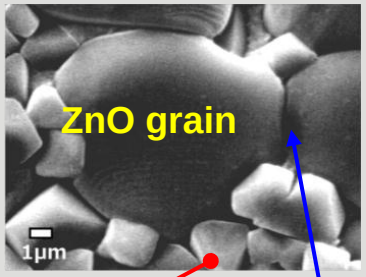
1. High Gradient Technology

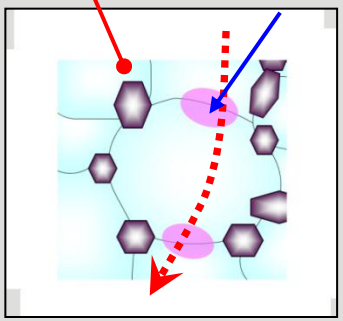
How to increase Gradient Voltage

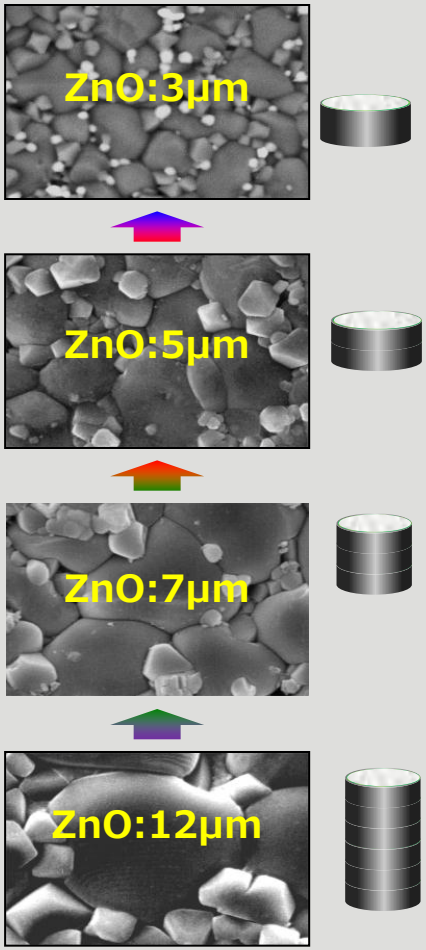
Microstructure



Spinel particle (Zn_7Sb2O_{12})

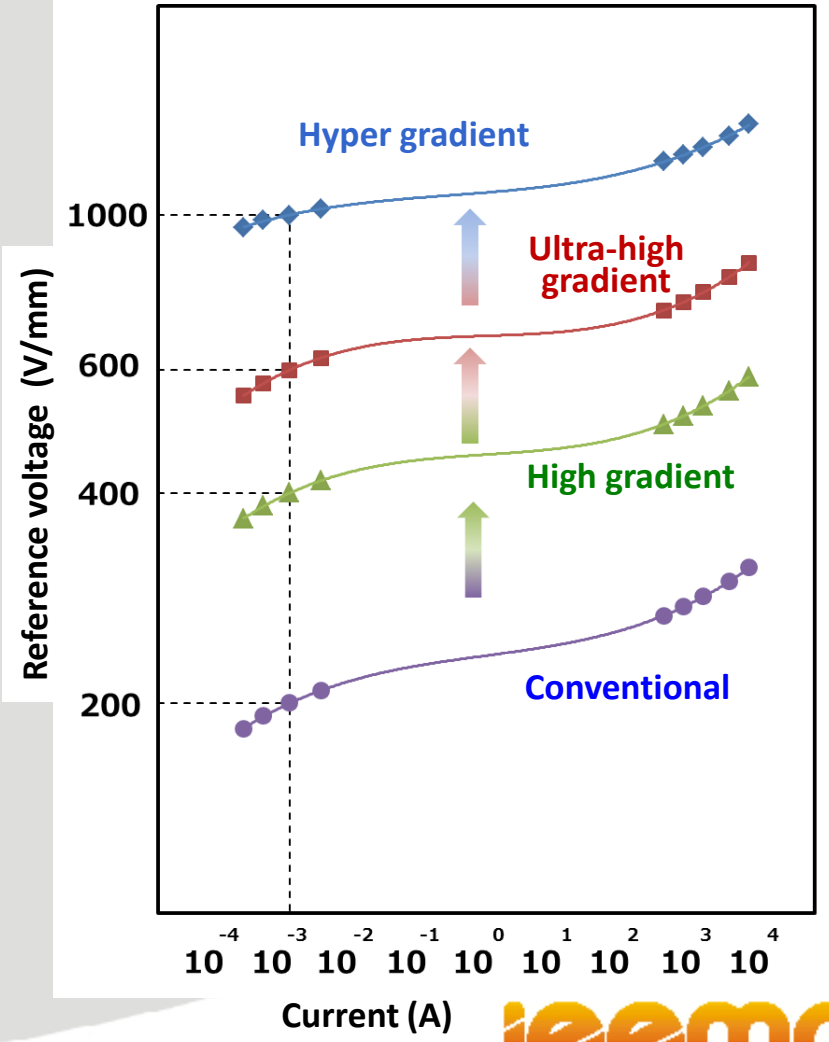
Grain boundary





Origin of Non-linearity is at grain boundaries.

Increase in the number of grain boundaries can increase the gradient voltage.



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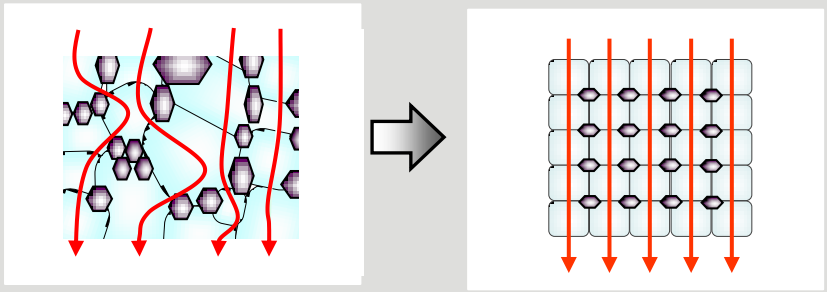
1. High Gradient Technology

Improvement of Characteristics

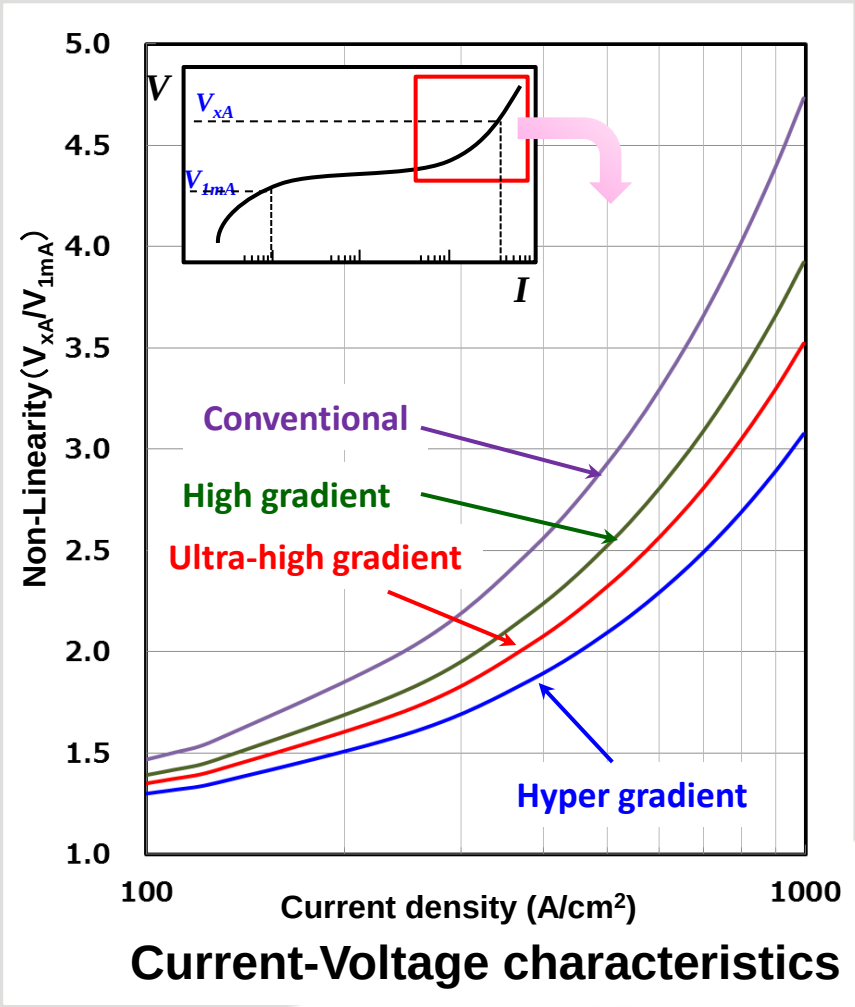
Model of micro-structure of MO blocks



Less-homogeneous

Homogeneous

Improvement of
1. Non-linearity
2. Energy absorption capability
3. Thermal stability



Current-Voltage characteristics

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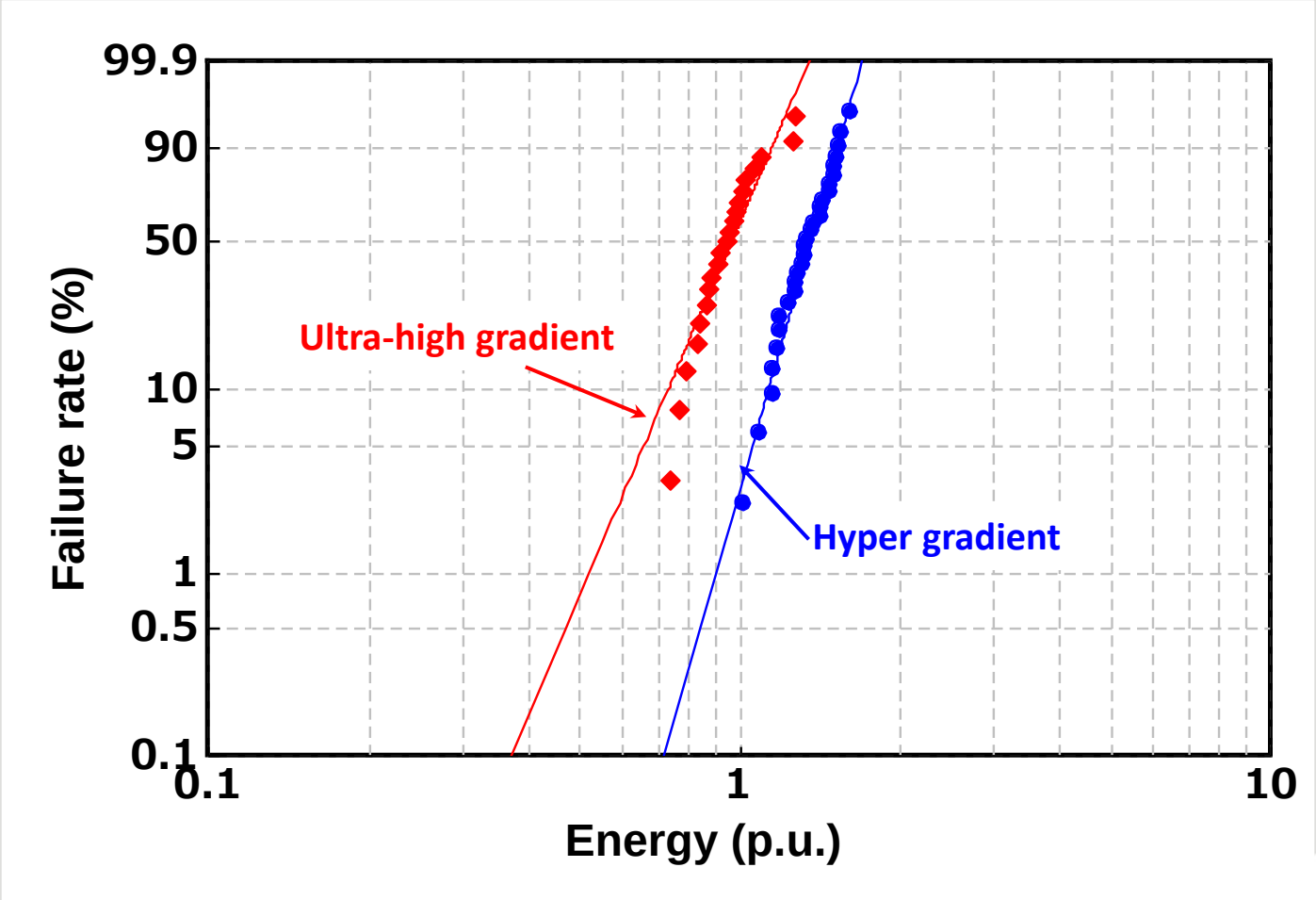
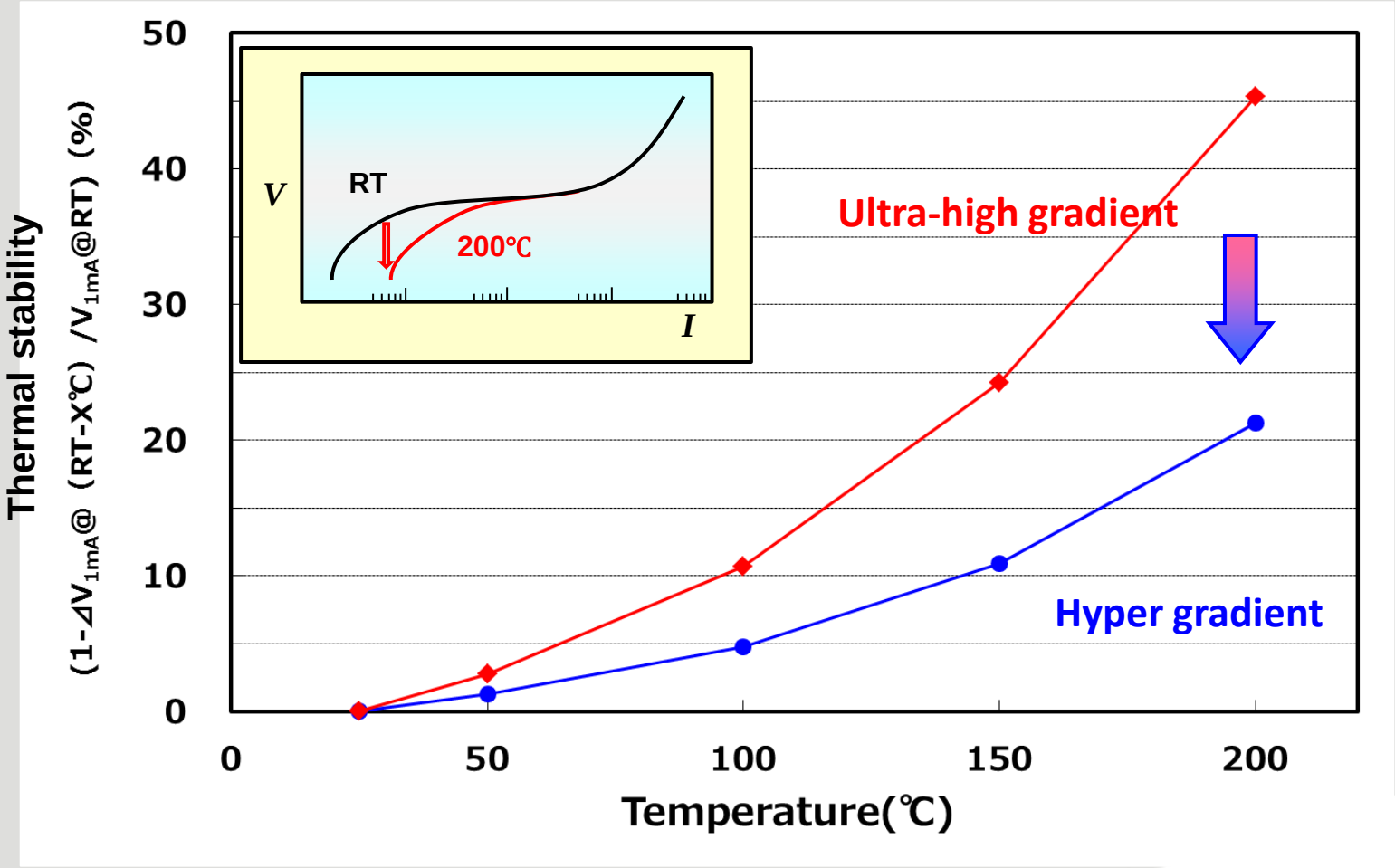
Energy absorption capability



1. High Gradient Technology

Thermal stability



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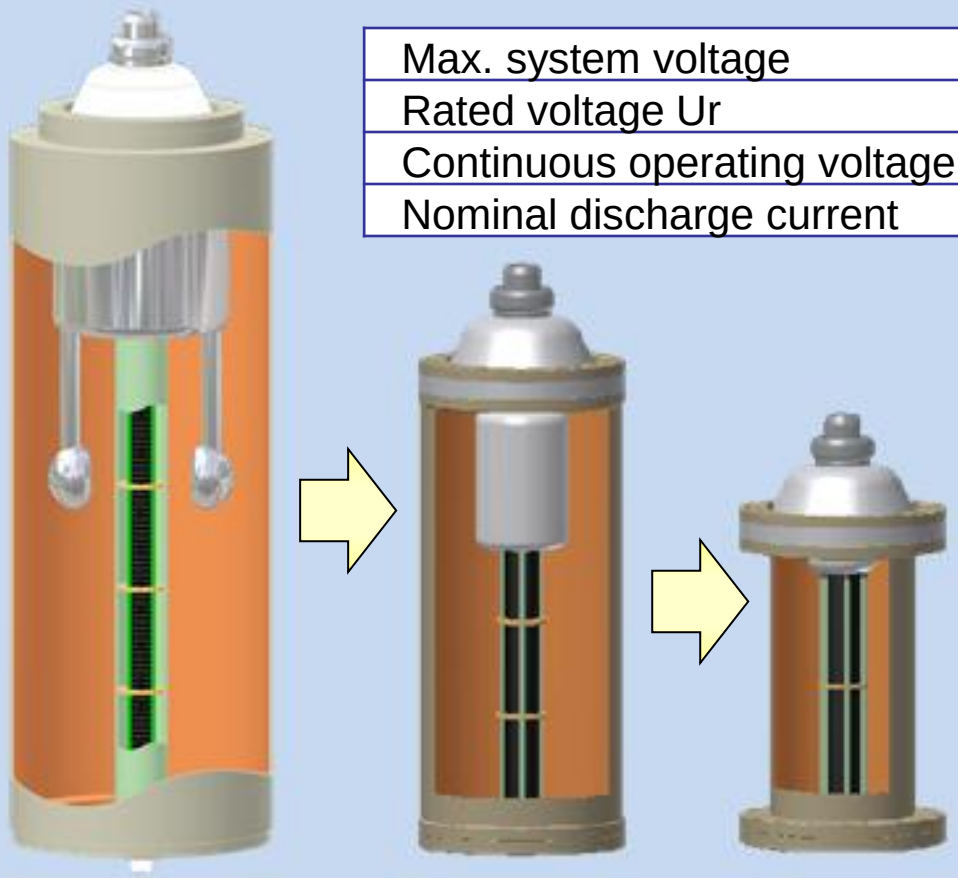
1. High Gradient Technology

Down-sizing of GIS Surge Arrester

Max. system voltage	550 kV
Rated voltage Ur	420 kV
Continuous operating voltage Uc	340 kV
Nominal discharge current	20 kA



High gradient **Ultra-high gradient** **Hyper gradient**
100 % **40%** **16%**

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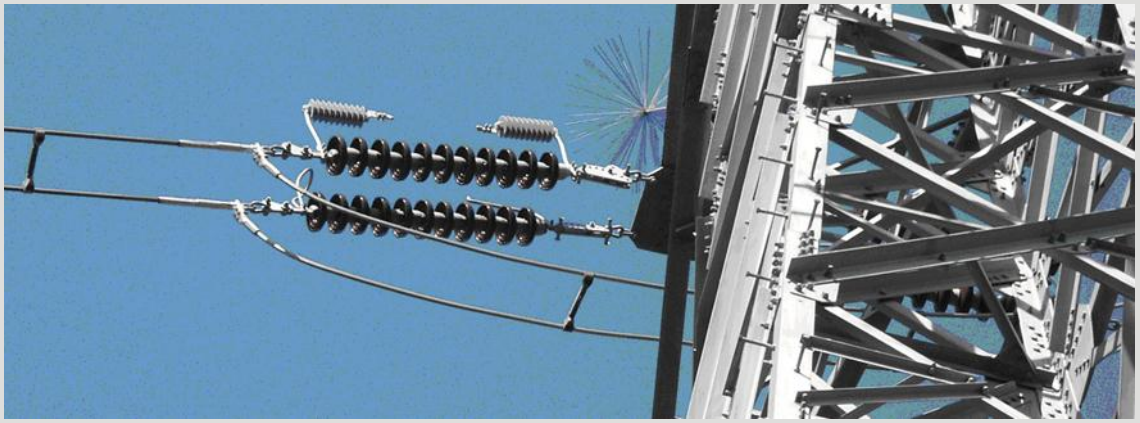
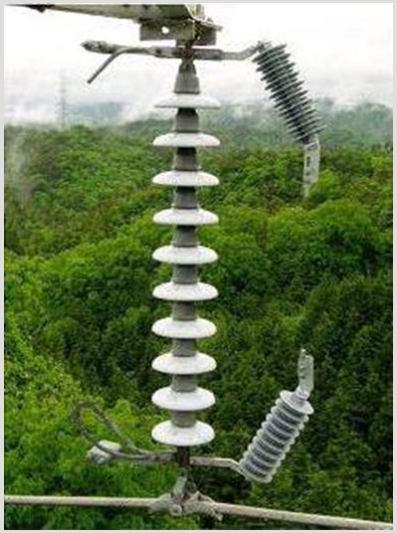
External Gapped Line Arresters (EGLA)



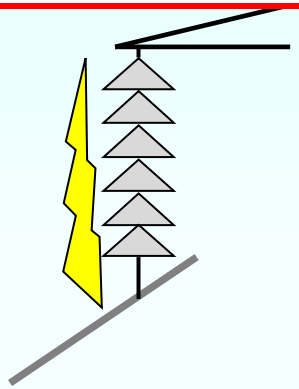


2. External Gapped Line Arresters

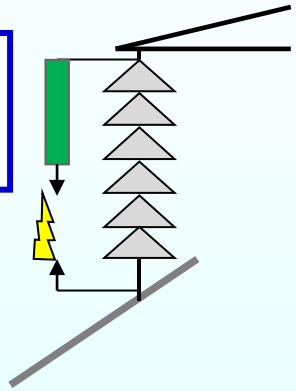
Purpose of EGLA application

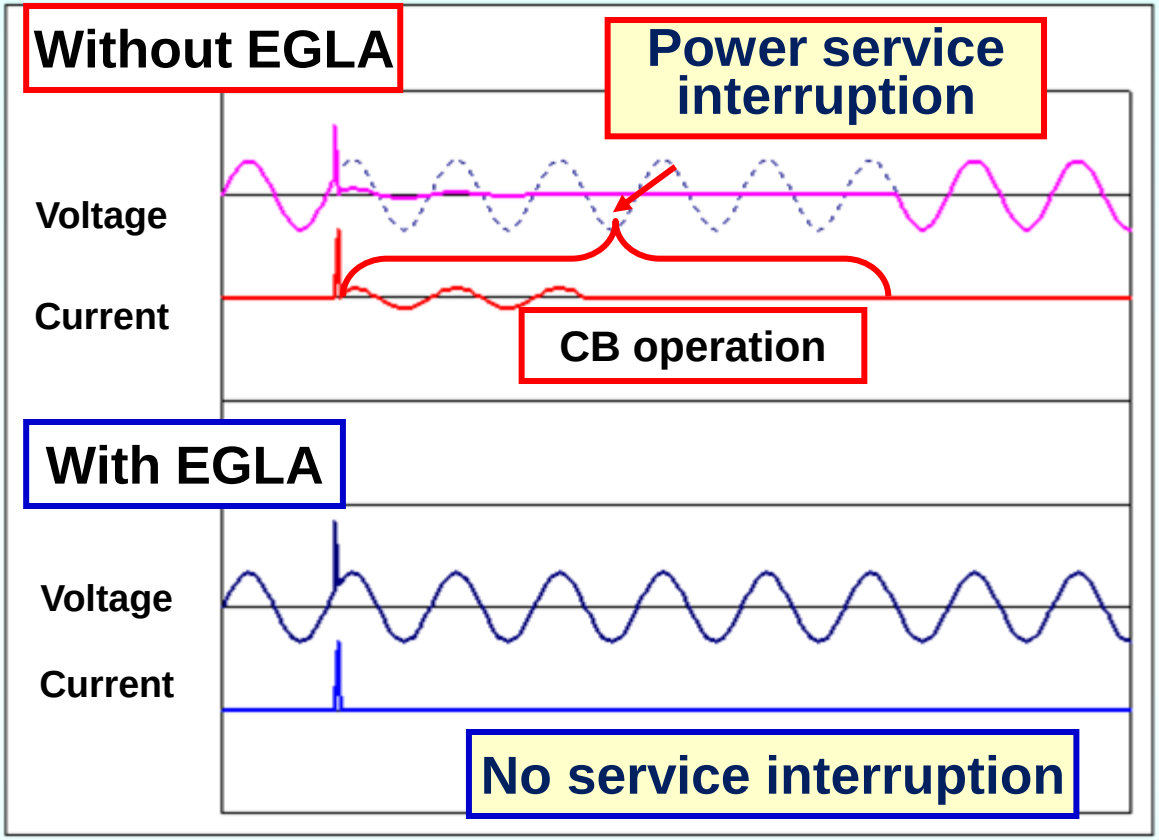
Lightning strokes, then · · ·

FO at insulators
CB operates



Spark over in series gap
CB kept closed





EGLA can prevent Power service interruption.

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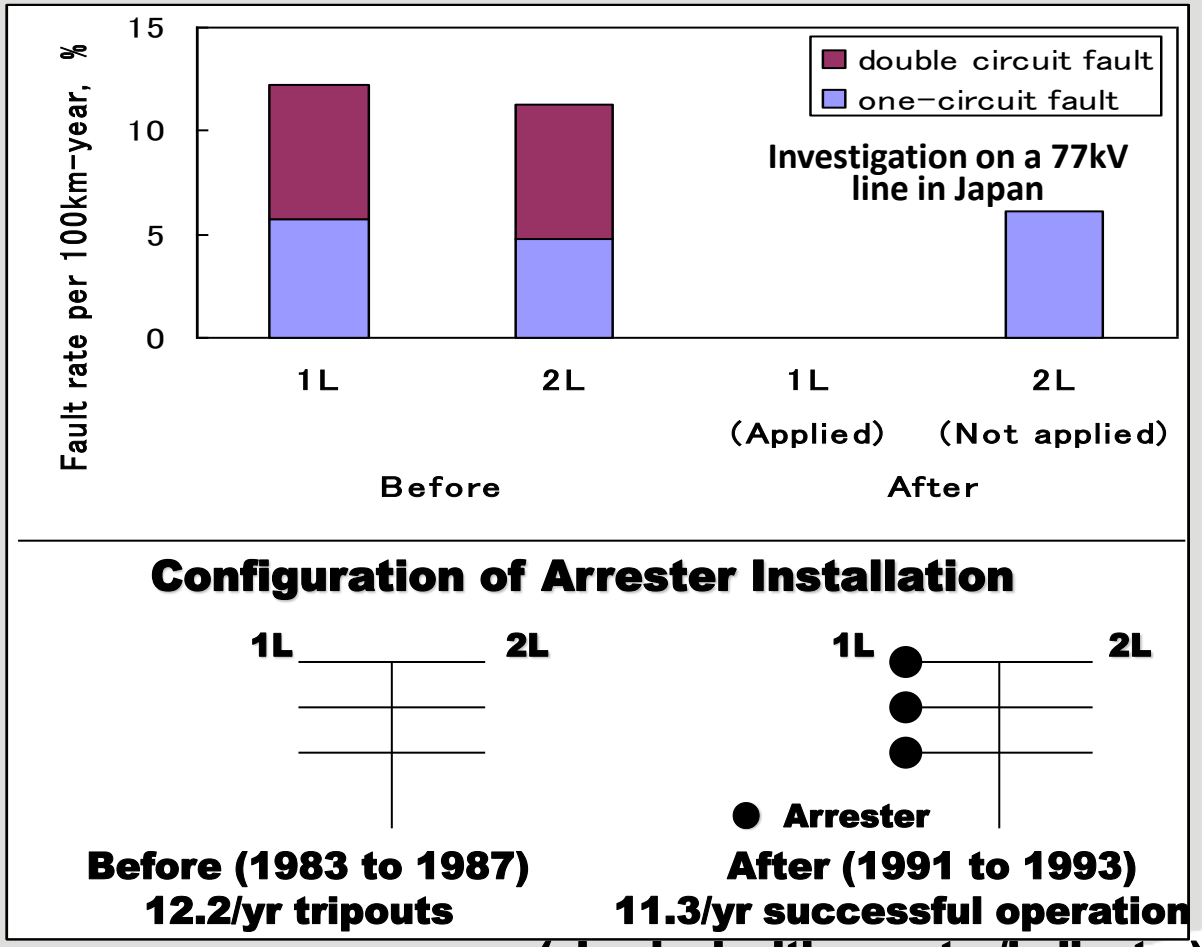
2. External Gapped Line Arresters

Effectiveness of EGLA (Fault rate Comparison)



T.Kawamura et al.
CIGRE 33-301 (1998)

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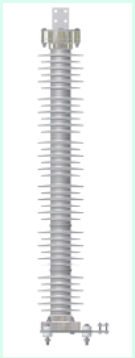
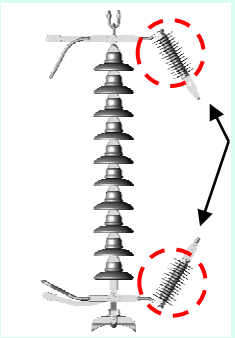
2. External Gapped Line Arresters

Comparison between Gapless and Gapped type

Item	Gapless type	Externally Gapped type
Schematic		
Size	Large and heavy	Compact and light
Operating duty	Lightning overvoltage Switching overvoltage Power freq. Overvoltage	Lightning overvoltage
Deterioration	Must be considered	Maintenance free (Not energized)
In case of failure	Disconnecting device necessary	Successfully re-closing
Standard	IEC 60099-4 (for substation)	IEC 60099-8 (for EGLA)

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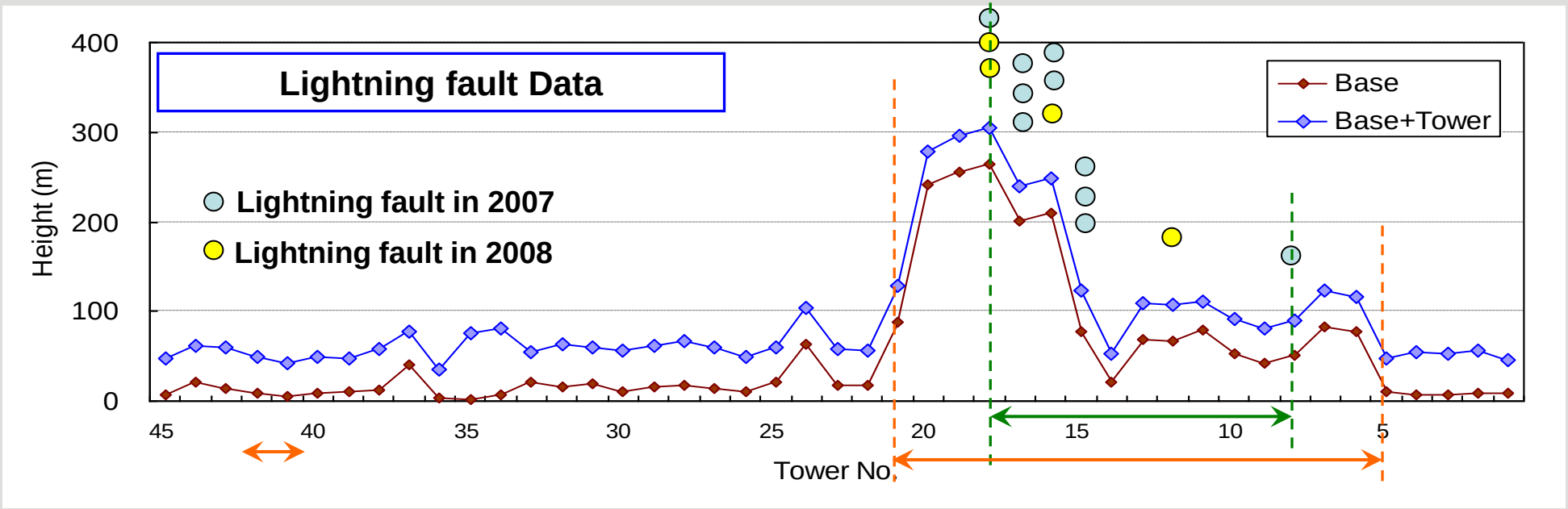
2. External Gapped Line Arresters

Example of installation



After investigation of lightning fault, EGLAs were installed to Towers from No. 5 to No.21. One circuit of double circuit line, three phases.

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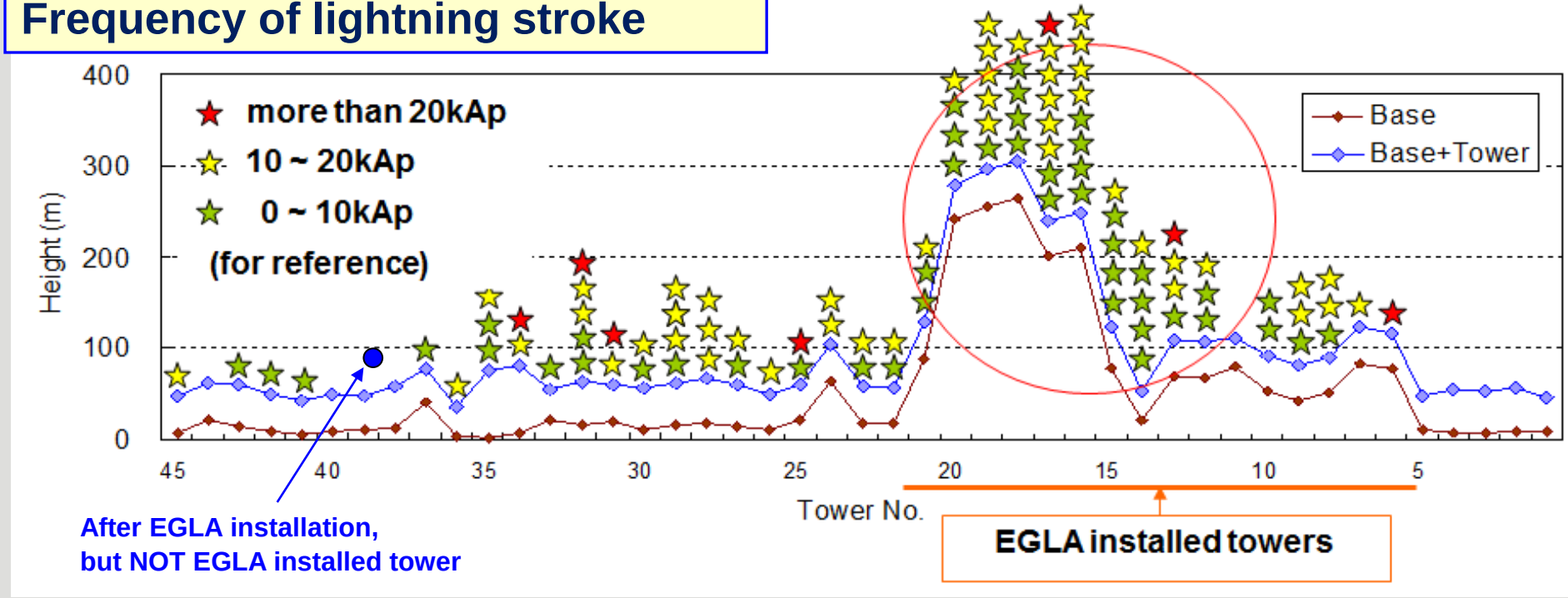
2. External Gapped Line Arresters

Example of installation

Frequency of lightning stroke



EGLA installed tower frequently receives Lightning stroke.

Lightning faults have not occurred in the EGLA installed section.

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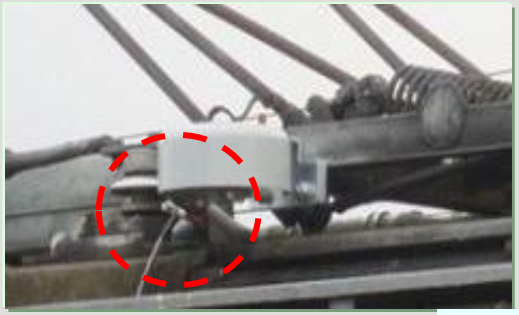
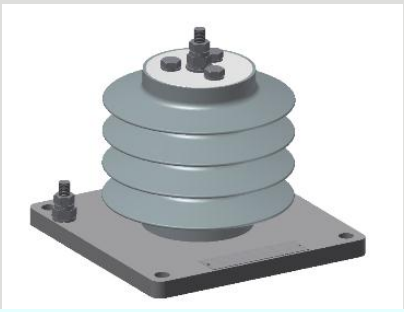
D.C. Surge Arresters for Rolling Stock





MO block; 200V/mm class

Ratings	Specification			
Applied standard	EN 50526-1:2012			
Nominal system voltage, Us	750V	1500V	3000V	3000V
Continuous operating voltage, Uc	1000V	2000V	4000V	4000V
Nominal discharge current, In	10kA			20kA
Arrester class	DC-B			DC-C
Charge transfer capacity	2.5As (=1250A, 2ms)			7.5As
Residual voltage at In	3.0kV	6.0kV	12.0kV	11.0kV

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3. D.C. Surge Arresters

D.C. Accelerated Ageing Test

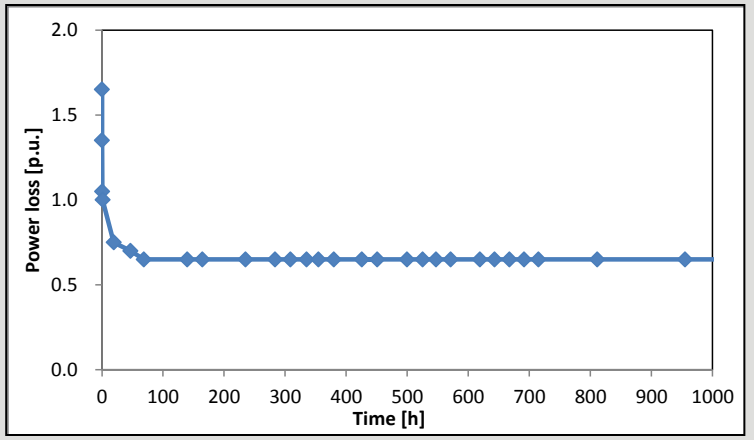
Test condition 1

Applied voltage; 90 % Reference voltage

Ageing term; 1000 hours

Temperature; 115±4° C

Standard; EN 50526-1



Test condition 2

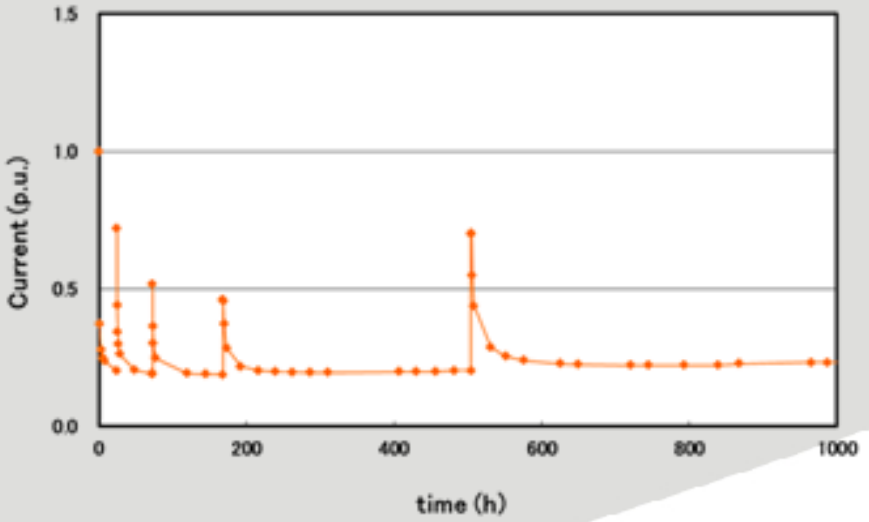
Applied voltage; 90 % Reference voltage

Polarity reversal

Ageing term; 1000 hours

Temperature; 115±4° C

Standard; IEC 60099-9



MO blocks have good D.C. ageing characteristics.
Verification tests of D.C. ageing test are necessary for D.C. use.

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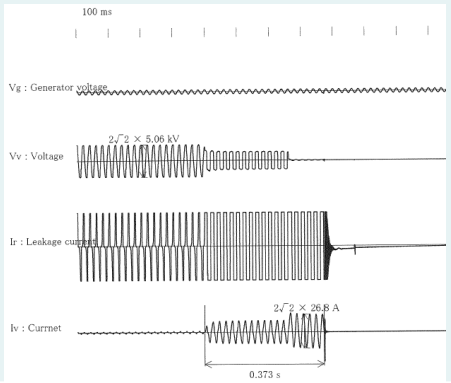
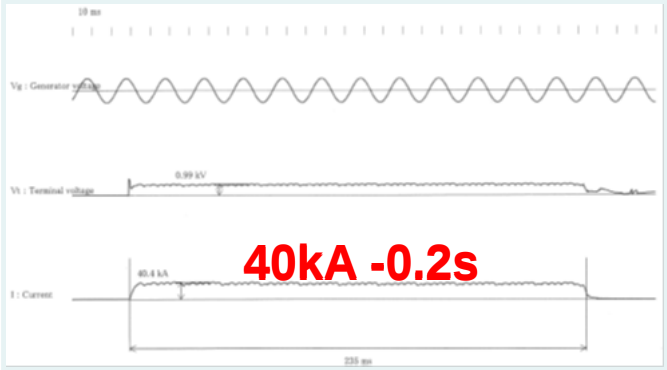
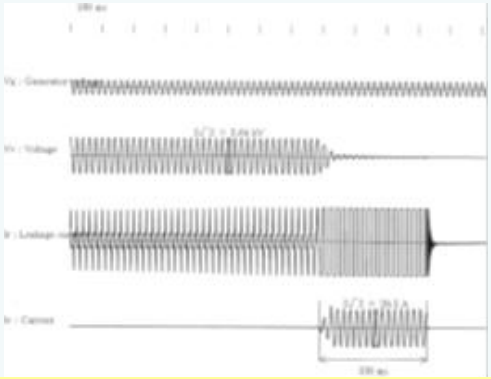
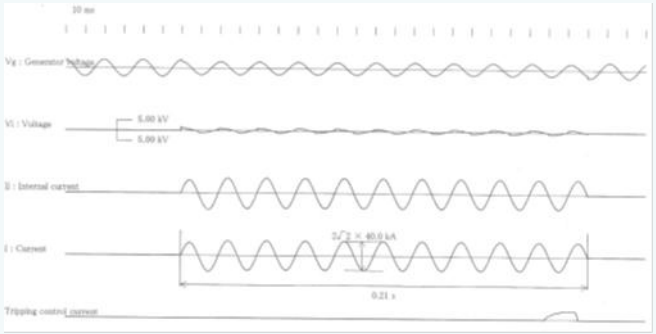
3. D.C. Surge Arresters

D.C. Short Circuit Test

	Wave form of pre-failing	Wave form of short circuit current application	After short circuit test
D.C.			
A.C.			

No significant difference in sample appearance between D.C. and A.C. short-circuit test was shown after application of short-circuit current.

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Summary

1. **High gradient technology of metal-oxide blocks**

- The hyper gradient metal oxide elements with the gradient voltage of 1000V/mm have been developed**.**

2. **Application of External Gapped Line Arresters**

- EGLA can improve against lightning protection of transmission and distribution lines.
- Cost-effective installation may be possible.

3. **D.C. use of Metal-oxide blocks**

- D.C. surge arrester shows good D.C. ageing & D.C. short circuit performance.
- No significant difference in samples between D.C. and A.C. short-circuit test was shown in the appearance of the test sample after application of short-circuit current.

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