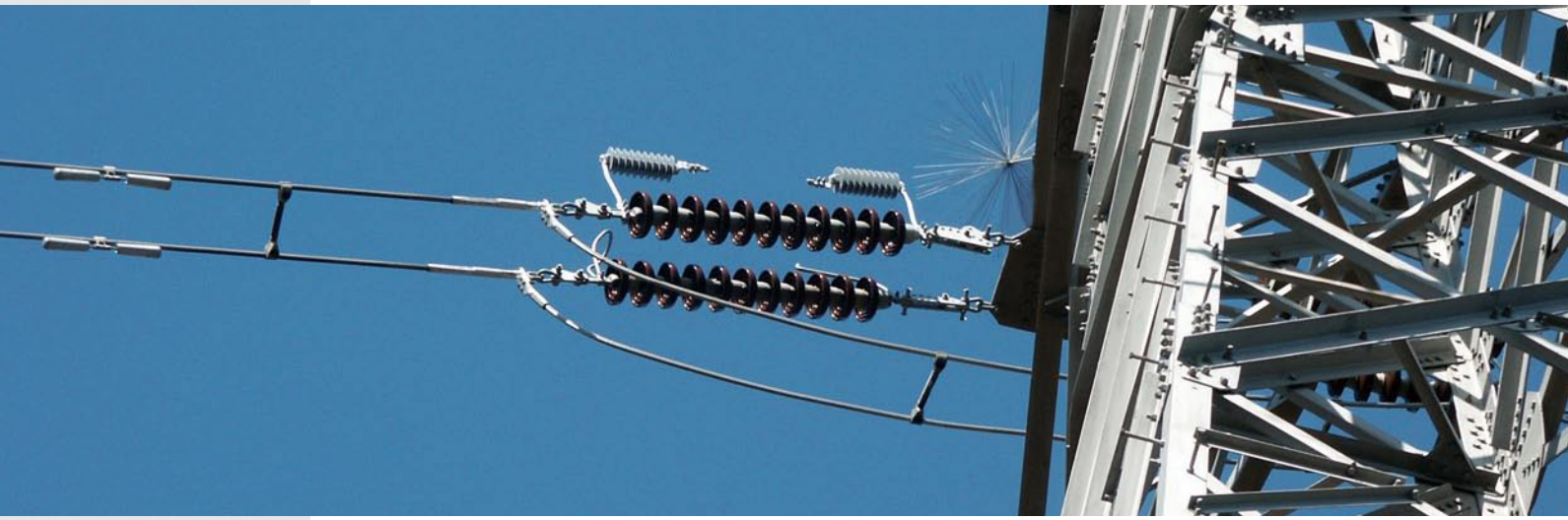
TOSHIBA

Leading Innovation

Externally Gapped Line Arresters

Smart Solution for Stable Power Supply



Metal-oxide surge arresters with external series gaps improve the reliability of transmission systems, and help eliminate not only lightning damages of transmission line equipment but also slight power interruptions after trip-outs caused by lightning. It meets the demands of our modern sophisticated society.

The integrated external series gap eliminates the need of countermeasures against switching overvoltage or the deterioration of ZnO disks, meaning transmission line arresters can be made compact and lightweight and significantly easing the workload of the installation and/or maintenance of the arresters.

Transmission Line Arrester with External Series Gap

Recently, there has been increased demand for a stable and highly reliable power supply. Lightning striking power transmission lines causes very slight power interruptions, despite the fact the transmission line can be successfully recharged. These interruptions may seriously damage IT equipment, which is unacceptable. Incorporating a design with lightning protection is crucial for ensuring a stable power supply.

The transmission line arrester is the optimal method of lightning protection. Toshiba can offer a much smarter lightning protection solution; namely a transmission line arrester with an external series gap, otherwise known as an Externally Gapped Line Arrester (EGLA).
EGLAs can help eliminate not only lightning damages of transmission line equipment but also slight power interruptions after trip-outs.

EGLAs can protect insulator assemblies from flashovers caused by lightning. The application of EGLA will definitely improve transmission system reliability.

The Toshiba EGLA features

- Compact and lightweight design thanks to the superior performance of ZnO disks
  → Easy installation of EGLA
- No deterioration of ZnO disks and no need to disconnect devices because of series gaps
  → Maintenance free for EGLA
- No violent scattering or burning
  → Ensuring public safety
- Successful re-closing even in the arrester failure
  → Improving transmission system reliability
- Long term performance based on advanced silicone technologies

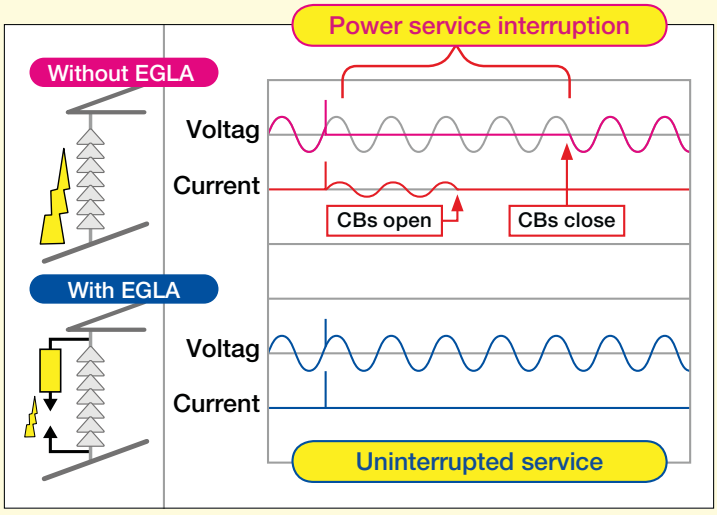
How will the EGLA prevent power service interruptions?

Before any EGLA is not fitted;
- When the lightning strikes, a flashover occurs at the insulator strings.
- Then the power service is slightly interrupted.

After EGLAs are fitted;
- Sparkover occurs across the series gap of the arrester.
- The lightning induced current flows through the ZnO disks (the non-linear resistors in the arrester unit)
- The voltage across the insulators is suppressed sufficiently by the arrester unit ,and any flashover at the arc horn will be prevented.
- The following current will be reduced and immediately removed.

Consequently the circuit breaker need not be tripped, and the power supply remains reliable and uninterrupted.

Event comparison between "without EGLA" and "with EGLA"

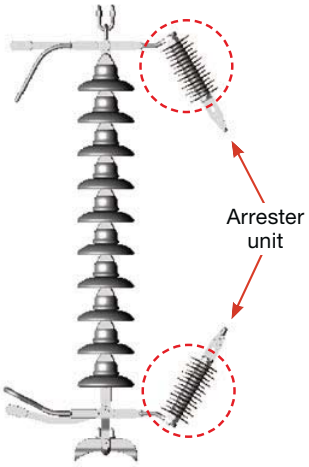


EGLA or Gapless Line Arrester ?

One of the countermeasures would appear to be installing full size arresters specified with IEC or ANSI classification. However, the application of EGLA is a much smarter solution to protect the transmission line from lightning.
Transmission systems are usually designed to withstand internal surges such as switching surges and power frequency overvoltage. Consequently it may be practical to design the arrester unit to handle lightning but not switching surge and power frequency overvoltage by ensuring it is equipped with an external series gap and having insulation coordination between the arrester unit and insulator strings.

Consequently, EGLA has advantages compared with Gapless type transmission line arresters. EGLA can be downsized compared to station type surge arresters and hence handled very easily. Moreover ZnO disks are not normally energized, and will thus not deteriorate when used under normal circumstances, eliminating the need for maintenance and/or monitoring for current leakage.

Table 1 Comparison between EGLA and gapless type arresters
Both are 120 kV rated for a 145 kV system as an example

Item	EGLA	Gapless type (Station type for reference)
Schematic illustration		
Size	Length of one arrester unit : 400 mm Mass of arrester units per phase : 10 kg (Mounting parts and balance weight are not included.)	Height : approx. 1200 mm Mass : 45 kg
Duty to be withstand	Only lightning overvoltage (Key factor to the compactness)	Lightning overvoltage Switching surge overvoltage, Power freq. overvoltage
Deterioration	Electrical stress free Maintenance free	Always electrically stressed Disconnector needed

How can the compact type be applicable?

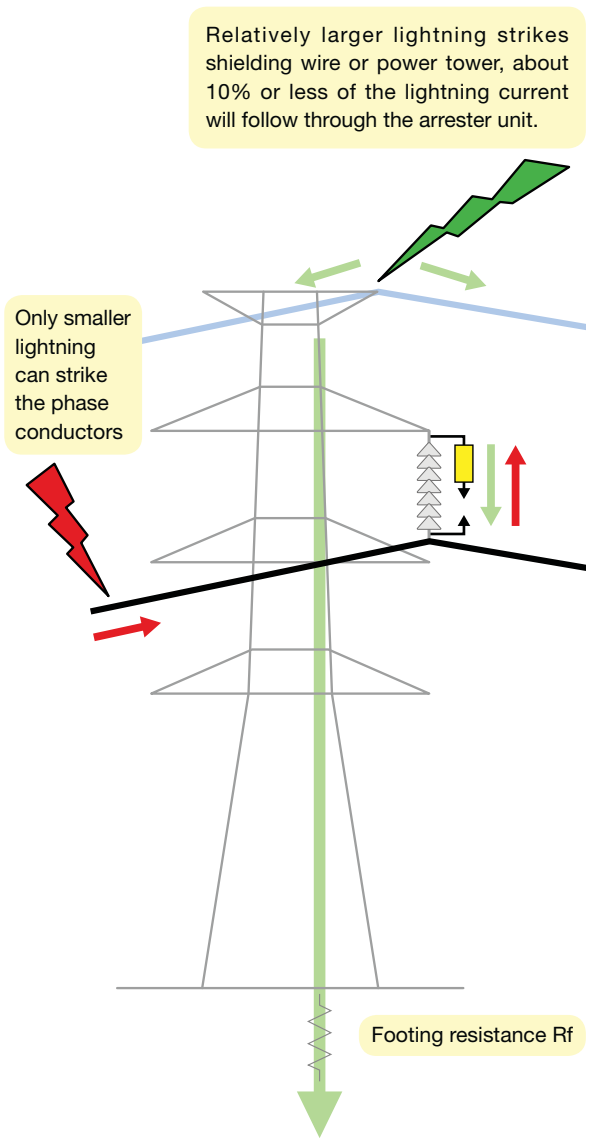
In the case of a shielded system, when lightning strikes the grounding wire or tower structure, the lightning current will decline as it traverses the grounding wire and tower structure, thus significantly reducing the load to which the EGLA body is exposed. EMTP analysis has shown that the following current through the arrester unit is decreased to approximately 10% or less of the lightning current.

The shielding distance from the grounding wire depends on the lightning current. Smaller lightning current may pass close to the grounding wire and strike a phase conductor. When such shielding failures occur, the lightning current is not significantly high and the load generated by such lightning is not considered so severe.

Consequently, to sum up, while larger lightning may strike the shielding wire, only smaller lightning can impact the phase conductor, meaning the current following through the arrester unit is expected to be small.

This explains why **the compact type EGLA** can be applicable and ensure the reliability of transmission systems. With analysis of the lightning phenomena and long term experience of EGLA applications in Japan, **the compact type EGLA** became a reality and a satisfactory experience was achieved.

The lightning current and subsequent current following through the arrester unit may be significantly larger under certain transmission system conditions, such as shielding conditions, footing resistance, etc. Arresters with much larger lightning withstand capability must be provided to protect such systems. Toshiba can also supply **heavy duty type EGLA** with sufficient lightning withstand capability.



Schematic Diagram of the Lightning Strike Event

Ratings

The compact type **"TMLRG series"** units are suitable for shielded systems of up to 245 kV. For unshielded systems or those up to 420 kV, the heavy duty type **"RVLRC series"** are applicable. The wave shape of 2/20 μs for the discharge current is based on practical applications in Japan. The high current impulse with a wave shape of 2/20 μs has much larger energy. The impulse current of 25 kA having the wave shape of 2/20 μs is equivalent to the energy as high as 60 kA if the wave shape is 4/10 μs.
Concerning the EGLA type selection, please contact us for information on EGLA applications.
Typical ratings for the TMLRG and RVLRC series are shown below.

Note: The other ratings are available based on users' requests.

Table 2 Covered Range of EGLA

System voltage (kV)		72.5	123	145	170	245	300	362	420
EGLA rated voltage (kV)		72	96	120	144	192	240	288	360
EGLA type	Max. Discharge current								
Compact type TMLRG series	25 kA (2/20 μs) 60 kA (4/10 μs)								
Heavy duty type RVLRC series	40 kA (2/20 μs) 100 kA (4/10 μs)								

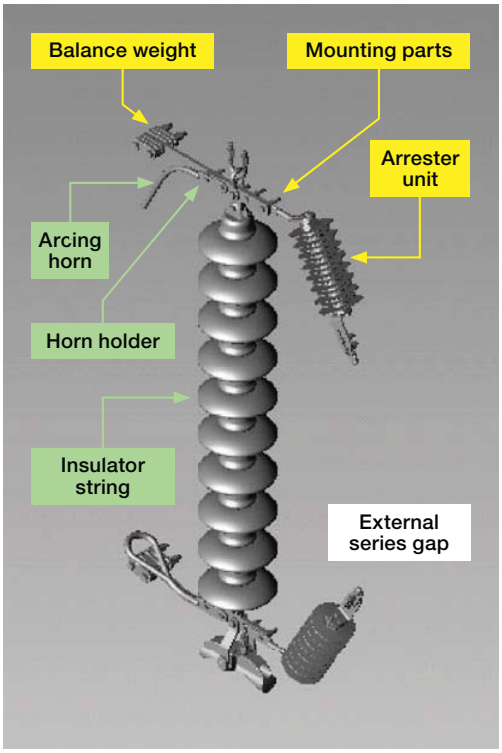
Table 3 Typical ratings of the compact type EGLA TMLRG series

System voltage (kV)		72.5	123	145	170	245
EGLA rated voltage (kV)		72	96	120	144	192
Nominal discharge current (kA), 2/20μs		10	10	10	10	10
Residual voltage (kV) at 10 kA, 2/20μs		184	263	315	394	525
Max. Discharge Current (kA),	2/20μs	25	25	25	25	25
	4/10μs	60	60	60	60	60
Rated short circuit current (kA), 0.2s		50	50	50	50	50
Gap distance (mm) (for reference) [1]		350	580	600	630	1000
Creepage distance (mm)		1600	2500	2500	3200	4100
Mass of arrester unit (kg)		3.5	6.5	7.0	7.0	10.5

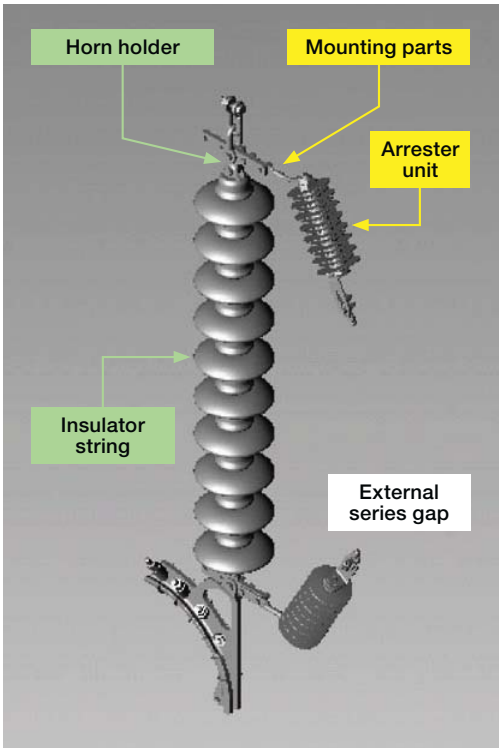
Table 4 Typical ratings of the heavy duty type EGLA RVLRC series

System voltage (kV)		72.5	123	145	170	245	300	362	420
EGLA rated voltage (kV)		72	96	120	144	192	240	288	360
Nominal discharge current (kA), 2/20μs		15	15	15	15	15	15	15	15
Residual voltage (kV) at 15kA, 2/20μs		184	245	306	368	490	612	735	918
Max. Discharge Current (kA),	2/20μs	40	40	40	40	40	40	40	40
	4/10μs	100	100	100	100	100	100	100	100
Rated short circuit current (kA), 0.2s		50	50	50	50	50	50	50	50
Gap distance (mm) (for reference) [1]		350	580	600	630	1000	1250	1500	1800
Creepage distance (mm)		2600	2600	3000	3800	4500	4500	6000	6000
Mass of arrester unit (kg)		35	35	50	50	70	95	95	120

Note (1): the gap distance may vary according to the condition of the insulator strings and/or towers.



EGLA for suspension type insulator strings



EGLA for tension type insulator strings

Structures

The Toshiba EGLA arrester unit consists of the ZnO column, which is directly molded with silicone rubber, helping reduce the size and weight of the arrester unit.

The silicone material has excellent weatherproof and hydrophobic characteristics, meaning the Toshiba EGLA boasts an extended service life.

Toshiba EGLA is mounted to the hardware of insulator strings, rather than directly to the power conductors. Direct installation to the power lines could damage the conductor, due to the load, vibration and torsion caused by the wind to which the line arrester is exposed, or arcing movements along the conductor.

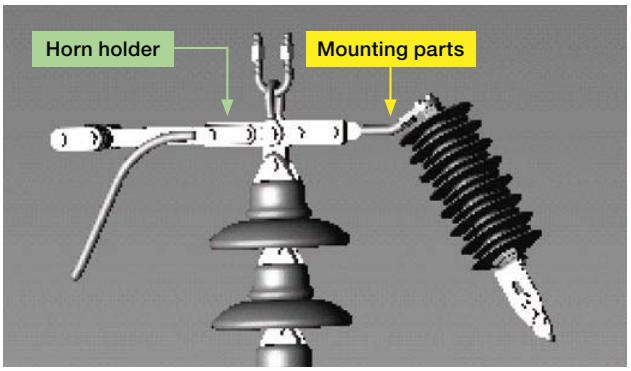
Installation

The Toshiba EGLA can be easily installed to the hardware of the insulator strings. Typical installations are shown in the figures. Mounting the arrester unit to the horn holder is typical and the easiest installation method. Even if mounting the arrester unit to other hardware, the mounting parts can be modified to fit to the latter.

Setting the external series gap distance is vital for EGLA, because of the need to consider the following items:

- The series gap must withstand switching overvoltage and power frequency.
- The series gap must be designed to coordinate the arcing horn against any lightning impulse.

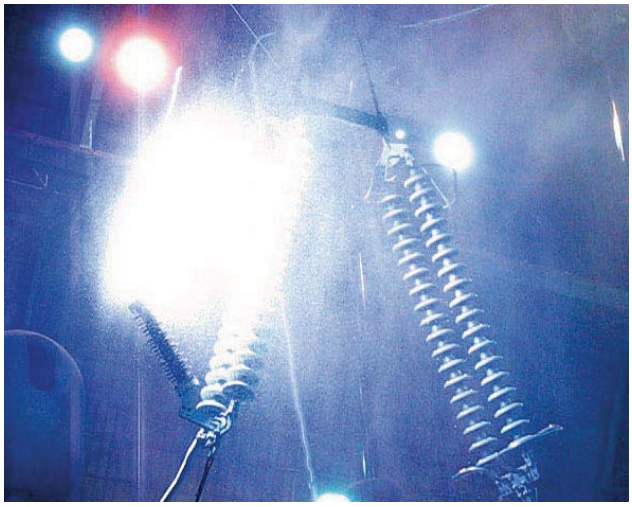
The gap horn is designed to be adjustable in order to fix the series gap distance correctly.



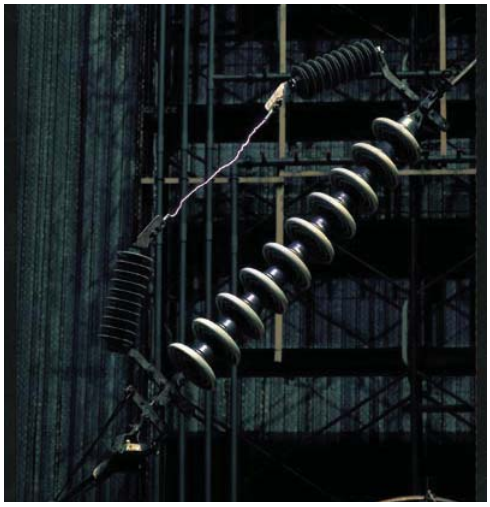
EGLA Installation

Hardware indicated in green represents existing parts.

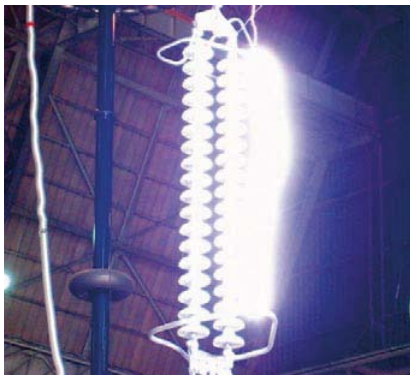
Hardware indicated in orange represents parts newly required for EGLA installation.



Insulation coordination testing view of the heavy duty EGLA for 275 kV system in wet condition



Follow current Interruption testing view of the compact EGLA for 170 kV system



Insulation coordination testing view of the insulators for 275 kV system

Short circuit testing view of the heavy duty EGLA unit

Verification tests

Toshiba has excellent testing facilities and tested the EGLA based on newly revised testing methods.
Its excellent performance has been confirmed in all test areas.

The insulation coordination between the complete arrester and the insulator assembly was tested repeatedly under dry and wet conditions and proved the high reliability of Toshiba EGLA.

A follow current Interruption test was conducted under wet and polluted conditions. The hydrophobicity of the tested arrester unit was completely eliminated via a method based on long experience. Such test conditions were far more severe than the other test methods and effectively simulated practical conditions.

A short circuit test was conducted, and the superior safety of the Toshiba EGLA was confirmed. The test proved that no violent scattering of fragments harmful to the human body occurred. The tests were conducted under circumstances where the arrester unit was shorted by a fuse wire and the arrester unit was pre-failed due to power frequency overvoltage. The self-extinguishing capability of open frames was also confirmed.

The vibration test is the key test item. Because A transmission line arrester is placed on top of the power towers, the effects of vibration caused by wind must be verified. The Toshiba EGLA was vibration tested with more than one million oscillations and its ability to withstand the vibration stress was confirmed.

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