Sediver High Resistivity insulators for HVDC applications

Experts & Pioneers

Introduction to Sediver HRTG insulators

At the end of the 1950's Sediver was among the first manufacturers to develop insulators for HVDC overhead transmission line applications.

Thanks to this unique and substantial field experience and ongoing research programs with utilities and international experts, the Sediver research team introduced a state-of-the-art new DC insulator using high resistivity toughened glass **(HRTG)** in the mid 1980's.
This development has largely contributed to establish a high performance benchmark in the industry, including specific criteria later on introduced in IEC 61325 which still is the only international standard describing HVDC performance requirements.

Today, nearly 6.5 million Sediver insulators have been in operation on HVDC lines with great success.
The applications cover all climatic and environmental conditions at up to 800 kV DC.

HVDC specific stresses

Insulators used on HVDC lines have to sustain very unique and specific stress conditions associated with the unidirectional e-field and current flow.

1. Ionic migration

Electrical conduction in insulating materials is the result of the movement of ions through the material.
During the life of insulators on a DC line, certain units can be exposed for extended periods to a combination of a high voltage - due to non-uniform voltage distribution - and high temperatures arising from ambient conditions and solar heating.
In DC applications, the unidirectional current can generate a significant increase of temperature locally in the dielectric.
Ionic migration is also sensitive to the purity of the dielectric material.
The effect of ionic migration on dielectric materials not specifically designed for DC application, or having an improper formulation, is a risk of formation of depletion layers resulting in a weakening of the dielectric itself.
This can lead to puncture for porcelain or shattering for toughened glass.

2. Thermal runaway

Thermal runaway can occur in insulators with a low resistivity material when the temperature of the dielectric is much higher than the ambient temperature, or when ionic currents flow in the vicinity of internal discontinuities of the dielectric. The temperature rise associated with the local heating increases the current which increases the temperature in a runaway spiral and finally leads to puncture for porcelain or shattering for toughened glass.

3. Pollution accumulation

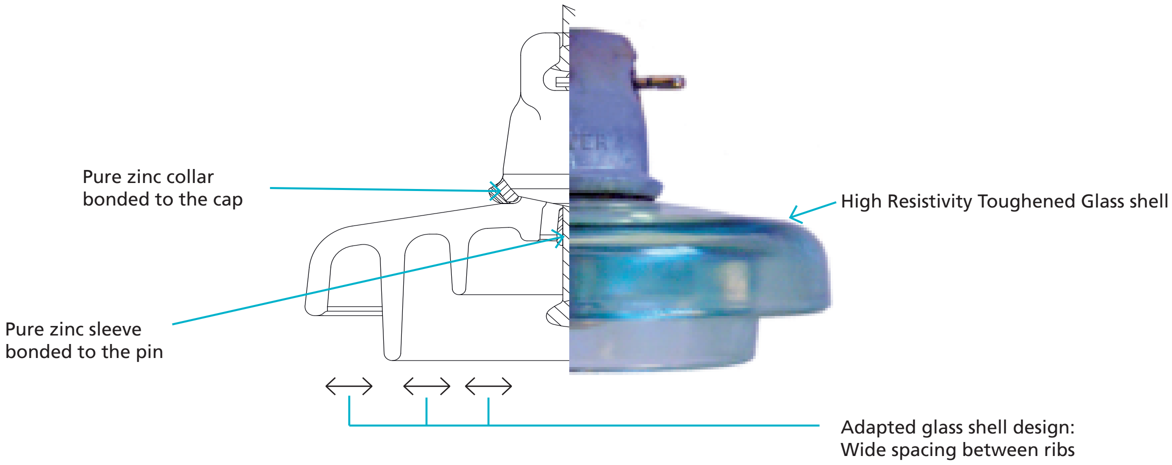
Under HVDC, the electrostatic field along the length of an insulator string, in conjunction with the wind, lead to a steady build-up of pollutants on the insulator surface. This pollution accumulation can be as high as 10 times more severe than that on comparable HVAC insulation in the same environment.
Therefore, while for high voltage alternating current (HVAC) systems, switching and lightning performance are the dominant factors influencing the overall length of insulation, for HVDC systems the length of the string is more often controlled by the level of pollution.

4. Metal part corrosion

Additionally direct current when associated with humidity conditions accelerates the corrosion of the metal parts due to electrolytic effects.

Sediver HRTG insulator design: the answer for HVDC T/L reliability

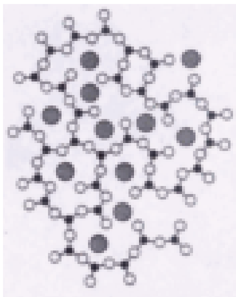
To achieve an optimum performance in DC and to cope with these 4 additional constraints, Sediver developed the High Resistivity Toughened Glass (HRTG) insulator, having a special type of glass and an adapted insulator design.



High Resistivity Toughened Glass to solve internal current effects

Glass is an amorphous material. Its atomic structure is a basic Silica/Oxygen network in which several other oxides are added, either for processing or for acheving specific properties depending upon the final application.

AC glass
chemical composition

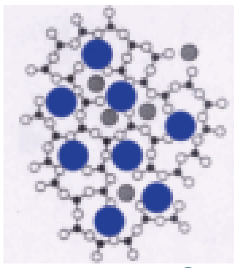


○ Si^{4+} ● O^{2-} Na^{+}

In AC glass chemistry, oxides such as Sodium are used.
In this case Sodium, which is not linked to the structural atomic backbone, can move under an electric field leading to ionic conductivity.

In DC, such ionic conductivity has to be inhibited.
In order to reduce ionic migration, the atomic network is modified by replacing part of the sodium ions with bigger cations or other cations having lower mobility.
The resulting glass material (HRTG) is characterized by a reduced mobility of sodium which is hindered by the addition of bigger cations.
The electrical resistivity of the glass is therefore increased by a factor of about 100, eliminating the risk of failure due to ionic migration or thermal runaway.

DC glass
chemical composition



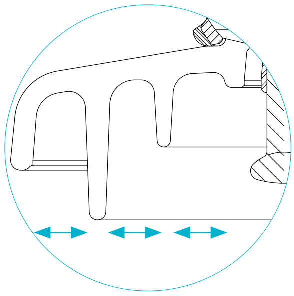
○ Si^{4+} ● O^{2-} Na^{+} K^{+}

Additionally, Sediver has developed a special manufacturing process able to produce glass shells with a very high degree of purity, and therefore having a lower impact on ionic accumulation.

Adapted glass shell design to prevent pollution accumulation

The specific pollution conditions of DC applications require that the insulators be designed with care to reduce the risk of excessive dust accumulation resulting from unidirectional electric fields. (See IEC 60815 part 4).
Test laboratory and field experience have largely demonstrated that the bottom of the insulator is of prime importance in this regard. The best insulators will offer an adapted leakage distance distributed in a way that will prevent both dust nests as well as rib to rib arc bridging.
In this regard, Sediver has been able to adapt the shape of the glass shell to DC specifics, made possible thanks to the glass pressing and toughening processes which:

- avoids arc bridging,
- reduces dust accumulation,
- maintains self-cleaning.



Protection of the metal end fittings against corrosion

Pin protection

Under DC stresses, the galvanized coating of the pin deteriorates over time leading to the corrosion of the pin itself which in the long term can lead to significant reduction of the mechanical strength.
In order to prevent this form of pin damage, Sediver HVDC insulators are equipped with a corrosion prevention sleeve made of high-purity zinc.

Pins from service insulators

Corroded pin without zinc sleeve — Pin with zinc sleeve

Cap protection

In HVDC, arcing activity and corrosion can also take place around the cap leading to rust deposits on the top surface of the skirt.

While no mechanical risk is expected from this phenomenon the generation of a conductive path on the insulators can substantially reduce the overall leakage distance of the entire string and therefore its electrical performance.

In order to avoid this type of corrosion, Sediver, went beyond the IEC specification in the early 80's and patented a specific zinc collar design to protect the cap.

Field observations

Rust appears on cap due to surface current

User benefits

Sediver HRTG features and User benefits

	HVDC stress consequence	Risk	Sediver HRTG solution	User benefit
Internal current	**Ionic migration** **Thermal runaway**	Dielectric breakdown	**High Resistivity Toughened Glass** imparting high resistance to localized thermal stresses and ion flow	No puncture = less maintenance
External current	**Pollution accumulation**	String flashover	**Adapted glass shell design** with wide spacing between ribs and increased leakage distance	High pollution efficiency = less maintenance
	Metal parts corrosion	String flashover Mechanical failure	**Protection of the metal end fittings** with pure zinc collar bonded to the cap and pure zinc sleeve bonded to the pin	Longer life expectancy

The condition of Sediver DC insulators after 30 years in service has been monitored jointly with Utilities. Today millions of Sediver HRTG insulators have proven their outstanding performance and reliability under all kinds of environmental conditions.