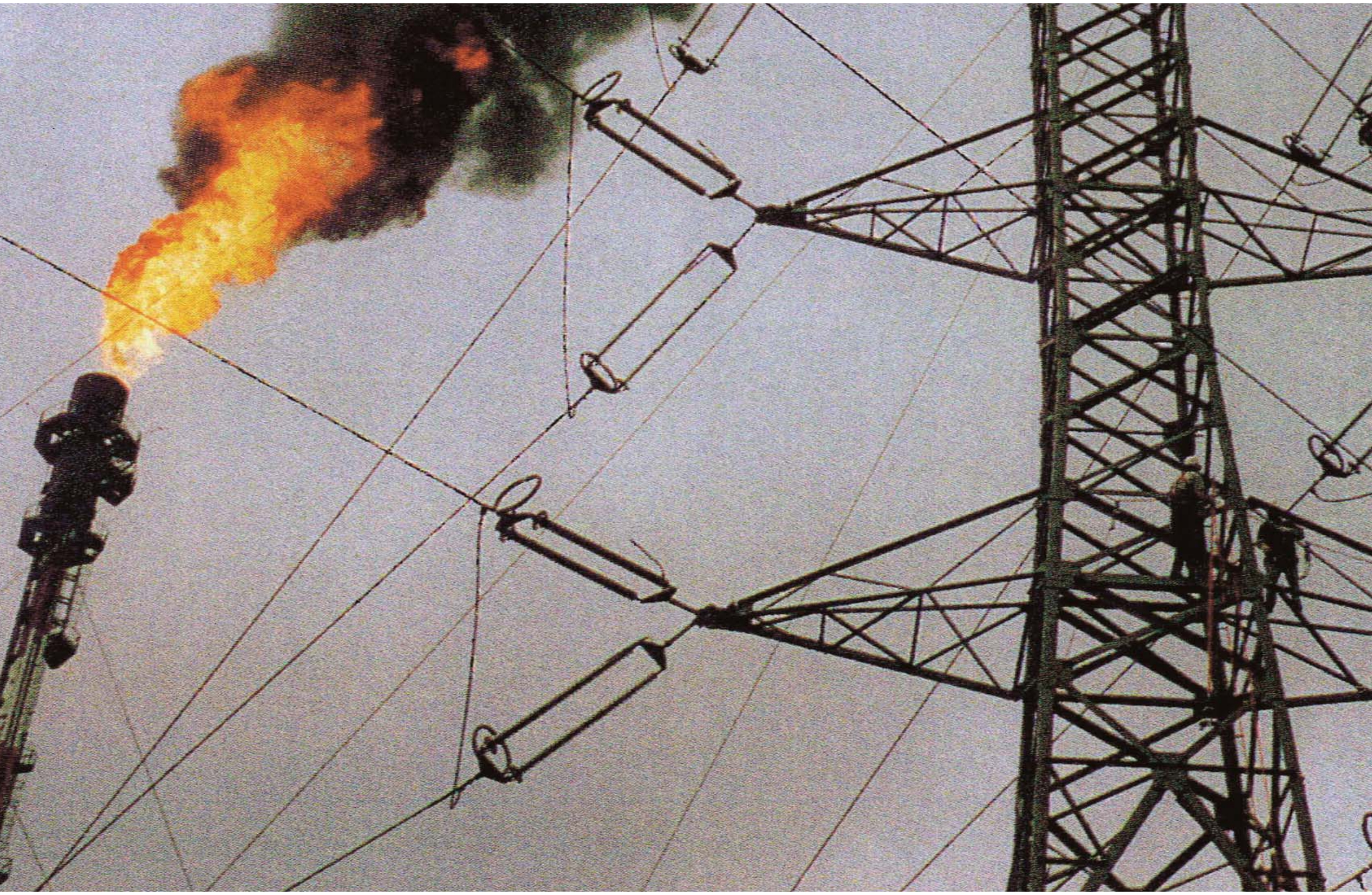
SEVES

SEDIVER

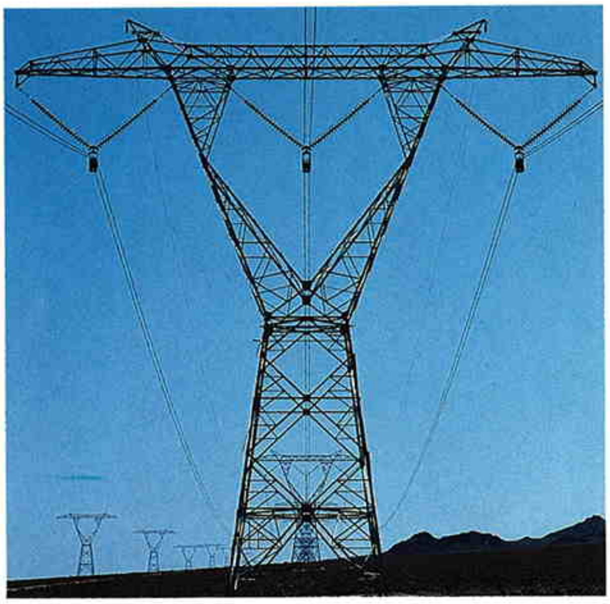


# Sediver toughened glass for contaminated area applications

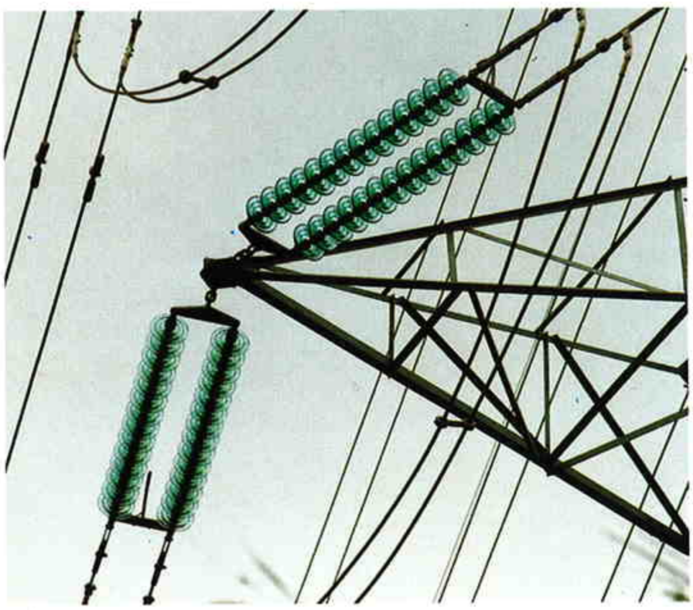
# SEDIVER SUSPENSION INSULATOR INSTALLATIONS IN CONTAMINATED AREAS

FRANCE 245 kV
Industrial and coastal conditions

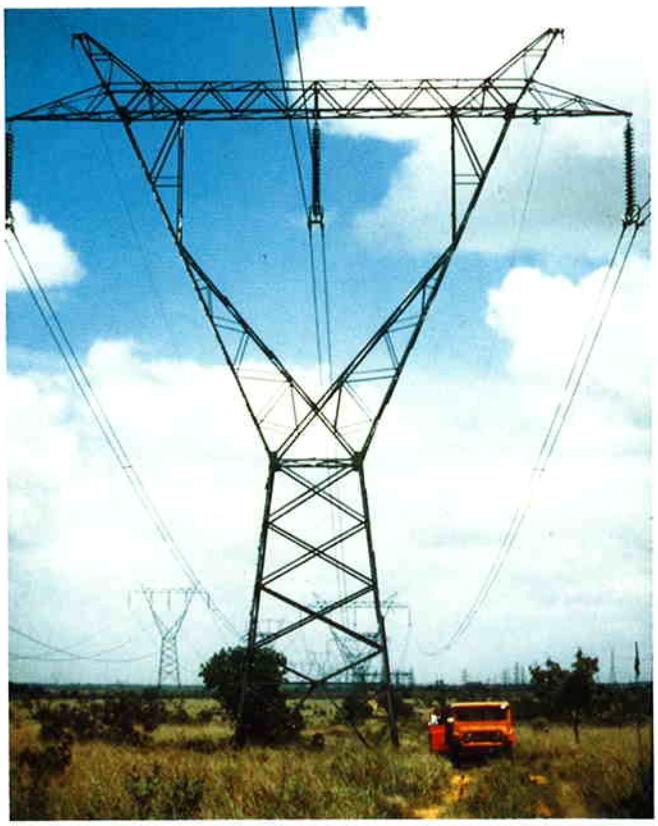
DUBAI 132 kV
Desert conditions



IRAN 400 kV
Desert conditions



Malaysia 275 and 132 kV
Tropical climate and coastal conditions



Venezuela 400 kV
Tropical climate and desert conditions

# TOUGHENED GLASS SUSPENSION INSULATORS FOR CONTAMINATED AREA APPLICATIONS

More than ten million Toughened Glass Suspension Insulators are now in service throughout the world in polluted areas which involve almost all possible combinations of contaminant source and weather pattern. Regardless of the contaminated condition encountered, these Sediver Insulators have successfully prevented power system disturbances due to contamination flashover, in a great many cases for time periods longer than 25 years.

In this brochure, the insulator design principles which influence performance under contaminated conditions are explained, the available Sediver Toughened Glass Insulator Types are presented, and guidelines for proper selection and string length determination are provided.

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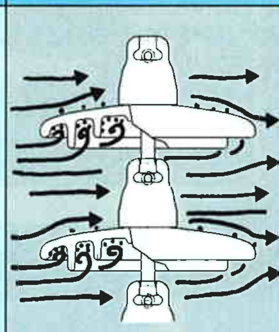
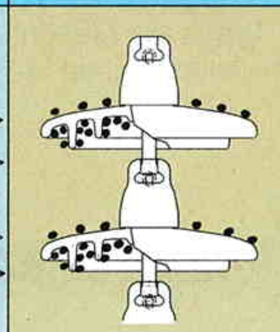
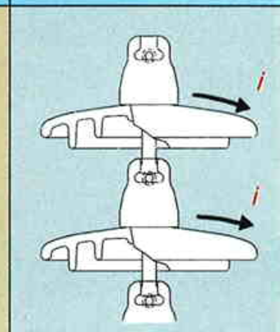
## DIRECT CURRENT APPLICATIONS

While much of the information provided in this brochure is valid for insulator applications on both AC and DC lines, there are several unique characteristics of direct current which lead to much more severe electrical stresses on suspension insulators. For that reason, the DC application must be considered as a special case, and readers should request the SEDIVER bulletins and technical papers which deal with this subject.

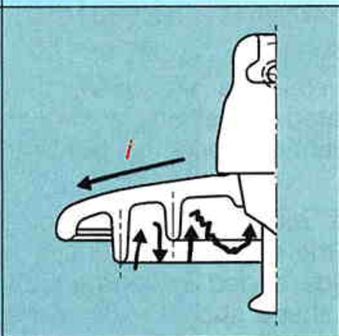
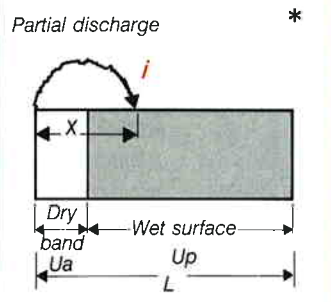
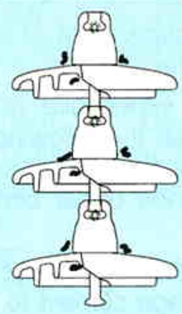
# THE PROCESSES WHICH DETERMINE INSULATOR

In designing transmission lines for operation in areas of atmospheric pollution, insulators of proper design must be chosen and an appropriate string length determined. When this is done, and when proper maintenance procedures are followed, system disturbances due to contamination flashover of insulators will be prevented, and a high degree of line reliability will be achieved.

| | CONTAMINATED ENVIRONMENT AT LINE LOCATION | DEPOSITION OF CONTAMINANT ON INSULATOR | EVOLUTION OF CONTAMINANT DEPOSIT | WETTING OF CONTAMINANT DEPOSIT |
|---|---|---|---|---|
| | |  |  |  |
| **A** DESCRIPTION OF THE PROCESS | Presence of a source of pollution: natural, industrial or mixed.<br><br>Typical sources are: salt spray, desert sand, industrial emissions, engine exhaust fumes, fertilizer deposits, generating station emissions. | Contaminant particles are brought into vicinity of insulators by wind, and are selectively deposited on various parts of insulator surface. | Deposition process continues, sometimes interrupted by washing and then starts again. After seasonal variations, the amount of deposit usually stabilizes around an average value. | Atmospheric moisture in the form of fog, mist, dew or light rain slowly wets deposit.<br><br>Contaminant deposit becomes conductive and a leakage current occurs. |
| **B** MECHANISM OF THE PROCESS | Contaminant particles are carried by wind.<br><br>Distance carried can be long or short. | Laminar flow of air is disturbed by insulator.<br><br>Particles are deposited in areas of turbulence between insulator ribs and behind cap. | Deposit can be washed away by heavy rain or blown away by high velocity wind.<br><br>Major cleaning effect is on top surface of insulator. | During wetting cycle, conductivity and current increase with time but are then reduced due to washing effects. Insoluble material in deposit traps water due to capillarity and maintains wetness on surface of insulator. Wetted contaminant deposit becomes electrically conductive. Leakage current flows when there is a continuous path of wetted contaminant deposit between cap and pin. |
| **C** PARAMETERS WHICH AFFECT THE PROCESS | Particle size and weight. Distance from source of pollution.<br>Wind velocity.<br><br>Presence or absence of screen to wind (tower, nearby hills or buildings).<br><br>Orientation of line and insulators with respect to wind. | Insulator configuration (I-String, V-String, Deadend).<br><br>Insulator orientation with respect to prevailing wind, and height of insulators above ground.<br>Screening effect of structure.<br><br>Insulator shell shape --with or without ribs and ribs spacing-- prevents accumulation and facilitates washing and wind. | | Nature and amount of dissolved salts in contaminant deposit.<br><br>Nature and amount of insoluble materials in contaminant deposit.<br><br>Time.<br><br>Hydrophobicity of material. |

# PERFORMANCE IN CONTAMINATED AREAS

In order to identify the insulator design characteristics which most effectively prevent contamination flashover, it is necessary to have an understanding of the processes by which contaminant layers build up on insulator surfaces and the mechanisms which explain leakage current flow and surface arcing effects. This chart presents these inter-related subjects in outline form. For more detailed information, thorough reading of the Technical Papers shown in the List of References on page 16 is suggested.

| FORMATION OF "DRY BANDS" | EVOLUTION OF SURFACE ARCING | RESULT OF SURFACE ARCING: STRING WITHSTAND | RESULT OF SURFACE ARCING: STRING FLASHOVER |
|---|---|---|---|
|  |  |  |  |
| At locations on the dielectric shell where leakage current density is high, water evaporates due to heating effect of current.<br><br>A "dry band" forms on those surface areas, most frequently near the insulator pin. | Leakage current flow is limited by "dry band".<br><br>Surface arcs bridge the "dry band".<br><br>Arc length may increase or decrease. | Visible arcing, but arc length does not increase.<br><br>Arcs extinguish when moisture disappears, or when conductive deposit is removed by washing effects. | Length of "dry band" arc increases.<br><br>Arcs extend completely across insulator. |
| Voltage distribution on the insulator surface is modified by the presence of the "dry band".<br><br>Most of the voltage is applied to the "dry band". | Voltage is sufficient to cause arcing across "dry band".<br><br>Resistance of wet contaminated surface layer is in series with arc, and therefore controls current in arc.<br><br>As result of further wetting, resistance of contaminated surface layer decreases.<br><br>An increase in leakage current occurs, allowing arcs length to increase. | Insulator leakage distance is long enough, even when all soluble salts are dissolved, to limit leakage current to a value less than Ic, the critical current, because any further small current increase results in a very large increase in arc length. | Because of increase of conductivity of the wetted contaminant path, and insufficient leakage distance, the current increases to the critical current value Ic.<br><br>In such conditions, the system becomes instable, leading to a point where the entire insulator is bridged by arcing. |
| Resistivity of wet contaminated surface.<br><br>Leakage distance, which limits leakage current. | | Adequate leakage distance of string.<br><br>Properly shaped dielectric shell. | Inadequate leakage distance of string.<br><br>Improperly shaped dielectric shell. |

* The applied voltage U is equal to the sum of the arc voltage Ua and the voltage drop in the wet pollution layer Up.
$U_a = A X I^{-n}$
$U_p = Z (L - X) I.$

Where A and n are arc constants
X is the arc length
I is the arc current
Z is the uniform resistance per unit length of the creepage distance
L is the creepage distance of the insulator.

## INSULATOR DIELECTRIC SHELL PROFILE

A key conclusion that can be derived from systematic analysis of the contamination build-up and surface arcing processes on insulators is that ability to withstand contamination flashover is:

- strongly influenced by dielectric shell shape,
- but independent of ceramic dielectric shell material.

Through experience and research, it is known that the following aspects of insulator shell shape are essential to efficient performance under contaminated conditions:

**1.** A leakage distance long enough to limit leakage current to a value less than that which causes a critical increase in dry band arc length.

**2.** When ribs are incorporated into the underside of the shell to provide the leakage length required, their location, depth and thickness must permit effective removal of pollutant deposits by wind, natural washing and artificial cleaning.

**3.** Shell profiles involving ribs should have shape characteristics which discourage pollutant particle accumulation on underside surfaces, particularly in the area of the pin which is subjected to high electrical stress.

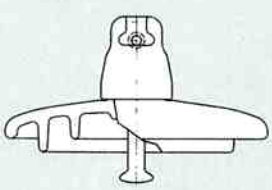
**4.** When several ribs are used, they should be located at positions far enough apart to prevent arc bridging between adjacent ribs.

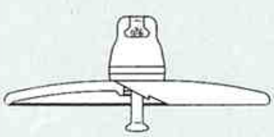
**5.** When an extended overhanging extension of the upper shell surface is used to provide added leakage length, the resultant shape should avoid water bridging across adjacent insulators in a string.

**6.** A shell profile completely free of ribs, but with a perimeter long enough to provide required leakage length, is useful in certain situations.

## EFFECT OF DIELECTRIC SHELL PROFILE ON SEVERITY OF CONTAMINANT DEPOSIT

The curves shown below illustrate the effect of dielectric shell profile on the amount and severity of contaminant build-up. The data source is a project in which Sediver engineers made E.S.D.D. measurements on the dielectric shells of two types of toughened glass insulators installed on a 132kV line located in the Arabian Peninsula. As indicated, the measurements were taken at two sites with different environments.


F12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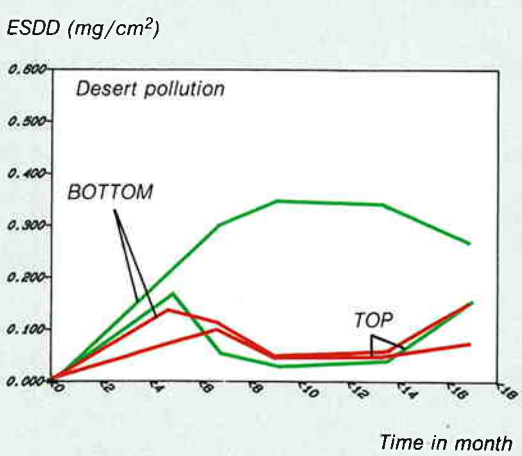
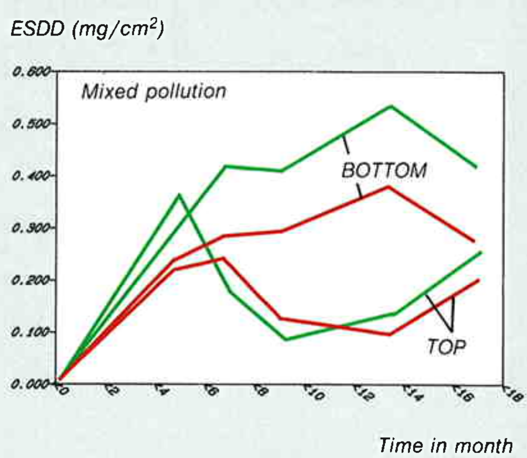



The test data clearly illustrate the tendency for wind-driven solid pollutants to accumulate more rapidly on the bottom surfaces of insulators with underribs, and demonstrates the effectiveness of a completely smooth profile in reducing contaminant accumulation, particularly in a desert environment.

# CONTAMINATION FLASHOVER

## CHARACTERISTICS OF POLLUTANT MATERIAL

There are three general categories of atmospheric pollution which lead to the formation of the conductive deposits which, when moistened, cause leakage current flow across insulator surfaces.
In the chart which follows, detailed listings of the sources of pollution are given, and the general characteristics of the pollutant materials are described.

| POLLUTION CATEGORY | | SOURCE OF POLLUTANT | CHARACTERISTICS OF DEPOSIT | AREA AND EXTENT OF EFFECT |
|---|---|---|---|---|
| NATURAL | Inland | Soil dust | Usually not very conductive and adhesive; may therefore be removed by natural or artificial washing. | May be extended. Occurs in areas of sandy soil or in desert locations. |
| NATURAL | Desert | Sand | Conductivity may be high; some sands contain more than 20 % of soluble materials. | |
| NATURAL | Coastal | Salt water leading to microscopic salt crystals carried by the wind | Crystalline deposit not very adhesive; can be removed by natural or artificial washing. | In direct vicinity of coast, but can sometimes be carried inland as far as 10-20 km. |
| INDUSTRIAL | | Steel mills, Coke Plants, Cement factories, Chemical Plants, Generating Stations, Quarries. | Usually highly conductive. Often combined with insoluble materials. | Localized to close vicinity of plant involved; therefore affects only a few structures. |
| MIXED | | Industries indicated above, but located close to sea coast or desert. | Very adhesive and often conductive; repeated washing necessary for effective removal. | Localized to close vicinity of plant involved. |

Pollutant deposits may consist entirely of conductive materials, or may be a combination of conductive and inert materials. Typically, the conductive component is an ionic salt, of which chlorides and sulphates are typical examples. These salts dissolve in the water added by wetting and form the conductive path on the insulator surface through which leakage current flows.
The inert components in pollutant deposits usually do not dissolve but may often form a mechanical matrix in which particles of the conductive component become embedded. Examples of such materials are silica and various clays. The significance of this matrix is that it acts as a coating which tends to decrease the effect of natural or artificial washing of the insulator.

## NATURE OF WETTING PROCESS

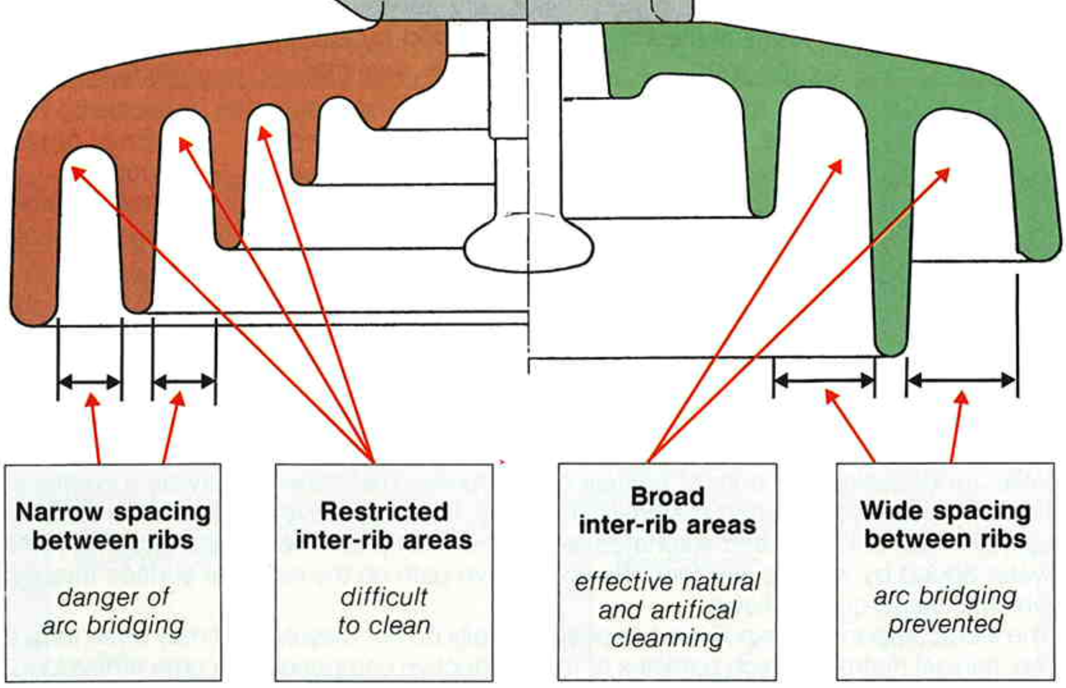
The most critical situation arises when atmospheric conditions are such that the contaminant deposit becomes moistened at a slow rate. Specific weather conditions which produce slow moistening are fog, mist, sleet, or a sudden temperature change causing condensation (dew). Light and intermittent rain can also lead to humidification, but steady or heavy rainfall does not cause serious trouble because a washing effect occurs as soon as heavy precipitation begins.

## OPTIMIZED DIELECTRIC SHELL SHAPE

Since the performance of a suspension insulator in a polluted environment is closely related to the accumulation of pollutant particles on its surface, the evolution of the shell shapes which most effectively reduce these deposits is SEDIVER 's primary design objective.

**In Porcelain Insulators,** dielectric shells are produced by pressing a paste mixture to shape, followed by firing. Because of the thermal stresses induced, the insulator designer must provide for gradual shape transitions and avoid thin sections. These factors limit the attainment of optimal shell profiles.

**In Toughened Glass Insulators,** dielectric shells are produced by molding, a process which places few restrictions on the insulator designer with regard to shape transition and section thickness. SEDIVER Insulators therefore have shell profiles of optimal efficiency for a wide variety of contaminated area applications.



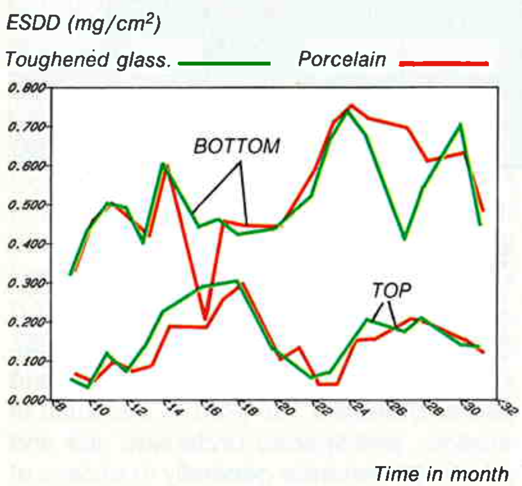

Tests conducted under field and laboratory conditions illustrate the superior contamination performance characteristics of SEDIVER Toughened Glass Insulators as compared to the porcelain types.
In the example shown on page 7, the evolution and amount of surface contamination on two dimensionally equivalent SEDIVER and porcelain insulators is shown to be similar. Howewer when contamination flashover tests were performed in a laboratory on identical samples, the SEDIVER Toughened Glass Insulator had a significantly higher flashover voltage at all levels of contamination. This result clearly illustrates the influence of the more optimal and efficient shape of the Sediver Toughened Glass Insulator.

## COMPARATIVE PERFORMANCE TEST RESULTS SEDIVER TOUGHENED GLASS AND PORCELAIN INSULATORS

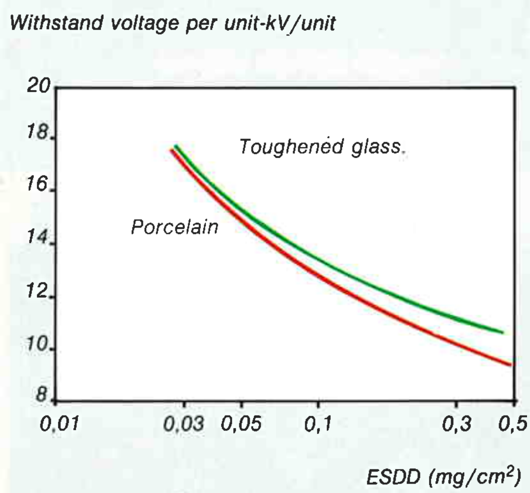
Ratings & dimensions of the tested insulators

| INSULATOR TYPE | MECHANICAL STRENGTH RATING | SPACING | DIAMETER | LEAKAGE DISTANCE |
|---|---|---|---|---|
| TOUGHENED GLASS | 178 kN | 170 mm | 320 mm | 530 mm |
| PORCELAIN | 178 kN | 171 mm | 321 mm | 546 mm |

Comparative accumulation of surface contamination
(data from test site in middle east desert location)




Comparative contamination flashover characteristics
(data from laboratory tests)




## RESISTANCE TO SURFACE ATTACK

Due to the superior mechanical and physical properties of toughened glass, surface damage related to the presence of pollution is prevented. Examples of such conditions are:

**Chemical:** SEDIVER glass is almost completely inert. It is therefore immune to attack by acidic or caustic chemical compounds. The only exception is hydrofloric acid, a pollutant rarely found in areas served by transmission lines at large enough concentration.

**Abrasion:** Even under prolonged exposure to sand storms, the surface hardness of SEDIVER Toughened Glass Shells prevents mechanical damage by wind-driven sand particles.

**Sustained surface arcing:** This effect only occurs under conditions of exceptionally severe contamination and steady humidification which lead to extremely high leakage currents. The heat of the resultant sustained and intense arc produces surface effects which evolve slowly with time, observable first as a loss in polish and then as a roughening followed by patterns of narrow and shallow channelling.

This effect rarely occurs on toughened glass and porcelain insulators in actual field applications, but is occasionally observed during certain non-representative laboratory tests involving accelerated procedures. In the highly exceptional case of field conditions severe enough to cause roughening and channelling effects, the compressive pre-stresses in the surface region of SEDIVER Toughened Glass dielectric shells retain their effectiveness in preventing formation and growth of surface microcracks. Any possible reduction in mechanical or electrical strength is thereby prevented.

## TRANSPARENCY OF GLASS

In areas with severe contamination, or low annual rainfall, periodic insulator cleaning is highly advisable. Because glass is transparent, the effectiveness of such cleaning operations is visually detectable on SEDIVER Suspension Insulators.

# *TOUGHENED GLASS INSULATORS:*

SEDIVER Suspension Insulators are available with dielectric shells of five different shapes, and in a broad range of mechanical strength ratings. The following chart indicates the specific mechanical ratings available for each shell shape, and is followed by descriptions of their general characteristics. All types shown have dielectric shells which are designed in accordance with the insulator profile parameters stated in IEC document 815 (Guide for the Selection of Insulators for Polluted Conditions).

| Insulator shell profile | MINIMUM FAILING LOAD RATING, kN | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 40 | 70 | 80 | 100 | 120 | 160 | 210 | 240 | 300 | 530 |
| **Standard** | X | X | X | X | X | X | X | X | X | X |
| **Fog-Type** | | | | | | | | | | |
| **Shape A** | | | | X | X | X | X | X | X | |
| **Shape B** | | | | X | X | | | X | | |
| **Open** | | X | | | X | X | X | | | |
| **Spherical** | X | | | | X | | | | | |

**Standard Profile:**
Shape and dimensions are in accordance with international standard IEC 305/1978 and with such national standards as ANSI C29.2-1983 (USA) and British Standard 137 (Part II). Because of shallow, well-spaced underside ribs and a leakage distance generally in excess of standard duty requirements, this design performs well in areas of mild contamination.

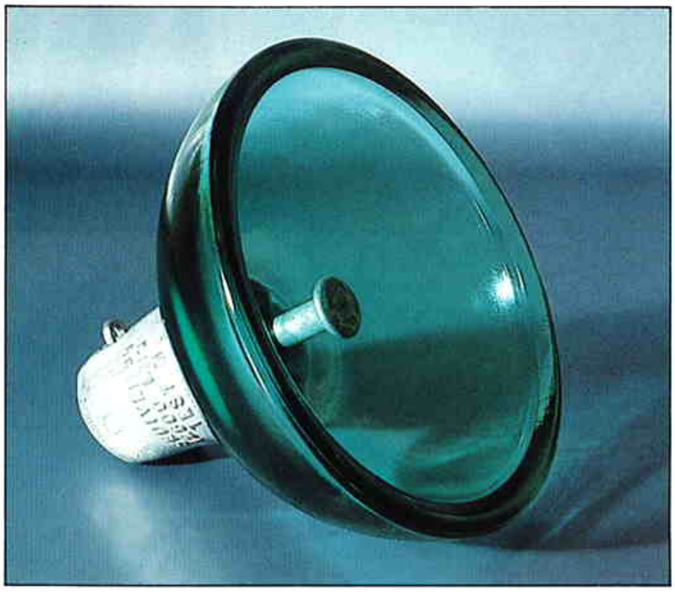
**Fog-Type Profile (Shape A):** A design with a larger diameter than the standard profile type, and with two or three ribs of greater depth. The profile and wide spacing of the ribs promote effective self-cleaning action by wind or rain, and permit easy manual cleaning if required. The wider spacing also prevents arcing across adjacent ribs under severe contamination, and the overall underside profile simplifies hot line maintenance.

## A BROAD RANGE OF AVAILABLE TYPES

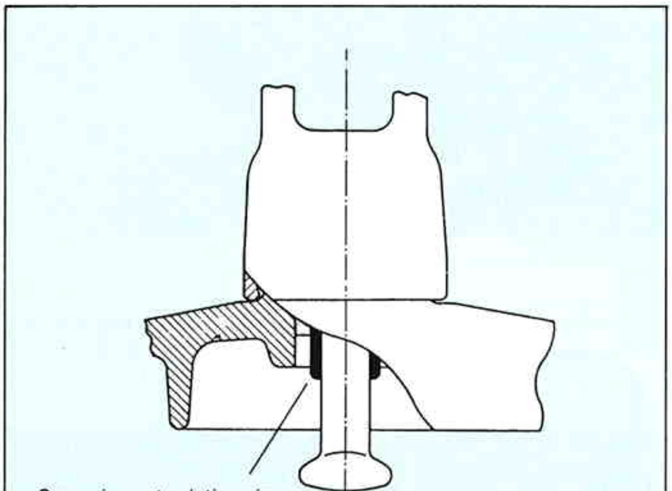
**Fog-Type Profile (Shape B) :**
In this design, the deep outside rib on the lower surface acts as a barrier against accumulation of pollutants at inner shell areas close to the pin. Also, the more sharply sloped upper surface reduces pollutant deposits in that area of the shell. This shell shape is effective against salt spray carried by off-shore winds in coastal areas, especially in suspension strings.

**Open Profile:**
Complete elimination of underside ribs in this shell type greatly reduces pollutant accumulation on the lower surface because air flow is smooth and uninterrupted. This design is particularly effective in desert areas where natural washing by rain is infrequent.

**Spherical Profile:**
The spherical shape permits a leakage distance equivalent to that of standard profile types, and the absence of underside ribs makes for easy, efficient manual cleaning.



## CORROSION RETARDATION RING



Corrosion retardation ring.

In severely corrosive marine and industrial atmospheres, the galvanized coating on Suspension Insulator pins may deteriorate in time and be followed by corrosion of the pin itself. To prevent this form of pin damage, SEDIVER supplies a corrosion retardation ring made of 99.7% purity zinc. As shown here, this ring is cast directly on to the pin and is located at the cement line. Because of position and relative mass, the ring acts as a sacrificial anode and thereby protects the pin against galvanic action.

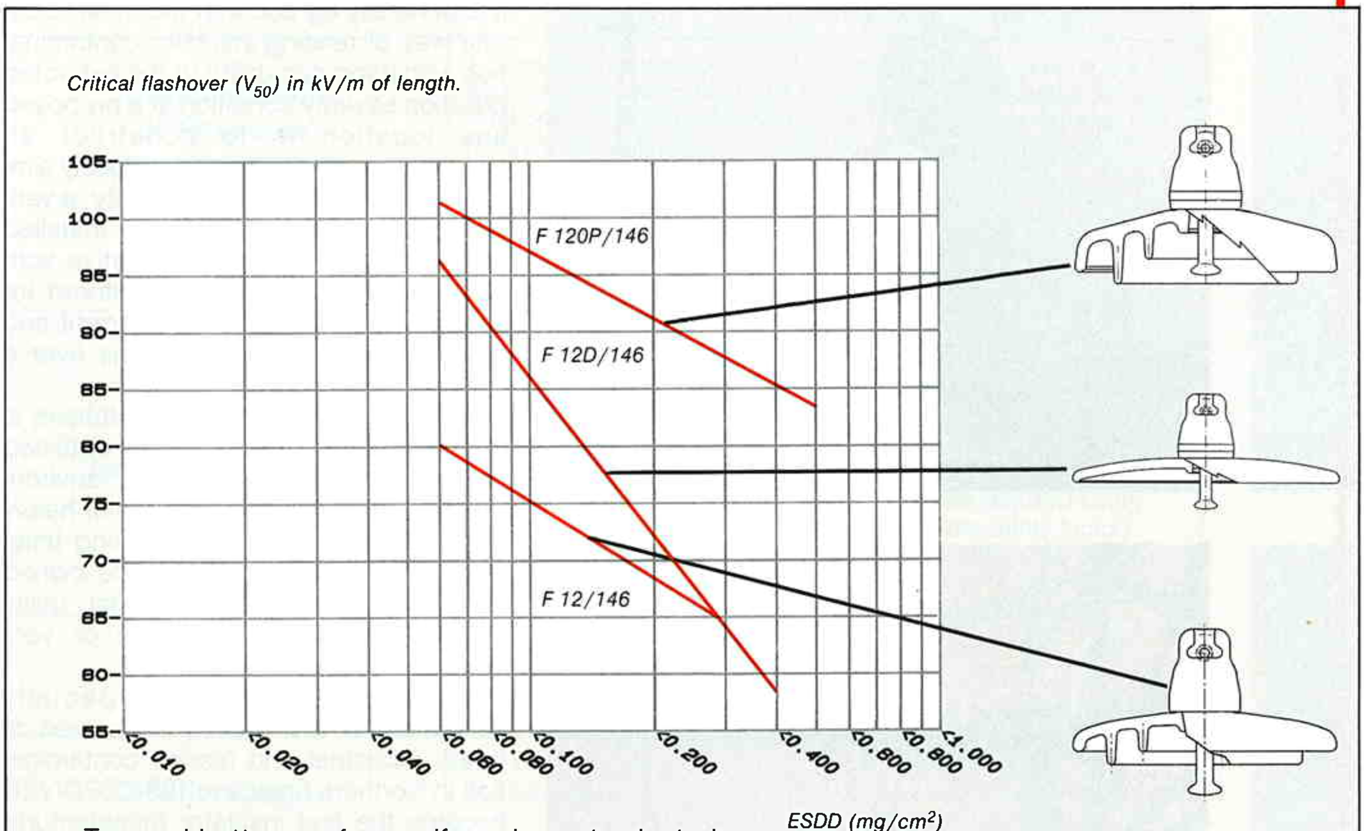
In certain very severely contaminated atmospheres, extended exposure to corrosive attack can cause pin expansion and a resultant high mechanical hoop-stress in the head area of the dielectric shell. However, as shown in this photograph of a SEDIVER toughened glass insulator removed after several years of service in a hot and coastal contaminated atmosphere in Senegal even through severe pin expansion hed occured, damage to the dielectric shell was prevented by the presence of surface prestresses imparted by the toughening process.
In similar condition even high strength porcelain will crack.

## ARTIFICIAL CONTAMINATION FLASHOVER CHARACTERISTICS

Typical data on contamination withstand characteristics of several SEDIVER Toughened Glass Insulators at various ESDD levels appear below. Additional data on other types are available on request.

ESDD, or Equivalent Salt Deposit Density, is a measurement of the amount and severity of contaminants which collect on a given insulator shape over a given period of time. It represents the equivalent quantity of Sodium Chloride (Na Cl) per unit surface of the insulator which, when dissolved in a determined volume of distilled water at a measured temperature, gives an electrical conductivity equal to that of the actual deposit.

For a description of the procedure for measuring ESDD, see article, pp. 101-116, ELECTRA N° 64 - 1979: "The Measurement of Pollution Severity and Its Application to insulator dimensioning for A.C. Systems" by working Group 04 of CIGRE Study Committee N°.33.




Top and bottom surface uniformely contaminated.

# SELECTION OF INSULATORS

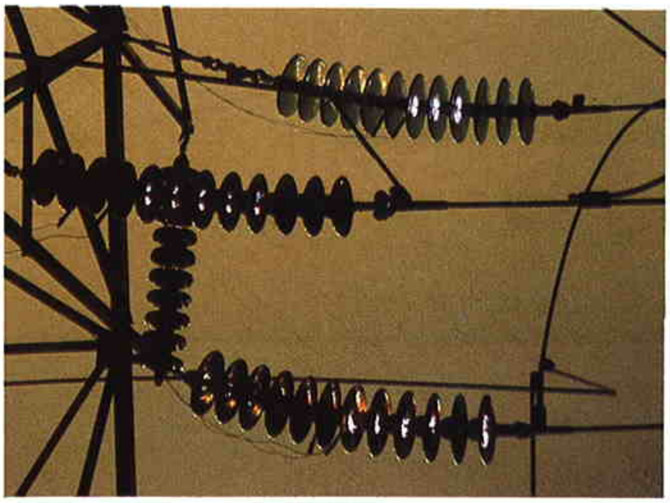
Two basic steps are involved in selecting the optimal insulator type and the string length necessary to prevent contamination flashover in a given polluted area:

- Determination of the relative ability of available or proposed insulator types to limit contaminant deposit build-up and to promote natural cleaning under the particular conditions of atmosphere and weather which prevail at the proposed line location.
- Determination of the flashover performance characteristics of those insulators after their surfaces have been contaminated by exposure to line location conditions.

Some of the more commonly employed methods for making these important determinations are :

- In an instrumented Test Station, located in an environment very similar to the proposed line location.
- Natural Contamination of the proposed insulator types, followed by laboratory testing for insulator flashover performance or by use of manufacturer's flashover characteristic curves.

## TEST STATIONS



It is generally agreed that the most accurate way of relating insulator contamination withstand capability to the expected pollution severity condition at a proposed line location is to construct an instrumented test station in a closely similar environment. At such a facility, a variety of insulator types may be installed and energized at a representative voltage, and then constantly monitored for flashover incidents, leakage current and temperature/humidity conditions over a 2-5 year period.

The prime advantage of test stations is the dependability of the results obtained and the close duplication of environmental conditions, but because of heavy expenditure and extended testing time, facilities of this type tend to be owned and operated by the national utility authorities of major countries or very large privately owned utilities.

Having constructed a specially instrumented test station in an area of heavy industrial and marine contamination in Northern France in 1984, SEDIVER became the first insulator manufacturer to operate an outdoor facility exclusively devoted to the acquisition of data on shell profile efficiency, component behavior and contamination withstand performance.

## SELECTION METHODS

Two other and relatively less costly methods exist for selecting optimal insulator type and required insulator string length for reliable performance in contaminated areas. These methods, which involve a combination of field and laboratory procedures, are summarized below and comments are given on their relative advantages and disadvantages.

| | INSULATOR SELECTION METHODS | |
|---|---|---|
| | Natural contamination of insulators and laboratory testing for insulator flashover performance | Natural contamination of insulators. Use of flashover characteristic curves |
| Assessment of contaminant build-up on insulator surface | Expose insulator strings of several alternate designs to natural conditions of pollution and weather on a typical structure located at proposed line location.<br>Period of exposure: 2 - 5 years | **1.** Same exposure of insulator strings as at left.<br>**2.** Determine Equivalent Salt Deposit Density (ESDD) of the naturally polluted insulators by computing the average of the data from top and bottom surfaces, or by using the higher of the two values. |
| Determination of flashover characteristic of contaminated insulator | **1.** Conduct contamination flashover test (clean fog type) in laboratory on all samples of naturally contaminated insulators.<br>**2.** Measure and record flashover or withstand voltage on all samples. | Obtain contamination flashover characteristic curves from the manufacturers of the alternate insulator designs under consideration.<br>(Curves are for flashover voltage vs. ESDD, and are usually based on artificially contaminated insulators.) |
| Insulator selection | Based on laboratory test results:<br>**1.** Determine flashover or withstand voltage per unit of insulator section length for all types tested.<br>**2.** Calculate required string length (allow safety factor)<br>**3.** Select most efficient and cost-effective insulator. | Based on manufacturers' flashover characteristic curves:<br>**1.** Determine flashover or withstand voltage (kV/m of section length) at selected ESDD level.<br>**2.** Calculate required string length (allow safety factor).<br>**3.** Select most efficient and cost-effective insulator. |
| Advantages | **1.** High degree of accuracy<br>**2.** Close duplication of actual environmental conditions | **1.** Fair degree of accuracy<br>**2.** Lower cost due to elimination of laboratory testing |
| Disadvantages | **1.** Time-consuming<br>**2.** High cost | **1.** Time-consuming<br>**2.** Does not consider effect of not-soluble contaminant particles |

Recognizing that it is not always possible for utilities to perform complex field and laboratory investigations, SEDIVER has developed guidelines for the selection of toughened glass insulators for contaminated area applications, and for determination of the string length necessary for optimal performance at a given line voltage. These guidelines, evolved from Sediver insulator application experience and contamination research, are based on the relative ability of the listed SEDIVER insulators to meet the following requirements:

**Minimized leakage current** by providing a leakage length and leakage efficiency necessary for the applicable type of contamination.

**Minimized pollution deposit** by having a profile best adapted to the applicable type of contamination and natural cleaning condition.

### STEP ONE - Identification of pollution category

This step is generally equivalent to defining relative pollution severity.
The four categories involved are listed below, and are more fully described on page 5. : Inland, coastal, industrial, mixed.

### STEP TWO - Choice of insulator profile

Choose the applicable SEDIVER insulator profile on the basis of string position (suspension or tension) and pollution category as indicated in Chart A.

### CHART A

| | For suspension strings (vertical or "V") | | | | For tension strings (horizontal) | | | |
|---|---|---|---|---|---|---|---|---|
| **Type of pollution** | **Standard profile** | **Fog-type profile** | **Open profile** | **Spherical profile** | **Standard profile** | **Fog-type profile** | **Open profile** | **Spherical profile** |
| **Coastal** | possible | recommended | possible | possible | recommended | possible | possible | possible |
| **Desert** | possible | recommended | recommended | possible | possible | N.R. | recommended | possible |
| **Industrial** | possible | recommended | recommended | recommended | recommended | N.R. | recommended | recommended |
| **Mixed** | N.R. | N.R. | recommended | recommended | N.R. | N.R. | recommended | possible |

**recommended** **possible** = **N.R. = not recommended**

**NOTE:** If the level of pollution is critically high and cleaning or washing operations are envisaged, it is desirable to consider the use of open profile or spherical-profile insulators which can be more effectively cleaned or washed. Ribbed insulators (fog-types or standard types) are less advisable in this case.

### STEP THREE - Determination of insulator string length

Determine the number of insulators per string by multiplying phase-to-phase voltage of line by the cm/kV level shown in following charts. Then divide by leakage distance (in cm) of insulator type chosen. Obtain string length by multiplying number of insulators by the spacing dimension of the insulator. Chart B should be used when very highly polluted areas are involved, while Chart C is applicable to less severe pollution situations.
If, for suspension strings, Chart B or C indicates alternate recommendations of two or three different profiles for the given pollution situations, the more desirable choice is the profile type which results in shortest string length. This permits reduction of structure height and cost of the line.

## CHART B - VERY HIGHLY POLLUTED AREAS

- Areas subjected to conductive dust and to industrial smoke producing particularly thick conductive deposits.
- Areas very close to the coast and exposed to salt spray or to very strong and polluting winds from the sea.
- Desert areas, characterised by no rain for long periods, exposed to strong winds carrying sand and salt, and subjected to regular condensation.

| | For suspension strings (vertical or "V") | | | For tension strings (horizontal) | | |
|---|---|---|---|---|---|---|
| | Required leakage distance (cm/kV) for indicated insulator profile | | | Required leakage distance (cm/kV) for indicated insulator profile | | |
| Type of pollution | Fog-type profile | Open profile | Spherical profile | Standard profile | Open profile | Spherical profile |
| Coastal | 3 | 2.8 | 2.8 | 2.75 | 2.7 | 2.7 |
| Desert | 3.3 | 2.5 | 2.8 | 2.75 | 2.5 | 2.7 |
| Industrial | 3 | 2.5 | 3.25 | 3 | 2.5 | 3 |
| Mixed | N.R. | 3.5 | 4 | N.R. | 3.25 | 3.75 |

## CHART C - LESS SEVERE POLLUTION SITUATIONS

- Areas with high density of industries; suburbs of large cities with high density of heating plants producing pollution.
- Areas close to the sea or exposed to relatively strong winds from the sea.

| | For suspension strings (vertical or "V") | | | For tension strings (horizontal) | | |
|---|---|---|---|---|---|---|
| | Required leakage distance (cm/kV) for indicated insulator profile | | | Required leakage distance (cm/kV) for indicated insulator profile | | |
| Type of pollution | Fog-type profile | Open profile | Spherical profile | Standard profile | Open profile | Spherical profile |
| Coastal | 2.75 | 2.5 | 2.5 | 2.5 | 2.4 | 2.5 |
| Desert | 3.25 | 2.25 | 2.5 | 2.5 | 2.25 | 2.5 |
| Industrial | 2.75 | 2.25 | 3.0 | 2.75 | 2.25 | 2.75 |
| Mixed | N.R. | 3.25 | 3.75 | N.R. | 3 | 3.5 |

### EXAMPLE OF INSULATOR SELECTION

**Conditions:**
240 kV line close to seacoast - Strong offshore wind carries salt spray to line structures. Required mechanical ratings for insulators are 160 kN (suspension) and 210 kN (tension).

**Selection:**
1. Pollution category is "COASTAL". Area is "highly polluted".
2. From Chart A, fog-type profile is recommended for suspension strings, and standard profile for tension strings.
3. From Chart B, required leakage distance for suspension string is 3 cm/kV. Total string leakage distance needed is 720 cm.
From SEDIVER Catalog TG 87, page 21, the fog-type insulator rated at 160 kN is Cat. N° F 160 P/170 (leakage distance = 54.5 cm)
720 cm ÷ 54.5 cm = 13.21.
Suspension string should therefore be 14 F 160 P/170 insulators.
4. From Chart B, required leakage distance for tension string is 2.75 cm/kV.
From Catalog TG 87, page 19, the standard profile insulator rated at 210 kN is Cat. N° F 21/170 (leakage distance = 38.0 cm).
600 cm ÷ 38.0 cm = 17.36.
Tension string should therefore be 18 F 21/170 insulators.

# SOME IMPORTANT APPLICATION PRECAUTIONS

## 1. Addition of insulators to increase string flashover

Experience has shown that the addition of clean insulators at the end of a polluted string in order to increase the insulation level often creates more problems than it solves. In fact, the resulting modification of the voltage distribution along the string can bring about flashovers. Therefore, if it is decided to lengthen the string, it is necessary to clean the existing insulators and to use insulators of the same type.

## 2. Precautions when greasing

Greasing of insulators, for the purpose of improving performance in contaminated areas, has some serious drawbacks. It is a time-consuming and expensive procedure which must be repeated once the grease becomes saturated with pollutant particles, and determination of the need for cleaning and re-greasing is difficult. In addition, certain types of greases are not suitable because decomposition occurs when they become saturated. This conditions causes formation of silica paths which favor concentration of leakage currents leading to damage of the dielectric shell.

## List of reference documents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## *SEDIVER TOUGHENED GLASS INSULATORS...*
## *IDEAL FOR CONTAMINATED AREA APPLICATIONS*

Dielectric shell profiles of optimal efficiency available for all combinations of contaminant source and weather conditions.

All shell profiles available in a broad range of mechanical strength ratings.

All component parts resist surface attack and corrosive effects.

Superior ability to endure mechanical and electrical overhead line conditions.

Mechanical strength unaffected by time and cyclic load.

## ISO certifications

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## Catalogs

- Sediver toughened glass suspension insulators
- Sediver glass and composite insulators for railway applications
- Sediver toughened glass for contaminated area applications
- Sediver toughened glass: endurance


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