# High Voltage Power Capacitors

**SCOPE**

Single phase capacitor units from 1kV up to maximum 24kV, 50 or 60Hz, 20kVAr up to maximum 1000kVAr
for indoor or outdoor use.
- with dead casing, open terminal IP00 (2 bushings)
- with dead casing, type of enclosure IP55 (2 bushings)
- with live casing, open terminal IP00 (1 bushing)

Three phase capacitor units from 1kV up to maximum 12kV, 50 or 60Hz, 20kVAr up to max. 800kVAr with pressure monitoring device.
- with dead casing (3 bushings), open terminal IP00 (indoor use only)
- with dead casing (3 bushings), protected terminals, type of enclosure IP55 (indoor or outdoor)

**STANDARDS**

- VDE 0560/4 "Bestimmungen für Leistungs-Kondensatoren"
- IEC 60871-1 Power Capacitors
- IEC 143 'Series capacitors for power systems
- AS 2897 Shunt Capacitors for connection to Power frequency systems
- ANSI IEEE Std 18 Shunt power capacitors
- NEMA CP-1 Shunt Capacitors
- CSA C22.2 No.190 'Capacitors for power factor correction
- BS 1650 Specification for Capacitors for connection to power frequency systems

Capacitors in accordance with other standards, available upon request.

**QUALITY MANAGEMENT SYSTEM**

ISO 9001, BS 5750

**QUALIFICATIONS**

- EDF (HN 54-S-05)
- CSA Std. C22.2 No 190-M1985

**SAFETY REGULATIONS**

When installing the equipment, relevant ICE or VDE recommendations shall be observed, in particular VDE 0101 and 0111, as well as VDE 0560 Part 4 Section C.

Quality management system: ISO 9001, BS 5750

Qualifications: EDF (HN 54-S-05), CSA

**FIELDS OF APPLICATION**

**POWER FACTOR CORRECTION**

The active power produced by the active current can alone be turned into an effective use for the consumer; while the reactive power produced by the reactive current does not yield usable power, and consequently, is not registered on the active performance meter. The reactive power has, however, a negative effect on generators, transformers, and conductor lines, while causing voltage drops and financial losses due to additional electric heating.

The reactive power required for the creation of the magnetic fields around motors, transformers, and conductor lines continuously oscillates between the current generators and the consumers. A more cost effective way to provide this reactive power is to produce it by placing capacitors close to the consumers of reactive power (motors, transformers), thus relieving the line between generator and consumer of the transport of the reactive current portion. This way, several more current consumers can be connected to an existing supply system without having to extend or amplify that system if the capacitors are suitably positioned.

**Individual Power Factor Correction**

The power factor correction capacitor is connected directly to the terminals of the consumer and will be switched together with it. The advantages of this method are: Relief of the conductor lines and switches, no capacitor switches or discharge resistors are needed, and the installation is simple and cheap. The individual compensation is the best solution for large consumers (e.g. motors), particularly if they are in continuous operation.

**Individual Power Factor Correction of 3-Phase Motors**

The motor and the capacitor are connected in parallel. They are both switched in and out by means of one and the same switchgear and also monitored by a common protective device. A discharge device is not required, because discharging takes place through the motor windings.

The switchgear must be rated to be capable of withstanding the inrush current of the capacitor and the connection lines must be capable of withstanding the full load current of the motor. The capacitor, in this case, has to be installed in close proximity to the motor.

**Individual Power Factor Correction of Power Transformers**

The direct connection of the capacitor to a power transformer, which is jointly switched in and out, is feasible and permissible both at the H.V. side and the L.V. side.

In cases where harmonics exist in the line, the line should be checked to determine whether the capacitors and the power transformer are connected in series and create a resonance.

Care should be taken not to overcompensate the power transformer during low load operation in order to avoid an unacceptable rise in voltage.

**Individual Power Factor Correction of Welding Machines**

The output of capacitors for welding transformers and resistance welding machines only needs to be in the range of 30% to 50% of the nominal transformer capacity. For welding rectifiers, a capacitor output of about 10% of the nominal capacity of the transformer/rectifier is sufficient.

**Group Power Factor Correction**

The power factor correction capacitor is connected to the secondary distribution system which feeds a number of individual motors, operating either continuously or at intervals.

The motors and the capacitors are each switched in and out separately and are monitored by separate protective devices. The capacitors can be switched in or out individually or in groups.


Document Number: 13107
Revision 27-May-02

### Central Power Factor Correction

In large installations where many individual electrical appliances of various size (motors etc.) operate at different times and for different periods, the power factor correction capacitors are centrally connected to the main buss bar. The capacitors can be switched either manually or, by means of power factor control relays, automatically.

### Advantage

Automatic control and optimal matching of the capacitor output to the specific requirements for reactive power insures that the specified cos phi is maintained in the most cost effective way.

### Disadvantage

The conductor lines between the buss bar and electrical appliances are not relieved of the reactive current.

## D General Data

### Dielectric

An all film dielectric is used and consists of polypropylene in the form of biaxially oriented film, hazy on both side, and in 2 or 3 layers with a laser cut aluminium foil for the electrodes.

### Impregnating Agent

The capacitors are impregnated with a NON-PCB based fluid.

### Dielectric Losses and Total Losses

Dielectric losses in new state are approx. 0.1W/kVar and reduce after 500 operating hours to a stable state of approx. 0.02 to 0.05W/kVar (see curve 1 and curve 2).

The dielectric losses, depending on capacitor design, shall be added to the losses caused by:

- discharge resistors
- internal connections
- internal fuses

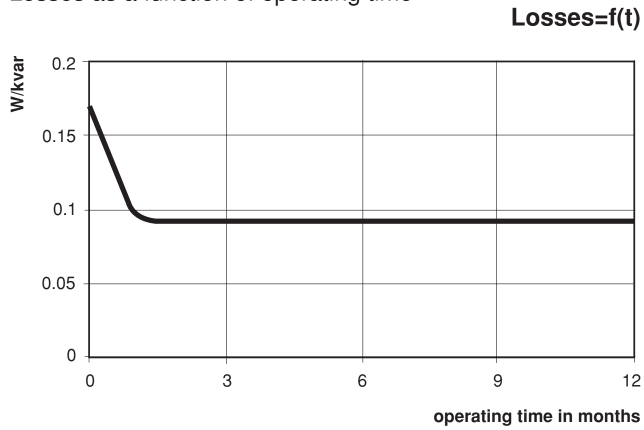
Total losses will reach values from 0.07 to approx. 0.15W/kVAr.

### Testing

Capacitors are tested in accordance with IEC-Standard 60871-1

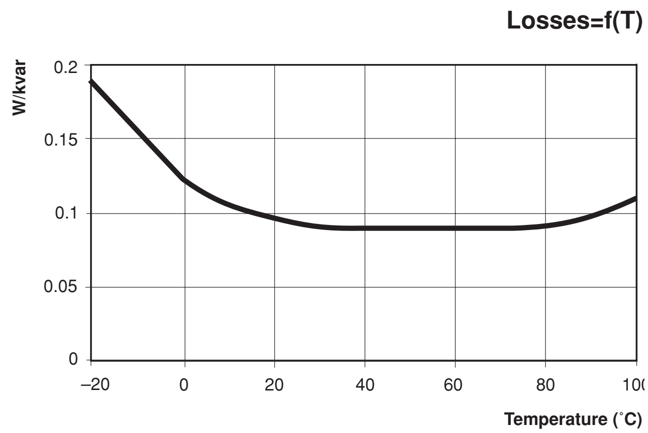
Other standards upon request.

**Curve 1**
Losses as a function of operating time

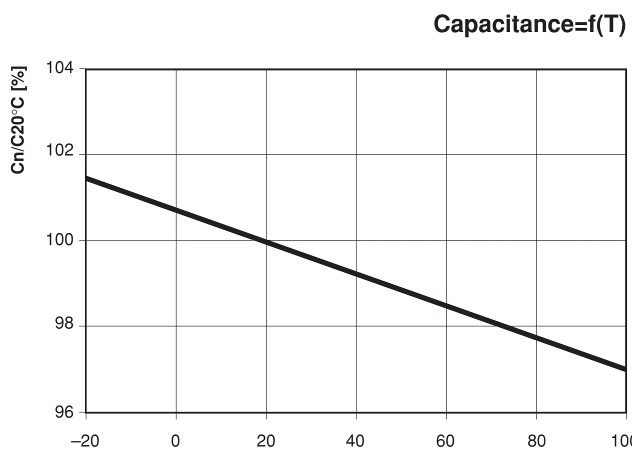



Losses variation of a representative capacitor unit

**Curve 2**
Losses as a function of dielectric temperature




**Curve 3**
Capacitance as a function dielectric temperature



**Temperature Range**

Capacitors are classified in temperature categories, with each category being specified by a number followed by a letter.

| SYMBOL | AMBIENT AIR TEMPERATURE (°C) | | |
|---|---|---|---|
| | MAXIMUM | HIGHEST MEAN OVER ANY PERIOD OF | |
| | | 24 HOURS | 1 YEAR |
| A | 40 | 30 | 20 |
| B | 45 | 35 | 25 |
| C | 50 | 40 | 30 |
| D | 55 | 45 | 35 |

The number represents the lowest ambient air temperature at which the capacitor may operate.
The letters represent upper limits of temperature variation ranges, having maximum values specified in above table.

**Overloads**

a) Maximum permissible voltage (continuous)
Capacitor units shall be suitable for operation at voltage levels according to the following table.
The amplitudes of the over voltages that may be tolerated without significant deterioration of the capacitor depend on the duration, the total number and the capacitor temperature.

| TYPE | VOLTAGE FACTOR (t.m.s) | MAXIMUM DURATION | OBSERVATION |
|---|---|---|---|
| Power frequency | $1.0U_N$ | continuous | Highest average value during any period of capacitor energization. For energization periods less than 24h, exceptions apply in accordance with the value below |
| | $1.1U_N$ | 12h in every 24h | System voltage regulation and fluctuations |
| | $1.15U_N$ | 30 min in every 24h | System voltage regulation and fluctuations |
| | $1.2U_N$ | 5 min | Voltage rise at light load |
| | $1.3U_N$ | 1 min | |

b) Maximum permissible current
Capacitor units shall be suitable for continuous operation at an r.m.s. current of 1.30 times the current that occurs at rated sinusoidal voltage and rated frequency, excluding transients.

**Discharging**

Following may be used as discharge device:
- discharge resistors
- discharge coils
- discharge transformers
- windings of motors or transformers

Each capacitor unit shall be provided with means for discharging to 75V or less.

**Corrosion Protection**

| | |
|---|---|
| Case material: | stainless steel (ref.: 4512) |
| Pre-treatment: | -pickling with acid<br>-washing with water<br>-alkalinous degreasing<br>-washing with water<br>-washing with distilled water |
| First coating: | two-component agent on polyacryl basis, (Percotex LA-Universal green) |
| Top coating: | Dedelan, two component agent on acryl-polyurethan basis (color RAL 7033) |
| Coating thickness: | total 50-60µm |

**Protection Devices for Power Capacitors**

Detailed information is provided in IEC 60871-3 “Protection of shunt capacitors and shunt capacitor banks.”

**a) Internal Fuses**

Detailed information is provided in IEC 60871-4 “Internal fuses.”

Internal fuses are designed to isolate faulty elements in order to allow further operation of the capacitor unit and the bank in which the capacitor is connected.

Complete protection is obtained when using internal fuses together with an unbalance protection device.

**b) Pressure Monitoring Device**

The pressure inside the capacitor casing is monitored by means of an over pressure sensor. In the event that the setting (critical value) is exceeded, a change-over contact initiates disconnection of the capacitor. Such an early disconnection from the source of supply after an internal breakdown can stop gas evolution in the capacitor casing, avoiding the bursting of it.

Complete protection is obtained when using the pressure monitoring device together with H.R.C. fuses.

**Technical Data**

| | |
|---|---|
| Casing: | Bakelite, resistant up to 100°C |
| Electrical connection: | AMP-plug type lugs 6.35mm |
| Contacts: | 1 change-over contact 15 A/220V ohmic load |
| Insulation test voltage: | 1500V |
| Setting range: | 0.2 - 0.9 bar |
| Standard setting: | 0.6 - 0.8 bar |
| Pressure limit: | 6.0 bar |
| Accessory: | rubber protective cap |
| Temperature range: | - 25° up to + 70°C |
| Dimension: | see dimension |
| Fitting: | R 1/4" and mechanical protection |
| Mounting position: | dependant on design of capacitor |
| Testing: | functional test and leakage test |

**Important !** **If the pressure monitoring device has operated, the capacitor must not be placed back into service, but returned together with the device to our factory for examination.**

## EXAMPLES OF MOUNTING: