High Voltage

(former Medium Voltage)

Power Factor Correction

IEC / EN 62271-1
IEC / EN 62271-200

Medium Voltage insulation levels

IEC			IEEE / ANSI		
Highest Voltage KVrms	**Power-Frequency** KVrms	**Lightning Impulse (BIL)** KVpeak	**Highest Voltage** KVrms	**Power-Frequency** KVrms	**Lightning Impulse (BIL)** KVpeak
3.6	10	20/40	2.4	15	45
7.2	20	40/60	5	19	60
12	28	60/75	8.7	26	75
17.5	38	75/95	15	34	95/110
24	50	95/125	25	40/50	125/150
36	70	145/170	34.5	70	200

BIL = Basic Insulation Level

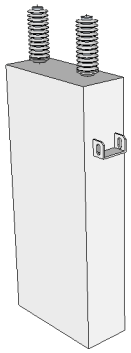
Network voltages

Voltage systems (belongs to IEC 60038 @50 Hz, belongs to IEC 60038 @60 Hz)

Insulation level [kV] (Power freq. voltage withstand [kVrms]/ Impulse voltage withstand [kV peak])	**Network voltage [V]**								
7.2 (20/60)	U_{line}	2400	3000	3300	4160	5500	6000	6300	6600
	U_{phase}	1386	1732	1905	2402	3175	3464	3637	3811
12 (28/75)	U_{line}	10000	10500	11000					
	U_{phase}	5774	6062	6351					
17.5 (38/95)	U_{line}	12000	13800	15000					
	U_{phase}	6928	7967	8660					
24 (50/125)	U_{line}	20000	22000						
	U_{phase}	11547	12702						
36 (70/170)	U_{line}	30000	31500	33000					
	U_{phase}	17321	18187	19053					

Available products

Capacitor units



CTMT

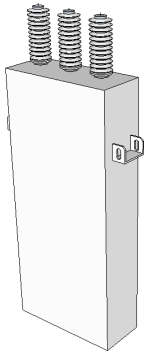
$Q_n \leq 450$ kVAr

$U_n \leq 24$ kV

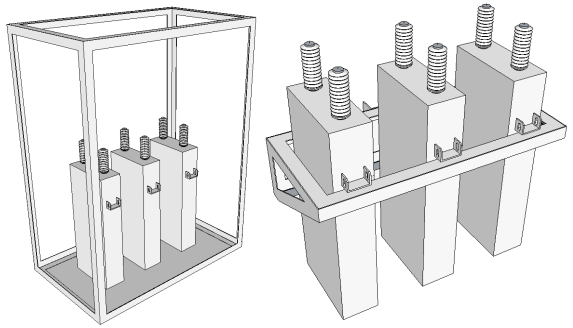
CMMT

$Q_n \leq 600$ kVAr

$U_n \leq 24$ kV

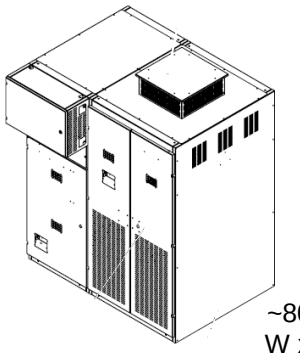


Capacitor banks (BMT)



Capacitor installations (MVcells)

1 stage

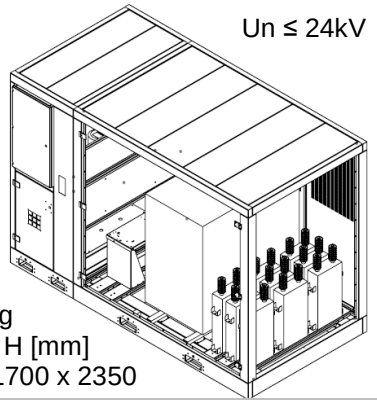


Power factor correction of motors

Un ≤ 12kV

~800 .. 1400 kg
W x D x H [mm]
1700 x 1150 x 2200

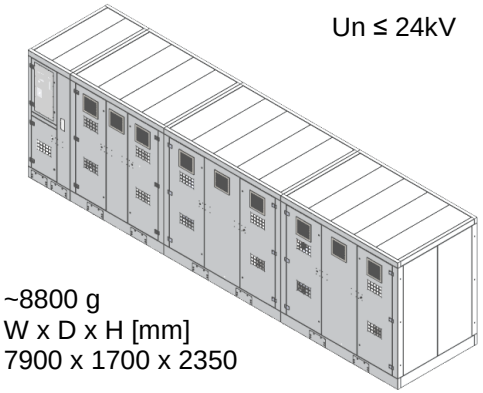
inlet + 1 stage



Un ≤ 24kV

~4000 kg
W x D x H [mm]
3800 x 1700 x 2350

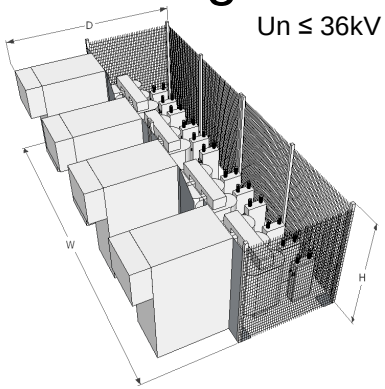
inlet + 3 stages



Un ≤ 24kV

~8800 g
W x D x H [mm]
7900 x 1700 x 2350

4 stages

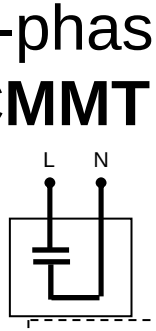


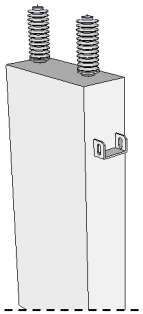
Un ≤ 36kV

Capacitor units

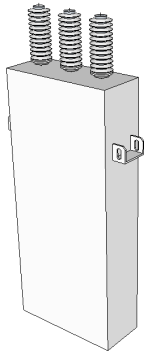
according to IEC 60871-1

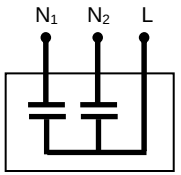
1-phase **CMMT**



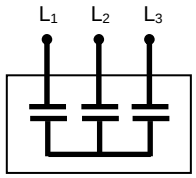


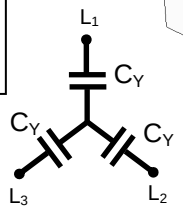
1-phase twin **CGMT**

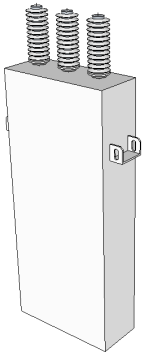




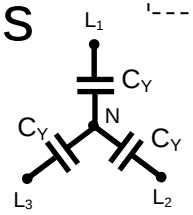
3-phase **CTMT**

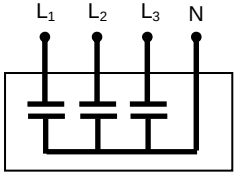




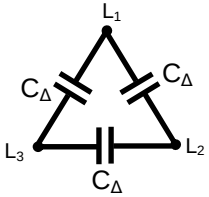


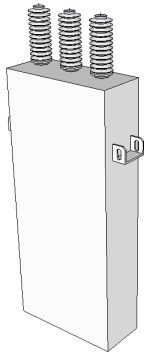
3-phase 4 bushings **CNMT**



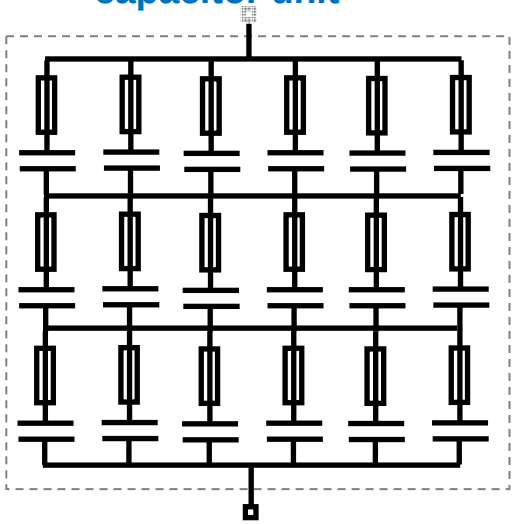


3-phase

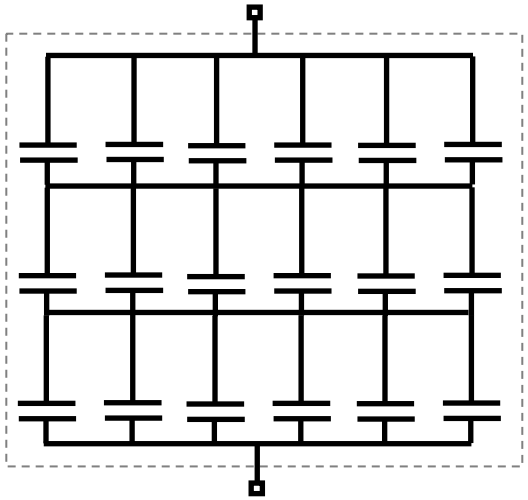




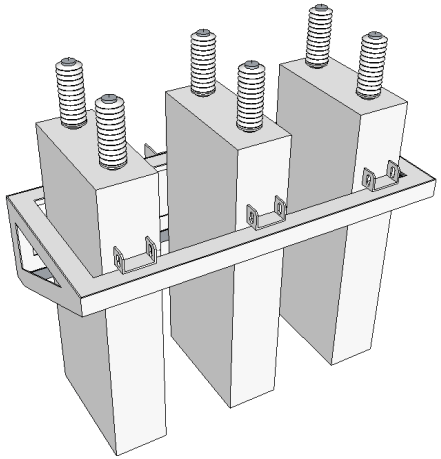
Internally fused 1-phase capacitor unit

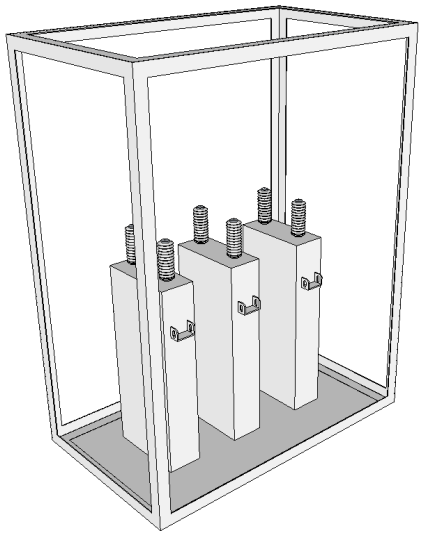


1-phase capacitor unit without internal fuses



Capacitor banks (BMT)



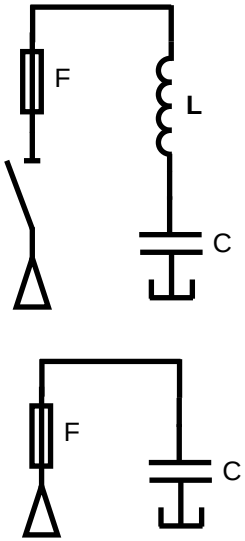


Indoor / Outdoor
Floor mounting (metallic cage IP00)

Outdoor
Pole mounting (metallic bracket IP00)

Accessories:

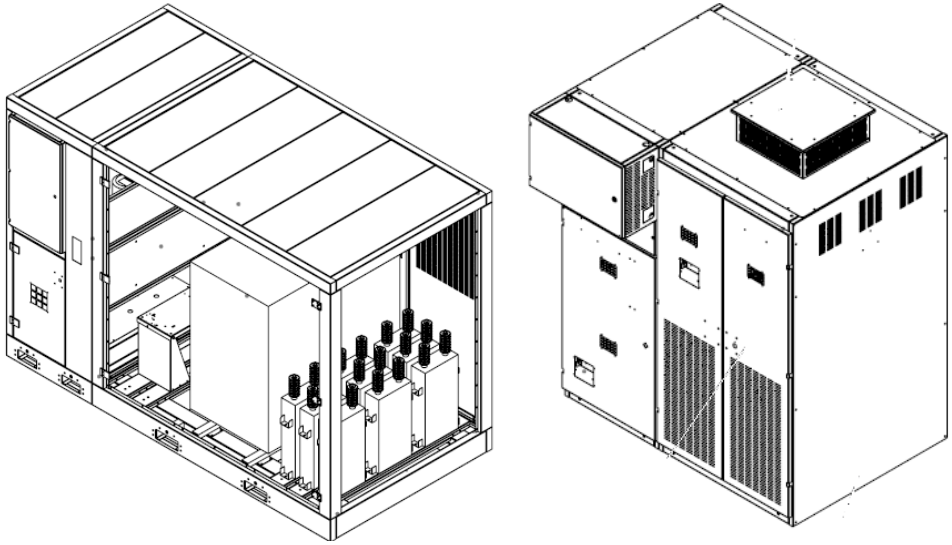
- **inrush reactors**
- **expulsion fuses**
- **fuse cut-outs (expulsion fuses)**



Capacitor stages

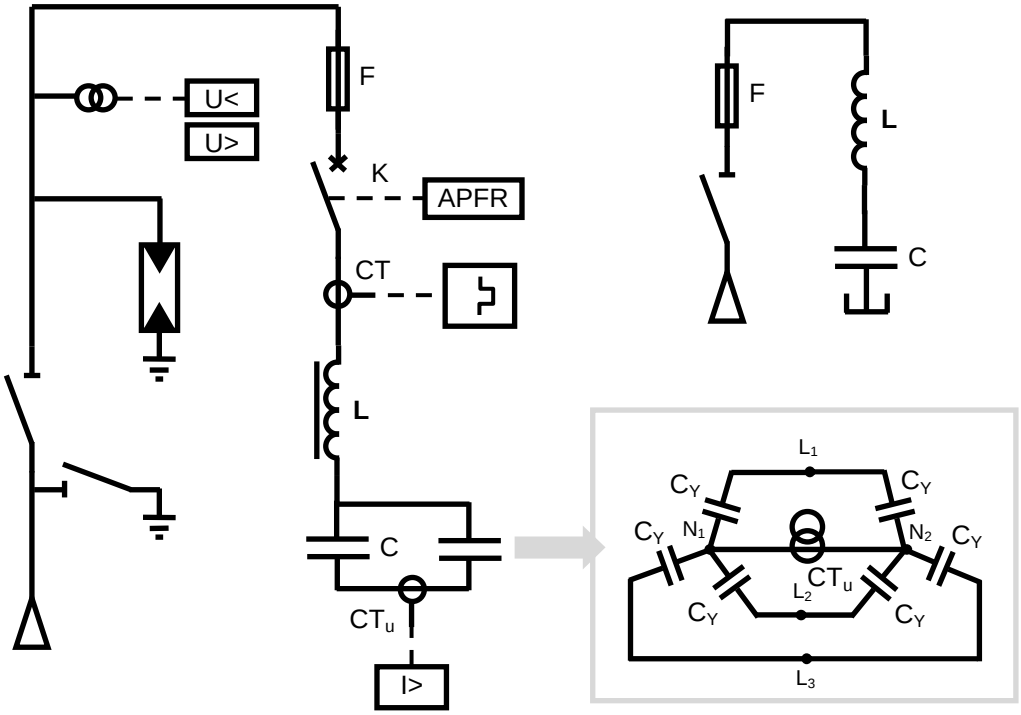
Indoor

Metallic enclosure IP3X



Options:

- **outdoor (IP41, IP54)**
- **inrush reactors or detuned reactors (189Hz)**
- **surge arrester**
- **overcurrent protection**
- **double Y connection, with unbalance protection**
- **infrared inspection window**
- **smoke detector**



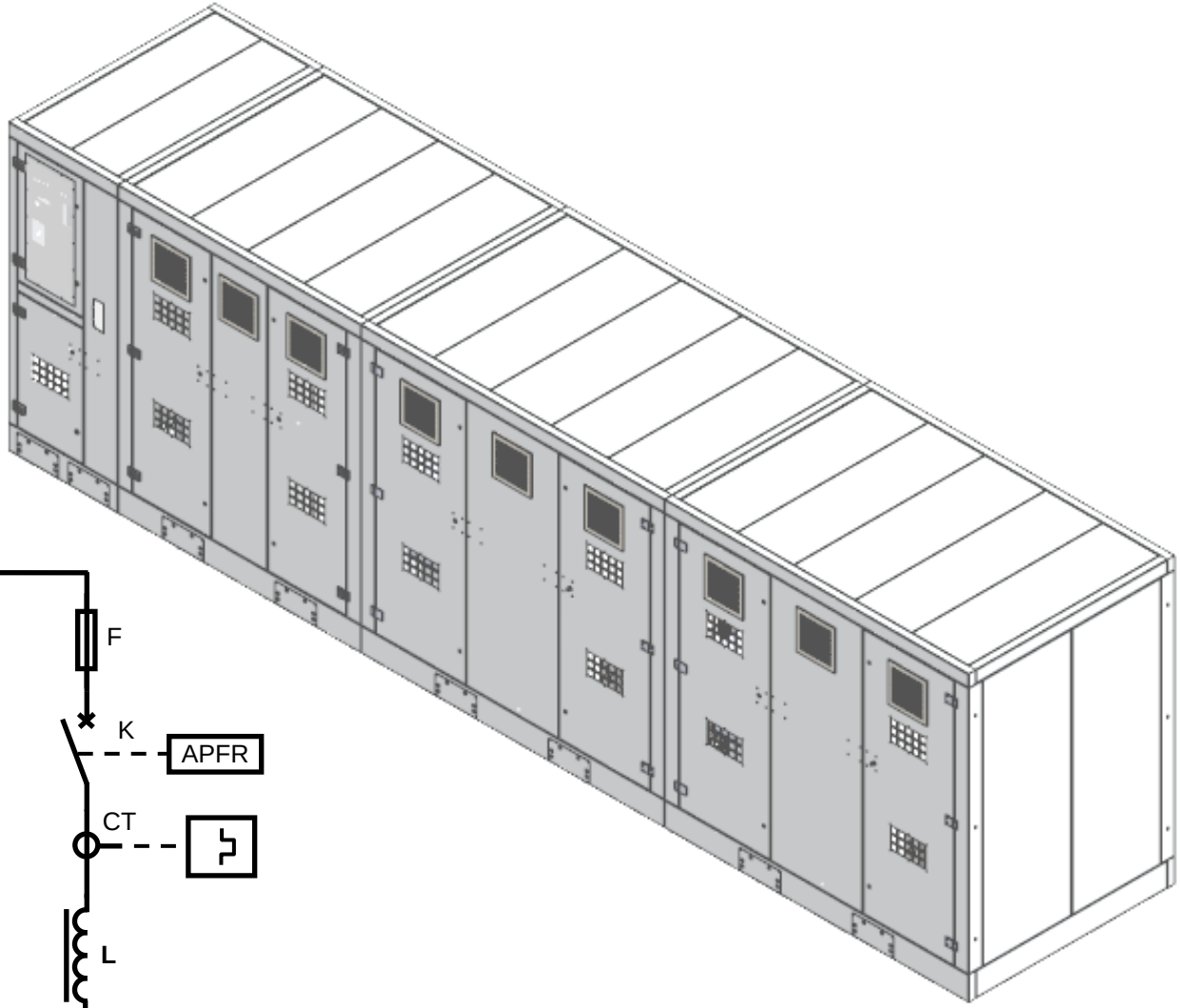
Capacitor installations

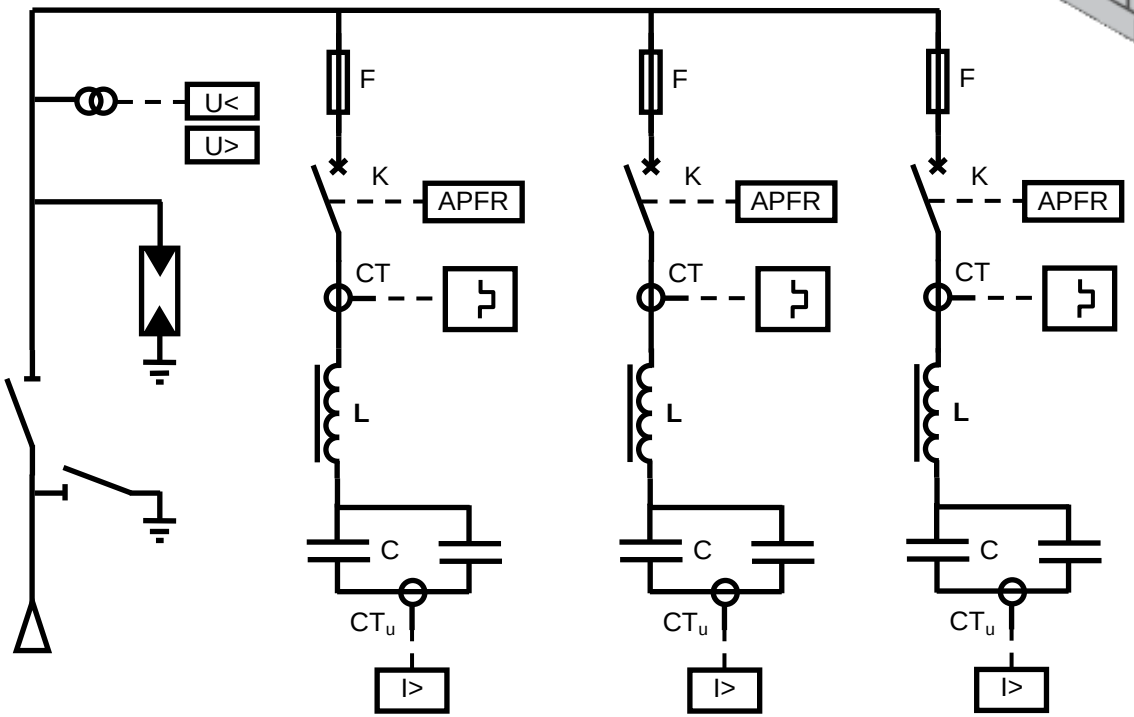
Indoor / Outdoor

Metallic enclosure IP3X

Example:

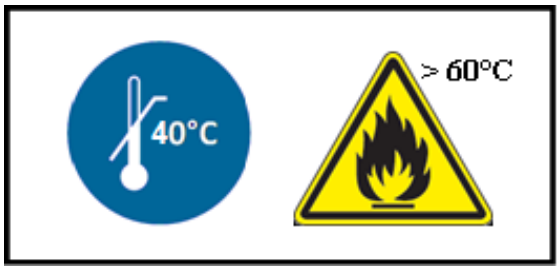
- 3 stages installation
- $12 < U_n \leq 24kV$



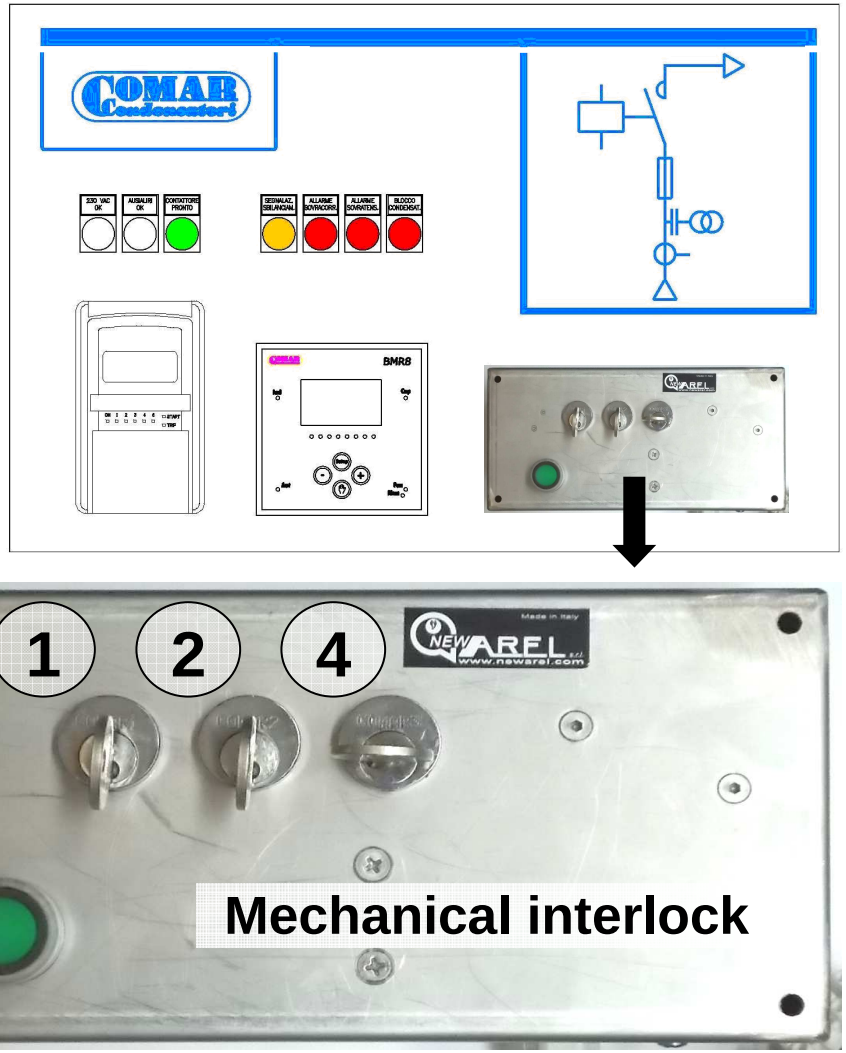


Control panel

Pictograms present on the front

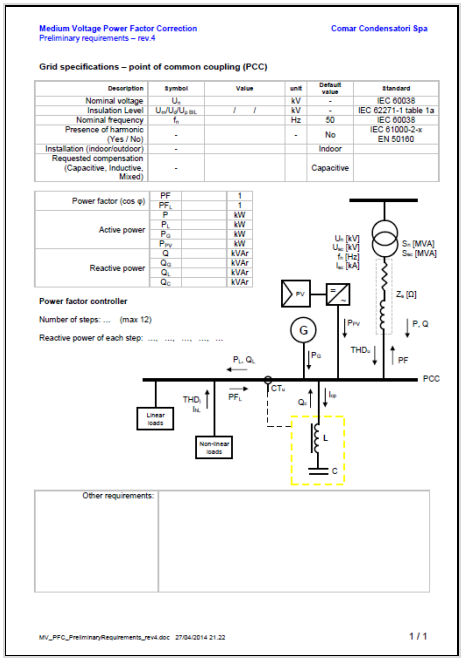


… on the eyebolts



Defining the technical specifications of a Power Factor Correction system

1. **evaluate the necessary reactive power**
2. **resonance risk analysis**
3. **harmonics forecast / measurement**
4. **gather all the other necessary information** (see enclosures)


Medium Voltage Power Factor Correction
Preliminary requirements – rev.4

Comar Condensatori Spa

Grid specifications – point of common coupling (PCC)

Description	Symbol	Value	unit	Default value	Standard
Nominal voltage	U_n		kV	-	IEC 60038
Insulation Level	$U_m/U_{d\ BIL}$	/ /	kV	-	IEC 62271-1 table 1a
Nominal frequency	f_n		Hz	50	IEC 60038
Presence of harmonic (Yes / No)	-		-	No	IEC 61000-2-x EN 50160
Installation (indoor/outdoor)	-			Indoor	
Requested compensation (Capacitive, Inductive, Mixed)	-			Capacitive	

Power factor (cos φ)	PF		1
Active power	P		kW
	P_n		kW
	P_{n1}		kW
	P_{PV}		kW
Reactive power	Q		kVAr
	Q_{n1}		kVAr
	Q_n		kVAr
	Q_C		kVAr

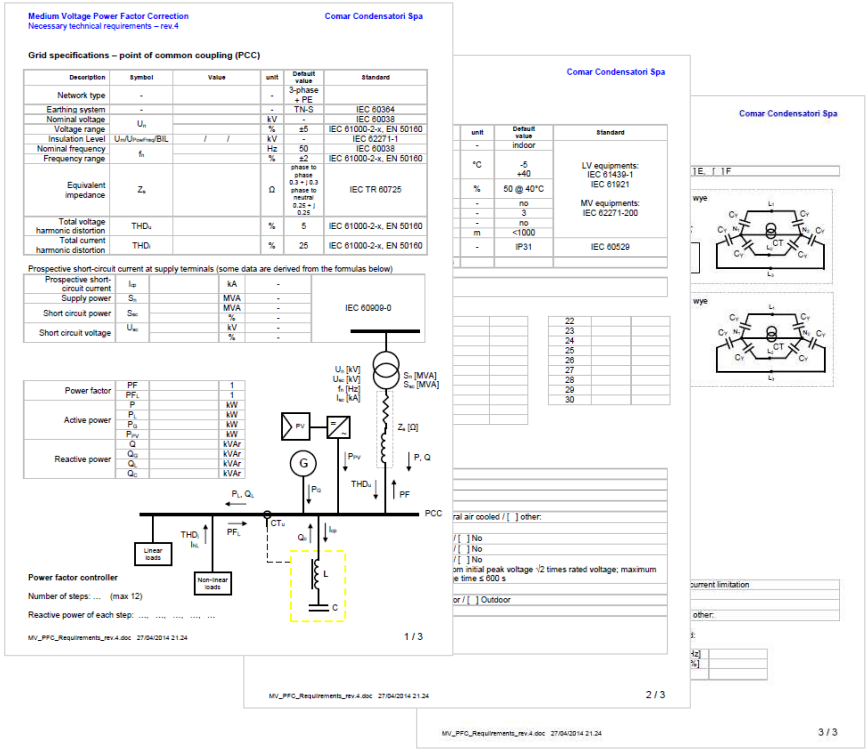
Power factor controller

Number of steps: ... (max 12)

Reactive power of each step: ..., ..., ..., ..., ...

Other requirements:

MV_PFC_PreliminaryRequirements_rev4.doc 27/04/2014 21.22 1 / 1


Medium Voltage Power Factor Correction
Necessary technical requirements – rev.4

Comar Condensatori Spa

Grid specifications – point of common coupling (PCC)

Description	Symbol	Value	unit	Default value	Standard
Network type	-		-	3-phase + PE	
Earthing system	-		-	TN-S	IEC 60364
Nominal voltage	U_n		kV	-	IEC 60038
Voltage range			%	±5	IEC 61000-2-x, EN 50160
Insulation Level	$U_m/U_{Impulse}$/BIL	/ /	kV	-	IEC 62271-1
Nominal frequency	f_n		Hz	50	IEC 60038
Frequency range			%	±2	IEC 61000-2-x, EN 50160
Equivalent impedance	Z_e		Ω	phase to phase 0.3 + j 0.3 phase to neutral 0.26 + j 0.23	IEC TR 60725
Total voltage harmonic distortion	THD_U		%	5	IEC 61000-2-x, EN 50160
Total current harmonic distortion	THD_I		%	25	IEC 61000-2-x, EN 50160

Prospective short-circuit current at supply terminals (some data are derived from the formulas below)

Prospective short-circuit current	I_{sc}		kA	-
Supply power	S_n		MVA	-
Short circuit power	S_{sc}		MVA	-
Short circuit voltage	U_{sc}		%	-
			kV	-
			%	-

IEC 60909-0

Power factor	PF		1
	PF_1		1
Active power	P		kW
	P_n		kW
	P_{n1}		kW
	P_{PV}		kW
Reactive power	Q		kVAr
	Q_{n1}		kVAr
	Q_n		kVAr
	Q_C		kVAr

Power factor controller

Number of steps: ... (max 12)

Reactive power of each step: ..., ..., ..., ..., ...

MV_PFC_Requirements_rev.4.doc 27/04/2014 21.24 1 / 3

Comar Condensatori Spa

unit	Default value	Standard
-	indoor	
°C	-5 +40	LV equipments: IEC 61439-1 IEC 61921
%	50 @ 40°C	
-	no	MV equipments: IEC 62271-200
-	3	
-	no	
m	<1000	
-	IP31	IEC 60529

22 23 24 25 26 27 28 29 30

ral air cooled / [ ] other:

[ ] No
[ ] No
[ ] No

om initial peak voltage √2 times rated voltage; maximum
e time ≤ 600 s

or / [ ] Outdoor

MV_PFC_Requirements_rev.4.doc 27/04/2014 21.24 2 / 3

Comar Condensatori Spa

1E, [ ] F

wye

wye

urrent limitation

other:

MV_PFC_Requirements_rev.4.doc 27/04/2014 21.24 3 / 3

5. **send an enquiry to Comar Condensatori Spa**

Safety devices to protect the capacitor installation

Inside the capacitor unit

- **Fuse on each capacitor element**
- **Pressure switch**

Inside each capacitor stage

- **Overcurrent protection (1 protection relay + 3 Current Transformers)**
- **Current Unbalance protection (YY configuration + 1 protection relay + 1 Current Transformer)**
- **Detuned reactor**
- **Over-temperature alarm**

In the inlet stage of the capacitor installation

- **Overvoltage protection**

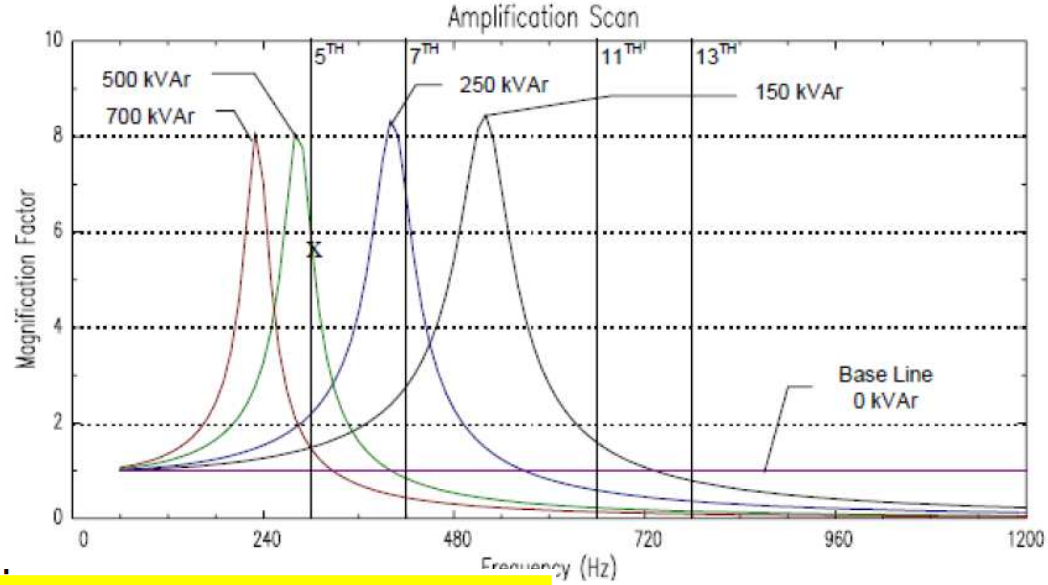
Outside the capacitor installation

- **Smoke detector and Over-temperature alarm connected to the fire protection system**
- **Upstream Residual Current Device**

Risk of resonance with the upstream transformer

P_{SC} Short circuit power at insertion point
Q_C Reactive power of the capacitor bank
X_C Capacitor reactance @ f_1
X_{SC} Transformer reactance at short circuit
P_{tr} transformer power
Z_{tr} transformer impedance %
$f_r = h_r f_1$

$$h_r = \sqrt{\frac{X_C}{X_{SC}}} = \sqrt{\frac{P_{SC}}{Q_C}} \approx \sqrt{\frac{1}{Q_C} \cdot \frac{P_{tr}}{\frac{Z_{tr}\%}{100}}}$$



The risk is present when:

$$h_r - 0.2 < \sqrt{\frac{1}{Q_C} \cdot \frac{P_{tr}}{\frac{Z_{tr}\%}{100}}} < h_r + 0.2$$