The development of capacitors for fluorescent and discharge lamps

Foreword.

During the last twenty years the push of the market for continuous cost reductions, both in lamps, ballast and other components has modified the "ambient" inside the fixtures. New types of lamps (vapours of mercury, metallic halides, ..) and starters, smaller ballast and smaller capacitors, have sharply reduced the cost of the whole assembly, nevertheless increasing temperatures, overvoltages and voltage spikes on the capacitors.

The mains has been too even more and more "polluted" during the eighties and nineties by the growing diffusion of UPS and other electronically driven power supplies. These systems "inject" into the mains harmonics of current which induce higher currents and voltages across the capacitors that are connected in parallel to the mains itself.

As it usually happens, the updating of the relevant standards has been slower than the evolving ambient had requested.
All these facts have induced in the field, at the beginning of the nineties, some failures of capacitors, with consequent damages to fixtures and the surrounding.

As soon as the capacitor manufacturers realised this dangerous distance between the new ambient requirements versus the existing standards and the capacitor technology, they reacted both modifying their products and agreeing to revise international standards.
So the international standard for capacitors for fluorescent lamps, IEC publication 61048, has been recently revised (Amendment 2, 1999) stating much more stringent requirements, taking in strong account the information coming from the application.

Development of capacitors.

Serie 4.16.34, while maintaining the patented overpressure safety device together with a case material with a high degree of fire resistance, has been redesigned to use a thicker dielectric film with a metallized layer that is highly resistant to ambient humidity.
The manufacturing process has been improved, both in curing temperature and in high current tests.
These types fit completely the requirements of the application in fluorescent and high-pressure mercury lamps together with those of the new IEC standards.

Series 4.16.31, using the same dielectric film and processes as 4.16.34 and 4.16.35, has been specially designed for use in parallel compensation of halide and high pressure sodium lamps, where the working conditions may be heavier, and higher the risk of dangerous end-of-life failures.
A metal can together with the patented "Floppy Cap" overpressure safety device, with a top-high reliability tested by tenth of millions of capacitors sold in the market without failures, grant the highest safety level to the user.

Saving energy is becoming more and more important.
The challenge of energy savings lies in finding the best way to make the most of the energy at our disposal: indeed, cutting waste represents the best energy source, as it means enjoying the same benefits while consuming less.

Energy analyzers also make it possible to keep the problem of harmonic pollution under close control. In particular, the SIM50 is capable of measuring the harmonic components of voltage and current from 0 to 49°. Moreover, it allows us to identify the direction and thus determine whether they are generated or imported in relation to the point of measurement. This is very important because harmonic pollution may spread throughout the network and in our own line we can find harmonics produced by others. Knowing the actual extent of harmonic pollution also enables us to identify which kind of power-factor correction system will best guarantee high efficiency and a long life.

In general, all analyzers

measure the True Effective Value, so the reading also takes into account the effects of harmonic pollution. The sectioning and protective devices installed on electric control boards may thus be dimensioned accordingly.

The need to reduce both energy costs and the risks associated with harmonics in the network today makes the synergy of these products increasingly valuable.

In fact, an accurate analysis of energy use and the application of industrial power-factor correction equipment brings us further toward the goal of optimizing and reducing energy consumption.

The range of measuring instruments includes both board analyzers and portable analyzers.

MACH

Panel energy analyzers

MACH 30

SMART 96

SMART Più

DAT Più

SIM 50

Portable energy analyzers

SIM 50

General information

All gas-discharge lamps (fluorescent tubes and bulbs, mercury vapour, sodium vapour lamps and similar types) require a reactor or transformer to switch them on, and to limit the arc current to the preset value. Since this reactor constitutes an inductive load, it causes an increase in the resulting current and a reduction in the power factor to cosφ = 0.5. The necessary correction of the power factor to cosφ = 0.9 is achieved by adding a capacitor of suitable capacitance to the circuit. The capacitor may be used for power factor correction using two installation systems:

a) power factor correction with capacitor shunt-connected to the power supply line: "parallel compensation".

b) power factor correction with capacitor connected in series on the power supply line: "series compensation".

Both types of power factor correction require the capacitor to provide constant service in heavy-duty conditions because of the high operating temperature (caused by the nearness of the power supply and the poor cooling inside ceiling lights).

Power factor correction of fluorescent lamps

"Parallel" compensation.

This is the type of power factor correction most generally used. The capacitor is shunt-connected to the power supply line, and may be for a single lamp (fig. 1), for 2 lamps connected in series (fig. 2) or centralized for a group of lamps. The capacitors used generally have tolerance on the rated capacity of ±10%, operating voltage 250 V, and a temperature range of -25+85°C, up to 100°C for some applications.

"Series" compensation.

The capacitors used in "series" compensation generally have narrower tolerance on the rated capacity (±4%), an operating voltage higher than that of the mains (420-440 V) and a temperature range of -25+85°C, up to 100°C for some applications. It must also be considered that at switch-on voltage transients may occur on the capacitor; their size depends on the type of lamp and they must be considered when selecting the capacitor.

"Series" compensation is today less and less used.

Table 1 shows the capacitance values obtained by the manufacturers of lamps and reactors for the power factor correction of fluorescent lamps; these are guideline values which must be confirmed by the suppliers of reactors.

It must also be remembered that since the capacitor may remain charged for a long period after the lamp has been switched off, each capacitor must be fitted with a discharge resistor. According to regulations, the resistance value must be such as to ensure that after the circuit is broken the capacitor discharges in 1 minute from the rated voltage to a residual tension ≤ 50 V.

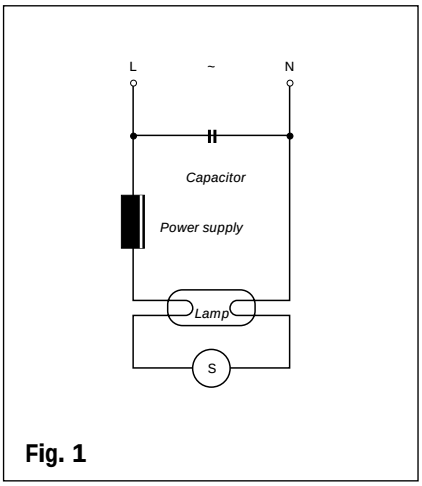


Fig. 1

Parallel compensation on a single lamp

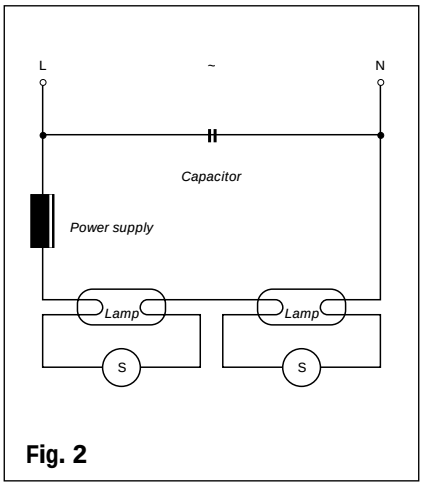


Fig. 2

Parallel compensation on lamps connected in series

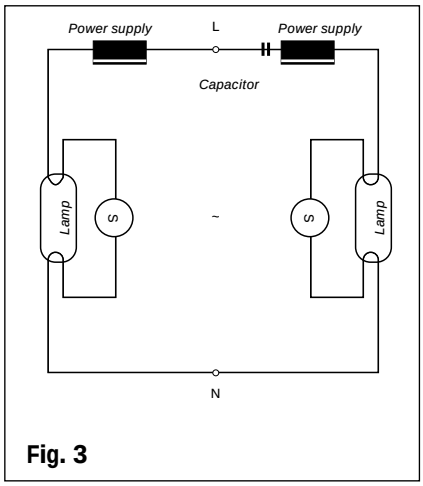


Fig. 3

Series compensation on "dual" circuit with two lamps

Tab. 1

Capacitance required to correct the power factor of fluorescent lamps to cosφ = 0,9 with mains voltage 220 V ~50Hz.

Lamp power W	*Capacitance for parallel connection µF*	*Capacitance for series connection µF*
4÷13	2	—
15	4,5	2,6 420 V
2x15	4,5	—
16	2,5	1,7 420 V
18	4,5	2,9 440 V
2x18	4,5	—
20	4,5	2,9 440 V
2x20	4,5	—
22	5	3,2 440 V
25	3,5	3 420 V
30	4,5	3 420 V

Lamp power W	*Capacitance for parallel connection µF*	*Capacitance for series connection µF*
32	5	3,6 420 V
36	4,5	3,6 420 V
40	4,5	3,6 420 V
58	7	5,7 420 V
65	7	5,7 420 V
65	9	6,8 440 V
80	10	7,2 440 V
115	18	12,2 440 V
140	18	12,7 440 V

Power factor correction of mercury vapour, sodium vapour and metal iodide lamps

On these types of lamp the power factor (generally 0.5-0.6, and 0.3 for sodium vapour lamps) is always corrected using a parallel-connected capacitor.

Table 2, 3, 4 and 5 show guideline values obtained from manufacturers of lamps and reactors for correction of the power factor to cosφ 0.9.

Tab. 2

Mercury vapour lamps

Lamp Power W	*Capacitance* µF
50	7
80	8
125	10
250	18
400	25
700	40
1000	60

Tab. 3

High-pressure sodium vapour lamps.

Lamp Power W	*Capacitance* µF
35	6
50	8
70	12
100	12
125	18
150	20
250	36
400	45
1000	100

Tab. 4

Low-pressure sodium vapour lamps.

Lamp Power W	*Capacitance* µF
18	5
35	20
55	20
90	30
135	45
180	40

Tab. 5

Metal iodide lamps.

Lamp Power W	*Capacitance* µF
35	6
70	12
150	20
250	32
400	45
1000	85
2000 380 V	60 380 V
3500 380 V	100 380 V

Electrical specifications and definitions

Rated voltage Vn
The rms value of the sinusoidal AC voltage which can be applied to the capacitor in normal working conditions.

Rated current In
The value of the current flowing through the capacitor of rated capacitance at the rated voltage and frequency.

Duty frequency range
The capacitors can be used at a frequency range of 50-60 Hz. Use at higher frequencies is possible provided the voltage, current, temperature and power limits are complied with.

Operating temperature class
Minimum temperature -25°C
Maximum temperature +85°C
In accordance with the reference standards, the temperatures are those measured on the surface on the capacitor.

Storage temperature
-40°... + 85°C

Capacitance tolerance
Rated tolerances ±5%, ±10%.
Different tolerance values are available on request.

Loss angle tanδ
It is the ratio between the power absorbed by the capacitor and its reactive power.
The value of the tangent of the loss factor measured at 50 Hz, 20°C at the rated voltage is:

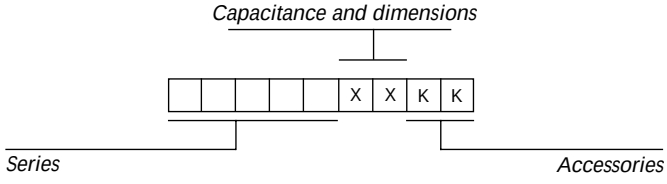
$\tan\delta \leq 20 \cdot 10^{-4}$

Pulsed stress
The capacitors are capable of withstanding steep wavefronts with a maximum voltage variation speed of 20 V/µs (dv/dt).

Insulation resistance between terminals and case
Measured at 500 Vdc, 20°C after 30 seconds.

Ri > 1000 Mohm.

Part number composition



Operating safety

The very widescale use in all sectors of fluorescent lamps implies particular care over safety requirements.

Any malfunction on the lighting elements in public or private premises could have unexpected consequences and it is not always easy to trace the cause of the accident. For this reason, it is necessary to have light fittings constructed by highly skilled companies capable of guaranteeing maximum safety.

International regulations also impose this obligation for capacitors, in order to avoid the risk of explosion or fire which could occur in case of especially critical operating conditions or at the end of the working life.

In particular, the ***EN 61048*** completely revised into the second edition of November 2000 ***and 61049 norms*** *"Capacitors for use in tubular fluorescent and other discharge lamp circuits - are in force in all European countries which are members of CENELEC (EC plus EFTA) since 1993.* ***These there-fore becomes the first harmonized European standard in the field of capacitors.***

This Norm requires capacitors to pass a specific Destruction Test intended to ensure that "Capacitors shall have adequate resistance against destructive failures").

The "LUM Agreement" has been in force all over Europe since March 1995; it set up the ENEC mark which remplaces and includes all previous national marks (IMQ, BSI, VDE, and so on) for lamps components complyng with the relevant European harmonized regulations.

The capacitors described in this catalogue have been tested and certified by the above - mentioned standard and are marked ENEC.

It has developed two classes of power factor correction capacitors for fluorescent and discharge lamps:

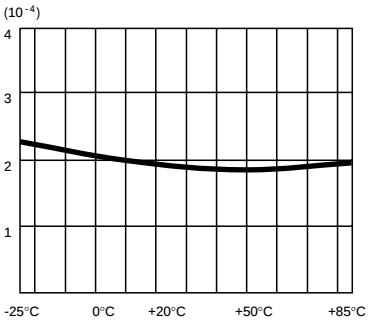
a. *"Standard" capacitors, Series 416.34/04*
   To be used preferably on fluorescent lamps, in the following conditions:
   - *Voltage: ≤ 250 V~;*
   - *Currents with a limited harmonic content, with a total value up to I=1,3 I_N;*
   - *Ambient humidity: standard for temperature countries, 21 days category, according to IEC 68-2-3.*

b. *"Heavy Duty" capacitors, Series 416.31 for parallel compensation.*
   To be used preferably on high intensity discharge lamps (vapours of sodium or mercury, metallic halides, etc) where the conditions can be as follows:
   - *Voltage up to 280 V~;*
   - *Currents with harmonic contents, with a total value up to I=1,5 I_N;*
   - *Ambient temperature up to 85°C, stable;*
   - *Ambient humidity up to "tropical" level, 56 days category, according to IEC 68-2-3.*

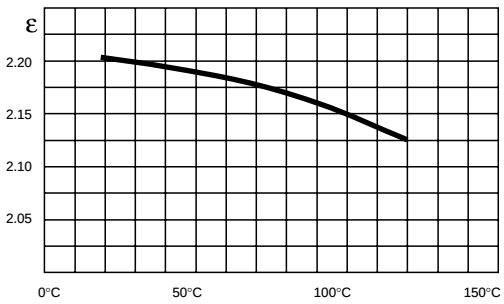
c. *Capacitors series 416.29 metallic case for series compensation.*

Typical performance of electrical characteristics of metallized polypropylene film vs. temperature

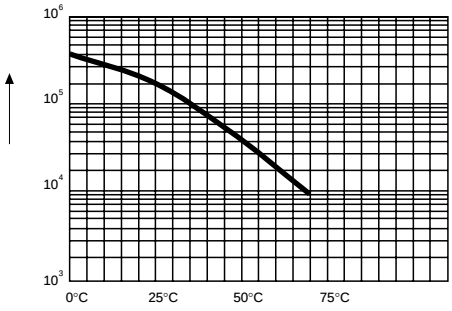
Dissipation factor



Dielectric constant



Insulation resistance

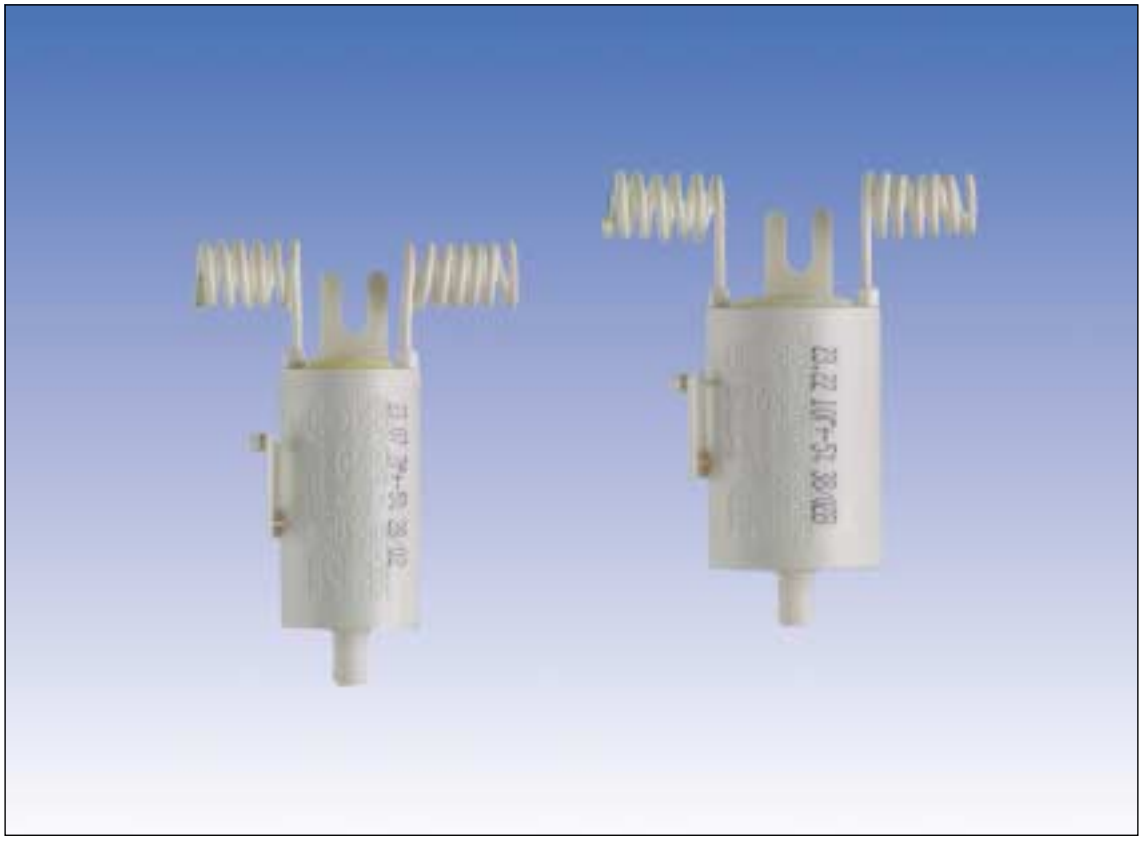


QUALITY

The great attention to the product quality and to the customer service are constant and these are main factors which contribute to its success all over the world.

Capacitor division,
as described in Quality Manual, has been one of the first in Italy (1991), to be approved by BSI according to ISO 9002 procedures (EN 29000). On 31/7/96 the certification has been completed according to ISO 9001 by CSQ .
All is granted thanks to fully automated and integrated processes, to completely new and innovative machines and technologies, to methodologies of the productive process control based on accurate specifications and on responsible operator.

Plastic case capacitors with overpressure safety device series 4.16.23



Descriptive information

Capacitors of this series are particularly suitable for parallel compensation of discharge lamps.
Dielectric consists of self-healing polypropylene film, case and cover are made of self-extinguishing and ultraviolet rays resistant thermoplastic material. An high safety capacitor realized with an original mechanical solution allowing the maximum efficiency in assembling and wiring.

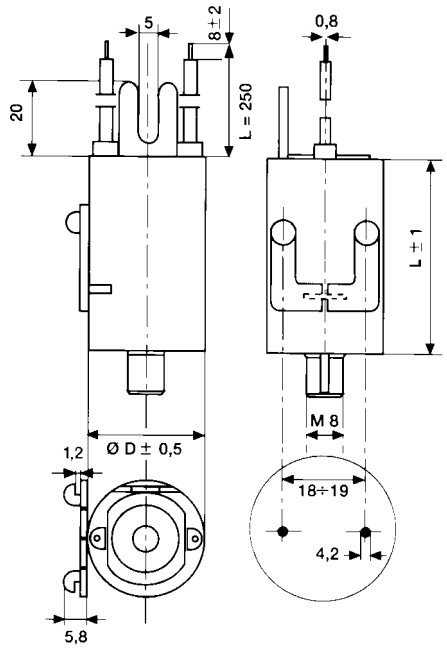
The capacitors of this series are available in the following models: insulated solid copper wire-lead.
Fixing device: M8 stud - Clamp - Captive Feet for roof lamps.
Capacitors are fitted with internal discharge resistor.

Overpressure safety device

The device which uses to guarantee the safety of series 416.23 capacitors is the system, patented in many countries, based on che use of a highly pressure-sensitive elastic mem brane.
A stable short-circuit inside the dielectric quickly causes it to dissociate, thus generating gas inside the capacitor. Before the pressure may cause the explosion of the capacitor, the membrane "bulges", taking with it the terminal connected lo the capacitor's upper electrode and breaking the electric circuit.

TECHNICAL CHARACTERISTICS

Rated voltage	*: 250 V~ -50/60Hz*
	280V~ -50Hz
Working temperature	*: -25...+85°C*
Dissipation factor	*: tan δ ≤ 20·10⁻⁴ @*
	20° C V =Vn, 50 Hz
Discharge resistor	*: 1 MW*
Test voltage	*: Between terminals*
	: 2,15 Un for 2 sec.
Between terminal and case	*: 2 kV for 60 sec. (type test)*
Approvals	*:*
Reference standards	*: EN 61048 /A1/A2*
	type B - EN 61049
Protection	*: Case in self.extinguishing*
	plastic material
Terminals	*: Unipolar rigid leads insulated in PVC*
	90°C 0.5 mm˜ L = 250 mm
Mounting devices	*: M8 stud, clamp, captive feet*
Capacitance tolerance	*: ± 5 % - ± 10%*



Drilling dimensions for fixing feet.

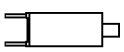
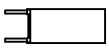
416.23

Capacitance tolerance µF	D x L mm	*Part number* 416.23.xx.kk	*Packages n. pcs x box* •
2 ± 5%	28 x 52	4.16.23.01.kk	250
2,5 »	»	» .08..	»
3,5 »	»	» .10..	»
4 »	»	» .02..	»
4,5 »	»	» .03..	»
5 »	»	» .04..	»
5,5 »	»	» .28..	»
6 »	»	» .05..	»
6,3 »	»	» .06..	»
7 »	»	» .07..	»
8 »	35 x 52	» .20..	200
8,4 »	»	» .27..	»
9 »	»	» .21..	»
10 »	»	» .22..	»
12 »	»	» .26..	»
12,5 »	»	» .23..	»
14 »	»	» .24..	»
15 »	»	» .29..	»
16 ± 10%	»	» .25..	»

• *Weight* 8 ÷ 10 Kg.
Standard box dim. 270x390x330 mm

Fig. 1.*Unipolar rigid leads solution for Ø 28 and Ø 35 with clamp, captive feet and stud. Should the safety device operate, the membrane bulges out up to 6 mm. KEEP FREE THAT DISTANCE BY THE SIDE OF TERMINALS.*

Accessories (kk)

Stud		.42
Captive feet		.43
Clamps, captive feet, stud		.47
Plain case		.07

Standard length leads 250 mm: on request are available different lengths leads.

Capacitors series 4.16.04
plastic case

The dielectric is polypropylene film, the electrodes consist of an extremely thin metal coating obtained by vacuum evaporation.
Case and cover are made with self-extinguishing plastic material, the capacitive element is sealed with polyurethanic resin.

The main characteristics of these capacitors are

- *Low losses non-inductive winding*
- *Self-healing property avoiding short circuits*
- *Small size and limited weight*
- *Dry tecnology no leakage risk.*

Safety

We know that short-circuits may result from two causes either individually or in combination: high overvoltages or excessively high temperatures.
The two conditions affect each other: a high overvoltage produces a high overcurrent, overheating of the internal connections, and thus also an increase in the capacitor temperature. On the other hand, a high temperature leads to rapid ageing and deterioration of the dielectric, reducing its rigidity (the voltage threshold at which perforation occurs). The capacitors is rated so that it will not reach even just one of the two risk conditions or a combination of them.

Series 4.16.04

TECHNICAL CHARACTERISTICS

Rated voltage	*: 250 V~ - 50/60 Hz*
	280 V~ - 50 Hz
Working temperature	*: –25... +85°C*
Dissipation factor	*: tanδ ≤ 20•10⁻⁴ (20°C, Vn, 50 Hz)*
Discharge resistor	*: 1 MΩ ≤ 22 µF*
	300 KΩ 25 ÷ 70 µF
	220 KΩ 80 ÷ 100 µF
Test voltage	*: Between terminals: 2,15 Un for 2 sec.*
	between terminal and case: 2 kV
	for 60 sec. (type test)
Approvals	*:*
Reference standards	*: EN 61048/A1/A2*
	type A - EN 61049
Protection	*: Case and cover in*
	self-estinguishing plastic material
Terminals	*: Plug-in terminals 2.8 mm²*
	Insulated solid core
	leads in PVC 90°C 0.5 mm² - push
	wire connection
Protection degree	*: IP00*

Standard values **4.16.04**

With integrated push wire					*With 2,8 mm tags and leads*			
Capacità µF	Cod. 4.16.04.xx.kk	Dim. DxH	*Packages n. pcs x box = =*	D∆	Dim. DxH	Cod. 4.16.04.xx.kk	*Packages n. pcs x box =*	D∆
2	4.16.04.07.kk	25x50	250	B				
2,5	.08.	»	»	»				
3	.09.	»	»	»				
3,15	.10.	»	»	»				
3,5	.11.	25x55	»	»				
4	.12.	»	»	»				
4,5	.32.	25x70"	200	B				
5	.40.	»	»	»				
6	.33.	»	»	»				
6,3	.34.	»	»	»				
7	.41.	30x70	125	A				
8	.35.	»	»	»				
9	.37.	»	»	»				
10	.30.	»	»	»				
12	.64.	30x92	100	B	36x70	4.16.04.25.kk	100	B
12,5	.65.	»	»	»	»	.45.	»	»
14	.31.	»	»	»	»	.26.	»	»
15	.66.	»	»	»	»	.57.	»	»
16	.67.	35x92	50	A	40x70	.27.	100	B
18	.69.	»	»	»	»	.28.	»	»
20	.54.	»	»	»	»	.29.	»	»
22	.70.	»	»	»	40x92	.68.	50	A
25					»	.42.	»	»
30					»	.62.	»	»
31,5					45x92	.51.	50	B
35					»	.60.	»	»
40					»	.47.	»	»
45					45x117	.58.	25	A
50					»	.48.	»	»
60					50x117	.49.	25	B
70*					»	.43.	»	»
80*					55x120	.76.	25	B
100*					60x120	.77.	20	B

* Not approved
= *Weight* 8 ÷ 9kg
= = *Weight* 7 ÷ 8 kg

D∆ *Standard box dimensions*
A = mm 195 x 390 x 200
B = mm 195 x 390 x 255

With integrated push wire: other dimensions available

Mechanical configurations

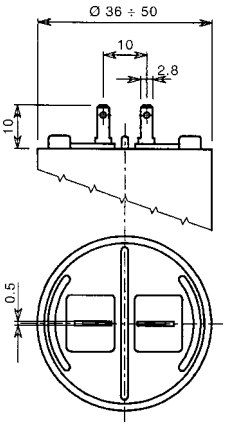


Fig. 1. *Tags 2.8 x 0,5 mm*

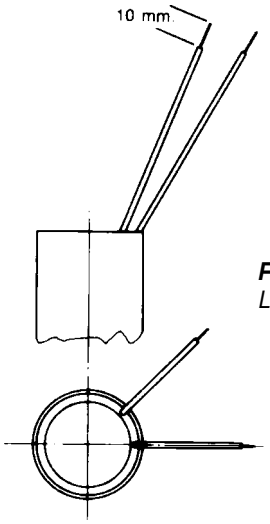


Fig. 2*. Insulated solid core leads 0.5 mm² L = 250 mm*

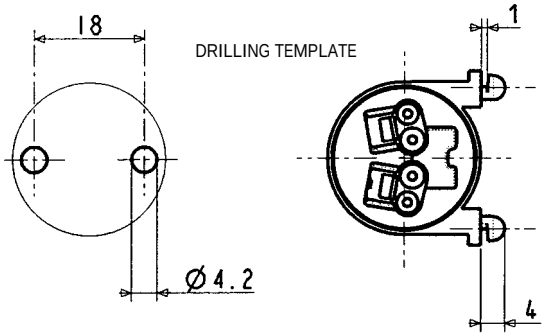


Fig. 3. *Push wire connection.*

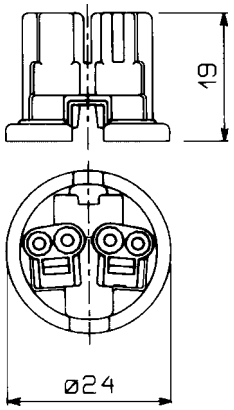
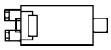
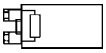
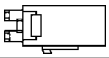
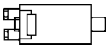
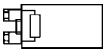


Fig. 4.
Insulating push wire connector, complete with discharge resistor.

Tab. 1 - *Accessories (kk)*

Fig. 1 Plug-in terminals 2,8 mm. P 10 mm		00
		40
Fig. 2 Unipolar leads L=250 mm		07
		47
From 2 to 22 µF		
Fig. 3 *Push wire with stud*		23
Fig. 3 *Push wire without stud*		18
Fig. 3 *Push wire, captive feet*		21
From 12 to 100 µF		
Fig. 4 Push wire connector (unmounted)	*Part number 316.23.1000*	
Push wire with stud		25
Push wire without stud		20

Capacitors series 4.16.31
"heavy duty" metallic case
for parallel compensation

The lamp power factor correction "Floppy cap" capacitors of these series are specifically employed in parallel power factor correction.
The dielectric is polypropylene film, the electrodes consist of an extremely thin metal coating obtained by vacuum evaporation.
The capacitor is liquid free, and has no risk of leakage.

The cases are metallic, the covers are in self extinguishing plastic (class V2 to UL-94 standards).

The capacitor is sealed by an edging of the case on the cover, ensuring air-tight closure.

The use of an insulating container between the capacitive element and the metal case, combined with the blocking of the capacitive element in resin, make the capacitor extremely safe both from the electric point of view (earthing insulation). The capacitors is protected by an overpressure safety device.

This protection is provided by a special construction technology (patented) which breaks both the connections in case of breakdown, without affecting case insulation, preventing the capacitor from exploding or burning.

In case of permanent short-circuit, the current causes the dieletric to decompose, forming gas: the resulting pressure pushes up the part of the lid where the terminals are mounted, thus breaking the internal connections and stopping the current flow.

TECHNICAL CHARACTERISTICS

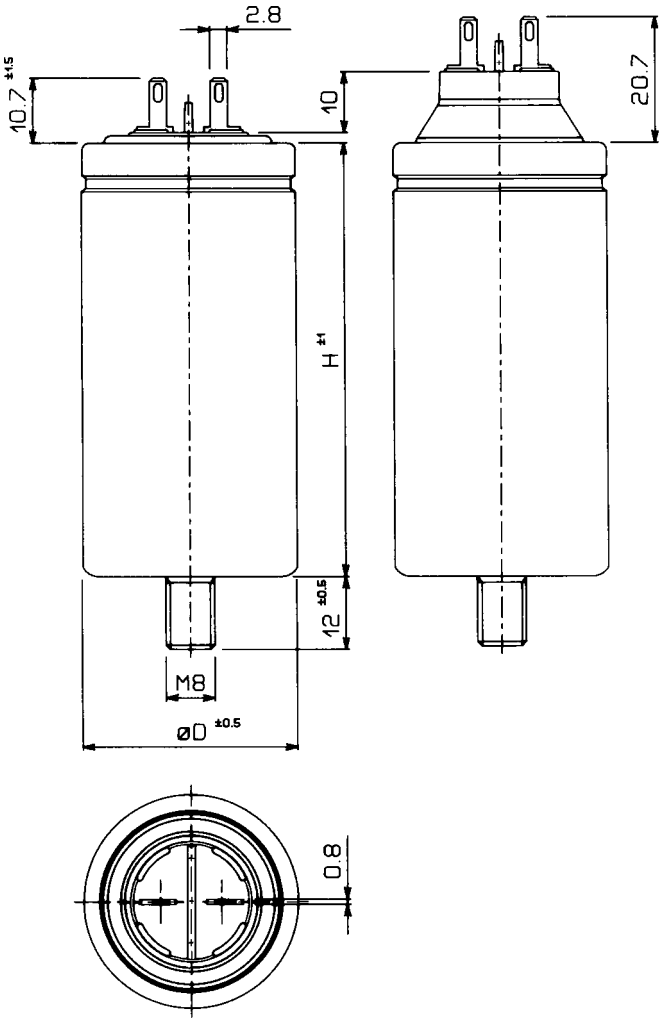
Rated voltage : 310 V~ - 50 Hz
Working temperature : *–25... +85°C*
280 V~ - 50/60 Hz
–25... +85°C
250 V~ - 50/60 Hz
–25... +100°C
Dissipation factor : tan $\delta \leq 20 \bullet 10^{-4}$ 20°C V = Vn 50 Hz
Test voltage : *Between terminals 2,15 Un for 2 sec.*
Between terminal and case: 3.000 V for 2 sec.
Approvals :
Reference standard : EN61048 second ed., cap type B
EN61049
Protection : *Aluminium case with plastic self extinguishing sealing cover, according to UL 94 Standard; grade V2*
Terminals : *Plug-in 2.8 mm*
Protection degree : IP00

4.16.31

Capacitance tolerance µF	D x H mm	*Part number*	*Packages n. pcs x box* •	Dim *box*
2	25 x 60	4.16.31.01.kk	250	A
2,5	»	» .02.	»	»
3	»	» .03.	»	»
3,5	25 x 72	» .04.	200	B
4	»	» .05.	»	»
4,5	»	» .06.	»	»
5	30 x 60	» .07.	»	A
6,3	30 x 72	» .08.	»	A
7	»	» .09.	»	»
8	»	» .10.	»	»
9	30 x 77	» .11.	125	B
9	35 x 60	» .12.	»	A
10	35 x 72	» .13.	100	B
12	»	» .14.	»	»
12,5	»	» .15.	»	»
14	35 x 77	» .16.	»	»
15	35 x 98	» .17.	50	»
15	40 x 72	» .18.	100	A
16	35 x 98	» .19.	50	B
16	40 x 72	» .20.	100	A
18	35 x 98	» .21.	50	B
18	40 x 72	» .22.	100	A
20	40 x 77	» .34.	50	B
20	35 x 98	» .23.	»	B
22	40 x 98	» .24.	»	B
25	»	» .25.	»	B
25	45 x 77	» .35.	»	B
30	40 x 98	» .26.	»	B
30	45 x 85	» .36.	»	A
31,5	40 x 122	» .27.	»	B
31,5	45 x 98	» .28.	»	A
35	40 x 122	» .29.	»	B
35	45 x 98	» .30.	»	A
40	50 x 98	» .37.	25	B
40	45 x 122	» .31.	50	A
45	»	» .32.	»	»
50	»	» .33.	»	»
50	55 x 98	» .38.	25	B

• *Weight* A = 8 ÷ 9 kg.
B = 6,5 ÷ 8 kg.
Standard box dim. A = 195x390x255 mm
B = 195x390x200 mm

Mechanical configurations



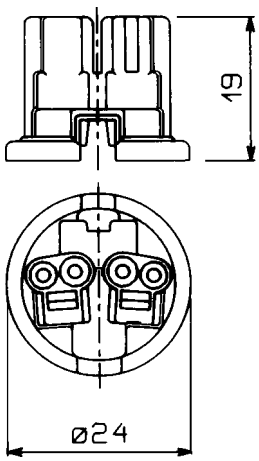
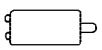
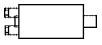


Fig. 2.
insulating push wire connector, complete with discharge resistor.

Fig. 1
Operation of the overpressure protection device.
In order to ensure proper operation of the device, when the capacitor is installed, a free space of at least 10 mm must be left above the terminals.

Tab. 1 - *Accessories (kk)*

Fig. 1 Plug-in terminals 2,8 mm.		00
		40
Fig. 2 Push wire connector (unmounted)	*Part number 316.23.1000*	
Push wire with stud		25
Push wire without stud		20