



VISHAY INTERTECHNOLOGY, INC.

INTERACTIVE

data book

CAPACITORS FOR INDUCTION EQUIPMENT

VISHAY ESTA

VSE-DB0042-0802

Notes:

1. To navigate:
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 - b) Click on the products within the Table of Contents to go directly to the datasheet.
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One of the World's Largest Manufacturers of
Discrete Semiconductors and Passive Components



VISHAY INTERTECHNOLOGY, INC.



CAPACITORS FOR INDUCTION EQUIPMENT

VISHAY ESTA

General Technical Information

Line-Frequency Capacitors

Medium-Frequency Capacitors

SEMICONDUCTORS

RECTIFIERS

Schottky (single, dual)
 Standard, Fast, and Ultra-Fast Recovery
 (single, dual)
 Bridge
 Superectifier®
 Sinterglass Avalanche Diodes

HIGH-POWER DIODES AND THYRISTORS

High-Power Fast-Recovery Diodes
 Phase-Control Thyristors
 Fast Thyristors

SMALL-SIGNAL DIODES

Schottky and Switching (single, dual)
 Tuner/Capacitance (single, dual)
 Bandswitching
 PIN

ZENER AND SUPPRESSOR DIODES

Zener (single, dual)
 TVS (TRANSZORB®, Automotive, ESD, Arrays)

FETs

Low-Voltage TrenchFET® Power MOSFETs
 High-Voltage TrenchFET® Power MOSFETs
 High-Voltage Planar MOSFETs
 JFETs

RF TRANSISTORS

Bipolar Transistors (AF and RF)
 Dual Gate MOSFETs
 MOSMICs®

OPTOELECTRONICS

IR Emitters and Detectors,
 and IR Receiver Modules
 Optocouplers and Solid-State Relays
 Optical Sensors
 LEDs and 7-Segment Displays
 Infrared Data Transceiver Modules
 Custom Products

ICs

Power ICs
 Analog Switches
 RF Transceivers and Receiver Modules
 ICs for Optoelectronics

MODULES AND ASSEMBLIES

Automotive Modules and Assemblies
 Power Modules (contain power diodes,
 thyristors, MOSFETs, IGBTs)
 DC/DC Converters

PASSIVE COMPONENTS

RESISTIVE PRODUCTS

Foil Resistors
 Film Resistors
 Metal Film Resistors
 Thin Film Resistors
 Thick Film Resistors
 Metal Oxide Film Resistors
 Carbon Film Resistors
 Wirewound Resistors
 Power Metal Strip® Resistors
 Chip Fuses
 Variable Resistors
 Cermet Variable Resistors
 Wirewound Variable Resistors
 Conductive Plastic Variable Resistors
 Networks/Arrays
 Non-Linear Resistors
 NTC Thermistors
 PTC Thermistors
 Varistors

MAGNETICS

Inductors
 Transformers

CAPACITORS

Tantalum Capacitors
 Molded Chip Tantalum Capacitors
 Coated Chip Tantalum Capacitors
 Solid Through-Hole Tantalum Capacitors
 Wet Tantalum Capacitors
 Ceramic Capacitors
 Multilayer Chip Capacitors
 Disc Capacitors
 Film Capacitors
 Power Capacitors
 Heavy-Current Capacitors
 Aluminum Capacitors
 Silicon RF Capacitors

STRAIN GAGE TRANSDUCERS AND STRESS ANALYSIS SYSTEMS

PhotoStress®
 Strain Gages
 Load Cells
 Force Transducers
 Instruments
 Weighing Systems
 Specialized Strain Gage Systems

Capacitors for Induction Equipment Vishay ESTA

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Capacitors for Induction Equipment

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General Technical Information

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Capacitors For Induction Equipment

PRODUCTION PROGRAM

“NF” = Line frequency 50/60 Hz: 200 to 3000 V
 “MF” = Medium frequency 100 - 100 000 Hz: 100 to 3000 V

TRADE NAMES

ESTAdry = MKP-type capacitor, dry,
 use at line frequency 50/60 Hz,
 voltage range 200 up to 1000 V

ESTAprop = MKP-type capacitor, impregnated,
 use at line frequency 50/60 Hz,
 voltage range 200 up to 1000 V

ESTAfilm = all-film capacitor, impregnated,
 use at line frequency 50/60 Hz,
 voltage range 800 up to 3000 V
 medium frequency, all ranges

STANDARDS

EN 60110-1/-2 applicable for frequencies
 IEC 60110-1 up to 50 000 Hz

ESTA capacitors for frequencies > 50 000 Hz are manufactured and tested in accordance with these standards, because no standard exists for this frequency range.

TESTING/QUALITY

Before shipping, each capacitor unit is subjected to the following test:

- leakage from the capacitor casing
- leakage from the cooling tubing
- capacitance measurement
- loss factor measurement
- dielectric test between terminals
- dielectric test between terminals and casing (for capacitors with insulated casing)

Customer-specific tests can be carried out upon agreement.

QUALITY ASSURANCE SYSTEM ISO 9001

Power capacitors for induction furnaces (furnace capacitors) cannot be provided with the CE-marking because they are not included in the scope of the European Community guidelines according to the EU Commission’s manual.

RATING LIMITS

Voltage: U_N continuous,
 $1.05 \times U_N$ up to 12 h per day

Current: $1.2 \times I_N$ permanent for $f_N \leq 60$ Hz
 $1.15 \times I_N$ for $f_N > 60$ Hz

Temperature: Self-cooling ESTAprop/ESTAdry:
 - 25/45 °C
 Self-cooling ESTAfilm:
 - 25/40 °C
 Liquid cooled ESTAprop/ESTAfilm:
 outflowing coolant: 40 °C
 ambient air: 50 °C
 For specific data, refer to 'Cooling methods'.

COOLING METHODS

SELF-COOLING (AN)

Cooling is obtained by natural air circulation. The ambient air temperature shall not exceed 40 °C (unless otherwise specified). It is measured at the warmest spot of the capacitor bank in the center of the clearance between two units at 2/3 of the height of the capacitor casings.

FORCED VENTILATION (AF)

Cooling air is directed forcefully onto the individual capacitor casings, e.g. by means of ventilators. During continuous operation, the maximum temperature of the outflowing air shall not exceed 40 °C.

LIQUID COOLING (WF)

The liquid (usually water) cools the capacitor either at the surface or inside the casing. Maximum temperature of the outflowing cooling liquid shall not exceed 40 °C, while the temperature of the ambient air shall not exceed 50 °C.

REMARKS ON WATER COOLING

COOLING WATER QUALITY

- mechanically pure (mesh size 0.38 mm)
- chemically neutral
- carbonate hardness 8° DH maximum
- electrical conductivity 500 µS/cm maximum

MAXIMUM PERMISSIBLE INDIVIDUAL			
With carbonate hardness	8° DH	6° DH	4° DH
PH value	7.8	8.1	8.3
Free carbon dioxide (CO ₂)	8 mg/l	4 mg/l	3 mg/l
Aggressive carbon dioxide	not permitted		
Ammonia (NH ₃)	not permitted		
Nitrides (NO ₂)	0.04 mg/l		
Iron	0.3 mg/l		
Manganese	0.05 mg/l		
Sulfates	250 mg/l		
Chlorides	150 mg/l		
KMnO ₄ consumption	15 mg/l		

GENERAL

The water temperature at the outlet is a function of the flow rate and of the inlet temperature. The minimum flow rate per capacitor is 1.5 l/min, and the maximum flow rate shall not exceed 12.5 l/min. The maximum water pressure at the entrance of the cooling system of a capacitor shall not exceed 8 bar.

Cooling systems of individual capacitors may be connected in series externally (6 units maximum). The pressure drop in the cooling system must be taken into account (refer to Fig. 1). The specific electric resistance of water is the basis for defining the hose length for the conductive water lines (refer to Fig. 2).

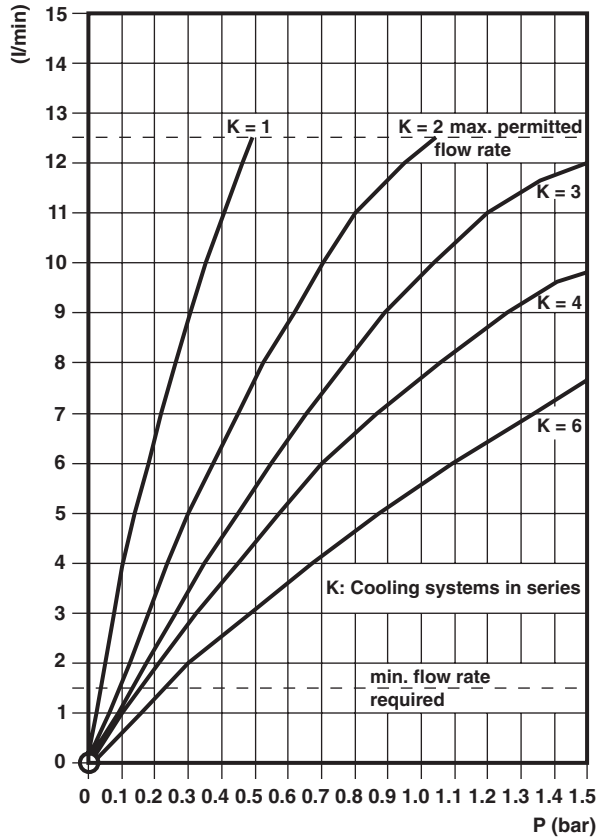


Fig. 1

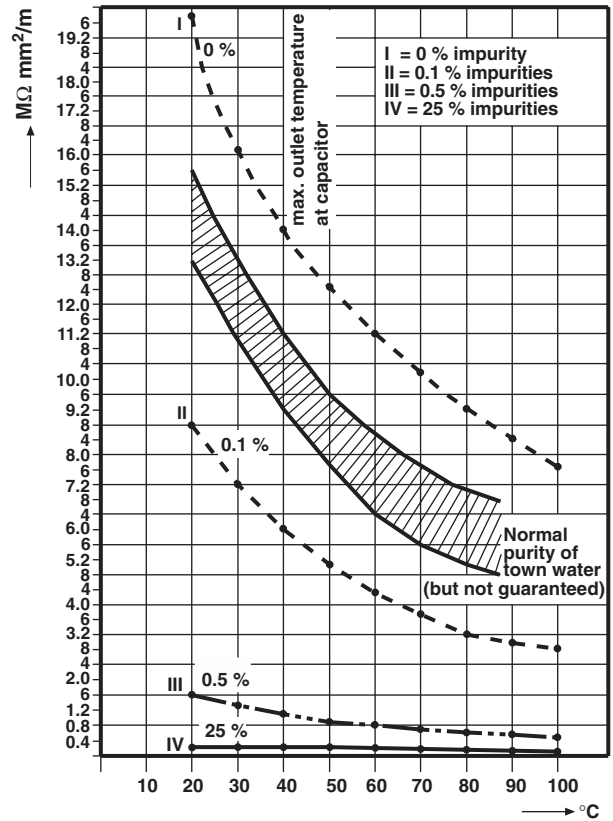


Fig. 2

CONSTRUCTION

Casing for line frequency capacitors:
 steel sheet or high-quality steel sheet with multi-layer varnish RAL 7033 for a rated current < 750 A, brass sheet with multi-layer varnish RAL 7033 for a rated current ≥ 750 A.

Preferred bottom sizes: 345 x 135 mm
 345 x 175 mm

Casing for medium frequency capacitors:
 brass sheet with multi-layer varnish RAL 7033.

Preferred bottom sizes: 369 x 165 mm
 354 x 142 mm

Other sizes, and a variety of mounting accessories are available upon consultation.

DIELECTRIC

ALL-FILM

The dielectric of ESTAFilm capacitors consists of a single-layer or multiple-layer polypropylene film. The film is made rough by a special surface treatment, permitting an even and thorough impregnation of the capacitor. The all-film capacitors are characterized by extremely low dielectric losses. The use of aluminum foils results in a high current-carrying capacity. This arrangement is used particularly in the field of medium-frequency applications (Fig. 3).

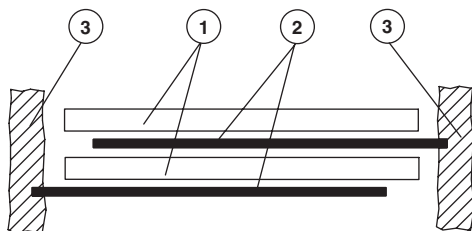


Fig. 3

Extended foil
 1 Dielectric
 2 Aluminum electrode
 3 Tin solder

MKP

Metallized polypropylene film.

The dielectric consists of a single-layer of polypropylene film to which is applied an evaporated metal coating, and then wound into cylindrical elements. Electrode contacts are achieved by spraying onto the two end faces of the winding element a metal coating (= Schoop metallizing; Fig. 4).

A property of these capacitors is the self-healing effect: in case of an electric breakdown, the suddenly appearing arc evaporates the metal coating of the dielectric film in the area of the puncture. As a consequence, a non-conductive spot is created, free of metal, and the capacitor remains fully operational (Fig. 5).

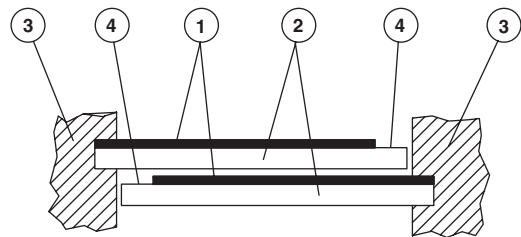


Fig. 4

Design of a MKP capacitor
 1 Metallized electrodes
 2 Polypropylene film
 3 Electric contact (schooping)
 4 Non-metallized edge

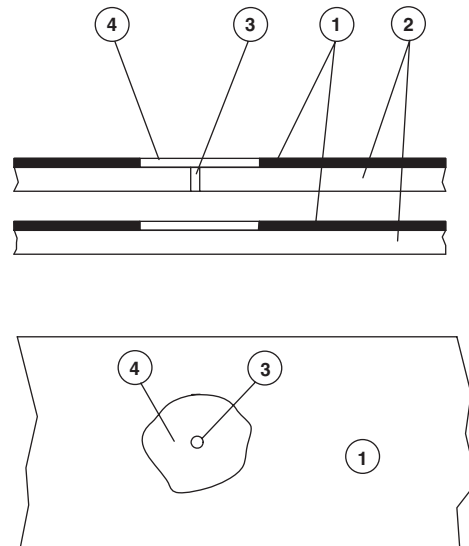


Fig. 5

Self healing breakdown on a MKP capacitor
 1 Metallized electrodes
 2 Polypropylene film
 3 Point of breakdown
 4 Non-conductive insulating crescent

DIELECTRICS' CHARACTERISTICS

MKP-TYPE ESTAdry/ESTAprop

ALL-FILM ESTAfilm

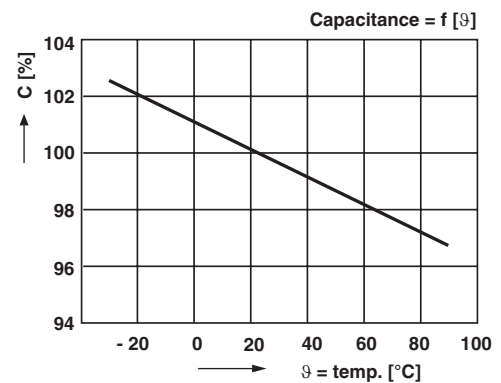
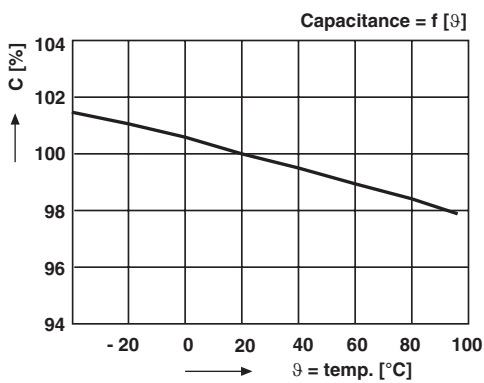
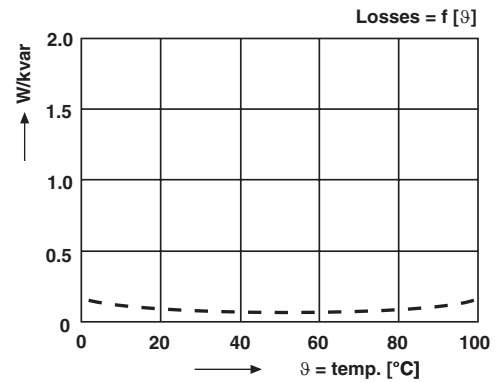
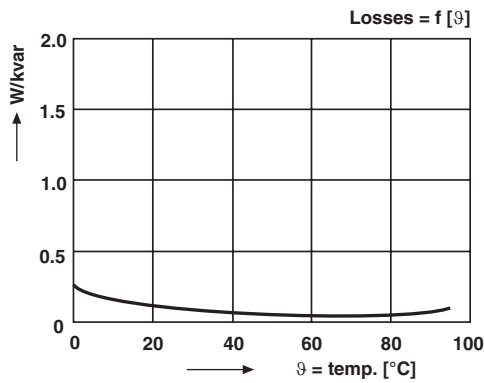
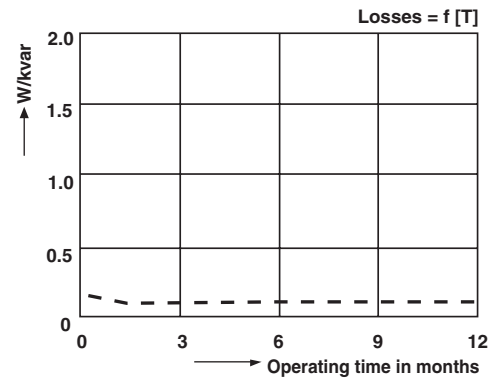


Fig. 6

Fig. 7

FILLERS

- ESTAprop = insulating oil on vegetable base, non-PCB,
flash point: 285 °C
ignition point: 315 °C
- ESTAdry = casting compound (resin)
The excellent heat conductivity of the resin
enables maximum capacitor loads under
high temperature stress conditions.
- ESTAfilm = non-chlorinated insulating oil, non PCB, high
thermal stability,
good hydrogen gas-absorbing capacity,
flash point: 146 °C
ignition point: 154 °C

All the filling agents employed are biodegradable and non-toxic.

A little "g" shows the difference in the type designation between ESTAprop (Phmkp...) and ESTAdry (Phmkpg...).

REMARKS

Before working on a capacitor or a capacitor bank, the equipment should be discharged and short-circuited.

Capacitors are supplied without discharging devices (unless otherwise agreed).

Terminals should be properly tightened while observing the maximum permissible fastening torque.

For medium-frequency applications, only connecting parts (nuts, screws, washers) made of non-magnetic material shall be used.

Water lines are current carrying (special versions with insulated water lines can be supplied upon request).

Depending on the type (e.g. type Phawos ...), even the casings may be current carrying (live case).

In addition, the Mounting and Maintenance Instructions MW 110, attached to all order acknowledgments, must be observed.



Line- Frequency Capacitors

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Phao	14

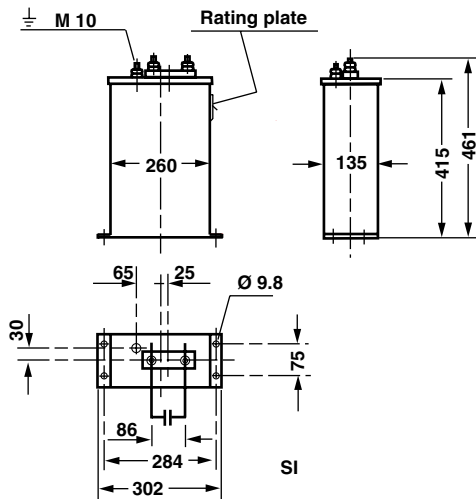
Line Frequency Capacitors 50/60 Hz

ESTAprop, 230 TO 525 V, SELF-COOLING, SINGLE-PHASE

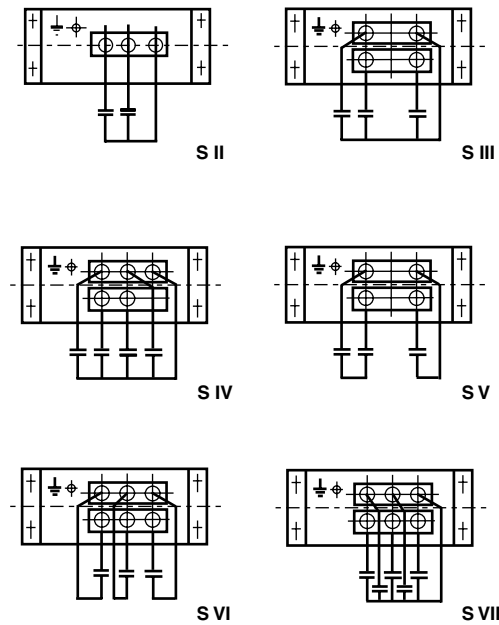
DESIGN

- MKP-type cup capacitor elements assembled and interconnected in steel sheet riveted casing
- Casing varnish RAL 7033
- IP00, indoor, - 25 °C/+ 45 °C (unless otherwise confirmed)
- Self-healing, with internal overpressure tear-off fuse in each cup
- Connection bolt M12, and grounding bolt M10
- Mounting in the upright position, or horizontally on the narrow side

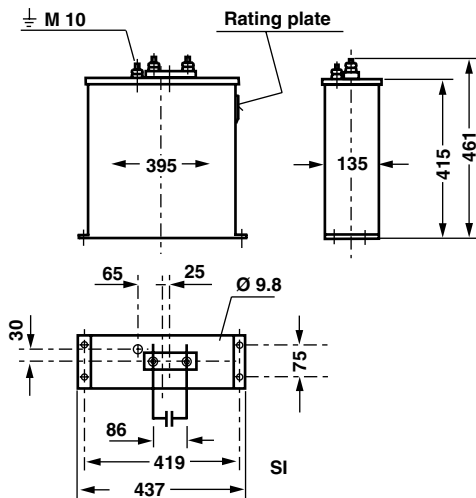
VERSION A/CIRCUITRY S I



ADDITIONAL CIRCUITRY VERSIONS



VERSION B/CIRCUITRY S I





230 TO 525 V, 50 Hz (60 Hz on request)					
U_N V	Q_N kvar	C_N μ F	I_N A	VERSION/ CIRCUITRY	TYPE Phmkp ...
230	40	2407	174	A/S I	..230/40/1
230	60	3610	261	B/S I	..230/60/1
400	80	1592	200	A/S I	..400/80/1
400	120	2387	300	B/S I	..100/120/1
500	72	917	144	A/S I	..500/72/1
500	108	1375	216	B/S I	..500/108/1
525	80	924	152	A/S I	..525/80/1
525	120	1386	229	B/S I	..525/120/1

Note

- Shown are the maximum power ratings, other power ratings, voltages, and subdivisions are available on request

Line Frequency Capacitors 50/60 Hz

ESTAprop/ESTAdry 200 TO 1000 V, SELF-COOLING, SINGLE-PHASE

DESIGN

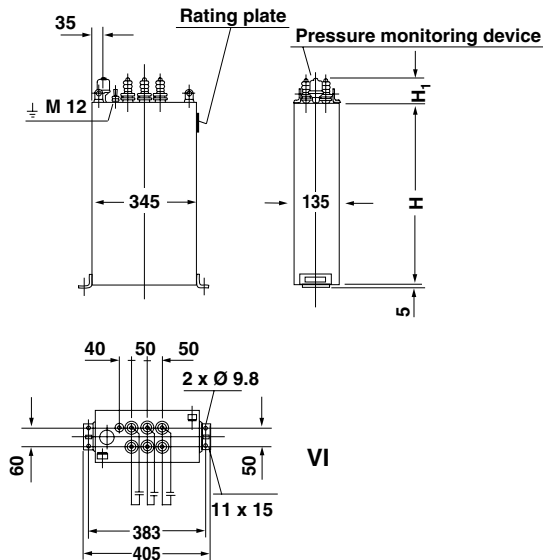
- MKP-type wound elements in high-quality steel sheet or brass sheet welded casing
- Casing varnish RAL 7033
- IP00, indoor, - 25 °C/+ 45 °C (unless otherwise confirmed);
- Self-healing, with overpressure switch ("DR") or tear-off fuse ("A")*, (*available only for a limited number of types!)

- Connection bolt M12, or M20 (depending on application current)
- Grounding bolt M12
- Mounting in the upright position, or horizontally on the narrow side

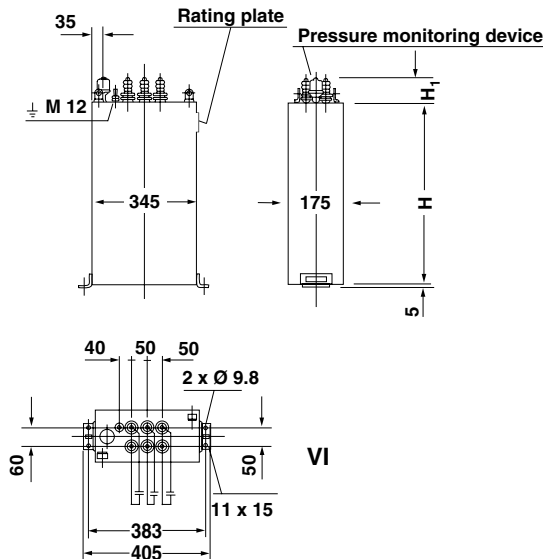
Note:

Water-cooled capacitors can be supplied upon request

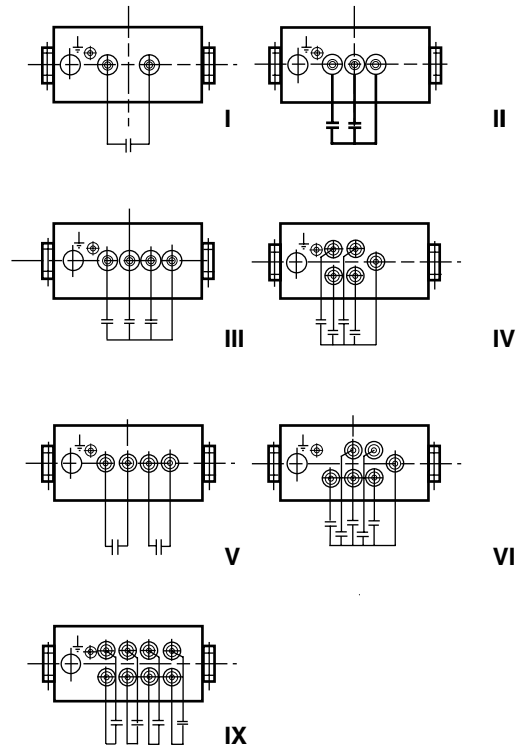
VERSION A/CIRCUITRY VI



VERSION B/CIRCUITRY VI



ADDITIONAL CIRCUITRY VERSIONS





200 TO 1000 V, 50 Hz (60 Hz on request)								
U _N V	Q _N kvar	SUBDIVISIONS .. x ..kvar	C _N µF	I _N A	VERSION/ CIRCUITRY	H mm	BUSHING	TYPE Phmkp ...
200	200	3 x 67	15915	1000	A/VI	900	M 12	..200/200/1 S-DR
200	200	3 x 67	15915	1000	B/VI	730	M 12	..200/200/1 S-DR
250	250	3 x 83	12732	1000	A/VI	720	M 12	..250/250/1 S-DR
250	250	3 x 83	12732	1000	B/VI	570	M 12	..250/250/1 S-DR
400	400	3 x 133	7958	1000	A/VI	650	M 12	..400/400/1 S-DR
400	400	3 x 133	7958	1000	B/VI	570	M 12	..400/400/1 S-DR
440	440	3 x 147	7234	1000	A/VI	720	M 12	..440/440/1 S-DR
440	440	3 x 147	7234	1000	B/VI	560	M 12	..440/440/1 S-DR
500	500	3 x 167	6366	1000	A/VI	910	M 12	..500/500/1 S-DR
500	500	3 x 167	6366	1000	B/VI	720	M 12	..500/500/1 S-DR
550	510	3 x 170	5367	927	A/VI	970	M 12	..550/510/1 S-DR
550	550	3 x 183	5787	1000	B/VI	800	M 12	..550/550/1 S-DR
600	510	3 x 170	4509	850	A/VI	970	M 12	..600/510/1 S-DR
600	550	3 x 183	4863	917	B/VI	820	M 12	..600/550/1 S-DR
660	420	2 x 210	3069	636	A/VI	960	M 12	..660/420/1 S-DR
660	550	3 x 183	4019	833	B/VI	970	M 12	..660/550/1 S-DR
750	550	3 x 183	3112	733	A/VI	970	M 12	..750/550/1 S-DR
750	600	3 x 200	3395	800	B/VI	860	M 12	..750/600/1 S-DR
800	600	3 x 210	2984	750	A/VI	9540	M 12	..800/600/1 S-DR
800	630	3 x 210	3133	788	B/VI	790	M 12	..800/630/1 S-DR
900	630	3 x 210	2476	700	A/VI	910	M 12	..900/630/1 S-DR
900	675	3 x 225	2653	750	B/VI	790	M 12	..900/675/1 S-DR
1000	555	3 x 185	1767	555	A/VI	970	M 12	..1/555/1 S-DR
1000	675	3 x 225	2149	675	B/VI	940	M 12	..1/675/1 S-DR

Note

- Shown are the maximum power ratings, other power ratings, voltages, and subdivisions are available on request

Line Frequency Capacitors 50/60 Hz

ESTAfilm, 850 TO 3000 V, SELF-COOLING, SINGLE-PHASE

DESIGN

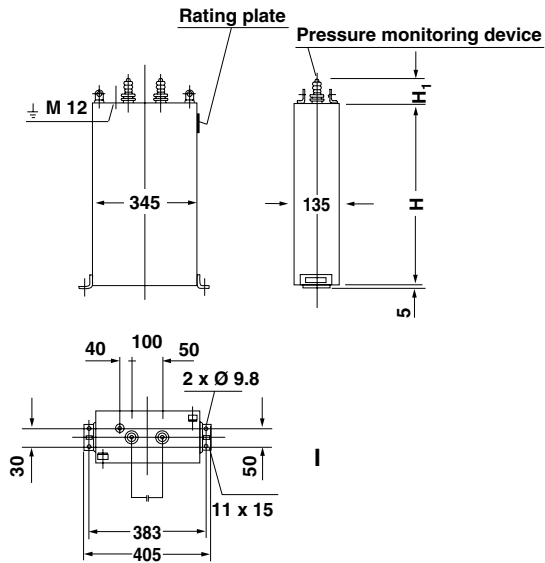
- All-film wound elements in high-quality steel sheet welded casings
- Casing varnish RAL 7033
- IP00, indoor, - 25 °C/+ 45 °C (unless otherwise confirmed);
- Winding elements provided with internal fuses

- Connection bolt M12, or M20 (depending on application current)
- Grounding bolt M12
- Mounting in the upright position, or horizontally on the narrow side

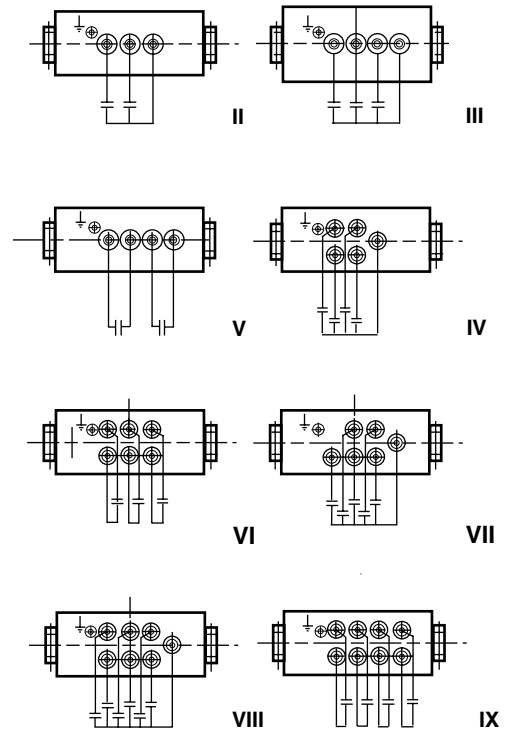
Note

Water-cooled capacitors can be supplied upon request

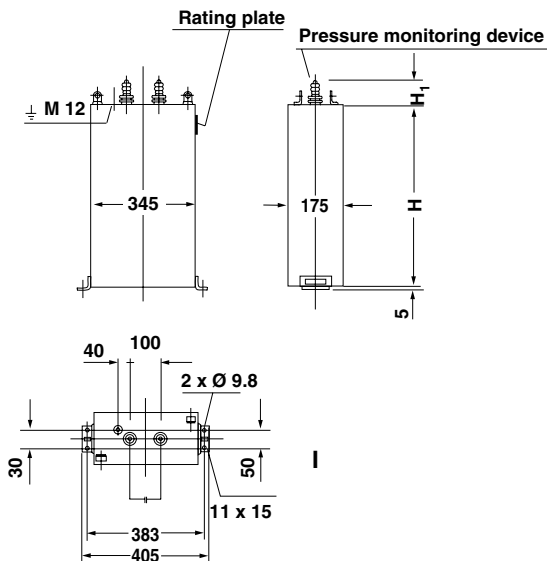
VERSION A/CIRCUITRY I



ADDITIONAL CIRCUITRY VERSIONS



VERSION B/CIRCUITRY I





850 TO 3000 V, 50 Hz (60 Hz on request)								
U_N V	Q_N kvar	SUBDIVISIONS .. x ..kvar	C_N μ F	I_N A	VERSION/ CIRCUITRY	H mm	BUSHING	TYPE Phao ...
850	370	no	1630	435	A/I	1000	M 20	..850/370/1
850	500	2 x 250	2203	588	B/V	1000	M 12	..850/500/1 S
900	360	no	1415	400	A/I	985	M 20	..900/360/1
900	490	2 x 245	1926	544	B/V	1000	M 12	..900/490/1 S
1000	380	no	1210	380	A/I	985	M 20	..1/380/1
1000	520	2 x 260	1655	520	B/V	1000	M 12	..1/520/1 S
1200	480	no	1061	400	A/I	990	M 20	..1.2/480/1
1200	650	2 x 325	1437	542	B/V	995	M 12	..1.2/650/1 S
1350	500	no	873	370	A/I	1000	M 12	..1.35/500/1
1350	660	2 x 330	1153	489	B/V	980	M 12	..1.35/660/1 S
1500	520	no	736	347	A/I	1000	M 12	..1.5/520/1
1500	700	2 x 350	990	467	B/V	1000	M 12	..1.5/700/1
1750	490	no	509	280	A/I	1000	M 12	..1.75/490/1
1750	660	no	686	377	B/V	1000	M 20	..1.75/660/1
2000	530	no	422	265	A/I	990	M 12	..2/530/1
2000	700	no	557	350	B/I	985	M 12	..2/700/1
2200	550	no	362	250	A/I	990	M 12	..2.2/550/1
2200	740	no	487	336	B/I	1000	M 12	..2.2/740/1
2400	730	no	403	304	B/I	995	M 12	..2.4/730/1
2500	720	no	367	288	B/I	985	M 12	..2.5/720/1
2700	660	no	288	244	B/I	990	M 12	..2.7/660/1
3000	690	no	244	230	B/I	1000	M 12	..3/690/1

Note

- Shown are the maximum power ratings, other power ratings, voltages, and subdivisions are available on request.



Medium-Frequency Capacitors

Contents

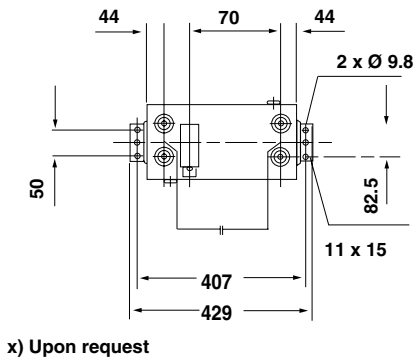
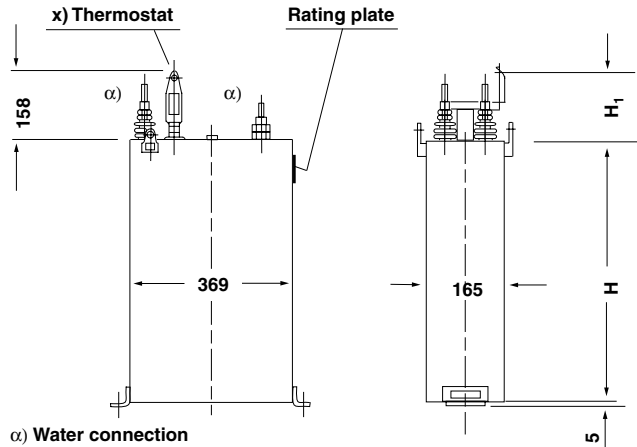
Phawo...k..	18
Phawo...kS..	21
Phawoz	24
Phawoc	27
Phao.../μF	29

Medium Frequency Capacitors, Water Cooled

ESTafilm, SINGLE OUTPUTS NOT SUBDIVIDED, 150 TO 5000 Hz

DESIGN

- All-film winding in brass sheet welded casing
- Casing conductive, or grounded
- Casing varnish RAL 7033
- IP00, indoor
- Ambient temperature 1 °C 50 °C
- Outflowing water temperature 40 °C maximum
- 2 water-cooled current connections M20
- Water tubing conductive
- Mounting in the upright or horizontal position
- Upon request, temperature or pressure monitoring



TYPE DESIGNATION										
Ph	a	w	o	s	750	/	1875	/	1k	- ...
monitoring device *)										
frequency (kHz)										
total output (kvar)										
voltage (V or kV)										
live casing (grounded casing: no entry Phawo 750/...)										
NON-PCB										
water-cooled										
all film dielectric										
power capacitor										

Note

- *) - ST = thermostat
- DR = pressure switch
- Not all types available



150 TO 5000 Hz (not subdivided)							
F _N V	U _N V	Q _N kvar	C _N µF	I _N A	CASING		H mm
					CONDUCTIVE	GROUNDED	
150	600	800	2358	1333	x	x	1000
	1000	1400	1485	1400	x	x	1000
	1500	1800	849	1200	x	x	1000
	2000	1720	456	860	x	x	1000
	2500	1350	229	540	x	x	1000
	3000	2000	236	667	x	x	1000
250	600	1120	1981	1867	x	x	1000
	1000	2000	1273	2000	x	x	1000
	1500	2750	778	1833	x	x	1000
	2000	2600	414	1300	x	x	1000
	2500	2000	204	800	x	x	1000
	3000	3333	236	1111	x	x	1000
300	600	1375	2026	2292	x	x	1000
	1000	2400	1273	2400	x	x	1000
	1500	3000	707	2000	x	x	1000
	2000	3150	418	1575	x	x	1000
	2500	2350	200	940	x	x	1000
	3000	4000	236	1333	x	x	1000
500	250	460	2343	1840	x	x	1000
	600	1500	1326	2500	x	x	800
	1000	2500	796	2500	x	x	700
	1500	3750	531	2500	x	x	800
	2000	4900	390	2450	x	x	1000
	2500	3700	188	1480	x	x	1000
600	3000	6666	236	2222	x	x	1000
	250	560	2377	2240	x	x	1000
	600	1500	1105	2500	x	x	700
	1000	2500	663	2500	x	x	600
	1500	3750	442	2500	x	x	700
	2000	5000	332	2500	x	x	900
	2500	4200	178	1680	x	x	1000
1000	3000	8000	236	2667	x	x	1000
	250	625	1592	2500	x	x	700
	600	1500	663	2500	x	x	500
	750	1875	531	2500	x	x	450
	1000	2500	398	2500	x	x	450
	1500	3750	265	2500	x	x	600
	2000	5000	199	2500	x	x	750
2500	6250	159	2500	x	x	950	



150 TO 5000 Hz (not subdivided)							
F _N V	U _N V	Q _N kvar	C _N μF	I _N A	CASING		H mm
					CONDUCTIVE	GROUNDED	
2000	250	625	796	2500	x	x	500
	600	1500	332	2500	x	x	500
	750	1875	265	2500	x	x	500
	1000	2500	199	2500	x	x	450
	1500	3750	133	2500	x	x	450
	2000	5000	99	2500	x	x	500
	2400	6000	83	2500	x	x	600
3000	250	625	531	2500	x	x	500
	600	1500	221	2500	x	x	500
	750	1875	177	2500	x	x	500
	1000	2500	133	2500	x	x	500
	1500	3750	88	2500	x	x	550
	2000	5000	66	2500	x	x	500
4000	250	625	398	2500	x	x	550
	600	1500	166	2500	x	x	550
	750	1875	133	2500	x	x	500
	1000	2500	99	2500	x	x	500
	1500	3750	66	2500	x	x	550
	2000	5000	50	2500	x	x	600
5000	250	600	306	2400	x	x	550
	600	1440	127	2400	x	x	550
	750	1800	102	2400	x	x	500
	1000	2400	76	2400	x	x	550
	1500	3600	51	2400	x	x	500
	2000	4800	38	2400	x	x	550

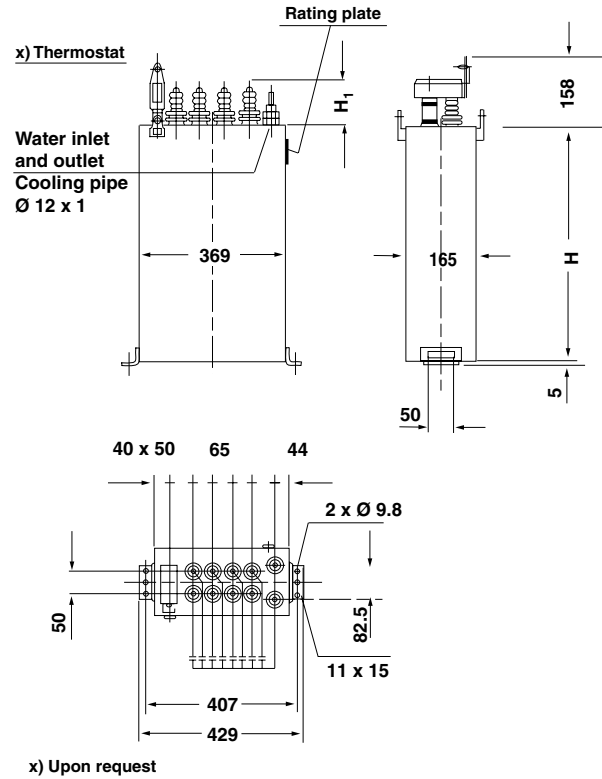
Note

- Shown are the maximum power ratings, other power ratings, voltages, and subdivisions are available on request

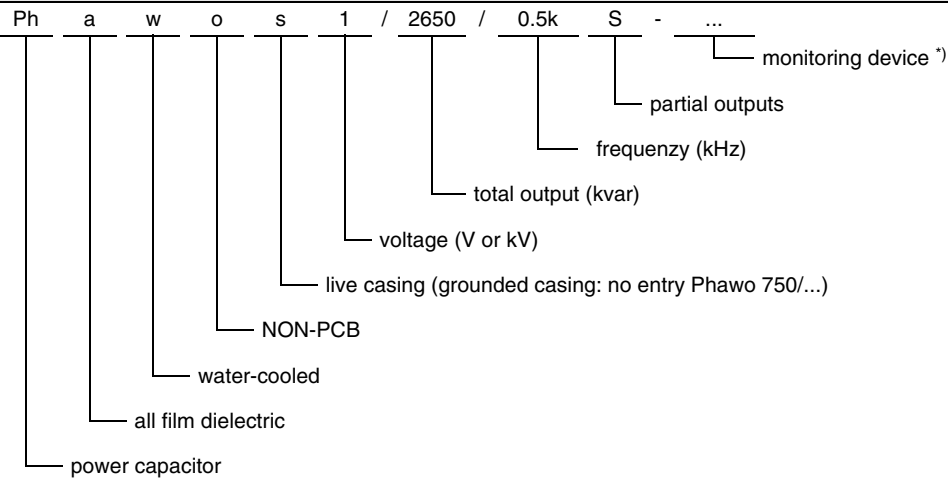
Medium Frequency Capacitors, Water Cooled

ESTAfilm, SUBDIVIDED IN PARTIAL OUTPUTS, 150 TO 10 000 Hz DESIGN

- All-film winding in brass sheet welded casing
- Casing conductive, or grounded
- Casing varnish RAL 7033
- IP00, indoor
- Ambient temperature 1 °C 50 °C
- Outflowing water temperature 40 °C maximum
- Common terminal with 2 water-cooled current connections M20
- Water tubing conductive
- A maximum of 8 partial outputs with connection bolts M12 or M20 (depending on application current)
- Mounting in the upright or horizontal position
- Upon request, temperature or pressure monitoring



TYPE DESIGNATION



Note

- *) - ST = thermostat
 - DR = pressure switch
 Not all types available



150 TO 10 000 Hz SUBDIVIDED IN PARTIAL OUTPUTS							
F _N V	U _N V	Q _N kvar	C _N μF	I _N A	CASING		H mm
					CONDUCTIVE	GROUNDED	
150	600	760	2240	1267	x	x	1000
	1000	1320	1401	1320	x	x	1000
	1500	1720	811	1147	x	x	1000
	2000	1650	438	825	x	x	1000
	2500	1300	221	520	x	x	1000
	3000	2000	236	667	x	x	1000
250	600	1000	1768	1667	x	x	950
	1000	1700	1082	1700	x	x	900
	1500	2550	722	1700	x	x	1000
	2000	2520	401	1260	x	x	1000
	2500	2000	204	800	x	x	1000
	3000	3333	236	1111	x	x	1000
300	600	1020	1503	1700	x	x	800
	1000	1760	934	1760	x	x	1000
	1500	2550	601	1700	x	x	950
	2000	3000	398	1500	x	x	1000
	2500	2240	190	896	x	x	1000
	3000	3950	233	1317	x	x	1000
	3000	4000	236	1333	x		1000
500	250	420	2139	1680	x	x	950
	600	1320	1167	2200	x	x	950
	600	1460	1291	2433	x		1000
	1000	2200	700	2200	x	x	800
	1000	2650	844	2650	x		900
	1500	3300	467	2200	x	x	950
	1500	3600	509	2400	x		1000
	2000	3600	287	1800	x	x	1000
	2500	3000	153	1200	x	x	950
	3000	6000	212	2000	x	x	950
600	250	420	1783	1680	x	x	850
	600	1320	973	2200	x	x	800
	600	1560	1149	2600	x		900
	1000	2200	584	2200	x	x	700
	1000	2650	703	2650	x		800
	1500	3300	389	2200	x	x	800
	1500	4000	472	2667	x		950
	2000	4160	276	2080	x	x	1000
	2500	3400	144	1360	x	x	1000
	3000	6000	177	2000	x	x	800
1000	250	550	1401	2200	x	x	850
	250	660	1681	2640	x		1000
	600	1320	584	2200	x	x	600
	600	1600	707	2667	x		700
	750	1650	467	2200	x	x	500
	750	1980	560	2640	x		600
	1000	2200	350	2200	x	x	500
	1000	2650	422	2650	x		550
	1500	3300	233	2200	x	x	600
	1500	3950	279	2633	x		650
	2000	4400	175	2200	x	x	750
	2000	5300	211	2650	x		850
	2450	4900	130	2000	x	x	1000
	2000	250	500	637	2000	x	x
250		660	840	2640	x		550
600		1200	265	2000	x	x	350
600		1600	354	2667	x		400
750		1500	212	2000	x	x	350
750		2000	283	2667	x		400



150 TO 10 000 Hz SUBDIVIDED IN PARTIAL OUTPUTS							
F _N V	U _N V	Q _N kvar	C _N µF	I _N A	CASING		H mm
					CONDUCTIVE	GROUNDED	
2000	1000	2000	159	2000	x		300
	1000	2650	211	2650	x	x	350
	1500	3000	106	2000	x		350
	1500	3975	141	2650	x	x	450
	2000	4000	80	2000	x		450
	2000	5300	105	2650	x	x	550
	2400	4800	66	2000	x		600
3000	2400	6360	88	2650	x	x	700
	250	480	407	1920	x		350
	250	660	560	2640	x	x	400
	600	1160	171	1933	x		300
	600	1600	236	2667	x	x	350
	750	1470	139	1960	x		250
	750	2000	189	2667	x	x	350
	1000	1950	104	1950	x		300
	1000	2650	141	2650	x	x	350
1500	2940	69	1960	x		300	
1500	3960	93	2640	x	x	350	
4000	250	470	299	1880	x		300
	250	660	420	2640	x	x	350
	600	1120	124	1867	x		250
	600	1600	177	2667	x	x	350
	750	1400	99	1867	x		250
	750	1980	140	2640	x	x	300
	1000	1900	76	1900	x		250
	1000	2650	105	2650	x	x	300
	1500	2840	50	1893	x		250
1500	3960	70	2640	x	x	300	
5000	250	460	234	1840	x		250
	250	640	326	2560	x	x	300
	600	1100	97	1833	x		250
	600	1520	134	2533	x	x	300
	1000	1850	59	1850	x		250
	1000	2560	81	2560	x	x	250
	1500	2770	39	1847	x		300
	1500	3840	54	2560	x	x	350
8000	250	420	134	1680	x		250
	250	600	191	2400	x	x	250
	600	1040	57	1733	x		200
	600	1420	78	2367	x	x	250
	1000	1740	35	1740	x		250
	1000	2400	48	2400	x	x	300
	1500	2600	23	1733	x		250
1500	3500	31	2333	x	x	300	
10 000	250	420	107	1680	x		250
	250	570	145	2280	x	x	300
	500	850	54	1700	x		200
	500	1140	73	2280	x	x	250
	600	1020	45	1700	x		200
	600	1360	60	2267	x	x	250
	750	1275	36	1700	x		200
	750	1720	49	2293	x	x	250
	1000	1700	27	1700	x		200
	1000	2300	37	2300	x	x	250
	1500	2550	18	1700	x		250
1500	3400	24	2267	x	x	300	

Note

- Shown are the maximum power ratings, other power ratings, voltages, and subdivisions are available on request

Medium Frequency Capacitors, Water Cooled

ESTafilm, TWIN OUTPUTS FOR EXTREME CURRENT LOADING, 1000 TO 10 000 Hz

VERSION A

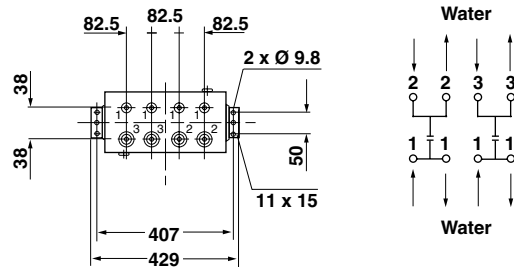
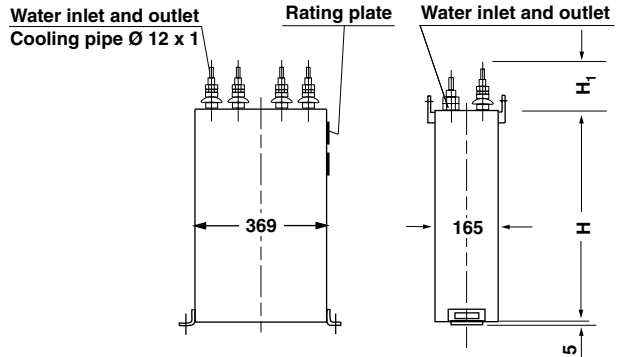
Total output subdivided in 2 sections of equal capacity

VERSION B

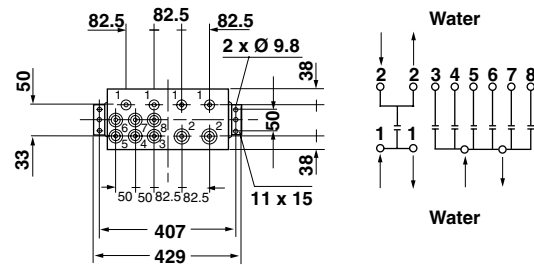
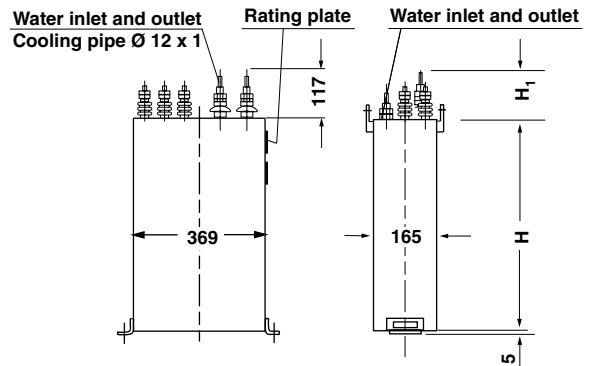
Total output subdivided in 2 sections of equal capacity, with one of the two sections subdivided in 6 equal-size partial outputs.

DESIGN

- All-film winding in brass sheet welded casing
- Casing conductive, or grounded
- Casing varnish RAL 7033
- IP00, indoor
- Ambient temperature 1 °C 50 °C
- Outflowing water temperature 40 °C maximum
- 2 water-cooled current connections M20
- Water tubing conductive
- Partial outputs of version B provided with connection bolts M12 or M20 (depending on application current)
- Mounting in the upright or horizontal position
- Upon request, temperature or pressure monitoring

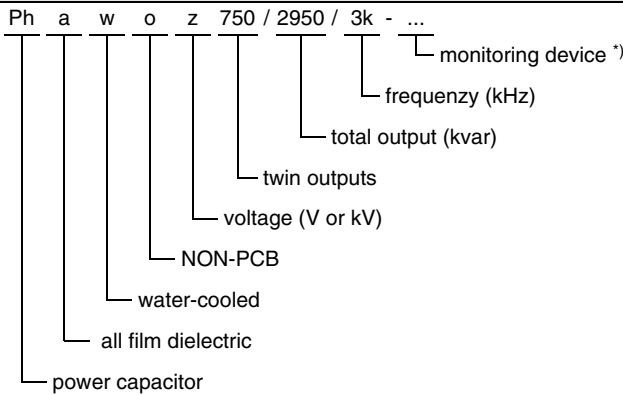


Version A

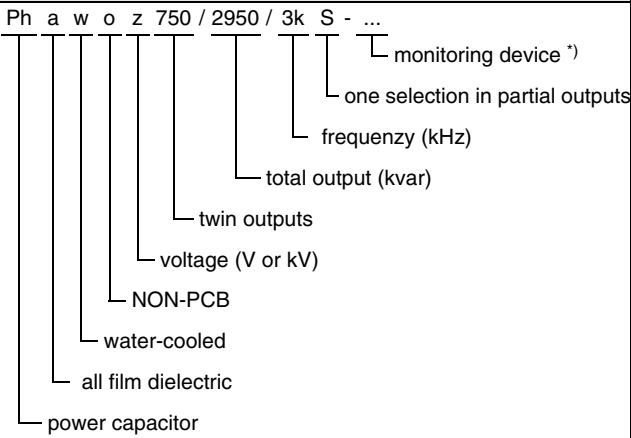


Version B

TYPE DESIGNATION: VERSION A



TYPE DESIGNATION: VERSION B



Note

*) -DR = pressure switch



1000 TO 10 000 Hz TWIN OUTPUTS						
F_N V	U_N V	Q_N kvar	C_N µF	I_N A	H mm	VERSION
1000	250	700	1783	2800	1000	A
	250	680	1732	2720	1000	B
	600	2500	1105	4167	1000	A
	600	2400	1061	4000	1000	B
	750	3375	955	4500	900	A
	750	3360	951	4480	900	B
	1000	4500	716	4500	850	A
	1000	4500	716	4500	900	B
	1500	6750	478	4500	1000	A
	1500	6540	463	4360	1000	B
	2000	6500	259	3250	1000	A
	2000	6400	255	3200	1000	B
2000	250	1000	1273	4000	750	A
	250	1000	1273	4000	800	B
	600	2500	553	4167	550	A
	600	2400	531	4000	600	B
	750	3000	424	4000	500	A
	750	3000	424	4000	550	B
	1000	4100	326	4100	500	A
	1000	4000	318	4000	550	B
	1500	6000	212	4000	550	A
	1500	6000	212	4000	650	B
	2000	8000	159	4000	700	A
	2000	8000	159	4000	800	B
	2400	9600	133	4000	1000	A
	2400	8800	122	3667	1000	B
3000	250	980	832	3920	550	A
	250	980	832	3920	550	B
	600	2300	339	3833	450	A
	600	2300	339	3833	450	B
	750	2950	278	3933	450	A
	750	2940	277	3920	450	B
	1000	3900	207	3900	400	A
	1000	3900	207	3900	450	B
	1500	5900	139	3933	400	A
	1500	5900	139	3933	450	B
	2000	7800	104	3900	550	A
	2000	7800	104	3900	600	B



1000 TO 10 000 Hz TWIN OUTPUTS						
F _N V	U _N V	Q _N kvar	C _N µF	I _N A	H mm	VERSION
4000	250	940	598	3760	400	A
	250	940	598	3760	450	B
	600	2200	243	3667	400	A
	600	2200	243	3667	400	B
	750	2800	198	3733	400	A
	750	2800	198	3733	400	B
	1000	3800	151	3800	450	A
	1000	3800	151	3800	450	B
	1500	5600	99	3733	400	A
	1500	5600	99	3733	500	B
	2000	7500	75	3750	450	A
	2000	7500	75	3750	650	B
5000	250	920	469	3680	450	A
	250	920	469	3680	450	B
	600	2200	195	3667	400	A
	600	2200	195	3667	400	B
	750	2700	153	3600	400	A
	750	2700	153	3600	450	B
	1000	3600	115	3600	450	A
	1000	3600	115	3600	400	B
	1500	5500	78	3667	450	A
	1500	5500	78	3667	550	B
	2000	7300	58	3650	400	A
	2000	7300	58	3650	650	B
8000	250	860	274	3440	450	A
	250	860	274	3440	450	B
	600	2000	111	3333	400	A
	600	2000	111	3333	400	B
	750	2500	88	3333	400	A
	750	2500	88	3333	400	B
	1000	3400	68	3400	450	A
	1000	3400	68	3400	400	B
	1500	5000	44	3333	400	A
	1500	5000	44	3333	400	B
10 000	250	820	209	3280	450	A
	250	820	209	3280	400	B
	600	2000	88	3333	450	A
	600	2000	88	3333	450	B
	750	2400	68	3200	400	A
	750	2400	68	3200	400	B
	1000	3300	53	3300	450	A
	1000	3300	53	3300	400	B
	1500	5000	35	3333	450	A
	1500	5000	35	3333	450	B

Note

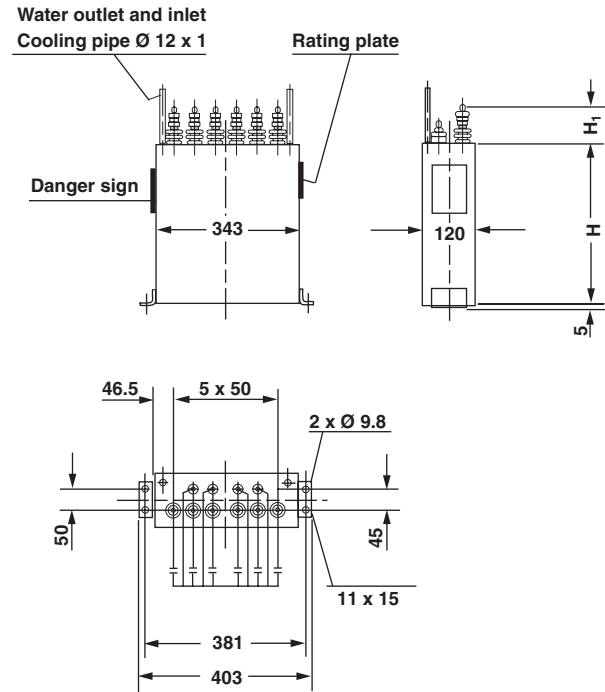
- Shown are the maximum power ratings, other power ratings, voltages, and subdivisions are available on request

Medium Frequency Capacitors, Water Cooled

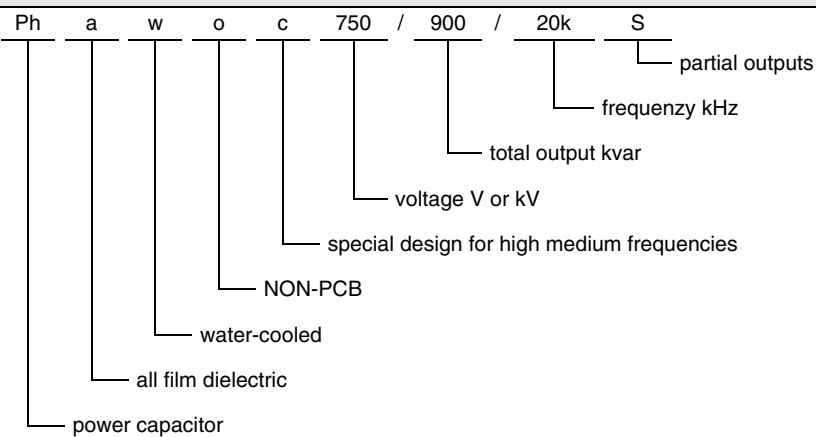
ESTAfilm, SUBDIVIDED IN PARTIAL OUTPUTS, 10 000 TO 100 000 Hz

DESIGN

- All-film windings in brass sheet welded casing
- Extremely low-inductance version
- Casing conductive
- Casing varnish RAL 7033
- 6 equal partial outputs
- IP00, indoor
- Ambient temperature 1 °C 50 °C
- Outflowing water temperature 40 °C maximum
- Water tubing conductive
- 4 casing connection bolts M12 x 30 mm
- Partial outputs with connection bolts M12 or M20 (depending on application current)



TYPE DESIGNATION



10 000 TO 100 000 Hz SUBDIVIDED IN PARTIAL OUTPUTS					
F_N V	U_N V	Q_N kvar	C_N μ F	I_N A	H mm
10 000	500	980	62.4	1960	300
	650	1280	48.2	1969	250
	750	1470	41.6	1960	250
	1000	1970	31.4	1970	250
20 000	500	900	28.7	1800	250
	650	1170	22.0	1800	250
	750	1350	19.1	1800	250
	1000	1800	14.3	1800	200
30 000	500	840	17.8	1680	250
	650	1100	13.8	1692	200
	750	1270	12.0	1693	200
	1000	1700	9.0	1700	250
40 000	500	810	12.9	1620	200
	650	1050	9.9	1615	200
	750	1220	8.6	1627	250
	1000	1620	6.4	1620	200
50 000	500	780	9.9	1560	200
	650	1020	7.7	1569	200
	750	1170	6.6	1560	200
	1000	1570	5.0	1570	200
60 000	500	760	8.1	1520	200
	650	990	6.2	1523	200
	750	1140	5.4	1520	200
	1000	1520	4.0	1520	200
80 000	500	720	5.7	1440	200
	650	940	4.4	1446	200
	750	1090	3.9	1453	200
	1000	1450	2.9	1450	250
100 000	500	700	4.5	1400	200
	650	910	3.4	1400	200
	750	1050	3.0	1400	250

Note

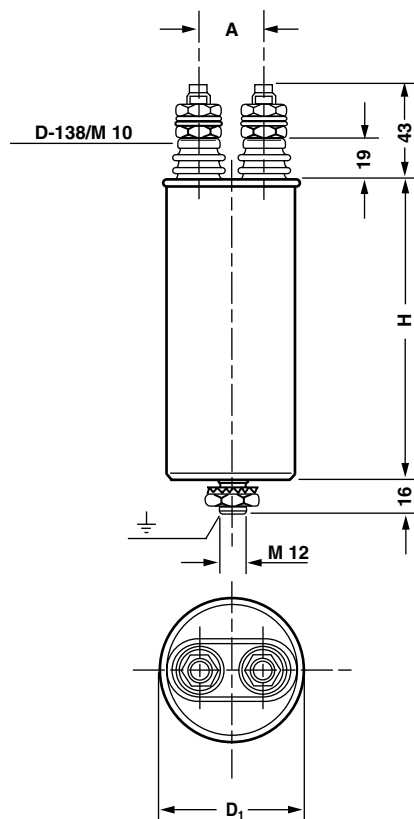
- Shown are the maximum power ratings, other power ratings, voltages, and subdivisions are available on request

Medium Frequency Capacitors

MEDIUM-FREQUENCY CAPACITORS, SELF-COOLED, SMALL CAPACITIES FOR COMPLETING FRACTIONAL OUTPUTS

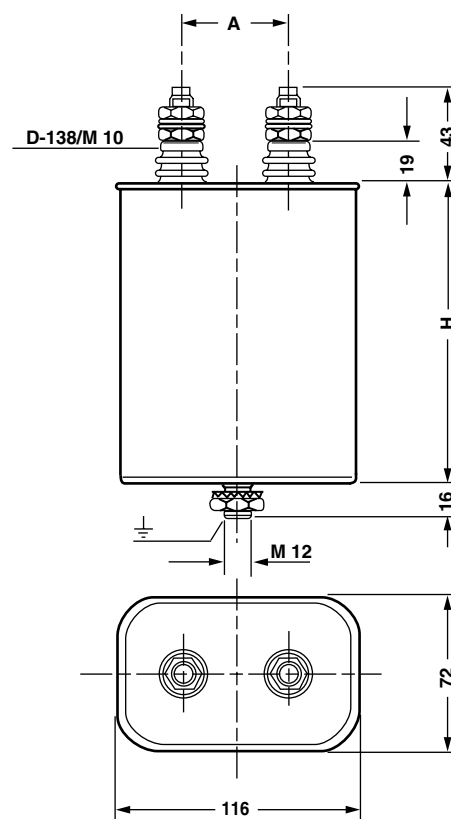
DESIGN

- All-film winding in insulated aluminum casing with non-magnetic lid
- IP00, indoor
- Operating temperature - 10 °C/+ 65 °C (= maximum temperature at surface of casing)
- Porcelain terminals with bolts M10
- The maximum permissible values U_N max., P_V max., and $I_{max.}$ must be observed



Version A

$I_{max.} = 80$ A
D1 x H = 64 x 109 mm



Version B

$I_{max.} = 80$ A
H = 180 mm

SMALL CAPACITORS SELF-COOLED					
U_N MAX. V	C_N μF	R_S Ω	P_V MAX. W	VERSION	TYPE Phao ...
2200	0.22	1×10^{-3}	3	A	.. 2.2/0.22 μ F
1800	0.45	1×10^{-3}	3	A	.. 1.8/0.45 μ F
1500	1.00	1×10^{-3}	3	A	.. 1.5/1.00 μ F
1300	2.00	1×10^{-3}	3	A	.. 1.3/2.00 μ F
900	4.00	1×10^{-3}	3	A	.. 900/4.00 μ F
2200	1.00	5×10^{-4}	9	B	.. 2.2/1.00 μ F
2200	1.50	5×10^{-4}	9	B	.. 2.2/1.50 μ F
2200	2.00	5×10^{-4}	9	B	.. 2.2/2.00 μ F
2200	3.00	5×10^{-4}	9	B	.. 2.2/3.00 μ F
1800	4.00	5×10^{-4}	9	B	.. 1.82/4.00 μ F

Formula for calculating P_v (W) and I (A):

$$Q = 2 \pi \times f \times U^2 \times C \times 10^{-9} \text{ (kvar)}$$

$$I = Q/U \text{ (A)}$$

$$P_V = I^2 \times R_S + Q \times 10^{-4} \text{ (W)}$$

EXAMPLE

Type Phao 1.5/1 μ F (= Version A) on U = 1000 V and f = 4000 Hz ?

$$Q = 2 \pi \times 4000 \times 1000^2 \times 10^{-6} \text{ (kvar)} = 25130 \text{ kvar}$$

$$I = 25 \text{ 130}/1000 = 25.13 \text{ A}$$

$$P_V = 25.13^2 \times 1 \times 10^{-3} + 25 \text{ 130} \times 10^{-4} = 3.145 \text{ W}$$

=> Version A not suitable, take version B type Phao 2.2/1 μ F

VDE Prüf- und Zertifizierungsinstitut

VDE VERBAND DER ELEKTROTECHNIK
ELEKTRONIK INFORMATIONSTECHNIK e.V.

CERTIFICATE

Registration-Number: 2556/QM/03.94

This is to certify that the company



VISHAY ELECTRONIC GmbH
Division ESTA

at the following locations

Hofmark-Aich-Straße 36, D – 84030 Landshut
Riegrova 1231, CZ - 38801 Blatna
Pasticka 1243, CZ – 38801 Blatna
Mlynska 1095, CZ – 33401 Prestice

has implemented and maintains a
Quality-Management System for the following scope:

Heavy Current Capacitors
High Voltage Units

This QM-System complies with the requirements of:

DIN EN ISO 9001:2000

This Certificate is valid until 2009-03-19.

VDE Testing and Certification Institute
Certification

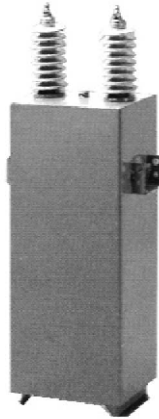
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