# SYSTEM-OPTIMISING COMPENSATION

## PARALLEL CAPACITORS

Capacitors are designed to compensate inductive reactive current of discharge lamps in 50/60 Hz networks when operated with electro-magnetic ballasts. As required by utility companies, capacitors serve to compensate the reactive current generated by the respective ballast. A power factor of $\lambda \geq 0.9$ is achieved.

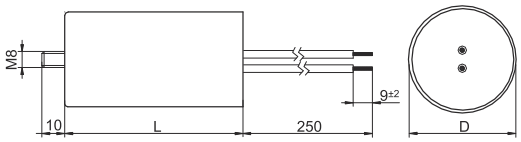
In addition, capacitors can also be used to compensate or generate phase displacements. Careful selection of the raw materials as well as special thermal treatment of the capacitor coil guarantee a long servicelife and stable capacitance.

# 4 Parallel Capacitors

# Parallel Connected Capacitors with Leads 250 V, 50/60 Hz

**Capacitors type A**

Casing: plastics, white
Fastening: male nipple M8x10
with nut and washer included
Discharge resistance
Leads: H05V2U 0,5 mm², length: 250 mm



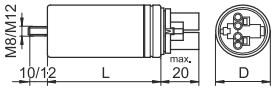

| Ref. No. | Capacity µF (±10%) | Temperature range °C | Ø (D) mm | Length (L) mm | Male nipple/ length (mm) | Weight g | Packaging unit pcs. |
|---|---|---|---|---|---|---|---|
| **571653** | 2.5 | –25 to 85 | 30 | 55 | M8x10 | 26 | 350 |
| **526169** | 4.0 | –25 to 85 | 30 | 55 | M8x10 | 27 | 350 |
| **571654** | 4.5 | –25 to 85 | 30 | 55 | M8x10 | 27 | 350 |
| **526170** | 6.0 | –25 to 85 | 30 | 55 | M8x10 | 28 | 350 |
| **526171** | 8.0 | –25 to 85 | 30 | 55 | M8x10 | 35 | 350 |
| **571655** | 9.0 | –25 to 85 | 33 | 63 | M8x10 | 40 | 250 |
| **529665** | 10.0 | –25 to 85 | 33 | 63 | M8x10 | 42 | 250 |
| **526172** | 12.0 | –25 to 85 | 33 | 63 | M8x10 | 45 | 250 |
| **543402** | 13.5 | –25 to 85 | 33 | 63 | M8x10 | 47 | 250 |
| **529666** | 16.0 | –25 to 85 | 40 | 63 | M8x10 | 61 | 200 |
| **551644** | 18.0 | –25 to 85 | 40 | 63 | M8x10 | 65 | 200 |
| **528552** | 20.0 | –25 to 85 | 40 | 63 | M8x10 | 69 | 200 |
| **508484** | 25.0 | –25 to 85 | 40 | 63 | M8x10 | 71 | 200 |
| **536743** | 30.0 | –25 to 85 | 45 | 88 | M8x10 | 95 | 120 |
| **528554** | 35.0 | –25 to 85 | 45 | 88 | M8x10 | 105 | 120 |
| **571656** | 40.0 | –25 to 85 | 45 | 88 | M8x10 | 113 | 120 |
| **528555** | 45.0 | –25 to 85 | 45 | 88 | M8x10 | 123 | 120 |
| **571657** | 50.0 | –25 to 85 | 45 | 88 | M8x10 | 127 | 120 |
| **571658** | 55.0 | –25 to 85 | 50 | 94 | M8x10 | 147 | 100 |
| **571659** | 60.0 | –25 to 85 | 50 | 94 | M8x10 | 157 | 80 |
| **571660** | 65.0 | –25 to 85 | 50 | 94 | M8x10 | 167 | 80 |

# Parallel Connected Capacitors with Break-action Mechanism

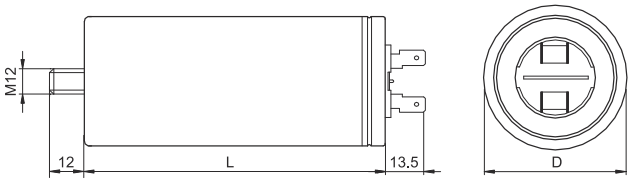
**Capacitors type B**

Casing: aluminium
Filling material: based on vegetable oil
Fastening: male nipple
with nut and washer included
Discharge resistance
Overpressure protection
On request further capacities or connectors

**A** Push-in twin terminals 0.5–1 mm²




**B** Double spade connector 6.3x0.8 acc. to IEC 61210




| Ref. No. | Capacity µF (±10%) | Temperature range °C | Drawing | Ø (D) mm | Length (L) mm | Male nipple/ length (mm) | Weight g | Packaging unit pcs. |
|---|---|---|---|---|---|---|---|---|
| **250 V, 50/60 Hz** | | | | | | | | |
| **536379** | 4.0 | –40 to 100 | A | 30 | 60 | M8x10 | 35 | 144 |
| **536380** | 6.0 | –40 to 100 | A | 30 | 60 | M8x10 | 40 | 144 |
| **536381** | 8.0 | –40 to 100 | A | 35 | 72 | M8x10 | 42 | 144 |
| **536382** | 10.0 | –40 to 100 | A | 35 | 72 | M8x10 | 46 | 144 |
| **536383** | 12.0 | –40 to 100 | A | 35 | 72 | M8x10 | 49 | 144 |
| **536386** | 18.0 | –40 to 100 | A | 40 | 72 | M8x10 | 76 | 105 |
| **536387** | 20.0 | –40 to 100 | A | 40 | 72 | M8x10 | 80 | 105 |
| **536388** | 25.0 | –40 to 100 | A | 40 | 72 | M8x10 | 82 | 105 |
| **536389** | 30.0 | –40 to 100 | A | 40 | 97 | M8x10 | 101 | 96 |
| **536390** | 32.0 | –40 to 100 | A | 40 | 97 | M8x10 | 105 | 96 |
| **536392** | 40.0 | –40 to 100 | A | 45 | 97 | M8x10 | 132 | 70 |
| **536393** | 45.0 | –40 to 100 | A | 45 | 97 | M8x10 | 142 | 70 |
| **536394** | 50.0 | –40 to 100 | A | 45 | 97 | M8x10 | 150 | 70 |
| **536396** | 60.0 | –40 to 100 | A | 45 | 121 | M8x10 | 175 | 35 |
| **537058** | 65.0 | –40 to 100 | B | 60 | 105 | M12x12 | 201 | 36 |
| **506360** | 85.0 | –40 to 100 | B | 60 | 130 | M12x12 | 248 | 36 |
| **506363** | 100.0 | –40 to 100 | B | 60 | 130 | M12x12 | 286 | 36 |

| Ref. No. | Capacity µF (±10%) | Temperature range °C | Drawing | Ø (D) mm | Length (L) mm | Male nipple/ length (mm) | Weight g | Packaging unit pcs. |
|---|---|---|---|---|---|---|---|---|
| **450 V, 50/60 Hz** | | | | | | | | |
| **536400** | 32.0 | –40 to 100 | A | 45 | 97 | M8x10 | 179 | 70 |
| **536401** | 37.0 | –40 to 100 | A | 45 | 97 | M8x10 | 200 | 70 |
| **536402** | 50.0 | –40 to 100 | B | 45 | 121 | M8x10 | 360 | 35 |
| **536404** | 60.0 | –40 to 100 | B | 60 | 130 | M12x12 | 270 | 36 |
| **536405** | 85.0 | –40 to 100 | B | 60 | 130 | M12x12 | 420 | 36 |

# 4 Capacitors for Fluorescent and Discharge Lamps

**Compensation of idle current**

When using magnetic ballasts a phase shift occurs between the mains voltage and the current drawn. This phase shift is expressed by the power factor λ, which generally ranges between a value of 0.3 and 0.7 with inductive circuits.

As a result of this phase shift, idle current, which does not boost the efficiency of the lighting unit, is also taken up from the power supply network in addition to real power. Power utility companies therefore require an increase of the power factor to values of over 0.85 for systems exceeding a certain rating (usually upwards of 250 W per external conductor).

Compensation capacitors are used to counteract idle current (by increasing the power factor) and can be connected either in parallel or in series.

Thanks to a power factor of approx. 0.95, electronic ballasts do not need to be operated with compensation capacitors.

**Compensation using series capacitors**

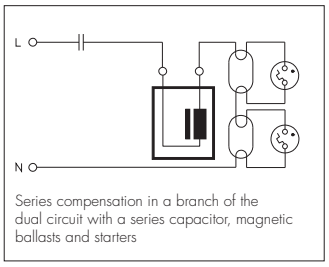
Series compensation employs a so-called dual circuit (two fluorescent lamp circuits connected in parallel), whereby the capacitor, which is connected in a branch of the circuit, over compensates the inductive idle current to such an extent that it covers the idle current of both ballasts. This type of circuit is only used with fluorescent lamps. As series capacitors are dimensioned for nominal-voltage and ballast tolerances, the lamp in the capacitor branch of the dual circuit operates with a higher current and thus also with a higher rating. Apart from differences in lamp brightness, the power loss in the circuit branch with the capacitor will also be greater.

An advantage of the dual circuit is that it prevents the radiated light from flickering.

The higher current in the so-called capacitive lamp circuit causes an up to 14% increase in lamp rating and a reduction of the lamp service life by as much as 20%. This goes hand in hand with substantial technical, ecological and economic disadvantages.

Series capacitors have to meet very high technical requirements to suit various aspects like temperature, nominal voltage, tolerances of the capacitance values, etc.

As defined by EC directive 2000/55/EC (European Standard EN 50294 governing the measurement of total power consumption), a series capacitor is considered to be a part of the ballast. If the system rating of the capacitive circuit containing the lamps and ballasts is then determined in line with the above definition, rating increases of up to 14% will become apparent in comparison to operation without a series capacitor. Experience has shown that this increased power consumption often means devices fall in the directive's "banned" category. It is therefore strongly advised that due consideration be given to the elevated power consumption values common to using series capacitors for compensation purposes.



Series compensation in a branch of the dual circuit with a series capacitor, magnetic ballasts and starters

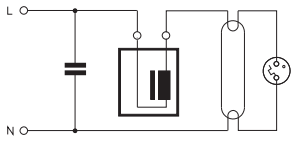
**Parallel compensation**

During parallel compensation, each lamp circuit is assigned to a capacitor connected in parallel to the mains. Only one capacitor providing sufficient capacitance is needed for luminaires with several lamps. Parallel compensation does not affect current flow through a discharge lamp. The requirements placed on parallel capacitors are clearly lower than those for series capacitors.

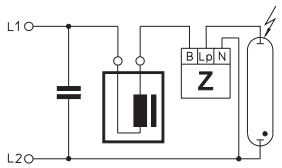
However, parallel compensation can be subject to limitations when using audio-frequency ripple control pulses if the system operates with a connected rating of over 5 kVA and ripple control frequencies of over 300 Hz are used. The respective power utility company should be consulted for advice in such cases.

Parallel compensation is used in fluorescent lamp and high-pressure discharge lamp circuits.

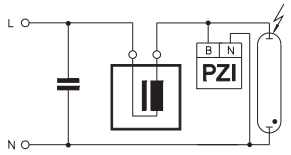
As parallel compensation offers substantial advantages, this has become the accepted method in the last few years.




Parallel compensation of a fluorescent lamp circuit




Parallel compensation of a high-pressure discharge lamp circuit with a superimposed ignitor




Parallel compensation of a high-pressure discharge lamp circuit with a pulse ignitor

**Metallised polypropylene film capacitors**

Metallised polypropylene film capacitors are designed to compensate the inductive idle current drawn by discharge lamps (fluorescent lamps, high-pressure mercury vapour lamps, high-pressure sodium vapour lamps and metal halide lamps with a ceramic discharge tube) in 50 Hz/60 Hz grids. All Vossloh-Schwabe compensation capacitors for luminaires feature a metallised polypropylene film dielectric. Compensation capacitors help to increase the power factor to values of over $\lambda$ 0.85 as required by power utility companies.

**Construction of metallised polypropylene film capacitors**

VS MPP capacitors contain a low-loss metallised polypropylene film dielectric, which is produced by depositing a thin layer of zinc and aluminium or pure aluminium vapour onto one side of the polypropylene film. The contacts at either end of the capacitor coil are created by spraying on a layer of metal and thus guarantee a high current-carrying capacity as well as a low-inductive connection between the terminals and the coils.

All capacitors with a nominal voltage upwards of 280 V are filled with oil or resin after the coils have been inserted and then hermetically sealed. This protects the coils from environmental influences and reduces partial discharge, which contributes to a long service life and stable capacitance. The effects of partial discharge only play a minor role for capacitors with a nominal voltage of under 280 V so that these devices do not need to be filled.

Hermetically sealed, filled capacitors with an overpressure contact breaker should always be used in critical ambient conditions (high humidity, aggressive atmospheres, high temperatures), if the workload and power supply conditions are unknown as well as in situations that demand increased attention to safety.

VS MPP capacitors feature a self-healing dielectric. In the event of a dielectric breakdown in the coil (short circuit), the metal coating vaporises around the breakdown site owing to the high temperature of the transient arc that is produced. Owing to the excess pressure generated during such a breakdown, the metal vapour is pushed outwards away from the centre of the site within the space of just a few microseconds. This creates a coating-free corona around the breakdown site that completely isolates it and means the capacitor remains fully functional during a dielectric breakdown.

The self-healing properties of a capacitor can decrease with time and with constant overloading. This bears the risk of a non-healing breakdown with a permanent short circuit. Therefore self-healing must not be confused with failsafe.

Compensation capacitors are divided into two type families (A and B) in accordance with IEC 61048 A2.

- Type A capacitors defined:
  "Self-healing parallel capacitors; without an (overpressure) contact breaker in the event of failure".
  They are referred to as unsecured capacitors.

- Type B capacitors defined:
  "Self-healing capacitors for series connection in lighting circuits or self-healing parallel capacitors; with an (overpressure) contact breaker in the event of failure".
  These are referred to as hermetically sealed, secured capacitors.

In accordance with the standard, the discharge resistor of both capacitor families must be capable of reducing capacitor voltage to a value of under 50 V in the space of 60 seconds after disconnection from the mains.

**Capacitors without a contact breaker, unsecured,**
**Type A capacitors in accordance with IEC 61048 A2**

IEC 61048 A2-compliant Type A capacitors are self-healing and require no short-circuit protection for normal operation.

Type A capacitors are not fitted with a specific failsafe mechanism as prescribed by the standards for Type B capacitors. Nevertheless, the requirements laid down in the standard for Type A capacitors, especially with regard to temperature and service life tests, are designed to ensure a sufficient degree of device safety and availability **provided the device was correctly installed and operated under calculable and known ambient operating conditions**.

Even so, in very rare cases these capacitors can still develop erratic behaviour due to overloading or at the end of the device's service life.

For that reason, Type A capacitors should only be integrated into luminaires for operation in ambient conditions that are uncritical with regard to flammable materials. Luminaires should feature protection against secondary damage inside and outside the luminaire in the event of a defect.

**Capacitors with a contact breaker,
secured Type B capacitors in accordance with IEC 61048 A2**

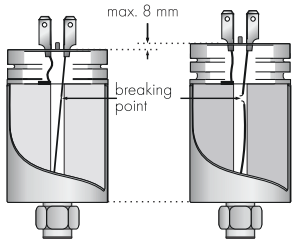
Self-healing capacitors do not require short-circuit protection for normal operation as they automatically regenerate after a dielectric breakdown. However, as a result of frequent self-healing caused by overloading (voltage, current, temperature) or towards the end of the capacitor's service life, overpressure can build up inside the capacitor (due to the decomposition products of the vaporised polypropylene).

In order to prevent the capacitor casing from exploding in such cases, hermetically sealed capacitors in accordance with IEC 61048 A2 (Type B capacitors) are fitted with an overpressure contact breaker. If excess pressure builds up within these capacitors, e.g. due to undue thermal loading or excessive voltages or at the end of the capacitor's service life, a concertina section opens out that causes the casing to expand lengthways. As a result, the wire contacts rupture at a predetermined breaking point, which irreversibly interrupts the current (contact breaker).

This type of overpressure-protected capacitor with a contact breaker is also referred to as a flame- and explosion-proof capacitor with a break-action mechanism.

Type B capacitors with a contact breaker are available in an aluminium casing.

**Contact breaker**




# Assembly Instructions for Capacitors

**For mounting and installing compensation capacitors**

**Mandatory regulations**

| | |
|---|---|
| DIN VDE 0100 | Erection of low voltage installations |
| EN 60598 | Luminaires – part 1: General requirements and tests |
| EN 55015 | Maximum values and testing methods for radio disturbance of electrical lighting facilities and similar electrical equipment |
| EN 61000-3-2 | Electromagnetic Compatibility (EMC) – part 3: maximum values – main section part 2: maximum values for mains harmonics (ballast input current up to and including 16 A per conductor) |
| EN 61048 | Operating devices for lamps – capacitors for fluorescent lamp circuits and other discharge lamp circuits; general and safety requirements |
| EN 61049 | Operating devices for lamps – capacitors for fluorescent lamp circuits and other discharge lamp circuits; performance requirements |

**Mechanical mounting**

Fastening

Base screw (permissible torque):
- M8x10 – 5 Nm (aluminium casing)
- M8x10 – 2.2 Nm (plastic casing)

Mounting location

Any
Capacitors fitted with overpressure protection require clearance of at least 10 mm above the contacts so ensure the casing can expand unhindered if the contact breaker is triggered.

Heat transfer — Capacitors should be mounted with the greatest possible clearance to heat sources or lamps. During operation, the temperature measured at the $t_c$ point must not exceed the specified maximum value.

$t_c$ point — The $t_c$ point is defined as an arbitrary point on the surface of the capacitor, which is not specifically marked.

UV Radiation — Capacitors should not be installed in an unprotected manner directly next to any sources of light, heat radiation or convection (ballasts, lamps, heating elements, etc.) as both high temperatures and constant exposure to UV radiation can lead to premature ageing. In combination with high temperatures, UV radiation or other substances and influencing factors, chemicals such as ozone and chlorine can lead to accelerated ageing and material embrittlement.

Thermal load — All capacitor casings are made of flame-retardant materials. However, the potting material, oils and the winding material are flammable and consideration must be taken of this fact during installation. The thermal load of an MKP capacitor is approx. 40 MJ/kg.

**Safety functions**

Type A capacitors
are not fitted with any special protective functions in case of defect. Temperature-protected capacitors are a further development of Type A capacitors and feature a thermal fuse that is triggered by excess temperatures and disconnects the capacitor from the mains.

Type B capacitors
are fitted with an overpressure contact breaker in case of defects at the end of the capacitor's service life.

Connection — Parallel capacitors for fluorescent lamps:
- Casing diameter 25–30 mm: push-in terminals for 0.5–1 mm² conductors
- Casing diameter > 30 mm: push-in terminals for 0.5–1 mm² conductors

Parallel capacitors for high-pressure lamps:
- Casing diameter 25–30 mm: push-in terminals for 0.5–1 mm² conductors
- Casing diameter > 30 mm: push-in terminals for 0.5–1 mm² conductors

**Reliability and service life**

Provided the max. specified voltage and current loads, temperature, humidity and mains harmonics values are observed,
- approx. 50,000 hours for overpressure-protected parallel capacitors
- approx. 30,000 hours for parallel capacitors without overpressure protection in a plastic or aluminium casing

A 3–10% decrease in capacitance must be expected in the course of the capacitor's service life.
Failure rate: 1‰ per 1,000 operating hours when maximum voltage, current and temperature values are not exceeded.

**Electrical installation**

Nominal voltage 250 V, 50/60 Hz; 450 V, 50/60 Hz
(dependent on type)

Capacitance tolerance
±10% (±5% dependent on type)

Temperature range
–25/–40 °C to +85/+100 °C (dependent on type, details see product page)

Optional thermal fuse

Relative humidity Class F for Type B capacitors: 75% annual mean, 95% peak value on 30 days
Class G for Type A capacitors: 65% annual mean, 85% peak value on 30 days

Condensation Impermissible

**Capacitors for fluorescent lamp circuits**

| Lamp | | Parallel compensation capacitor (µF ±10% at 250 V) | |
|---|---|---|---|
| Output W | Type | 220–240 V/50 Hz µF | 220–230 V/60 Hz µF |
| 4 | T | 2** | 2** |
| 6 | T | 2** | 2** |
| 8 | T | 2** | 2** |
| 10 | T | 2 | 2 |
| 13 | T | 2 | 2 |
| 14 | T | 4.5 | 4.5 |
| 15 | T | 3.5 or 4* | 3 or 4* |
| 16 | T | 2 | 2 |
| 18 | T | 4.5 or 4* | 4** |
| 20 | T | 4.5 or 4* | 4** |
| 23 | T | 3.5 | 3 |
| 25 | T | 3.5 | 3 |
| 30 | T | 4.5 | 4 |
| 36 | T | 4.5 | 4 |
| 36-1m | T | 6.5 | – |
| 38 | T | 4.5 | 4 |
| 40 | T | 4.5 | 4 |
| 42 | T | 6.5 | – |
| 58 | T | 7 | 6 |
| 65 | T | 7 | 6 |
| 70 | T | 6 | – |
| 75 | T | 6 | – |
| 80 | T | 9 | 8 |
| 85 | T | 8 | 6.5 |
| 100 | T | 10 | 9 |
| 115 | T | 18 | 16 |
| 140 | T | 14 | 14 |
| 160 | T | 14 | 14 |
| 16 | T-U | 2 | 2 |
| 18/20 | T-U | 4.5 or 4* | 4** |
| 36/40 | T-U | 4.5 | 4 |
| 58/65 | T-U | 7 | 6 |
| 22 | T-R | 5 | 4.5 |
| 32 | T-R | 5 | 4.5 |
| 40 | T-R | 4.5 | 4 |

| Lamp | | Parallel compensation capacitor (µF ±10% at 250 V) | |
|---|---|---|---|
| Output W | Type | 220–240 V/50 Hz µF | 220–230 V/60 Hz µF |
| 5/7/9/11 | TC-S | 2** | 2** |
| 10 | TC-D/TC-T | 2 | 2 |
| 13 | TC-D/TC-T | 2 | 2 |
| 18 | TC-D/TC-T | 2 | 2 |
| 26 | TC-D/TC-T | 3.5 | 3 |
| 10 | TC-DD | 2 | 2 |
| 16 | TC-DD | 2 | 2 |
| 21 | TC-DD | 3 | 3 |
| 28 | TC-DD | 3.5 | 3 |
| 38 | TC-DD | 4.5 | 4 |
| 18 | TC-L/TC-F | 4.5 or 4* | 4** |
| 24 | TC-L/TC-F | 4.5 | 4 |
| 34 | TC-L/TC-F | 4.5 | 4 |
| 36 | TC-L/TC-F | 4.5 | 4 |

*) Two lamps connected to a ballast in series
**) Applies to one lamp connected to a ballast or two lamps connected in series

**Capacitors for discharge lamp circuits**

| Lamp | | Compensation capacitor (µF ±10%) | | | |
|---|---|---|---|---|---|
| Output W | Type | 220/230/240/252 V 50 Hz (µF) | 220 V 60 Hz (µF) | 380/400/420 V, 50 Hz (µF) | 380 V/60 Hz 60 Hz (µF) |
| **high-pressure mercury vapour lamp circuits** | | | | | |
| 50 | HM | 7 | 6 | | |
| 80 | HM | 8 | 7 | | |
| 125 | HM | 10 | 10 | | |
| 250 | HM | 18 | 15 | | |
| 400 | HM | 25 | 25 | | |
| 700 | HM | 40 | 35 | | |
| 1000 | HM | 60 | 50 | | |
| **high-pressure sodium vapour lamp circuits** | | | | | |
| 35 | HS | 6 | 5 | | |
| 50 | HS | 8 | 8 | | |
| 70 | HS | 12 | 10 | | |
| 100 | HS | 12 | 10 | | |
| 150 | HS | 20 | 16 | | |
| 250 | HS | 32 | 25 | | |
| 400 | HS | 45 | 40 | | |
| 600 | HS | 65 | 55 | 25 | 20 |
| 750 | HS | 70 | 60 | 25 | 25 |
| 1000 | HS | 100 | 85 | | |
| **metal halide lamp circuits** | | | | | |
| 35 | HI | 6 | 5 | | |
| 70 | HI | 12 | 10 | | |
| 100 | HI | 12 | 10 | | |
| 150 | HI | 20 | 16 | | |
| 250 | HI | 32 | 25 | | |
| 400 | HI | 35/45 | 35/45 | | |
| 1000 | HI | 85 | 75 | | |
| 2000 | HI | 125 | 125 | | |
| 2000 | HI | | | 37 | 37 |
| 2000 | HI | | | 60 | 60 |
| 2000 | HI | | | 60 | 60 |
| 2000 | HI | | | 100 | 100 |