

P278, Metallized Impregnated Paper, Class X1, 480 VAC

Overview

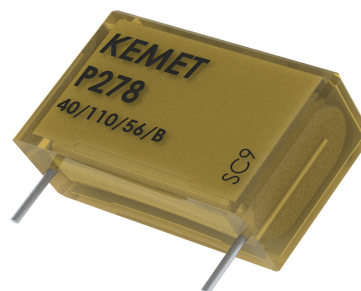
The P278 is constructed of multilayer metallized paper encapsulated and impregnated in self-extinguishing material, meeting the requirements of UL 94 V-0.

Applications

Typical applications include worldwide use as an electromagnetic interference suppressor in all X1 and across-the-line applications.

Benefits

- Approvals: ENEC, UL, cUL
- Rated voltage: 480 VAC 50/60 Hz
- Capacitance range: 0.001 μ F – 0.15 μ F
- Lead Spacing: 10.2 mm – 25.4 mm
- Capacitance tolerance: $\pm 20\%$
- Climatic category: 40/110/56, IEC 60068-1
- Tape and reel in accordance with IEC 60286-2
- RoHS compliance and lead-free terminations
- Operating temperature range of -40°C to $+110^{\circ}\text{C}$
- 100% screening factory test at 2,700 VDC
- Highest possible safety regarding active and passive flammability
- Excellent self-healing properties which ensure long life even when subjected to frequent overvoltages
- Good resistance to ionization due to impregnated paper dielectric
- Impregnated paper ensures excellent stability and reliability properties, particularly in applications with continuous operation



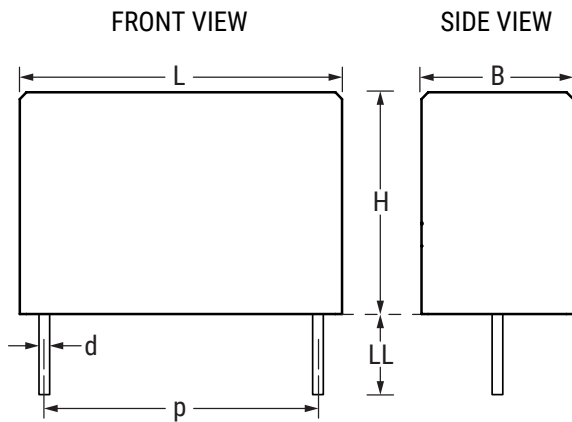
Part Number System

| P | 278 | H | E | 102 | M | 480 | A |
|-----------------|----------------------|--|---------------------|--|-----------------------|---------------------|----------------------------|
| Capacitor Class | Series | Lead Spacing (mm) | Size Code | Capacitance Code (pF) | Capacitance Tolerance | Rated Voltage (VAC) | Packaging |
| P = Paper | X1, Metallized Paper | H = 10.2 Q = 15.2 C = 20.3 S = 22.5 E = 25.4 | See Dimension Table | First two digits represent significant figures. Third digit specifies number of zeros. | M = $\pm 20\%$ | 480 = 480 | See Ordering Options Table |

Ordering Options Table

| Lead Spacing Nominal (mm) | Type of Leads and Packaging | Lead Length (mm) | KEMET Lead and Packaging Code | Legacy Lead and Packaging Code |
|----------------------------------|--|----------------------------|-------------------------------|--------------------------------|
| 10.2 | Standard Lead and Packaging Options | | | |
| | Bulk (Bag) – short leads | 6 +0/-1 | C | R06 |
| | Bulk (Bag) – maximum length leads | 30 +5/-0 | A | R30 |
| | Tape & Reel (standard reel) | H ₀ = 18.5 ±0.5 | L | R19T0 |
| | Other Lead and Packaging Options | | | |
| | Tape & Reel (large reel) | H ₀ = 18.5 ±0.5 | P | R19T1 |
| Native 10.2 formed to 7.5 | Ammo Pack | H ₀ = 18.5 ±0.5 | LAF3 | R30XA |
| 15.2 | Standard Lead and Packaging Options | | | |
| | Bulk (Bag) – short leads | 6 +0/-1 | C | R06 |
| | Bulk (Bag) – maximum length leads | 30 +5/-0 | A | R30 |
| | Tape & Reel (standard reel) | H ₀ = 18.5 ±0.5 | L | R19T0 |
| | Other Lead and Packaging Options | | | |
| | Tape & Reel (Large Reel) | H ₀ = 18.5 ±0.5 | P | R19T1 |
| 20.3 | Standard Lead and Packaging Options | | | |
| | Bulk (Tray) – short leads | 6 +0/-1 | C | R06 |
| | Bulk (Bag) – maximum length leads | 30 +5/-0 | A | R30 |
| | Tape & Reel (standard reel) | H ₀ = 18.5 ±0.5 | L | R19T0 |
| | Other Lead and Packaging Options | | | |
| | Tape & Reel (large reel) | H ₀ = 18.5 ±0.5 | P | R19T1 |
| 22.5 | Standard Lead and Packaging Options | | | |
| | Bulk (Tray) – short leads | 6 +0/-1 | C | R06 |
| | Bulk (Bag) – maximum length leads | 30 +5/-0 | A | R30 |
| | Tape & Reel (standard reel) | H ₀ = 18.5 ±0.5 | L | R19T0 |
| | Other Lead and Packaging Options | | | |
| | Tape & Reel (large reel) | H ₀ = 18.5 ±0.5 | P | R19T1 |
| 25.4 | Standard Lead and Packaging Options | | | |
| | Bulk (Tray) – short leads | 6 +0/-1 | C | R06 |
| | Bulk (Bag) – maximum length leads | 30 +5/-0 | A | R30 |

Dimensions – Millimeters



| Size Code | p | | B | | H | | L | | d | |
|---|----------|-----------|----------|-----------|----------|-----------|----------|-----------|----------|-----------|
| | Nominal | Tolerance | Nominal | Tolerance | Nominal | Tolerance | Nominal | Tolerance | Nominal | Tolerance |
| HE | 10.2 | ±0.4 | 3.9 | Maximum | 7.5 | Maximum | 13.5 | Maximum | 0.6 | ±0.05 |
| HH | 10.2 | ±0.4 | 4.1 | Maximum | 8.2 | Maximum | 13.5 | Maximum | 0.6 | ±0.05 |
| HL | 10.2 | ±0.4 | 5.1 | Maximum | 10.5 | Maximum | 13.5 | Maximum | 0.6 | ±0.05 |
| QE | 15.2 | ±0.4 | 5.2 | Maximum | 10.5 | Maximum | 18.5 | Maximum | 0.8 | ±0.05 |
| QJ | 15.2 | ±0.4 | 5.5 | Maximum | 11.1 | Maximum | 18.5 | Maximum | 0.8 | ±0.05 |
| QS | 15.2 | ±0.4 | 8.5 | Maximum | 14.3 | Maximum | 18.5 | Maximum | 0.8 | ±0.05 |
| CE | 20.3 | ±0.4 | 7.6 | Maximum | 14.0 | Maximum | 24.0 | Maximum | 0.8 | ±0.05 |
| CJ | 20.3 | ±0.4 | 9.0 | Maximum | 15.0 | Maximum | 24.0 | Maximum | 0.8 | ±0.05 |
| CP | 20.3 | ±0.4 | 11.3 | Maximum | 16.5 | Maximum | 24.0 | Maximum | 0.8 | ±0.05 |
| SJ | 22.5 | ±0.4 | 8.0 | Maximum | 17.0 | Maximum | 27.0 | Maximum | 0.8 | ±0.05 |
| SP | 22.5 | ±0.4 | 10.0 | Maximum | 19.0 | Maximum | 27.0 | Maximum | 0.8 | ±0.05 |
| SU | 22.5 | ±0.4 | 12.0 | Maximum | 22.0 | Maximum | 27.0 | Maximum | 0.8 | ±0.05 |
| EJ | 25.4 | ±0.4 | 12.1 | Maximum | 19.0 | Maximum | 30.5 | Maximum | 1.0 | ±0.05 |
| EL | 25.4 | ±0.4 | 15.3 | Maximum | 22.0 | Maximum | 30.5 | Maximum | 1.0 | ±0.05 |
| Note: See Ordering Options Table for lead length (LL) options. | | | | | | | | | | |



Performance Characteristics

| | | |
|--------------------------------|--|------|
| Rated voltage | 480 VAC 50/60Hz | |
| Capacitance range | 0.001 – 0.15 μ F | |
| Capacitance tolerance | $\pm 20\%$ | |
| Temperature range | -40°C to $+110^{\circ}\text{C}$ | |
| Climatic category | 40/110/56/B | |
| Approvals | ENEC, UL, cUL | |
| Dissipation factor | Maximum values at $+23^{\circ}\text{C}$ | |
| | 1 kHz | 1.3% |
| Test voltage between terminals | The 100% screening factory test is carried out at 2,700 VDC. The voltage level is selected to meet the requirements in applicable equipment standards. All electrical characteristics are checked after the test. It is not permitted to repeat this test as there is a risk to damage the capacitor. KEMET is not liable in such case for any failures. | |
| Insulation resistance | Between terminals: | |
| | $\geq 12,000 \text{ M}\Omega$ | |
| In DC applications | Recommended voltage $\leq 1,000 \text{ VDC}$ | |
| Resonance frequency | Tabulated self-resonance frequencies (f_0), refer to 5 mm lead length | |

Environmental Test Data

| Test | IEC Publication | Procedure |
|------------------------|-------------------------|--|
| Vibration | IEC 60068-2-6 Test Fc | 3 directions at 2 hours each 10 – 500 Hz at 0.75 mm or 98 m/seconds ² |
| Bump | IEC 60068-2-29 Test Eb | 4,000 bumps at 390 m/seconds ² |
| Change of temperature | IEC 60068-2-14 Test Na | Upper and lower rated temperature 5 cycles |
| Active flammability | IEC 60384-14 | $V_R + 20$ surge pulses at 4.0 kV (pulse every 5 seconds) |
| Passive flammability | IEC 60384-14 | IEC 60384-1, IEC 60695-11-5 Needle-flame test |
| Damp heat steady state | IEC 60068-2-78 Test Cab | $+40^{\circ}\text{C}$ and 93% RH, 56 days |

Approvals

| Certification Body | Mark | Specification | File Number |
|--------------------|---|-------------------------------------|-------------|
| Intertek Semko AB |  | EN/IEC 60384-14 | SE/0140-35A |
| UL |  | UL 60384-14 CAN/CSA-E60384-14-09 | E73869 |

Environmental Compliance

All KEMET EMI capacitors are RoHS Compliant.

Table 1 – Ratings & Part Number Reference

| Capacitance Value (μF) | Maximum Dimensions in mm | | | Lead Spacing (p) | f _o (MHz) | dV/dt (V/μs) | KEMET Part Number |
|------------------------|--------------------------|--------|--------|------------------|----------------------|--------------|-------------------|
| | B | H | L | | | | |
| 0.001 | 3.9 | 7.5 | 13.5 | 10.2 | 53 | 2,000 | P278HE102M480(1) |
| 0.0015 | 3.9 | 7.5 | 13.5 | 10.2 | 44 | 2,000 | P278HE152M480(1) |
| 0.0022 | 3.9 | 7.5 | 13.5 | 10.2 | 37 | 2,000 | P278HE222M480(1) |
| 0.0033 | 4.1 | 8.2 | 13.5 | 10.2 | 30 | 2,000 | P278HH332M480(1) |
| 0.0047 | 5.1 | 10.5 | 13.5 | 10.2 | 24 | 2,000 | P278HL472M480(1) |
| 0.0068 | 5.2 | 10.5 | 18.5 | 15.2 | 18.5 | 1,400 | P278QE682M480(1) |
| 0.010 | 5.2 | 10.5 | 18.5 | 15.2 | 15.5 | 1,400 | P278QE103M480(1) |
| 0.015 | 5.5 | 11.1 | 18.5 | 15.2 | 13 | 1,400 | P278QJ153M480(1) |
| 0.022 | 8.5 | 14.3 | 18.5 | 15.2 | 9.6 | 1,400 | P278QS223M480(1) |
| 0.033 | 7.6 | 14.0 | 24.0 | 20.3 | 9.6 | 1,000 | P278CE333M480(1) |
| 0.047 | 9.0 | 15.0 | 24.0 | 20.3 | 7.5 | 1,000 | P278CJ473M480(1) |
| 0.068 | 11.3 | 16.5 | 24.0 | 20.3 | 6.2 | 1,000 | P278CP683M480(1) |
| 0.033 | 8.0 | 17.0 | 27.0 | 22.5 | 7.2 | 1,000 | P278SJ333M480(1) |
| 0.047 | 8.0 | 17.0 | 27.0 | 22.5 | 6 | 1,000 | P278SJ473M480(1) |
| 0.068 | 10.0 | 19.0 | 27.0 | 22.5 | 4.8 | 1,000 | P278SP683M480(1) |
| 0.1 | 12.0 | 22.0 | 27.0 | 22.5 | 3.6 | 600 | P278SU104M480(1) |
| 0.1 | 12.1 | 19.0 | 30.5 | 25.4 | 3.9 | 600 | P278EJ104M480(1) |
| 0.15 | 15.3 | 22.0 | 30.5 | 25.4 | 3.2 | 600 | P278EL154M480(1) |
| Capacitance Value (μF) | B (mm) | H (mm) | L (mm) | Lead Spacing (p) | f _o (MHz) | dV/dt (V/μs) | KEMET Part Number |

(1) Insert ordering code for lead type and packaging. See Ordering Options Table for available options.

Soldering Process

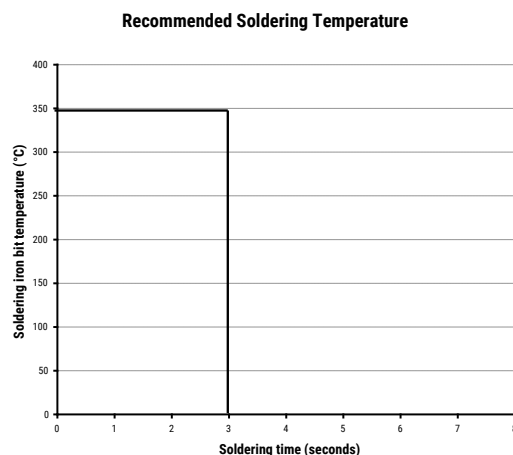
The implementation of the RoHS directive has resulted in the selection of SnAuCu (SAC) alloys or SnCu alloys as primary solder. This has increased the liquidus temperature from 183°C for SnPb eutectic alloy to 217 – 221°C for the new alloys. As a result, the heat stress to the components, even in wave soldering, has increased considerably due to higher pre-heat and wave temperatures. Polypropylene capacitors are especially sensitive to heat (the melting point of polypropylene is 160 – 170°C). Wave soldering can be destructive, especially for mechanically small polypropylene capacitors (with lead spacing of 5 mm to 15 mm). Great care has to be taken during soldering. The recommended solder profiles from KEMET should be used. Please consult KEMET with any questions. In general, the wave soldering curve from IEC Publication 61760-1 Edition 2, serves as a solid guideline for a successful soldering. Please see Figure 1.

Reflow soldering is not recommended for through-hole film capacitors. Exposing capacitors to a soldering profile in excess of the above the recommended limits may result in degradation or permanent damage to the capacitors.

Do not place the polypropylene capacitor through an adhesive curing oven to cure resin for surface mount components. Insert through-hole parts after the curing of surface mount parts. Consult KEMET to discuss the actual temperature profile in the oven if through-hole components must pass through the adhesive curing process. A maximum two soldering cycles are recommended. Please allow time for the capacitor surface temperature to return to a normal before the second soldering cycle.

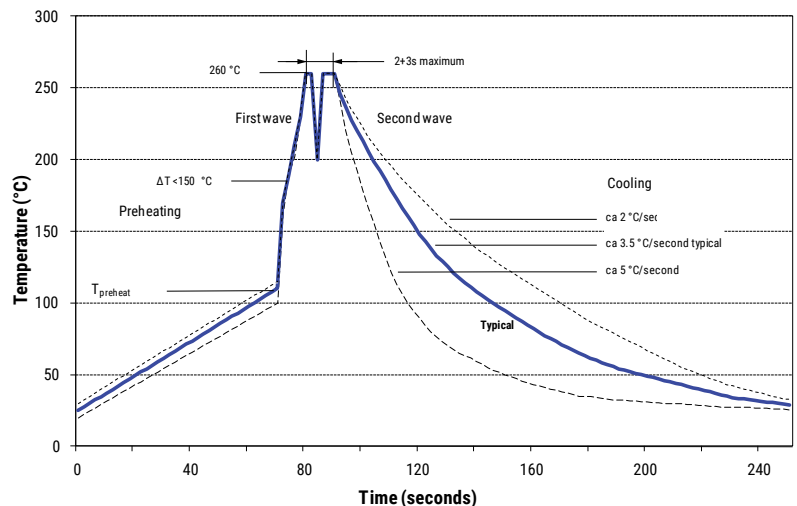
Manual Soldering Recommendations

Following is the recommendation for manual soldering with a soldering iron.



The soldering iron tip temperature should be set at 350°C (+10°C maximum) with the soldering duration not to exceed more than 3 seconds.

Wave Soldering Recommendations



Soldering Process cont'd

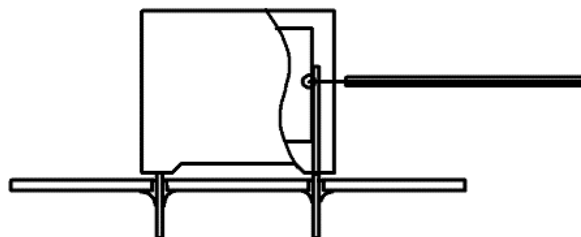
Wave Soldering Recommendations cont'd

1. The table indicates the maximum set-up temperature of the soldering process
Figure 1

| Dielectric film material | Maximum Preheat Temperature | | | Maximum Peak Soldering Temperature | |
|--------------------------|-----------------------------|-------------------------|-------------------------|------------------------------------|-------------------------|
| | Capacitor Pitch ≤ 10 mm | Capacitor Pitch = 15 mm | Capacitor Pitch > 15 mm | Capacitor Pitch ≤ 15 mm | Capacitor Pitch > 15 mm |
| Polyester | 130°C | 130°C | 130°C | 270°C | 270°C |
| Polypropylene | 100°C | 110°C | 130°C | 260°C | 270°C |
| Paper | 130°C | 130°C | 140°C | 270°C | 270°C |
| Polyphenylene sulphide | 150°C | 150°C | 160°C | 270°C | 270°C |

2. The maximum temperature measured inside the capacitor:
Set the temperature so that the maximum temperature inside the element is below the limit:

| Dielectric Film Material | Maximum temperature measured inside the element |
|--------------------------|---|
| Polyester | 160°C |
| Polypropylene | 110°C |
| Paper | 160°C |
| Polyphenylene sulphide | 160°C |



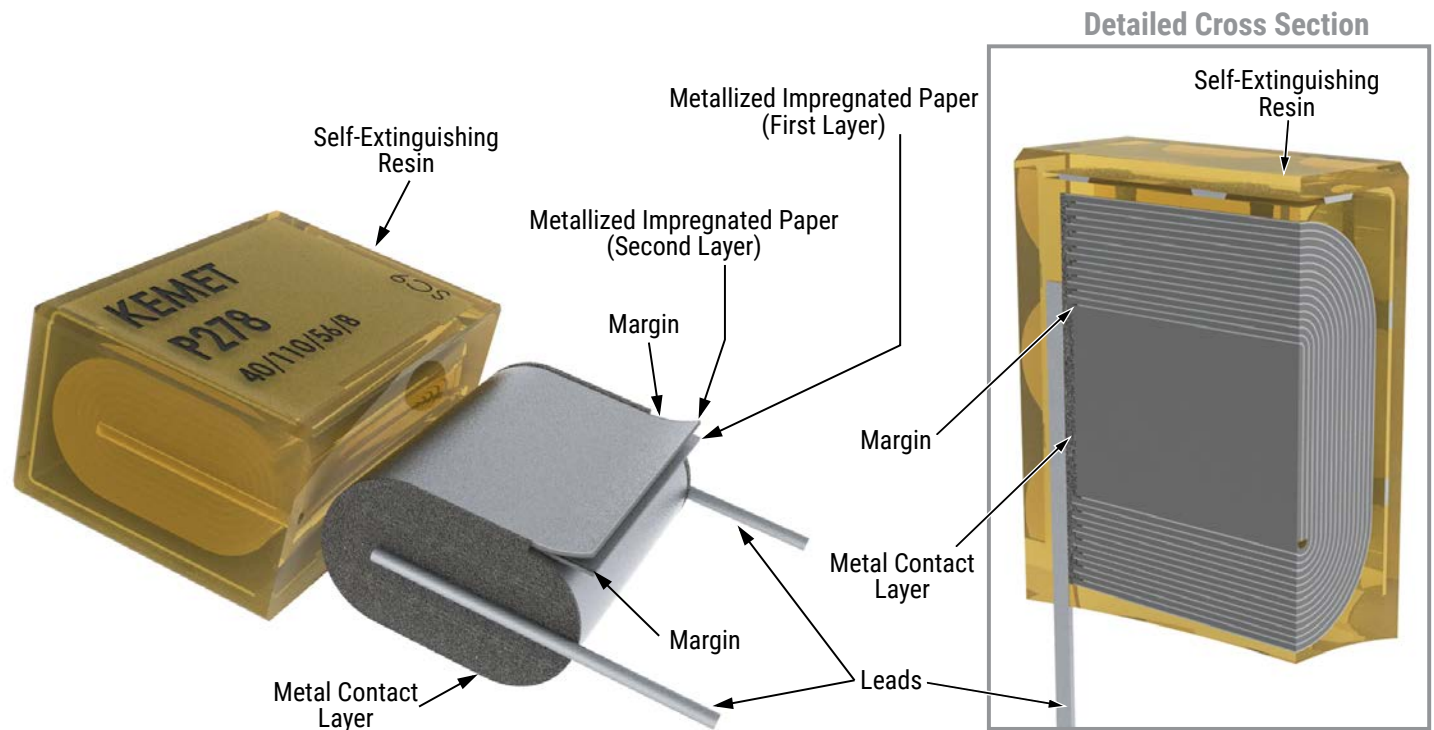
Temperature monitored inside the capacitor.

Selective Soldering Recommendations

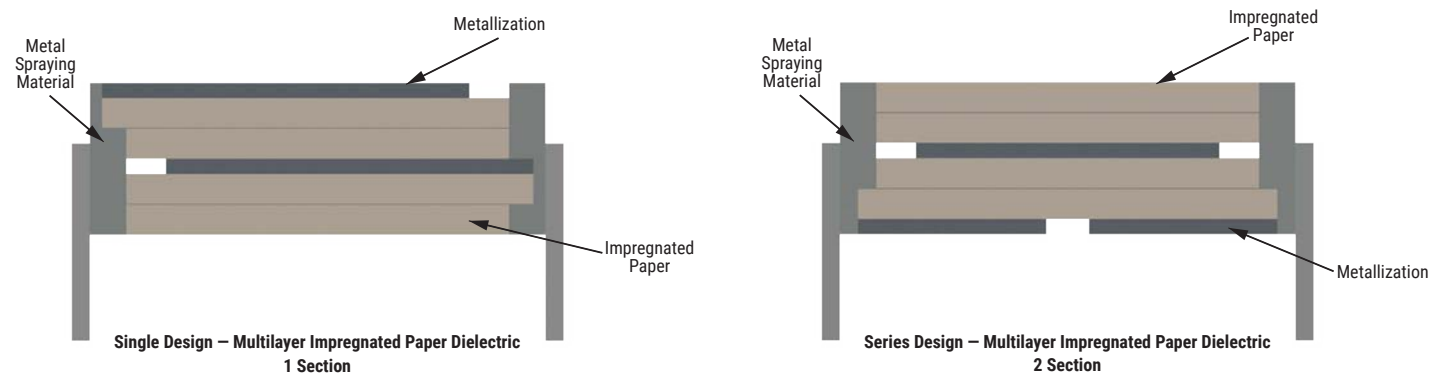
Selective dip soldering is a variation of reflow soldering. In this method, the printed circuit board with through-hole components to be soldered is preheated and transported over the solder bath as in normal flow soldering, without touching the solder. When the board is over the bath, it is stopped and pre-designed solder pots are lifted from the bath with molten solder only at the places of the selected components, and pressed against the lower surface of the board to solder the components.

The temperature profile for selective soldering is similar to the double wave flow soldering outlined in this document. **However, instead of two baths, there is only one with a time from 3 to 10 seconds.** In selective soldering, the risk of overheating is greater than in double wave flow soldering. Great care must be taken so that the parts are not overheated.

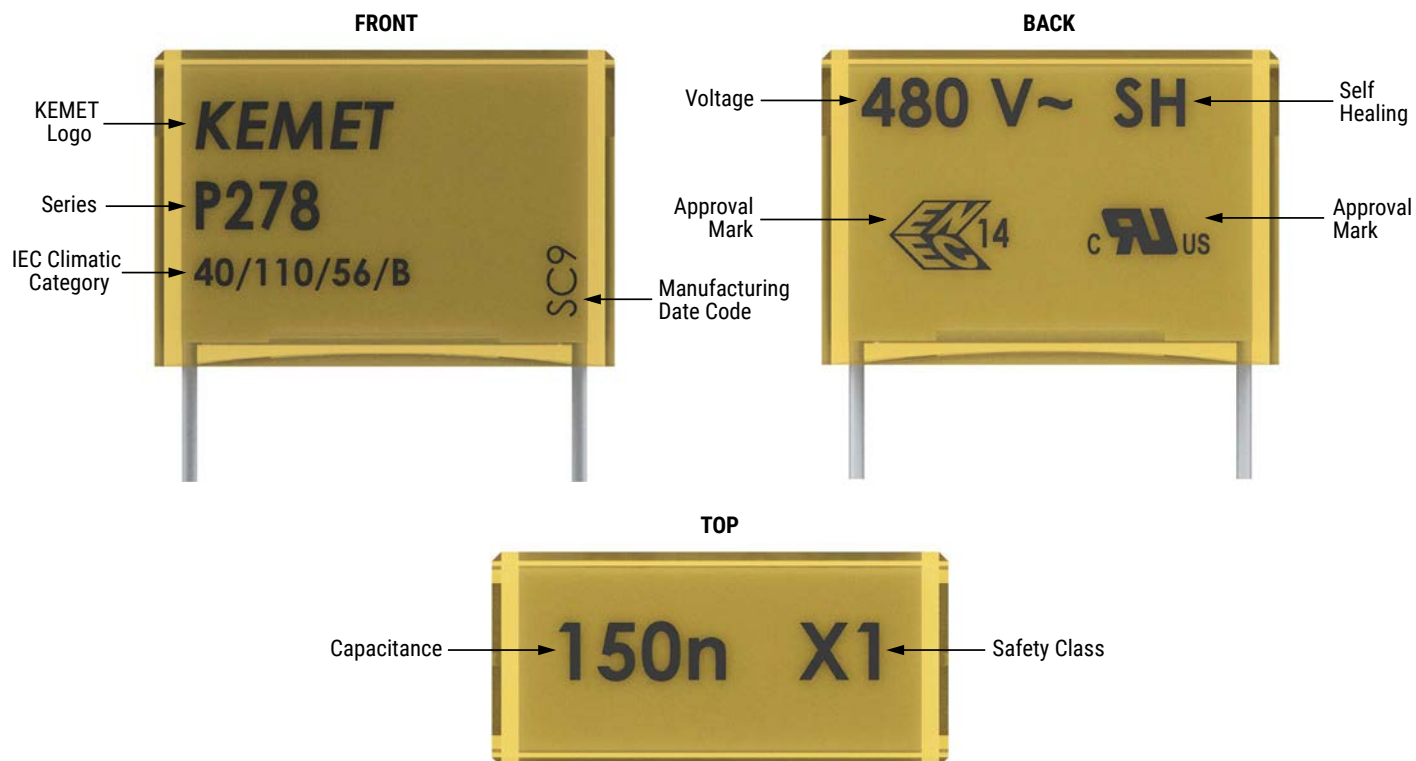
Construction



Winding Scheme



Marking

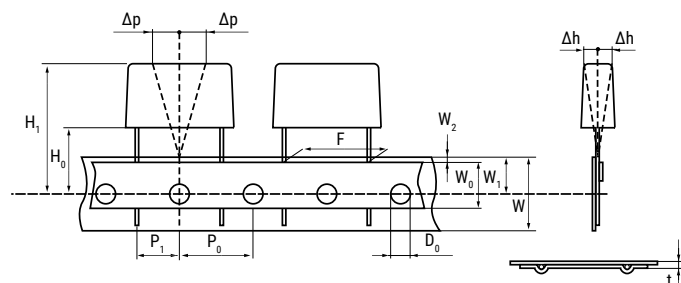


Packaging Quantities

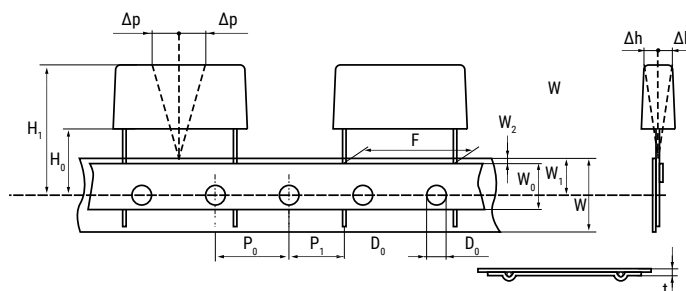
| Lead Spacing (mm) | Thickness (mm) | Height (mm) | Length (mm) | Bulk Short Leads | Bulk Long Leads | Standard Reel 360 mm | Large Reel 500 mm | Ammo Formed |
|----------------------|-------------------|----------------|----------------|---------------------|--------------------|-------------------------|----------------------|----------------|
| 10.2 | 3.9 | 7.5 | 13.5 | 2,000 | 1,000 | 700 | 1,400 | 800 |
| | 4.1 | 8.2 | 13.5 | 2,000 | 1,000 | 600 | | 780 |
| | 5.1 | 10.5 | 13.5 | 1,600 | 800 | 600 | 1,200 | 630 |
| 15.2 | 5.5 | 12.5 | 18.0 | 1,000 | 500 | 600 | | |
| | 6.5 | 12.5 | 18.0 | 600 | 400 | 400 | | |
| | 7.5 | 14.5 | 18.0 | 600 | 400 | 400 | | |
| | 8.5 | 16.0 | 18.0 | 400 | 250 | 400 | | |
| | 5.2 | 10.5 | 18.5 | 1000 | 500 | 600 | | |
| | 5.5 | 11.1 | 18.5 | 1,000 | 500 | 500 | | |
| | 6.0 | 12.5 | 18.5 | 600 | 400 | 400 | | |
| | 7.3 | 13.0 | 18.5 | 600 | 400 | 400 | 800 | |
| | 7.8 | 13.5 | 18.5 | 600 | 400 | 400 | | |
| | 8.5 | 14.3 | 18.5 | 500 | 300 | 350 | | |
| 20.3 | 7.6 | 14.0 | 24.0 | 1,500 | 250 | 250 | 500 | |
| | 8.4 | 14.0 | 24.0 | 1,200 | 200 | 250 | 500 | |
| | 9.0 | 15.0 | 24.0 | 1,500 | 200 | 250 | | |
| | 11.3 | 16.5 | 24.0 | 1,000 | 150 | 180 | 400 | |
| 22.5 | 8.0 | 17.0 | 27.0 | 1,200 | 200 | | | |
| | 10.0 | 19.0 | 27.0 | 1,000 | 150 | 200 | | |
| | 12.0 | 22.0 | 27.0 | 800 | 100 | 180 | 350 | |
| 25.4 | 10.6 | 16.1 | 30.5 | 1,000 | 150 | | | |
| | 10.5 | 17.3 | 30.5 | 1,000 | 100 | | | |
| | 12.1 | 19.0 | 30.5 | 800 | 100 | | | |
| | 15.3 | 22.0 | 30.5 | 600 | 75 | | | |

Lead Taping & Packaging (IEC 60286-2)

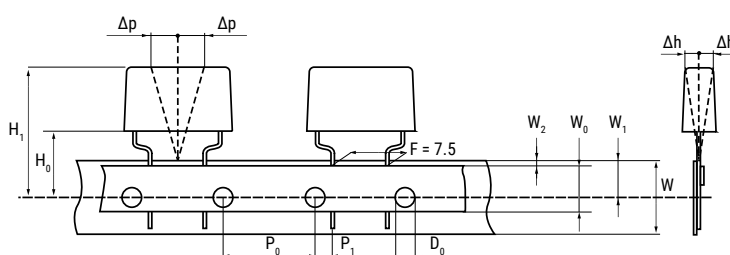
Lead Spacing 10.2 – 15.2 mm



Lead Spacing 20.3 – 22.5 mm



Formed Leads from 10.2 to 7.5 mm



Taping Specification

| Dimensions in mm | | | | | | | | Standard IEC 60286-2 |
|-------------------------------|---------|-------------------------------|---------------------|---------------------|---------------------|---------------------|------------------------|-------------------------|
| Lead spacing | +6/-0.1 | F | Formed 7.5 | 10.2 | 15.2 | 20.3 | 22.5 | F |
| Carrier tape width | +/-0.5 | W | 18 | 18 | 18 | 18 | 18 | 18 ^{+1/-0.5} |
| Hold-down tape width | +/-0.3 | W ₀ | 9 | 12 | 12 | 12 | 12 | |
| Position of sprocket hole | +/-0.5 | W ₁ | 9 | 9 | 9 | 9 | 9 | 9 ^{+0.75/-0.5} |
| Distance between tapes | Maximum | W ₂ | 3 | 3 | 3 | 3 | 3 | 3 |
| Sprocket hole diameter | +/-0.2 | D ₀ | 4 | 4 | 4 | 4 | 4 | 4 |
| Feed hole lead spacing | +/-0.3 | P ₀ ⁽¹⁾ | 12.7 ⁽⁴⁾ | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 |
| Distance lead – feed hole | +/-0.7 | P ₁ | 3.75 | 7.6 | 5.1 | 8.9 | 5.3 | P ¹ |
| Deviation tape – plane | Maximum | Δp | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| Lateral deviation | Maximum | Δh | 2 | 2 | 2 | 2 | 2 | 2 |
| Total thickness | +/-0.2 | t | 0.7 | 0.7 | 0.7 | 0.7 | 0.9 ^{MAX} | 0.9 ^{MAX} |
| Sprocket hole/cap body | Nominal | H ₀ ⁽²⁾ | 18 ^{+2/-0} | 18 ^{+2/-0} | 18 ^{+2/-0} | 18 ^{+2/-0} | 18.5 ^{+/-0.5} | 18 ^{+2/-0} |
| Sprocket hole/top of cap body | Maximum | H ₁ ⁽³⁾ | 35 | 35 | 35 | 35 | 58 | 58 ^{MAX} |

(1) Maximum cumulative feed hole error, 1 mm per 20 parts.

(2) 16.5 mm available on request.

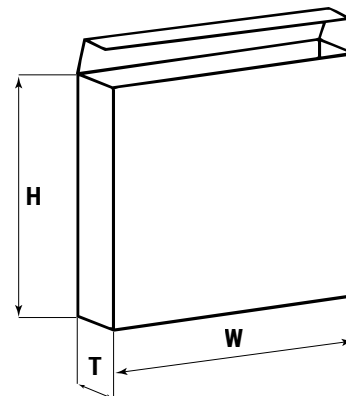
(3) Depending on case size.

(4) 15 mm available on request.

Lead Taping & Packaging (IEC 60286-2) cont'd

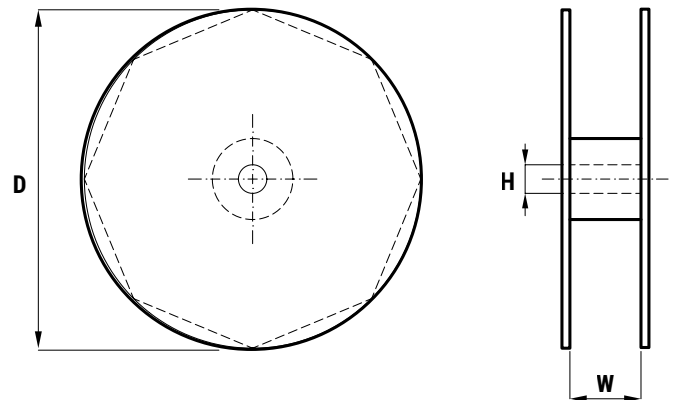
Ammo Specifications

| Series | Dimensions (mm) | | |
|--------|-----------------|-----|----|
| | H | W | T |
| P278 | 330 | 330 | 50 |



Reel Specifications

| Series | Dimensions (mm) | | |
|--------|-----------------|----|----------|
| | D | H | W |
| P278 | 360 500 | 30 | 46 (Max) |



Manufacturing Date Code (IEC-60062)

| Y = Year, Z = Month | | | |
|---------------------|------|-----------|------|
| Year | Code | Month | Code |
| 2000 | M | January | 1 |
| 2001 | N | February | 2 |
| 2002 | P | March | 3 |
| 2003 | R | April | 4 |
| 2004 | S | May | 5 |
| 2005 | T | June | 6 |
| 2006 | U | July | 7 |
| 2007 | V | August | 8 |
| 2008 | W | September | 9 |
| 2009 | X | October | 0 |
| 2010 | A | November | N |
| 2011 | B | December | D |
| 2012 | C | | |
| 2013 | D | | |
| 2014 | E | | |
| 2015 | F | | |
| 2016 | H | | |
| 2017 | J | | |
| 2018 | K | | |
| 2019 | L | | |
| 2020 | M | | |

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