

## Overview

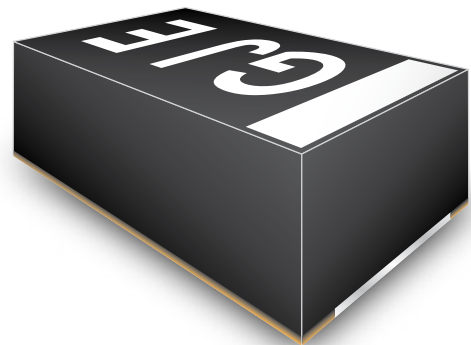
The T488 Series uses a substrate termination design, which results in one of the highest volumetric efficient packaging technologies available today in Tantalum Chip Capacitors. This series offers high capacitance values in the small EIA 2012-12 (2.0 mm (L) x 1.2 mm (W) x 1.2 mm (H)) package size. The T488 Series is ideal for use in densely populated circuits such as smart phones and digital cameras where space restrictions do not allow for larger and more commonly available case sizes.

## Applications

Typical applications include densely populated circuits where space restrictions do not allow for larger and more commonly available case sizes such as smart phones, digital cameras, MP3 players, GPS navigation systems, WiFi modules, analytical and test equipment, and audio/sound circuits.

## Benefits

- Tantalum Technology
- Substrate Termination
- EIA Case Size 2012 (0805 MLCC Equivalent)
- Low Profile: 1.2 mm maximum
- Improved Volumetric Efficiency
- Use up to 80% of rated voltage (20% derating)
- Capacitance: 220 µF
- Voltage: 4 V
- RoHS Compliant and Halogen Free
- 125°C maximum temperature capability
- Lead free 260°C reflow capable
- MSL Reflow Temp ≤ 260°C = 1



## Environmental Compliance

RoHS Compliant (6/6) according to Directive 2002/95/EC. Halogen free.



RoHS Compliant



Halogen Free

## Ordering Information

T	488	R	227	M	004	A	A	E2K0
Capacitor Class	Series	Case Size	Capacitance Code (pF)	Capacitance Tolerance	Voltage	Failure Rate/ Design	Lead Material	ESR Code
T = Tantalum	Substrate Terminal MnO <sub>2</sub>	R = 2012	First two digits represent significant figures. Third digit specifies number of zeros. e.g., 227 = 220 μF	M = ±20%	004 = 4 V	A = N/A	A = Ni - Au	E = ESR Last three digits specify ESR in mΩ (2K0 = 2,000 mΩ)

## Performance Characteristics

Item	Specifications
Operating Temperature	-55°C to 125°C
Rated Capacitance Range	220 μF @ 120 Hz/25°C
Capacitance Tolerance	M Tolerance (20%)
Rated Voltage Range	4 V
ESR (100 kHz)	Refer to Part Number Electrical Specification Table
Leakage Current	≤ 0.1 CV (μA) at rated voltage after 5 minutes

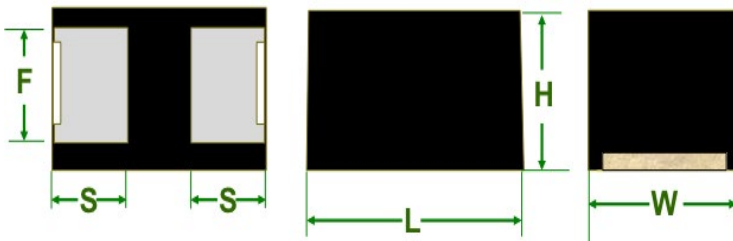
## Qualification

Test	Condition/Characteristics				
Endurance	85°C @ rated voltage, 1,000 hours	Δ C/C	Within initial Δ C/C limits		
		DF	Within 1.5 x initial limits		
		DCL	Within initial limit		
Damp Heat Steady State	40°C, 90 to 95% RH, 500 hours	Δ C/C	Within ±20% of initial Δ C/C limits		
		DF	Within 1.5 x initial limits		
		DCL	Within initial limit		
Temperature Stability	Extreme temperature exposure at -55°C and +125°C	Δ C/C	+25°C	-55°C	+125°C
		DF	IL*	-20% to 0% of Δ C/C	-50% - 0% of Δ C/C
		DCL	IL	IL	IL
Surge Voltage	1.3 Vr, 85°C, 1,000 Ω resistor, 1,000 cycles	Δ C/C	Within initial Δ C/C limits		
		DF	Within initial limit		
		DCL	Within initial limit		
Mechanical Shock	100 G, Saw-Tooth wave	Δ C/C	Within initial Δ C/C limits		
		DF	Within initial limit		
		DCL	Within initial limit		
Vibration	Frequency: 10 to 2 kHz, Sweep: 1 minute, Amplitude of vibration: 1.5 mm, Vibration Time: Each plane shall be 2 hours for a total of 4 hours.	Δ C/C	Within initial Δ C/C limits		
		DF	Within initial limit		
		DCL	Within initial limit		
Terminal strength	Strength: 4.9 N, Time: 10 ±0.5 seconds (two directions)	Visual	No evidence of mechanical damage		

\*IL = Initial limit

## Dimensions – Millimeters

Metric will govern



KEMET	EIA	L	W	H	F	S
R	2012-12	2.0 ±0.1	1.35 ±0.1	1.2 Maximum	0.9 ±0.1	0.55 ±0.1

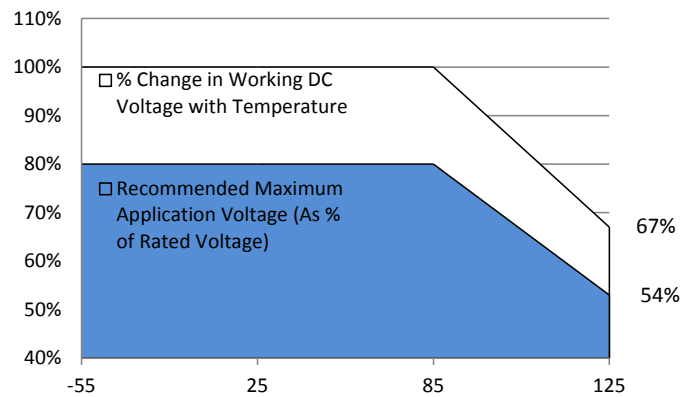
**Table 1 – Ratings & Part Number Reference**

Rated Voltage	Rated Capacitance	Case Code/ Case Size	KEMET Part Number	DC Leakage	DF	ESR	Maximum Allowable Ripple Current			Rated Temp.
							(mA) 100 kHz, 25°C	(mA) 100 kHz, 85°C	(mA) 100 kHz, 125°C	
VDC	μF	KEMET/EIA	(See below for part options)	μA @ +20°C Maximum/ 5 Minutes	% @ +20°C 120 Hz Maximum	Ω @ +20°C 100 kHz Maximum				°C
4	220	R/2012-12	T488R227M004AAE2K0	88.0	6.0	2	224	202	90	125

Refer to Ordering Information for additional detail.

## Recommended Voltage Derating Guidelines

	-55°C to 85°C	85°C to 125°C
% Change in Working DC Voltage with Temperature	V <sub>R</sub>	See Chart
Recommended Maximum Application Voltage	80% of V <sub>R</sub>	See Chart



## Ripple Current/Ripple Voltage

Permissible AC ripple voltage and current are related to equivalent series resistance (ESR) and the power dissipation capabilities of the device. Permissible AC ripple voltage which may be applied is limited by two criteria:

1. The positive peak AC voltage plus the DC bias voltage, if any, must not exceed the DC voltage rating of the capacitor.
2. The negative peak AC voltage in combination with bias voltage, if any, must not exceed the allowable limits specified for reverse voltage. See the Reverse Voltage section for allowable limits.

The maximum power dissipation by case size can be determined using the table at right. The maximum power dissipation rating stated in the table must be reduced with increasing environmental operating temperatures. Refer to the table below for temperature compensation requirements.

Temperature Compensation Multipliers for Maximum Power Dissipation		
T ≤ 25°C	T ≤ 85°C	T ≤ 125°C
1.00	0.90	0.40

KEMET Case Code	EIA Case Code	Maximum Power Dissipation (P max) mWatts @ 25°C w/+20°C Rise
R	2012-12	25

The maximum power dissipation rating must be reduced with increasing environmental operating temperatures. Refer to the Temperature Compensation Multiplier table for details.

T = Environmental Temperature

Using the P max of the device, the maximum allowable rms ripple current or voltage may be determined.

$$I(max) = \sqrt{P_{max}/R}$$

$$E(max) = Z \sqrt{P_{max}/R}$$

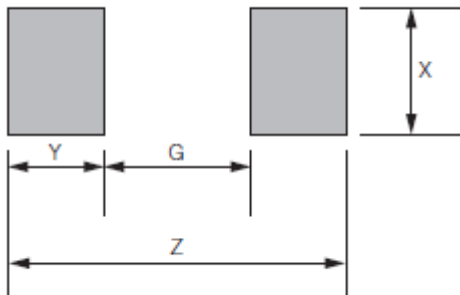
- I = rms ripple current (amperes)
- E = rms ripple voltage (volts)
- P max = maximum power dissipation (watts)
- R = ESR at specified frequency (ohms)
- Z = Impedance at specified frequency (ohms)

## Reverse Voltage

Solid tantalum capacitors are polar devices and may be permanently damaged or destroyed if connected with the wrong polarity. The positive terminal is identified on the capacitor body by a stripe plus in some cases a beveled edge. A small degree of transient reverse voltage is permissible for short periods per the table. The capacitors should not be operated continuously in reverse mode, even within these limits.

Temperature	Permissible Transient Reverse Voltage
25°C	15% of Rated Voltage
85°C	5% of Rated Voltage
125°C	1% of Rated Voltage

**Table 2 – Land Dimensions/Courtyard**



KEMET Case	Metric Size Code EIA	Dimensions in mm			
		G Maximum	Z Minimum	X Minimum	Y ref
R	2012-12	1.05	2.05	0.80	1.05

## Soldering Process

KEMET's families of surface mount capacitors are compatible with wave (single or dual), convection, IR, or vapor phase reflow techniques. Preheating of these components is recommended to avoid extreme thermal stress. KEMET's recommended profile conditions for convection and IR reflow reflect the profile conditions of the IPC/J-STD-020D standard for moisture sensitivity testing. The devices can safely withstand a maximum of three reflow passes at these conditions.

Note that although the X/7343-43 case size can withstand wave soldering, the tall profile (4.3 mm maximum) dictates care in wave process development.

Hand soldering should be performed with care due to the difficulty in process control. If performed, care should be taken to avoid contact of the soldering iron to the molded case. The iron should be used to heat the solder pad, applying solder between the pad and the termination, until reflow occurs. Once reflow occurs, the iron should be removed immediately. "Wiping" the edges of a chip and heating the top surface is not recommended.

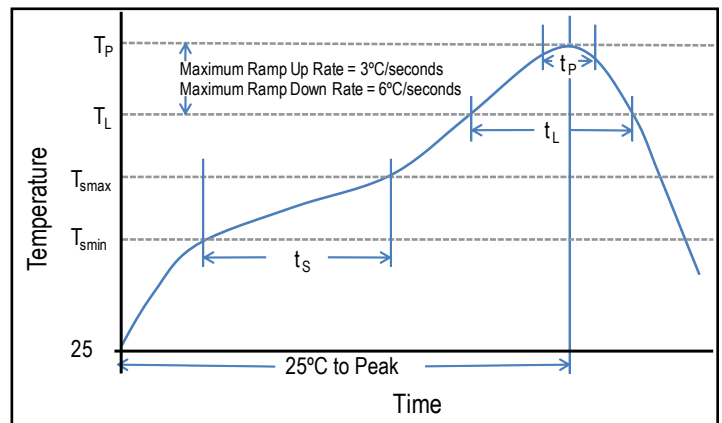
During typical reflow operations, a slight darkening of the gold-colored epoxy may be observed. This slight darkening is normal and not harmful to the product. Marking permanency is not affected by this change.

Profile Feature	SnPb Assembly	Pb-Free Assembly
Preheat/Soak		
Temperature Minimum ( $T_{Smin}$ )	100°C	150°C
Temperature Maximum ( $T_{Smax}$ )	150°C	200°C
Time ( $t_s$ ) from $T_{Smin}$ to $T_{Smax}$	60 – 120 seconds	60 – 120 seconds
Ramp-up Rate ( $T_L$ to $T_P$ )	3°C/seconds maximum	3°C/seconds maximum
Liquidous Temperature ( $T_L$ )	183°C	217°C
Time Above Liquidous ( $t_L$ )	60 – 150 seconds	60 – 150 seconds
Peak Temperature ( $T_P$ )	220°C* 235°C**	250°C* 260°C**
Time within 5°C of Maximum Peak Temperature ( $t_p$ )	20 seconds maximum	30 seconds maximum
Ramp-down Rate ( $T_P$ to $T_L$ )	6°C/seconds maximum	6°C/seconds maximum
Time 25°C to Peak Temperature	6 minutes maximum	8 minutes maximum

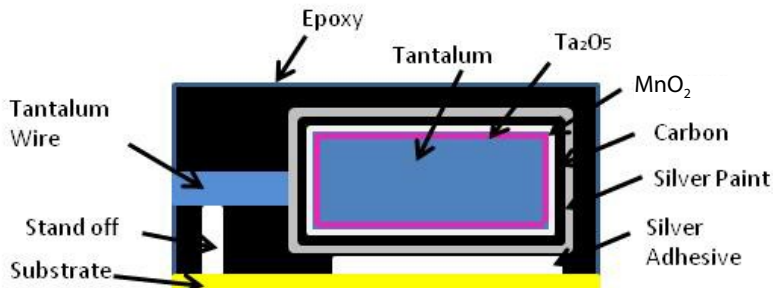
Note: All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow.

\*Case Size D, E, P, Y, and X

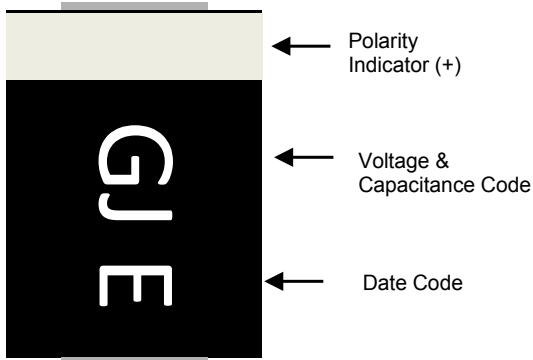
\*\*Case Size A, B, C, H, I, K, M, R, S, T, U, V, W, and Z



## Construction



## Capacitor Marking



Code	G
Rated Voltage	4 V

Code	J
Capacitance	220

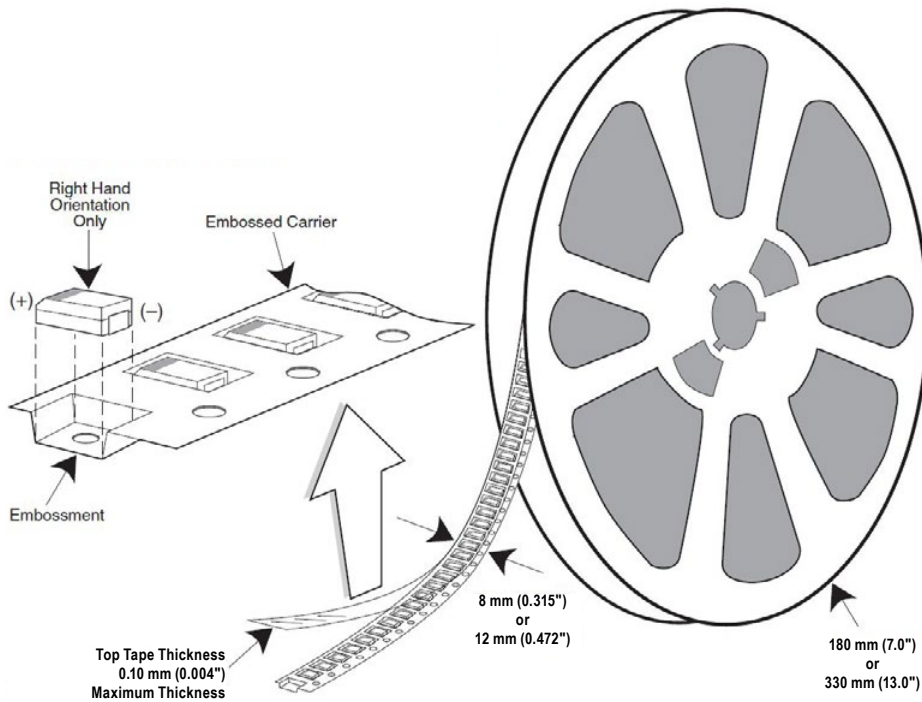
Date Code *												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	A	B	C	D	E	F	G	H	J	K	L	M
2014	N	P	Q	R	S	T	U	V	W	X	Y	Z
2015	a	b	c	d	e	f	g	h	j	k	l	m
2016	n	p	q	r	s	t	u	v	w	x	y	z

## Storage

The T488 Series is shipped in moisture barrier bags with a desiccant and moisture indicator card. This series is classified as MSL3 (Moisture Sensitivity Level 3). Product contained within the moisture barrier bags should be stored in normal working environments with temperatures not to exceed 30°C and humidity not in excess of 60% RH.

## Tape & Reel Packaging Information

KEMET's molded tantalum and aluminum chip capacitor families are packaged in 8 and 12 mm plastic tape on 7" and 13" reels in accordance with *EIA Standard 481-1: Embossed Carrier Taping of Surface Mount Components for Automatic Handling*. This packaging system is compatible with all tape-fed automatic pick-and-place systems.

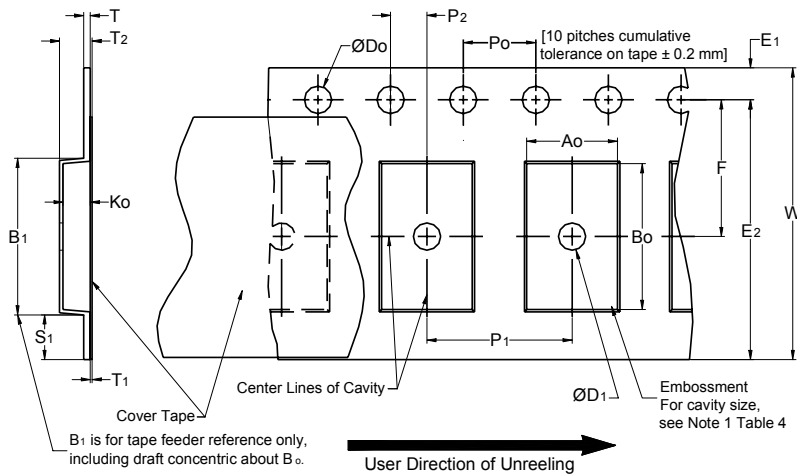


**Table 3 – Packaging Quantity**

KEMET Case Codes		Tape and Reel Dimensions	
		Tape Width (mm)	180 mm (7" diameter)
R	2012	8	3,000

(Quantity per reel)

**Figure 1 – Embossed (Plastic) Carrier Tape Dimensions**



**Table 4 – Embossed (Plastic) Carrier Tape Dimensions**

Metric will govern

Constant Dimensions — Millimeters (Inches)									
Tape Size	D <sub>0</sub>	D <sub>1</sub> Minimum Note 1	E <sub>1</sub>	P <sub>0</sub>	P <sub>2</sub>	R Reference Note 2	S <sub>1</sub> Minimum Note 3	T Maximum	T <sub>1</sub> Maximum
8 mm	1.5 +0.10/-0.0 (0.059 +0.004/-0.0)	1.0 (0.039)	1.75 ±0.10 (0.069 ±0.004)	4.0 ±0.10 (0.157 ±0.004)	2.0 ±0.05 (0.079 ±0.002)	25.0 (0.984)	0.600 (0.024)	0.600 (0.024)	0.100 (0.004)
12 mm		1.5 (0.059)				30 (1.181)			
16 mm									
Variable Dimensions — Millimeters (Inches)									
Tape Size	Pitch	B <sub>1</sub> Maximum Note 4	E <sub>2</sub> Minimum	F	P <sub>1</sub>	T <sub>2</sub> Maximum	W Maximum	A <sub>0</sub> , B <sub>0</sub> & K <sub>0</sub>	
8 mm	Single (4 mm)	4.35 (0.171)	6.25 (0.246)	3.5 ±0.05 (0.138 ±0.002)	4.0 ±0.10 (0.157 ±0.004)	2.5 (0.098)	8.3 (0.327)	Note 5	
12 mm	Single (4 mm) & Double (8 mm)	8.2 (0.323)	10.25 (0.404)	5.5 ±0.05 (0.217 ±0.002)	8.0 ±0.10 (0.315 ±0.004)	4.6 (0.181)	12.3 (0.484)		
16 mm	Triple (12 mm)	12.1 (0.476)	14.25 (0.561)	5.5 ±0.05 (0.217 ±0.002)	8.0 ±0.10 (0.315 ±0.004)	4.6 (0.181)	16.3 (0.642)		

- The embossment hole location shall be measured from the sprocket hole controlling the location of the embossment. Dimensions of embossment location and hole location shall be applied independent of each other.
- The tape, with or without components, shall pass around R without damage (see Figure 5).
- If S<sub>1</sub> < 1.0 mm, there may not be enough area for cover tape to be properly applied (see EIA Standard 481–D, paragraph 4.3, section b).
- B<sub>1</sub> dimension is a reference dimension for tape feeder clearance only.
- The cavity defined by A<sub>0</sub>, B<sub>0</sub> and K<sub>0</sub> shall surround the component with sufficient clearance that:
  - the component does not protrude above the top surface of the carrier tape.
  - the component can be removed from the cavity in a vertical direction without mechanical restriction, after the top cover tape has been removed.
  - rotation of the component is limited to 20° maximum for 8 and 12 mm tapes and 10° maximum for 16 mm tapes (see Figure 2).
  - lateral movement of the component is restricted to 0.5 mm maximum for 8 mm and 12 mm wide tape and to 1.0 mm maximum for 16 mm tape (see Figure 3).
  - see Addendum in EIA Standard 481–D for standards relating to more precise taping requirements.

## Packaging Information Performance Notes

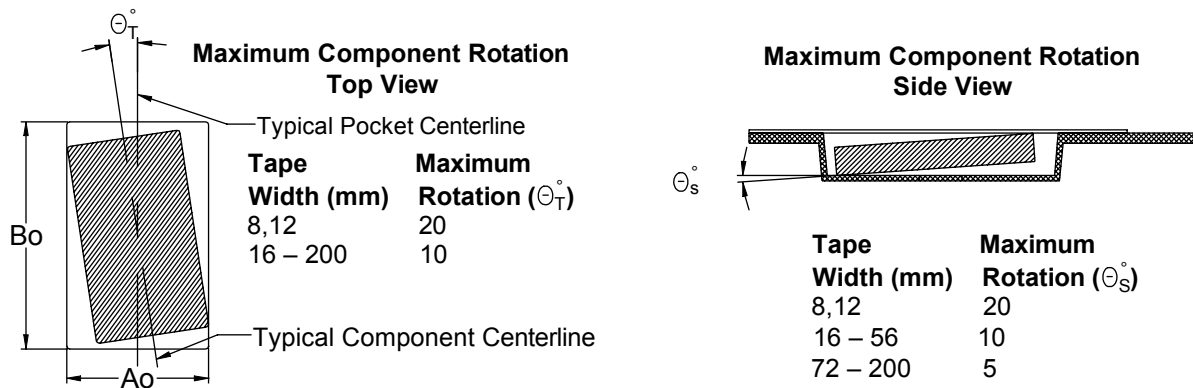
- Cover Tape Break Force:** 1.0 Kg minimum.
- Cover Tape Peel Strength:** The total peel strength of the cover tape from the carrier tape shall be:

Tape Width	Peel Strength
8 mm	0.1 to 1.0 Newton (10 to 100 gf)
12 and 16 mm	0.1 to 1.3 Newton (10 to 130 gf)

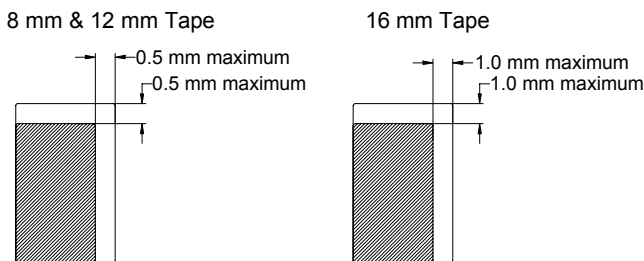
The direction of the pull shall be opposite the direction of the carrier tape travel. The pull angle of the carrier tape shall be 165° to 180° from the plane of the carrier tape. During peeling, the carrier and/or cover tape shall be pulled at a velocity of 300 ±10 mm/minute.

- Labeling:** Bar code labeling (standard or custom) shall be on the side of the reel opposite the sprocket holes. Refer to EIA Standards 556 and 624.

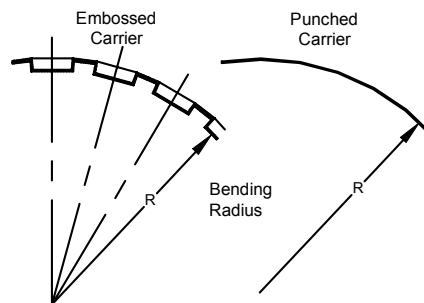
### Figure 2 – Maximum Component Rotation



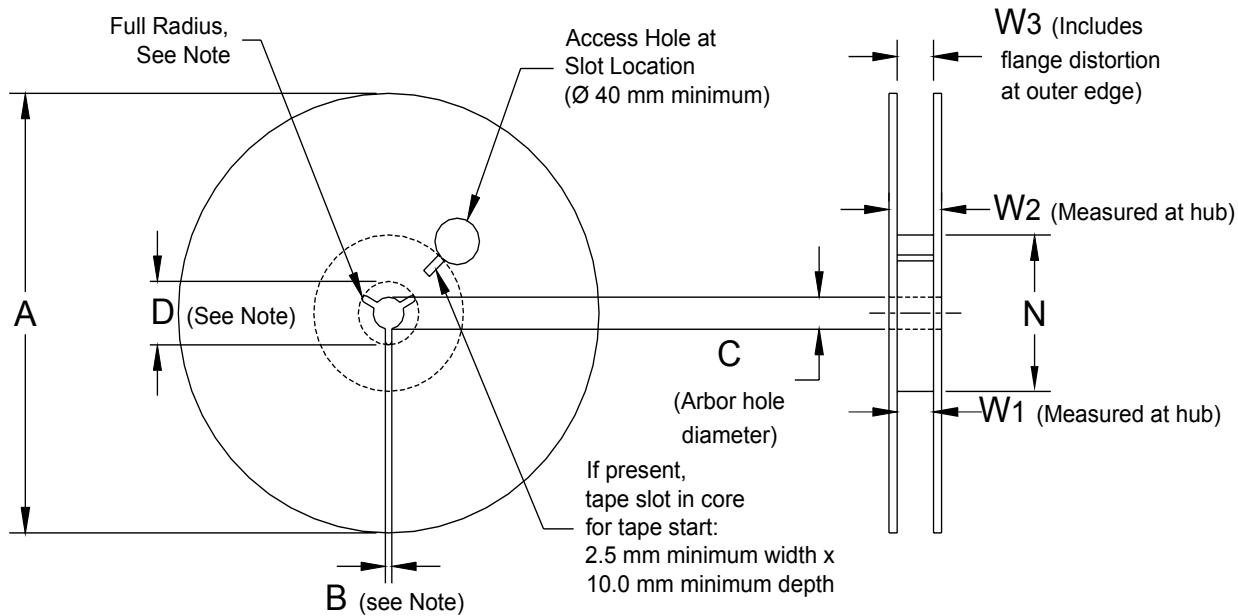
### Figure 3 – Maximum Lateral Movement



### Figure 4 – Bending Radius



## Figure 5 – Reel Dimensions



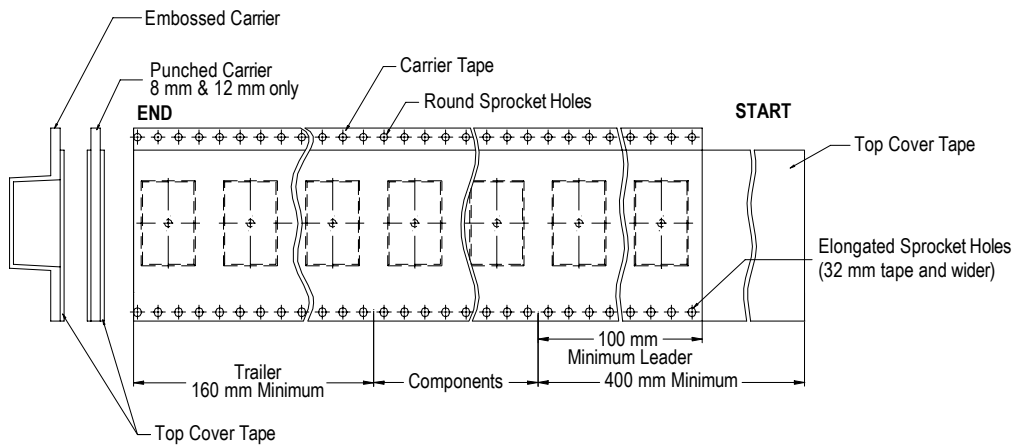
Note: Drive spokes optional; if used, dimensions B and D shall apply.

## Table 5 – Reel Dimensions

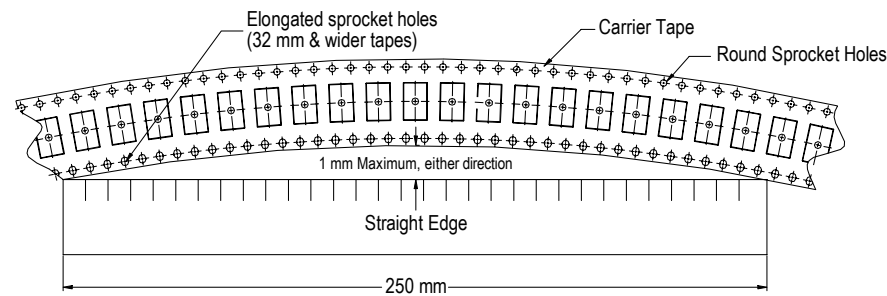
Metric will govern

Constant Dimensions — Millimeters (Inches)				
Tape Size	A	B Minimum	C	D Minimum
8 mm	178 ±0.20 (7.008 ±0.008) or 330 ±0.20 (13.000 ±0.008)	1.5 (0.059)	13.0 +0.5/-0.2 (0.521 +0.02/-0.008)	20.2 (0.795)
12 mm				
16 mm				
Variable Dimensions — Millimeters (Inches)				
Tape Size	N Minimum	W <sub>1</sub>	W <sub>2</sub> Maximum	W <sub>3</sub>
8 mm	50 (1.969)	8.4 +1.5/-0.0 (0.331 +0.059/-0.0)	14.4 (0.567)	Shall accommodate tape width without interference
12 mm		12.4 +2.0/-0.0 (0.488 +0.078/-0.0)	18.4 (0.724)	
16 mm		16.4 +2.0/-0.0 (0.646 +0.078/-0.0)	22.4 (0.882)	

**Figure 6 – Tape Leader & Trailer Dimensions**



**Figure 7 – Maximum Camber**



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## Other KEMET Resources

Tools	
Resource	Location
Configure A Part: CapEdge	<a href="http://capacitoredge.kemet.com">http://capacitoredge.kemet.com</a>
SPICE & FIT Software	<a href="http://www.kemet.com/spice">http://www.kemet.com/spice</a>
Search Our FAQs: KnowledgeEdge	<a href="http://www.kemet.com/keask">http://www.kemet.com/keask</a>
Electrolytic LifeCalculator	<a href="http://www.kemet.com:8080/elc">http://www.kemet.com:8080/elc</a>

Product Information	
Resource	Location
Products	<a href="http://www.kemet.com/products">http://www.kemet.com/products</a>
Technical Resources (Including Soldering Techniques)	<a href="http://www.kemet.com/technicalpapers">http://www.kemet.com/technicalpapers</a>
RoHS Statement	<a href="http://www.kemet.com/rohs">http://www.kemet.com/rohs</a>
Quality Documents	<a href="http://www.kemet.com/qualitydocuments">http://www.kemet.com/qualitydocuments</a>

Product Request	
Resource	Location
Sample Request	<a href="http://www.kemet.com/sample">http://www.kemet.com/sample</a>
Engineering Kit Request	<a href="http://www.kemet.com/kits">http://www.kemet.com/kits</a>

Contact	
Resource	Location
Website	<a href="http://www.kemet.com">www.kemet.com</a>
Contact Us	<a href="http://www.kemet.com/contact">http://www.kemet.com/contact</a>
Investor Relations	<a href="http://www.kemet.com/ir">http://www.kemet.com/ir</a>
Call Us	1-877-MyKEMET
Twitter	<a href="http://twitter.com/kemetcapacitors">http://twitter.com/kemetcapacitors</a>

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Although all product-related warnings, cautions and notes must be observed, the customer should not assume that all safety measures are indicated or that other measures may not be required.