Advances in Wet Tantalum Capacitor Technology

ESA SPCD

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Tantalum Capacitors

A WORLD OF SOLUTIONS™

INTRODUCTION

- **Tantalum Capacitor Definition**
  - tantalum anode with tantalum pentoxide dielectric
  - solid or non-solid cathode or electrolyte
- **Tantalum advantages**
  - highest capacitance per unit volume
- **Tantalum applications**
  - automotive, consumer, industrial, telecom
  - avionics, medical, military, space
- **Tantalum Capacitor Technology Advances**
  - Solid – size, CV, ESR, performance, polymer cathode
  - Wet – CV, case configuration/ form factor, performance

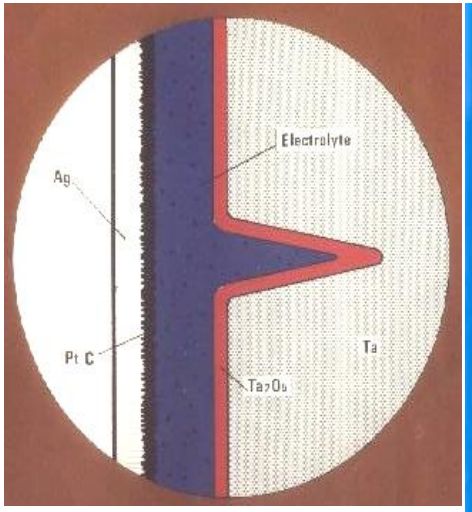
WET TANTALUM CAPACITOR DEFINITION

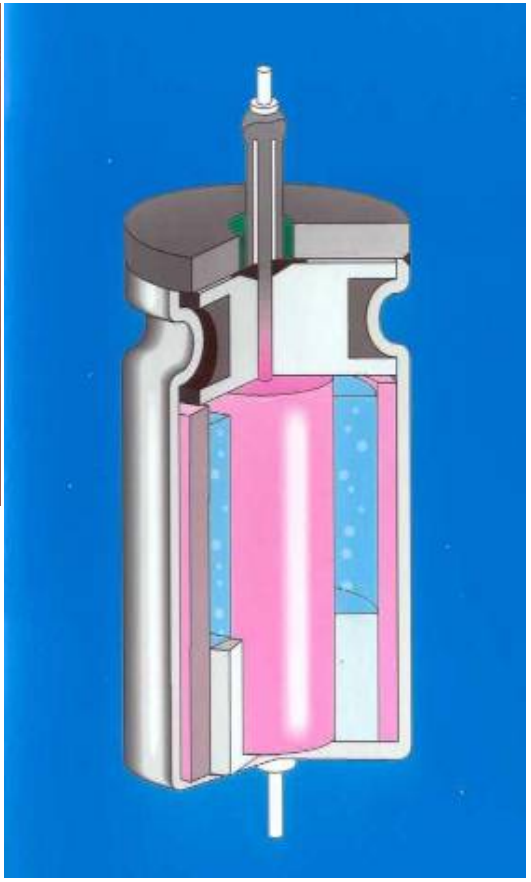
- **What is a Wet Tantalum Capacitor?**

  Tantalum capacitor with a liquid electrolyte.

- **Higher quality dielectric with a self healing effect resulting in:**

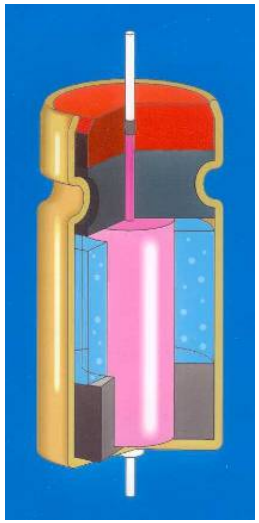
  - Low leakage current (>10 times less than solids)
  - Higher CV and Higher Voltage (up to 150V)
  - High reliability (>10 times better than solids)

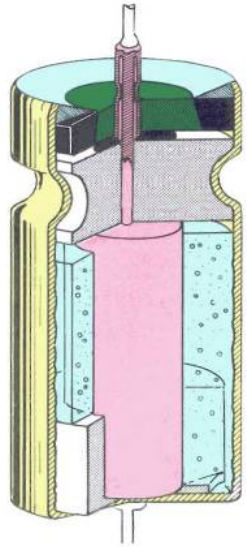




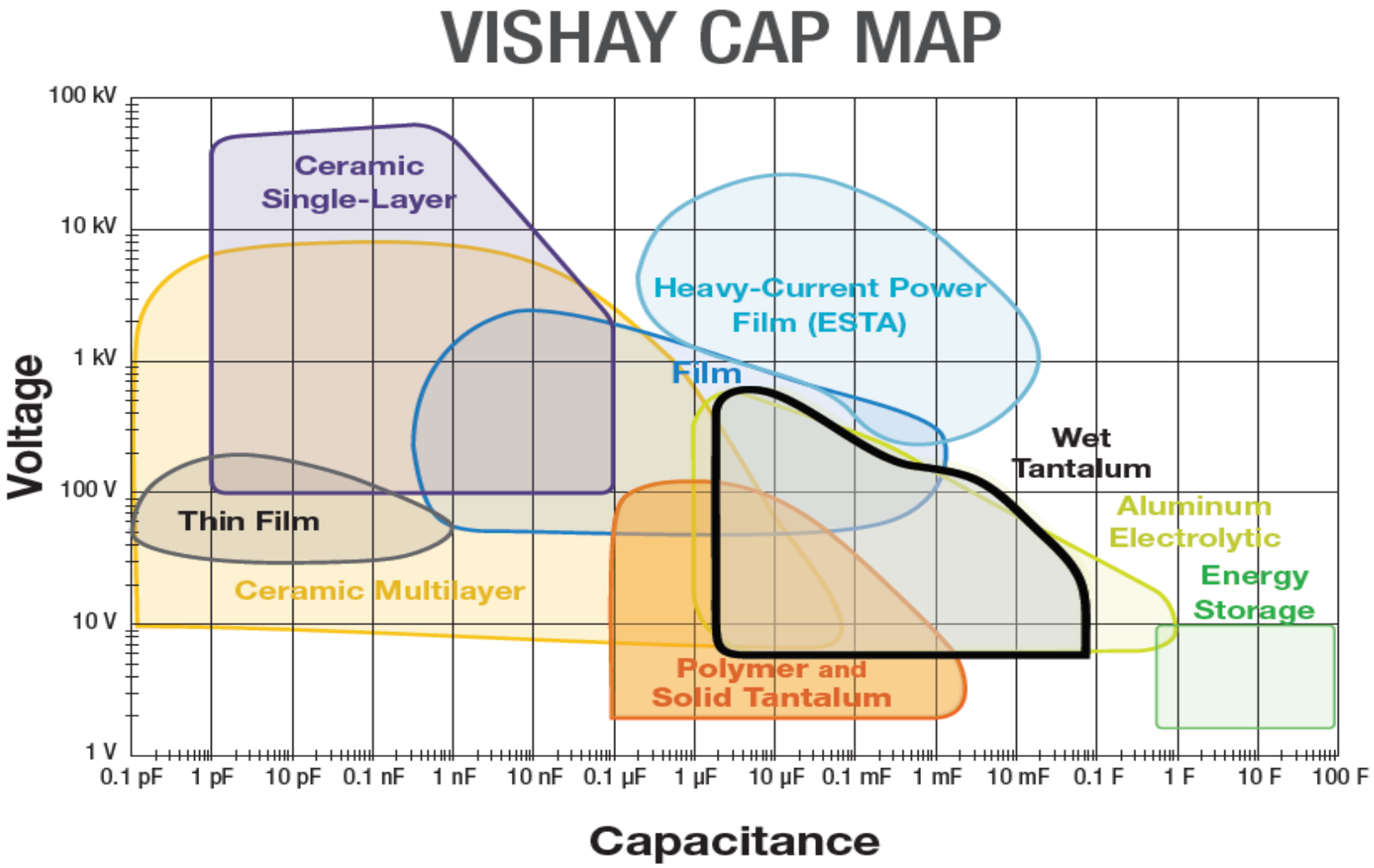
DESCRIPTION

- Wet electrolyte, sintered anode tantalum capacitors
  - Pressed tantalum powder anode
  - Sintered tantalum anode
  - Tantalum pentoxide dielectric
  - Tantalum or silver case
  - Liquid or “wet” electrolyte (sulfuric acid solution)
  - Seal – elastomer or hermetic



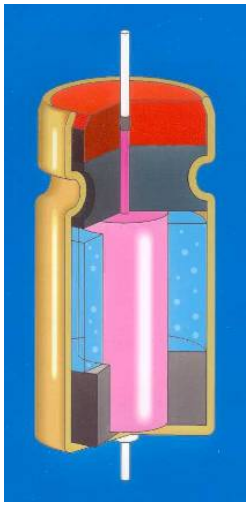


ADVANTAGES

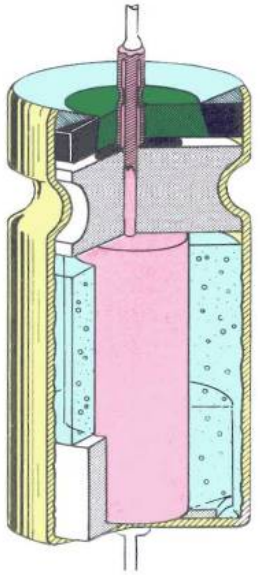


SILVER CASE, AXIAL LEAD

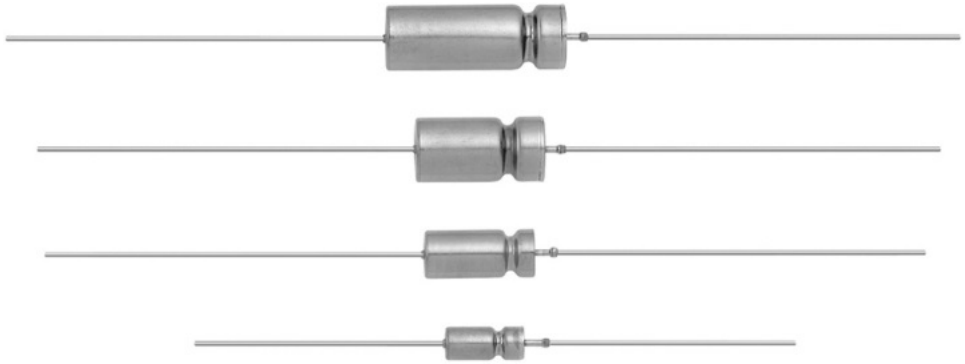
Elastomer Seal, Silver Case
Commercial Series: 109D
MIL Approved: MIL-DTL-3965/4 Style CL64/65
Operating Temperature: -55˚ C to +125˚ C
Capacitance Range: 1.7µF to 2200µF
Voltage Range: 6 to 125Vdc
Case Sizes: T1, T2, T3, T4
Failure Rate: Non-ER



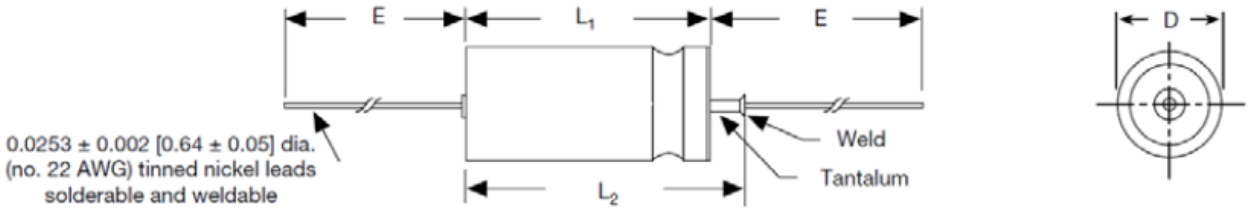
Hermetic Seal, Silver Case
Commercial Series: 138D
CECC Approved: 30 202 004 Styles CT9, 738D
MIL Approved: CLR65 (M39006/09) – Standard Values
CLR69 (M39006/21) – Extended Range Values
Operating Temperature: -55˚ C to +125˚ C
Capacitance Range: 1.7µF to 2200µF
Voltage Range: 6 to 125Vdc
Case Sizes: T1, T2, T3, T4
Failure Rates: L (2%), M (1%)



AXIAL, FOUR INDUSTRY STANDARD CASE SIZES



DIMENSIONS in inches [millimeters]



CASE CODE	DCLR 79 / 81 EQUIV.	D	L_1	L_2 (max.)	E	WEIGHT (g) (Max.)
C	T1	0.188 ± 0.016 [4.78 ± 0.41]	0.453 + 0.031 / - 0.016 [11.51 + 0.79 / - 0.41]	0.734 [18.64]	1.500 ± 0.250 [38.10 ± 6.35]	2.6
F	T2	0.281 ± 0.016 [7.14 ± 0.41]	0.641 + 0.031 / - 0.016 [16.28 + 0.79 / - 0.41]	0.922 [23.42]	2.250 ± 0.250 [57.15 ± 6.35]	6.2
T	T3	0.375 ± 0.016 [9.53 ± 0.41]	0.766 + 0.031 / - 0.016 [19.46 + 0.79 / - 0.41]	1.047 [26.59]	2.250 ± 0.250 [57.15 ± 6.35]	11.6
K	T4	0.375 ± 0.016 [9.53 ± 0.41]	1.062 + 0.031 / - 0.016 [26.97 + 0.79 / - 0.41]	1.343 [34.11]	2.250 ± 0.250 [57.15 ± 6.35]	17.7

Tantalum Case, Axial Lead

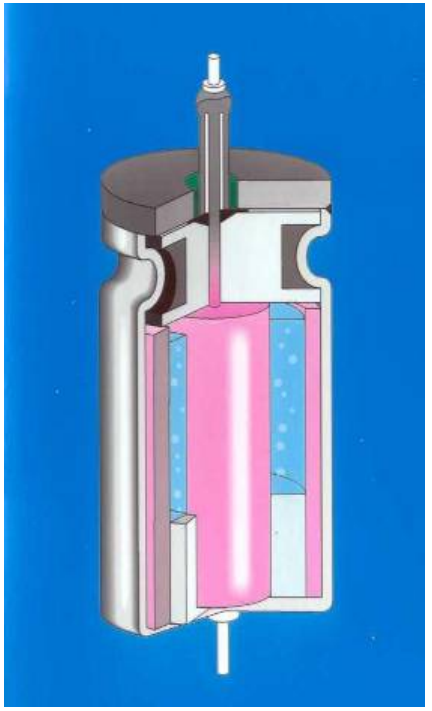
In 1973, Sprague Electric Company was contacted by NASA for the Design, Development, Manufacture, and Qualification of Wet Slug All-Tantalum Capacitors. The purpose of the program was to develop a hermetically sealed all-tantalum capacitor capable of meeting the performance requirements of MIL-C-39006, but with the ability to withstand nominal reverse voltages and ripple currents.

Hermetic Seal, Tantalum/Glass Cover

Commercial Series: 135D
136D (low ESR)

CECC Approved: **30 202 001 Style 735D**
30 202 801 Style 735DE
30 202 005 Style CT79

MIL Approved: **CLR79 (M39006/22) – Standard Values**
CLR81 (M39006/25) – Extended Range Values
CLR90 (M39006/30) – Low ESR, Standard Values
CLR91 (M39006/31) – Low ESR, Extended Range Values



Operating Temperature: -55ºC to +200ºC
Capacitance Range: 1.7µF to 2200µF
Voltage Range: 6 to 125Vdc
Case Sizes: T1, T2, T3, T4
Failure Rates: M (1%), P (0.1%), R (0.01%)
Characteristic H: 54g random, 80g sine, 500g shock

LONG TERM STORAGE, CLR79 TYPE

Table 2: CLR79 Long Term Storage Data

WET TANTALUM LONG TERM STORAGE (15 years At Room Temperature Storage)							
		Measured December 1979			Measured July 1996		
UNIT	RATINGS	CAP	ESR	DCL	CAP	ESR	DCL
1	47uF, 10 vdc	46.7	1.37	0.42	46.6	1.38	0.92
2	120uF, 15 vdc	120.3	0.72	0.20	120.8	0.72	0.24
3	170uF, 15 vdc	164.1	0.48	0.45	164.1	0.49	0.44
4	2.5uF, 100 vdc	2.6	3.64	0.62	2.54	3.93	0.76
5	22uF, 100vdc	22.9	0.85	0.47	22.8	0.9	0.54
6	43 uF, 100 vdc	44.4	0.55	0.63	44.4	0.57	0.93
NOTES: 1) Capacitors were manuafctured to MIL-PRF-39006/22, style CLR79							
2) All parts were subjected to 300 thermal shock cycles prior to the intial measurements							
3) Data was derived from 3 to 5 sampls of each rating							

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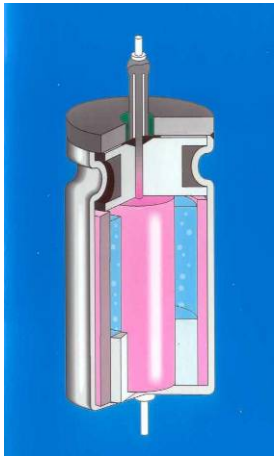
Space Grade DLA Drawings (original dated 2006)

DLA Styles: 06013 [CLR79 (M39006/22) Values]
06014 [CLR81 (M39006/25) Values]
06015 [CLR90 (M39006/30) Values]
06016 [CLR91 (M39006/31) Values]

Failure Rate: R (0.01%/1000 Hours)

Characteristic H: 80g Sine Vibration, 54g Random Vibration, 500g Mechanical Shock

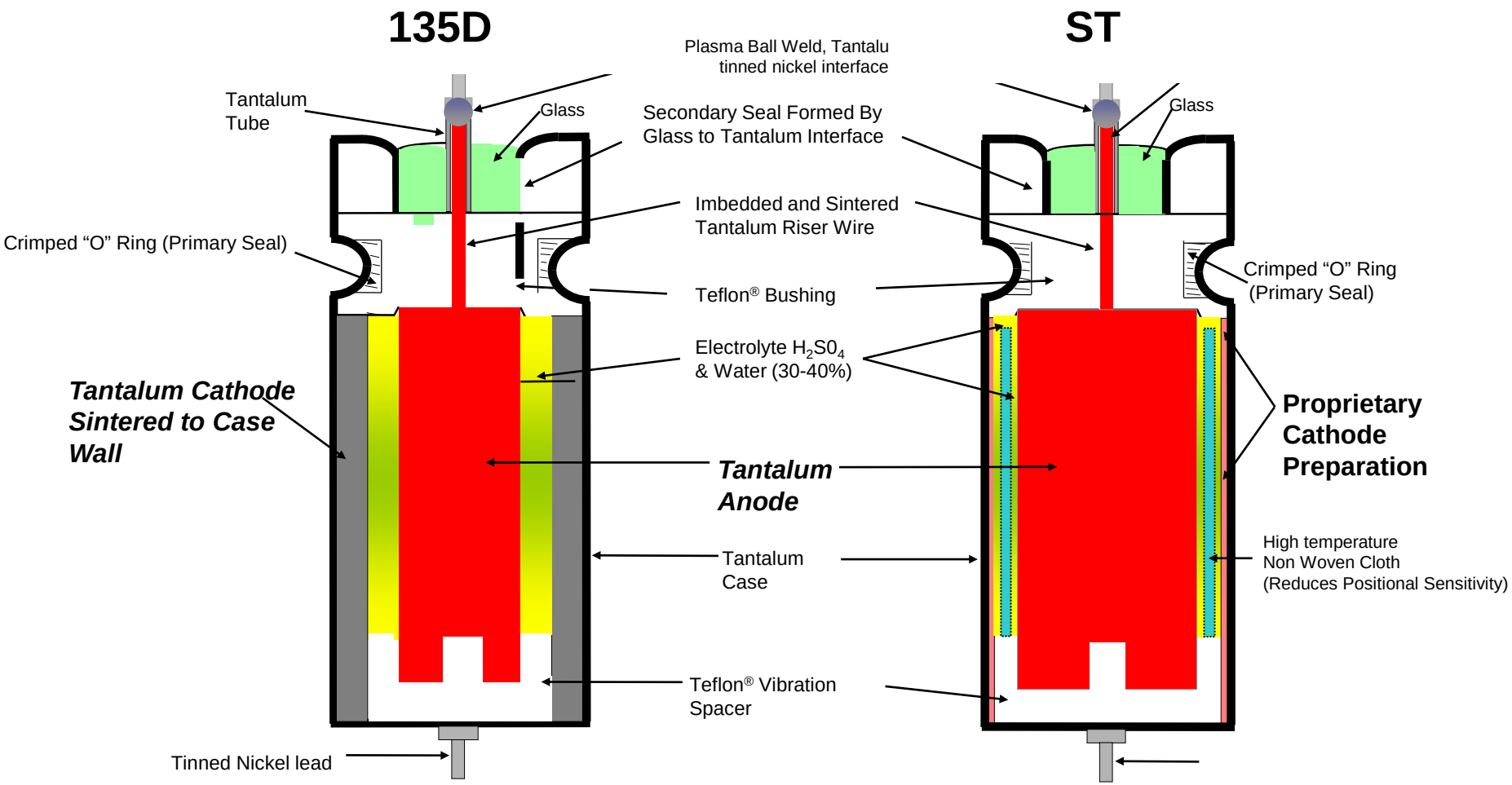
DSCC 06013 -- 06016		
Group A Inspection	**Sample**	**Description**
Thermal Shock	100%	10 Cycles, -55°C to +125°C
Voltage Conditioning	100%	168 Hours at +85°C
DC leakage at 25°C & +85°C	100%	
Capacitance	100%	
Dissipation Factor	100%	
Seal (Fine Leak)	100%	MIL-STD-202, Method 112, Condition C
Seal (Gross Leak)	100%	MIL-STD-202, Method 112, Condition A or D
Solderability	5/0	MIL-STD-202, Method 108
Group B Inspection	**Sample**	**Description**
Temperature Stability	13/0	-55°C to +125°C
Thermal Shock	10/0	30 Cycles, -55°C to +125°C
Life	10/0	1000 Hours at +85°C



DLA 06013-06016 specifications meet or exceed NASA/TP-2003-212242, Level 1 requirements.

SuperTan® Era

135D vs. ST Construction

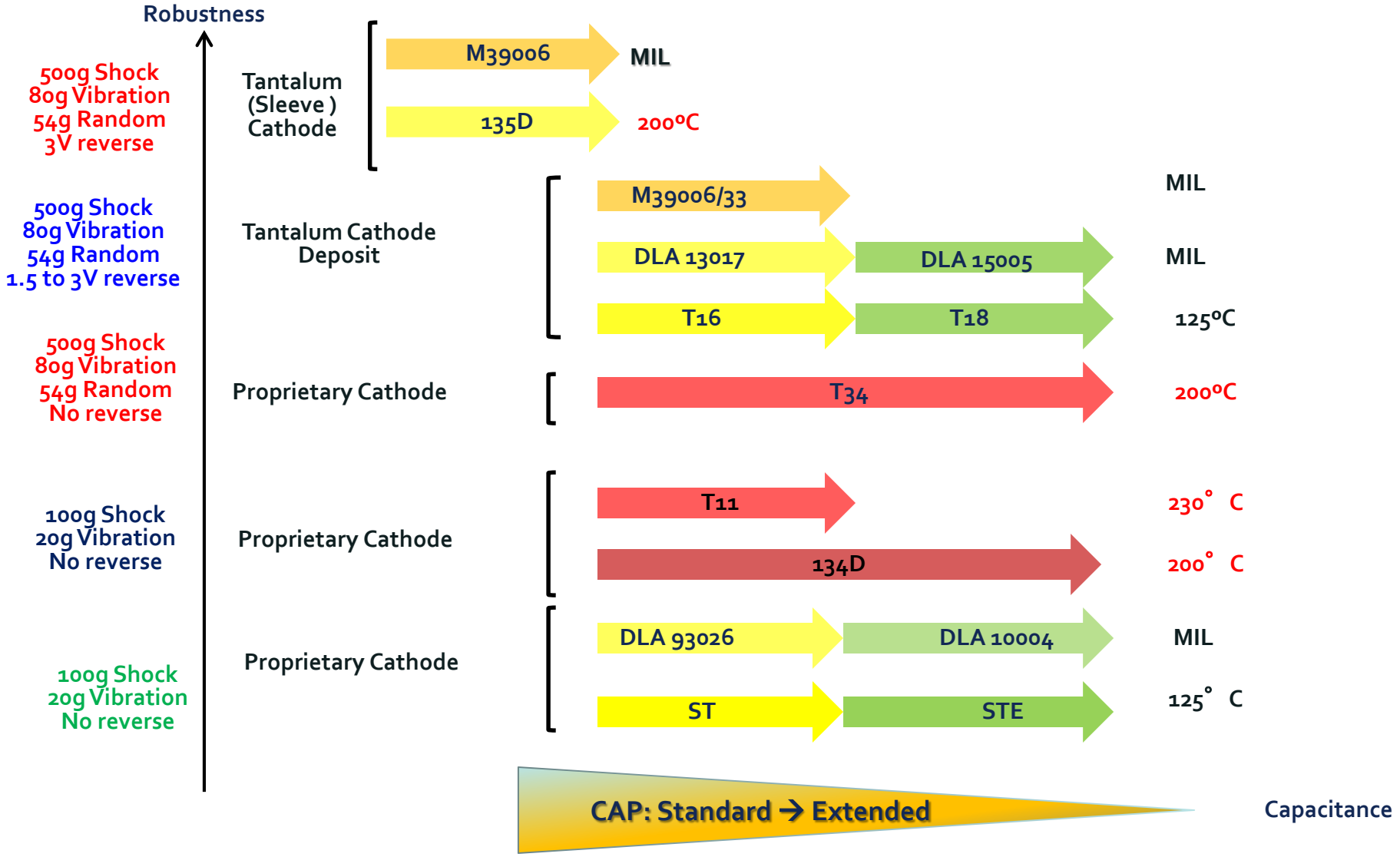


CAPACITANCE EXTENSION, SUPERTAN® AXIAL CASE

Table 4: Examples of 100 V Capacitance Extension with the ST

Case Size	CLR79	CLR81	ST
1	4.7 µF	10 µF	15 µF
2	22 µF	39 µF	68 µF
3	43 µF	68 µF	150 µF
4	86 µF	120 µF	220 µF

WET TANTALUM AXIAL CASE PRODUCT OVERVIEW



Tantalum Case, Axial Lead
High Capacitance, "*High Performance*"

New

Hermetic Seal, Tantalum/Glass Cover
Commercial Series: T16 – standard range (equal to *ST*)
Military: *DLA 13017*
Military: MIL-PRF-39006/33
Operating Temperature: -55° C to +125° C
Capacitance Range: 10µF to 1800µF
Voltage Range: 25V – 125V
Case Sizes: T1, T2, T3, T4

New

Commercial Series: T18 – extended range (equal or greater than STE)
Military: DLA 15005
Operating Temperature: -55° C to +125° C
Capacitance Range: 18uF – 1500uF
Voltage Range: 50V – 125V
Case Sizes: T1, T2, T3, *T4*
Ratings available: 1000uF 75V
470uF 100V
Under development: 1500uF/ 50V - 2nd QTR 2019
1200uF/ 75V - 1st QTR 2019
560uF/ 100V - 1st QTR 2019
240uF/125V - 1st QTR 2019
340uF/ 125V - 1st QTR 2019

Enhanced performance for Avionics and Space
300 thermal shocks
500g mechanical shock
80g sine vibration
54g random vibration
1.5 to 3.0 V reverse voltage

CAPACITANCE EXTENSION, T18 AXIAL CASE

Table 5: Examples of 100 V Capacitance Extension with the T18

Case Size	CLR79	CLR81	T16	T18
1	4.7 µF	10 µF	15 µF	22 µF
2	22 µF	39 µF	68 µF	86 µF
3	43 µF	68 µF	150 µF	220 µF
4	86 µF	120 µF	220 µF	470 µF

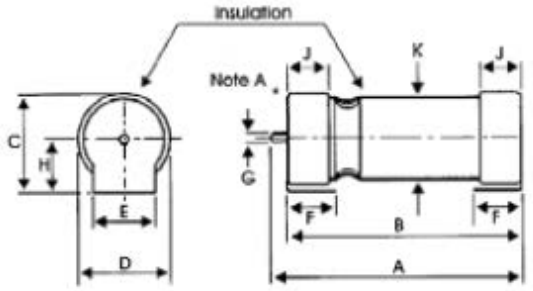
Oil Exploration Capacitors

- T34
- Tantalum case, axial leaded, high capacitance, *"high performance" , HI-TMP®, +200° C*
- Target Market/Applications: Oil Exploration
- Provides high capacitance with high performance
  - 3V reverse
  - 500g mechanical shock
  - 57g random vibration
  - 80g sine vibration
  - 1000 hour life minimum @ +200°C
  - stable ESR over life

- Example of Ratings available: **350uF/125v T4**
  470uF/ 50v T3
  220uF/ 50v T2
  33uF/ 75v T1
- Ratings under development
  - **560uF/100v T4**
  - **100uF/125v T3**
  - **220uF/ 75v T2**
  - **150uF/100v T2**
  - **10uF/125V T1**

SURFACE MOUNT "SMD" WET TANTALUM CAPACITORS

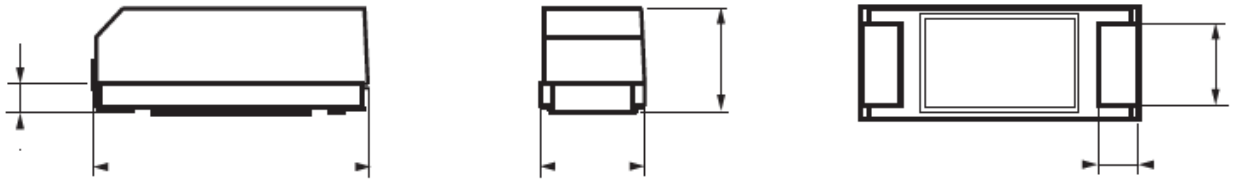
- First Generation



[8]

- Second Generation

DIMENSIONS in inches [millimeters]



CASE CODE	L (MAX.)	W	H	P (MIN.)	T_W	T_H (MIN.)
C	0.835 [21.2]	0.315 ± 0.012	0.295 ± 0.012	0.118 [3.0]	0.236 ± 0.012	0.075 [1.9]

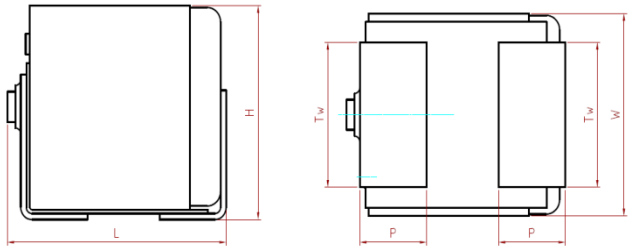
[9]

Surface Mount

- Third Generation

Industry First!

Small size SMD , Hermetic Seal, Tantalum Case Capacitors
Commercial Series: T22
Capacitance Range: 10µF to 120µF
Voltage Range: 6 to 125Vdc
Operating Temperature: -55° C to +125° C
Case Size: R
Ratings: any T1 axial rating
Rating available: 10uF 125V
15uF 100V
33uF 75V
68uF 50V



CASE CODE	L	W	H	P	Tw
WET SMD	0.323±0.008 [8.2±0.2]	0.275±0.008 [6.98±0.2]	0.291±0.008 [7.38±0.2]	0.098±0.008 [2.5±0.2]	0.197±0.008 [5.0±0.2]

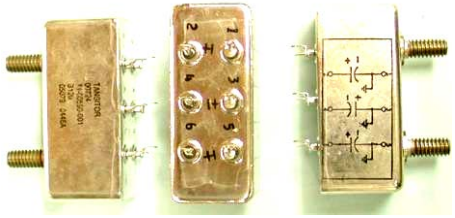
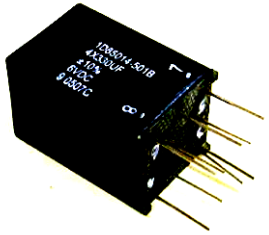
https://nepp.nasa.gov/files/29192/NEPP-TR-2018-Teverovsky-T22-Capacitors-TN52048.pdf

High Energy Assemblies and Arrays

Standard and Custom

Vishay has over 40 years experience with AMS (Avionics, Military, Space) energy storage and pulsed power applications and petroleum data logging applications.

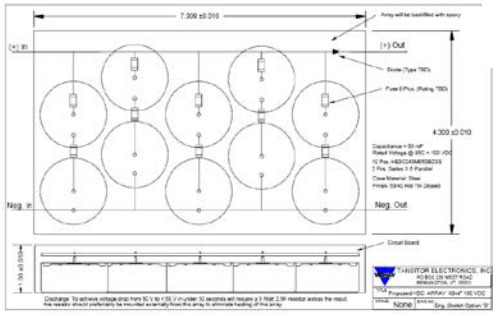
Vishay continues to provide solutions for these applications with the assembly of arrays or modules built from our extensive line of tantalum capacitors. Assemblies and arrays can be industry standard packages, or a customer driven custom design. Internal elements can be Commercial or Military Grade (Established Reliability) Wet or Solid Tantalum Capacitors.









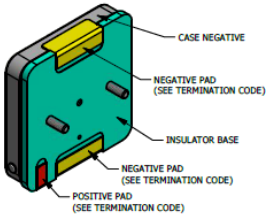

High energy or hybrid capacitor designs

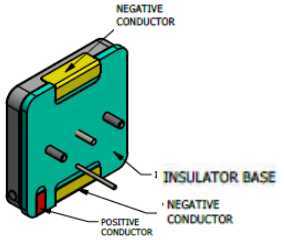
Hermetic Seal, Tantalum/Glass Cover
Commercial Series: HE3
Military: DLA 10011
Operating Temperature: -55° C to +125° C
Capacitance Range: 1100µF to 72,000µF
Voltage Range: 25 to 125Vdc
Case Sizes: A, B, C
Failure Rate: Non-ER

Hermetic Seal, Tantalum/Glass Cover
Commercial Series: HE5 w/ mounting studs
Operating Temperature: -55° C to +125° C
Capacitance Range: 1100µF to 72,000µF
Voltage Range: 25 to 125Vdc
Case Sizes: A, B, C
Failure Rate: Non-ER

Hermetic Seal, Tantalum/Glass Cover
Commercial Series: EP1 Energy-Pack
Operating Temperature: -55° C to +125° C
Capacitance Range: 1100µF to 72,000µF
Voltage Range: 25 to 125Vdc
Case Sizes: A (available)
B (under development – 4th QTR 2018)
C (under development – 1st QTR 2019)
Failure Rate: Non-ER

New





EP1 ROADMAP

- Scope of rating qualification plan going forward

EP1 ROADMAP								
Case (# anodes)	A (1)		B (2)		C (3)		D (4)	
	Capacitance (mF)							
Voltage	EP1	*Comp*	EP1	*Comp*	EP1	*Comp*	EP1	*Comp*
125V	2.0	*1.5*	3.6	*3.0*	5.3	*4.5*	7.1	*6.0*
100V	3.0	*2.2*	5.8	*4.4*	7.9	*6.6*	10.6	*8.8*
80V	4.0	*3.0*	8.5	*6.0*	12.0	*9.0*	17.0	*12.0*
63V	6.0	*4.7*	12.0	*9.4*	18.0	*14.0*	24.0	*18.0*
50V	13.0	*11.0*	24.0	*22.0*	34.0	*33.0*	46.0	*44.0*
35V	22.0	*16.0*	40.0	*32.0*	58.0	*48.0*	78.0	*64.0*
25V	30.0	*24.0*	55.0	*48.0*	79.0	*72.0*	106.0	*96.0*

Available
Under Development 2018
Future Potential Development

Rev. 3 091518

CONCLUSION

- Wet tantalum capacitors provide:
  - High capacitance
  - High voltage
  - Low DC leakage
  - Long Life
  - Mechanical Robustness

- Developments Continue
  - Higher capacitance
  - New form factors such as High energy and surface mount
  - High shock and vibration

- Wet tantalum capacitors will continue to be an important segment of the tantalum capacitor market

WET TANTALUM CAPACITORS IN A NUTSHELL

THE ULTIMATE RELIABILITY AND PERFORMANCE CHOICE FOR EXTREME APPLICATIONS

KEY FACTORS

HIGH

Capacitance
Performance
Energy
Temperature

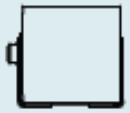
QUALIFICATIONS

- M39006/09/21/22/25/30/31/33
- DLA 06013/06014/06015/06016
- DLA 04003/10004/10011/13017/15008/93026
- CECC 30202/001/002/004/005/801

LEAD CONFIGURATIONS

Axial

Radial

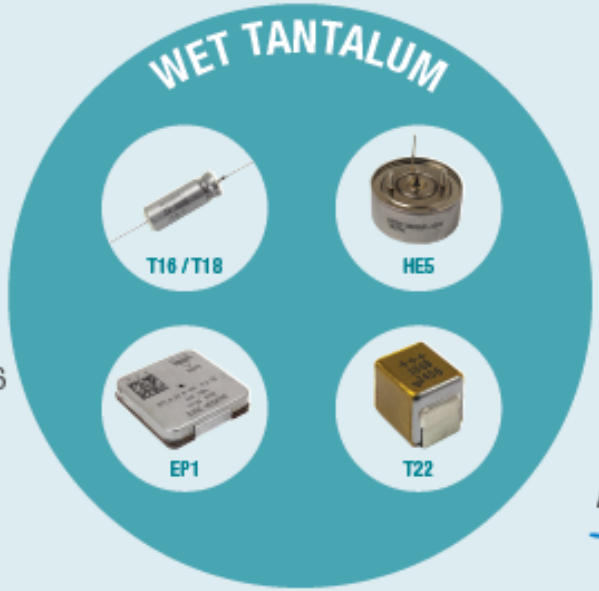


SMD

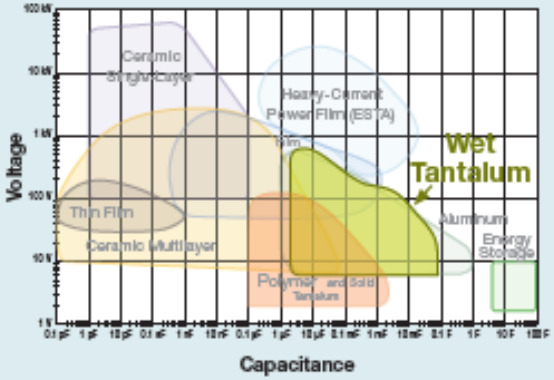
TERMINATION OPTIONS Tin / Lead

Lead-free (100 % tin)
RoHS compliant

www.vishay.com



VISHAY CAP MAP



APPLICATIONS

AVIONICS

OIL and GAS

SPACE

VISHAY CAPABILITY

FOOTPRINT + PROFILE

Shown at actual size (when viewed or printed at 100 %)

For Technical Questions: tantalum@vishay.com

VMN-MS7361-17xx