PAKTRON
CAPACITORS

Angstor® Capacitor Quality Summary

October, 2012

Paktron
P.O. Box 4539
1205 McConville Road
Lynchburg, Virginia 24502
Phone: 434-239-6941
Fax: 434-239-4730
Web: http://www.paktron.com

INDEX

Paktron System Summary

PAKTRON CAPACITORS

Company Overview

In existence since 1953, Paktron is one of the oldest capacitor manufacturers in the US. Paktron is the technological leader in the manufacture of multilayer polymer film capacitors and sells across diverse markets including automotive, commercial, Hi-Rel, military, space, and telecommunications. As a quality conscience company, Paktron follows the proven philosophy of building quality into its products. Inherent quality provides for both long-term reliability as well as outstanding product performance. Paktron's longevity is testament to its commitment to Quality.

Quality System Overview

Because of Paktron's multi-industry sales markets, rather than attempting to maintain registrations to each of the vast assortment of standardized qualty sytems specific to each of these markets, since 1953 Paktron has utilized an ever evolving, capacitor industry specific, documented quality system of its own which equals or exceeds the requirements of market oriented, standardized systems without the limitations imposed by market standardization. Paktron's Quality Assurance System is a full-featured system giving Paktron the ability to produce the finest products possible. The system includes, but is not limited to:

1. Operator Training
2. Receiving Inspection
3. Calibration
4. Out-going Inspection
5. Failure Analysis
6. Statistical Process Control
7. New Product/Process Authorization
8. Vender Qualification
9. Material Review
10. In-Process Inspections
11. Surveillance Testing
12. Qualification Testing
13. Reliability Testing

Documentation System

The Paktron documentation system strictly follows the guidelines as outlined in ISO-900x. The documentation system is separated into three different sections:

1) Procedure manuals:
   - a) Quality Manual
   - b) Document Control Procedures Manual
   - c) Accounting Procedures Manual
   - d) Engineering Procedures Manual Specifications
   - e) Marketing and Sales Procedures Manual
   - f) Purchasing Procedures Manual
   - g) Production Control Procedures Manual
   - h) Quality Control Procedures Manual
   - i) Shipping and Receiving Procedures Manual
   - j) Supplier Quality Assurance Procedures Manual
   - k) Test and Reliability Procedures Manuals

2) General Procedures:

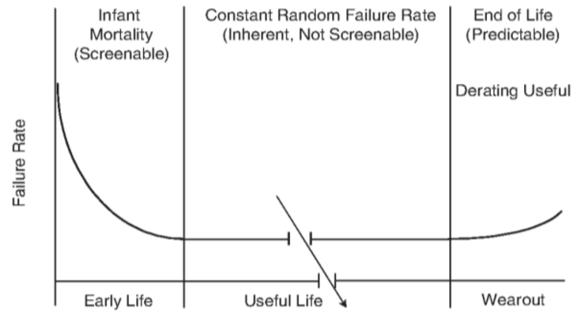
3) Specification systems:
   - a) Assembly Specifications
   - b) Design Specifications
   - c) Equipment
   - d) Material Specifications
   - e) Process Specifications
   - f) Quality Specifications

Statistical Process Control

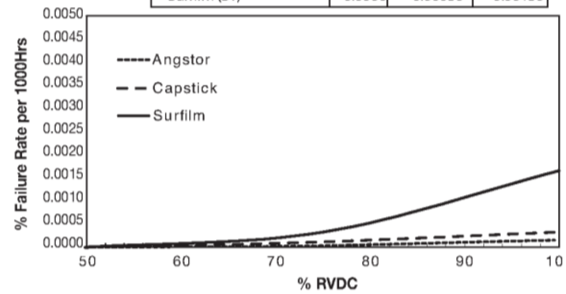
Like many other manufacturers, in order to meet the changing quality needs of its various customers, Paktron has long ago implemented a program of Statistical Process Control (SPC). This program placed the responsibility for quality directly on the production operators who must build quality into the product rather than trying to test defects out in the final test operations. This results in the production of more consistent quality and performance products. Day-to-day process control is being done with process control charts (X bar and R, percent defective, histograms and range charts) with the Paktron QA department moving into an overview function of doing trending analysis, process averaging, specification compliance control, etc. Using these systems of certification, quality levels in the low PPMs becomes not just a goal, but a reality.

Reliability

Paktron's Quality Assurance does not end once the product has been shipped to the customer. The long-term reliability of the product is as important as its initial implementation. Theoretically, a well-designed, well-engineered, thoroughly tested and properly applied component should "never" fail in operation (within the life of the equipment). However, practical experience shows that even the best design, manufacturing, and engineering efforts do not completely eliminate the occurrence of "field" failures. Usually, field failure categories encountered in components are the "infantile", "random", and in the case of mis-application, "wearout". Paktron eliminates the "infantile" category through extensive testing and strict controls (QA/SPC). The "wearout" category is eliminated by "guard-banding" the performance characteristics of the products and by maintaining close contacts between the Paktron and customer Engineering groups. "Random" failures occur after the infant mortality stage. They occur because of "undetectable" weaknesses in the products. Although the time of occurrence of random failures cannot be predicted, the probability of occurrence or non-



	@ %RVDC and 40°C		
	50%	75%	100%
Angstor (RA)	0.0000	0.00003	0.00014
Capstick (CS, CB)	0.0000	0.00010	0.00030
Surfilm (ST)	0.0000	0.00030	0.00150



occurrence of such failures can be calculated by means of the theory of probability. Paktron's reputation for "Quality" in the Industry is based not only on its ability to eliminate "infantile" failures through strict QA controls, but also on being able to minimize "random" failures through its SPC controls which detects/eliminates heretofore "undetectable" weaknesses and significantly increases the reliability of the product. Paktron's film capacitors are so inherently reliable that use life is measured in decades rather than hours of operation. While Paktron's own rigorous accelerated testing shows theoretical PPM failure levels in the single digits, customer feedback consistently reports zero PPM failure levels.

Voltage Ratings

Like all polymer film capacitors, Paktron's product offerings have "true" voltage ratings and unlike other dielectric systems require no voltage de-ratings for maximizing reliability (MTBF) or use life. With FIT rates of well under 5 FIT when used at rated voltage, these capacitors provide a positive contribution to circuit MTBF calculations.

Circuit designers requiring 500 volt ratings in other dielectric systems for their 370 volt input applications are being penalized by that dielectric system's inherent deficiencies. In the polymer film capacitor industry, if a capacitor is rated at a certain voltage, then the capacitor is designed to be fully functional and reliable at that voltage for the life of the equipment. Many leading edge circuit designs take advantage of a polymer film capacitor's inherent reliability at rated voltage to both reduce board size and significantly improve performance.

Material Content

Paktron's product offerings neither contain nor are manufactured with any risk level hazardous material. The material content for polymer film capacitors is basically: polymer, aluminum, copper, tin, iron, microcrystalline polyolefin, trace amounts of other materials such as antimony and lead and various non-toxic, non-hazardous thermoplastics used for encasements. The polymers typically used are polyethylene terephthalate (PET), polyethylene napthalate (PEN) and/or polyphenylene sulfide (PPS). The products' terminations are coated (tinned) with either 60Sn-40Pb or 100% Sn to a thickness of 100-500 micro inches in order to facilitate soldering without the possibility of whisker growth with the 100% Sn meeting current industry guidelines for lead-free (Pb-free) with a lead (Pb) material content of under 0.1 wt% (1000ppm).

Capacitor Test Data

Angstor Test Packet Contents

1. Life Testing
    a. Accelerated DC Dry Life Test (85°C / 125vdc / 1000 hrs): 225K100RA4
    b. Accelerated DC Dry Life Test (85°C / 125vdc / 2000 hrs): 106K100RA4
    c. Accelerated DC Dry Life Test (85°C / 500vdc / 2000 hrs): 474K400RA6
    d. Accelerated AC Dry Life Test (85°C / 270vac / 1000 hrs): 474K400RA6
    e. Accelerated DC Dry Life Test (85°C / 300vdc / 2000 hrs): 684K250RA6
2. Steady State Moisture Resistance
3. Thermal Shock
4. Lead Pull

Test File Comparison Report
225K100RA4

Test File Data

Tests	Code Names	Operators	Test Type
Initial	000108P010a	R.P.	Performance evaluation
Final	000219P010b	R.P.	Dry life

Test Criteria

Voltage	Temperature	%RH	Duration
125VDC	85°C ± 3°C	NA	1000 hrs ± 12 hrs

Special: Standard RA4 units.
Tested to IEC 384-1, paragraph 4.23

Test Data

	Initial				Final				
	Cap		DF	IR	Cap			DF	IR
Unit #	mfds	%Nom.	%	MΩ x µF	mfds	%Nom.	% Δ	%	MΩ x µF
1	2.314	5.18	< 1.0%	> 1,000	2.277	3.50	-1.60	< 1.0%	> 1,000
2	2.325	5.68	< 1.0%	> 1,000	2.283	3.77	-1.81	< 1.0%	> 1,000
3	2.348	6.73	< 1.0%	> 1,000	2.306	4.82	-1.79	< 1.0%	> 1,000
4	2.299	4.50	< 1.0%	> 1,000	2.238	1.73	-2.65	< 1.0%	> 1,000
5	2.303	4.68	< 1.0%	> 1,000	2.257	2.59	-2.00	< 1.0%	> 1,000
6	2.317	5.32	< 1.0%	> 1,000	2.283	3.77	-1.47	< 1.0%	> 1,000
7	2.322	5.55	< 1.0%	> 1,000	2.283	3.77	-1.68	< 1.0%	> 1,000
8	2.316	5.27	< 1.0%	> 1,000	2.272	3.27	-1.90	< 1.0%	> 1,000
9	2.305	4.77	< 1.0%	> 1,000	2.259	2.68	-2.00	< 1.0%	> 1,000
10	2.322	5.55	< 1.0%	> 1,000	2.287	3.95	-1.51	< 1.0%	> 1,000
11	2.317	5.32	< 1.0%	> 1,000	2.276	3.45	-1.77	< 1.0%	> 1,000
12	2.319	5.41	< 1.0%	> 1,000	2.278	3.55	-1.77	< 1.0%	> 1,000
13	2.298	4.45	< 1.0%	> 1,000	2.269	3.14	-1.26	< 1.0%	> 1,000
14	2.305	4.77	< 1.0%	> 1,000	2.269	3.14	-1.56	< 1.0%	> 1,000
15	2.337	6.23	< 1.0%	> 1,000	2.295	4.32	-1.80	< 1.0%	> 1,000
16	2.319	5.41	< 1.0%	> 1,000	2.270	3.18	-2.11	< 1.0%	> 1,000
17	2.301	4.59	< 1.0%	> 1,000	2.271	3.23	-1.30	< 1.0%	> 1,000
18	2.305	4.77	< 1.0%	> 1,000	2.281	3.68	-1.04	< 1.0%	> 1,000
19	2.282	3.73	< 1.0%	> 1,000	2.247	2.14	-1.53	< 1.0%	> 1,000
20	2.316	5.27	< 1.0%	> 1,000	2.284	3.82	-1.38	< 1.0%	> 1,000
21	2.333	6.05	< 1.0%	> 1,000	2.296	4.36	-1.59	< 1.0%	> 1,000
22	2.327	5.77	< 1.0%	> 1,000	2.287	3.95	-1.72	< 1.0%	> 1,000
23	2.352	6.91	< 1.0%	> 1,000	2.315	5.23	-1.57	< 1.0%	> 1,000
24	2.302	4.64	< 1.0%	> 1,000	2.267	3.05	-1.52	< 1.0%	> 1,000
25	2.310	5.00	< 1.0%	> 1,000	2.271	3.23	-1.69	< 1.0%	> 1,000
Max	2.352	6.91	< 1.0%		2.315	5.23	-1.04	< 1.0%	
Min	2.282	3.73		> 1,000	2.238	1.73	-2.65		> 1,000
Avg	2.316	5.26			2.277	3.49	-1.68		
Std	0.0156	0.71			0.0166	0.75	0.31		
Range	0.0700	3.18			0.0770	3.50	1.61		

Conclusion

Performance:

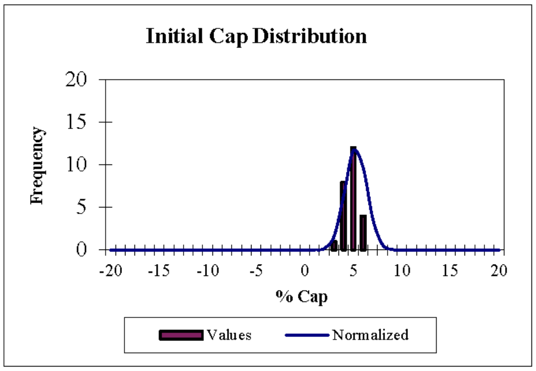
	Design Limits	Test Data	Pass
% Δ Cap (max)	5.00	2.65	✓
%DF (max)	1.00	< 1.0%	✓
IR (min)	1,000	> 1,000	✓

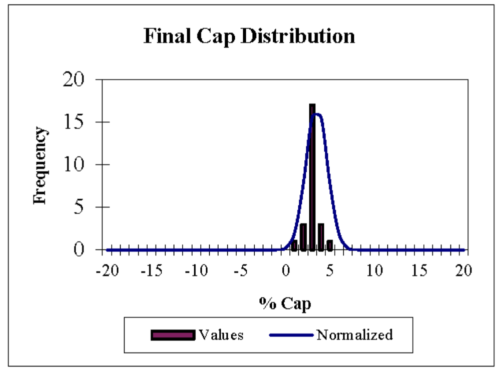
Notes:

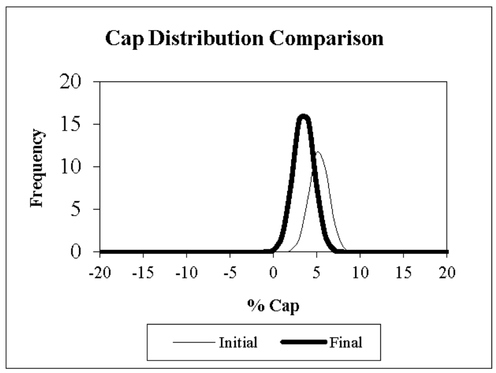
Test parts successfully meet performance criteria.

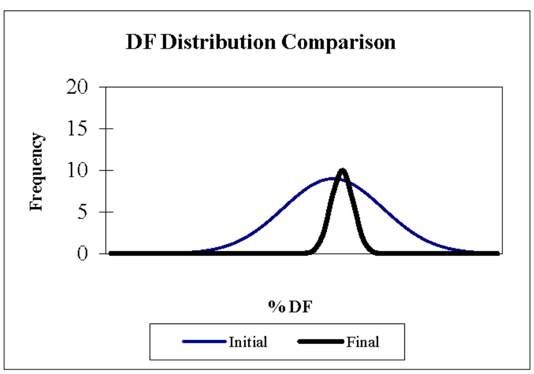
Paktron

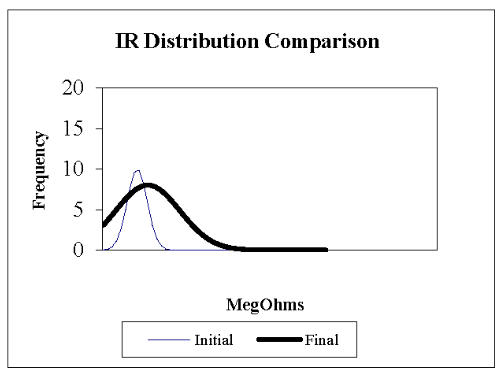
225K100RA4-Dry life











PAKTRON CAPACITORS

Test File Comparison Report
106K100RA4

Test File Data

Tests	Code Names	Operators	Test Type
Initial	091009P011Ca	R.P.	Performance evaluation
Final	091009P011Ce	R.P.	Dry life

Test Criteria

Voltage	Temperature	%RH	Duration
125VDC	85°C ± 3°C	NA	2000 hrs ± 12 hrs

Special: Standard RA4 units.
Tested to IEC 384-1, paragraph 4.23

Test Data

	Initial				Final				
	Cap		DF	IR	Cap			DF	IR
Unit #	mfds	%Nom.	%	MΩ x µF	mfds	%Nom.	% Δ	%	MΩ x µF
1	9.905	-0.95	< 1.0%	> 1,000	9.610	-3.90	-2.98	< 1.0%	> 1,000
2	9.594	-4.06	< 1.0%	> 1,000	9.545	-4.55	-0.51	< 1.0%	> 1,000
3	9.869	-1.31	< 1.0%	> 1,000	9.729	-2.71	-1.42	< 1.0%	> 1,000
4	9.761	-2.39	< 1.0%	> 1,000	9.703	-2.97	-0.59	< 1.0%	> 1,000
5	9.700	-3.00	< 1.0%	> 1,000	9.635	-3.65	-0.67	< 1.0%	> 1,000
6	10.113	1.13	< 1.0%	> 1,000	9.923	-0.77	-1.88	< 1.0%	> 1,000
7	10.060	0.60	< 1.0%	> 1,000	9.997	-0.03	-0.63	< 1.0%	> 1,000
8	10.101	1.01	< 1.0%	> 1,000	9.798	-2.02	-3.00	< 1.0%	> 1,000
9	9.707	-2.93	< 1.0%	> 1,000	9.615	-3.85	-0.95	< 1.0%	> 1,000
10	9.847	-1.53	< 1.0%	> 1,000	9.777	-2.23	-0.71	< 1.0%	> 1,000
11	10.118	1.18	< 1.0%	> 1,000	9.847	-1.53	-2.68	< 1.0%	> 1,000
12	9.826	-1.74	< 1.0%	> 1,000	9.599	-4.01	-2.31	< 1.0%	> 1,000
13	10.087	0.87	< 1.0%	> 1,000	9.731	-2.69	-3.53	< 1.0%	> 1,000
14	10.145	1.45	< 1.0%	> 1,000	9.919	-0.81	-2.23	< 1.0%	> 1,000
15	10.197	1.97	< 1.0%	> 1,000	9.850	-1.50	-3.40	< 1.0%	> 1,000
16	9.813	-1.87	< 1.0%	> 1,000	9.747	-2.53	-0.67	< 1.0%	> 1,000
17	9.913	-0.87	< 1.0%	> 1,000	9.823	-1.77	-0.91	< 1.0%	> 1,000
18	9.654	-3.46	< 1.0%	> 1,000	9.571	-4.29	-0.86	< 1.0%	> 1,000
19	10.177	1.77	< 1.0%	> 1,000	9.792	-2.08	-3.78	< 1.0%	> 1,000
20	10.046	0.46	< 1.0%	> 1,000	9.687	-3.13	-3.57	< 1.0%	> 1,000
21	10.139	1.39	< 1.0%	> 1,000	9.955	-0.45	-1.81	< 1.0%	> 1,000
22	10.201	2.01	< 1.0%	> 1,000	9.885	-1.15	-3.10	< 1.0%	> 1,000
23	9.952	-0.48	< 1.0%	> 1,000	9.902	-0.98	-0.50	< 1.0%	> 1,000
24	9.622	-3.78	< 1.0%	> 1,000	9.585	-4.15	-0.38	< 1.0%	> 1,000
25	9.806	-1.94	< 1.0%	> 1,000	9.764	-2.36	-0.43	< 1.0%	> 1,000
Max	10.201	2.01	< 1.0%		9.997	-0.03	-0.38	< 1.0%	
Min	9.594	-4.06		> 1,000	9.545	-4.55	-3.78		> 1,000
Avg	9.934	-0.66			9.760	-2.40	-1.74		
Std	0.1913	1.91			0.1284	1.28	1.18		
Range	0.6070	6.07			0.4520	4.52	3.40		

Conclusion

Performance:

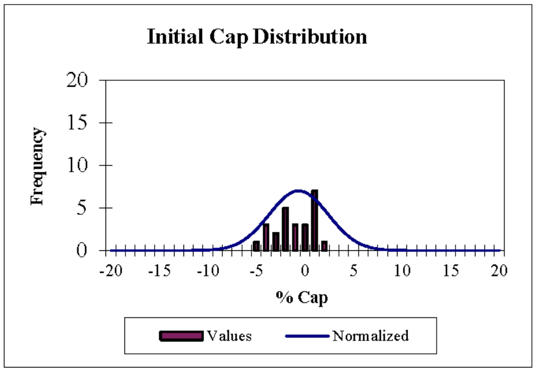
	Design Limits	Test Data	Pass
% Δ Cap (max)	5.00	3.78	✓
%DF (max)	1.00	< 1.0%	✓
IR (min)	1,000	> 1,000	✓

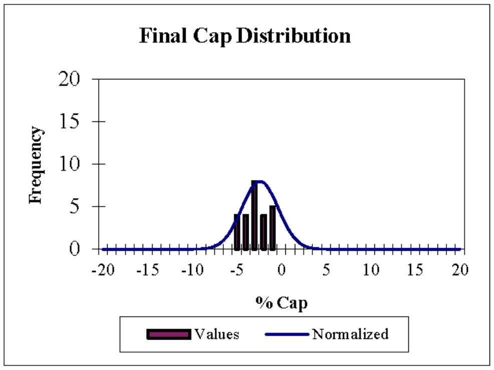
Notes:

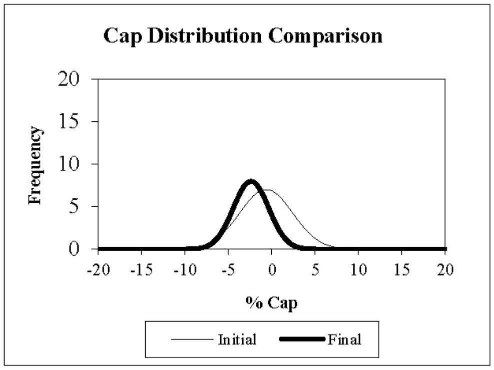
Test parts successfully meet performance criteria.

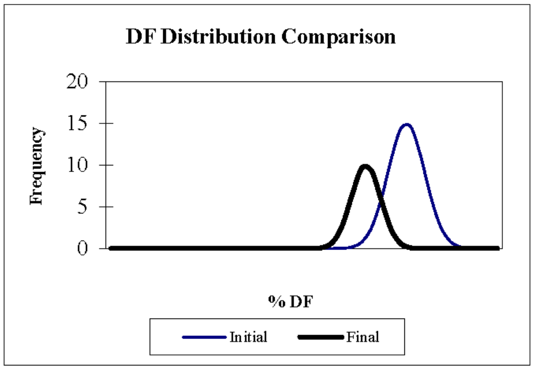
Paktron

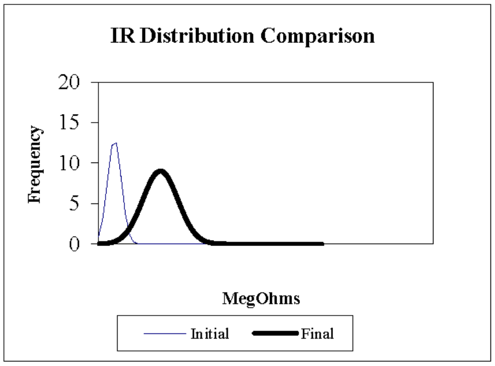
106K100RA4-Dry life











PAKTRON CAPACITORS

Test File Comparison Report
474K400RA6

Test File Data

Tests	Code Names	Operators	Test Type
Initial	1242R08Aa	B.A.	Performance evaluation
Final	1242R08Da	B.A.	Dry life

Test Criteria

Voltage	Temperature	%RH	Duration
500VDC	85°C ± 3°C	NA	2000 hrs ± 12 hrs

Special: Standard Angstor units.
Tested to IEC 384-1, paragraph 4.23

Test Data

	Initial				Final				
	Cap		DF	IR	Cap			DF	IR
Unit #	mfds	%Nom.	%	MegOhms	mfds	%Nom.	% Δ	%	MegOhms
1	0.481	2.34	< 1.0%	> 1,000	0.479	1.91	-0.42	< 1.0%	> 1,000
2	0.463	-1.49	< 1.0%	> 1,000	0.452	-3.83	-2.38	< 1.0%	> 1,000
3	0.480	2.13	< 1.0%	> 1,000	0.479	1.91	-0.21	< 1.0%	> 1,000
4	0.484	2.98	< 1.0%	> 1,000	0.483	2.77	-0.21	< 1.0%	> 1,000
5	0.479	1.91	< 1.0%	> 1,000	0.477	1.49	-0.42	< 1.0%	> 1,000
6	0.452	-3.83	< 1.0%	> 1,000	0.450	-4.26	-0.44	< 1.0%	> 1,000
7	0.477	1.49	< 1.0%	> 1,000	0.475	1.06	-0.42	< 1.0%	> 1,000
8	0.482	2.55	< 1.0%	> 1,000	0.481	2.34	-0.21	< 1.0%	> 1,000
9	0.479	1.91	< 1.0%	> 1,000	0.478	1.70	-0.21	< 1.0%	> 1,000
10	0.458	-2.55	< 1.0%	> 1,000	0.457	-2.77	-0.22	< 1.0%	> 1,000
11	0.475	1.06	< 1.0%	> 1,000	0.473	0.64	-0.42	< 1.0%	> 1,000
12	0.461	-1.91	< 1.0%	> 1,000	0.460	-2.13	-0.22	< 1.0%	> 1,000
13	0.454	-3.40	< 1.0%	> 1,000	0.451	-4.04	-0.66	< 1.0%	> 1,000
14	0.482	2.55	< 1.0%	> 1,000	0.481	2.34	-0.21	< 1.0%	> 1,000
15	0.477	1.49	< 1.0%	> 1,000	0.476	1.28	-0.21	< 1.0%	> 1,000
16	0.479	1.91	< 1.0%	> 1,000	0.478	1.70	-0.21	< 1.0%	> 1,000
17	0.464	-1.28	< 1.0%	> 1,000	0.463	-1.49	-0.22	< 1.0%	> 1,000
18	0.477	1.49	< 1.0%	> 1,000	0.476	1.28	-0.21	< 1.0%	> 1,000
19	0.487	3.62	< 1.0%	> 1,000	0.485	3.19	-0.41	< 1.0%	> 1,000
20	0.459	-2.34	< 1.0%	> 1,000	0.458	-2.55	-0.22	< 1.0%	> 1,000
21	0.483	2.77	< 1.0%	> 1,000	0.482	2.55	-0.21	< 1.0%	> 1,000
22	0.484	2.98	< 1.0%	> 1,000	0.483	2.77	-0.21	< 1.0%	> 1,000
23									
24									
25									
Max	0.487	3.62	< 1.0%		0.485	3.19	-0.21	< 1.0%	
Min	0.452	-3.83		> 1,000	0.450	-4.26	-2.38		> 1,000
Avg	0.474	0.74			0.472	0.36	-0.39		
Std	0.0107	2.28			0.0114	2.43	0.45		
Range	0.0350	7.45			0.0350	7.45	2.17		

Conclusion

Performance:

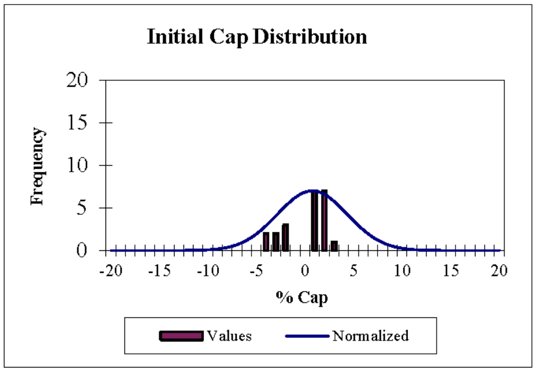
	Design Limits	Test Data	Pass
% Δ Cap (max)	5.00	2.38	✓
%DF (max)	1.00	< 1.0%	✓
IR (min)	1,000	> 1,000	✓

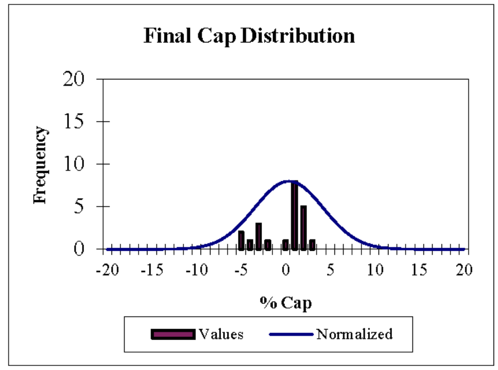
Notes:

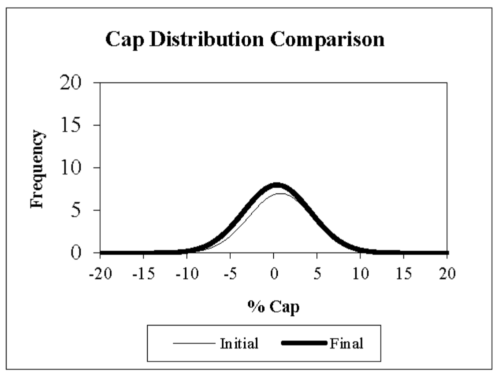
Test parts successfully meet performance criteria.

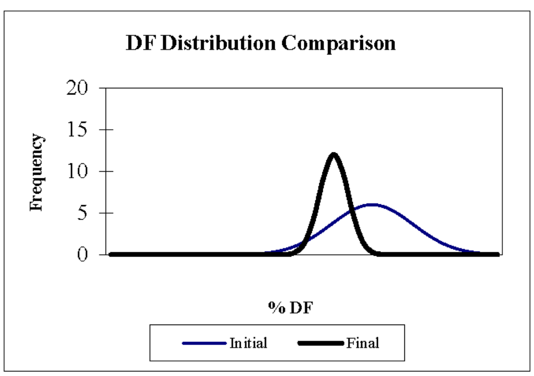
Paktron

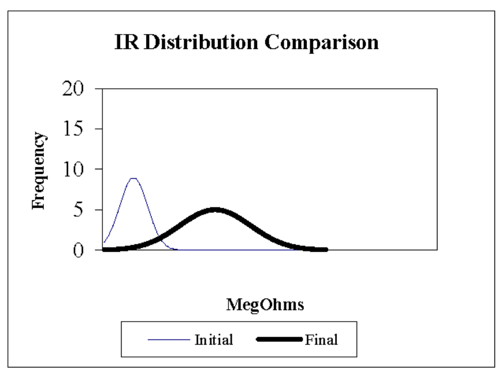
474K400RA6-Dry life











Test File Comparison Report
474K400RA6

Test File Data

Tests	Code Names	Operators	Test Type
Initial	1243R08Aa	B.A.	Performance evaluation
Final	1243R08Da	B.A.	Accelerated AC Dry life

Test Criteria

Voltage	Temperature	%RH	Duration
270vac/60Hz	85°C ± 3°C	NA	1000 hrs ± 12 hrs

Special: Standard Angstor units.
Tested to IEC 384-1, paragraph 4.23

Test Data

	Initial				Final				
	Cap		DF	IR	Cap			DF	IR
Unit #	mfds	%Nom.	%	MegOhms	mfds	%Nom.	% Δ	%	MegOhms
1	0.487	3.62	< 1.0%	> 1,000	0.481	2.34	-1.23	< 1.0%	> 1,000
2	0.456	-2.98	< 1.0%	> 1,000	0.468	-0.43	2.63	< 1.0%	> 1,000
3	0.456	-2.98	< 1.0%	> 1,000	0.450	-4.26	-1.32	< 1.0%	> 1,000
4	0.463	-1.49	< 1.0%	> 1,000	0.460	-2.13	-0.65	< 1.0%	> 1,000
5	0.485	3.19	< 1.0%	> 1,000	0.481	2.34	-0.82	< 1.0%	> 1,000
6	0.481	2.34	< 1.0%	> 1,000	0.477	1.49	-0.83	< 1.0%	> 1,000
7	0.481	2.34	< 1.0%	> 1,000	0.477	1.49	-0.83	< 1.0%	> 1,000
8	0.481	2.34	< 1.0%	> 1,000	0.477	1.49	-0.83	< 1.0%	> 1,000
9	0.482	2.55	< 1.0%	> 1,000	0.477	1.49	-1.04	< 1.0%	> 1,000
10	0.480	2.13	< 1.0%	> 1,000	0.476	1.28	-0.83	< 1.0%	> 1,000
11	0.426	-9.36	< 1.0%	> 1,000	0.432	-8.09	1.41	< 1.0%	> 1,000
12	0.485	3.19	< 1.0%	> 1,000	0.481	2.34	-0.82	< 1.0%	> 1,000
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
Max	0.487	3.62	< 1.0%		0.481	2.34	2.63	< 1.0%	
Min	0.426	-9.36		> 1,000	0.432	-8.09	-1.32		> 1,000
Avg	0.472	0.41			0.470	-0.05	-0.43		
Std	0.0175	3.73			0.0146	3.10	1.14		
Range	0.0610	12.98			0.0490	10.43	3.95		

Conclusion

Performance:

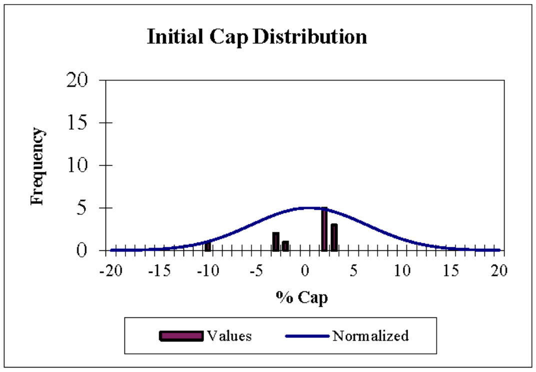
	Design Limits	Test Data	Pass
% Δ Cap (max)	5.00	2.63	✓
%DF (max)	1.00	< 1.0%	✓
IR (min)	1,000	> 1,000	✓

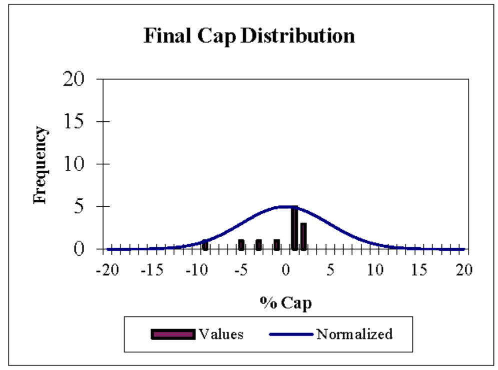
Notes:

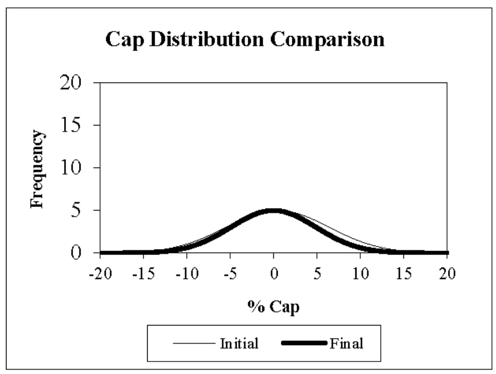
Test parts successfully meet performance criteria.

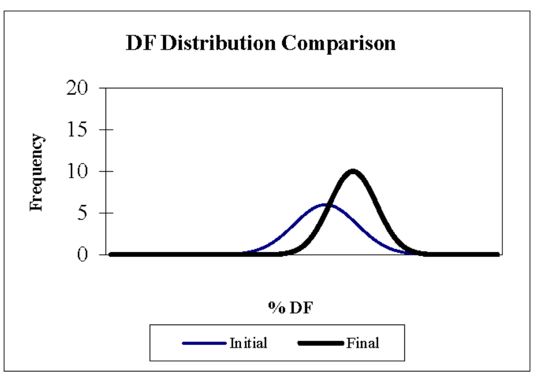
Paktron

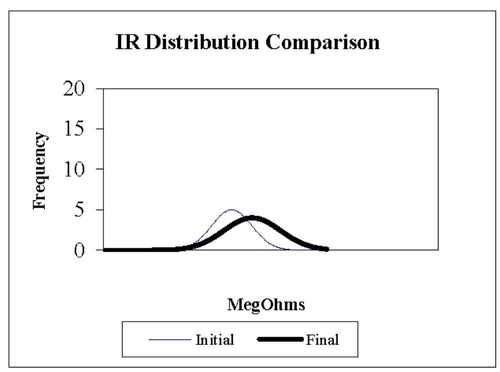
474K400RA6-Accelerated AC Dry life











PAKTRON CAPACITORS

Test File Comparison Report
684K250RA6-AA

Test File Data

Tests	Code Names	Operators	Test Type
Initial	041222P08Aa	R.P.	Performance evaluation
Final	050316P08Da	R.P.	Dry life

Test Criteria

Voltage	Temperature	%RH	Duration
300VDC	85°C ± 3°C	NA	2000 hrs ± 12 hrs

Special: Standard Angstor units.
Tested to IEC 384-1, paragraph 4.23

Test Data

	Initial				Final				
	Cap		DF	IR	Cap			DF	IR
Unit #	mfds	%Nom.	%	MegOhms	mfds	%Nom.	% Δ	%	MegOhms
1	0.702	3.29	< 1.0%	> 1,000	0.682	0.26	-2.93	< 1.0%	> 1,000
2	0.696	2.37	< 1.0%	> 1,000	0.680	-0.01	-2.33	< 1.0%	> 1,000
3	0.678	-0.31	< 1.0%	> 1,000	0.671	-1.38	-1.08	< 1.0%	> 1,000
4	0.679	-0.22	< 1.0%	> 1,000	0.664	-2.43	-2.21	< 1.0%	> 1,000
5	0.672	-1.21	< 1.0%	> 1,000	0.685	0.75	1.98	< 1.0%	> 1,000
6	0.677	-0.43	< 1.0%	> 1,000	0.693	1.88	2.32	< 1.0%	> 1,000
7	0.663	-2.56	< 1.0%	> 1,000	0.667	-1.99	0.59	< 1.0%	> 1,000
8	0.693	1.91	< 1.0%	> 1,000	0.682	0.22	-1.66	< 1.0%	> 1,000
9	0.692	1.72	< 1.0%	> 1,000	0.673	-1.01	-2.69	< 1.0%	> 1,000
10	0.670	-1.47	< 1.0%	> 1,000	0.690	1.47	2.99	< 1.0%	> 1,000
11	0.687	0.96	< 1.0%	> 1,000	0.695	2.26	1.30	< 1.0%	> 1,000
12	0.673	-1.04	< 1.0%	> 1,000	0.664	-2.38	-1.35	< 1.0%	> 1,000
13	0.669	-1.62	< 1.0%	> 1,000	0.670	-1.44	0.18	< 1.0%	> 1,000
14	0.663	-2.51	< 1.0%	> 1,000	0.675	-0.74	1.83	< 1.0%	> 1,000
15	0.695	2.22	< 1.0%	> 1,000	0.692	1.69	-0.52	< 1.0%	> 1,000
16	0.694	2.04	< 1.0%	> 1,000	0.671	-1.40	-3.37	< 1.0%	> 1,000
17	0.671	-1.28	< 1.0%	> 1,000	0.691	1.65	2.96	< 1.0%	> 1,000
18	0.694	2.01	< 1.0%	> 1,000	0.698	2.65	0.62	< 1.0%	> 1,000
19	0.699	2.74	< 1.0%	> 1,000	0.686	0.93	-1.76	< 1.0%	> 1,000
20	0.688	1.21	< 1.0%	> 1,000	0.679	-0.18	-1.37	< 1.0%	> 1,000
21	0.700	2.97	< 1.0%	> 1,000	0.688	1.12	-1.80	< 1.0%	> 1,000
22	0.681	0.12	< 1.0%	> 1,000	0.682	0.28	0.16	< 1.0%	> 1,000
23	0.679	-0.13	< 1.0%	> 1,000	0.678	-0.26	-0.13	< 1.0%	> 1,000
24	0.690	1.41	< 1.0%	> 1,000	0.681	0.15	-1.25	< 1.0%	> 1,000
25	0.685	0.79	< 1.0%	> 1,000	0.693	1.93	1.12	< 1.0%	> 1,000
Max	0.702	3.29	< 1.0%		0.698	2.65	2.99	< 1.0%	
Min	0.663	-2.56		> 1,000	0.664	-2.43	-3.37		> 1,000
Avg	0.684	0.52			0.681	0.16	-0.34		
Std	0.0116	1.71			0.0099	1.45	1.84		
Range	0.0398	5.85			0.0345	5.07	6.36		

Conclusion

Performance:

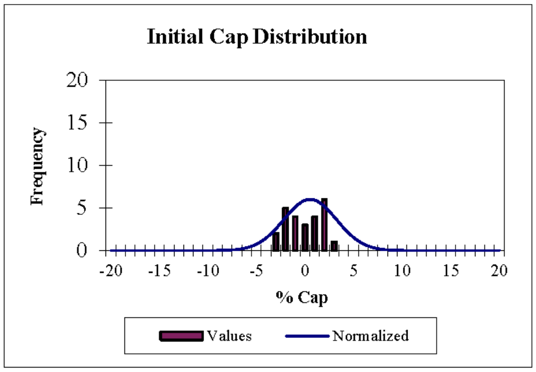
	Design Limits	Test Data	Pass
% Δ Cap (max)	5.00	3.37	✓
%DF (max)	1.00	< 1.0%	✓
IR (min)	1,000	> 1,000	✓

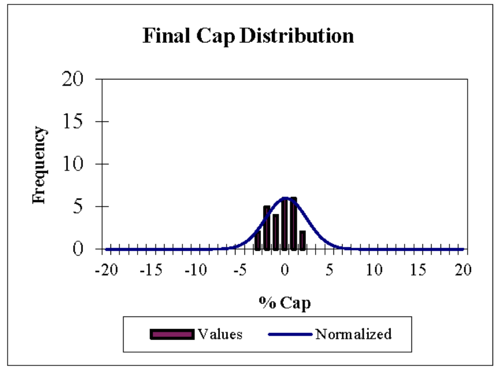
Notes:

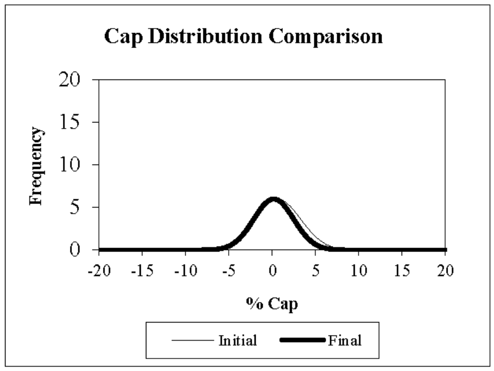
Test parts successfully meet performance criteria.

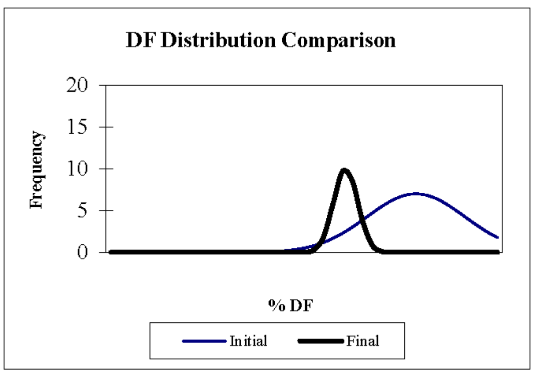
Paktron

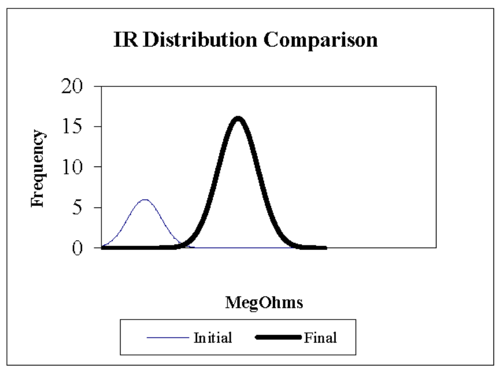
684K250RA6-AA-Dry life











PAKTRON CAPACITORS

Test File Comparison Report
105K100RA4

Test File Data

Tests	Code Names	Operators	Test Type
Initial	000315P010a	R.P.	Performance evaluation
Final	000315P010b	R.P.	Thermal Shock

Test Criteria

Voltage	Temperature	%RH	Duration
0	85°C ± 3°C	NA	0 hrs ± 12 hrs

Special: Standard RA4 units; 2 ovens @ 40°C+-3°C & 85°C+-3°C
Alternate units in ovens at 30 minutes in each oven for nine cycles.

Test Data

	Initial				Final				
	Cap		DF	IR	Cap			DF	IR
Unit #	mfds	%Nom.	%	MegOhms	mfds	%Nom.	% Δ	%	MegOhms
1	1.047	4.74	< 1.0%	> 1000	1.046	4.55	-0.18	< 1.0%	> 1000
2	1.046	4.60	< 1.0%	> 1000	1.039	3.86	-0.71	< 1.0%	> 1000
3	1.079	7.88	< 1.0%	> 1000	1.074	7.39	-0.45	< 1.0%	> 1000
4	1.045	4.50	< 1.0%	> 1000	1.041	4.10	-0.38	< 1.0%	> 1000
5	1.037	3.66	< 1.0%	> 1000	1.033	3.28	-0.37	< 1.0%	> 1000
6	1.046	4.61	< 1.0%	> 1000	1.043	4.27	-0.33	< 1.0%	> 1000
7	1.045	4.49	< 1.0%	> 1000	1.041	4.13	-0.34	< 1.0%	> 1000
8	1.050	5.04	< 1.0%	> 1000	1.038	3.78	-1.20	< 1.0%	> 1000
9	1.042	4.23	< 1.0%	> 1000	1.039	3.93	-0.29	< 1.0%	> 1000
10	1.042	4.21	< 1.0%	> 1000	1.038	3.84	-0.36	< 1.0%	> 1000
11	1.040	4.04	< 1.0%	> 1000	1.037	3.72	-0.31	< 1.0%	> 1000
12	1.045	4.49	< 1.0%	> 1000	1.039	3.87	-0.59	< 1.0%	> 1000
13	1.046	4.61	< 1.0%	> 1000	1.042	4.18	-0.41	< 1.0%	> 1000
14	1.045	4.49	< 1.0%	> 1000	1.041	4.12	-0.35	< 1.0%	> 1000
15	1.050	4.96	< 1.0%	> 1000	1.048	4.77	-0.18	< 1.0%	> 1000
16	1.046	4.55	< 1.0%	> 1000	1.043	4.27	-0.27	< 1.0%	> 1000
17	1.050	5.02	< 1.0%	> 1000	1.047	4.71	-0.30	< 1.0%	> 1000
18	1.039	3.87	< 1.0%	> 1000	1.035	3.52	-0.34	< 1.0%	> 1000
19	1.044	4.39	< 1.0%	> 1000	1.041	4.06	-0.32	< 1.0%	> 1000
20	1.040	3.95	< 1.0%	> 1000	1.035	3.46	-0.47	< 1.0%	> 1000
21	1.047	4.74	< 1.0%	> 1000	1.044	4.37	-0.35	< 1.0%	> 1000
22	1.040	4.03	< 1.0%	> 1000	1.038	3.77	-0.25	< 1.0%	> 1000
23	1.041	4.07	< 1.0%	> 1000	1.069	6.87	2.69	< 1.0%	> 1000
24	1.039	3.93	< 1.0%	> 1000	1.036	3.60	-0.32	< 1.0%	> 1000
25	1.048	4.81	< 1.0%	> 1000	1.043	4.32	-0.47	< 1.0%	> 1000
Max	1.079	7.88	< 1.0%		1.074	7.39	2.69	< 1.0%	
Min	1.037	3.66		> 1000	1.033	3.28	-1.20		> 1000
Avg	1.046	4.56			1.043	4.27	-0.27		
Std	0.0077	0.77			0.0092	0.92	0.64		
Range	0.0422	4.22			0.0411	4.11	3.89		

Conclusion

Performance:

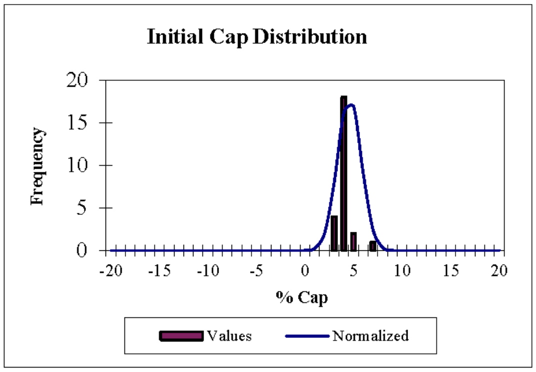
	Design Limits	Test Data	Pass
% Δ Cap (max)	5.00	2.69	✓
%DF (max)	1.00	< 1.0%	✓
IR (min)	1,000	> 1000	✓

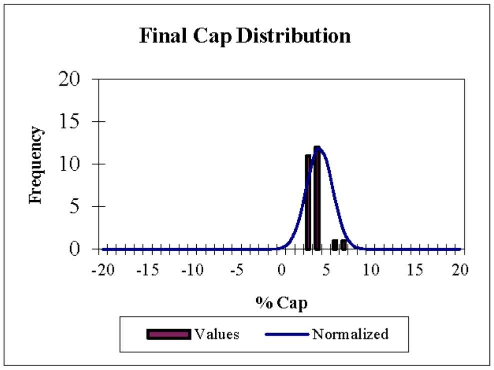
Notes:

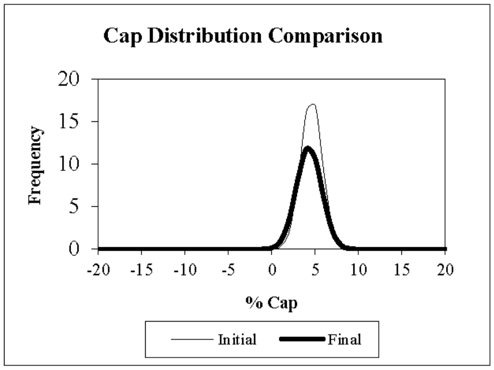
Test parts successfully meet performance criteria.

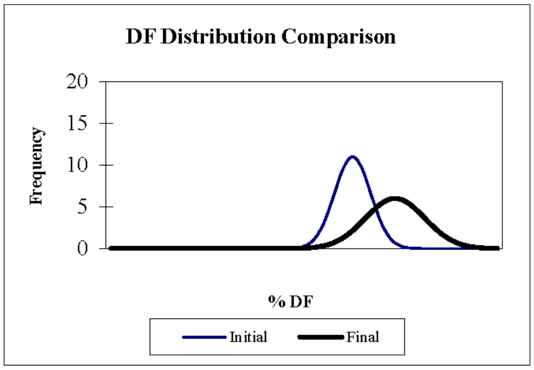
Paktron

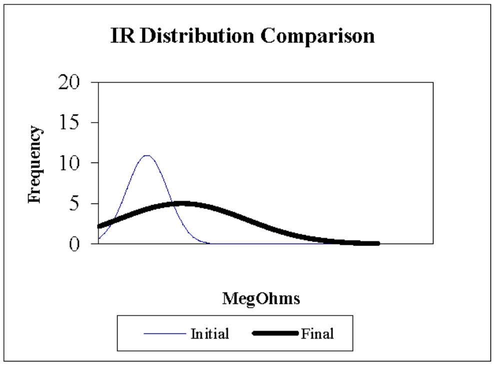
105K100RA4-Thermal Shock











PAKTRON CAPACITORS

Test File Comparison Report
104K250RA3

Test File Data

Tests	Code Names	Operators	Test Type
Initial	000525P009a	R.P.	Performance evaluation
Final	000525P009b	R.P.	Lead Pull

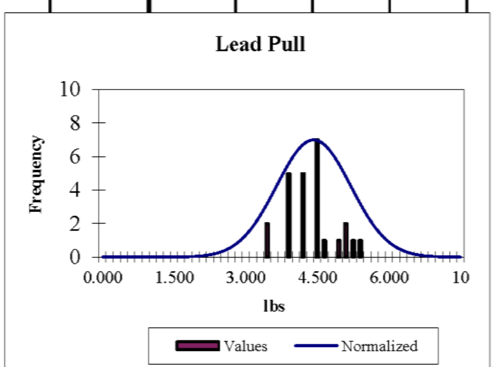
Test Criteria

Voltage	Temperature	%RH	Duration
0	0	NA	0 hrs ± 12 hrs

Special: Standard RA3 units
Mechanical pull perpendicular to the lead

Test Data

	Initial				Final				
	Lead Pull								
Unit #	Lbs								
1	4.000								
2	4.250								
3	4.250								
4	4.000								
5	4.500								
6	4.500								
7	3.500								
8	4.500								
9	5.125								
10	3.500								
11	4.250								
12	4.750								
13	5.000								
14	5.500								
15	4.340								
16	4.250								
17	4.500								
18	4.000								
19	4.500								
20	4.000								
21	5.250								
22	4.500								
23	5.125								
24	4.000								
25	4.500								
Max	5.500								
Min	3.500								
Avg	4.424								
Std	0.4914								
Range	2.0000								



Conclusion

Performance:

	Design Limits	Test Data	Pass
Lead Pull (min)	2.21	3.50	✓

Notes:

Test parts successfully meet performance criteria.

PAKTRON CAPACITORS

Test File Comparison Report
334K100RA4

Test File Data

Tests	Code Names	Operators	Test Type
Initial	1005S01Aa	P.C.	Performance evaluation
Final	1005S01Ca	P.C.	Moisture Test

Test Criteria

Voltage	Temperature	%RH	Duration
0 VDC	85°C ± 3°C	85%	2000 hrs ± 12 hrs

Special: Standard Angstor units.
Tested to IEC 68-2-3 (steady state moisture test, no applied voltage),
except: 85°C instead of 40°C, 85%RH instead of 95% and 83.3days instead of 56.

Test Data

	Initial				Final				
	Cap		DF	IR	Cap			DF	IR
Unit #	mfds	%Nom.	%	MegOhms	mfds	%Nom.	% Δ	%	MegOhms
1	0.322	-2.45	< 1.0%	> 300	0.339	2.59	5.17	< 1.0%	> 300
2	0.321	-2.76	< 1.0%	> 300	0.337	2.19	5.09	< 1.0%	> 300
3	0.324	-1.73	< 1.0%	> 300	0.341	3.21	5.03	< 1.0%	> 300
4	0.322	-2.45	< 1.0%	> 300	0.339	2.65	5.23	< 1.0%	> 300
5	0.332	0.52	< 1.0%	> 300	0.348	5.52	4.98	< 1.0%	> 300
6	0.332	0.61	< 1.0%	> 300	0.347	5.27	4.64	< 1.0%	> 300
7	0.323	-2.15	< 1.0%	> 300	0.340	2.97	5.23	< 1.0%	> 300
8	0.326	-1.24	< 1.0%	> 300	0.342	3.78	5.09	< 1.0%	> 300
9	0.325	-1.61	< 1.0%	> 300	0.341	3.29	4.98	< 1.0%	> 300
10	0.336	1.85	< 1.0%	> 300	0.352	6.72	4.78	< 1.0%	> 300
11	0.325	-1.52	< 1.0%	> 300	0.342	3.58	5.18	< 1.0%	> 300
12	0.326	-1.36	< 1.0%	> 300	0.342	3.60	5.03	< 1.0%	> 300
13	0.328	-0.73	< 1.0%	> 300	0.344	4.31	5.07	< 1.0%	> 300
14	0.333	0.85	< 1.0%	> 300	0.349	5.82	4.93	< 1.0%	> 300
15	0.333	0.76	< 1.0%	> 300	0.349	5.75	4.95	< 1.0%	> 300
16	0.328	-0.67	< 1.0%	> 300	0.344	4.28	4.98	< 1.0%	> 300
17	0.323	-2.03	< 1.0%	> 300	0.339	2.87	5.00	< 1.0%	> 300
18	0.322	-2.36	< 1.0%	> 300	0.339	2.61	5.09	< 1.0%	> 300
19	0.324	-1.79	< 1.0%	> 300	0.341	3.21	5.08	< 1.0%	> 300
20	0.328	-0.58	< 1.0%	> 300	0.345	4.40	5.00	< 1.0%	> 300
21	0.333	0.82	< 1.0%	> 300	0.350	5.92	5.06	< 1.0%	> 300
22	0.329	-0.18	< 1.0%	> 300	0.347	5.00	5.19	< 1.0%	> 300
23	0.324	-1.91	< 1.0%	> 300	0.340	3.09	5.09	< 1.0%	> 300
24	0.326	-1.24	< 1.0%	> 300	0.342	3.60	4.90	< 1.0%	> 300
25									
Max	0.336	1.85	< 1.0%		0.352	6.72	5.23	< 1.0%	
Min	0.321	-2.76		> 300	0.337	2.19	4.64		> 300
Avg	0.327	-0.97			0.343	4.01	5.03		
Std	0.0042	1.26			0.0041	1.24	0.13		
Range	0.0152	4.61			0.0149	4.53	0.60		

Conclusion

Performance:

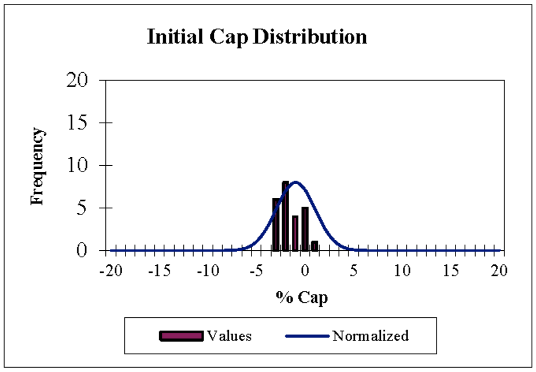
	Design Limits	Test Data	Pass
% Δ Cap (max)	7.00	5.23	✓
%DF (max)	1.00	< 1.0%	✓
IR (min)	300	> 300	✓

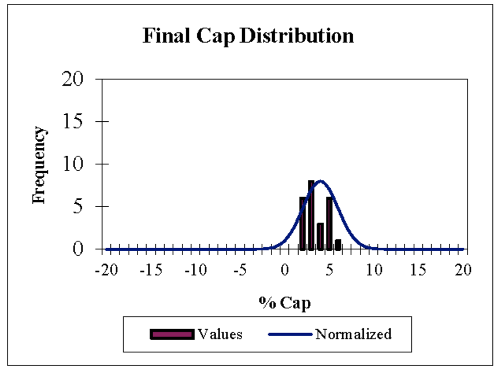
Notes:

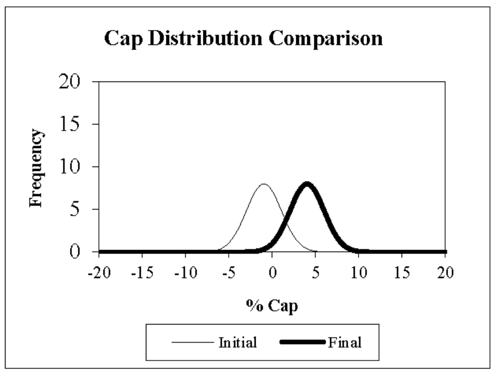
Test parts successfully meet performance criteria.

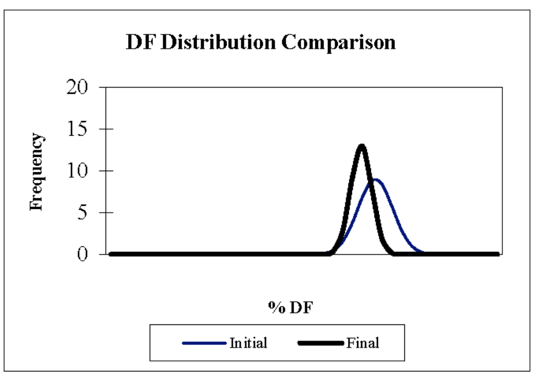
Paktron

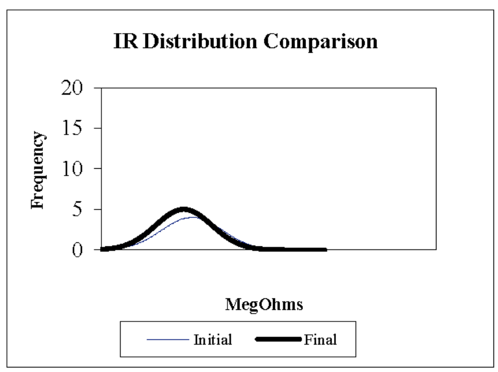
334K100RA4-Moisture Test











APPENDIX A

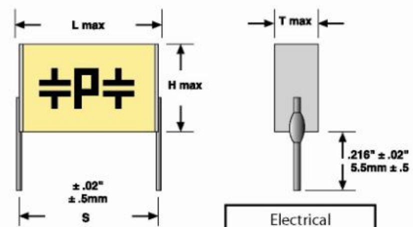
Type RA Angstor® Capacitor
Metallized Polyester (PET) Dielectric

PAKTRON CAPACITORS

Capacitor Type

RA

- Efficient size
- Rugged construction
- Does not fail short – Self healing
- Low ESR/ESL
- No entrapped moisture or air in self-encased design
- No dissimilar metals to chemically degrade or attract moisture
- High dv/dt
- Wave solderable
- Operating temperature range: –55°C to +125°C
- Made in U.S.A.



Electrical Schematic

Non-polarized

100 VDC / 80 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
224	0.22	0.350 (8.9)	0.155 (3.9)	0.280 (7.1)	0.295 (7.5)	0.025 (.6)	75	RA3	224K100RA3 _ _
474	0.47	0.350 (8.9)	0.180 (4.6)	0.305 (7.7)	0.295 (7.5)	0.025 (.6)	65	RA3	474K100RA3 _ _
105	1.0	0.450 (11.4)	0.175 (4.4)	0.285 (7.2)	0.394 (10)	0.025 (.6)	35	RA4	105K100RA4 _ _
225	2.2	0.350 (8.9)	0.250 (6.3)	0.350 (8.9)	0.295 (7.5)	0.025 (.6)	25	RA3	225K100RA3 _ _
225	2.2	0.450 (11.4)	0.205 (5.2)	0.285 (7.2)	0.394 (10)	0.025 (.6)	25	RA4	225K100RA4 _ _
335	3.3	0.450 (11.4)	0.250 (6.3)	0.350 (8.9)	0.394 (10)	0.025 (.6)	25	RA4	335K100RA4 _ _
405	4.0	0.450 (11.4)	0.200 (5.1)	0.380 (9.7)	0.394 (10)	0.032 (.8)	20	RA4	405K100RA4 _ _
505	5.0	0.450 (11.4)	0.220 (5.6)	0.480 (12.2)	0.394 (10)	0.032 (.8)	20	RA4	505K100RA4 _ _
106	10.0	0.650 (16.5)	0.260 (6.6)	0.460 (11.7)	0.591 (15)	0.032 (.8)	13	RA6	106K100RA6 _ _

250 VDC / 160 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
104	0.1	0.450 (11.4)	0.160 (4.1)	0.255 (6.5)	0.394 (10)	0.025 (.6)	100	RA4	104K250RA4 _ _
224	0.22	0.450 (11.4)	0.190 (4.8)	0.305 (7.7)	0.394 (10)	0.025 (.6)	75	RA4	224K250RA4 _ _
334	0.33	0.450 (11.4)	0.250 (6.3)	0.330 (8.4)	0.394 (10)	0.025 (.6)	75	RA4	334K250RA4 _ _
474	0.47	0.450 (11.4)	0.210 (5.3)	0.305 (7.7)	0.394 (10)	0.025 (.6)	55	RA4	474K250RA4 _ _
474	0.47	0.650 (16.5)	0.230 (5.8)	0.340 (8.6)	0.591 (15)	0.032 (.8)	50	RA6	474K250RA6 _ _
105	1.0	0.650 (16.5)	0.240 (6.1)	0.340 (8.6)	0.591 (15)	0.032 (.8)	35	RA6	105K250RA6 _ _

Dimensions in inches, metric (mm) in parenthesis.

Tolerance: K (±10%) standard, J (±5%) available

RoHS part number information:

No suffix indicates RoHS-5 compliant standard part number. RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) in levels exceeding the industry defined limits. Component lead wires are plated with Sn / Pb and match conventional SnPb board assembly requirements.
For a **RoHS-6** compliant part, add a **–FA** suffix. RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits. Component lead wires are plated with Sn.

PAKTRON CAPACITORS

Type RA Angstor® Capacitor
Metallized Polyester (PET) Dielectric

400 VDC / 250 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
224	0.22	0.650 (16.5)	0.230 (5.8)	0.340 (8.6)	0.591 (15)	0.032 (.8)	65	RA6	224K400RA6 _ _
474	0.47	0.650 (16.5)	0.290 (7.4)	0.440 (11.1)	0.591 (15)	0.032 (.8)	120	RA6	474K400RA6 _ _

500 VDC / 250 VAC

PF Code	Value µF	L MAX	T MAX	H MAX	S ±.02 (.5)	d	Max dv/dt (V/µs)	Case	Part Number
504	0.5	0.650 (16.5)	0.280 (7.1)	0.540 (13.7)	0.591 (15)	0.032 (.8)	120	RA6	504K500RA6 _ _

Dimensions in inches, metric (mm) in parenthesis.

Tolerance: K (±10%) standard, J (±5%) available

RoHS part number information:

No suffix indicates RoHS-5 compliant standard part number. RoHS-5 product does not contain five of the RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) in levels exceeding the industry defined limits. Component lead wires are plated with Sn / Pb and match conventional SnPb board assembly requirements.
For a **RoHS-6** compliant part, add a **–FA** suffix. RoHS-6 product does not contain any of the six RoHS banned materials (Hg, CrVI, Cd, PBB, PBDE and Pb) in levels exceeding the industry defined limits. Component lead wires are plated with Sn.

Electrical

Capacitance Range:
0.1 µF to 10.0 µF @ 1KHz

Tolerance:
Available in ± 5%, 10% (standard), 20%

Voltage Range:
100, 250, 400, 500 VDC

Dissipation Factor:
≤ 1.0 % @ 25°C, 1KHz

Insulation Resistance:
≥ 1,000 Megohms x µF
Need not exceed 1,000 Megohms

Rated Voltage	≤ 100 VDC	> 100 VDC
Test Voltage	10 VDC	100 VDC

Dielectric Strength:
1.6 x RVDC, 2 seconds max.
(Bold P/Ns) 1.3 x RVDC, 2 seconds max.

Self Inductance:
2 to 6nh typical

Temperature Range:
-55°C to 125°C @ rated DC voltage
(Bold P/Ns) –55°C to 125°C,
derate voltage 1.25% / °C above 85°C

Performance

Accelerated DC Voltage Life Test:
1,000 Hours, 85°C, 1.25 × Rated VDC
Δ C/C ≤ 5%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 1,000 Megohm x µF
Need not exceed 1,000 Megohms

Moisture Test:
85°C / 85% RH / 21 days
Applied Voltage: zero bias
Δ C/C ≤ 7%
DF ≤ 1.0%, 1KHz, 25°C
IR ≥ 30% of initial limit

Long Term Stability:
After 2 years storage, standard environment
Δ C/C ≤ 2%

Physical

Vibration:
Mil Std 202 Method 204D

Solder Resistance:
260°C, 5 Sec. Δ C/C ≤ 2%

Construction:
Non-inductively constructed with metallized polyester dielectric (polyethylene terephthalate). Parallel plate–multilayer polymer (MLP) design.

Electrode:
Aluminum metallization

Case:
Polyester tape wrap

Marking:
Parts are continuously marked ≑P≑ and pf code. Capacitance, tolerance and working voltage are printed on container.

Packaging:
Bulk Packaging Standard

Angstor® Capacitor Application Notes

Paktron developed the highly advanced Interleaf® Technology method of capacitor manufacturing to improve device electrical properties and stability in actual use conditions. As opposed to the conventional winding method, Interleaf® Technology uses a high laminating pressure, linear stacking technology. The resulting capacitor chip is a construction hybrid resembling a multilayer ceramic capacitor in cross section, while offering all the fail-safe advantages of a stacked plastic film capacitor. We refer to the resultant parts as MLP or multilayer polymer. The Angstor® Capacitor (or RA Style) is a self-encased, metallized film capacitor which features small size, high dv/dt capability and very low ESR at high frequency.

Intended for thru-hole and wired applications, the units feature all aluminum electrodes and terminals that are pulse welded to the lead wires. The units are back impregnated with a microcrystalline polymer sealant, and require no external coatings for moisture protection. The internal layers are heavily laminated to eliminate air from the core material which improves high frequency response compared to competitive units. Operating temperature limit is extended to125ºC.

The following are a few examples of applications wherein the Angstor's unique features have proven desirable:

HIGH FREQUENCY SWITCHING POWER INPUTS

As the modern power converter broke the 100 KHz switching frequency barrier, the ripple voltage and RFI control components changed drastically. On the input side of 48 volt converters, a low ESR and ESL capacitor is needed in the pi filter network to control EMI generated by the switching MOSFET. Metallized film capacitors should be used because of the voltage bias and due to the unit's ability to "clear" during a high voltage event, rather than short out like a common MLC capacitor. Electrolytic (aluminum and tantalum) capacitors are not useful because of their extremely high parasitic resistance and inductance. Under ripple voltage the Angstor is stable, while ceramic capacitors increase in loss factor, creating incremental I_2R losses.

LINE AND DATA LINE NOISE SUPPRESSION

A ≥ 250V Angstor will not lose value due to the bias voltage and can be used on higher voltage lines as a differential noise bypass for RFI control. High input dv/dt up to 100 volts per micro second can be handled. In modems, the Angstor is a space efficient alternative to other input current control devices. Since the capacitor body is "plastic" there exists no piezoelectric emf due to input di/dt.

EMI/RFI SUPPRESSION

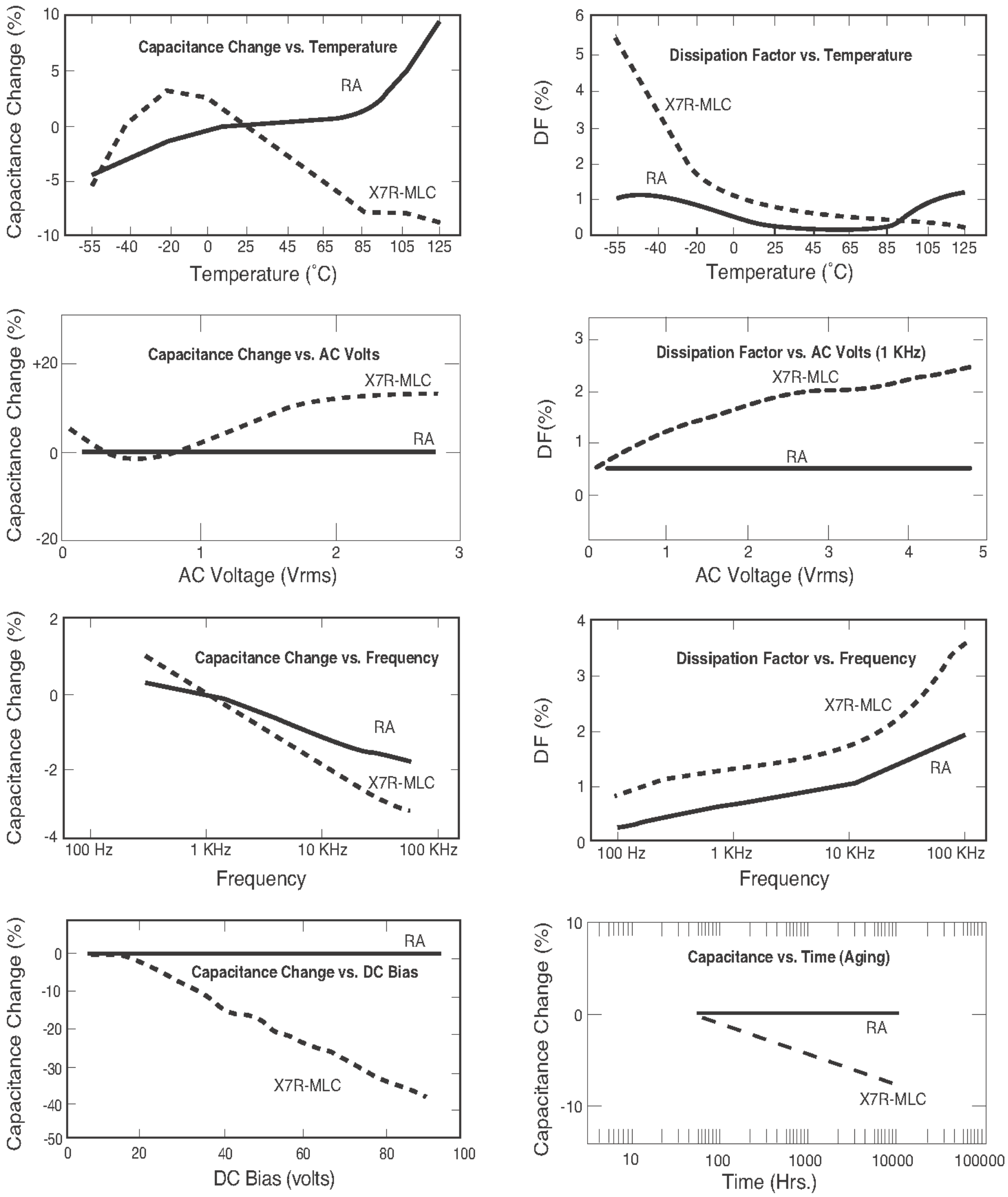
Noise suppression is required on a variety of motors and field effect devices close to the offending source to minimize RFI on the voltage bus. Noise or transients emanating from switched state motors or inductors require a low ESR capacitor as part of the filtering arrangement. The Angstor is an excellent choice for these 12, 36 and 48 volt bus-rails because of its small size compared to other film capacitors and better ESR and reliability than ceramic capacitors. As the automotive bus voltage rises from 12 to 36/42 volts, this technology will replace many ceramic and tantalum capacitors because of its enhanced voltage coefficient (stability).

A significant new market is in on-board converters to charge batteries in EV and HEV applications.

GRACEFUL AGING

There exists no chemical interactions within the MLP Capacitor to effect long term life. The parts are suitable for 10 to 20 year life applications due to their stability and inherently low loss. The polymer dielectric becomes more crystalline over long periods of time, which can gradually lower the capacitance value. The thin-film metallized electrodes are capable of "self healing" under high voltage events. This feature avoids the shorting, cracking and rapid heat generation problem often found in ceramic capacitors.

Typical Performance Curves
Comparison of Multilayer Polmer (RA) vs. Multilayer Ceramic (X7R)

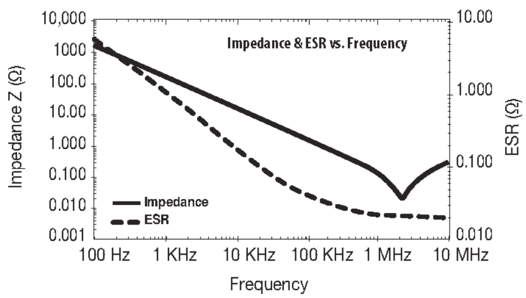


Type RA Angstor® Capacitor
Metallized Polyester (PET) Dielectric

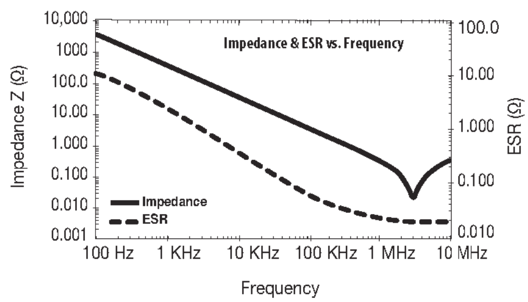
PAKTRON CAPACITORS

Typical Performance Curves
Selected High Value "Power" Capacitors

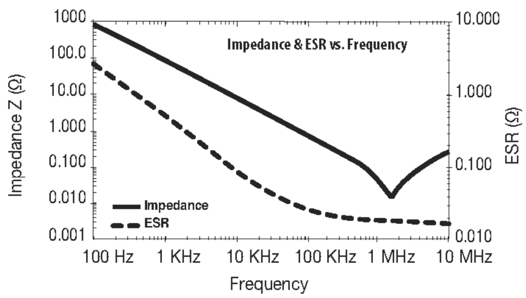
1.0 µF 100 VDC RA4



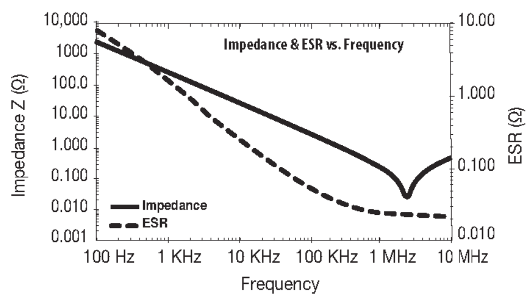
0.47 µF 250 VDC RA4



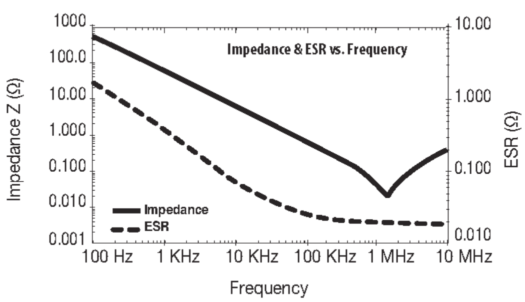
2.2 µF 100 VDC RA4



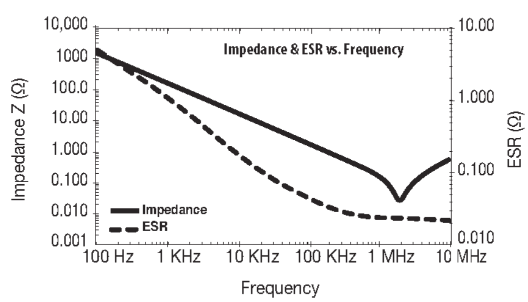
0.47 µF 400 VDC RA6



3.3 µF 100 VDC RA4

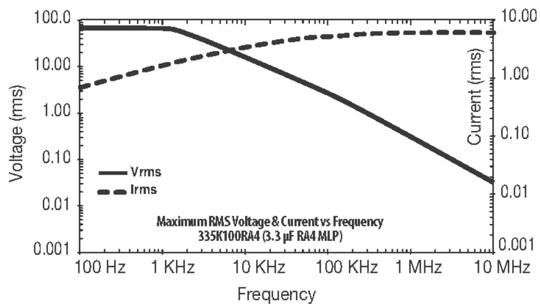


1.0 µF 250 VDC RA6

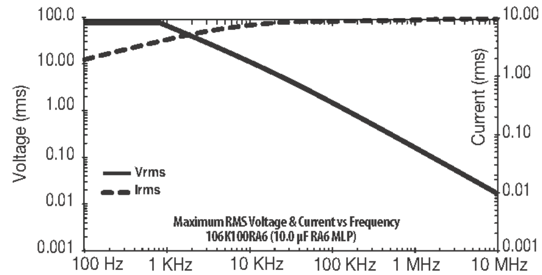


Typical Performance Curves
Selected High Value "Power" Capacitors

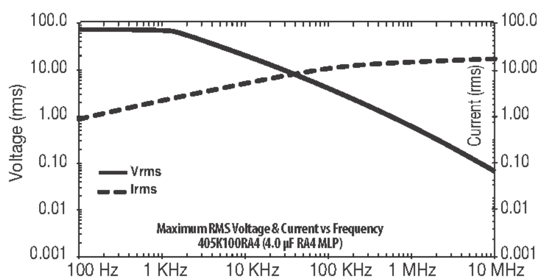
3.3 µF 100 VDC RA4



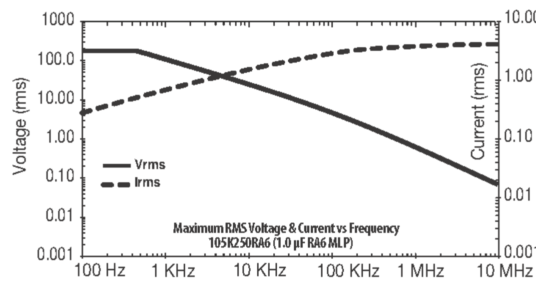
10.0 µF 100 VDC RA6



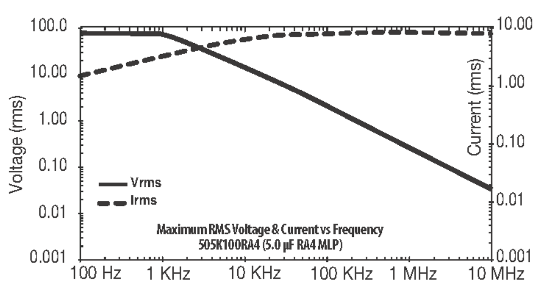
4.0 µF 100 VDC RA4



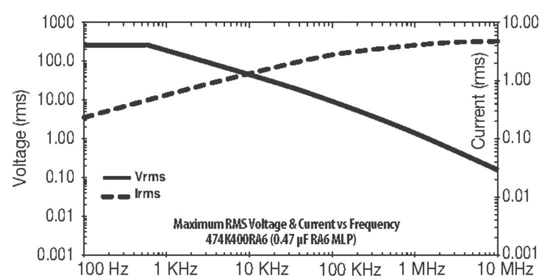
1.0 µF 250 VDC RA6



5.0 µF 100 VDC RA4



0.47 µF 400 VDC RA6

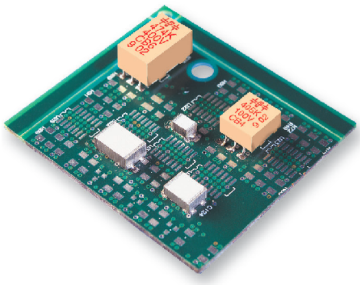


APPENDIX B

PAKTRON CAPACITORS

MULTILAYER POLYMER CAPACITORS

- Ultra Low ESR
- High Frequency
- High Ripple Current
- Long Life



Paktron specializes in Ultra Low ESR multilayer polymer film capacitors and leads in Film-Chip and SMT designs. Paktron has been manufacturing film capacitors for over 50 years. Paktron holds in excess of seventyfive patents for film capacitors and machine design.

Capacitors featured are:

Angstor® Miniature Radial

Capstick® Lead-Framed MLP

Surfilm® Surface Mount Chip

Quencharc® R-C Network/Snubber

The metallized electrode used in Paktron's proprietary Interleaf® Technology process assures reliable performance. Multilayer Polymer (MLP) surface mount, chip and lead framed capacitors are replacing MLC (ceramic) capacitors in higher voltage and reliability-sensitive equipment. This includes the popular -48 volt telecom bus, off-line HVAC and PFC front ends.

Today, the fastest-growing market segment that Paktron serves is Power Conversion for industries such as Telecommunications/Datacom, military infrastructure, automotive, medical and high-end industrial. The 100 volt rated MLP film capacitor is becoming the part of choice for input/output filtering in -48 volt telecom bus power applications (on-board or dc/dc modules). The MLP capacitor provides improved stability, both electrically and mechanically, compared to multilayer ceramics. The MLP features "non-shorting" operation and does not crack like large ceramic blocks.

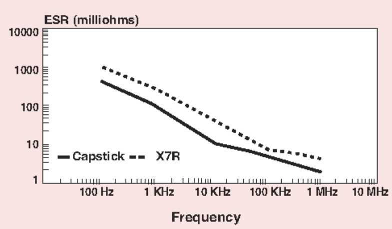
MLP Capacitor Advantages over Ceramics

Multilayer Polymer Film (MLP)	X7R Ceramic (MLC)
✔ Stable under voltage	Cap drops 40% at 100 volts bias
✔ Stable under AC voltage	DF increases with AC voltage
✔ Chip is plastic with good TCE	Body is ceramic which cracks
✔ Stable over temperature	DF increases at low temperature
✔ No aging mechanism	Cap drops per decade hour
✔ Resilient under thermal shock	Ceramic body cracks easily
✔ Self-clearing thin electrodes	Thick film electrodes fail short
✔ Stable under mechanical stress	Piezoelectric voltage sensitive
✔ Ultra Low ESR	Low ESR
✔ Dissipation Factor ≤ 1%	Dissipation Factor ≤ 2.5%

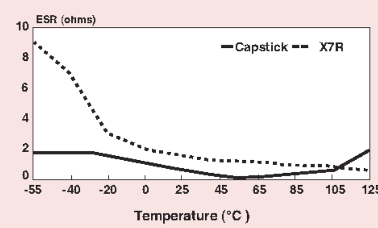
TYPICAL CHARACTERISTICS

The following graphs contrast important characteristics of MLP Capsticks to MLC ceramic units in typical, dynamic converter conditions. The electrical stability of the MLP capacitor is clear.

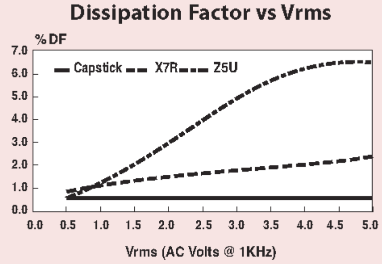
ESR vs. Frequency



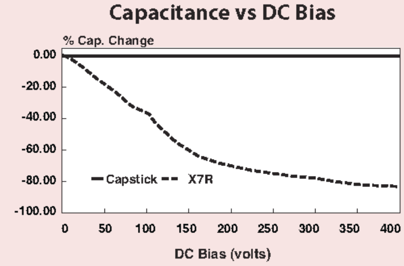
120 Hz ESR vs. Temperature



Dissipation Factor vs Vrms



Capacitance vs DC Bias



Light Weight Construction

By the very nature of the materials from which they are constructed, polymer film capacitors are a “lightweight” in terms of mass while being a “heavyweight” in terms of performance making for a combination unmatched by any other capacitor technology.

Typical Capacitor Weights per Piece

Series	Part Number	Description	Unit Weight lbs	Unit Weight grams
Angstor				
	474K250RA4	0.47µF, ±10% , 250vdc, L.S. 0.400"	0.0014	0.634
	225K100RA4	2.20µF, ±10% , 100vdc, L.S. 0.400"	0.0009	0.408
	335K100RA4	3.30µF, ±10% , 100vdc, L.S. 0.400"	0.0013	0.590
	405K100RA4	4.00µF, ±10% , 100vdc, L.S. 0.400"	0.0018	0.837
	474K400RA6	0.47µF, ±10% , 400vdc, L.S. 0.600"	0.0030	1.352
	105K250RA6	1.00µF, ±10% , 250vdc, L.S. 0.600"	0.0021	0.953
Capstick				
	405K100CB4	4.00µF, ±10% , 100vdc, L.S. 0.400"	0.0028	1.252
	475K100CB4	4.70µF, ±10% , 100vdc, L.S. 0.400"	0.0031	1.406
	106K100CB4	10.0µF, ±10% , 100vdc, L.S. 0.400"	0.0062	2.798
	405K100CS4	4.00µF, ±10% , 100vdc, L.S. 0.400"	0.0021	0.93
	475K100CS4	4.70µF, ±10% , 100vdc, L.S. 0.400"	0.0025	1.13
	106K050CS4	10.0µF, ±10% , 050vdc, L.S. 0.400"	0.0043	1.95
	106K100CS4	10.0µF, ±10% , 100vdc, L.S. 0.400"	0.0056	2.53
	206K050CS4	20.0µF, ±10% , 050vdc, L.S. 0.400"	0.0086	3.90
	334K400CS6	0.33µF, ±10% , 400vdc, L.S. 0.600"	0.0029	1.29
	474K400CS6	0.47µF, ±10% , 400vdc, L.S. 0.600"	0.0044	2.01
	105K250CS6	1.00µF, ±10% , 250vdc, L.S. 0.600"	0.0029	1.32
	105K400CS6	1.00µF, ±10% , 400vdc, L.S. 0.600"	0.0094	4.28
	105K500CS6	1.00µF, ±10% , 500vdc, L.S. 0.600"	0.0120	5.44
Surfilm				
	105K100ST2824	1.00µF, ±10% , 100vdc, L.S. 0.300"	0.0005	0.23
	225K100ST3827	2.20µF, ±10% , 100vdc, L.S. 0.400"	0.0009	0.41

APPENDIX C

Angstor Product Process Flow and Control Plan

Process	Variables	Control
Margin	Lane Spacing Margin Spacing	Individual Readings (each roll) Individual Readings (each roll)
Wind	Floater Extension	Individual Readings (each belt) Individual Readings (each belt)
Load	None	None
Spray	Stick Width	X-bar and R Control Chart
Stick Calibration	Capacitance Dissipation Factor Voltage	AC and DC voltage is applied to each stick and then each stick is 100 % measured for Capacitance and Dissipation Factor
Saw	Capacitance Cut Height	X-bar and R Control Chart X-bar and R Control Chart
Block Test	Capacitance Dissipation Factor Voltage Insulation Resistance	100 % Capacitance, Dissipation Factor, Voltage and Insulation Resistance test
Tape (premarked)	Tape Quality	Visual
Lead Attach	Lead Strength, Lead Placement	Median Control Chart
Wax	None	None
Final Test	Capacitance Dissipation Factor Voltage Insulation Resistance	100 % Capacitance, Dissipation Factor, Voltage and Insulation Resistance test
First QC Inspection	Capacitance Dissipation Factor Voltage Insulation Resistance Physical Dimensions	AQL sampling of Capacitance, Dissipation Factor, Voltage, Insulation Resistance and Physical dimensions
Lead Cut and bulk/tubing/reeling	Lead dimensions	Go/No-go gauges and AQL sampling
Final QC Inspection	Lead Dimensions and bulk/tubing/reeling quality	Visual and AQL sampling
Ship/Stock		

Appendix D

PAKTRON CAPACITORS

RoHS Position Statement

RoHS-5
Standard Product
Angstor, Capstick and Surfilm (RA, RB, RS, CB, CS, ST3 and ST4):

I hereby certify that Paktron is in compliance with Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the use of certain hazardous substances in electrical and electronic equipment for all articles, products, materials and parts thereof being supplied to Paktron's target Sales markets on a RoHS-5 compliance level and that the information submitted is true and accurate. RoHS-5 means that the content of five RoHS banned materials (Hg, CrVI, Cd, PBB and PBDE) are under the industry-defined limits stated below. RoHS-5 compliant products have Pb in the termination (secondary interconnect: i.e. terminal leads and lead frames) and match conventional SnPb board assembly requirements for those markets exercising Pb solder exemptions. Exempt categories under RoHS currently include the Servers, Storage, Network and Telecom equipment, Medical, Aerospace, Military and Automotive markets. While the terminations contain Pb, the total unit Pb content of Paktron's products is under the industry-defined limits stated below.

RoHS-6
Standard Product
Quencharc and Surfilm (QA, QB, QC, QD, QE, QH, QRL, QV, ST2824 and ST3827):

I hereby certify that Paktron is in compliance with Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the use of certain hazardous substances in electrical and electronic equipment for all articles, products, materials and parts thereof being supplied by Paktron on a full RoHS-6 compliance level and that the information submitted is true and accurate. These Paktron products do not contain any of the six RoHS banned chemicals, compounds or elements listed, in levels exceeding the industry-defined limits stated below.

Chemical, Compound, or Element Content:

Maximum limit of 0.1% by weight (0.1w percent or 1000ppm):

- Polybrominated Diphenyl Ethers (PBDE); C12H(10–n)BrnO
  - Pentabromodiphenyl ether (PentaBDE) – CAS number 32534-81-9; C12H5Br5O;
  - Octabromodiphenyl ether (OctaBDE) - CAS number 32536-52-0; C12H2Br8O
  - Decabromodiphenyl ether (DecaBDE) – CAS number 1163-19-5; C12Br10O
- Polybrominated Biphenyls (PBB)
  - Decabromobiphenyl (DeBBB) – CAS number 13654-09-6; C12H(10–x-y)Brx+y
- Mercury – CAS number 7439-97-6; Hg
- Hexavalent Chromium – CAS number 18540-29-9; CrVI
- Lead – CAS number 7439-92-1; Pb

Maximum limit of 0.01% by weight (0.01w percent or 100ppm):

- Cadmium – CAS number 7440-43-9; Cd

Special Lead-Free Product
Angstor, Capstick and Surfilm (RA, RB, RS, CB, CS, ST3 and ST4):

Subject to minimum order quantities and limited availability, I hereby certify that Paktron is in compliance with Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the use of certain hazardous substances in electrical and electronic equipment for all articles, products, materials and parts thereof being supplied by Paktron on a full RoHS-6 compliance level, on a specialized part number basis (consisting of an added suffix of –F?; with the ? assigned at time of order/quote), and that the information submitted is true and accurate. Paktron's special lead-free products do not contain any of the six RoHS banned chemicals, compounds or elements listed, in levels exceeding the industry-defined limits stated below and also do not contain Pb in the terminations.

The maximum reflow temperature for surface mount product remains at 220°C while the maximum wave solder temperature for thru-hole product is 260°C. The maximum reflow temperature for surface mount product with the "-FS" suffix is 245°C.

Important Notice to Purchasers and Users All statements, technical information and recommendations are based on tests we believe to be reliable, but their accuracy or completeness is not guaranteed. Buyer shall determine the suitability of the product for the intended use and Buyer and User assume all risk and liability of every kind. Any other statement or recommendation shall not be binding or have any force unless in a separate written agreement signed by officers of Seller and Manufacturer. On all orders with special arrangements we reserve the right to over -or short supply of 5% of the quantity ordered.

PAKTRON CAPACITORS

REACH Certificate of Compliance

Paktron is aware of REACH as a European Community regulation on chemicals. Currently Paktron supports the underlying goals of REACH, which are consistent with our own commitment to promote the responsible manufacturing, use and handling of hazardous materials and substances.

REACH (Substances of Very High Concern):

Article 57 of Regulation (EC) No 1907/2006 of the European Parliament and the Council of 18 December 2006 concerning the registration, evaluation, authorization and restriction of chemicals (REACH) defines Substances of Very High Concern (SVHC). At this time member states or European Chemical Agency (ECHA) have approved a candidate list of 84 SVHC. Reach article 33 requires:

- The supplier to inform the recipient if the article (in this case capacitor) supplied contains a substance of very high concern (SVHC) above 0.1% by weight (0.1w percent or 1000ppm).
- Upon request by any consumer provide sufficient information to allow for safe use. Request must be responded to free of charge within 45 days.

Registration of Substances:

After careful review of the EU legislation, it is our current view that Paktron products are to be considered as "articles". Because the legislation requires registration of an article only if it contains a regulated substance that "is intended to be released under normal or reasonably foreseeable conditions of use", our conclusion is that Paktron products constitute non-registerable articles for their intended and anticipated use.

Correspondence with Substances of Very High Concern (SVHC):

Per the candidate list of Substances of Very High Concern (SVHC) first published June 20, 2011 (see attached table for the latest revision), Paktron has reviewed these substances and based on information obtained from our material suppliers certifies that all Paktron's products are compliant per the EU "REACH" requirements of less than 0.1% by weight for each substance.

If new SVHC candidates are published by the European Chemicals Agency (ECHA), and relevant substances are confirmed to exist in Paktron's products that exceed legislation limits, Paktron will provide an updated compliance status. The official list of SVHC candidates can be found at: http://echa.europa.eu/candidate-list-table

Paktron has reviewed the European Chemicals Agency substances of very high concern (listed in the appended table) and certifies that all Paktron products are compliant per the EU "REACH" requirements of less than 0.1% by weight for each substance.

SUPPLIER NAME Paktron

NAME Rick Price TITLE Q.A. Manager E-MAIL rprice@panconcorp.com
(Authorized Agent for Company)

PHONE 434-239-6941

SIGNATURE [signature] DATE 9/10/2012
(Authorized Agent for Company)

Paktron - REACH Certificate of Compliance

REACH Candidate List of SVHC

	Substance Name	EC Number	CAS Number
1	α,α-Bis[4-(dimethylamino)phenyl]-4 (phenylamino)naphthalene-1-methanol (C.I. Solvent Blue 4) *[with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)]*	229-851-8	6786-83-0
2	N,N,N',N'-tetramethyl-4,4'-methylenedianiline (Michler's base)	202-959-2	101-61-1
3	1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (β-TGIC)	423-400-0	59653-74-6
4	Diboron trioxide	215-125-8	1303-86-2
5	1,2-bis(2-methoxyethoxy)ethane (TEGDME; triglyme)	203-977-3	112-49-2
6	4,4'-bis(dimethylamino)-4''-(methylamino)trityl alcohol *[with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)]*	209-218-2	561-41-1
7	Lead(II) bis(methanesulfonate)	401-750-5	17570-76-2
8	Formamide	200-842-0	75-12-7
9	[4-[4,4'-bis(dimethylamino) benzhydrylidene]cyclohexa-2,5-dien-1-ylidene]dimethylammonium chloride (C.I. Basic Violet 3) *[with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)]*	208-953-6	548-62-9
10	1,2-dimethoxyethane; ethylene glycol dimethyl ether (EGDME)	203-794-9	110-71-4
11	[4-[[4-anilino-1-naphthyl][4-(dimethylamino)phenyl]methylene]cyclohexa-2,5-dien-1-ylidene] dimethylammonium chloride (C.I. Basic Blue 26) *[with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)]*	219-943-6	2580-56-5
12	1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)	219-514-3	2451-62-9
13	4,4'-bis(dimethylamino)benzophenone (Michler's ketone)	202-027-5	90-94-8
14	4-(1,1,3,3-tetramethylbutyl)phenol	205-426-2	140-66-9
15	N,N-dimethylacetamide	204-826-4	127-19-5
16	Phenolphthalein	201-004-7	77-09-8
17	Lead diazide, Lead azide	236-542-1	13424-46-9
18	Lead dipicrate	229-335-2	6477-64-1
19	1,2-dichloroethane	203-458-1	107-06-2
20	Calcium arsenate	231-904-5	7778-44-1
21	Dichromium tris(chromate)	246-356-2	24613-89-6
22	2-Methoxyaniline; o-Anisidine	201-963-1	90-04-0
23	Pentazinc chromate octahydroxide	256-418-0	49663-84-5
24	Arsenic acid	231-901-9	7778-39-4
25	Potassium hydroxyoctaoxodizincatedichromate	234-329-8	11103-86-9
26	Formaldehyde, oligomeric reaction products with aniline	500-036-1	25214-70-4
27	Lead styphnate	239-290-0	15245-44-0
28	Trilead diarsenate	222-979-5	3687-31-8
29	Zirconia Aluminosilicate Refractory Ceramic Fibres	650-017-00-8	650-017-00-8
30	Bis(2-methoxyethyl) phthalate	204-212-6	117-82-8
31	Aluminosilicate Refractory Ceramic Fibres	650-017-00-8	650-017-00-8
32	Bis(2-methoxyethyl) ether	203-924-4	111-96-6
33	2,2'-dichloro-4,4'-methylenedianiline	202-918-9	101-14-4
34	Cobalt dichloride	231-589-4	7646-79-9
35	1,2-Benzenedicarboxylic acid, di-C6-8-branched alkyl esters, C7-rich	276-158-1	71888-89-6
36	1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear alkyl esters	271-084-6	68515-42-4
37	Strontium chromate	232-142-6	7789-06-02
38	1-Methyl-2-pyrrolidone	212-828-1	872-50-4
39	1,2,3-Trichloropropane	202-486-1	96-18-4
40	2-Ethoxyethyl acetate	203-839-2	111-15-9
41	Hydrazine	206-114-9	302-01-2, 7803-57-8
42	Cobalt(II) diacetate	200-755-8	71-48-7
43	Cobalt(II) sulphate	233-334-2	10124-43-3
44	2-Ethoxyethanol	203-804-1	110-80-5
45	Acids generated from chromium trioxide and their oligomers. Names of the acids and their oligomers: Chromic acid, Dichromic acid, Oligomers of chromic acid and dichromic acid.	231-801-5, 236-881-5	7738-94-5, 13530-68-2
46	2-Methoxyethanol	203-713-7	109-86-4
47	Chromium trioxide	215-607-8	1333-82-0
48	Cobalt(II) carbonate	208-169-4	513-79-1
49	Cobalt(II) dinitrate	233-402-1	10141-05-6
50	Trichloroethylene	201-167-4	79-01-6
51	Potassium dichromate	231-906-6	7778-50-9
52	Tetraboron disodium heptaoxide, hydrate	235-541-3	12267-73-1
53	Ammonium dichromate	232-143-1	7789-09-5
54	Boric acid	233-139-2, 234-343-4	10043-35-3, 11113-50-1
55	Sodium chromate	231-889-5	11/3/7775
56	Disodium tetraborate, anhydrous	215-540-4	1303-96-4, 1330-43-4, 12179-04-3
57	Potassium chromate	232-140-5	7789-00-6
58	Acrylamide	201-173-7	79-06-1
59	Lead sulfochromate yellow (C.I. Pigment Yellow 34)	215-693-7	1344-37-2
60	Lead chromate molybdate sulphate red (C.I. Pigment Red 104)	235-759-9	12656-85-8
61	Anthracene oil	292-602-7	90640-80-5
62	2,4-Dinitrotoluene	204-450-0	121-14-2
63	Anthracene oil, anthracene paste, anthracene fraction	295-275-9	91995-15-2
64	Anthracene oil, anthracene-low	292-604-8	90640-82-7
65	Tris(2-chloroethyl)phosphate	204-118-5	115-96-8
66	Diisobutyl phthalate	201-553-2	84-69-5
67	Lead chromate	231-846-0	7758-97-6
68	Anthracene oil, anthracene paste	292-603-2	90640-81-6
69	Pitch, coal tar, high temp.	266-028-2	65996-93-2
70	Anthracene oil, anthracene paste,distn. lights	295-278-5	91995-17-4
71	Lead hydrogen arsenate	232-064-2	7784-40-9
72	Benzyl butyl phthalate (BBP)	201-622-7	85-68-7
73	Bis (2-ethylhexyl)phthalate (DEHP)	204-211-0	117-81-7
74	5-tert-butyl-2,4,6-trinitro-m-xylene (musk xylene)	201-329-4	81-15-2
75	Diarsenic trioxide	215-481-4	1327-53-3
76	Bis(tributyltin)oxide (TBTO)	200-268-0	56-35-9
77	Triethyl arsenate	427-700-2	15606-95-8
78	Diarsenic pentaoxide	215-116-9	1303-28-2
79	Sodium dichromate	234-190-3	7789-12-0, 10588-01-9
80	Dibutyl phthalate (DBP)	201-557-4	84-74-2
81	4,4'- Diaminodiphenylmethane (MDA)	202-974-4	101-77-9
82	Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins)	287-476-5	85535-84-8
83	Anthracene	204-371-1	120-12-7
84	Hexabromocyclododecane (HBCDD) and all major diastereoisomers identified: Alpha-hexabromocyclododecane Beta-hexabromocyclododecane Gamma-hexabromocyclododecane	247-148-4 and 221-695-9	25637-99-4, 3194-55-6 (134237-50-6) (134237-51-7) (134237-52-8)