APPLICATION NOTE

Oxidation Risk and Impact on Bourns® Iron-based Power Inductors

Bourns® SRP Series
Power Inductors

Bourns® SPB Series
Power Inductors

INTRODUCTION

Following years of continuous development and optimization of material technology and inductor manufacturing processes, Bourns is able to produce a wide variety of inductors from an extensive database of materials. Particular types of power inductor products using the element iron can exhibit surface oxidation after a length of time, whether in application or storage. This oxidation, found on the surface only, is purely cosmetic and causes no change to form, fit, function, reliability or quality over the lifespan of the power inductor products.

Bourns® power inductor products may be classified into two distinct categories: powder based and ceramic. The following will go into more detail on the materials, characteristics, processes and subsequent oxidation risks for each category of the power inductor products.

POWDER BASED INDUCTOR PRODUCTS

Bourns offers three distinct types of non-ceramic power inductors manufactured using iron formulations that pass through a molding process. Bourns® SRP Series power inductors are used in the testing in Exhibit A, and shown in the product photos to the left, as they are manufactured using all three types of iron formulations currently available.

Below is a description of the main characteristics of such power based inductor products, including the susceptibility to oxidation.

- **Powder: carbonyl iron powder**
  Features: High purity, sphere shape, soft Fe powder is used to achieve a very high saturation current.
  Particle Insulation Method: Phosphate insulation and SiO2 ceramic insulation treatments on the powder surface + resin binder insulation between powders + epoxy coating on the surface of the component.

- **Powder: alloy1 (FeSiCr) + alloy2 (Nanocrystal alloy, FeNi alloy)**
  Features: Fe-Si-Cr alloy-based powder and other Fe-based alloy powders are used to achieve low core loss and high saturation current. Low temperature rises when used.
  Particle Insulation Method: Phosphate insulation treatment on powder surface + resin binder insulation between powders. No epoxy coating on the surface.

- **Powder: alloy1 (FeSiCr) + alloy2 (Amorphous alloy)**
  Features: Fe-Si-Cr alloy-based powder and other Fe-based alloy powder are used and computer simulated for best performance. Very low core loss and high saturation current. Very low temperature rises when used.
  Particle Insulation Method: Phosphate insulation treatment on the powder surface + resin binder insulation between powders + epoxy coating on the surface of the component.

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POWDER BASED INDUCTOR PRODUCTS (Continued)

Susceptibility to Oxidation:

Bourns has studied the effect of surface oxidation in depth, and the results provided in **Exhibit A** attached hereto, include details on the specific testing performed and conditions under which performance was measured. The results demonstrate that Bourns' method of manufacture using particle insulation assures that normally occurring oxidation remains on the surface (see **Exhibit A's** conclusion section).

Generally, all tested parts exhibit some level of surface oxidation, with potential for some microscopic oxidation present shortly after manufacturing.

While in time, and certainly with humidity and temperature, that oxidation level can increase, in all cases measured by Bourns the oxidation remains contained within the surface coating of the part.

As shown in the test results set forth in **Exhibit A**, after exceeding the standard reliability testing requirements (Bourns tested for 2,000 hours compared to the standard 1,000 hours), and even with greater than 50 % oxidation coverage of the part surface, there is close to zero change in electrical performance for the tested parts. Further reliability testing continues to show a very stable performance.

Based on the test results set forth in Exhibit A, Bourns believes that its iron-based power inductor products will perform as per the specification even with greater than 50 % surface based oxidation.

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CERAMIC FERRITE BASED INDUCTOR PRODUCTS

Bourns offers power inductors with ceramic ferrite materials based on NiZn and MnZn compounds (such as the Bourns® SPB Series power inductors, shown to the left).

Below is a description of the main characteristics of such powder based inductor products, including the susceptibility to oxidation.

- **NiZn powder Ferrite:**
  Features: Wide permeability range from 14~15000 for a variety of applications. High insulation resistance. Medium saturation current. Zero oxidation post manufacturing.
  Insulation Method: Fully oxidized after sintering.

- **MnZn powder Ferrite**
  Features: Wide permeability range from 14~15000 for a variety of applications. High insulation resistance. Medium saturation current. Zero oxidation post manufacturing.
  Insulation Method: Almost fully oxidized after sintering.

Susceptibility to Oxidation:

There is no risk of oxidation for the ceramic ferrite based inductors in application or storage.

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EXHIBIT A
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

High Temperature Exposure (Storage) Test

Bourns® SRP Series inductors have been subjected to the following reliability tests:

Temperature: 150 ± 2 ˚C

Duration: 1000 hrs.

Measured at room temperature after placing for 24 ± 2 hrs.

Equipment: DRP-8802DZ-CK, OHM METER LCR METER

Test quantity: 77 pcs.

Performance criteria after the test:

a. Appearance: cracking, chipping, and any other defects harmful to the characteristics should not be allowed, inspected at 50x CCD (magnification)
b. Inductance: within ± 10 % of initial value
c. RDC SPEC: within ± 15 % of initial value and shall not exceed the specification value
d. Ls SPEC: 4.7 µH ± 20 %

Oxidation Risk and Impact on Bourns® Iron-based Power Inductors

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EXHIBIT A (Continued)
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

High Temperature Exposure (Storage) Test

NO.	Before		After		Change Rate, %		Appearance	NO.	Before		After		Change Rate, %		Appearance
	LS	RDC	LS	RDC	LS	RDC			LS	RDC	LS	RDC	LS	RDC	
1	4.38	127.1	4.30	123.2	-1.8	-3.1	PASS	39	4.14	114.4	4.19	116.4	1.2	1.7	PASS
2	4.09	123.5	4.11	122.8	0.5	-0.6	PASS	40	4.76	120.2	4.78	124.5	0.4	3.6	PASS
3	4.36	124.9	4.43	127.9	1.6	2.4	PASS	41	4.04	110.9	4.09	106.4	1.2	-4.1	PASS
4	4.15	119.2	4.15	120.9	0.0	1.4	PASS	42	4.81	116.1	4.85	115.9	0.8	-0.2	PASS
5	4.35	125.6	4.18	127.2	-3.9	1.3	PASS	43	3.95	116.1	4.03	116.2	2.0	0.1	PASS
6	4.31	121.3	4.44	120.6	3.0	-0.6	PASS	44	3.92	111.7	4.02	111.6	2.6	-0.1	PASS
7	4.24	126.8	4.34	124.8	2.4	-1.6	PASS	45	3.81	110.6	3.96	111.5	3.9	0.8	PASS
8	4.33	122.6	4.28	125.9	-1.2	2.7	PASS	46	4.21	115.7	4.21	116.0	0.0	0.3	PASS
9	4.17	121.5	4.21	122.5	1.0	0.8	PASS	47	3.96	112.3	4.01	117.8	1.3	4.9	PASS
10	4.66	126.1	4.58	127.4	-1.7	1.0	PASS	48	4.27	118.2	4.28	121.6	0.2	2.9	PASS
11	4.53	122.8	4.48	125.1	-1.1	1.9	PASS	49	4.00	109.7	4.11	114.5	2.8	4.4	PASS
12	4.15	119.7	4.23	121.9	1.9	1.8	PASS	50	4.04	111.2	4.07	112.0	0.7	0.7	PASS
13	4.41	121.4	4.33	122.0	-1.8	0.5	PASS	51	4.21	115.1	4.24	116.7	0.7	1.4	PASS
14	4.23	119.5	4.15	121.4	-1.9	1.6	PASS	52	4.34	115.4	4.35	113.0	0.2	-2.1	PASS
15	4.25	122.9	4.21	123.1	-0.9	0.2	PASS	53	4.82	124.1	4.77	126.3	-1.0	1.8	PASS
16	4.22	123.1	4.43	122.0	5.0	-0.9	PASS	54	4.82	120.6	4.79	121.8	-0.6	1.0	PASS
17	4.12	118.7	4.22	121.6	2.4	2.4	PASS	55	5.03	116.7	5.00	121.9	-0.6	4.5	PASS
18	4.13	123.5	4.37	127.7	5.8	3.4	PASS	56	4.49	119.4	4.39	123.7	-2.2	3.6	PASS
19	4.48	121.9	4.33	121.9	-3.3	0.0	PASS	57	4.11	112.2	4.09	115.0	-0.5	2.5	PASS
20	4.10	120.7	4.12	122.2	0.5	1.2	PASS	58	4.09	119.6	4.11	121.4	0.5	1.5	PASS
21	4.34	123.1	4.18	122.9	-3.7	-0.2	PASS	59	3.81	113.4	3.97	111.5	4.2	-1.7	PASS
22	4.63	123.1	4.59	124.5	-0.9	1.1	PASS	60	4.24	115.1	4.10	116.4	-3.3	1.1	PASS
23	4.19	124.4	4.17	122.8	-0.5	-1.3	PASS	61	4.41	119.6	4.49	117.4	1.8	-1.8	PASS
24	3.95	119.9	4.14	121.0	4.8	0.9	PASS	62	4.64	117.1	4.56	120.2	-1.7	2.6	PASS
25	4.58	122.3	4.49	123.4	-2.0	0.9	PASS	63	4.46	119.9	4.42	120.2	-0.9	0.3	PASS
26	4.56	117.9	4.36	118.9	-4.4	0.8	PASS	64	4.52	117.4	4.38	120.0	-3.1	2.2	PASS
27	4.47	119.6	4.47	120.6	0.0	0.8	PASS	65	4.85	118.6	4.84	123.8	-0.2	4.4	PASS
28	4.60	124.8	4.45	126.9	-3.3	1.7	PASS	66	4.15	121.2	4.18	125.0	0.7	3.1	PASS
29	4.39	120.2	4.47	122.0	1.8	1.5	PASS	67	4.43	119.3	4.31	121.1	-2.7	1.5	PASS
30	4.72	127.5	4.58	126.9	-3.0	-0.5	PASS	68	3.87	115.1	3.98	120.5	2.8	4.7	PASS
31	4.11	111.7	4.13	114.5	0.5	2.5	PASS	69	3.94	123.6	3.99	125.8	1.3	1.8	PASS
32	4.29	109.3	4.21	110.3	-1.9	0.9	PASS	70	4.02	115.2	4.06	120.0	1.0	4.2	PASS
33	4.21	109.8	4.39	109.8	4.3	0.0	PASS	71	3.99	114.4	4.01	111.8	0.5	-2.3	PASS
34	4.26	112.7	4.29	112.7	0.7	0.0	PASS	72	4.46	124.3	4.36	126.4	-2.2	1.7	PASS
35	4.39	114.2	4.42	115.2	0.7	0.9	PASS	73	4.18	115.1	4.22	120.5	1.0	4.7	PASS
36	3.98	113.2	4.03	114.8	1.3	1.4	PASS	74	4.32	119.3	4.37	118.0	1.2	-1.1	PASS
37	4.07	112.3	4.15	115.2	2.0	2.6	PASS	75	4.17	113.7	4.21	116.4	1.0	2.4	PASS
38	4.16	111.7	4.34	111.6	4.3	-0.1	PASS	76	4.00	115.5	4.02	120.5	0.5	4.3	PASS
AVG	4.28	118.4	4.29	119.79	-	-	-	77	3.97	115.1	4.02	117.8	1.3	2.3	PASS
MAX	5.03	127.5	5.00	127.90	-	-	-	R	1.22	18.2	1.04	21.50	-	-	-
MIN	3.81	109.3	3.96	106.40	-	-	-	Σ	0.27	4.8	0.23	5.00	-	-	-

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EXHIBIT A (Continued)
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

High Temperature Exposure (Storage) Test (1000 hours) - Visual Inspection

NO.	Before	After	NO.	Before	After	NO.	Before	After	NO.	Before	After
1			21			41			61		
2			22			42			62		
3			23			43			63		
4			24			44			64		
5			25			45			65		
6			26			46			66		
7			27			47			67		
8			28			48			68		
9			29			49			69		
10			30			50			70		
11			31			51			71		
12			32			52			72		
13			33			53			73		
14			34			54			74		
15			35			55			75		
16			36			56			76		
17			37			57			77		
18			38			58					
19			39			59					
20			40			60					

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EXHIBIT A
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

Biased Humidity Reliability Test

Bourns® SRP Series inductors have been subjected to the following reliability tests:

Humidity: 85 ± 3 % R.H.

Temperature: 85 ˚C ± 2 ˚C

Duration: 1000 hrs.

Measured at room temperature after placing for 24 ± 2 hrs.

Equipment: D-TH-225D, OHM METER LCR METER

Test quantity: 77 pcs.

Performance criteria after the test:

a. Appearance: cracking, chipping, and any other defects harmful to the characteristics should not be allowed, inspected at 50x CCD (magnification)
b. Inductance: within ± 10 % of initial value
c. RDC SPEC: within ± 15 % of initial value and shall not exceed the specification value
d. Ls SPEC: 4.7 µH ± 20 %

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EXHIBIT A (Continued)
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

Biased Humidity (1000 hours AEC-Q200 Spec.) Standard: MIL-STD-202 Method 103
Functional Test

NO.	Before		After		Change Rate, %		Appearance	NO.	Before		After		Change Rate, %		Appearance
	LS	RDC	LS	RDC	LS	RDC			LS	RDC	LS	RDC	LS	RDC	
1	4.37	118.1	4.45	121.3	1.8	2.7	PASS	39	4.63	120.0	4.71	121.0	1.7	0.8	PASS
2	4.52	121.6	4.51	126.2	-0.2	3.8	PASS	40	4.25	115.8	4.48	121.4	5.4	4.8	PASS
3	4.53	123.2	4.41	124.6	-2.6	1.1	PASS	41	4.21	115.2	4.20	116.3	-0.2	1.0	PASS
4	5.01	132.8	4.93	126.3	-1.6	-4.9	PASS	42	4.31	115.4	4.29	118.3	-0.5	2.5	PASS
5	4.66	124.4	4.58	128.2	-1.7	3.1	PASS	43	4.32	116.4	4.46	120.5	3.2	3.5	PASS
6	4.53	125.1	4.48	122.8	-1.1	-1.8	PASS	44	3.94	110.7	4.02	111.2	2.0	0.5	PASS
7	4.56	126.7	4.58	126.9	0.4	0.2	PASS	45	4.03	111.3	4.20	117.7	4.2	5.8	PASS
8	4.51	128.2	4.60	127.3	2.0	-0.7	PASS	46	4.14	112.6	4.13	114.9	-0.2	2.0	PASS
9	4.05	119.8	4.01	121.7	-1.0	1.6	PASS	47	4.34	117.1	4.42	120.3	1.8	2.7	PASS
10	4.16	122.5	4.27	126.1	2.6	2.9	PASS	48	4.90	121.5	4.92	122.5	0.4	0.8	PASS
11	4.12	124.3	4.22	126.9	2.4	2.1	PASS	49	3.89	114.0	4.03	117.0	3.6	2.6	PASS
12	4.32	126.4	4.13	125.0	-4.4	-1.1	PASS	50	4.33	116.0	4.38	121.5	1.2	4.7	PASS
13	4.29	121.2	4.49	120.5	4.7	-0.6	PASS	51	4.23	114.2	4.30	118.5	1.7	3.8	PASS
14	4.28	123.2	4.16	123.6	-2.8	0.3	PASS	52	4.25	113.1	4.30	114.2	1.2	1.0	PASS
15	4.42	123.4	4.32	123.1	-2.3	-0.2	PASS	53	4.33	114.8	4.23	117.2	-2.3	2.1	PASS
16	4.43	126.6	4.36	123.2	-1.6	-2.7	PASS	54	4.08	116.6	4.10	120.2	0.5	3.1	PASS
17	4.39	122.5	4.44	122.2	1.1	-0.2	PASS	55	4.52	117.8	4.39	120.7	-2.9	2.5	PASS
18	4.14	119.2	4.28	126.2	3.4	5.9	PASS	56	4.36	114.5	4.43	114.8	1.6	0.3	PASS
19	4.55	122.7	4.33	128.4	-4.8	4.6	PASS	57	4.05	115.6	4.11	116.4	1.5	0.7	PASS
20	4.12	120.4	4.23	127.2	2.7	5.6	PASS	58	4.20	121.1	4.34	124.3	3.3	2.6	PASS
21	4.34	122.6	4.26	124.6	-1.8	1.6	PASS	59	4.15	118.3	4.09	120.0	-1.4	1.4	PASS
22	4.02	119.5	4.11	125.3	2.2	4.9	PASS	60	4.43	118.6	4.46	123.3	0.7	4.0	PASS
23	4.33	117.9	4.45	121.6	2.8	3.1	PASS	61	4.48	118.3	4.45	120.5	-0.7	1.9	PASS
24	4.41	122.1	4.33	122.6	-1.8	0.4	PASS	62	4.38	121.4	4.44	123.2	1.4	1.5	PASS
25	4.03	122.8	4.11	127.2	2.0	3.6	PASS	63	3.88	112.7	4.03	113.6	3.9	0.8	PASS
26	4.31	119.1	4.25	125.0	-1.4	5.0	PASS	64	4.57	115.1	4.70	120.0	2.8	4.3	PASS
27	4.34	122.5	4.24	123.8	-2.3	1.1	PASS	65	4.50	116.6	4.40	120.9	-2.2	3.7	PASS
28	4.59	120.8	4.39	121.3	-4.4	0.4	PASS	66	4.48	117.8	4.34	121.6	-3.1	3.2	PASS
29	4.22	126.4	4.10	123.7	-2.8	-2.1	PASS	67	4.29	119.6	4.41	125.9	2.8	5.3	PASS
30	4.47	123.7	4.53	124.2	1.3	0.4	PASS	68	4.40	118.2	4.41	122.8	0.2	3.9	PASS
31	4.24	118.6	4.17	120.6	-1.7	1.7	PASS	69	4.33	119.6	4.46	125.9	3.0	5.3	PASS
32	4.33	115.2	4.48	115.0	3.5	-0.2	PASS	70	4.63	120.4	4.48	120.7	-3.2	0.2	PASS
33	4.29	120.4	4.14	122.7	-3.5	1.9	PASS	71	4.38	116.6	4.17	120.2	-4.8	3.1	PASS
34	4.19	113.9	4.31	115.5	2.9	1.4	PASS	72	4.12	113.9	4.22	117.6	2.4	3.2	PASS
35	4.13	113.6	4.19	113.1	1.5	-0.4	PASS	73	4.31	117.4	4.20	118.4	-2.6	0.9	PASS
36	4.32	124.4	4.20	120.8	-2.8	-2.9	PASS	74	3.88	112.3	4.07	118.3	4.9	5.3	PASS
37	4.04	116.0	4.23	114.0	4.7	-1.7	PASS	75	4.28	119.9	4.47	126.8	4.4	5.8	PASS
38	4.31	114.9	4.10	112.9	-4.9	-1.7	PASS	76	4.02	111.7	4.16	112.5	3.5	0.7	PASS
AVG	4.31	119.0	4.33	121.2	-	-	-	77	4.56	116.5	4.41	120.4	-3.3	3.3	PASS
MAX	5.01	132.8	4.93	128.4	-	-	-	R	1.13	22.1	0.92	17.2	-	-	-
MIN	3.88	110.7	4.01	111.2	-	-	-	Σ	0.21	4.4	0.19	4.2	-	-	-

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EXHIBIT A (Continued)
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

Biased Humidity (1000 hours) - Visual Inspection

NO.	Before	After	NO.	Before	After	NO.	Before	After	NO.	Before	After
1			21			41			61		
2			22			42			62		
3			23			43			63		
4			24			44			64		
5			25			45			65		
6			26			46			66		
7			27			47			67		
8			28			48			68		
9			29			49			69		
10			30			50			70		
11			31			51			71		
12			32			52			72		
13			33			53			73		
14			34			54			74		
15			35			55			75		
16			36			56			76		
17			37			57			77		
18			38			58					
19			39			59					
20			40			60					

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EXHIBIT A
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

Biased Humidity Reliability Test

Bourns® SRP Series inductors have been subjected to the following reliability tests:

Humidity: 85 ± 3 % R.H.
Temperature: 85 ˚C ± 2 ˚C
Duration: 2000 hrs.
Measured at room temperature after placing for 24 ± 2 hrs.
Equipment: D-TH-225D, OHM METER LCR METER
Test quantity: 77 pcs.
Performance criteria after the test:

a. Appearance: cracking, chipping, and any other defects harmful to the characteristics should not be allowed, inspected at 50x CCD (magnification)
b. Inductance: within ± 10 % of initial value
c. RDC SPEC: within ± 15 % of initial value and shall not exceed the specification value
d. Ls SPEC: 4.7 µH ± 20 %

Biased Humidity (2000 hours AEC-Q200 Spec.) Standard: MIL-STD-202 Method 103

NO.	Before		After		Change Rate, %		Appearance	NO.	Before		After		Change Rate, %		Appearance
	LS	RDC	LS	RDC	LS	RDC			LS	RDC	LS	RDC	LS	RDC	
4	5.01	132.8	4.85	127.0	-3.2	-4.4	PASS	21	4.34	122.6	4.49	127.8	3.5	4.2	PASS
5	4.66	124.4	4.43	124.0	-4.9	-0.3	PASS	22	4.02	119.5	4.11	118.6	2.2	-0.8	PASS
6	4.53	125.1	4.40	124.9	-2.9	-0.2	PASS	23	4.33	117.9	4.43	125.9	2.3	6.8	PASS
7	4.56	126.7	4.56	129.1	0.0	1.9	PASS	24	4.41	122.1	4.54	123.7	2.9	1.3	PASS
8	4.51	128.2	4.36	127.9	-3.3	-0.2	PASS	25	4.03	122.8	4.05	125.1	0.5	1.9	PASS
10	4.16	122.5	4.23	124.1	1.7	1.3	PASS	26	4.31	119.1	4.46	123.6	3.5	3.8	PASS
11	4.12	124.3	4.38	126.5	6.3	1.8	PASS	27	4.34	122.5	4.34	124.3	0.0	1.5	PASS
13	4.29	121.2	4.35	119.8	1.4	-1.2	PASS	28	4.59	120.8	4.54	119.5	-1.1	-1.1	PASS
14	4.28	123.2	4.42	122.5	3.3	-0.6	PASS	29	4.22	126.4	4.13	128.0	-2.1	1.3	PASS
15	4.42	123.4	4.56	129.3	3.2	4.8	PASS	30	4.47	123.7	4.41	124.5	-1.3	0.6	PASS
16	4.43	126.6	4.49	128.7	1.4	1.7	PASS	31	4.24	118.6	4.35	129.8	2.6	9.4	PASS
17	4.39	122.5	4.39	125.8	0.0	2.7	PASS	32	4.33	115.2	4.55	113.7	5.1	-1.3	PASS
18	4.14	119.2	4.21	121.5	1.7	1.9	PASS	33	4.29	120.4	4.43	129.3	3.3	7.4	PASS
19	4.55	122.7	4.39	125.1	-3.5	2.0	PASS	34	4.19	113.9	4.42	123.4	5.5	8.3	PASS
20	4.12	120.4	4.19	119.3	1.7	-0.9	PASS	35	4.13	113.6	4.21	119.6	1.9	5.3	PASS
AVG	4.35	122.1	4.39	124.4	-	-	-	-	-	-	-	-	-	-	-
MAX	5.01	132.8	4.85	129.8	-	-	-	R	0.99	19.2	0.80	16.1	-	-	-
MIN	4.02	113.6	4.05	113.7	-	-	-	Σ	0.210	4.1	0.163	3.8	-	-	-

Oxidation Risk and Impact on Bourns® Iron-based Power Inductors

Bourns® SRP Series
Power Inductors

Bourns® SPB Series
Power Inductors

EXHIBIT A (Continued)
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

Biased Humidity (2000 hours) - Visual Inspection

NO.	Before	After	NO.	Before	After	NO.	Before	After
4			16			26		
5			17			27		
6			18			28		
7			19			29		
8			20			30		
10			21			31		
11			22			32		
13			23			33		
14			24			34		
15			25			35		

Bourns® SRP Series
Power Inductors

Bourns® SPB Series
Power Inductors

EXHIBIT A (Continued)
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

Highly Accelerated Temperature and Humidity Stress Test (Reference JESD22-A110)

Sample Quantity: 30 ea.

Integrated Service Technology Inc.
Reliability & Failure Analysis Engineering Group
No.10-1, Lixing 1st Rd., East Dist., Hsinchu City 300, Taiwan (R.O.C.).
Tel: 886-3-579-9909, Fax: 886-3-5634868
http://www.istgroup.com

2. Highly-Accelerated Temperature and Humidity Stress Test

2.1 DESCRIPTION OF TEST EQUIPMENT

Test Equipment	Serial Number	Calibration Trace Code
HIRAYAMA PC-422R8D	1804767946 (2220012)	A111-03-101-01

2.2 LABORATORY AMBIENCE CONDITION

Verification area temperature : 25 ± 5°C

Verification area relative humidity : 55% ± 10%

Laboratory area temperature : 30 ± 5°C

Laboratory area relative humidity : 45% ± 10%

2.3 REFERENCE DOCUMENT

The test refers to JESD22-A110E Test Method

2.4 TEST CONDITION

Temperature	: 110°C
Humidity	: 85% RH
Pressure	: 17.7 Psia
Bias Setting	: PS1:0.38V
Test Time	: 264 hours

2.5 SUMMARY OF TEST

No abnormal samples were found in the visual inspection.

The function test will be performed by Bourns.

without the 3rd party lab (IST) person participation.

To follow customer's requirement, attached functional test result as below.

Item	Test result
Full functional test	30ea passed

<< The Following Blank >>

Oxidation Risk and Impact on Bourns® Iron-based Power Inductors

Bourns® SRP Series
Power Inductors

Bourns® SPB Series
Power Inductors

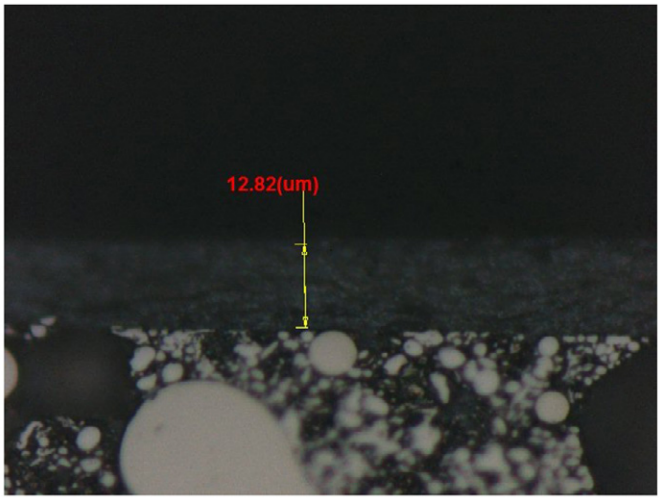
EXHIBIT A
Reliability Testing to Confirm Performance of Inductors Exhibiting Surface Oxidation

Analysis

In Bourns® SRP Series power inductors:

a. Phosphate insulation treatment on powder surface:
   A chemical treatment applied to iron-based powder that creates a thin adhering layer of iron phosphate to achieve corrosion resistance.
b. Resin binder insulation between powders:
   Resin is used as a bonding material in the molding process but also as an insulation material between powders (an effective barrier against oxidation intrusion).
c. Epoxy coating on the surface of the inductor:
   Neither electrical failure nor appearance change was observed and minor surface oxidation is acceptable.

Example: Sample # 45 was selected for cross-section. The coating thickness is 12.82 um.



Bourns® SRP Series power inductors passed the Biased Humidity Test (500 hours, 1000 hours, and 2000 hours) at a 77 piece sample and Highly Accelerated Temperature and Humidity Stress Test (110 ˚C / 85 RH, 264 hours) at a 30 piece sample.

APPLICATION NOTE

Oxidation Risk and Impact on Bourns® Iron-based Power Inductors

Bourns® SRP Series
Power Inductors

Bourns® SPB Series
Power Inductors

CONCLUSION

Bourns' manufacturing process offers enhanced resistance to oxidation penetrating from the surface to the main body of the inductor core material.

The oxidation on the surface of iron (Fe) powder based inductors is commonly observed in the electronics industry and, in alignment with the industry's general conclusion on oxidation of these parts, all Bourns' tests/analyses show that **oxidation is a purely cosmetic issue that is only on the surface** of the parts.

The resin binder effectively stops further oxidation penetration and Bourns has not observed/documented any impact on the electrical specifications due to surface oxidation.

There is no evidence that the oxidation has a detrimental effect on the form, fit, function, quality, performance or reliability of the inductors.

In contrast, Bourns' testing demonstrates that surface level oxidation does not pose a reliability risk.

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