Reliability Report Update Small Outline (SO) Package

National Semiconductor
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National Semiconductor continues to conduct reliability tests on our complete line of surface mount components to assure you of the highest level of reliability performance possible.

This Reliability Report Update presents additional data recently gathered on National's family of plastic small outline packages with leadcounts of 8, 14, 16, and 20.

The data demonstrates that the reliability performance of products assembled in National's small outline package is excellent and is comparable to the reliability performance of product assembled in National's standard dual-in-line package (DIP).

INTRODUCTION

The SO (Small Outline) package has been developed to meet customer demand for ever-increasing miniaturization component density, and surface mounting requirements. These devices occupy only 30–50% of the PC board area required for conventional DIP packages.

These small packages mount directly on the surface of a PC board or substate. Users should note that boards for SO devices have different design considerations from those typically used for traditional insertion-mounted DIPs. Several techniques for ''high density surface mounting'' have been developed, as well as new board and substrate materials.

National's Reliability Department has performed a series of accelerated environmental tests to determine the reliability of this package. Descriptions of these tests and results follow. Thermal resistance charcteristics for the SO appear at the end of this report.

HIGH TEMPERATURE BIAS

Continuous operation at rated supply voltage; $T_A = 125°C$–150°C.

High Temperature Bias is the most generally accepted accelerated life test. The elevated temperature along with the applied voltage stress accelerates many failure mechanisms associated with the die in the packaging system. As with all accelerated environmental tests, all failures are analyzed for package related failure mechanisms.

TEMPERATURE HUMIDITY BIAS

Continuous operation at rated supply voltage; $T_A = 85°C$, RH = 85%.

Temperature Humidity Bias is the standard test for plastic package integrity with respect to moisture and external contaminant penetration. The combination of temperature, humidity and bias accelerates any failure mechanisms that would occur if moisture penetrates the package.

AUTOCLAVE

Unbiased at $T_A = 121°C$, RH = 100%, 15 psi.

Autoclave is designed to accelerate the penetration of moisture into the package in order to determine the resistance of the die and packaging system to moisture and external contaminants.

TEMPERATURE CYCLE

Unbiased at $T_A = -65°C$ to $T_A = +150°C$, 20 minutes per cycle.

Temperature cycle tests the thermal expansion coefficient compatibility of the materials used and design of the packaging systems at alternating temperature extremes. The expected failure mechanisms include cracking at encapsulation-leadframe interfaces and fractured or lifted bond wires. In addition, moisture and contaminants tend to be driven into the cracks and openings of seals and seams as the package expands and contracts.

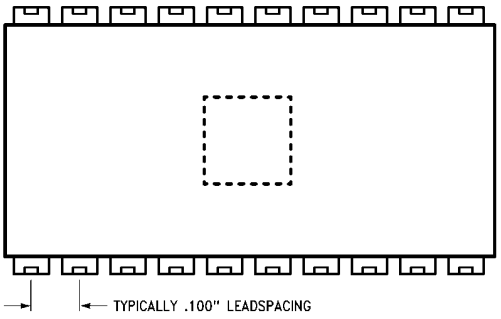
THERMAL SHOCK

Unbiased at −65°C to +150°C liquid, 5 minutes immersion, 5 seconds transfer time per cycle.

This test, while similar to Temperature cycle, is designed to examine how the different rates of thermal conductivity for package materials affect the integrity of the package materials when exposed to alternating temperature extremes.

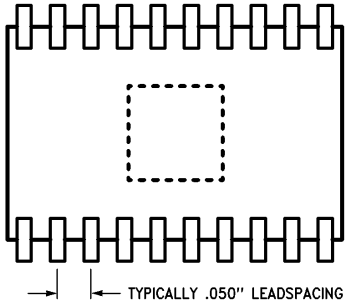
Component Size Comparison

Dual-In-Line Package



TL/HH/8685–3

Small Outline Package



TL/HH/8685–4

High Temperature Bias*: $T_A = 125°C$

Device	Package	168 Hours	500 Hours	1000 Hours
54HC245	SO-20	0/75	0/75	0/75
54HC373	DIP-20	0/65	0/65	0/62
54HC373	SO-20	0/75	0/75	0/75
54HC373	SO-20	0/65	0/65	0/62
74HC00	DIP-14	0/77	†	0/77
74HC00	DIP-14	1/77 (1)	†	3/76 (1)
74HC00	SO-14W	0/75	†	0/75
74HC00	SO-14W	0/77	†	0/77
74HC74	DIP-14	0/77	0/77	0/77
74HC74	SO-14W	0/77	0/77	0/77
74HC244	DIP-20	0/77	†	0/77
74HC244	SO-20	0/75	†	0/75
74HC373	DIP-20	0/77	0/77	0/77
74HC373	SO-20	0/77	0/77	1/77 (1)
74HC374	DIP-20	2/77 (1)	†	0/75
74HC374	SO-20	0/77	†	0/77
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/44	0/44
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/45	0/45
LM339	SO-14	0/45	0/45	0/45
LM339	SO-14	0/45	0/45	0/45
LM358	SO-8	0/45	0/45	0/45
LM358	SO-8	0/45	0/45	0/45
LM358	SO-8	0/45	0/45	0/45
LM358	SO-8	0/45	0/45	0/45
	Total DIP	3/527	0/219	3/521
	Total SO	2/1321	0/937	1/1318

Note 1: Parametric, I_{CC} leakage

†No measurements taken

*All SO packages board mounted (vapor-phase reflow soldering)

High Temperature Bias*: $T_A = 150°C$

Device	Package	168 Hours	500 Hours	1000 Hours
74LS08	DIP-14	0/50	0/50	0/50
74LS08	SO-14	0/84	0/84	0/84
74LS240	SO-20	0/50	0/50	0/50
74LS240	SO-20	0/49	0/49	0/49
CD4601	SO-14	0/90	0/90	0/90
LF347	DIP-14	1/50 (1)	0/49	0/49
LF347	SO-14W	0/50	0/50	1/50 (2)
LF351	DIP-8	0/50	1/50 (3)	0/49
LF351	SO-8	0/50	0/50	0/50
LF351	SO-8	0/50	0/50	0/50
LF353	DIP-8	0/50	0/50	0/50
LF353	SO-8	0/49	0/49	0/49
LF353	SO-8	0/50	0/50	0/50
LF353	SO-8	0/46	0/46	0/46

High Temperature Bias*: T_A = 150°C (Continued)

Device	Package	168 Hours	500 Hours	1000 Hours
LF411	DIP-8	0/50	0/50	0/50
LF411	SO-8	0/50	0/50	0/50
LF411	SO-8	0/49	0/49	0/49
LF412	DIP-8	0/50	0/50	0/50
LF412	SO-8	0/50	0/50	0/50
LF412	SO-8	0/50	0/50	0/50
LM111	DIP-14	0/55	0/55	0/55
LM111	SO-14	0/52	0/52	0/52
LM308	DIP-8	0/80	0/80	0/80
LM308	DIP-8	0/80	0/80	0/80
LM308	SO-8	0/100	0/100	0/100
LM308	SO-8	1/80 (3)	0/79	1/79 (4)
LM311	DIP-8	0/50	0/50	0/50
LM311	DIP-8	0/60	1/60 (5)	0/59
LM311	SO-8	1/60 (3)	0/59	0/59
LM311	SO-8	0/50	0/50	0/50
LM346	DIP-16	0/50	0/50	0/50
LM346	SO-16	0/50	0/50	0/50
LM348	DIP-14	0/50	0/50	0/50
LM348	SO-14	0/50	0/50	0/50
LM359	DIP-14	0/50	0/50	0/50
LM359	SO-14	0/50	0/50	0/50
LM442	DIP-8	0/50	0/50	0/50
LM442	SO-8	0/50	0/50	0/50
LM592	DIP-14	1/50 (6)	0/49	0/49
LM592	SO-14	0/50	0/50	1/50 (6)
LM723	DIP-14	0/50	0/50	0/50
LM723	SO-14	1/50 (7)	0/49	0/49
LM741	DIP-8	0/50	0/50	0/50
LM741	SO-8	0/50	0/50	0/50
LM741	SO-8	0/50	0/50	0/50
LM741	SO-8	0/50	0/50	0/50
LM1496	SO-14	0/35	0/35	0/35
LM1524	DIP-16	0/50	0/50	0/50
LM1524	SO-16	1/48 (8)	0/47	0/47
LM1558	DIP-8	0/50	0/50	0/50
LM1558	SO-8	0/50	0/50	0/50
LM1558	SO-8	0/50	0/50	0/50
LM2903	DIP-8	0/60	0/60	0/60
LM2903	SO-8	0/60	0/60	0/60
LM3086	DIP-14	0/50	0/50	0/50
LM3086	SO-14	0/50	0/48	0/48
	Total DIP	2/1185	2/1183	1/1181
	Total SO	4/1852	0/1846	2/1846

Note 1: Parametric, gain bandwidth

Note 2: Parametric, V_{OS}

Note 3: Oxide short-ESD

Note 4: Package cracked (handling damage)

Note 5: No visual defect

Note 6: Parametric, gain

Note 7: Parametric, load regulation

Note 8: Parametric, V_{SAT}

†No measurements taken

*All SO packages board mounted (vapor-phase reflow soldering)

Temperature Humidity Bias*: 85°C, 85% RH

Device	Package	168 Hours	500 Hours	1000 Hours
74HC00	DIP-14	0/88	†	0/88
74HC00	SO-14	0/77	†	0/77
74HC00	DIP-14	0/77	†	0/77
74HC00	SO-14	0/88	†	0/88
74HC74	DIP-14	0/77	0/77	0/77
74HC74	SO-14	0/77	0/77	0/77
74HC244	DIP-20	†	0/77	0/77
74HC244	SO-20	†	0/70	0/77
74HC245	SO-20	0/75	0/75	0/75
54HC373	DIP-20	0/65	0/65	0/65
54HC373	SO-20	0/64	0/63	0/63
54HC373	SO-20	0/75	0/75	1/75 (1)
74HC373	DIP-20	0/76	†	0/76
74HC373	SO-20	0/76	†	0/76
74HC374	DIP-20	0/77	†	0/77
74HC374	SO-20	0/76	†	0/76
74LS08	DIP-14	0/50	0/50	0/50
74LS08	SO-14	0/100	0/100	0/100
74LS240	SO-20	0/55	0/55	0/55
74LS240	SO-20	0/55	0/55	0/55
CD4601	SO-14	0/90	0/90	0/90
LF347	DIP-14	0/50	0/50	0/50
LF347	SO-14W	0/50	0/50	0/50
LF351	DIP-8	0/50	0/50	0/50
LF351	SO-8	0/50	0/50	0/50
LF351	SO-8	0/50	0/50	0/50
LF353	DIP-8	0/50	0/50	0/50
LF353	SO-8	0/50	0/50	0/50
LF353	SO-8	0/50	0/50	0/50
LF353	SO-8	0/50	0/50	0/50
LF411	DIP-8	1/50 (2)	0/49	0/49
LF411	SO-8	0/50	0/50	0/50
LF411	SO-8	0/50	0/50	0/50
LF412	DIP-8	1/50 (3)	0/49	0/49
LF412	SO-8	0/100	0/98	0/98
LM111	DIP-14	0/57	0/57	0/57
LM111	SO-14	0/57	0/57	0/57
LM308	DIP-8	1/80 (4)	0/79	0/79
LM308	SO-8	1/80 (4)	0/79	0/79
LM311	DIP-8	0/59	0/59	0/59
LM311	SO-8	0/60	0/60	0/60
LM311	DIP-8	0/49	0/49	0/49
LM311	SO-8	0/70	0/70	0/70
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	1/55 (5)	0/54	0/54
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/50	0/49	†
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/50	0/50	0/50
LM324	SO-14	0/49	0/49	1/49 (6)
LM324	SO-14	0/45	0/45	0/45
LM324	SO-14	0/40	0/40	0/40
LM346	DIP-16	0/50	0/50	0/50
LM346	SO-16	0/50	0/50	0/50

Temperature Humidity Bias*: 85°C, 85% RH

Device	Package	168 Hours	500 Hours	1000 Hours
LM348	DIP-14	0/50	0/50	0/50
LM348	SO-14	0/50	0/50	0/50
LM358	SO-8	0/45	0/45	0/45
LM358	SO-8	0/45	0/45	0/45
LM358	SO-8	0/45	0/45	0/45
LM359	DIP-14	0/50	0/50	0/50
LM359	SO-14	0/50	0/50	0/50
LM442	DIP-8	1/50 (7)	0/49	2/49 (7)
LM442	SO-8	0/50	0/50	0/50
LM592	DIP-14	0/50	0/50	0/50
LM592	SO-14	0/50	0/50	0/50
LM723	DIP-14	0/50	0/50	0/50
LM723	SO-14	0/50	0/50	0/50
LM741	DIP-8	1/50 (8)	0/49	0/49
LM741	SO-8	0/50	0/50	0/50
LM832	SO-14	0/53	2/53 (9)	0/51
LM1496	DIP-14	0/50	0/50	0/50
LM1496	SO-14	0/50	0/50	0/50
LM1524	DIP-16	2/50 (10)	2/48 (10)	0/46
LM1524	SO-16	2/50 (10)	0/48	0/48
LM1558	DIP-8	0/49	0/49	0/49
LM1558	SO-8	0/50	0/50	0/50
LM1558	SO-8	0/48	0/49	0/49
LM1902	DIP-14	0/60	0/60	0/60
LM1902	SO-14	0/60	0/60	0/60
LM2903	DIP-8	0/60	0/60	0/60
LM2903	SO-8	0/58	0/58	0/58
LM3086	DIP-14	0/50	0/50	0/50
LM3086	SO-14	0/50	0/50	0/50
	Total DIP	7/1674	2/1426	2/1742
	Total SO	4/3193	2/2937	2/3202

Note 1: Short to V_{CC}

Note 2: Parametric, I_B = 13.84 nA (Max = 300 pA)

Note 3: Marginal parametric (PSRR)–Tested good at 500 Hrs.

Note 4: Open metallization-ECR

Note 5: Parametric, V_{OUT}, High = 12.54V (Min = 26V)

Note 6: Parametric, V_{OUT}, High = 14.14V (Min = 26V)

Note 7: Parametric, I_B

Note 8: Parametric, V_{OS}

Note 9: Parametric, DC gain

Note 10: Parametric, MAXDCY

†No measurements taken

*All SO packages board mounted (vapor-phase reflow soldering)

Autoclave: 121°C, 15 psi and 100% RH

Device	Package	96 Hours	168 Hours	336 Hours
74HC244	DIP-20	†	0/55	0/55
74HC244	SO-20	†	0/55	0/55
74HC245	SO-20	†	0/60	0/60
74HC373	DIP-20	0/50	0/50	0/48
74HC373	SO-20	0/50	0/50	0/50
74HC373	DIP-20	†	0/55	0/55
74HC373	SO-20	†	0/53	0/53
74HC374	DIP-20	†	0/55	0/55
74HC374	SO-20	†	0/55	1/55 (1)
	Total DIP	0/50	0/215	0/213
	Total SO	0/50	0/273	1/273

Note 1: Parametric—I_{CC} leakage

†No measurements taken

Autoclave: 100% RH, 15 psi and 121°C

Device	Package	168 Hours	500 Hours	1000 Hours
74LS240	SO-20	0/98	0/98	0/98
74LS240	SO-20	0/97	0/97	0/97
CD4601	SO-14	0/100	†	†
LF351	DIP-8	0/50	0/50	†
LF351	SO-8	0/50	0/50	†
LF351	SO-8	0/50	0/50	†
LF353	DIP-8	0/49	0/49	†
LF353	SO-8	0/32	0/32	†
LF353	SO-8	0/42	0/42	†
LF353	SO-8	0/42	0/42	†
LF411	DIP-8	0/50	0/50	0/50
LF411	SO-8	0/50	0/50	0/50
LF411	SO-8	0/50	0/50	0/50
LF412	DIP-8	0/50	0/50	†
LF412	SO-8	0/50	0/50	†
LF412	SO-8	0/50	0/50	†
LM308	DIP-8	0/100	0/100	†
LM308	SO-8	0/99	0/99	†
LM308	DIP-8	0/100	0/100	†
LM308	SO-8	0/100	0/100	†
LM308	DIP-8	0/80	0/80	†
LM308	SO-8	0/66	0/66	†
LM311	DIP-8	0/100	0/100	0/75
LM311	SO-8	0/100	0/100	0/70
LM311	DIP-8	0/49	0/49	†
LM311	SO-8	0/50	0/50	†
LM311	DIP-8	0/60	0/60	†
LM311	SO-8	0/60	0/60	†
LM324	SO-14	0/100	0/100	0/100
LM324	DIP-14	0/20	0/20	0/20
LM324	SO-14	0/100	0/100	0/100
LM324	SO-14	0/60	0/60	0/60
LM324	SO-14	0/60	0/60	0/60
LM348	DIP-14	0/50	0/50	0/50
LM348	SO-14	0/50	0/50	0/50
LM359	DIP-14	0/50	0/50	0/50
LM359	SO-14	0/50	0/50	0/50

Autoclave: 100% RH, 15 psi and 121°C (Continued)

Device	Package	168 Hours	500 Hours	1000 Hours
LM442	DIP-8	0/50	0/50	†
LM442	SO-8	0/50	0/50	†
LM592	DIP-14	0/50	0/50	†
LM592	SO-14	0/50	0/50	†
LM723	DIP-14	0/50	0/50	0/50
LM723	SO-14	0/50	0/50	0/50
LM741	DIP-8	0/50	0/50	†
LM741	SO-8	0/50	0/50	†
LM741	SO-8	0/50	0/50	†
LM741	SO-8	0/49	0/49	†
LM832	SO-14	0/100	0/100	0/100
LM1496	DIP-14	0/50	0/50	†
LM1496	SO-14	0/50	0/50	†
LM1524	DIP-16	0/50	0/50	†
LM1524	SO-16	0/50	0/50	†
LM1558	DIP-8	0/50	0/50	0/50
LM1558	SO-8	0/49	0/49	0/49
LM1558	SO-8	0/50	0/50	1/50 (1)
LM1902	DIP-14	0/90	0/90	†
LM1902	SO-14	0/90	0/90	†
LM2903	DIP-8	0/97	0/97	0/97
LM2903	SO-8	0/99	0/99	0/99
LM3086	DIP-14	0/50	0/50	†
LM3086	SO-14	0/50	0/50	†
	Total DIP	0/1395	0/1395	0/442
	Total SO	0/2443	0/2343	1/1133

Note 1: ECR-open metallization

†No measurements taken

Temperature Cycle*: $T_A = -65°C$ to $+150°C$

Device	Package	500 Cycles	1000 Cycles	2000 Cycles
LM324	SO-14	0/55	†	0/55
LM324	SO-14	0/55	†	0/55
LM324	SO-14	0/45	†	0/45
LM324	SO-14	0/45	†	0/45
LM324	SO-14	0/45	†	0/45
LM324	SO-14	0/45	†	0/45
LM324	SO-14	0/45	†	0/45
LM324	SO-14	0/45	†	0/45
LM339	SO-14	0/55	†	0/55
LM339	SO-14	0/45	†	0/45
LM358	SO-8	0/45	†	0/45
LM358	SO-8	1/45 (1)	†	0/44
LM358	SO-8	0/45	†	0/45
LM358	SO-8	0/45	†	0/45
	Total SO	1/660	†	0/659

Note 1: Parametric—swing failure

†No measurements taken

*All SO packages board mounted (vapor-phase reflow soldering)

Temperature Cycle*: −65°C to +150°C

Device	Package	500 Cycles	1000 Cycles	2000 Cycles
74HC74	SO-14	0/77	0/77	0/77
74HC244	SO-20	0/41	0/41	0/41
74HC373	SO-20	0/77	0/77	0/77
74HC374	SO-20	0/35	0/35	0/35
74LS08	DIP-14	0/50	0/50	0/50
74LS08	SO-14	0/89	0/89	0/89
74LS240	SO-20	0/100	0/100	0/100
74LS240	SO-20	0/100	0/100	0/100
CD4601	SO-14	0/99	†	†
DS75451	SO-14	†	0/50	0/50
LM324	DIP-14	†	0/99	0/99
LM324	SO-14	†	0/60	0/60
LM332	SO-14	†	0/100	0/100
LM1902	DIP-14	†	0/60	0/60
LM1902	SO-14	†	0/60	0/60
LM2903	DIP-8	†	0/54	0/54
LM2903	SO-8	†	0/90	0/90
	Total SO	0/618	0/879	0/879
	Total DIP	0/50	0/263	0/263

†No measurements taken

*All SO packages board mounted (vapor-phase reflow soldering)

Thermal Shock*: −65°C to +150°C

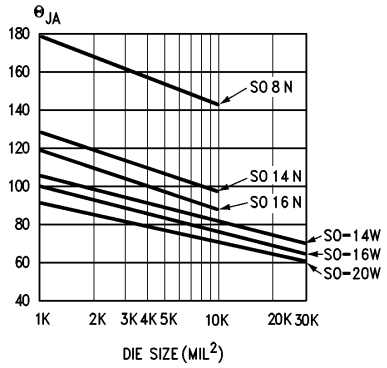
Device	Package	15 Cycles	30 Cycles	50 Cycles	100 Cycles
CD4601	SO-14	0/100	0/100	0/100	0/100
DS75451	SO-14	0/50	0/50	0/50	0/50
LM111	SO-14	0/75	0/75	0/75	0/75
LM111	DIP-14	0/75	0/75	0/75	0/75
LM308	DIP-8	0/100	0/100	0/100	0/100
LM308	SO-8	0/100	0/100	0/100	0/100
LM324	DIP-14	0/20	0/19	0/19	0/19
LM324	SO-14	0/60	0/59	0/59	0/59
LM324	SO-14	0/50	0/50	0/50	0/50
LM832	SO-14	0/60	0/60	0/60	0/60
LM1902	DIP-14	0/30	0/30	0/30	0/30
LM1902	SO-14	0/30	0/30	0/30	0/30
	Total DIP	0/225	0/224	0/224	0/224
	Total SO	0/525	0/524	0/524	0/524

*All SO packages board mounted (vapor-phase reflow soldering)

CONCLUSION

Data presented in this report demonstrate that the reliability performance of a product assembled in National's Small Outline (SO) Package is excellent and comparable to the reliability performance of product assembled in National's Standard Dual-In-Line (DIP) Package.

θ_{jA} - Thermal Resistance for SO Packages (Board Mount)



Body Width
N = Narrow (0.150 inches)
W = Wide (0.300 inches)

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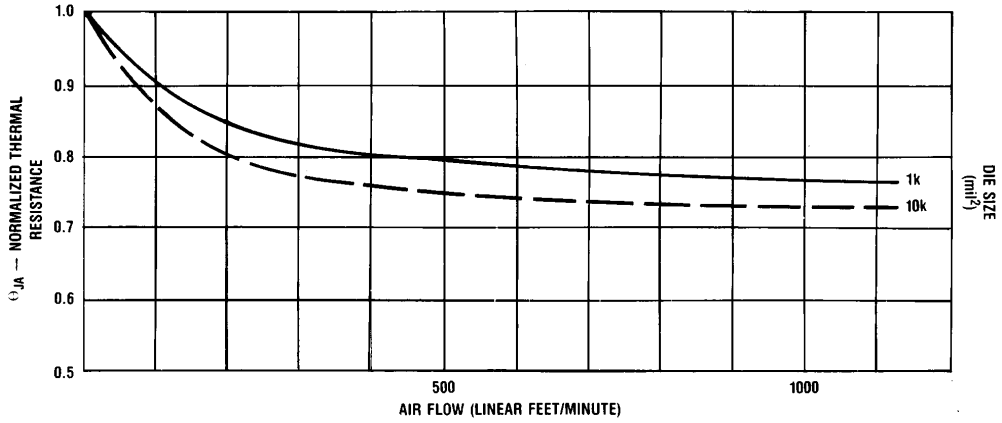
Air Flow

When a high power situation exists and ambient-temperature cannot be reduced, the next best thing is to provide air flow in the vicinity of the package. The graph below illustrates the impact this has on thermal resistance. This graph plots the relative reduction in thermal resistance normalized to the still air condition for National's 14-pin molded small outline package. The thermal ratings on National's data sheets relate to the still air environment.

14-Pin Molded Small Outline Package



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Reliability Report Update Small Outline (SO) Package

Lit. # 980045

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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