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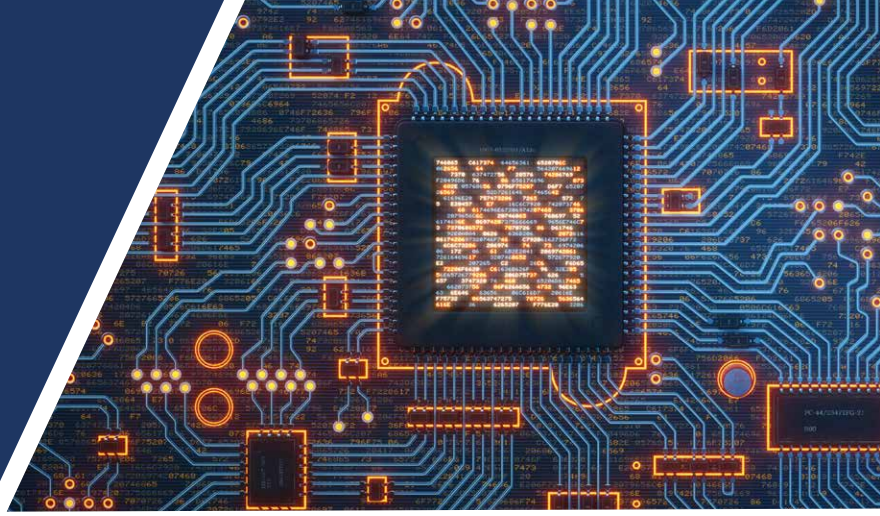
Indusil™ ETM 90 Silicone



MARKETING BULLETIN

Epoxy Modified Phenyl-Methyl Silicone Resin

Indusil ETM 90 silicone is an epoxy and phenyl group functionalized solid silicone resin that is may be used in the manufacture of thermoset plastic compounds, which can help reliability of the electric device by providing in such a way as to release stress of EMC and reduce rate of water absorption and compression rate change.

Epoxy molding compounds (EMC) have typically been used in thermoset plastics due to their mechanical, electrical insulative and temperature-resistant properties where they perform well under thermal cycling and high humidity conditions present during curing.

EMC device reliability is largely dependent on compatibility of materials such as epoxy resins, hardeners, silica and other additives. For example, a mismatch in coefficient of thermal expansion (CTE) of an EMC and the substrate and the high modulus of cured EMC properties can result in warpage, which significantly impacts reliability of the molded part. To predict potential warpage issues in EMC applications, a stress index is calculated by multiplying the CTE and modulus. The stress index can be reduced by lowering the CTE and modulus. To improve reliability, higher loading filler is commonly used to reduce CTE in EMC formulations; however, it can limit spiral flow (higher viscosity) and higher modulus due to increased filler content.

Indusil ETM 90 can help enhance reliability as well as help to improve processability.

Key Features and Typical Benefits

- Excellent stress relief [low CTE and low flexural modulus (E')]
- Reduced rate of water absorption
- Reduced compression rate change
- Increased spiral flowability when Indusil ETM 90 silicone displaced some filler
- Excellent compatibility with organic resins via the presence of phenyl groups

Potential Applications

- Additive for epoxy molding compounds (EMC)
- Additive for epoxy-based copper clad laminate (CCL)

Typical Physical Properties

Property	Measure	Value
Physical state	n/a	Solid
Appearance	n/a	White powder
Epoxy equivalent	g/mol	1,200 – 2,100
Specific gravity at 25 °C	g/ml	1.3

Typical properties are average data and are not to be used as or to develop specifications.

General Considerations for Use

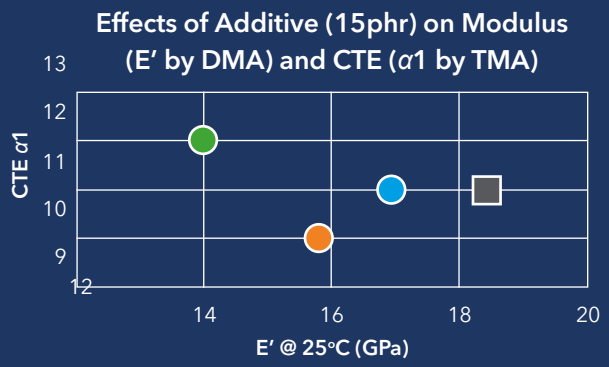
The typical product usage range is approximately 7-20 weight % in parts per hundred resin (PHR); optimal levels may vary, however, and should be determined through preliminary evaluation of processing conditions and product loading required to achieve desired effect.

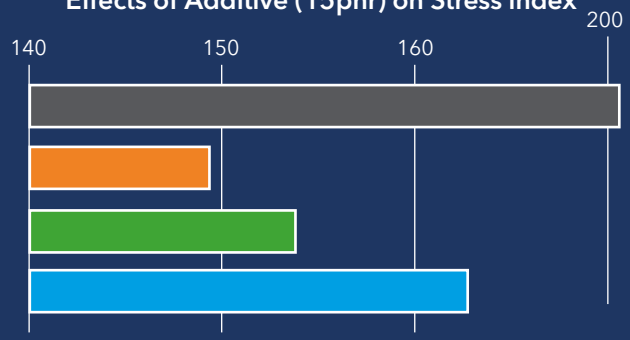
Indusil ETM 90 silicone can generally be incorporated into the polymer matrix by melt blending using a twin-screw extruder. The silicone can be introduced into the extruder by absorption into granules.

Indusil ETM 90 Silicone Reduced Stress of Epoxy Molding Compound

As most common encapsulation material, EMC provides strong mechanical properties and electrical insulation for reliability. Higher stress index, which is calculated by CTE and Modulus, is one of the major causes of solder crack including package level and board level solder crack during Thermal Cycle Test (TCT) condition.

To reduce potential warpage at molding steps and curing steps, additives are often used to help lower the Coefficient of Thermal Expansion (CTE) and modulus, which improves EMC properties. ElectroSil SIM 76E is epoxy and polyether modified methyl silicone oil. Stress index is calculated by the following formula.
Stress index = CTE (α) × Modulus (E′).





			Run 1 □	Run 2 ○	Run 3 ○	Run 4 ○
TMA[1]	CTE α1 (25°C~80°C)	(ppm)	11	10	12	11
	CTE α1 (25°C~80°C)	(ppm)	44	38	48	46
DMA[2]	E' @ 25°C	(GPa)	18	16	14	17
	E' @ 50°C	(GPa)	18	16	13	16
Stress Index	CTE α1 × E' @ 25°C	-	201	159	168	185
	CTE α1 × E' @ 50°C	-	197	156	161	179
	CTE α2 × E' @ 25°C	-	805	604	672	776
	CTE α2 × E' @ 50°C	-	788	593	643	748

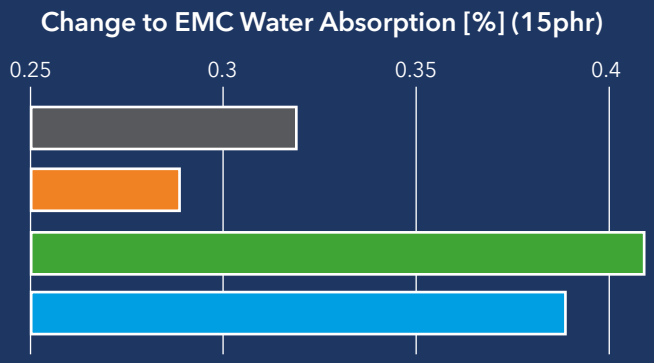
- No additive
- Indusil ETM 90 15phr
- ElectroSil SIM 76E 15phr
- Competitive benchmark 15phr

(1) Compression mode at N_2 purge condition, r.t. → 300°C by 5°C/min, 10Hz
(2) Three point bending mode at N_2 purge condition, r.t. → 300°C by 5°C/min, 10Hz
Note: Test results. Actual results may vary and are composition, molding and operator dependent.

Indusil ETM 90 Silicone Reduced Water Absorption Rate

Water absorption can significantly impact EMC reliability. If it's too high, it can result in interface delamination or a moisture-induced cracking known as "popcorn effect" during the soldering reflow process.

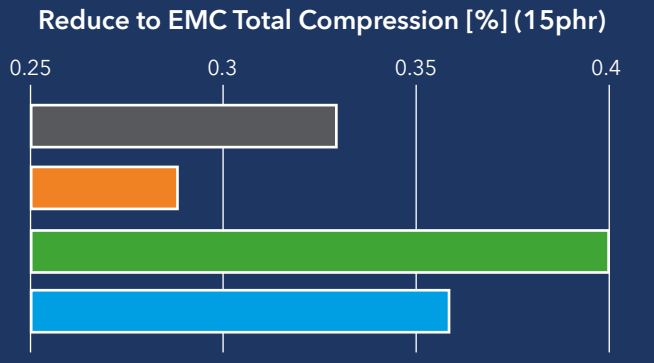
Moisture absorption rate of the samples was determined by the following calculation:
Water absorption rate (%) = [Weight (after PCT for 24 hrs.) – Weight (initial)] / Weight (initial) ×100



No additive | Indusil ETM 90 15phr | ElectroSil SIM 76E 15phr | Competitive benchmark 15phr

Indusil ETM 90 Silicone Reduced Total Compression Rate

Along with CTE, compression rate can influence reliability of EMC devices. That's because as compression rates increase, internal stress may also increase. Generally, areas of comparison include a) compression rate after compression vs. mold size and b) shrinkage after cure at 175 °C after 5 hours vs. after compression / before cure process.



Note: Test results. Actual results may vary and are composition, molding and operator dependent.

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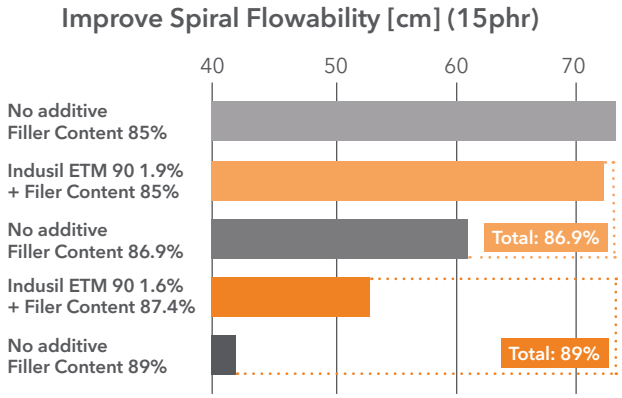
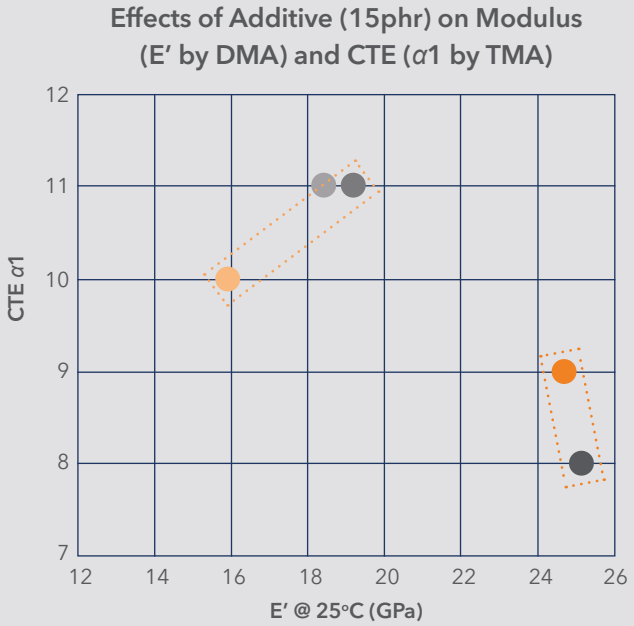
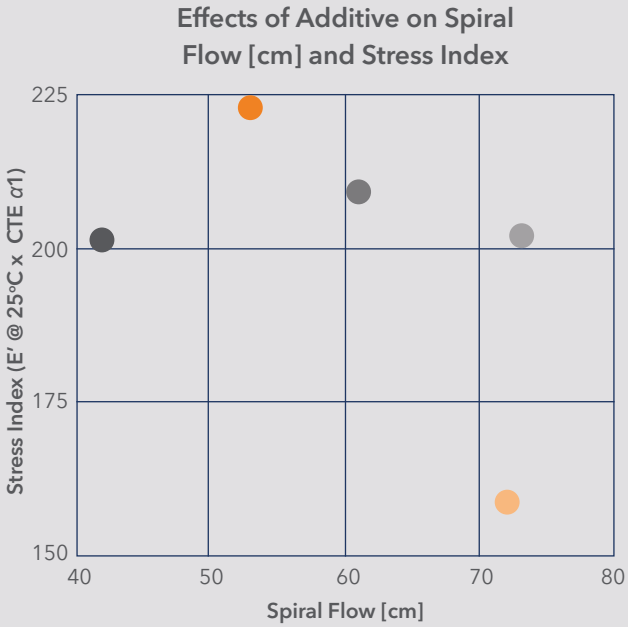
Indusil ETM 90 Silicone Reduced Water Absorption Rate

Increasing the use of filler Contents (FC) can reduce the CTE of EMC compounds; however, it could also reduce spiral flowability, which could negatively impact the molding process. Replacing some of the filler with Indusil ETM 90 silicone can be reconciled to conflicting features such as "spiral flowability" and "stress index" as shown in the below figures.







No additive Filler Content 85%

No additive Filler Content 86.9%

No additive Filler Content 89%

Indusil ETM 90 1.9% + Filer Content 85%

Indusil ETM 90 1.6% + Filer Content 87.4%

Note: Test results. Actual results may vary and are composition, molding and operator dependent.

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Sample Formulation Used for Evaluation

No additive | Indusil ETM 90 15phr[a] | ElectroSil SIM 76E 15phr[b] | Competitive benchmark 15phr[c]

		Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7
	Additive (%)	0.00	1.91	1.91	1.91	0.00	1.61	0.00
	Filler content (%)	85.00	85.00	85.00	85.00	86.91	87.39	89.00
	Additive + Filler (%)	85.00	86.91	86.91	86.91	86.91	89.00	89.00
Epoxy	YX-4000H[1]	6.41	5.56	5.56	5.56	5.56	4.70	4.70
	NC-3000[2]	1.60	1.39	1.39	1.39	1.39	1.17	1.18
Hardener	MEHC-7800[3]	6.72	6.72	6.72	5.82	5.82	4.92	4.93
Additive	**Indusil ETM 90[4]**	0.00	**1.91**	0.00	0.00	0.00	**1.62**	0.00
	ElectroSil SIM 76E[5]	0.00	0.00	**1.91**	0.00	0.00	0.00	0.00
	Competitive bentchmark	0.00	0.00	0.00	**1.91**	0.00	0.00	0.00
Filler	Fused silica (FB-820)[6]	85.00	85.00	85.00	85.00	**86.91**	**87.39**	**89.00**
Silane	Silquest A-187[7]	0.16	0.16	0.16	0.14	0.14	0.12	0.12
Catalyst	Triphenyl Phosphate	0.10	0.10	0.10	0.09	0.09	0.08	0.08
	Total	100	100	100	100	100	100	100

(a) Epoxy modified methyl phenyl silicone solid resin / Momentive

(b) Epoxy and polyether modified methyl silicone oil / Momentive

(c) Epoxy and polyether modified silicone

(1) Epoxy equiv. 197g/eq. melting point 105°C / Mitsubishi Chemical

(2) Epoxy equiv. 275g/eq. melting point 58°C / Mippon Kayaku

(3) Phenol equiv. 175g/eq. melting point 61-90°C / Meiwa Plastic Industries

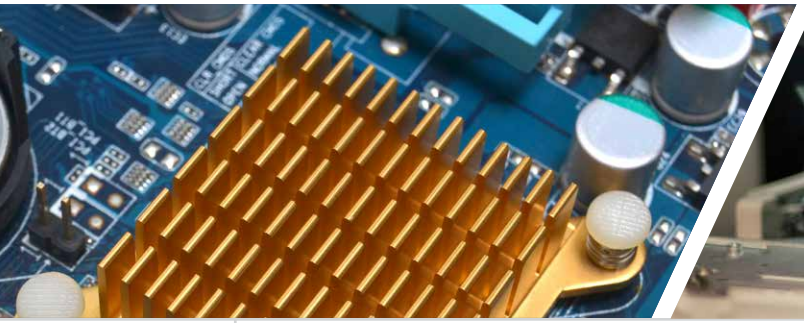
(4) Epoxy equiv. 1700g/eq melting point 98°C / Momentive

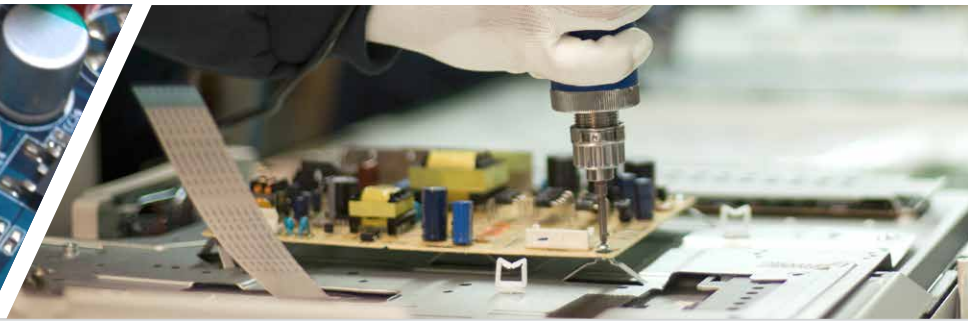
(5) Epoxy equiv. 7000g/eq liquid / Momentive

(6) Average partcle size 17.5μm, Specific surface area 3.8m^2/g / Denka

(7) Glycidoxypropyltrimethoxysilane / Momentive

Note: Test results. Actual results may vary and are composition, molding and operator dependent.





Sample Formulation Used for Evaluation (continued)

No additive | Indusil ETM 90 15phr[a] | ElectroSil SIM 76E 15phr[b] | Competitive benchmark 15phr[c]

			Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7
		Additive (%)	0	1.91	1.91	1.91	0	1.61	0
		Filler content (%)	85	85	85	85	86.91	87.39	89
		Additive + Filler (%)	85	86.91	86.91	86.91	86.91	89	89
Spiral Flow[d]		(cm)	73	72	75	73	61	53	42
Gel Time[e]		(s)	30	33	25	26	28	30	29
Water Absorption rate[f]		(%)	0.32	0.29	0.41	0.39	0.28	0.25	0.28
Compression rate[g]	**After compression**								
	Long hand direction	(%)	0.14	0.14	0.14	0.17	0.12	0.13	0.11
	Short hand direction	(%)	0	0	0	0.16	0.03	0	0
	Cure shinkage[h]								
	Long hand direction	(%)	0.19	0.15	0.26	0.19	0.14	0.13	0.12
	Short hand direction	(%)	0.2	0.1	0.33	0.23	0.1	0.1	0.07
	Total compresion rate								
	Long hand direction	(%)	0.33	0.29	0.4	0.36	0.26	0.26	0.23
	Short hand direction	(%)	0.2	0.1	0.33	0.39	0.13	0.1	0.07
TMA[i]	Tg	(°C)	18	16	14	17	19	25	25
	CTE α1 (25°C~80°C)	(ppm)	117	114	92~112	93	116	123	121
	CTE α2 (150°C~250°C)	(ppm)	11	10	12	11	11	9	8
DMA[j]	E' @ 25°C	(GPa)	44	38	48	46	41	32	35
	E' @ 50°C	(GPa)	18	16	13	16	19	24	25
	tan δ (peak)	(°C)	133	129/163	125	122	136	132	135
3 Point Bending Test [k]	Flexural Modulus @ 0.1-1.0N	(N/mm^2)	54,600	45,800	33,800	51,800	43,900	31,800	57,900
	Peak Stress at break	(N)	286	241	188	244	295	254	287

(a) Epoxy modified methyl phenyl silicone solid resin / Momentive
(b) Epoxy and polyether modified methyl silicone oil / Momentive
(c) Epoxy and polyether modified silicone
(d) Transfer molding @175°C 6.9MPa, 3min
(e) evaluated at 175°C
(f) Mold sample is cured at 175°C by 5 hrs and compared weight of cured material w/ before & after PCT at 24hrs
(g) Transfer molding @175°C 6.9MPa, 3min and then compared w/ test sample size vs mold size
(h) Cured at 175°C by 5 hours and then compared sample size w/ before and after cure process
(i) Compression mode at N_2 purge condition, r.t. → 300°C by 5°C/min, 10Hz
(j) Three point bending mode at N_2 purge condition, r.t. → 300°C by 5°C/min, 10Hz
(k) JIS K7271 : 2016
Note: Test results. Actual results may vary and are composition, molding and operator dependent.

Product Safety, Handling and Storage

Customers should review the latest Safety Data Sheet (SDS) and label for product safety information, safe handling instructions, personal protective equipment if necessary, emergency service contact information, and any special storage conditions required for safety. Momentive Performance Materials (MPM) maintains an around-the-clock emergency service for its products. SDS are available at www.momentive.com or, upon request, from any MPM representative. For product storage and handling procedures to maintain the product quality within our stated specifications, please review Certificates of Analysis, which are available in the Order Center. Use of other materials in conjunction with MPM products (for example, primers) may require additional precautions. Please review and follow the safety information provided by the manufacturer of such other materials.

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