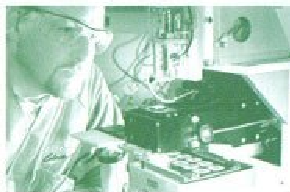
Hysol® LOCTITE® Multicore®

Go Lead-Free
Materials Guide



Henkel

July 1st 2006

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The RoHS (Restriction of Hazardous Substances) will be implemented in the EU in July 2006. By then all EU countries will have laws supporting this directive and all but a few exempted electronics applications will have to comply with the elimination of lead and other hazardous materials.

Why Lead-Free?

Lead is toxic and a cumulative poison causing damage to the nervous system. Although there is poor evidence of ground water contamination from electronics disposed of in landfills, the reality is that pressure to eliminate lead in all applications will increase, and the use of lead-free solders will continue to rise to comply with both legislative and consumer demand.

The elimination of lead and other hazardous substances from electronic packaging and assembly materials is making much existing knowledge and characterization data obsolete.

Henkel recognized this fact early, and is already leading the race to re-acquire material sets. As a true solutions provider, we believe it is essential for us to do this for our customers. Henkel delivers turnkey solutions, including the technical and engineering support crucial to your process engineers. We will not leave you to fill in the blanks.

Henkel's 'Lead-Free That Works' initiative is ready for action, minimizing the risks of conversion, and giving you the confidence to introduce new lead-free products and services quickly, in high volumes, and at high quality from the outset. The Henkel range includes lead-free solder materials, as well as qualified compatible SMD adhesives, die attach, mold compounds, underfill, and liquid encapsulants for semiconductors and other components.

Used together, Henkel's product brands deliver unique lead-free advantages:

- Multicore® solder materials offer a variety of solder paste, cored wires and flux systems for use in lead-free applications.
- Loctite® lead-free-compatible surface mount adhesives withstand the greater rigors of lead-free wave soldering operations and prevent chip loss.
- Hysol® die attach adhesives offer very high adhesion strength and elongation at lead-free solder reflow temperatures to ensure the entire package will not crack or popcorn.
- Hysol® fast-flow underfill materials offer excellent adhesion to a variety of no-clean flux residues that will not crack after thermal shock or thermal cycling.
- Hysol® liquid encapsulants are designed to withstand up to 260°C peak solder reflow temperatures without degradation, and meet JEDEC Level 2A standards.
- Hysol® molding compounds meet flammability requirements without the use of antimony, bromine, or phosphorous flame retardant compounds. They provide excellent long term high temperature performance and lead-free processing for packaging a variety of power devices, sensors, ICs, and passive components.

Alloy selection

Assembly:

Henkel supports the standard SAC305 and SAC387 lead-free alloys for reflow soldering:

SAC305 (Multicore® code 97SC): SnAg3Cu0.5 with melting point of 217°C
SAC387 (Multicore® code 96SC): SnAg3.8Cu0.7 with melting point of 217°C

These alloys perform the closest to traditional Sn/Pb alloys, offering the best compromise on peak temperatures during reflow, and are proven as highly reliable selections when used in this type of assembly process.

Rework:

Henkel supports SAC alloys along with alternative lead-free alloy such as 99C (SnCu0.7).

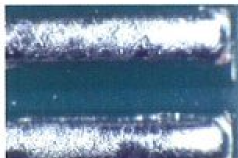
Temperature

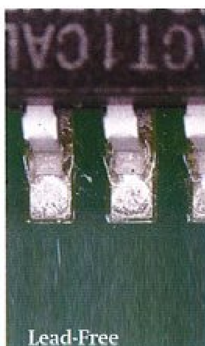
All lead-free solder materials, used today in high volumes, melt at higher temperatures than traditional tin-lead alloys. The temperature rating of components and substrate materials needs to withstand these elevated temperatures.

Alloy	Tin	Lead	Copper	Silver	Melting Point/Range (°C)
Sn63	63	37	-	-	183
SAC387 (96SC)	95.5	-	0.7	3.8	217
SAC305 (97SC)	96.5	-	0.5	3	217
99C	99.3	-	0.7	-	227

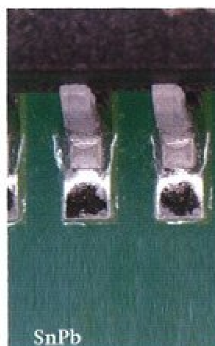
Inspection

Lead-free joints usually appear duller than tin/lead joints, and typically feature reduced spread, resulting in quite steep contact angles at the perimeter where the solder meets the substrate. This is normal and indeed some studies have already proven that a lead-free solder joint can be even more robust and reliable than an equivalent tin/lead joint.





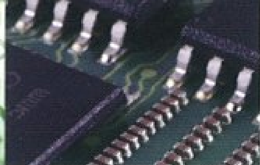
Lead-Free



SnPb

Rework and Repair

To ensure there is no risk of lead contamination, it is necessary to be sure which solder has been used during manufacture or previous rework, before attempting to rework any assembly. Consult your manufacturing specifications for process flow.



Multicore® Paste Solutions

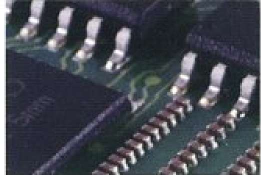
The latest generation of Multicore® lead-free solder pastes are formulated to cope with a wide range of application conditions, offering manufacturers the benefit of using one single solder paste on a large variety of boards, under different production conditions – such as changing ambient temperatures and/or humidity conditions.

Multicore® LF318 Lead-Free No-Clean Solder Paste

Mulitcore® LF318 is a no-clean, halide-free solder paste with a wide print process window and extremely long abandon and open time. This paste has superior slump resistance to minimize the risk of bridging. Its outstanding humidity resistance reduces process variation due to environmental factors, a particular advantage where assembly is carried out in hot and humid conditions. The soft, non-stick, pin-testable residues improve ease and reliability of in-circuit testing and reduce the frequency with which test probes require cleaning. In addition, low voiding characteristics further reduce the risk of bridging on fine pitch BGAs or CSPs and the possibility of decreased joint reliability due to outgassing.

The excellent solderability characteristics guarantee compatibility with a wide range of surface finishes including HASL, Ni/Au, immersion Sn, immersion Ag and OSP Cu. The wide printing and reflow process windows accommodate a broad range of printer settings and reflow profiles under both air and nitrogen environments.

Alloy	Powder Type	Metal %	Tack (g/mm²)	Print speed (mm/s)	J-STD Classification
SAC387 (96SC) SAC305 (97SC)	AGS (45-20mm)	88.5	2.0	25-150	ROLO



Multicore® WS300 Lead-Free Water Washable Paste

Multicore® WS300 is a high activity, water washable material with superior cleaning characteristics suitable for fine pitch, high speed printing applications. Multicore® WS300 exhibits excellent print definition with long open and abandon times. The high activity flux offers excellent wetting to a wide range of surface finishes, and provides an exceptional reflow process window. In addition, this material is highly resistant to humidity and slump, and is formulated to minimize any defects due to voiding. Other unique benefits of Multicore® WS300 include no visible residue on PCBs washed up to 3 days after being reflowed, and superior slump resistance resulting in decreased defects due to bridging.

Alloy	Powder Type	Metal %	Tack (g/mm²)	Print speed (mm/s)	J-STD Classification
SAC387 (96SC) SAC305 (97SC)	AGS (45-20mm)	89	0.8	25-150	ORH1

96SC alloy (Sn 95.5, Ag 3.8, Cu 0.7%) with a melting point of 217°C. 97SC alloy (Sn 96.5, Ag 3.0, Cu 0.5%) with a melt point of 217°C. Licensed under US Patent No. 5,527,628 and Japan Patent No. 3,027,441.

Multicore® Flux Solutions

Multicore® VOC-free Fluxes

The Multicore® range of VOC (Volatile Organic Compound)-free fluxes offers reliable, high yield, no-clean wave soldering whilst providing significant environmental and safety benefits due to the non flammable VOC-free (water based) flux carrier systems. Great cost reductions are achievable when changing to a VOC-free wave soldering process through the elimination of fire risk (lower insurance and storage costs) and by complying with VOC emissions control legislation where this is required.

Multicore® MF101 No-Clean, Rosin Emulsion VOC-free Liquid Flux

Multicore® MF101 offers all the benefits of high yield soldering with a rosin based flux, and the safety and environmental benefits of being VOC-free. The special low solder balling formulation ensures sustained activity in dual wave and lead-free processes and the activity of rosin in the flux provides excellent topside fillet formation on PTH boards. Multicore® MF101 is halide free, passes the Bellcore SIR and J-STD-004 standards, is no-clean and complies with all VOC emissions control legislation.

% Solids	% Halide	Acid Value	J-STD Classification	Application
6.5 – 7.0	Zero	40	ROMO	Spray

Multicore® MF300 No-Clean, VOC-free Liquid Flux

Multicore® MF300 is a high activity, no-clean, resin and halide-free flux, which meets the most demanding legislation on VOC emissions. Multicore® MF300 is highly effective on low solderability surfaces, e.g. oxidized copper, and can be applied by both spray and foam fluxing systems.

% Solids	% Halide	Acid Value	J-STD Classification	Application
4.6	Zero	37	ORMO	Spray/Foam

Multicore® Alcohol Based Fluxes

The Multicore® range of alcohol based fluxes also offers reliable, high yield, no-clean wave soldering typical of this type of flux solvent system. Rapid evaporation of the flux carrier solvent offers faster throughput and lower energy costs (lower preheat temperatures are possible depending on the assembly design). When using equipment designed for an alcohol-type flux process, the Multicore® range delivers optimum wave soldering results.

Multicore® MFR301 No-Clean, Alcohol Based Liquid

Multicore® MFR301 is an alcohol based no-clean, high activity liquid flux with exceptional performance on surfaces with poor solderability. The high activity ensures fast soldering on conventional leaded and SMT components, ensuring no bridges or icicles and consistently good through-hole penetration. Multicore® MFR301 leaves minimal residues which reduces ATE probe contamination without the need for cleaning, and can be applied via either a foam or spray fluxing system.

% Solids	% Halide	Acid Value	J-STD Classification	Application
6.5	Zero	41	ROMO	Spray/Foam

Multicore® MF200 No-Clean, Alcohol Based Liquid Flux

Multicore® MF200 is an alcohol based no-clean, resin free, halide-free, liquid flux that has been specially designed for high yield lead-free wave soldering processes. It provides excellent PTH filling and topside fillet formation, while significantly reducing the incidence of mid-pad solder balling. Multicore® MF200 is also designed to be fully compatible with standard tin/lead eutectic wave soldering processes. Multicore® MF200 passes the Bellcore GR-78-CORE SIR test and is classified as ORMO (J-STD-004).

% Solids	% Halide	Acid Value	J-STD Classification	Application
6.4	Zero	48.5	ORMO	Spray/Foam

Multicore® Solder Wire Solutions

Multicore® Lead-Free Cored Solder Wire

Now Henkel's world famous Multicore® multiple cored solder wire range is available in a comprehensive range of lead-free alloys. Standard cored wire fluxes are available in combination with the lead-free alloys SAC305 (97SC), SAC387 (96SC) and 99C. Other metal variants can be made available on request. SAC387 (96SC) and SAC305 (97SC) alloys when used for rework or repair of lead-free assemblies, guarantees total compatibility with SMT reflowed solder joints that usually use the same alloy. When hand soldering, reworking or repairing lead-free solder joints, the temperatures during soldering are much less likely to be as carefully controlled as those in an SMT manufacturing reflow process and hence the 99C (99.3% Sn, 0.7% Cu) alloy is a perfectly safe alternative to SAC387 (96SC) and SAC305 (97SC) alloy. 99C is also fully compatible with most lead-free alloys and offers a significant price advantage.

No-Clean Low Color Residue

The low color residue wires include activity levels from the safest halide-free 400 flux type to the slightly activated 500 series. This range is ideal for all types of hand soldering assembly and rework applications.

Products	Description	Halide Content (%)	J-STD Classification	Alloy Option
400	Halide-free, no-clean, clear residue, increased flux content for improved wetting.	0	ROLO	SAC305 (97SC) SAC387 (96SC), 99C
502	No-clean, clear residue, medium activity flux with good wetting on difficult substrates. Note: Not sold in the U.S.	0.2	ROM1	SAC305 (97SC), SAC387 (96SC), 99C
511	No-clean, clear residue, high activity flux with excellent wetting on difficult substrates.	1.1	ROM1	SAC305 (97SC), SAC387 (96SC), 99C

No-Clean High Activity Rosin Based

The 309 rosin based cored wire is a highly reliable and safe flux for all assembly and rework applications. The amber colored residues are typical for rosin cored wire and can be removed easily with normal flux cleaners, or left as added protection of the soldered joint if required.

Products	Description	Halide Content (%)	J-STD Classification	Alloy Option
309	No-clean, rosin based flux with excellent wetting performance on difficult substrates. Can be cleaned in solvents if necessary. Note: Not sold in the U.S.	<1.0	ROM1	SAC305 (97SC), SAC387 (96SC), 99C

Other Multicore® Product offerings

Water Washable

The Multicore® Hydro-X flux system brings high activity water washable soldering to Henkel's Multicore® lead-free solder wire range. Typical of high acidity fluxes, Multicore® Hydro-X ensures excellent wetting while the requirement for the complete removal of all flux residues in a water wash process guarantees a completely safe and reliable assembly.

Products	Description	Halide Content (%)	J-STD Classification	Alloy Option
Hydro-X	High activity, water washable with excellent wetting on difficult substrates.	3	ORH1	SAC305 (97SC), SAC387 (96SC), 99C

Lead-Free Tip Tinner

Multicore® TTC-LF is a small block of electronics-grade lead-free solder powder and flux compacted into the shape of a thick disc. It is ideal for speedy and effective cleaning and re-tinning of de-wetted and badly oxidized soldering irons that cannot be re-tinned by sponges, pads or rosin-cored solder wire. Multicore® TTC-LF is suitable for both lead & lead-free applications.

Products	Description	Classification	Alloy
TTC-LF	Lead-free tip tinner	DTD 599A & BS 5625 copper mirror corrosion tests.	Meets lead-free standard.

Loctite® Surface Mount Adhesives

The requirements for lead-free process capability extend well beyond just solder process materials. It is necessary to ensure that all other materials likely to be affected by the elevated temperatures are also able to perform adequately.

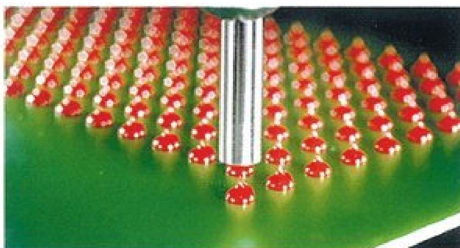
The Loctite® Chipbonder® lead-free process compatible surface mount adhesives have been rigorously tested in typical lead-free wave soldering systems to ensure maximum adhesion throughout the full lead-free process temperature range.

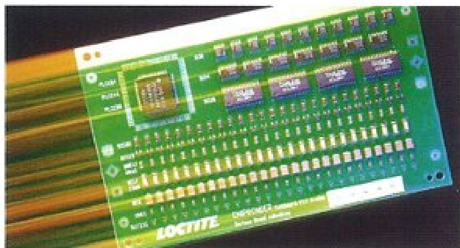
Loctite® Chipbonder Syringe Dispense Adhesives

Material	Description/Application	Color	Cure	Process Method (Protect from heat)	Storage	Shelf Life
3621	**High performance for ultra high-speed syinge dispense.** Good green strength. Superior humidity resistance and electrical properties. **Room temperature storage capable.**	Red	90 s @ 150°C or 2-3 min @ 125°C	Very high speed syringe dispensing 47,000 DPH capable. Jettable.	5°C ± 3°C or 8°C -21°C for 30 days	10 months
3629	High reliability low temperature cure dispense grade adhesive. Also compatible with DEK ProFlow printing.	Pink -makes inspection easier. The uncured product is fluorescent in UV light.	110-140 s @ 120°C or 3-5 min at 110°C. Cure as short as 60 s at 150°C.	Syringe Dispense	5°C ± 3°C	6 months

Loctite® Chipbonder Stencil Print

Material	Description/Application	Color	Cure	Process Method (Protect from heat)	Storage	Shelf Life
3616	**High speed** stencil print adhesive. Compatible with DEK ProFlow and MPM Rheopump.	Red	60 s @ 150°C 90 s @ 125°C	Stencil Print (60-150 mm/s)	5°C ± 3°C	6 months





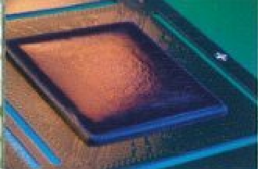
Hysol® Underfills

Hysol® package level underfill encapsulants meet stringent JEDEC testing requirements and are compatible with the high temperature processing required for lead-free assembly. These environmentally friendly materials are developed to meet demanding end user requirements, including low warpage/low stress, fine pitch, high reliability, and high adhesion.

Product	Description /Application	Pot Life @ 25°C	Recommended Care	Flow Speed	Viscosity @ 25°C (cps)	Tg (°C)	CTE (1) (PPM/°C)	% Filler	Storage Temp (°C)
FP4548FC Flux Compatible	Lead-free flip chip packages (L3/260°C); low-k/Cu flip chip packages with hi-Pb 3 bumps.	24 hrs	30 min @ 165°C	Medium	25,000	115	22	65	-40

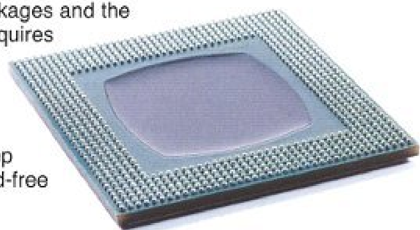
Hysol® CSP/BGA lead-free compatible underfills offer excellent vibration and impact resistance. These underfills deliver many processing advantages such as fast flow, fast cure, and long pot life. Our new Cornerbond technology fits easily into an SMT process flow, saving time and money by eliminating a separate underfill dispense and cure process.

Product	Description	Viscosity /Application (cps)	Pot Life @ 25°C	Cure Schedule	Tg (°C)	CTE (1) (PPM/°C)	Capillary Flow	Storage Temp (°C)
3509	For corner reinforcement. Designed to cure during reflow while allowing self alignment of the IC package. Compatible with lead-free profile.	134,000	1 day	Lead-free reflow cure (see TDS)	111	72	N/A	-40
3518	CSP/BGA underfill, low temp cure, high reliability, 200 micron gap compatible. Note: Not sold in the U.S.	3,200	2 days	15 min @ 120°C or 30 min @ 100°C	72	30	Medium	-15
FF2300	CSP/BGA and flip chip fluxing underfill for lead-free process	2,500	16 hrs	Lead-free reflow cure (see TDS)	75	75	N/A	-40
FP6101	CSP/BGA underfill, fast flow, reworkable	3,700	14 days	5 min @ 165°C	15	80	Fast	-20



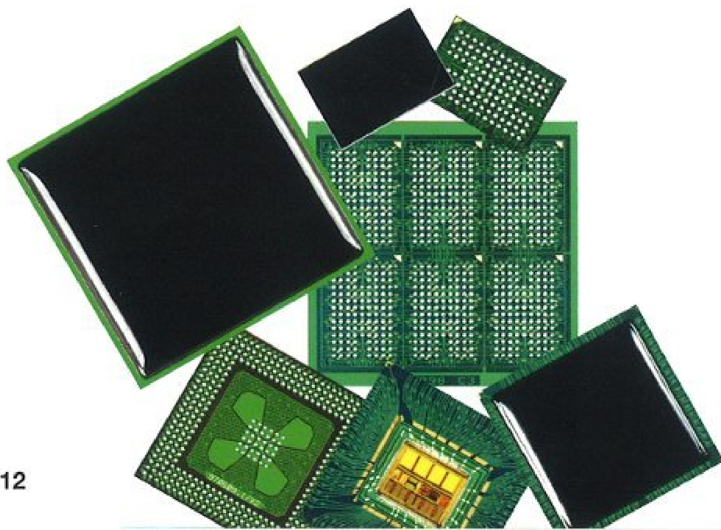
Hysol® Dam and Fill Encapsulants

The combination of the need to produce smaller and thinner packages and the high temperature processing demands for lead-free assembly requires new materials that support high throughput, low cost package assembly processes and the high temperature reliability requirements demanded by lead-free processes.



Hysol® high purity dam and fill encapsulants cure in one easy step and meet the stringent JEDEC level testing requirements for lead-free processes.

Product	Description /Application	Pot Life @ 25°C	Recommended Cure	Flow Properties	Viscosity @ 25°C (cps)	Tg (°C)	CTE (1) (PPM/°C)	% Filler	Storage Temp (°C)
FP4451TD	Flow control barrier	24 hrs	30 min @ 125°C + 90 min @ 165°C	None	300,000	150	21	73	-40
FP4470	High adhesion material for dam and fill or cavity down BGAs. 260°C JEDEC L3 performance.	5 days	30 min @ 125°C + 90 min @ 165°C	High	48,000	148	18	75	-40
FP4800	A high purity encapsulant for lead-free applications. Excellent adhesion, can withstand JEDEC Level 2 preconditioning.	24 hrs	60 min @ 120°C + 120 min @ 165°C	Medium	80,000	55	18	72	-40



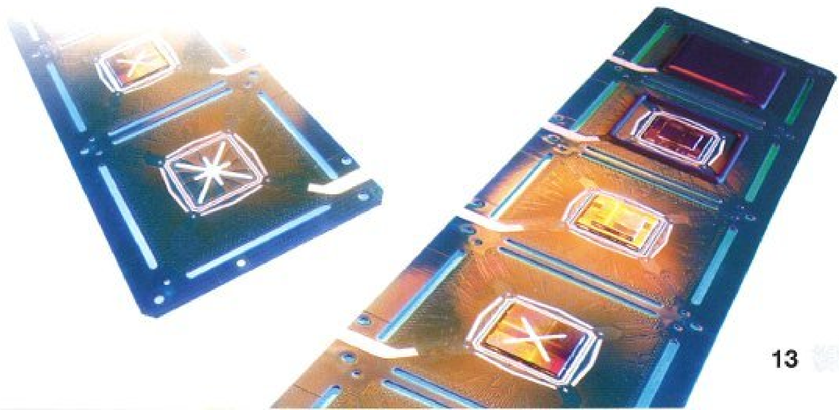
Hysol® Die Attach Adhesives

Lead-free processing capability is achieved by using Hysol® patented Bismaleimide (BMI) chemistry which allows for lower moisture absorption, lower stress, and higher adhesion to Au and preplated leadframes compared to older epoxy technology. Newer no/low-bleed formulations are providing the performance that today's smaller package designs and thinner die requirements demand.

Based on ultra-hydrophobic chemistry, BMI Hysol® die attach adhesives offer very high adhesive strength, elongation at break, and cohesive energy at reflow temperatures. These properties help electronic packages retain adhesive strength and structural integrity during moisture soak, and absorb stresses during the deformations associated with lead-free reflow processing.

In addition to the proven compatibility with 260°C lead-free processes, < BMI die attach adhesives offer ultra fast cure properties that enable inline SkipCure™ processing to increase throughput.

Materials	Description /Application	Resin	Filler	Recomended Cure	Viscosity snm @ 25°C (cps)	Thermal Conductivity (W/mK)	Tg (°C)	CTE (PPM /°C)	Modelus @ 25°C (GPa)	Storage Temp (°C)
QMI529HT	JEDEC L1 260°C for exposed pad TSOP. Highly filled version of QM1519. For component attach or die attach where very high electrical and thermal conductivity is required.	BMI	Silver	30 min @ 185°C Oven 60 s @ 185°C *Skip*Cure	18,000	7.0	16	53 127	3.3	-40
QMI168	Cost effective version of QMI519 similar properties as QMI519.	BMI	Silver	15 min @ 185°C Oven 10 s @ 200°C *Skip*Cure	9,000	3.8	75	40 140	5.3	-40



Hysol® Semiconductor Molding Compounds

Elevated lead-free processing temperatures demand electronic packaging materials that can withstand polymer decomposition during reflow, increased interfacial stresses, and loss of adhesive and cohesive strength.

Hysol® Semiconductor Molding Compounds combine low stress and low water absorption properties with high physical strength and meet JEDEC level testing requirements up to Level One.

They also meet flammability requirements without the use of antimony, bromine, or phosphorous flame retardant compounds.

Hysol® Electronic Molding Compounds

Material	General Description	Properties and Features: Glass Transition Temperature, Tg (°C)	Spiral Flow @ 177°C, in.	Specific Gravity	CTE, α1 (PPM/°C)	CTE, α2 (PPM/°C)	Flexural Modulus (kg/mm²)	Flexural Strength (kg/mm²)	Moisture Absorption (85/85 168 hrs)	260°C Reflow Profile Precondition	Green FR	Typical Package Type
GR725-AG	Automotive (20,000 hrs @ 185°C), green, designed for surface mount discrete packages operating at high temperature. Passes JEDEC Level 1.	135	41	1.95	12	35	2,000	11.6	0.28	J1	•	SO, PSO, SMD
GR828	Green, specifically designed for SO packages up to TSSOP/ TQFP. Passes JEDEC Level 1 @ 260°C reflow.	145	40	1.91	13	45	1,800	12.7	0.25	J1	•	SOIC, SSOP, SOP QSOP, TQFP
GR9810	Laminate based packages. Designed for use as an overmold, low warpage, JEDEC Level 2 capability.	195	45	2.01	11	35	2,300	12.0	0.30	J2	•	SIP, BGA
GR9820	Matrix QFN, green, very low stress, ultra low warpage, adhesion can be optimized for specific lead frame metalization. JEDEC Level 1 capable.	195	40	2.01	11	35	2,200	11.0	0.30	J1	•	QFN

RoHS: The impact on the electronics manufacturing industry

As the July 2006 deadline for the implementation of the EU's Restriction of Hazardous Substances (RoHS) Directive approaches, the sourcing of suitable materials solutions for the assembly of electronics devices has assumed paramount importance.

The most publicized aspect of the RoHS directive is its restriction on the use of lead (Pb), which has already had a major impact on the use of soldering, tinning and plating materials in electronics manufacturing. Some industry sectors and applications currently escape the full implications of the directive, summarized here:

Lead in high melting temperature solders, i.e. tin-lead solders containing more than 85 per cent lead;
Lead in solders for servers, storage and array systems – these are exempted until 2010;
Lead in solders for network infrastructure equipment for switching, signaling and transmission, as well as network management for telecommunications;
Lead in electronic ceramic parts (e.g. piezoelectronic devices)...

...but even these will be reviewed periodically, so they cannot be considered to be permanent exemptions. Additionally, several newly-proposed exemptions or modifications to the above list are under review at the time of writing.

Interestingly, the defense industries are not specifically covered by any of the RoHS exclusions, although they are mentioned in Article 2.3 of the Waste Electrical and Electronic Equipment (WEEE) Directive: "Equipment which is connected with the protection of the essential interests of the security of Member States, arms, munitions and war material shall be excluded from this Directive" – and for defense-related purposes this is understood to be an exclusion that will also apply to the RoHS Directive.

The effects of the directive impact not only solder alloys but also component finishes and temperature ratings, board finishes and flame retardancy issues. The five other hazardous substances to be limited are cadmium (Cd), mercury (Hg), hexavalent chromium (Cr-VI), polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE), all of which are commonly used in various components found in electronic assemblies.

Restrictions on the use of these substances is changing the way that electronic assemblies are designed and built, from the components and assembly materials to the solder reflow profiles and inspection criteria used. Now, more than ever, it is important to use materials that are compatible with one another in these new processes. As a supplier of materials used across the board, and a leader in the field of lead-free soldering innovation, Henkel is ideally placed to provide the materials solutions and the support to help you succeed in the technical challenges you face today.