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1.0 Introduction and Scope

Ramtron will serve the marketplace with environmentally sound products manufactured using environmentally responsible processes. Recent European directives such as the WEEE, ELV, RoHS and REACH serve to define standards for such environmental concerns. They will require certain electronic OEMs to provide products that reduce or eliminate certain substances from their products. The most prevalently used of these is lead (Pb) which is a component in the current industry standard lead (connector) finish. Other regulations are in the approval and implementation cycles on all major continents seeking to serve the public interest via environmental preservation and improvement. Many other chemical compounds are listed and are under advisement. Other chemicals, compounds and their uses are identified in company-to-company correspondence. Ramtron will adhere to the contents of the Joint Industry Guide proposed by the EIA (USA), the EICTA (EU) and GPSSI (Japan) as company policy and will generally respond in the standard format of IPC1752 to avoid confusion caused by the duplication of formats. Please refer to www.ipc.org/IPC-175x.

Ramtron has developed, qualified and provides products that serve these environmental requirements since the 1st quarter of 2004. We adopted the industry standard terminology of "Green Packaging". One significant change is the lead finish plating. The industry standard is 80/20 Sn/Pb. This is usually replaced with 100% matte tin (Sn) in Ramtron's green packaging options. In those cases using matte tin, Ramtron's green packages have undergone a whisker mitigation annealing process without the use of an undercoat or underplating. The plastic packaging mold compound is replaced with a more environmentally friendly formulation. The plastic mold compound is able to withstand the higher temperatures of Pb-free soldering. Technical detail regarding these changes is presented.

Ramtron uses a ceramic fired material, doped PZT (Lead Zirconate Titanate), as the dielectric/ferroelectric in a F-RAM capacitor. This is the fundamental storage element for ferroelectric memories, F-RAM. This use of lead (Pb) is minuscule in its concentration and is exempted for its use in electronic components in all regulatory jurisdictions known to Ramtron. Applicability, limitations, calculations and analytical results are presented.

Recycling and conservation efforts are also important to be part of responsible corporate citizens' activity portfolios. Ramtron has achieved the values ISO14001 certification in this regard.

This application note serves to provide Ramtron's current understanding and offerings in regards to these issues.

2.0 Green Packaging

2.1 Ramtron products offered in green packages can be found in document #02-60-2028, Ramtron Moisture Sensitivity Level by Package:

2.2 It is Ramtron's intention to end-of-life lead (Pb) containing solder coated parts. The part number suffix will typically denote green versions of the parts when two versions were at one time available. These suffixes contain a "G" and include –G, -GTR, -SG, -SGTR, -QG, -DG and -TG. Datasheets are to consult for materials content as is a Ramtron website link for each part.

2.3 Moisture Sensitivity Level (MSL):

This classification is the result of environmental testing per IPC/JEDEC J-STD-020D. The testing scheme for the moisture classification contains several steps. The process is listed below. Storage conditions are specified according to the MSL. Parts are shipped from Ramtron under the appropriate environmental storage conditions.

J-Std-020D Moisture Classification Testing for MSL 1

Initial Electrical Test
Initial Inspection: visual and scanning acoustic microscope examination
Bake: 24 hours at 125 +5/-0°C
Moisture Soak: 168 hours, 85°C/85% RH

Reflow: Peak temp 260°C
Final External Visual: 40X visual
Final Electrical Test
Final Acoustic Microscopy

Lead Free Packaging Qualification Testing Scheme

The following tests were performed to qualify the lead free process on the 8 pin SOIC package:

Highly Accelerated Stress Test (HAST) per JEDEC JESD22-A110
Thermal Shock (TS) per JEDEC JESD22-A106Test condition C
Autoclave (AC) per JEDEC JESD22-A102
Memory Cell Data Retention (RETN) per Ramtron 02-60-1001
Physical Dimension (PD) per JEDEC JESD22-B100
Lead Integrity (LI) per JEDEC JESD22 B-105
Solderability (SD) per JEDEC JESD 22B-102
Wire Bond Strength (WS) per Mil Std 883 M2011
Die Shear Strength (DS) per Mil Std 883 M2019

2.4 Soldering Considerations

The use of lead-free solder requires a slightly higher solder reflow temperature profile. Refer to the example profiles in Appendix A. Basically, lead-free products need to undergo testing and pre-conditioning at 260°C in order to guarantee reliability through industry standard qualification testing. This is slightly higher than the 240°C profiles typical for lead-containing solder manufacturing operations. It should be noted that the matte tin leadframe plating can be used with both lead-free and lead-containing solders. For reflow soldering, the recommended dwell time is 10-30 sec, and the absolute maximum is 40 sec. at 260 ±5°C. The recommended ramp up is 3°C/sec maximum and ramp down is 6°C/sec maximum. The ramp profiles shown in the appendix are for reference only and don't reflect the absolute maximum rating mentioned here. For a more complete profile description, please see JEDEC J_STD-020D or JEITA. Solderability results showing the compatibility with lead-free lead finishes with standard solders are provided in Appendix G.

2.5 Materials Content

Appendices B and C list the materials content of green packaged Ramtron parts. This listing is in compliance with RoHS and ELV and is intended to conform to the EIA Joint Industry Guide for reporting listed substances. The following is a link to the draft JIG: www.eia.org/resources/2003-09-19.10.pdf. Appendix H provides chemical analysis results for typical Ramtron parts.
Additional analytical reports are available upon request.

3.0 Regulatory compliance on a worldwide basis

Ramtron believes that the corporate entity, employees and all products are in compliance with applicable regulation, standards and industry standard practices. These include clean air and water mandates, restrictions on use of hazardous substances, safety and personal injury protection guidelines and laws, as well as guidelines for the use and disposal of electrical products.

Appendices D through F list the requirements Ramtron believes to be pertinent to FRAM products. Covered are the Waste Electrical and Electronic Equipment Directive (WEEE), the Restrictions on Hazardous Substances (RoHS) and End-of-Life Vehicles (ELV). REACH documentation is available on the EU website.

4.0 Energy Conservation

Ramtron practices energy conservation within the factory and outside sales offices. Vendors are routinely queried as to environmental and conservation practices.

5.0 Recycling at Ramtron International Corporation

Recycling of shipment packing materials significantly reduces the volume of the waste stream generated by activities at Ramtron's sites worldwide.

6.0 Customer Input

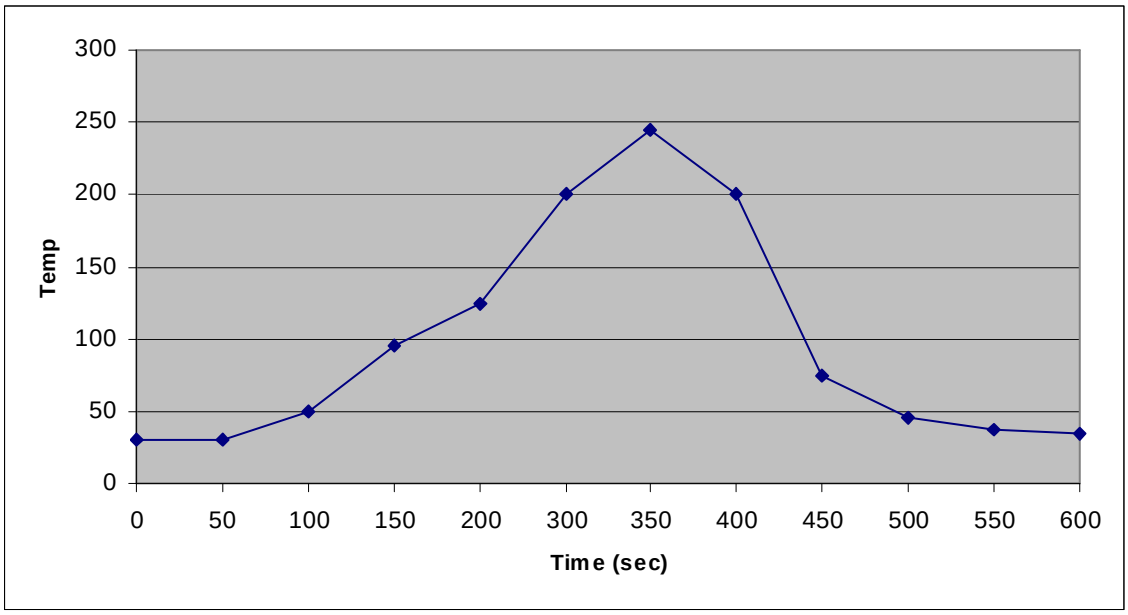
Ramtron is a designated Green Partner of Sony Corporation. Other corporate cooperation is underway and a significant number of questionnaires and audits have addressed green packaging and environmental concerns.

7.0 Appendices

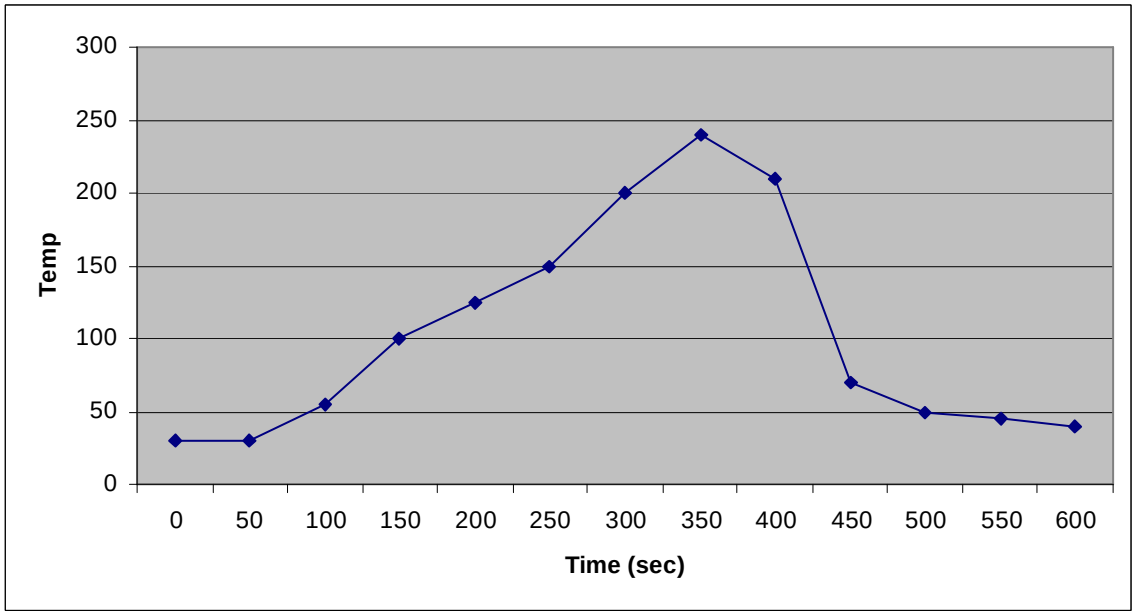
Appendix A - Solder Profiles

Typical profiles for reference are shown here. The thermal budget for the green package is as specified in Section 2.4.

260°C



240°C



Appendix B - Material Content of Green Devices

Device Material	8L EIAJ-Green	8L SOIC-Green	8L PDIP-Green
3.5 Device Weight	**0.25 gm**	**0.0757 gm**	**0.496 gm**
3.6 Silicon Die	**4.33% of Unit Weight**	**3.34% of Unit Weigh**	**0.58% of Unit Weigh**
Silicon (Si)			
Silicon Oxide (SiO_2) & Silicon Nitride (Si_3N_4)			
Aluminum (Al)			
Small amounts of As, B, P, Ti <0.1 % by weight %. Cd < 75 PPM. PCDD and PCDF < 2 PPB			
Mold Compound	**84 % of Unit Weight**	**57.73 % of Unit Weight**	**65.4% of Unit Weight**
Silica	75-95 %	75-95 %	75-95 %
Cresol Novolac	1-3%	1-3%	1-3%
Phenol resin	2-8 %	2-8 %	2-8 %
Epoxy resin	2-8%	2-8%	2-8%
3.7 Carbon Black	0.1-0.5%	0.1-0.5%	0.1-0.5%
3.8			
3.9 Lead Frame	**6.4% of Unit Weight**	**37.53% of Unit Weight**	**33.7% of Unit Weight**
Copper (Cu)	97 %	99.5%	96%
Iron (Fe)	2.4 %	-	2.3%Min
Zinc (Zn)	0.13 %	-	0.1%
Lead (Pb)	0.02 %	-	0.002%
Phosphorous (P)	0.04 %	-	0.04%
Nickel (Ni)	-	-	-
Manganese (Mn)	-	-	-
Magnesium (Mg)	-	-	-
Silicon (Si)	-	-	-
Silver Plating (Ag)	0.4 %	0.5%	0.42% Min

3.10 Silver Adhesive	**0.49 % of Unit Weight**	**1.1% of Unit Weight**	**0.002% of Unit Weight**
Silver (Ag)	70-90%	70-90%	70-90%
Epoxy Resin	1-10%	1-10%	1-10%
Diester Resin	5-20%	5-20%	5-20%
Functionalized urethane	5-15%	5-15%	5-15%
3.11			
3.12 Solder Plating	**4.69 % of Unit Weight**	**0.14% of Unit Weight**	**0.9% of Unit Weight**
Tin	100%	100%	100%
3.13 Bond Wires	**0.084% of Unit Weight**	**0.16% of Unit Weight**	**0.06% of Unit Weight**
99.99 % Gold (Au)			
No Ozone Depleting Chemicals or CFC's Used			

Device Material	**28L SOIC (JEDEC)-Green**	**28L PDIP (JEDEC)-Green**	**32L VSOP-Green**
3.14 Device Weight	**0.7538 gm**	**4.3 gm**	**0.2999 gm**
3.15 Silicon Die	**1.11%**	**2.90%**	**14.30%**
Silicon (Si)	100%	100%	100%
Silicon Oxide (SiO_2) & Silicon Nitride (Si_3N_4)			
Aluminum (Al)			
Small amounts of As, B, P, Ti <0.1 % by weight %. Cd < 75 PPM. PCDD and PCDF < 2 PPB			
Mold Compound	**72.95%**	**75.92%**	**50.78%**
Silica	75-95 %	75-95 %	75-95 %
Cresol Novolac	1-3%	1-3%	1-3%
Phenol resin	2-8 %	2-8 %	2-8 %
Epoxy resin	2-8%	2-8%	2-8%
3.16 Carbon Black	0.1-0.5%	0.1-0.5%	0.1-0.5%
3.17			

3.18 Lead Frame	**22%**	**20.85%**	**33.14%**
Copper (Cu)	99.5%	99.5%	99.5%
Iron (Fe)			
Zinc (Zn)			
Lead (Pb)	0.01%	0.01%	0.01%
Phosphorous (P)			
Nickel (Ni)			
Manganese (Mn)			
Magnesium (Mg)			
Silicon (Si)			
Silver Plating (Ag)	0.49%	0.49%	0.49%
3.19 Silver Adhesive	**0.29%**	**0.04%**	**0.47%**
Silver (Ag)	70-90%	70-90%	70-90%
Epoxy Resin	1-10%	1-10%	1-10%
Diester Resin	5-20%	5-20%	5-20%
Functionalized urethane	5-15%	5-15%	5-15%
3.20			
3.21 Solder Plating	**1.8%**	**0.25%**	**0.63%**
Tin	100%	100%	100%
3.22 Bond Wires	**1.6%**	**0.05%**	**0.67%**
99.99 % Gold (Au)	99.99%	99.99%	99.99%
No Ozone Depleting Chemicals or CFC's Used			

Appendix C - Trace lead contained as PZT in packaged parts

Calculation of Lead Content in Ramtron Products

Part #	FM24CL04	FM24C16	FM24CL64	FM24C256	FM25640	FM18L08	FM18L08
Density	4K	16K	64K	256K	64K	256K	256K
Description	SOIC	PDIP	SOIC	SOIC	SOIC	SOIC	PDIP
Die Size (mm^2)	1.56	2.09	5.65	10.03	6.34	20.29	20.29
% FE on chip	3.58%	10.83%	15.68%	21.86%	14.57%	17.02%	17.02%
PZT area on chip (mm2)	0.055848	0.226347	0.88592	2.192558	0.923738	3.453358	3.453358
PZT thickness (Å)	2000	2000	2000	2000	2000	2000	2000
PZT density (g/cm^3)	8.6	8.6	8.6	8.6	8.6	8.6	8.6
%Pb in PZT	60.70%	60.70%	60.70%	60.70%	60.70%	60.70%	60.70%
Pb wt/die	5.831E-08	2.36E-07	9.25E-07	2.29E-06	9.64E-07	3.61E-06	3.61E-06
Wt/pkg (g)	0.08	0.52	0.08	0.14	0.08	0.76	4.48
Pb/part (ppm)	0.7	0.5	11.6	16.4	12.1	4.7	0.8

Appendix D - WEEE Link and Excerpt

The link takes you to a government website: http://www.icer.org.uk/legislation.htm

Excerpt: Product Design

Member States shall encourage the design and production of electrical and electronic equipment which take into account, and facilitate dismantling and recovery, in particular the reuse, and recycling of WEEE, their components and materials. In this context, Member States shall take appropriate measures so that producers do not prevent, through specific design features or manufacturing processes, WEEE from being reused, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements.

Appendix E - RoHS Link and Excerpt

The link takes you to a government website: http://www.icer.org.uk/legislation.htm

Excerpt: Applications of lead, mercury, cadmium and hexavalent chromium, which are exempted from the requirements of Article 4(1)

1. Mercury in compact fluorescent lamps not exceeding 5 mg per lamp.
2. Mercury in straight fluorescent lamps for general purposes not exceeding:
   — halophosphate 10 mg
   — triphosphate with normal lifetime 5 mg
   — triphosphate with long lifetime 8 mg.
3. Mercury in straight fluorescent lamps for special purposes.
4. Mercury in other lamps not specifically mentioned in this Annex.
5. Lead in glass of cathode ray tubes, electronic components and fluorescent tubes.
6. Lead as an alloying element in steel containing up to 0,35 % lead by weight, aluminum containing up to 0,4 % lead By weight and as a copper alloy containing up to 4 % lead by weight.
7. — Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead),
   — lead in solders for servers, storage and storage array systems (exemption granted until 2010),
   — lead in solders for network infrastructure equipment for switching, signaling, transmission as well as network management for telecommunication,
   — lead in electronic ceramic parts (e.g. piezoelectronic devices).

Appendix F – ELV Link and Excerpt

The links take you to a government websites for the end-of-life for vehicles directives:
http://www.dti.gov.uk/environment/consultations/elv.htm
http://www.europa.eu.int/servlet/portail/RenderServlet?search=DocNumber&lg=en&nb_docs=25&domain=Legislation&coll=&in_force=NO&an_doc=2002&nu_doc=525&type_doc=Decision

Excerpt: Materials and components exempt from Article 4(2)(a)

14. Electrical components which contain lead in a glass or ceramic matrix compound except glass in bulbs and glaze of spark plugs

Appendix G – Solderability test results: lead-free lead finish for SnPb application

As following are the data of solderability testing qty 10u of each 3 lots both 8L soic green pkg and 8L pdip green pkg per request on item 2 and 3.

device#	pkg#	order#	cust lot#	Rej/SS
SOIC 8L GREEN				
FM25640-G	SOIC-008B	RAWP41216.102	40048G	0/10
FM25C160-G	SOIC-008B	RAWP41654.1	40013G	0/10
FM24CL64-G	SOIC-008B	RAWP40509.103	40017G	0/10
PDIP 8L GREEN				
FM25CL64-PG	PDIP-008A	RAWE30854.1	30015G1	0/10
FM25CL64-PG	PDIP-008A	RAWQ30848.1	30015G	0/10
FM25CL64-PG	PDIP-008A	RAWQ30849.1	30016G	0/10

Conclusion : All lots are acceptable

Solder test condition :

1. Steamage age 8 hrs
2. Application Flux
   - 2.1 Kester flux 145
   - 2.2 dipping time 5-10 sec
3. Dip& look method
   - 3.1 Solder bar composition : Sn 63% Pb 37 %
   - 3.2 dipping time 5+/-0.5 sec
   - 3.3 dipping angle
     - SOIC 90 degree with solder surface
     - PDIP 180 degree with solder surface
   - 3.4 immersion/emersion rate 25+/-6 mm/sec
4. visual inspection
   - Criteria ; reject if found new solder coverage less than 95 %
   - Solder test result

Appendix H – Chemical Analysis Results for RoHS Substances

CoorsTek
Amazing Solutions.

Colorado Operations
Clear Creek Valley, Golden
17750 W. 32nd Avenue
Golden, CO 80401 USA
Phone: (303) 277-4797
Fax: (303) 277-4779
E-mail: elecsales@coorstek.com
www.coorstek.com

Lab No. 2k4-0823r
Date: 19 Nov 2004

ICP ANALYSIS REPORT

Requester: Tom Davenport

Customer: Ramtron, Inc.

Analyst: Steve Govorchin

Analysis Requested: Analyze four semiconductor chips for lead, mercury, cadmium and chromium content.

Sample ID:

1. 8L SOIC
2. 8L PDIP
3. 28L SOIC
4. 28L PDIP

Procedure: The samples were decomposed by microwave digestion with nitric acid. The samples were then transferred to volumetric flasks and diluted with deionized water. The solutions were spiked with indium for use as an internal standard and analyzed for Cd, Pb, Cr, and Hg on the PlasmaQuad 2+ ICP-MS.

Results: Results are given in units of micrograms per gram (parts per million).

	µg/g Cd	µg/g Cr	µg/g Hg	µg/g Pb	Absolute Mass
8L SOIC	<0.50	<1.0	<0.50	16	0.0726g
8L PDIP	<0.50	<1.0	<0.50	15	0.5400g
28L SOIC	<0.50	<1.0	<0.50	11	0.7884g
28L PDIP	<0.50	<1.0	<0.50	8.4	4.3469g