2004/04/01 Draft

JEITA

JEITA ETR-7021

Japan Electronics and Information Technology Industries Association

Guidance for the lead-free marking of materials, components and mounted boards use in electronic and electric equipment

2004.XX

Technical Standardization Committee on surface mount technology
Japan Electronics and Information Technology Industries Association

Guidance for the lead-free marking of materials, electronic components and mounted boards used in electronic and electric equipment

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Preface: There is a world trend to reduce the load to environment from electric and electronic products. The RoHS Directive, 2002/95/EC, issued by the European Parliament is the most important driving force to this trend. The Directive bans use of six substances as environmentally hazardous materials in all the electric and electronic products to be sold within EC countries after the 1st of July, 2006. The substances include lead (Pb) based solder used in interconnection of components mounted onto board, plated metals used to electrodes and leads of components, and lead as a composition material of a component. The Japan Electronics and Information Technology Industries Association (hereafter abbreviated as JEITA) has been promoting to realize the lead-free technology in electronics. Many manufacturers in Japan have succeeded in adopting the lead-free technology in their products. In the course of adoption of lead-free technology there has arisen a need to clearly identify that a product is lead-free. A project group was formed in JEITA to study the marking of lead-free products including electronic components and to develop a Guidance of marking (labeling) for products employing lead-free technology The present Guidance was prepared based on an extensive analysis of the questionnaire sent to leading manufacturers in Japan.

1. General

1.1 Scope: This Guidance is used to identify the phase of lead-free technology employed in solder used in interconnections, materials for leads and terminals, electronic components and board mounted with components (hereafter stated as assembled board).

The marking is used as source information of the degree of lead-free technology employed, 1) employed in the products of material producers, materials to be supplied to electronic component or equipment manufacturers, 2) in electronic components to be supplied to equipment manufacturers, 3) for repair of electric and electronic equipment, and 4) to reduce environmental load when recycle vendors discard the products as industrial waste by classifying the products, or parts, by the degree of lead-free technology employed. Standardized designation of the phase of lead-free technology employed is developed to promote the industry to cope with requests from the society for the lead-free environment.

The applicable board for marking is the assembled board whether it is a main (mother) board or a sub-system (daughter) board with components assembled using lead-free solder.

1.2 References

1) **JEITA EDR-7605** 200X Marking of lead-free packages for semiconductor devices.

2) **IEC 61190-1-3** Attachment materials for electronic assembly – Part 1-3: Requirements for electronic grade solder alloys and fluxed and non-fluxed solid solders for electronic soldering applications.

3) **ISO 9453** Soft solder alloys – Chemical compositions and forms.

4) **Lead-free Roadmap 2002** JEITA.

5) **Study report on the standardization of marking for recycling of home appliances – First report** – Working Group on the standardization of the recycling mark applicable to home appliances, Assessment Committee of the Japan Electric Manufacturers Association (JEMA).

6) RoHS Directive: Directive 2002/95/EC of the European Parliament and of the Council issued on 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

2. Terms and Definitions The terms and their definitions are given below.

2.1 Lead-free The state that the lead content of the relevant part of an electronic component is less than 0.1 % in weight.
Note: The threshold value (proposed) of lead content described in both of the Lead-free Roadmap of JEITA and in the RoHS Directive is 0.1 % in weight.

2.2 Electronic component The electronic component described in this document includes semiconductor devices, passive components (resistor, capacitor, inductor, varistor, thermister, etc.), connecting devices (connector, socket, switch, etc.), transducers (transformer, DC power supply, sensor, crystal oscillator, etc.), printed wiring boards (with components mounted on), and modules (hybrid IC, PA, VCO, etc.).

2.3 Phase of lead-free adoption: The levels of lead-free adoption specified in the **Lead-free Roadmap, 2002** are specified by the phases as specified below.

a) Electronic component

Phase 1: Electronic components contain lead excluding Phase 2 and Phase 3A.
Phase 2: Terminals with which the device is mounted on a board, and the electrodes of a device are lead-free. Lead may be contained in any constituent electronic component of the device, or in any material used in the device.
Phase 3A: All the internal connections, constructing components and all materials used in a device are lead-free except the materials listed in the exemption list of the RoHS.
Phase 3: Lead is completely eliminated from interconnections, components of a device and materials used in the device.

b) Assembled board

Phase 1: Assembled board contains lead excluding Phase 2 and Phase 3A.
Phase 2: Board surface treatment, solder print and solder bath are all lead-free at the level of board assembly, and lead is eliminated in the interconnections of devices to the board. Lead may be contained in any electronic component of the device, or in any material used in the device.
Phase 3A: All the internal connections, constructing components and all materials used in a device are lead-free at the level of board assembly except the materials listed in the exemption list of the RoHS.
Phase 3: Lead is completely eliminated at the level of an assembled board.

2.4 Minimum unit of packaging This is the minimum unit of a package of products. Figure 1 shows examples of minimum units of packages including bag, reel, bulk case, stick magazine and tray. The minimum unit of packaging in this Guidance is the smallest package to which a label should be attached.

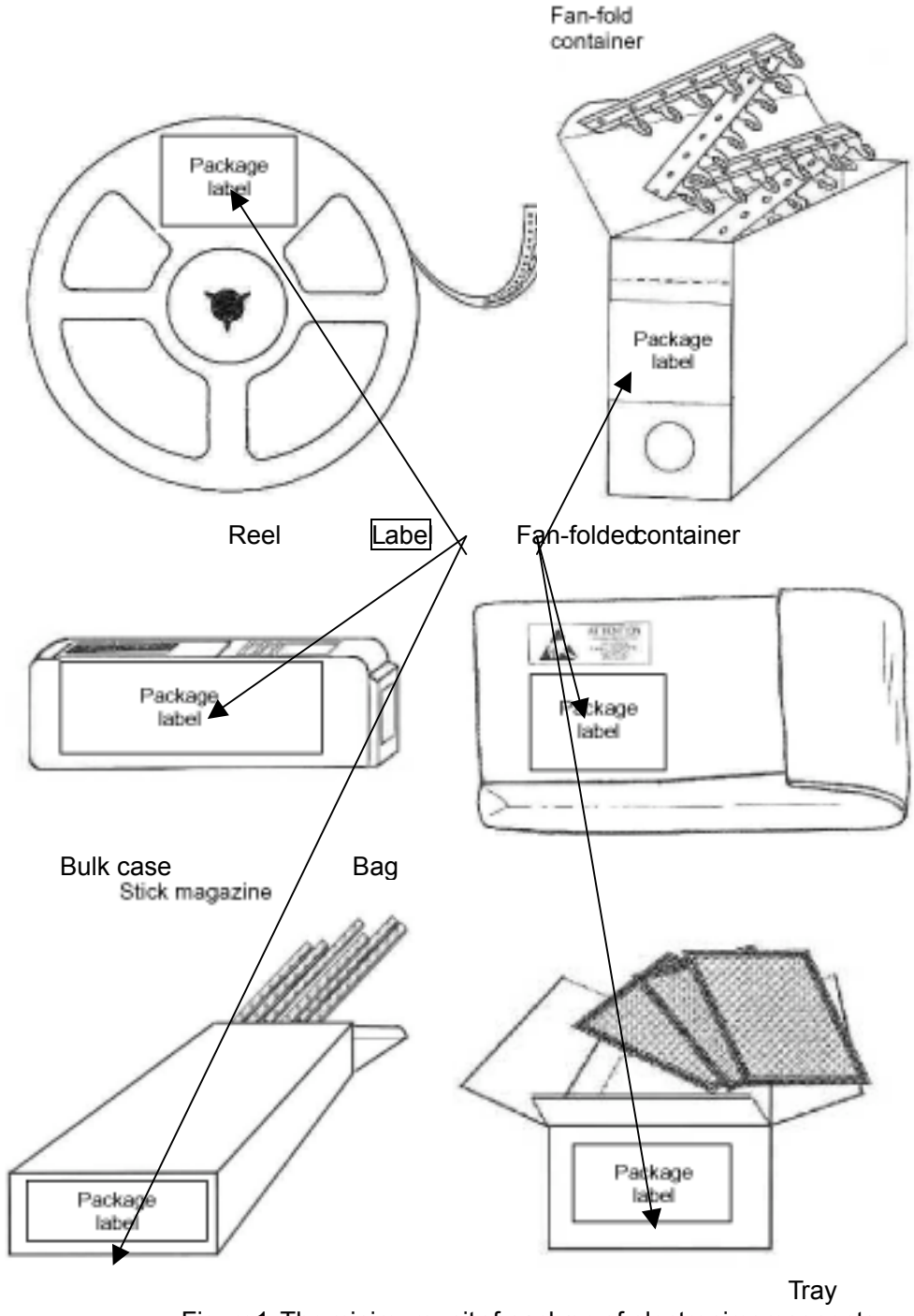


Figure 1 The minimum unit of package of electronic components

3. Lead-free Marking

3.1 General items in the Marking of Lead-free products The marking should be made on a package by means of printing, stamp printing, engraving, emboss, or seal that will stay on the package and not easily be erased until the package is discarded. The marking should be easily recognizable of its content but the size of the marking is not specified. The colour of the marking is basically mono-colour If there is an agreement between user and supplier on the content of the

marking, the agreed items should be prioritized.

Use the symbol of the substance if the substance is made of the material included in the RoHS list and needs to be shown in the label.

3.2 Lead-free Marking for materials of solders Unless otherwise agreed between user and supplier, marking of the composition of solder should be made using the designation using the element symbols to describe the alloy composition, or the composition symbols as shown in Table 1. It is not required to state the actual compositions of each constituting element in the element designation. Table 1 may also be used for used solder and solder paste.

Table 1 Examples of designation of lead-free solders

Solder	Element designation	Composition symbol
Sn96.5Ag3Cu0.5	SnAgCu	A30C5
Sn89Zn8Bi3	SnZnBi	Z80B30

3.3 Lead-free Marking for electronic devices Unless otherwise agreed between user and supplier, the lead-free marking is recognized as a designation of the presence of a substance in a device for banned materials listed in the RoHS Directive of; Lead, Mercury, Cadmium, six-valent Chromium, and PBB and PBDE as the specified fire retardants. The levels of presence of lead is expressed by the Phase as given in Table 2. Presence of other hazardous substances is designated as shown in Table 3 in the Note of this section.

Table 2 Marking for lead-free phases

Phases of lead-free	Marking
Phase 1 (containing lead)	Pb
Phase 2 (lead-free for terminals only)	FT-Pb *
Phase 3A (containing lead but only for RoHS exemptions)	RoHS-Pb or R-Pb (short marking)*
Phase 3	Eco **
Note * [FT] or [RoHS] and [Pb] are connected by [-] to make into one word. ** [Eco] is used when all the six substances specified by RoHS	

a) The size of marking is not specified. Marking is required to be recognizable.
b) The font and position of marking are arbitrary but should be in one place of the same label.
c) The surrounding by square of a mark is for easy recognition but its use is arbitrary

Note: Table 3 shows examples of marking for cases containing more than two substances specified in RoHS of Mercury, Cadmium, 6-valent Chromium, PBB and PBDE.

Table 3 Marking for cases containing more than two hazardous substances

Hazardous substance	Marking of hazardous substance
Mercury	Hg
Cadmium	Cd
6-valent Chromium	Cr
Specified fire-retardant (PBB, PBDE)	Br
Containing Hg in Phase 3A in lead-free	RoHS-Pb, Hg or R-Pb, Hg
Containing Hg in Phase 2 in lead-free	FT-Pb, Hg
Note 1: Use the symbol or its abbreviated mark for an element contained. **2**: The marking for a substance specified as excluded in the RoHS list is RoHD-xx (or R-xx as abbreviation). "RoHS" and "xx" are connected by "-" into one word. **3:** When more than two substances are included, state all the substances connected by [,]. RoHS-Pb, Hg shows only lead is excluded from the RoHS list.	

3.4 Lead-free marking on assembled board The lead-free marking to be made on an assembled board is composed of the Logo mark to denote the phase as specified in **2.2**, and the symbol to denote the hazardous material as shown in Table 3. Examples of marking are shown in Figure 2. The arrangement of the three items, composition symbol, Logo mark, and the notation of the hazardous material included is not specified but it should be made on one place. The marking should be easily recognizable of its content but the size of the marking is not specified.

A30C5 A30C5 A30C5
Hg, Cr Br Hg,Cr
a) Phase 2 b) Phase 3A c) Phase 3

Figure 2 Examples of lead-free marking for assembled board

a) The composition of lead-free solder is designated using the symbols specified in **IEC 61190-3-1** and shown in **Table 4**.

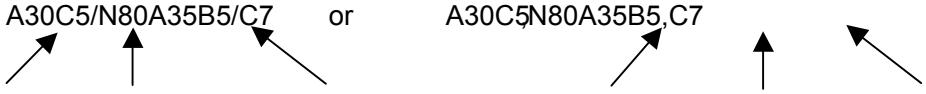
Table 4 Composition symbols and abbreviated designation of solders

Solder	Composition symbol
Sn96.5Ag3Cu0.5	A30C5
Sn99.3Cu0.7	C7
Sn89Zn8Bi3	Z80B30
Sn88In8Ag3.5Bi0.5	N80A35B5

b) It is desirable to show all the solder compositions if multiple types of lead-free solder are used on a board (front and back surfaces).
Note Each marking is separated by "/", or ",".

Examples

A30C5/N80A35B5/C7 or A30C5,N80A35B5,C7



Frontreflow backreflow backflow Frontreflow back reflow back flow

4 Packageunitfor markingand its position

4.1 Generalitems in packageunit for markingand its position The packageunit on which a markingis madeis theminimumpackageon which a spacefor a labelis available. The positionfor markingis the placethatis easly identified byobservation.

4.2 Unit for lead-freemarking for solder and positionof marking Unless otherwiseagreed betweenuser and supplier, the unit of packageof solderand positionof markingare specified in Table5, togetherwith examplesof positons of markingin Figure3.
Table5 mayalso be usedfor used solderand solderpaste.

The Table5 Unitfor lead-freemarkingand positionof marking

Type ofsolder	Markingunit	Position	Arrangement	Remarks
Bar solder	Rod itself,or minimum packaging unit	Arbitrary	Arbitrary	-
Resin cored solder	Spool (bobbin), minimum packaging unit	On labelof spool (bobbin)	Arbitrary	Also applicableto wiresolder
Solder paste	Container	On labelof container	Arbitrary	Also applicableto solder ball

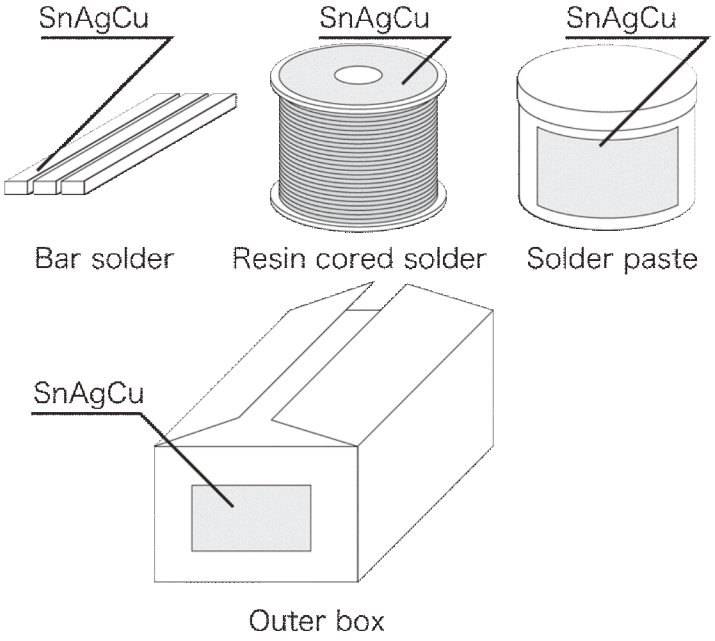


Figure3 Examplesof designationof lead-freephasefor solders

4.3 Unit for lead-free marking for electronic devices and position of marking Unless otherwiseagreed between user and supplier, the unit of packageof electronicdevices andthe position formarking are as specifiedin **2.3** in the space available ona label of the minimum package. Figure4. shows an exampleof thepositionof marking.

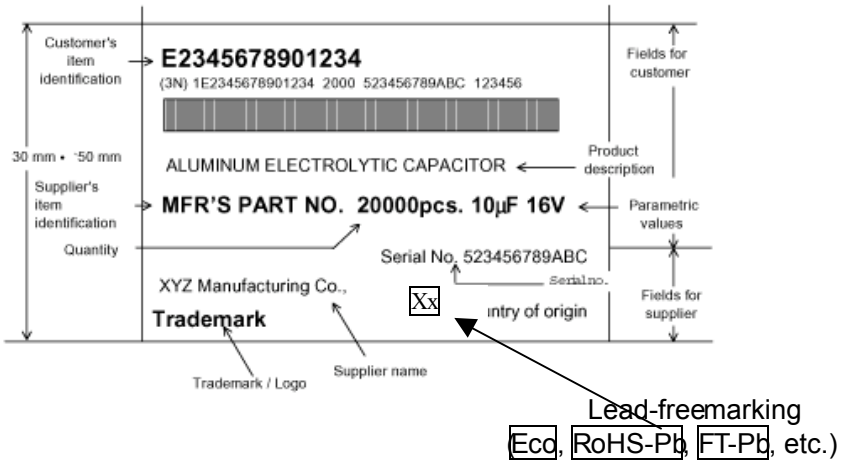


Figure4 Examples of designation of lead-free phase for electronic devices

4.4 Unit for lead-free marking for assembles board and position of marking The assembled board with a size larger than 10 cm^2 should have the marking as specified in **3.4**. The marking should be made on an arbitrary position of the assembled board on a place easily identifiable. An example of the marking is shown in Figure5.

a) If there are multiple boards, the marking should be made as follows.

1) The marking is to be made as a principle on the representing board of the unit.

Note When the phases of different boards combined into one unit are different, mark the phase of the lowest level of lead-free.

2) Separate markings are to be made on each board when separate boards are connected by a connector(s).

b) It is desirable to mark all the types of solder used if multiple types of solder are to be marked on a board.

c) If the marking made to an assembled board is not easily recognizable from above, a marking may be made on each composing board to a place recognizable from outside.

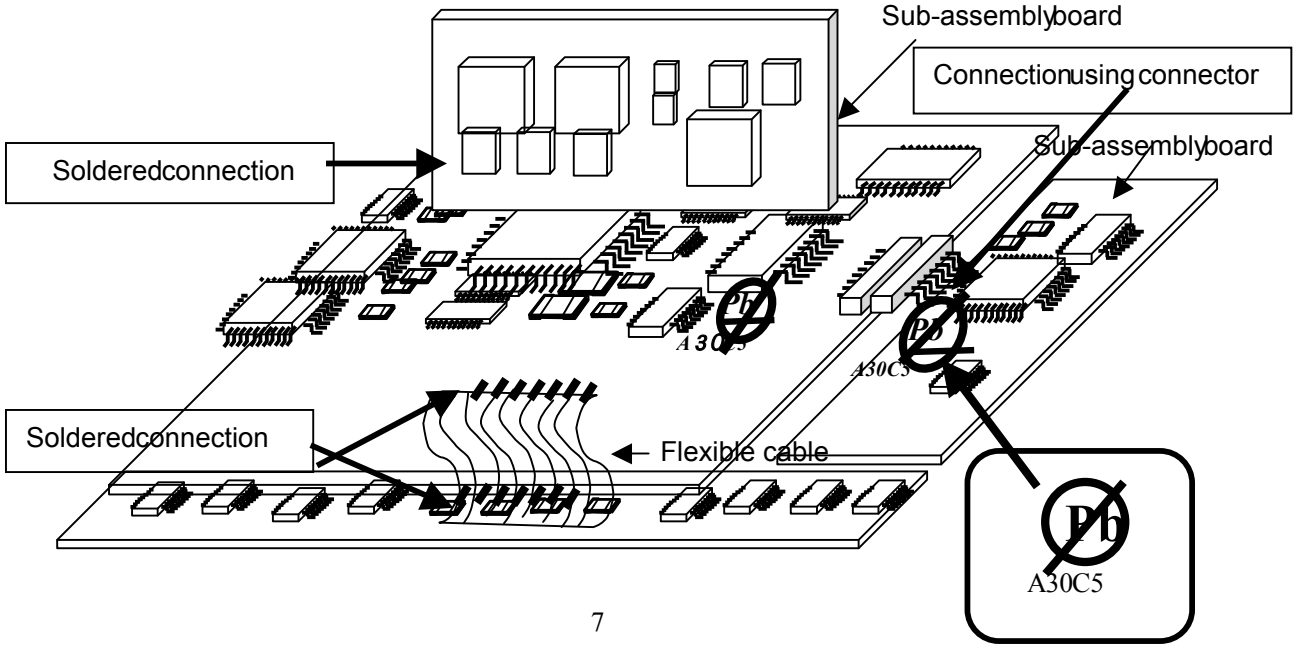


Figure 5 Examples of positions for designation of lead-free phase for assembled board

Additional Remarks

The additional remarks stated here are not the part of this Guidance but give additional information for better understanding of this Guidance.

2. The reason why this Guidance was developed

1.1 Basic understanding of the environmental issue The basic concept of the Fundamental Protection Law of the Environment is the effort of elimination or reduction of hazardous chemical substances from our industrial activities to less environment loads to establish continuing economical development and welfare for the human beings. The environmentally hazardous materials as globally acknowledged include lead, mercury cadmium, 6-valent chromium and some fire retardant materials. There are regulations in various countries and areas for controlled emission of these materials.

Lead has been used in solders in electronics as the material for interconnection because of its superior mechanical and electrical properties and for its low cost. Lead-free solders have been developed from the consideration of environmental loading of lead. Solders used in manufacturing electronic products are having been switched to lead-free solders. The Assembly Technology Standardization Committee of JEITA has organized a project team to promote the use of lead-free solders by resolving problems arisen in the use of lead-free solder in manufacturing. A Lead-free Roadmap Committee was first organized to attain consensus of the industry by providing them milestones of realization of lead-free technology and released the Lead-free Roadmap 2002. There was a common request from the industry that a marking method should also be standardized to denote a product is at a specific stage of lead-free technology

1.2 Marking of lead-free products The Assembly Technology Standardization Committee organized a project team to develop markings of lead-free products (devices and equipment) together with the Packaging Standardization for Mounting Components Committee of JEITA in April 2003. Questionnaire was sent to companies involved in this country and replies were extensively analyzed together with exchange of comments and opinions with relevant trade organizations in this country. A study was also made on intellectual properties on the Logos and other designation of lead-free products. This "Guidance for the lead-free marking of materials, components and mounted board used in electronic and electric equipment" was finalized in April, 2004.

Comments from related four trade associations compiled by the Japan Electrical Manufacturers' Association (JEMA) were very valuable sources of information to develop this Guidance of lead-free marking.

2. The issues needed to clarify during the development of this Guidance

2.1 Scope (1.1 of the main body of this document) The scope was specified for the marking of materials, electronic devices, and assembled boards used in electronic and electric products manufactured. This Guidance was developed to provide the industry with the information of a standardized marking for the use of lead-free technology in various levels of incorporation of lead-free technology by reducing possible confusion among the industry for marking. It is our intention to support the smooth transition of the electronic industry to lead-free products to reduce the environmental load for the benefit of the humanity

2.2 References (1.2 of the main body of this document) **IEC 61190-3-1** is cited to clearly specify the materials used in solder and solder to be used in assembly **The Lead-free Roadmap 2002** are referenced to take into account of the [Phases] of lead-free levels. The Study Report on the Standardization of Recycling Marks made by JEMA was a good source of information on lead-free

technology and relevant intellectual properties. The **RoHS Directive** provided us with the information on the hazardous materials and their threshold values.

2.3 Terms and definitions (2. of the main body of this document): The Pb value for lead-free technology was adopted from the Lead-free Roadmap 2002 and the TAC (Technical Adaptation Committee) of the RoHS Directive. The Phases of lead-free technology is adopted from the Lead-free Roadmap 2002. Consideration was made to take into account of the exemption list of the RoHS Directive. **Phase 2A** and **Phase 3A** later were added to the list (**Phase 2A** was the phase first considered based on the replies to the questionnaire).

The term "component (or device)" was used first, however the term "electronic component" was defined in this Guidance to avoid ambiguity that components (or devices) may refer to components used in home appliances.

2.4 General items in marking (3.1 of the main body of this document): The bottom line of the marking is that the mark made on a component stays on it until the component is discarded for recycling, incineration or land-fill. The colour of marking is not specified here but it was agreed to be mono-colour for an economical reason. The size of marks is not specified either as a label on which the marking is made is different for various packages. It should only be clearly recognizable. Aside from the scope of Guidance, a patent application of marking (Patent Application Heisei 11-026896) was noted. The method of marking is not specified in this document.

There is a proposal in Europe that hazardous substances specified in the RoHS Directive are eliminated from a product and the product is marked to show the product is in accordance with the Directive. In the Guidance developed in Japan denotes the chemical symbols of hazardous materials regardless of the specification in the RoHS Directive, difference in the concept of designation of hazardous substances. However, we also adopt a scheme of using designation of [RoHS-xx] or a logo showing the lead-free Phase reflecting the concept in Europe.

2.5 Lead-free marking to materials for solders (3.2 of the main body of this document): The method of marking is studied incorporating comments of component and equipment manufacturers who actually use the lead-free solders in their products. There are various types of lead-free solders. Typical systems are Sn-Ag, Sn-Sb, Sn-Zn, Sn-Bi, or Sn-In systems. There is a need to identify the solder being used as there are few chances of mixing these solders from the point of soldering process control and recycling of left over solder. It is not possible to identify the composition of solder from its colour. This is why we recommend to mark also to the solder whether to solder itself or to a package of solder.

2.6 Lead-free marking to electronic components/devices (3.3 of the main body of this document): The marking to electronic components was first studies for marking of lead-free only. The hazardous substances listed in the RoHS Directive include mercury, cadmium, 6-valent chromium and specified fire-retardant brome compounds (PBB and PBDE). We noticed that there was a request from equipment manufacturers to component suppliers also to identify presence of such hazardous substances in addition to lead.

The above-mentioned six substances are discussed in this Guidance. There are additional concerns in the industry on the use of PVC (polyvinylchloride) and halogen free board materials.

There was a suggestion to identify the fire retardant brome compounds (PBB and PBDE) separately or state directly PBB and PBDE. Material producers commented that it was not easy to identify each of these two substances by chemical analysis and these two could be handled similarly as industrial waste, and the mark may erratically be taken as to lead. We adopted to identify only by Br to indicate the brome compounds included in materials (Pb). It is recommended to state that only PBB and PBDE are to be specified in the materials in a purchase agreement or in the agreement

between user and supplier It is also recommended to specify only 6-valent chrome in such a document as a substance of serious concern. The level to mark to a product is the value agreed in the RoHS Directive.

Regulations to control such hazardous chemical substances are also now being considered by many countries in addition to the RoHS Directive. There are exemptions of the use of lead in the RoHS Directive and the exemptions may vary as time goes. There was an opinion to state the year of issue of any regulation. Such comments are not incorporated in this Guidance, as highly professional knowledge in chemistry is required to make appropriate decisions to such a request.

Especially in Europe, use of a diamond shaped mark for identification is proposed. The marking is basically for the marking of components supplied by component manufacturers to equipment manufacturers. The area needed for such a diamond shape label is rather large while the area available to a label on a package of component is limited. We adopted a square label that requires less space for marking.

The [Eco] is adopted to imply the marking is for ecological purpose.

The Semiconductor Packaging Sub-Committee of JEITA has specified to use a marking of [**Pb-Free T**] to identify semiconductor devices whose terminals are lead-free in the document **JEITA EDR-7605**. This designation is only for the lead-free applied to terminals of a semiconductor device but does not specify any other part of a device.

2.7 Lead-free marking to assembled boards (3.4 of the main body of this document): The lead-free marking to assembled boards is incorporated by considering the status and comments supplied from production lines, distributions, servicing, and recycling operations. It was made clear from recycling point of view that it is very desirable to have indications of names and contents of expensive metals such as gold, silver, platinum, indium and of metals difficult to isolate from other metals such as bismuth and zinc. Global service systems addressed a need to know the composition of solders used in equipment. These studies resulted in a conclusion that an indication of the information of the composition of solders used was necessary by means of easily recognizable logos. The logo of the proposal made by JEDEC were also studies. It was agreed to indicate substances other than lead as indicated in the RoHS list should also be identified. The same indications symbol for hazardous chemical substances used in electronics devices is used. Possible difference of solder used for mounting of components on top surface of a board and on the back surface of a board was considered.

[/] or [,] is used to show multiple compositions of solder used on an assembled board. It is desirable to show all the solder compositions on the representative board if a space is available on the board. It is necessary to investigate the method to indicate compositions such as to show only typical solder composition if space is limited.

2.8 General items in package unit for marking and its position (4.1 of the main body of this document): The package to which marking is required is basically the unit package. It is almost impossible in general to find a place to mark on a component except for boards. This should be the place for a recognizable marking.

2.9 Unit for lead-free marking for solder and position of marking (4.2 of the main body of this document): The position of the marking of the type of solder or composition is selected. For the rod solder, the marking is to be made to the solder bar itself.

2.10 Unit for lead-free marking for an electronic component/device and position of marking (4.3 of the main body of this document): The marking of lead-free for components is to be made to the smallest package unit on the label attached to the package. If there is no space on the label

as shown in **Figure 1** of the main text, the marking may be made on an arbitrary place on the package. The reasons to select the minimum unit package for marking are given below:

a) Marking can be confirmed when component suppliers ship components to board manufacturers or repair agents.
b) The marking can be confirmed at the assembly process or repair.
c) Components are not removed from board when it is discarded.
d) Electronic components are generally very small and there is no space for marking on it.
e) It is possible to state lead-free in a purchase order.

There was an opinion that the marking of lead-free might be made from the time of enactment of the RoHS to the time of ending of shipping of components involved (ca up to 2010). An example of marking on a label is shown in **Figure 4** of the main text.

2.11 Unit for lead-free marking for a board and position of marking (4.4 of the main body of this document): The marking on a board with soldered sub-assemblies is made on the main board, and also to each board connected to the main board with a connector, a conclusion based on the replies to the questionnaire. The smallest unit is shown in this Guidance for marking but certainly each board may have marks if a place is available for marking.

In the case boards with different phases of lead-free are connected by soldering, marking on each board is considered useful when the board is brought to repair.

The position of marking on a board was agreed to be arbitrary as it is impractical to select a specific place as the positions of mounting electronic components are not predetermined and because of the present high density packaging technology. The only restriction is to mark on a board recognizable by observation from above the board in some way. When it is difficult to select an appropriate position, an arbitrary position may be selected on each board. Examples of marking on boards are given in **Figure 5** of the main text.

The minimum size of a board that is required for marking is 10 cm^2 as recommended by the RoHS Directive. The lowest phase is to be marked when boards of different phases are combined into one body.

3 Comments from recycling agents: Following comments were given from recycling agents.

1) Large characters or symbols are desirable.
2) It is desirable to indicate the presence of Au and Ag if they are present in solders.
3) It is desirable to indicate the presence of metals that are not easily separated such as Bi and Zn (Information of the substances included is useful for smelting. The information may directly be related to the number of smelting in recycling.)
4) It is desirable to have a marking of the composition of solder used for a repair service of equipment.
   (Information may be useful in the selection of solder in hand soldering.)

5 Intellectual property issues The following applications are filed for intellectual property

Company	Type	Number	Contents	Status	Remarks
Sharp	Patent	2002-94198	Marking		
Matsushita	Patent	2000-269614	Circuit	Denied	
Senju Metals	Patent	3365364	Marking	Registered	
Matsushita	Patent	2002-217504	Composition		
Conica	Patent	2001-284752	Identification		
NEC Electr.	Trademark	2003-006249	Pb-FREE	Withdrawn	
NEC Electr.	Trademark	2003-006250	Pb-FreeT	Withdrawn	
Mitsubishi	Trademark	4664878	Mark	Registered	
Sony	Trademark	4473342	L&F	Registered	
Hitachi	-	-	F mark	Not applied	
Sanyo	-	-	PbF,Pb(speci)	Not applied	
Micron Tech	Trademark	US2017878	PB		
Advanced Micron D.	Trademark	US76/452078 76/452129 76/452114	PB-1000 PB-1500	In process	
Pota & Pulfield	Trademark	Korean 369264	P&B	Registered	
Japan Filler Metals	Trademark	44750789	PBF	Registered	
Oki Electr.	Trademark	4653768	LF in aleaf	Registered	

Members of the Committee

Assembly Technology Standardization Comm.	Chair		Yamamoto, K	Sony
Component Packaging Standardization Comm.	Chair		Toshima, K	Gold
Guidance Project Group	Project Leader		Ushio, N.	Matsushita Comp.
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			Igawa, C.	NEC Electr.
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			Ito, Y.	Senju Metals
			Aragane, H.	Sony
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			Morita, S.	NEC
			Takada, N.	NEC
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	Observer		Shibata, A.	JPCA
			Yamamoto, K	Independent
	Secretariat		Kubotani, K.	JEITA
			Iwabushi, K.	JEITA

Comments and contributions from the following trade organizations, committees and companies were very much useful in developing this Guidance.

Association for Electric Home Appliances (AEHA)
The Japan Electrical Manufacture's Association (JEMA)
Japan Business Machine and Information System Industries Association (JBMISIA)
The Japan Refrigeration and Air Conditioning Industry Association (JRAIA)
Japan Robot Association (JARA)
Electronic Materials Manufacturers Association of Japan (EMAJ)
Quartz Industries Association of Japan (QIAJ)
Japan Printed Circuit Association (JPCA)
Japan Electronics and information Technology Industries Association (JEITA)
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Tokyo Eco recycle Co., Ltd.
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Hokkaido Eco Recycle Systems Co., Ltd.