NIMS-EMC MDE Report No.2
Fundamental Survey for Lead Material Flow in Japan

EcoMaterials Center
NIMS National Institute for Materials Science

Contents

1. Summary

(1) Decrease of lead ore import

Most of this survey is based on Resource Statistics data for the main uses of lead in terms of production, demand and recycling corresponding to the years 2001 and 2002. From the results, the following characteristics can be summarized.

Starting in October 1994, cooperation between manufacturers and dealers of lead storage batteries resulted in the design and implementation of a system for recycling of waste

Lead acid storage batteries. As a result, production of primary refined lead by lead ore has been sharply reduced. Production decreased from 320,000 t in 1990 to half this value, 140,000 t in 2003, and a decrease of 160,000 t in the amount of lead.

(2) Trends lead demand by industrial sector

- A noticeable decrease in the demand for lead acid storage batteries occurred from around 1990 to 1992. This decrease can be attributed to a reduction in the domestic production of automobiles. After this period, there was not an observable trend of further decrease.

The domestic production of industrial inorganic chemicals

halved from 64,000 t in 1990 to 29,000 t in 2001 during these 10 years. This trend can be directly attributed to the increase in import lead oxide from China...

Since more than 10 years ago, the production of electric appliances has been shifted overseas, but in the case of vacuum tube glass (glass for CRT), the production of large diameters vacuum tubes had remained in Japan. However, from the years 2002 through 2004, the two largest domestic manufacturers of vacuum tubes glass (Asahi Glass and Nippon Electric Glass) have shifted or intend to shift production overseas. However, although the recycling of CRT may have lost its base, the Electric Appliances Recycling Law, which has set a high rate of recycling for used TV sets remains in force, stressing the need for an effective strategy for recycling of used glass vacuum tubes and sales of recycled products.

- Lead tubes and sheets have not shown a marked decrease, from 110,000 t in 1990 to 90,000 t in 2002, but there has been a slight decrease of lead tubes for use in water and sewage services.
- Lead cable sheath for electric wires had stabilized at a low point of approximately 3,000 t, but it has recently shown a slight increase that can be attributed to a growth in exports to the Middle East.
- There is a clear trend, centered in the automobile industry, for lead-free products in four items: solder, copper alloys blocks free-cutting brass and free-cutting steel. Regarding electronic and electric equipment, as the RoHS directive is scheduled to be implemented on July 1, 2006 (restricting the use of hazardous substances in EU member states), a further decrease in lead demand is estimated. Regarding mainly copper based casting (using copper alloys blocks), from April 1, 2003 standards regulating lead content in water have become stricter in Japan.

(3) Statistical problems

Regarding Production Statistics and Demand and Supply Statistics related to lead, there were no statistics for free-cutting steel, and since the year 2002, there are no statistics for free-cutting brass. Statistics for electric wire cable sheath will disappear in the year 2004.

(4) Future trends

Amid increasing awareness of environmental conservation, demand in Japan for lead is estimated to decrease in the long term due to its toxicity. There is a pressing need for a survey on the world production of lead ore, and demand of lead.

2. General Flow

(1) Raw material supply

Figure 2-1 and Table 2-1 No.2 show the supply of lead raw materials. The graph in Figure 2-1 corresponds to the data in columns 1 to 6 of Table 2-1 No.2 , and it includes the portion of exported lead scrap. According to this figure, the production of mineral ore has decreased noticeably since October 1994, when active recycling of spent lead storage batteries started. Column (11)in Table 2-1 No.2 shows that total refined lead production of domestic primary refined lead, including imported primary refined lead has declined from 320,000 t in 1990 to 140,000 t in 2003, representing a decrease of more than 50% in a period of ten years.

(2) Demand trends by industrial sector

Numerical values for demand trends by application are shown in Table 2-4, and Figure 2-2 presents composed graphs of demand by application. A line graph representing the supply of raw lead is presented for comparison purposes.

- Lead consumption for lead storage batteries have decreased noticeably from the period of 1990 to 1992 and the following years, but this decline can be attributed to a decrease in the domestic production of automobiles, and there is no evidence of a trend for further decrease.

Domestic production of industrial inorganic chemicals has halved during these 10 years. This trend can be directly attributed to the increase in imports from China..

- Starting several years ago, the production of electric appliances has been shifted overseas, but in the case of vacuum tube glass (glass for CRT), the production of vacuum tubes of large diameters had remained in Japan. However, from the years 2002 through 2004, the two largest domestic manufacturers of vacuum tube glass have shifted or intend to shift production overseas. Although the recycling of CRT may have lost its base, the Electric Appliances Recycling Law, which has set a high rate of recycling for used TV sets, remains in force, and a sound recycling strategy is needed.
- Lead tubes and sheets have not shown a marked decrease but there is a slight decrease probably caused by the decline of lead pipes for use in water and sewage services.
- Lead cable sheath for electric wires has stabilized at a low point of approximately 3,000 t, but it has recently shown a slight increase that can be attributed to a growth in exports.
- There is a clear trend, centered in the automobile industry, for lead-free products in four items: solder, copper alloys blocks, free-cutting brass and free-cutting steel. Regarding electronics and electric equipment, as the RoHS directive is scheduled to be implemented on July 1st, 2006 (a ban on the use of specified substances in EU member states) a further decrease in lead demand is expected. Regarding mainly copper based casting (using copper alloys blocks), from April 1st, 2003 standards regulating lead content in water have become stricter.

(3) Lead scrap

The values in column (13) in Table 2-1 No.2 , estimated from values of raw material supply, are compared to those in column 17, that is, the amount of scrap recovered from waste products, for a three year period ranging from the year 2000 to 2002. The values in column

(13)are 20,000 t higher than the values in column (17). This discrepancy can be attributed to the fact that demand should not be included in line 2 of Table 2-5, but approximately 10,000 t should be "included in" column (13) of the table (details in 3.1.1). Also, recently secondary refineries has obtained approximately 10,000 t of scrap from sources other than waste storage batteries. Approximately 6,000 t of the remaining 10,000 could also be justified. Summarizing, the difference between columns (13) and (17) is reduced to approximately 4,000 t, a value that can be considered to be inside the range of error.

As for the 10,000 t of the secodary refineries, the values for column 1 "received amount" and column (2) "sold amount" in Table 2-3 show an increase in sales of about 10,000 t during the years 1999 through 2003. In particular, in the year 2003, there is an increase of 17,000 t, which suggests the existence of other sources for scrap besides waste storage batteries or ore. About 2,000 to 3,000 t from lead tubes and sheets, whereas the amount of processing scrap from storage battery plants is in the order of 3,000 to 4,000 t. Taking into account that recently refined lead is being used to keep up the quality of soft refined lead, the other 2,000 to 3,000 t can be accounted for, with the remaining 2,000 to 3,000 t from other sources of scrap. As shown in Table 2-5, "Scrap Statistics", the most recent collected amount is in the range 6,000 to 7,000 t. This value includes 3,000 t for lead pipes and boards, the remaining amount to complete the number above can be attained by adding "solder" and other scrap from processing. The processing scrap from storage battery plants that report to the recycling industry is in the order of 5,000 to 7,000 t, and has not been included in these statistics.

(4) Statistical problems

a) Resource Statistics and statistics from the Battery Association of Japan

The Battery Association of Japan keeps statistics on the collection of waste lead storage batteries as well as the sale of storage batteries for primary refineries and secondary refineries. A portion of Table 2-1 No.1 2-1 originating from Resource Statistics was substituted by data from the Battery Association of Japan to produce Table 2-1 No.2 For example, in the case of primary refineries, column (4) (production) in Table 2-2, values corresponding to the received amount, column (1), were entered. During the period from the years 1995 to 1998, the values in column (1) were 30,000 t higher than values in column (4). On the other hand, in the case of secondary refineries, for production in column (4) of Table 2-3, we registered the values corresponding to the sales of column (2). In this case, in contrast, the Battery Association of Japan presents a value that is 20,000 t higher.

In conclusion, statistics from the Battery Association of Japan are considered to be more reliable than the Demand and Supply Statistics compiled by the Ministry of Economy, Trade and Industry and Table 2-1 No.2 will be used hereinafter instead of Table 2-1 No.1 .

b) Effects of change form the designated statistics to the approved statistics of the Resource Statistics

Perhaps because in the year 2002, demand and supply statistics were downgraded from designated statistics into approved statistics without penalties for non-compliance, the collection of data from the supply side of lead scrap has not been carried out properly, and presents markedly small figures. The sources of data for lead scrap collection are mainly distributors to non-ferrous wholesale houses and corporations. If the data is used as provided, column 6 in Table 2-1 No.1 , corresponding to “scrap, others” has a negative value. Here, average data for scrap production and collection corresponding to the years 2000 and 2001 in

Table 2-1 No.2 , 40,000 and 230,000 were used for the years 2002 and 2003 to carry out calculations. The results are 57,000 t and 31,500 for the years 2002 and 2003, respectively.

c) Reduced investigation area of Statistics

To establish a material flow for lead, the existence or lack of statistics from the Ministry of Economy, Trade and Industry or from the industry is crucial.

From the following table, it is noticed that there are no statistics corresponding to the year 2004 for electric wire cable sheathing, free-cutting brass, or free-cutting steel.

Reliability and Continuation of Statistics

	～1998年			1999年～			～2001年			2002年～			2004年～		
	METI			METI			METI			METI			METI		
	D/S	Prod.	Ind.	D/S	Prod.	Ind.	D/S	Prod.	Ind.	D/S	Prod.	Ind.	D/S	Prod.	Ind.
Item															
Storage batteries	◎		◎	◎		◎	◎		◎	◎		◎	◎		◎
Inorganic chemicals			◎			◎			◎			◎			◎
Solder and copper alloys blocks	○	○		○	○		○	○		○	○		○	○	
Lead tubes and sheets	◎	◎	◎	△		◎	△		◎	△		◎	△		◎
Electric wire sheath	◎	◎	◎	◎	◎	◎	◎	◎	◎			◎			
Free-cutting brass		◎			◎			◎							
Free-cutting steel															

note 1 (1)D/S→Demand and supply statistics , (2)prod→production statistics , (3) Ind.→Industrial sector statistics
note 2 (1)□→reliable、(2)○→some reliable、(3)□→unreliable (as judged by the author)
note3 METI→Ministry of Economy, Trade and Industry

(5) Future tasks

(a) Lead storage amount for a year

The amount of lead stock for a given year, including not only domestic production but also the balance of exports and imports for lead products, is of crucial importance for assessing the amount of domestic lead stock.

This remains a task to be carried out in the future and in this report it was omitted.

(b) Lead products that could not be evaluated

Surveys on items such as anti-friction alloys (bearings), fishing weights and bullet could not be carried out, and remain topics for future research item.

(c) The present survey was limited to the domestic production and demand of lead. It is true that consumption of lead is decreasing in Japan, but it is necessary to carry out a comparative evaluation of trends in world production of ore as well as global trends in consumption.

Table 2-1 Comparison between input raw material and production of lead, and waste lead discarded

Source: Production, Demand and Supply Statistics from the annual report of Resource Statistics. Estimated the discard data concerning waste storage batteries are from hearing and data by the Battery Association of Japan.

Note 1: Data about inventory at the beginning of the month are excluded from lead scrap supply statistics in the “scrap, others” columns. In addition, scrap

consumption of the supply side by primary refineries and secondary refineries are also excluded from the addition.
(Correction made based on reports that, in lead scrap statistics, lead for recycling is counted twice: once for primary refineries and once for secondary refineries. Export scrap is included.
Note 2: Several errors were detected in demand and supply figures of the resource statistics. During the period from 1995 to 2001, the values corresponding to “refined lead for primary refineries” from Resource Statistics in Table 2-1 were substituted by Battery Association of Japan statistics (Table 2-2-(1) primary refineries spent storage batteries input). There is no change in the total output of refined lead for primary refineries . Also, data corresponding to secondary refineries were also substituted by data corresponding to the “amount sold” provided by the Battery Association of Japan.
Note3: As the column “scrap, others” in Table 2-1 No.1 corresponds to the supply of lead scrap, adjustment was made to amend a discrepancy with demand statistics. Starting in the year 2002, Demand and Supply Statistics were downgraded from designated statistics to approved statistics without penalties for non-compliance, which is the probable cause of the reduction of collected data for lead scrap. The main collectors of lead scrap data are the market related players, such as non-ferrous traders and wholesalers. If the data is used without adjustment, it results in a negative figure, and therefore the average figures of 40,000 and 230,000, corresponding to production and collection of the years 2000 and 2001, were used to estimate the values for the years 2002 and 2003, resulting in 57,000 t and 31,000 t respectively.
Note 4: As the accuracy of data from the supply side is lost, data for “scrap, others 1” in column (7) is estimated from the demand side, excluding storage batteries, primary smelting and secondary smelting, and including the amount exported. The amount not added is presented in “scrap, other 2” in column (8). The difference between “scrap, other 1” and “scrap, other 2” corresponds to exports

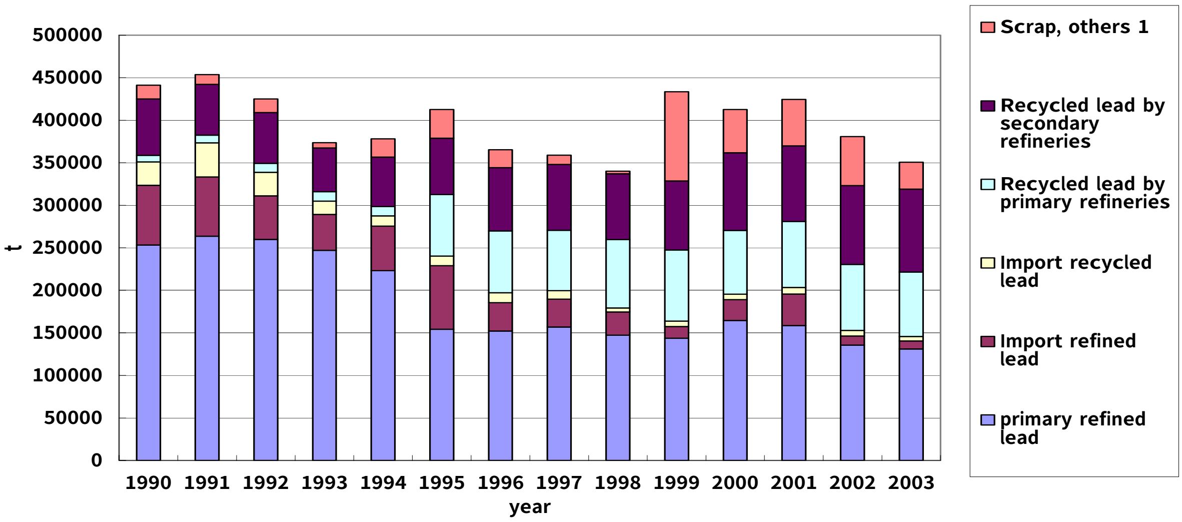
Table 2-2 Comparative between resource statistics and industrial statistics for primary refineries (units: t)

	Battery association of Japan statistics		Annual Report of Resource Statisitics		difference
	Input	Sales	Input	Produt.	
	(1)	(2)	(3)	(4)	(5)
					(1)-(4)
1995	72388	59424	66343	38021	34367
1996	72558	77703	77666	43009	29549
1997	70994	73492	93195	49932	21062
1998	80368	67531	86894	48565	31803
1999	83454	64994	119802	72502	10952
2000	74822	62344	93384	87547	-12725
2001	77576	57148	132168	85719	-8143
2002	72093	58459	114210	77594	-5501
2003	75756	56618	153189	95279	-19523

Table 2-3 Comparative between resources statistics and industrial statistics for secondary refineries (units: t)

	Battery association of Japan statistics		Annual Report of Resource Statisitics		difference
	Input	Sales	Input	Produt.	
	(1)	(2)	(3)	(4)	(5)
					(2)-(4)
1995	65214	66200	99456	61014	5186
1996	68970	74288	112383	62644	11644
1997	82131	77338	121646	68811	8527
1998	78789	77280	106010	74526	2754
1999	73946	81340	58745	66307	15033
2000	82835	91392	84757	72178	19214
2001	77942	88885	85652	66404	22481
2002	82079	92803	78073	72808	19995
2003	80536	97605	84458	62603	35002

Figure 2-1 The amount of refined lead produced by lead raw material



2-4 Lead consumption by application (units: t)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Storage batteries	306773	307792	289916	259422	267142	260952	267933	267477	255642	261618	276620	262477	259201
Inorganic chemicals	63958	68774	64075	59047	50657	45828	40997	38418	32325	33139	25199	29325	20146
Solder and copper alloys blocks	20152	18929	14221	15183	14585	14104	13258	13041	10580	11260	11045	10104	11310
Lead tubes and sheets	12322	12493	12556	11022	10795	11850	12824	13431	12783	11500	11204	10470	9286
Electric wire sheath	4880	6932	5885	6956	4529	3836	6173	4079	2871	2378	4588	6440	8854
Free-cutting brass	3028	3235	2907	3077	3321	3240	3362	3364	2552	2833	2821	2486	2291
Free-cutting steel	1401	1387	1204	1149	1160	1196	1131	1229	979	1025	1167	1063	1092
Total	412513	419542	390764	355856	352189	341006	345677	341039	317731	323753	332644	322365	312180

Figure 2-2 Lead supply and consumption by application (units: t)

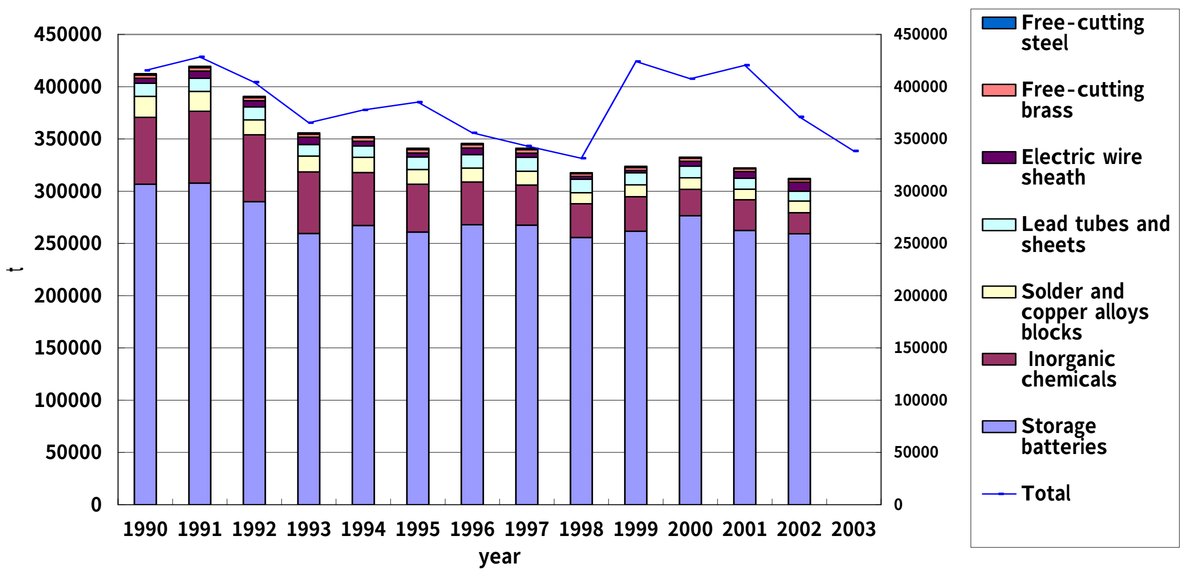


Table 2-5 “Scrap excluding waste batteries” aggregated from lead Demand and Supply Statistics

(1) Demand statistics of lead scrap

			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Lead tubes and sheets	(1)		45	33	43	36	45	32	38	87	148	-	-			0
Storage batteries	(2)		15654	14427	13846	13113	11747	11361	11797	11846	11258	9684	10754	10915	8231	10426
Inorganic chemicals	(3)				1728						-	-	-			2980
Solder and copper alloys block	(4)		2038	2034	28	1543	1655	2014	2672	2423	1680	1880	1857	1659	5142	1317
Others	(5)		7880	4943	4773	2972	3947	3091	1383	3400	5193	37943	1572	828	197	1094

Note 1: There is no sign that the scrap in column 2 of storage batteries is purchased, solution losses (3-5% vaporization of PbO during solution) may be wrongly recorded.
Note 2: Perhaps data of inorganic chemicals are wrong.

(2) Demand statistics of recycled lead

			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Lead tubes and sheets	(6)		1308	1282	1043	864	821	894	870	1259	148	-	448	433	448	416
Solder and copper alloys block	(7)		3881	3756	2931	3114	3106	2641	1920	1824	1680	2332	2355	2179	2335	2120
Others	(8)		3384	2329	3541	3028	2488	3178	2502	2019	5193	2280	1105	1519	1105	1134

(3) Scrap total

			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Lead tubes and sheets	(9)	(1)+'(6)	1353	1315	1086	900	866	926	908	1346	296	0	448	433	448	416
Solder and copper alloys block	(10)	(4)+(7)	5919	5790	2959	4657	4761	4655	4592	4247	3360	4212	4212	3838	7477	3437
Others	(11)	(5)+(8)	11264	7272	8314	6000	6435	6269	3885	5419	10386	40223	2677	2347	1302	2228
Totals	(12)	(9)～(11)	18536	14377	12359	11557	12062	11850	9385	11012	14042	44435	7337	6618	9227	6081

Source: Demand and Supply Statistics

3 Material Flow by Industrial Sector

3.1 Lead storage batteries

3.1.1 Lead supply for storage batteries

Column （c） in Table 3-1-1 shows a figure in the range of about 10,000 to 15,000 t. Despite the fact that storage battery manufacturers are not buying lead scrap, on the demand side of the Resource Statistics it appears as if they are. This can be attributed to the fact that solution losses (vaporization of lead oxide during solution), which usually comprise 3 to 5%, are being wrongly included in this figure. It is evident that this figure should be excluded from total supply of lead of statistics.

Before, as Table 2-3 shows, the Battery Association of Japan has started to compile statistics for secondary refined lead from the latter half of 1994. According to these data, from the value of column (b) of Resource Statistics, the value of column (f) from the Battery Association of Japan is higher; assuming a higher reliability of the later, we used this data. Finally, instead of data of column d in the Resource Statistics, we used column (h) for years 1990 to 1994, and data from column i for years 1995 to 2003.

Although the recycling from primary refineries of storage batteries has not increased too noticeably, recycling from secondary refineries has increased, because the following two types of batteries were used before:

(1) Maintenance free battery

This is a maintenance free lead storage battery containing metallic Ca (lead ore is supplied from primary refineries, and metallic Ca is supplied to the storage battery manufacturers).

Due to the need for an additional supply of water to the electrolyte, the frequency of use of maintenance free storage batteries is slighter lower than of antimony containing storage batteries, but maintenace free batteries has spread. The current high rate of use of maintenance free batteries is a trend that started in 1970 and was almost peaked in 1980.

(2) Antimony containing battery

The source of material from secondary smelting comes from antimony containing storage batteries.

That antimony containing storage batteries continue to be in use can be attributed to their superb properties of deep electric discharge and heavy load which are required for use in equipment such as:

(a) Trucks, buses

(b) Forklifts

However, recently, secondary refineries have begun to use Ca containing spent storage batteries. This so-called soft refining uses coke as thermal source, caustic soda as a refining additive (lead dissolves equally in acid and in alkali), sulfur (liberated copper), and oxygen to obtain an refined lead with purity higher than 99.97% (newly refined lead has a purity of 99.999%). This refined lead is being supplied to storage battery manufacturers, and, obviously, is making inroads into the production of storage batteries for use in automobiles.

3.1.2 Lead consumption for the production of lead storage batteries

Figure 3-1-1 shows lead supply to the production of lead storage battery and lead consumption in each lead battery product. As shown in this figure, after 1997 the amount of lead consumption related to lead storage battery manufacturing was smaller than the amount of lead supply, except for year 2000. However, before 1996, especially in 1994, this consumption considerably exceeded the supply. Before the year 1994, only figures from Resource Statistics were available, and it is possible that secondary refined lead producers were supplying more refined lead than was indicated by the statistics. The increase observed in the years 1995 and 1996 can then be attributed to that data from storage battery producers which do not reply total 100% in the Resource Statistics.

The sales of lead storage batteries is shown in Table 3-1-2, , domestic production is estimated from "the above table3-1-4, where approximately 2% of shipping statistics is constituted by imports of storage batteries for use in four wheel and two wheel vehicles." Figure 3-1-1 shows the supply of lead for storage batteries and production of lead storage batteries. Shipping of storage batteries decreased starting from the years 1990 to 1992, but this decline can be attributed to a decrease in automobile production. After that, decline cannot be seen.

Storage batteries for four-wheel vehicles have decreased. The decrease of compact lead seal storage batteries for use in portable machinery is a characteristic point.

Table 3-1-1 Lead supply for storage batteries (units: t)

Demand and Supply Statistics in Resource Statistics (demand)					Battery Asso. Statistics				
	Electrolytic lead	Recycled lead	lead scrap	Total	Waste batteries input for primary refineries	Recycled lead output by secondary refineries	Total 1	Total 2	Total 3
	a	b	c	d	e	f	g	h	k
				a＋b＋c			a+c+f	a+b	a+f
1990	195953	98668	15654	310275				294621	
1991	202134	92450	14427	309011				294584	
1992	200023	84295	13846	298164				284318	
1993	180066	76127	13113	269306				256193	
1994	179087	60083	11747	250917				239170	
1995	187809	45314	11361	244484	72388	66200	265370		254009
1996	187652	45139	11797	244588	72558	74288	273737		261940
1997	190335	46140	11846	248321	70994	77338	279519		267673
1998	182724	42074	11258	236056	80368	77280	271262		260004
1999	177243	34481	9684	221408	83454	81340	268267		258583
2000	168715	32433	10754	211902	74822	91392	270861		260107
2001	184219	28093	10915	223227	77576	88885	284019		273104
2002	168715	32433	8231	209379	72093	92803	269749		261518
2003	166028	28685	10426	205139	75756	97605	274059		263633

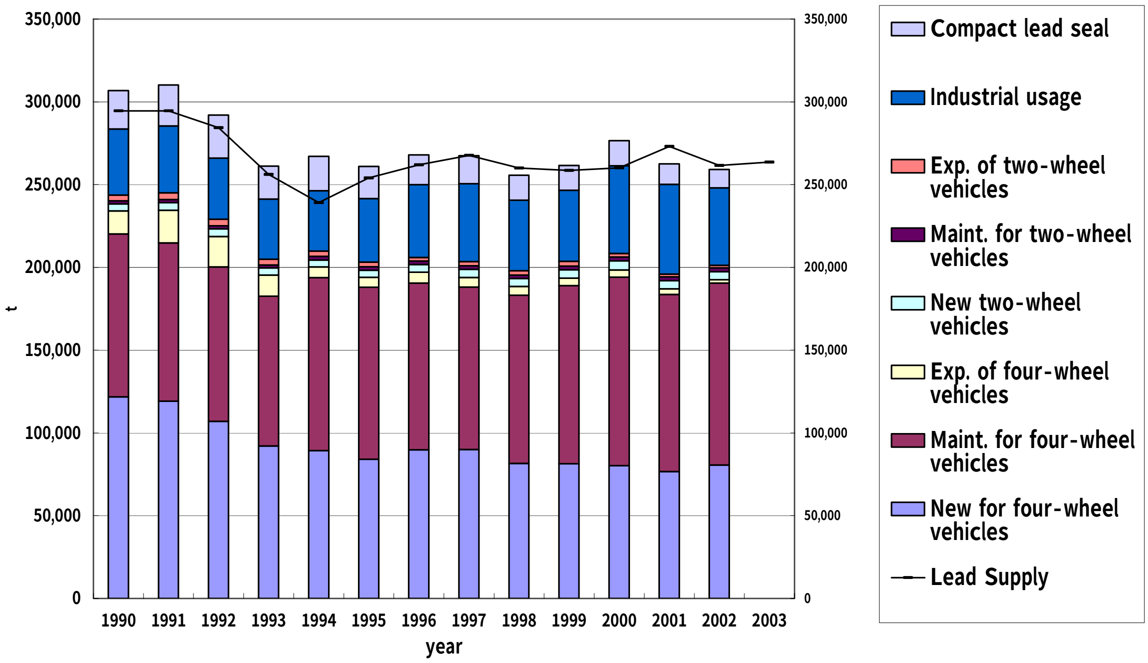
Source: Demand and Supply Statistics from Resource Statistics and statistics compiled by the Battery Association of Japan

Table 3-1-2 Sales weights of lead storage batteries (units: t)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
New for four-wheel vehicles	118,188	124,249	119,117	107,081	92,129	91,047	85,849	91,575	91,806	83,205	82,960	81,954	78,293	82,296
Maint. for four-wheel vehicles	97,323	100,409	97,571	95,020	92,393	106,638	106,024	102,811	100,195	103,725	109,860	116,150	109,142	112,072
Exp. of four-wheel vehicles	19,775	14,232	20,158	18,746	12,863	6,629	6,141	6,835	5,886	5,362	4,628	4,371	3,469	2,118
Total of four-wheel vehicles	235,286	238,890	236,846	220,847	197,385	204,314	198,014	201,221	197,887	192,292	197,448	202,475	190,904	196,486
New two-wheel vehicles	4,335	4,359	4,682	4,866	4,430	4,308	4,246	4,581	4,990	4,973	5,237	5,655	5,036	4,942
Maint. for two-wheel vehicles	1,879	1,858	1,908	1,820	1,830	2,224	2,259	2,231	2,160	2,027	2,208	2,305	2,292	2,288
Exp. of two-wheel vehicles	3,829	3,511	4,117	4,070	3,595	3,280	2,719	2,190	2,641	2,783	2,819	2,209	1,651	1,588
Total of two-wheel vehicles	10,043	9,728	10,706	10,756	9,855	9,812	9,224	9,002	9,791	9,783	10,264	10,169	8,979	8,818
Total for automobiles	245,329	248,618	247,552	231,603	207,240	214,126	207,238	210,223	207,678	202,075	207,712	212,644	199,883	205,304
Industrial usage	54,672	40,036	40,498	36,928	36,318	36,528	38,420	43,864	46,996	42,522	43,070	52,954	54,272	46,856
Compact lead seal	0	23,091	24,693	26,017	20,009	20,771	19,439	18,050	16,957	15,086	14,990	15,275	12,320	11,147
Total	300,001	311,745	321,743	294,548	263,567	271,425	265,097	272,137	271,632	259,683	265,772	280,873	266,475	263,307
Est. domestic product. weights	295,094	306,773	307,792	289,916	259,422	267,142	260,952	267,933	267,477	255,642	261,618	276,620	262,477	259,201

Source: Battery Association of Japan Statistics August 14, 2003

Figure 3-1-1 Production of lead storage batteries and lead supply



3.1.3 Discard and recycling of lead storage batteries

(1) Discard of waste storage batteries

Table 3-1-3 shows the weights of waste storage batteries for discard for the years 1994, 2000, 2001, and 2002. The method used to estimate the amount of discard will be described below using the year 2002 for example.

(Amount of disposal of storage batteries for the year 2002)

(a) Maintenance for domestic four-wheel vehicles

Number of storage batteries sold for general use (sales to automobile manufacturers or overseas manufacturers of automobiles are excluded)

14,446,000 in 2000

13,937,000 in 2001

14,209,000 in 2002

The unit weights of lead requirement for storage batteries decreased from 8.2 kg 10 years ago (1993) to a current 7.8 kg (2002). Usually, for a service life for maintenance of 4-5 years, the unit weights has been estimated as 8.0 kg.

14,209,000 x 8 / 1000 = 113,672 t

Assuming the number of batteries in use at 5 years previous to the year 2000, that is for the year 1995, as 66,854,000, if we divide the maintenance number for year 2000, 1440/66854=0.1260 1/4, and a service life of 4 years can be assumed (the service life is set at 2 or 3 years, but usually it is a little longer). Regarding the batteries equipped on the imported vehicles, 290,514 four-wheel vehicles were imported in the year 2002, which makes

290,000 x 8.0 kg=2,320 t

Total 115,992 t

(b) Maintenance for two-wheel vehicles

The number of storage batteries sold for general use (excluding sales to automobile manufacturers, but including imports of overseas manufactured vehicles)

1,498,000 in 2000

1,489,000 in 2001

1,490,000 in 2002

Table 3-1-5 Estimated discard of waste lead storage batteries (units: t)

	Item	*1) 1994		2000	2001	2002	
1	Maint. For domestic motor vehicles	Battery Association of Japan statistics 2,831t(For imported vehicles)	102,240	117,848t	113,816t	14,209 thou.×8.0kg÷1000= 113,672t Imports for motor vehicle 2,320t	115,992t
2	Maint. For motorcycles	Battery Association of Japan statistics	2,091	2,322t	2,165t	1490 thou.×1.55kg÷1000=	2,310t
3	Imports for motor vehicles	1,486,749×8.5=12,637t	12,637	16,320t	16,640t	2166 thou. t×8.0kg÷1000=	17,328t
4	Discarded motor vehicles	*2) ~~4,950,000~~×8.5= 4,478,000	~~42,075~~ 38,063	32,000t	33,200t	4211thou.×8.0kg÷1000=	33,688t
5	Discarded motorcycles	*3)~~1,844,442~~×1.66= 922,221	~~3062~~ 1,531	775t	758t	430thou. ×1.55kg÷1000	667t
6	*4) Waste domestic prod. Ind. usage	35,214(prod.)-17,472(exp.)	17,742	18,000t	18,000t	36,922t-18,696t=18,226t□18,000t	18,000t
7	Waste imported Ind. use	35.2×07 (8507.10-020 853.7×0.7 (8507-20.010 44426×0.7(8507.20-020	3,721	6,567t	7,157t	65t×0.65=42t 5,527t×0.65=3,593t 3144t×0.65=1884t	5,519t
8	Waste compact lead seal	20,771×0.35=	7,270	2,577t	1,983t	10,024×0.5×0.35=1,754t	1,754 t
Total			~~188,838~~				
			183,296	187,930t	193,759t		195,258

*1) Estimated figures for discard of spent lead storage batteries in the year 1994 have been collected from the "Copper, Zinc, Lead Material Flow Survey of Japan" dated June 1996 and carried out by the Metal Economics Research Institute, Japan. Values in the cancelled portions have been corrected to next line.

*2) According to a year 2003 issue of The Motor Industry of Japan (Japan Automobile Manufacturers Association, Inc.), the number of discarded four-wheel vehicles in the year 1994 was 4,778,000. For this year 360,000 used automobiles were exported, 4,478,000 vehicles for collection of spent storage batteries.

*3) There is some mistake regarding the figures for two-wheel vehicles in use. There is a large number of vehicles in this category that have been exported, so actual figures for vehicles in use should be about halved, and the figure corresponding to discarded two-wheel vehicles should be also reduced by a half.

4*) Production for domestic industrial usage increased sharply in the years 2000, 2001. This increase is attributed to an increase in cellular base stations related to mobile telephone expansion, a trend that decreased in year 2002. Their expected service life is 10 years (7 years for sealed compact models and 15 years for large models) and industrial usage storage battery production statistics have been substituted by the data corresponding to the year 1993, the year when statistics were first collected.

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The unit weights lead of the storage battery has increased from 1.55 kg ten years ago (1993) to 1.89 kg in 2003.

However, 1.55 kg of lead is being used for maintenance for two-wheel vehicles, and we used this as the unit weights.

1,490,000 x 1.55 kg/ 1000 = 2,310 t

Assuming the number of batteries in use in 1995(5 years before 2000) to be 15,587,000 units, if we divide the maintenance number for year 2000, 1498/15587=0.0961□1/10, approximately 10 years of useful life. Discrepancies in the actual figures can be attributed to the fact that a large number, constituted of two-wheel vehicles of 51 cc, are not included in the register, and these represent a large volume of exports.

(c) Imports of four-wheel vehicles

Adding the number of storage batteries for use in imported foreign automobiles: 2,166,000 (year 2002) (taken from trade statistics of storage batteries for ignition excluding storage batteries for two-wheel vehicles and for use in imported four-wheel vehicles) 2,166,000 t x 8.0 kg / 1000 = 17,328 t

(d) Discarded four-wheel vehicles

The number of vehicles Discarded in the year 2002 was 5,210,505 and the number of them that were exported is in the order of 1,000,000 vehicles, and the corresponding number of batteries is estimated to be in the order of 4,211,000. The number of Discarded vehicles corresponds to ten years ago, but the incorporated batteries date from 4 or 5 years ago, therefore the basic unit is set at 8.0 kg.

4,211,000 x 8.0 kg / 1000 = 33,688 t

(e) Discarded two-wheel vehicles

The number of discarded two-wheel vehicle is estimated to be in the 1,200,000 range (for the months January to March, according to results from a hearing of the Japan Automobile Manufacturers Association, Inc.). However, 700,000 of these vehicles have been exported, leaving 500,000 vehicles for our estimations in the year 2000. In 2002 the number of retained vehicles had decreased approximately 700,000 since 2000, but the number discarded decreased by 70,000. It is assumed that the rate for the number of vehicles for this year is the same as for year 2000.

Assuming the lead unit weights is 1.55 kg for storage batteries,

430,000 x 1.55 kg / 1000 = 667 t

(f) Domestic production of the industrial usage

The service life of storage batteries for industrial use is set at 10 years (7 years for compact batteries, 15 years for large type). Statistics are available from 1993 but there are no statistics for storage batteries for industrial use corresponding to the previous 10 years, that is 1990.

Accordingly, taking year 1993,

Production - Exports

1) Production for 1993: 36,922 t

2) Exports of batteries for industrial use. Total exports of batteries for industrial use: 26,709 t (HS8507-2000)…

26,709 t x 0.70 = 18,696 t

3) Total

36,922 t - 18,696 t = 18,226 t □ 18,000 t

(g) Imports for industrial use:

1) (HS8507-10020) Total production 66 t

65 t x 0.65 = 42 t

2) (HS8507-2020010) Total production 5527 t

5,527 t x 0.65 = 3,593 t

3) (HS8507-2020020) Lead basic unit   Total production: 3144 t

(2) Recycling Law for lead storage batteries for automobile use

Recycling of lead storage batteries for automobiles by batteries manufacturers was enforced in October 1994, in accordance with Article 19-2 of the Waste Management and Public Cleansing Law, effective from July 1994, and under the direction of the Ministries of Health, Labor and Welfare, and of Economy, Trade and Industry.

Afterwards, in April of 2000, with the recycling promotion law, the scope of recycling responsibilities was extended beyond makers of compact lead shield storage batteries. Currently, recycling of lead storage batteries for use in automobiles will be contemplated in the Automobile Recycling Law which will be in effect from January 2005. Currently it is not possible to collect fees for discard of waste lead storage batteries but this is under consideration.

3.2 Inorganic chemicals

3.2.1 Lead supply for production of inorganic chemicals

As Table 3-2-1 shows, the amount of domestically refined lead used for the production of inorganic chemicals has been decreasing steadily. This decline can be attributed, in part, to a decrease in the consumption of inorganic chemicals, but the most important cause is the effect of low cost lead oxide imported from China, etc.

Table 3-2-1 Trends lead consumption for inorganic chemicals

	Refined lead	Recycled lead	Scrap	Total
1990	63958			63958
1991		68774		68774
1992	62347		1728	64075
1993	59047			59047
1994	50372	285		50657
1995	45828			45828
1996	40996	1		40997
1997	38418	-		38418
1998	32325	-	-	32325
1999	33139	-	-	33139
2000	20134	5065	-	25199
2001	29325			29325
2002	20134		12	20146
2003	20588	21	2980	23589

Source: Annual report of Resource Statistics

3.2.2 Lead consumption for inorganic chemicals

(1) Lead for inorganic chemicals

Lead is used in the production of the following inorganic chemicals:

- Red lead Pb_3O_4 … Glass (glass vacuum tube, optical, general), dyes, electronic materials

- Litharge PbO … Polyvinyl chloride stabilizer, glass (glass vacuum tube, optical, general), dyes, electronic materials
- White lead, $2PbCO_3$-$Pb(OH)_3$ … dyes, glazes
- Chrome yellow, $PbCrO_4$ … dyes, Molybdenum red, $PbCrO_4$, $nPbMoO_4$, $mPbSO_4$, $Al(OH)_3$ … dyes

From this list, red lead and litharge are not only imported low cost chemicals but also domestically refined lead . The remaining compounds are produced using exclusively domestically produced ore. The largest consumption corresponds to litharge, and the largest portion of this consumption corresponds to fabrication of glass vacuum tubes of glass and polyvinyl chloride stabilizer. Here we will concentrate on these two items.

Table 3-2-2 Inorganic chemical gross amount-lead content shipping for the year 2000 (unit : t)

Content	Red lead	Litharge				White lead	Chrome yellow	Molybdenum Red	Total	Resource Statistics	Difference
			Vacuum tube glass	Polyvinyl chloride	Others						
Dom. ship. amount	5,612	26,380	11,488	9,671	5,221	190	3,559	1,200			
Lead amount	5,107	24,533	10,684			152	2,278	768	32,838	38,302	5,464
Imports	2,260	50,304	40,243		10,061	-	0	-	-		
	2,057	46,783	37,426						48,839		
Exports	29	66				-	619	-	-		
For dom. consumption	7,843	76,618	51,731	9,671	15,282	190	2,940	1,200	-		
Lead content (%)	91	93	93			80	64	64	-		
Lead amount	7,137	71,255	48,110	8,994	14,212	152	1,882	768	81,193		

Source: Statistics from the Japan Inorganic Chemical Industry Association, Customs Clearance Statistics of the Finance Ministry, interviews with producers, etc.

Table 3-2-3 Inorganic chemical gross amount-lead content shipping for the year 2001 (unit :t)

Content	Red lead	Litharge				White lead	Chrome yellow	Molybdenum Red	Total	Resource Statistics	Difference
			Vacuum tube glass	Polyvinyl chloride	Others						
Dom. ship. amount	4,334	19,261	7,132	8,001	4,128	174	2,800	1,168			
Lead amount	3,944	17,913				139	1,792	748	24,535	29,325	5,160
Imports	1,647	29,064	23,251		5,813	-	0	-	-		
Exports	138	88			88	-	495	-	-		
For dom. consumption	5,843	48,237	30,383	8,001	9,853	174	2,305	1,168	-		
Lead content (%)	91	93				80	64	64	-		
Lead amount	5,434	44,860	28,256	7,441	9,163	162	2,144	1,086	53,686		

Source: Statistics from the Japan Inorganic Chemical Industry Association, Customs Clearance Statistics of the Finance Ministry, interviews with producers, etc.

Table 3-2-4 Inorganic chemical gross amount-lead content shipping for the year 2002 (unit:t)

Content	Red lead	Litharge				White lead	Chrome yellow	Molybdenum Red	Total	Resource Statistics	Difference
			Vacuum tube glass	Polyvinyl chloride	Others						
Dom. ship. amount	4,532	19,020	8,520	6,537	3,963	161	2,751	1,057			
Lead amount	4,124	17,689				129	1,761	676	24,379	29,337	5,341
Imports	1,308	26,556	21,245		5,311				-		
Exports									-		
For dom. consumption	5,840	45,576	29,765	6,537	9,274	174	2,751	1,168	-		
Lead content (%)	91	93				80	64	64	-		
Lead amount	5,431	42,386	27,681	6,079	8,625	162	2,558	1,086	51,623		

Source: Statistics from the Japan Inorganic Chemical Industry Association, Japna Exports & Imports Statistics of the Finance Ministry, interviews with producers, etc.

(2) Vacuum tube glass (glass for CRT[cathode ray tube])

A large amount of litharge (PbO) is imported from China. This litharge has a relatively low purity, but it can be used for vacuum tubes glass . On the other hand, most of the primary refined lead domestically is supply for other uses, such as storage batteries or polyvinyl chloride stabilizer. In particular, polyvinyl chloride stabilizer requires a high purity ore and the final product is exported. For a long period, production of electric appliances (including TV sets) has been being shifted to overseas, but the production of glass vacuum tubes, especially of large diameter, had remained in Japan. However, in 2002, Asahi Glass shifted a large portion of production to overseas plants, and Nippon Electric Glass announced the shift of production to overseas locations in 2004.

Table 3-2-5 Chemical composition of vacuum tube glass (units: %)

	Monochrome vacuum tube	Color vacuum tube glass		subj. of investigation	
	P,F	P	F	P	T (＊1)
SiO2	64〜67	59〜61	51〜52		
Al2O3	2〜4	2	3〜5		
Na2O	7〜9	7〜8	5〜7		
K2O	6〜8	6〜8	8〜9		
SrO		8〜10		9	6.0
BaO	11〜12	6〜10		8	5.3
CaO		0〜3			
PbO	3.5		21〜24	22.5	7.5
ZrO2		1〜3			
CeO2	0〜0.2	0.2〜0.4		0.3	0.2
SbO3	0.2〜0.5	0.3〜0.5			
MgO		0〜0.5	2		
ZnO		0〜0.5			
TiO2		0.4〜0.5			
Fe2O3	0〜0.2				

*1 The total amount of vacuum tube glass is estimated from the weight rate P(panel): F(funnel) = 2:1

Table 3-2-6 Vacuum tube glass (CRT) production and rare metal oxide demand (unit : t)

		CRT glass prod.			Rare metal oxide demand			Metal demand		
		Color	Monochrome	Total	PbO	BaO	SrO	Ba	Sr	Pb
		(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)
					(1)×0.O75+(2	(1)×0.053+(2)×0.0	(1)×0.06	(4)×0.8956	(5)×0.8456	(3)×0.9283
1	1989	514,187	87,863	602,050	41,639	36,917	30,851	33,063	26,088	38,654
2	1990	575,357	51,995	627,352	44,972	36,213	34,521	32,433	29,191	41,747
3	1991	613,596	36,763	650,359	47,306	36,565	36,816	32,747	31,131	43,915
4	1992	585,322	32,733	618,055	45,045	34,623	35,119	31,008	29,697	41,815
5	1993	641,629	23,972	665,601	48,961	36,643	38,498	32,818	32,554	45,451
6	1994	754,249	14,709	768,958	57,083	41,593	45,255	37,251	38,268	52,991
7	1995	764,557	10,109	774,666	57,696	41,634	45,873	37,287	38,791	53,559
8	1996	685,561	10,638	696,199	51,789	37,505	41,134	33,589	34,783	48,076
9	1997	656,835	4,147	660,982	49,408	35,268	39,410	31,586	33,325	45,865
10	1998	637,213	3,136	640,349	47,901	34,117	38,233	30,555	32,330	44,466
11	1999	668,606	1,166	669,772	50,186	35,564	40,116	31,851	33,922	46,588
12	2000	749,180	659	749,839	56,212	39,779	44,951	35,626	38,010	52,181
13	2001	583,854	581	584,435	43,809	31,008	35,031	27,771	29,622	40,668
13'	2001			548,784	41,159	29,086	32,927	26,049	27,843	38,208
14	2002	562,649	511	563,160	42,237	29,847	33,790	26,731	28,572	39,209
14'	2002			510,223	38,267	27,042	30,613	24,219	25,887	35,523

Source: Data on CRT glass production based on Electric Glass Industry Association statistics.
Note: The above amount of metal oxide is estimated from Table 3-2-5, Chemical composition of vacuum tube glass.

Table 3-2-7 PbO supply for vacuum tube glass (units: t)

	PbO imports		PbO prod. for vacuum tubes	Est. PbO demand	Notes
	(1)	(2)	(3)	(4)	(5)
		(1)×α		(2)+(3)	
1989	33,724	30,352	22,366	52,718	α=0.9
1990	31,832	28,330	19,627	47,957	α=0.89
1991	34,157	30,058	20,710	50,768	α=0.88
1992	23,077	20,077	18,420	38,497	α=0.87
1993	35,133	30,214	20,159	50,373	α=0.86
1994	51,808	44,037	19,167	63,204	α=0.85
1995	55,069	46,258	16,694	62,952	α=0.84
1996	47,676	39,571	13,374	52,945	α=0.83
1997	37,673	30,892	10,611	41,503	α=0.82
1998	36,879	29,872	11,373	41,245	α=0.81
1999	37,815	30,252	10,074	40,326	α=0.80
2000	50,304	40,243	11,488	51,731	α=0.80
2001	29,064	29,064	7,132	36,196	α=1.00
2002	24,933	24,933	6,400	31,333	α=1.00

Source: Data on production of PbO for vacuum tubes glass is based on Japan Inorganic Chemical Industry Association statistics. PbO imports are based on monthly reports for Japna Exports & Imports Statistics of the Finance Ministry

Note: The grade of PbO for use in vacuum tube glass is not too high and PbO imports are almost exclusively used for vacuum tubes. Ten years ago, this share was 90%, changing later to 80% (α in the table), to return to the current 100% level. Comparing data from Japan Inorganic Chemical Industry Association statistics and the amount of glass manufactured, it is apparent that the actual amount for 1999 (estimated from glass statistics) is a little larger than the statistics.

Table 3-2-8 Estimation of SrO supply for vacuum tube glass (units: t)

	Imports		Vacuum tube glass prod.Total input		Est. raw material supply			
	SrCO3	SrO	SrCO3	SrO	Gross SrO	Sr	SrCO3	net SrO
	(1)	(2)	(3)	(4)	(5)	(6)		(7)
		(1)×0.7019		(3)×0.7019	(2)+'(4)	(5)×0.8456	(5)/0.7019	(5)-20000
1989	35,749	25,092	19,271	13,526	38,619	32,656	55,020	
1990	36,524	25,636	20,452	14,355	39,991	33,817	56,976	
1991	37,446	26,283	20,290	14,242	40,525	34,268	57,736	
1992	37,595	26,388	18,320	12,859	39,247	33,187	55,915	
1993	55,422	38,901	19,486	13,677	52,578	44,460	74,908	32,578
1994	70,950	49,800	21,061	14,783	64,583	54,611	92,011	44,583
1995	64,262	45,105	22,713	15,942	61,048	51,622	86,975	41,048
1996	55,827	39,185	22,590	15,856	55,041	46,543	78,417	35,041
1997	58,423	41,007	21,254	14,918	55,925	47,290	79,677	35,925
1998	59,991	42,108	21,040	14,768	56,876	48,094	81,031	36,876
1999	69,632	48,875	19,855	13,936	62,811	53,113	89,487	42,811
2000	81,338	57,091	22,659	15,904	72,995	61,725	103,997	52,995
2001	52,856	37,100	13,132	9,217	46,317	39,166	65,988	26,317
2002	60,490	42,458	13,508	9,481	51,939	43,920	73,998	31,939

Reports indicate that imports of $SrCO_3$ are used almost exclusively for vacuum tube glass, and the imports were added to vacuum tube glass.

When Japan Inorganic Chemical Industry Association statistics and the amount of glass manufactured are compared, it is apparent that, from year 1993, the association statistics are almost 20,000 t larger. This may be caused by Honjo Chemical Corporation producing overseas for export to Japan (double count).

(3) Polyvinyl Chloride Stabilizer

Table 3-2-9 Domestic shipping of PbO for use as a Polyvinyl Chloride Stabilizer

	Domestic shipping
1989	11554
1990	12187
1991	11688
1992	11346
1993	11323
1994	10957
1995	10057
1996	11582
1997	11127
1998	9930
1999	10212
2000	9671
2001	8001
2002	6537

Source: Domestic shipping of PbO for use as a Polyvinyl Chloride Stabilizer from Japan Inorganic Chemical Industry Association statistics

(a) Polyvinyl Chloride Stabilizer consumption by application[1)]

1- In polyvinyl chloride for cable sheathing Pb has been substituted by Ca-Zn,

Sn has substituted Pb in polyvinyl chloride for construction (pipes, substitution started in 2000)

2- Toyota Motor Corp. (Sumitomo Electric Industry, Yazaki) has started a substitution process to Ca-Zn in 1998. Other automobile manufacturers have been following this trend.

3- In home appliances, substitution of electric wire has been carried out. In other products, there is substitution of electric wire used in electric equipment.

Electric appliance manufacturers excluding Panasonic and Sony have not yet conducted substitution.

(b) Items still using Pb for polyvinyl chloride

- Sewage pipes

- Cable insulation for values lower than 600V (mainly CV, VVF for building wiring)

- High voltage wire over 6600v (for electric power). It is estimated that approximately more than 60% of the Polyvinyl Chloride used in Japan for electric wire contains Pb as a stabilizer (this is under investigation by the Japanese Electric Wire & Cable Makers' Association).

(c) The recent status of use of polyvinyl chloride stabilizer newspaper articles [2)]

Currently, half of the polyvinyl chloride stabilizer contains lead. Elimination of Pb from the polyvinyl chloride stabilizer started 30 years ago. In 1994, with the enforcement of a standard for water quality (0.05 mg/l or less)[*1] use of Pb stabilizer in pipes for water supply and connection (stiff plastic) stopped. Sn became the main substitute for Pb. Public works stagnation has also contributed to a decline in the number of water supply works, as new facility investement have completed a round.

Sewage pipes made of rigid plastics containing Pb are being used as before.

Food packaging material of soft plastic films has shifted to barium and zinc. There is still use of stabilizer for packing films and vinyl films for agricultural use, but also for these applications substitution by polyethylene has advanced.

Up to this point, the best market for Pb stabilizer was soft plastic insulation for cables, but the plan of the Japan Automobile Manufacturers Association to diminish the use of Pb aims at a reduction for the year 2005 to 1/3 of the level in the year 1996. Wire harnesses and battery cables have shifted to calcium-zinc. Recently there has also been a tendency for substitution from Pb in electric appliances.

The main polyvinyl chloride stabilizer producers are Sakai Chemical Industry, Mizusawa Industrial Chemicals, Shinagawa Chemical Industry, Kikuchi Colors, etc.

*1) In December of 1992, the Ministry of Health, Labour and Welfare revisited the standard for lead content in drinking water. The standard was tightened from 0.1 mg/l to 0.05 mg/l[3)].

3.2.3 Discard and recycling of inorganic chemicals

(1) Discard and recycling of used vacuum tube glass

(a) Discard of used TV sets

1- Discard of used TV sets

The data of the number of electric appliances for discard have been estimated above. From recent surveys, it is apparent that the amount of electrical appliances retained in dead storage is larger than expected. Because of this result, the amount of TV sets fordiscard has been estimated. The Japan Association for Electric Home Appliances report from the 1997 survey is summarized in Table 3-2-10. However, after enforcing of the Electric Appliance Recycling Law in April 2001, the number of home appliances collected, presented in Table 3-2-11, 1/3 of the estimated discard for TV sets and 1/2 for other home appliances, is unexpectedly low. In the year 2001, the retention amount of electrical appliances (Table 3-2-12), and the average retention number of years (Table 3-2-13) are calculated. From Table 3-2-12 and Table 3-2-13, the number of TV sets for discard disposal is calculated.

107,890,000 sets / 12.5 years = 8,631,200 sets

This figure is assumed to correspond to the number of TV sets for disposal in 2000.

Table 3-2-10 Waste electrical appliances for discard (units: one thousand)

	1997	1998	1999	2000	2001	2002
Color TVs	7,937	8,280	8,687	9,031	9,175	9,102
Refrigerators	3,937	3,822	3,940	4,071	4,210	4,331
Washing machines	3,925	4,075	4,294	4,530	4,719	4,817
Air conditioners	2,678	2,666	2,774	3,023	3,378	3,788
Total	18,289	18,853	19,695	20,655	21,482	22,038

Source: Association for Electric Home Appliances. Total environment handbook. March 2003

Table 3-2-11 Receiving number at designated places (units: one thousand)

]	TV sets	Air conditioners	Refrigerators	Washing machines
2001	3,083	1,334	2,191	1,930
2002	3,520	1,836	2,565	2,426

Source: Association for Electric Home Appliances home page (year data)

Table 3-2-12 The retention number of electric appliances (year 2001. units: 10,000)

	TV sets	Refrige rator	Washing machines	Refrigerat ors	Total
Est. from Num.of retained units for 100 hundred households for46,790,000 households	230 台 10,789	121 台 5,600	109 台 5,132	217 台 10,172	677 台 31,693

Source: Industrial Structure Council Report. Electric appliances industry handbook, year 2001

Table 3-2-13 Trends of average service life of electrical appliances

	TV sets	Refrigerators	Washing machines	Air conditioners
survey in 2001 1)	12.5	13.4	11.3	14.0
Est. in 1997 2)	11.8	12.1	10.9	15.6

Source: Industrial Structure Council Report
1) Data from 8,000 units received at designated places
2) Calculated from a survey of retention status in 4,700 households.

(b) The domestic recycling number of used TV sets (total number of used TV sets for discard subtracted by the amount for export) The figure shown in Table 3-2-14, for example domestic market for used TV and for export amounts is 2.5%. The number of TV sets available for domestic recycling constitutes 4,962,940, that is 7.5%. However, according to some information , in 2000, the exports of used TV sets exceeded 50%. Taking this into account, if this value is added to the 5% of the domestic market for used goods, it amounts to 55%, and the number of TV sets available for domestic recycling becomes 3,884,040, that is 45%. This value seems to be more accurate.

Table 3-2-14 The used electrical appliances number for domestic and overseas markets (year 1999, units: 10,000)

	Est.No. discarded	Domestic market for used appliance	Overseas market for used appliance
TV sets	868.6	42.8 (4.9%)	326.8 (37.6%)
Refrigerators	394.0	18.2 (4.6%)	36.3 (9.2%)
Washing machines	429.4	30.6 (7.1%)	23.8 (5.6%)
Air conditioners	277.3	5.2 (1.9%)	91.7 (33.1%)
Total	1,969.3	96.8	478.6
Ratio	100%	4.9%	24.3%

(c) Amount of discard vacuum tube glass for TV sets (conversion of oxides)

Tables 3-17-1 to 3-17-9 show the unit weights of vacuum tube glass, “TV CRT production estimation by year.”

According to some information, calculation of the amount of oxides PbO, SrO, as well as vacuum tube glass from spent CRTs in the year 2000 was carried out assuming an average weight of 10 kg per CRT in the discarded TV sets.

From the above table, during the years 1986 and 1987, the average production weight was 10 kg. The service life of a TV set can be assumed to be 13.5 years. However, Table 3-2-13 shows the official value for TV service life is 12.5 years. In this report, we assume an intermediate value of 13 years.

Table 3-2-15 Discarded amount of used vacuum tube glass (glass, PbO, SrO)

	Num. of discarded units of VTG (units : thou.)	Num. of dom. discarded units of vtg	Weight of dom.discarded VTG (t)	Weight of PbO in VTG	Weight of SrO in VTG
	(1)	(2)	(3)	(4)	(5)
		(1)× α	(2)× β	(3) × 0.075	(3)×0.06
2000	8686	3909	44,950	3,371	2,697
2001		3083	41,312	3,098	2,479
2002		3520	52,096	3,907	3,126

Note 1: VTG→vacuum tube glass

Note 2: Estimated using the domestic rate of recycling as α=0.45 from Table 3-2-14. Estimation for the years 2000 and 2001 was not performed as data on collection is found in Table 3-2-11.

Note 3: Each the unit weight for used vacuum tubes (β) is assumed from the figure for shipping 13 years ago. In 2002, this value is 11.5 kg (1987 as the unit weights), in 2001 it is 13.4 kg (1988), and in 2002 it is 14.8 kg (1989).

Note 4: Ratio Pb/PbO=0.928315, Sr/SrO=0.8456

Note 5: The 0.075 in column 4 and 0.06 in column 5 are cited from Table 3-2-5 "Chemical composition of vacuum tube glass."

(1)- Amount of recycled vacuum tube glass from used TV sets in 2000

The amount of recycled glass in 2000 is 2000 to 3000 t (as glass weight,150 ~ 225 t as PbO, and 139~209 t as lead metal). Relative to the total amount of discarded material (99,889 t), the maximum rate of recycling is about 3%. For the amount actually available for recycling (57,431 t), it is only 3.48 ~ 5.2%, a relatively small portion. It is assumed that the remaining amount of material is used for landfill Besides the TV sets, CRT (vacuum tubes) can be also found in personal computers but the diameter is small, and the amount of glass is one or two orders of magnitude lower than for TV sets, therefore this amount is not taken into account.

(2)- Amount of vacuum tube glass recycled from used TV sets in 2001

The Electric Appliance Recycling Law was enforced in April, 2001, contributing to a trend in the marked increase in the amount of vacuum tube glass recycled.

- PbO

Table 3-2-6 shows that the amount of PbO consumed in vacuum tubes is 43,817 t, according to an estimation of the Electric Glass Industry Association.

When compared, the imports and production of PbO amount to 36,196 t (Table 3-2-7), whereas the amount discarded of used vacuum tube glass adds to 3,098 t (Table 3-2-15). In total there is 39,294 t, which is 5,000 t short of the above amount. This can be interpreted as follows. In Table 3-2-3 the Japan Inorganic Chemical Industry Association reports imports of vacuum tube glass of 23,251 t (of Pb)a total shipping of 24,379 t (of Pb), whereas from the Resource Statistics the amount of Pb consumption in inorganic chemicals is 29,325 t (of Pb), indicating a deficit of 5,160 t (Pb) in the Japan Inorganic Chemical Industry Association statistics (5,560 t (PbO)). On the other hand, in Table 3-2-7, 80% of imports of PbO for the year 2001 are consumed in the production for for vacuum tubes glass, but recently, consumption has shown a declining trend. Since the time of the hearing, it seems that there has been an increase in the consumption of glass for vacuum tubes. Assuming that all the imports are consumed in vacuum tubes glass, the difference of PbO imports for vacuum tubes glass becomes 5,813 t. If the deficit for the Japan Inorganic Chemical Industry Association and the increase in imports for use in vacuum tubes are added, it becomes 11,373 t and it is possible to find an explanation for the apparent discrepancy of 10,000 t. At least, it has been concluded that 100% of the PbO in used vacuum tubes available for recycling is surely being recycled.

•SrO

Using statistics from the Electric Glass Industry Association in Table 3-2-6 it is estimated that the consumption of SrO in vacuum tubes glass is 35,037 t. Imports and production of SrO are presented in Table 3-2-7 and when compared to the amount discarded of used vacuum tube glass in Table 3-2-15, imports and production amount to 26,317 t, whereas discarded is 2,479 t for a total of 28,796 t. As a result the input of raw material is small. However, during the previous year in 2000, there was a large amount of imports of SrO, 52,996 t- 44,951 t = 7,945 t in excess. If we assume that this excess was added to the amount of the following year, we have 26,317 t + 7,945 t = 34,262 t. In conclusion, the difference between input and consumption of SrO, 35,037 t - 34,262 t= 775 t that was not added. This value corresponds to 1/3 of the amount of SrO discarded of used TV sets. The remaining 2/3 has not been consumed, but as the excessive amount of imports in the year 2001 may be the cause of this excess import, it seems more appropriate to explain this by the data in 2002.

(3)- Recycling of vacuum tube glass in 2002

・PbO

Table 3-2-6 shows that the amount of PbO consumed in vacuum tubes is 42,237 t, according to an estimation of the data regarding the Electric Glass Industry Association statistics. Imports and production (supplement) of PbO are 33,453 t + 5,341 / 0.928315 t = 39,206 t, the difference from consumption of PbO amounts to 3,031 t.

Table 3-2-15 shows that the amount of PbO amount discarded of used TV sets is 3,907 t, and it is assumed that this amount is fully consumed in the production of vacuum tubes glass.

・SrO

From the statistics from the Electric Glass Industry Association in Table 3-2-6, it is estimated that the consumption of SrO in the production of vacuum tubes glass is 33,790 t. From Table 3-2-8, the total amount of imports and production of SrO is 31,933 t, a difference of 1,857 t if compared with consumption of SrO for vacuum tube glass. According to Table 3-2-15, the amount of SrO discarded of used TV sets is 3,126 t, approximately only half of the total, so half remains unconsumed.

When studying to recycle used vacuum tubes started in 1999, it was supposed that it would be consumed mainly in the black glass of panel glass, which was at its peak of production. However, there was a sudden increase in the consumption of clear glass . The recycled glass cannot be used to clear glass. It can be used for funnel glass and for the current production of black panel glass. Studies in 2002 show that recycling rate of SrO containing panel glass is about 1/2. The panel glass comprises approximately 2/3 of the total amount of vacuum tubes glass, with the remaining 1/3 being for funnel glass. In other words, half of the panel glass 2/3 x 1/2 = 1/3 and 1/3 of the total of funnel glass are recycled, and the remaining 1/3 is not recycled. It is possible that the amount discarded of used vacuum tubes glass not recycled will gradually increase.

Starting from August 15, 2002, China stopped the importation of waste electrical appliances and electronic equipment, changing drastically the recycling situation of vacuum tube glass from TV sets.

Before more than 10 years production of electrical appliances (including TV sets) has been being shifted overseas, but the production of glass vacuum tubes, especially ones of large diameter, had remained in Japan. However, in 2002 Asahi Glass Co ,Ltd shifted a large portion of production to overseas plants, and Nippon Electric Glass Co,Ltd announced the shift of production to overseas locations in 2004. In this way, the recycling of vacuum tube glass has stopped, but the Electric Appliance Recycling Law has become the framework for a high ratio of recycling of TV sets. Regarding the recycling of vacuum tube glass, a meeting between the Ministry of Economy, Trade and Industry of Japan and representatives of the Chinese Government was carried out in August, but an accord on a joint recycling operation based on the Basel Convention could not be reached. Currently, it seems that Thailand and Japan are having talks on this topic.

Table 3-2-16 CRT (vacuum tube glass) weight

Size (in)	KG		
(1)	(2)	(3)	(4)
		(2)/(1)	(3)/(1)
13	4.2		0.025
14	5.1	0.36428571	0.0260204
15	6.2	0.41333333	0.0275556
17	9.0	0.52941176	0.0311419
19	10.5	0.55263158	0.0290859
20	11.5	0.57500000	0.0287500
21	15.0	0.71428571	0.0340136
22	16.2		0.0335000
23	17.7		0.0335000
24	19.3		0.0335000
25	20.9		0.0335000
29	28.5	0.98275862	0.0338882
32	38.0	1.18750000	0.0371094
36	56.0	1.55555556	0.0432099
38	70.0	1.84210526	0.0484765

Source: Nippon Electric Glass
Note: Data for 13 in, 22-25 in is not included. Figures for column 4 are estimated as 0.025, 0.0335, respectively.

Table 17-1 Estimation of average CRT weight from shipping number and TV size in 1986

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	4035	14	5.1	20578.5		Typical weight is as the typical size
16～21	3142	18.5	9.75	30634.5		
22～25	429	23.5	18.5	7936.5		
26～29	664	27.5	24.7	16400.8		
30～	0	36	56	0		
	8270			75550.3	9.1354655	

Source: JEITA Consumer Electric Equipment Data, March 2003, for domestic shipping figures by TV size

Table 17-2 Estimation of average CRT weight from shipping figures by TV size for 1987

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	3468	14	5.1	17686.8		Typical weight is as the typical size
16～21	3362	18.5	9.75	32779.5		
22～25	781	23.5	18.5	14448.5		
26～29	1368	27.5	24.7	33789.6		
30～	90	36	56	5040		
Total	9069			103744.4	11.439453	

Table 17-3 Estimation of average CRT weight from shipping figures by TV size for 1988

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	2782	14	5.1	14188.2		Typical weight is as the typical size
16～21	3363	18.5	9.75	32789.25		
22～25	1153	23.5	18.5	21330.5		
26～29	2075	27.5	24.7	51252.5		
30～	132	36	56	7392		
計	9505			126952.45	13.356386	

Table 17-4 Estimation of average CRT weight from shipping figures by TV size for 1989

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	2506	14	5.1	12780.6		Typical weight is as the typical size
16～21	2953	18.5	9.75	28791.75		
22～25	1369	23.5	18.5	25326.5		
26～29	2409	27.5	24.7	59502.3		
30～	246	36	56	13776		
計	9483			140177.15	14.781941	

Table 17-5 Estimation of average CRT weight from shipping figures by TV size for 1990

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	2419	14	5.1	12336.9		Typical weight is as the typical size
16～21	2577	18.5	9.75	25125.75		
22～25	1397	23.5	18.5	25844.5		
26～29	2347	27.5	24.7	57970.9		
30～	308	36	56	17248		
計	9048			138526.05	15.310129	

Table 17-6 Estimation of average CRT weight from shipping figures by TV size for 1991

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	2596	14	5.1	13239.6		Typical weight is as the typical size
16～21	2679	18.5	9.75	26120.25		
22～25	1382	23.5	18.5	25567		
26～29	2024	27.5	24.7	49992.8		
30～	333	36	56	18648		
計	9014			133567.65	14.8178	

Table 17-7 Estimation of average CRT weight from shipping figures by TV size for 2000

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	2934	14	5.1	14963.4		Typical weight is as the typical size
16～21	2928	18.5	9.75	28548		
22～25	1596	23.5	18.5	29526		
26～29	1602	27.5	24.7	39569.4		
30～	813	36	56	45528		
計	9873			158134.8	16.016895	

Table 17-8 Estimation of average CRT weight from shipping figures by TV size for 2001

Inch	Thou. units	Typical size	Kg/unit	t	Average (kg/unit)	Notes
～15	2831	14	5.1	14438.1		Typical weight is as the typical size
16～21	2790	18.5	9.75	27202.5		
22～25	1514	23.5	18.5	28009		
26～29	1720	27.5	24.7	42484		
30～	777	36	56	43512		
計	9632			155645.6	16.159219	

Table 17-9 Estimation of average CRT weight from shipping figures by TV size for 2002

Inch	Thou. uni	Typical	Kg/unit	t	Average (kg/unit)	Notes
～15	2387	14	5.1	12173.7		Typical weight is as the typical size
16～21	2474	18.5	9.75	24121.5		
22～25	1279	23.5	18.5	23661.5		
26～29	1597	27.5	24.7	39445.9		
30～	697	36	56	39032		
計	8434			138434.6	16.413872	

References

1) Vinyl Environmental Council hearing of March 2003

2) The Chemical Daily (January, 2003)

3) Japan Water Research Center: Report on Evaluation of Guidelines for technology for removal of lead from water supply pipes (Commission from the Ministry of Health, Labour and Welfare in the year 1999), March 2000.

3.3 Solder

3.3.1 Lead supply for solder

The next table shows "other non-ferrous products production" and "Demand and Supply Statistics." Until 1998, "other non-ferrous products production" included lead tubes, lead sheets, anti-friction alloys, and solder, cast alloys blocks, but from the year 1999, only statistics concerning solder and cast alloys blocks are being compiled.

Comparison between Demand and Supply Statistics and Production Statistics during the years 1990 to 1998 corresponds to comparison between columns d and f. It is observed that the amount of lead for solder in d is approximately 1000 t lower than in f. This difference can be attributed to the consumption of lead for cast alloys blocks . After 1999, the lead consumption is the difference between columns d and j, and the statistics include cast alloys blocks besides solder. The figures in column d and j are identical from 1999 until the year 2001, which is attributed to the fact that Demand and Supply Statistics and production statistics come from the same source. Values for demand statistics for the year 2002 are extremely large, but this is due to a mistake such as a transcription etc.

3.3.2 Lead consumption in solder production

(1) Lead consumption for circuits boards

The largest consumption of "solder" takes place during production of circuits boards (printed circuits). Table 3-3-1 deals with circuits boards from machinery statistics. Statistics from the Japan Printed Circuit Association are presented in Table 3-3-2. Figures from machinery statistics refer to plants with more than 50 employees, but as small and medium enterprises produce a large rate of one sided or double sided printed boards, it seems that a

Table 3-3-1 Lead supply for solder (units: t)

	(1*) Demand and Supply Statistics in Resource					(2*) Other non-ferrous products production									
	Refined lead	Recycled lead	Scrap	Total	Scrap containing ratio(%)	revised	Lead	Recycled lead	Lead scrap	Total	Lead tubes and sheets	Anti-friction alloy	Lead amount of anti-friction alloy	solder	Lead amount of solder
	a	b	c	d	e	f	g	h	i	j	k	l	m		
					(b+c/d)*100	j-k-m				g+h+i					
1990	14233	3881	2038	20152	29.37	21184	24027	5197	2440	31664	10170	621	311	36796	17147
1991	13139	3756	2034	18929	30.59	20023	23242	5053	2448	30743	10449	543	272	36380	16953
1992	11262	2931	28	14221	20.81	16978	21902	3990	2120	28012	10717	634	317	31248	14562
1993	10526	3114	1543	15183	30.67	16129	20329	4111	2044	26484	9934	843	422	29600	13794
1994	9824	3106	1655	14585	32.64	15195	19255	4153	1975	25383	9870	637	319	28799	13420
1995	9449	2641	2014	14104	33.00	14993	19650	3610	2366	25626	10322	623	312	29862	13916
1996	8666	1920	2672	13258	34.64	14492	19805	2835	3123	25763	10959	625	313	28873	13455
1997	8794	1824	2423	13041	32.57	14425	19687	3121	3052	25860	11145	580	290	28712	13380
1998	7081	1819	1680	10580	33.07	11598	17380	3039	2386	22805	10910	595	298	24828	11570
1999	7048	2332	1880	11260	37.41		2332	7048	1880	11260				24425	11382
2000	7654	2485	1857	11996	36.20		7654	2485	1857	11996				27825	12966
2001	6266	2179	1659	10104	37.98		6266	2179	1659	10104					
2002	6833	2335	5142	14310	52.25		6817	2335	1531	10683					
2003	6524	2120	1317	9961	34.50										

Source: Years 1990 to 2001 → Demand and Supply Statistics of the Resource Statistics 2002 →Iron and Steel, ,non-ferrous alloys and fabricated metals statistical report

Note 1: The figure, 14310 for solder demand in year 2002 from (*1) the Demand and Supply Statistics is not reliable, because the waste rate 52.25% is too large. This can be attributed to the fact that, from 2002, these statistics are no longer “designated statistics” (with penalty).

Note 2: Demand and Supply Statistics from the demand side for solder were, until 1999, collected exclusively as solder.

Note 3: Since 1999, lead tubes and sheets and anti-friction alloys were excluded from “other non-ferrous products” of the designated statistics. Solder and cast alloys blocks remain.

Note 4: According to JIS standards, anti-friction alloys are called white metal, usually known as babbit metal. With a lead content of 45 to 85%, its use in high-speed bearings has been decreasing. As a typical composition is not known, the amount of lead has been estimated as half of the amount of metal.

large portion of the data is missing. However, as the Japan Printed Circuit Association presents only recent data, to observe the past variation it becomes necessary to rely on the data from machinery statistics. This is enough to obtain an overall view of the general trend.

Tables 3-3-1 to 3-3-3 and Figure 3-3-1 show that the production of printed circuits until the year 1994 and the consumption of solder are in good agreement. From this year, the production of printed circuits increases noticeably, whereas there is a decrease in solder consumption. As is written in Tables 3-3-1 to 3-3-3, the cause of this decrease is attributed to the decrease of production of one sided or two side printed circuits, which consume large amounts of solder, whereas the production of multi-layer or flexible circuits, with a low rate of solder consumption, increased.

The lowest line of Figure 3-3-1 shows a sudden increase in the consumption of lead in 2002, but in the year 2003 consumption goes back to its previous level.

Observing monthly Demand and Supply Statistics for the year 2002, it is noticed that, starting in January 2002, figures corresponding to “waste or scrap lead” demand increased from a regular level of 100 t /month to 400 t/month, and this trend continues until December 2002, going back to its previous level in January 2003. As can be observed in Table 3-3-3, for the Demand and Supply Statistics from the year 2000 the data presentation changed from individual values for “solder” to combined values for “solder and copper alloys blocks.” However, the reason for the sudden increase in demand of “waste or scrap lead” is not clear.

Starting in April 2003, stricter standards for lead content in tap water were enforced, and in consequence it was supposed that there would be a rush of preventive buying which would increase demand. This directive was promulgated in February 2001, and it would be understandable that preventive buying started from this date. However, this phenomenon has not been observed. On the other hand, there is no noticeable increase in production of products using lead scrap, making it very probable that the sudden increase in statistics is just a compilation error. The figure of 11,310 t (other non-ferrous products production:10,383), reached after subtraction of 3000 t from the total corresponding to the year 2002, seems to be in the appropriate range.

Table 3-3-2 Production of printed circuit boards from machinery statistics (units: 1000 m^2)

	Printed circuit	Rigid circuit boards	One-sided circuit	Two-sided circuit	Multi-layer circuit boards	Flexible circuit boards
	a	b	c	d	e	f
	c+d+e;f	c+d+e				
1990	36655	34596	21963	7370	5262	2059
1991	34127	31990	18917	7808	5266	2136
1992	28107	26181	14536	7282	4364	1926
1993	26486	24302	13743	6904	3655	2184
1994	26537	24174	13550	6446	4178	2363
1995	30827	26662	14638	6833	5192	4165
1996	30665	26188	14121	6498	5570	4477
1997	38346	32063	17261	8488	6314	6283
1998	36853	30395	16098	7986	6312	6457
1999	36437	29189	14209	7578	7403	7248

Source: Machinery statistics annual report

Table 3-3-3 Printed circuits boards prod. by Japan Printed Circuit Association (unit: 1000 m^2)

	Printed circuit	Rigid circuit boards	One-sided circuit	Two-sided circuit	Multi-layer circuit boards	Flexible circuit boards	Others
	a	b	c	d	e	f	
	c+d+e;f	c+d+e					
1992							
1993							
1994							
1995							
1996							
1997							
1998	51142	43867	21225	13705	8936	6767	508
1999	51029	42144	18595	13210	10339	8096	789
2000	51432	42179	16367	14004	11807	8587	666
2001	37809	30810	10634	10901	9275	6489	510
2002	36668	29085	9535	10447	9104	7024	559
2003							

Source: Japan Printed Circuit Association statistics

(2) Solder shipping by industrial sector

Data from the Tokyo Solder Tin Association are shown in Table 3-3-3. Production has been reduced to a half in the period from the year 1994 until the year 1998. This decrease has caused the secession of a leading producer from this industry.

As the share has been decreasing, it is difficult to use these data to estimate the domestic production of "solder," but they are useful for estimation of shipping ratio by each industrial sector.

In the following there are some information by members of the Tokyo Solder Tin Association pertaining to the effect of these rates on the changing conditions.

(a) Decline by each industrial sector

Automobile — Boards, automobile assembly

Improvements in metal plates and pressing processes have reduced its use to 0 level.

Radiators

Aluminum has been substituted for copper as an assembly material

Can manufacturing — 18 l (5 gallon)

Changes in joining materials (welding)

Food uses

Concentrated production of tin plates in one piece results in exclusive use of lead.

Others

Changes in welding materials or no soldering at all

Construction materials

Gutters, buckets Changed to plastic materials

Telecommunication, light electric appliance

Printed circuits

Decrease caused by size reduction of boards following the trend for lighter and smaller

(b) Others

Lead-free solder

The total production of lead-free solder is considered to be in the range 20 to 30%. Currently, there is no considerable decrease in the production of lead containing solder. However, it is estimated that domestic production of lead-free solder may reach 80% of the total, and that production of lead containing solder will decrease.

Scrap

The scrap used for soldering comes mainly from lead tubes and sheets, with almost no lead from batteries or wire sheathing. Other sources of scrap (from processing plants) are also used. (Some members of the Association)

"Production of lead-free solder comprising 20 to 30% of the total," corresponds to data for the year 2003. From Table 3-3-3, in 2003, the amount of lead used for "solder and copper alloys blocks" was 9961 t 10,000 t.

Copper radiators from waste automobiles are the source of lead for copper alloys blocks, and copper alloys blocks are the source material for production of bronze casts. In copper radiators (classified as copper scrap), solder is used for welding of the cooling copper fins, and the components of the copper and lead in this waste (Cu, Pb, Sn) can be effectively recycled. This is the reason for using these radiators as an exclusive source of material for copper alloy casting. However, since 1990, aluminum radiators have been substituted for copper radiators, and production of this waste material has decreased, making it necessary to use lead based scrap or lead mineral ore as a source material for bronze castings.

"Solder and copper alloys blocks" statistics appeared first in the year 2000, and it is not possible to estimate the amount of lead consumed in copper cast alloys blocks , but assuming a value from 500 to 1000 t, it can be estimated that the remaining 9,000 t have been used for solder. In 2003, the share of lead-free solder is set at 20%, and the total amount of lead consumed in the production of solder can be estimated as 11,000 t. This coincides approximately with the values for lead consumption corresponding to the period when the lead containing solder was mainly used.

Regarding standards for the use of lead, the automotive industry reports that "for the year 2005 it will reduce the level to 1/3 of 1996." The industry use of lead containing solder is 10% of the total amount of solder used in 2003. It will soon catch up with the electronics and electric machinery industry.

Table 3-3-4 Relationship between lead consumption for solder and printed circuit board production

	Lead consumption for solder (t) (*1)					Mach. Statistics	Indust. statistics
		Electrolytic lead (including smelted lead)	Recycled lead	Lead scra	Total	Printed circuit board prod. amout(unit: 1000 m2) (*2)	Printed circuit board prod. amout(unit: 1000 m2) (*3)
1990	Solder	14233	3881	2038	20152	36655	
1991	Solder	13139	3756	2034	18929	34127	
1992	Solder	11262	2931	28	14221	28107	
1993	Solder	10526	3114	1543	15183	26486	
1994	Solder	9824	3106	1655	14585	26537	
1995	Solder	9449	2641	2014	14104	30827	
1996	Solder	8666	1920	2672	13258	30665	
1997	Solder	8794	1824	2423	13041	38346	
1998	Solder	7081	1819	1680	10580	36853	51142
1999	Solder	7048	2332	1880	11260	36437	51029
2000	Solder and CAB	6833	2355	1857	11045	36764	51432
2001	Solder and CAB	6266	2179	1659	10104	27437	37809
2002	Solder and CAB	6833	2335	5142	14310		36668
2003	Solder and CAB	6524	2120	1317	9961		

Source: (*1) "Solder demand" on annual report of Resource Statistics. Steel, non-ferrous materials, metal products for years 2002 and 2003.
(*2) Printed circuit board production from Machinery Statistics
(*3) Printed circuit board production by the Japan Printed Circuit Association
note : CAB→copper alloy blocks

Table 3-3-5 Solder shipping amount for industrial sector (units: kg)

	1994		1998	1999	2000	2001	2002	Lead content
	Kanto Area	Japan	Kanto Area	Kanto Area	Kanto Area	Kanto Area	Kanto Area	
Mfg cans	117,071	354,000	44,128	42,762	38,140	10,830	55,340	95%
Communication light electric appliance	5,140,305	15,520,000	3,298,274	3,000,970	2,942,047	2,399,937	2,443,975	40%
Vessels	0	0	0	0	0	0	1,192	-
vehicles	675,479	2,040,000	234,615	259,111	262,628	185,380	168,602	60%
Machinery	450,948	1,359,000	425,178	417,383	468,269	439,252	478,609	50%
Others	3,213,988	9,704,000	1,211,038	1,406,087	1,773,679	1,413,725	1,599,198	55%
Total	9,597,791	28,977,000	5,213,233	5,126,313	5,484,761	4,449,124	4,693,916	

Source: Tokyo Solder Tin Association
Note 1: According to a 1994 survey, the share of the Tokyo Solder Tin Association was 33%, but this share has decreased. For the year 1994, it was 13,782 t (14,585 t according to Resource Statistics)
Note 2: Lead content corresponds to the 1994 survey. Currently there is also lead-free solder. The figure includes both.

(4) Trends in lead-free solder

Research & development on lead-free solder started in the USA, but it lost momentum there, and currently Japan leads the world of research and practical use of lead-free solders. In 2000, there was competition among the three lead-free solders mentioned above. Iowa University (USA) had the patent on the basic components of the solder shown in Table 3-3-1. On February 14 of 2001, Senju Metal Industry Co., one of the largest players in the solder industry, acquired these patent license from Iowa University . As a result the production of Sn-Ag based lead-free solder make up the majority. Compared to regular lead-containing solder, this lead-free solder is of high reliability for welding process but it presents some problems regarding the high temperature during welding which can affect the thermal corrosion resistance of the parts, as well as a higher consumption of electricity. Development and implementation of other lead-free solders remains under steady investigation.

As was described above, production of lead-free solder represents 20 to 30%, but it is not clear what the future trends for the production of lead-free solder are. The Waste Electrical and Electronic Equipment (WEEE) directive, as well as the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) were officially promulgated on February 13, 2003.

From these directives,

(a) The cost of waste disposal is born by the original electric and electronic equipment producers entering the European market.

(b) The directive must be implemented in member countries within a period of 18 months from February 13, 2003 (by August 13, 2004).

(c) Prohibition of use of six articles described in the RoHS directive will be enforced on July 1, 2006.

These six articles are:

1- Mercury (Hg)

2- Cadmium (Cd)

3- Lead (Pb)

4- Hexavalent chromium (Cr6+)

5- PBB (Poly brominated biphenyl)

6- PBDE (Poly brominated diphenyl ether)

In accordance, Japan also has been working to complete the total substitution of the above substances, including achieving 80% use of lead-free solder. There are still problems with the substitution compounds, as was described in the section pertaining to substances prohibited by the RoHS directive, such as “high fusion point solder containing lead (for example, tin lead solder containing more than 85% of lead (280 ℃).”

Figure 3-3-1 Circuit boards Prod. and lead consumption for solder

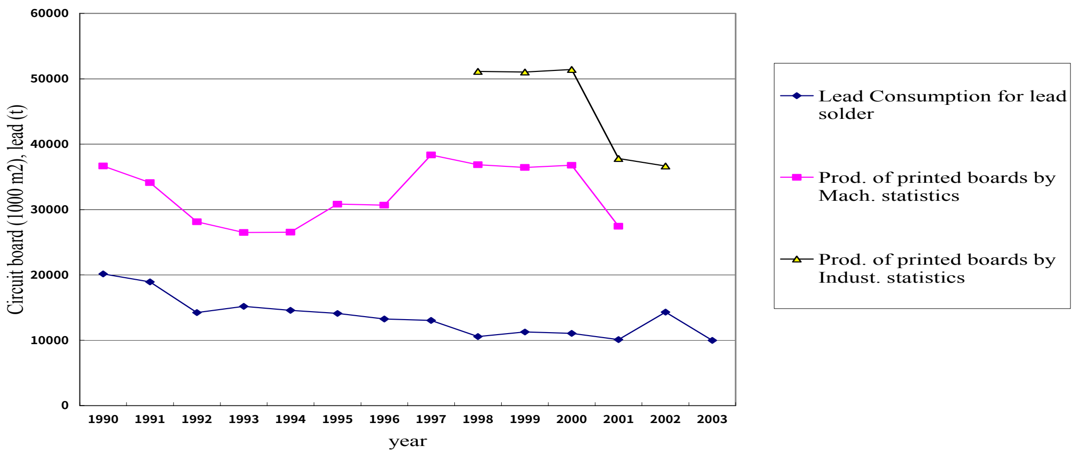


Table 3-3-6 Candidates for lead free solder [1), 2)]

			Typical composition	Melting point
1	High temp.	Sn-Ag system	Sn-3Ag-0.5Cu	217～220℃
2	Medium temp.	Sn-Zn system	Sn-9Zn	199℃
3	Low temp.	Sn-Bi system	Sn-58Bi	139℃

Table 3-3-7 Comparison between typical lead-free alloys and traditional lead solder [3)]

Item	Alloy composition	Melting temp. (℃)	Tensile strength (MPa)	Elongation (%)	Young modulus (MPa)	Specific Gravity
Lead-free alloys	Sn-3.0Ag-0.5Cu	217～220	53.5	46	41.6	7.4
Traditional lead solder	Sn37Pb	183	56	56	25.6	6.4

3.3.3 Discard and recycling of solder waste

A large portion of lead scrap from the mounting process of of circuit boards is recycled. During the years 1990 to 1995, 5,000 to 6,000 t were recycled including the recycled lead. Since 1999, this amount has decreased to 3,000 to 4,000 t. In general, lead scrap from soldering processes is not re-routed to other processes.

Copper radiators from waste automobiles provide the raw material of the copper for copper cast alloys blocks . In this case, the solder contains not only copper, but also lead and tin, which can be effectively used.

References:

1) Katsuaki Suganuma (Osaka University): Current situation of lead-free soldering mounting technologies, Seminar of the Japan Electronic Materials Society, November 17, 2000

2) Yoshihisa Kamiya, et al. (Fujitsu Co.) Practical use of a tin, zinc, and aluminum based lead-free solder. FUJITSU, 54, 2, p 154-160 (March, 2003)

3) Senju Metal Industry Co. home page.

3.4 Lead tubes and sheets

3.4.1 Lead supply of lead tubes and sheets

Table 3-4-1 Lead supply for tubes and sheets (units: t)

	Annual report of Resource Statistics (*1)					(＊2)	(＊3)		
	Refined lead	Recycled lead	Lead scrap	Total	Revised		Refined lead	Lead sheets	Total
	a	b	c	d	e	f	g	h	i
				a+b+c	f×1.055				g+h
1990	9616	1308	45	10969			5026	5144	10170
1991	9863	1282	33	11178			4432	6017	10449
1992	10384	1043	43	11470			4175	6542	10717
1993	9222	864	36	10122			3563	6371	9934
1994	9063	821	45	9929			3104	6766	9870
1995	9998	894	32	10924			2936	7386	10322
1996	11008	870	38	11916			3040	7919	10959
1997	10739	1259	87	12085			2983	8162	11145
1998	10199	1144	148	11491		10903	2820	8090	10910
1999	-	-	-	0	11500	10947			
2000	2413	448	-	2861	11204	10631			
2001	2688	433		3121	10470	9934			
2002	2413	448	2384	5245	9286	8811			
2003	2933	416	0	3349	9091	8626			

Source: (*1) Demand and supply statistics of the annual report of Resource Statistics
(*2) Japanese Association of Producers of Lead Boards and Pipes production statistics
(*3) Production statistics of non-ferrous materials in the annual report of Resource Statistics
Note: As statistics from the Japanese Association of Producers of Lead Boards and Pipes are considered reliable (column f), proportional allotment is carried for the adjustment column (column e).

The supply of lead tubes and sheets is found on “Demand and Supply Statistics” and “Production statistics for other non-ferrous materials.” As can be observed, columns f and j are similar. From the year 1999, “Production statistics for other non-ferrous materials” disappear from the table, and all statistics are consolidated as “Demand and Supply Statistics.” Also, from 1999, Demand and Supply Statistics for lead tubes and sheets are smaller than the figures provided by the Japanese Association of Producers of Lead Tubes and Sheets, suggesting low reliability of the former. The data from the association is shown in column e for comparison purposes.

3.4.2 Lead consumption for production of lead tubes and sheets

As is shown in column g of Table 3-4-1, the supply of lead tubes is decreasing year by year, whereas the amount of lead sheets is increasing. The current situation can be assessed from Table 3-4-2, with data provided by the Japanese Association of Producers of Lead Tubes and Sheets. A decline in lead Tubes is observed not only for water supply, but also for sewer Sheets.

Lead sheets show a slightly decreasing tendency, but demand has remained stable in the order of 5000 t. These lead Sheets are used not only as an anti-corrosive material for wall construction, but are also used as shelter against radiation and for sound proof rooms (lead solid parts or parts joined to gypsum plaster boards). The ratio of production is approximately 8:2. "Casting" refers to balance weight casting inside an iron frame. "Others" refers to use as energy absorbing material for earthquake resistant structures.

Table 3-4-2Production of lead tubes and sheets, casting, and others (units: t) January 23, 2004

	1998	1999	2000	2001	2002	'03 1-6	Comparison to before year(%)
Water supply tubes	341	283	268	151	25	10	83
Sewer tubes	1,899	1,778	1,589	1,175	1,010	396	87
Others	266	234	232	195	207	99	89
Total	2,506	2,295	2,089	1,521	1,242	505	88
Lead sheets	6,636	6,279	6,017	5,692	5,534	3,027	113
Casting	910	680	630	853	237	177	221
Others	851	1,693	1,895	1,868	1,798	797	91
Total	8,397	8,652	8,542	8,413	7,569	4,001	110
Total	10,903	10,947	10,631	9,934	8,811	4,506	107

Source: Japanese Association of Producers of Lead Sheets and Tubes

3.4.3 Discard and recycling of lead tubes and sheets

The following table shows the reason why almost no scrap is used in the production of lead tubes and sheets.

	Standards	Items	Lead content
	JIS standards	Lead sheets	99.5%≦
	JIS standards	Lead alloy tubes	99.9%≦(Type 1), 99.6%≦(Type 2)
	None	Lead sheets for radiation shelter	99.99%≦

Scrap cannot be used because, according to JIS standards, the amount of lead for lead tubes and sheets must be higher than 99.5%. In the case of sheets for use as radiation shelter there are no JIS standards, but the purity requirements are still higher at 99.99%.

3.5 Electric wire sheathi3.5.1 Lead supply for electric wire sheath

There is good agreement between , Demand and Supply of Resource Statistics and production statistics for electric wire sheathing . Supply and consumption of lead also coincide. These statistics for lead were halted from the year 2002. The Japanese Electric Wire & Cable Makers' Association stopped collecting data regarding lead consumption from its members. In consequence, from the year 2004, there is no data for lead containing electric wire sheathing, and domestic production statistics are lacking.

Table 3-5-1 Supply and consumption of lead for electric wire sheath

	Prod.•Demand and Supply Statistics of Resource Statistics					JERWMA Statistics
	Refined lead	Recycled lead	Lead scrap	Total	Estimation	
	a	b	c	d	e	f
				a+b+c	f*1.243	
1988	3488	1062	3106	7656		
1989	5093	415	28	5536		
1990	4750	103	27	4880		
1991	6453	474	5	6932		
1992	5775	94	16	5885		
1993	6930	26	-	6956		
1994	4483	24	22	4529		
1995	3806	30	-	3836		
1996	5309	864	-	6173		
1997	3931	148	-	4079		
1998	2851	20	-	2871		
1999	2368	10		2378		
2000	4588	-	-	4588		
2001	6440	-	-	6440		5179
2002					8854	7120
2003					10479	8427

Source: Production, Demand and Supply statistic of the annual report of Resource Statistics
Note 1: From the year 2002, lead columns for electric wiring disappeared from Demand and Supply Statistics, and Raw Material Statistics of Resource Statistics. Japanese Electric Wire & Cable Makers' Association stopped collecting the data of lead at the end of the year 2003.
Note 2: Data by the Japanese Electric Wire & Cable Makers' Association for 2003 are estimated from values from April through December.
Note 3: Figures in the estimation column were calculated based on proportional allotment.
Note4 : JEWMA→ Japanese Electric Wire & Cable Makers' Association Statistics

3.5.2 Lead consumption in electric wire sheathing

Lead sheathed wires have been used in underground cables for communication with consumption in the order of 30,000 t per year up to the 80's. Since 1987, plastic has been used as substitute material and lead use has decreased. Table 3-5-1 will be explained. On the table it can be observed that there is a transition in the 4000 to 6000 t range for lead sheathed wire, the main uses are service wire for the bottom of the ocean.

There is an increase in demand during the last 2 to 3 years, but this trend does not correspond to an increase in domestic demand but of exports (Lead sheathing for underground cables is still widely used in the Middle East).

3.5.3 Discard and recycling of electric wire sheathing

Table 3-5-2 Discard of electric wire sheathing and lead input amount by lead recyclers (units: t)

	Lead input by secondary refineries		Lead sheath sold off by NTT
	(＊1)	(＊2)	(＊3)
	a	b	c
1990		93384	
1991		87369	
1992		80737	
1993		67325	
1994		76225	
1995	65214	99456	5550
1996	68970	112383	17150
1997	82131	121646	
1998	78789	106010	15900
1999	73946	58745	7045
2000	82835	84757	5344
2001	77942	85652	3600
2002	82079	78073	1097
2003	80536	84458	300

Source: (*1) Battery Association of Japan statistics
(*2) Demand and Supply Statistics of the Resource Statistics
(*3) East Japan Cooperative for Recycling and Smelting of Lead and Tin

Use of optical fiber for communication cable started around 1995. Simultaneously, at this time, works aimed at replacement of copper cables by optical fiber started. The great volume of waste lead sheathing are discarded. Currently, this replacement work has almost been completed.

The East Japan Cooperative for Recycling and Refining of Lead and Tin has provided the data in column c of Table 3-5-2. Spaces without data correspond to sales made by NTT, which is scattered and lost. Column (a) corresponds to statistics by the Battery Association of Japan for reception of lead waste for recycling, so it only includes lead waste for storage batteries. On the other hand, column (b) contains lead input data of recyclers from Resource Statistics, therefore it includes not only storage batteries, but also processing scrap from soldering, lead tubes and sheets processing, as well as waste lead from cable sheathing. In general, used lead sheathing is received by facilities for recycling storage batteries. The values in column (b) are largest in 1997. Although there are no data in column (c) for 1997, this figure is attributed to a large sale of electric wire by NTT.

3.6 Copper alloys casting

3.6.1 Lead supply for copper alloys casting

Table 3-6-1 Production of copper and copper alloy casting, and lead content in bronze castings (units: t)
No. 1

	Copper casting			Copper alloys block			Total 1	Total 2	Total 3
	Refined copper	Copper scrap	Copper alloy	Refined copper	Copper scrap	Copper alloy			
	Cu content	Cu content	Cu content	Cu content	Cu content	Cu content	Cu content	Cu content	Cu content
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
							(1)+(2)+(3)+(4)+(5)+(6)	(7)-4000	
1989	2236	6326	68270	1026	27102	62153	167113	127113	
1990	1996	6512	69378	1327	27428	58039	164680	124680	
1991	2491	6253	68728	590	28863	60806	167730	127730	
1992	2476	4793	61393	522	24920	56739	150843	110843	
1993	2247	4097	59224	612	24461	53485	144126	104126	
1994	2952	4557	60155	621	24409	52941	145634	105634	118423
1995	3201	4668	63788	596	23018	55200	150471	110471	125859
1996	2847	3970	62399	525	22851	58338	150930	110930	123564
1997	2781	3870	63997	539	22685	61573	155446	115446	117981
1998	2308	3141	54053	537	18995	55376	134410	94410	98120
1999	1757	4750	33890	−	−	−			94920
2000	−	−	−	−	−	−			99939
2001	−	−	−	−	−	−			**99379**
2002	−	−	−	−	−	−			**99534**

No.2

	Copper alloys block prod. amount		Copper alloys casting prod. amount		Ratio	Est. copper alloy	Bronze casting gross	Lead in bronze casting
	gross	Cu content	gross	Cu content		gross		Pb content
	(10)	(11)	(12)	(13)	(14)	(15)		(16)
		(10)*0.85		(12)*0.85	(8)/(13)	(8)or(9)/0.85	(15)×0.7	(15)*0.7*0.05
1989	91788	78020	108421	92158	1.37930	149545	104681	5234
1990	89088	75725	110574	93988	1.32655	146682	102677	5134
1991	91584	77846	110610	94019	1.35856	150271	105190	5259
1992	81972	69676	97407	82796	1.33875	130404	91283	4564
1993	82032	69727	90480	76908	1.35391	122501	85751	4288
1994	81012	68860	103201	87721	1.20421	139321	97525	4876
1995	84216	71584	109681	93229	1.18495	148069	103649	5182
1996	87828	74654	107681	91529	1.21197	145369	101759	5088
1997	88068	74858	102816	87394	1.32098	138802	97161	4858
1998	82164	69839	85508	72682	1.29895	115436	80805	4040
1999	83868	71288	82719	70311		111671	78169	3908
2000	86364	73409	87093	74029		117576	82303	4115
2001	87912	74725	86605	73614		116917	81842	4092
2002	86640	73644	86740	73729		117099	81969	4098

Source: Instead of lead, copper Demand and Supply Statistics of the Resource Statistics

Note 1) JIS standards are BC1 to BC6 for a copper content of 85% in bronze castings, which comprise 70% of the copper alloy castings. These values for copper content are introduced in columns (3) and (6).

Note 2) Total 2 excludes 40,000 t of copper that is reported as returned scrap by large traders in non-ferrous material. Namely, the figure in column (3) becomes 40,000 t larger.

Note 3) The data for copper casting in the Demand and Supply Statistics of the Resource Statistics are available only until 1998.

Note 4) The data in column (10) correspond to statistics of the Designated Statistics Survey Report of the Ministry of Economy, Trade and Industry provided by the Copper Alloy Blocks Manufacturers Association.

Note 5) The data in column (12) from the Machinery Statistics annual report (includes only enterprises with more than 20 employees)

Note 6) Regarding the (8)/(13) ratio, it remains steady at approximately 1.35 averaging the five years from 1989 to 1993, but it decreases from 1994. Demand and Supply Statistics in the Resource Statistics are lower than in Machinery Statistics. There is a similar trend between industry statistics for aluminum secondary alloy production (Japan Aluminum Alloys Society), and Demand and Supply Statistics. Values (9) for copper and copper alloy casting (copper content) have been estimated assuming that the 1.35 ratio continues from 1994.

Note 7) In Machinery Statistics, copper and copper alloy casting comprise about 70% of the bronze casting production. In the representative material for bronze castings, BC6, the amount of lead is between 4 and 6%, so 5% was selected to estimate the amount of lead (16) in the bronze casting. The copper alloy casting and bronze casting ratio are calculated from the Machinery Statistics. Production statistics of bronze casting have disappeared since 2002.

Copper and copper alloys casts include pure copper, bronze, brass, etc. In the case of bronze, there are several types, such as phosphor bronze, aluminum bronze, and silicon bronze. Here, we are mainly concerned with the Cu-Sn-Zn-Pb bronze alloy (CAC406, formerly BC6) containing lead. This is a low cost material that comprises 60 to 70% of the market for copper alloy castings.

In the Lead Demand and Supply Statistics of the Resource Statistics, copper casting and copper alloys blocks were not included until the year 1998. Statistics were compiled in 1999, but the figures correspond to the total with solder. Copper alloys blocks are included into the "other non-ferrous products" but copper alloys blocks appear only as one of the materials for copper casting, whereas copper casting products directly using copper scrap and other alloy scrap are excluded. Non-ferrous casting products are included into the machinery statistics, but because of the collecting conditions, data are limited to enterprises with more than 20 employees.

Non-ferrous cast manufacturers are usually small enterprises, with many of them with less than 20 employees. So it is not possible to estimate the total production of copper alloy casting from the machinery statistics, and, therefore, it is not possible to assess the actual status of the market for copper casting. Here, we intend to estimate the extent of the market for copper castings using Table 3-6-1 and Figure 3-6-1. From these figures, we will estimate the amount of lead supply for bronze casting.

3.6.2 Lead consumption for manufacture of copper casting products

(1) Demand trends for copper and copper alloy casting products

As shown in Table 3-6-1 and Figure 3-6-1, during the period from 1989 to 1991 demand decreased with the economic collapse, but recovered during the years 1995 and 1996, to fall again, stabilizing since 1998 at the 110,000,000 t level (the figure for bronze casting is 80,000 t which is 30,000 t lower). Recovery during 1995 and 1996 can be attributed to an increase in house construction work. In general, bronze casting is used for valve cocks. The copper products, competitors of brass casting, are used for valves and cocks for gas equipment (zinc leakage causes a liquid corrosive environment for brass), whereas brass casting (problems because of porosity) is frequently used for valves and cocks in water and sewage services. For example, faucets and metal fixings for sanitary.

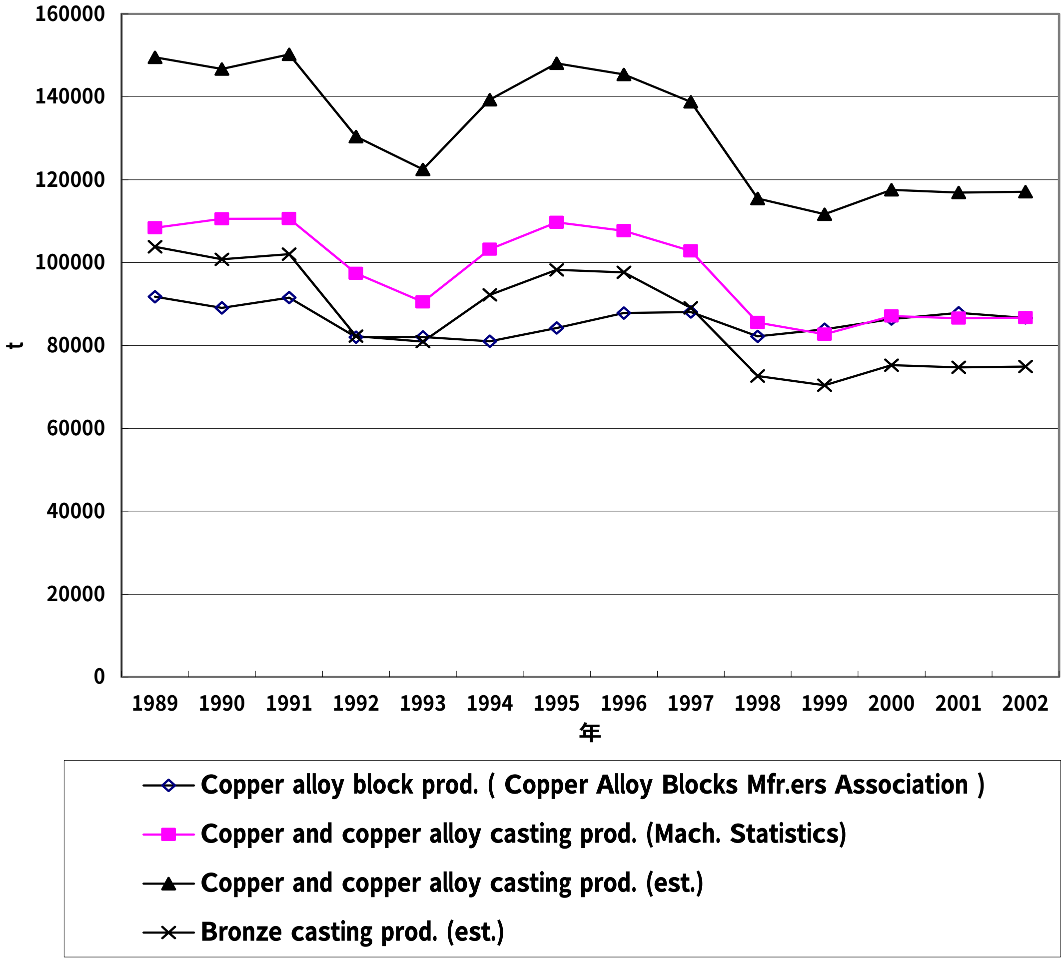
As shown in Table 3-6-1, bronze casting type 6 includes 4,000 to 5,000 t of lead per year. Half of the cutting scrap from valve and cock processing is returned, so the new addition is in the order of 2,000 to 2,500 t. Usually, lead for waste in bronze casting comes from used copper radiators from discarded automobiles (solder lead). Radiators are usually considered copper scrap and, according to only the] value of statistics, bronze alloy casting maybe is produced without original lead. However, since 10 years ago, the substitution of aluminum as a material for radiator has progressed, and since 1998 almost all radiators are made of aluminum. However, there is still discard of radiators, and although there are some manufacturers that do not get enough lead from radiators, but there are the other manufacturers that continue to obtain lead from radiators.

(2) Environmental problems

Recently, lead leaching in water pipes has become a problem. Bronze casting type 6 (CAC406, formerly BC6) contains 4 to 6% of lead.

The Water Division of the Health Bureau of The Health, Labour and Welfare Ministry announced that the following standards will be enforced starting April 1, 2003 (promulgation made on February 2001). Among the standards indicated in the directive, the standards related

Figure 3-6-1 Production of copper and copper alloy casting



to lead content are presented below.[1)]

Table 3-6-2 Standard for lead leaching pipes for water supply

	Current standard	New standard
Implements located at the user end, such as faucets and other water supply equipment	0.005 mg/l or less	0.001mg/ l or less
	＊0.047mg/l or less	＊0.007mg/l or less
Implements located in other parts of the equipment, such as water implements, or water supply pipes	0.05mg/ l or less	0.01mg/ l or less

* Standard for assessment of leaching in faucets or water supply implements located at the end of other water supply equipment made mainly of copper alloys.

This standard follows the World Health Organization guidelines for drinking water quality (1992, as a long-term objective of 10 years). As shown below, upon implementation of these guidelines, there are two ways to avoid lead leaching in valves and cocks: they should either be lead-free, or receive a surface treatment to remove the lead [2)].

Table 3-6-3 Composition of traditional copper castings and lead free alloys

	Standards	Cu	Sn	Zn	Bi(1	Bi(2	Si	Se	Sb(1	Sb(2	Pb	MFR.er
Traditiona	CAC406	83-87	4-6	4月6日	≦4.9		-		≦2.0		4.0-6.0	
Lead-free	Bi sys.	78.0-88.0	2.0-6.0	4.0-10.0	≦4.9	0.5-5.0	-		≦0.25	0.1-1.5	≦0.2	*1
	Bi-Se sys.	84.0-89.0	3.5-6.0	4.0-6.0	0.8-3.3		-	0.1-1.2	≦0.2		≦0.2	*2
	Cu-Zn-Si sys.	72.0-77.0	4.0-6.0	Remnant	-		2.7-7.2	－	－		≦0.1	*3

Source: Japan Non-ferrous Casting Society
Notes *1): Joetsu Material, Daimaru Industries, Chuetsu Alloy Casting, Japan Bronze, Kyowa Bronze
*2 Nippo Valve, Kitz
*3 Sanbo Copper Alloy

Table 3-6-4 Surface treatment technology[2)]

Developer	Treatment	Notes
Toto Ltd.	Removal of approximately 5mμ of surface by immersion in a special alkali etching solution or in a special (acid based) etching solution.	Widely used in the industry through technical contracts
		Name: NPb treatment technology
Nippon Parkerizing C	Removal of lead from the surface through a phosphate based treatment produces a	Name: PLCS (Parker lead clear system)
Kitz Co.	Surface treatment by mixed acid based on diluted nitric acid	Name: SLA (Surface treatment for lead reduction by acid)
Kouei Industries Co.	Electrolytic removal of lead	Electrolytic treatment

In the case of CAC406 (BC6), usually there is a low fusing component located near the casting surface with a lead content higher than the composition ratio. This component works as a lubricant during machining process. The Surface treatment shown in Table 3-6-4 is effective at preventing lead leaching. For copper casting for water service use, a draft of JIS standards is to be prepared before the end of 2004. According to an inquiry carried out in 2003 from February to March, the production of lead free copper casting is in the order of 1,000 to 1,400 t[2).

However, the problem of high cost remains to be solved before the shift into lead-free products can be attained. 1) It is necessary to set new installations for the management of lead-free products. 2) It was possible to receive scrap from processing of casting for valves to make bronze casting, but in the case of producers of not only lead-free products, the scrap has to be sent to a refinery. 3) Costs will increase if it is not possible to use radiators as scrap. Especially, currently copper ore undergoes a steep price rise, and even players that were considering lead-free products, because of the points described above price rise are going back to the alternative of surface treatment and coating.

3.6.3 Discard and recycling of copper alloy casting

Bronze casting is related to the fabrication of valves and cocks, and a large portion of scrap from machining is returned for recycling. As for the collection of waste products, it is based mainly on collection of bronze castings for faucets and metal fixings for sanitary, as well as flow control parts in water services. As the life service of the building comes to an end, these parts are put out of service and sent for recycling. The assessment of the amount of discard and recycled remains a task to be accomplished.

References:

1) Water Division of the Health Bureau of Health, Labour and Welfare Ministry: Partial modification of the Ministerial Ordinance concerning the standards for structure and materials for water service equipment. Kensui No. 1203003. December 3, 2002.

2) Takahiko Fujii (Fuji Technical Office), Toshimitsu Okane (AIST), Hiroshi Kato (Professor of Saitama University), Takaaki Umeda (professor emeritus of Tokyo University): Reduction of lead leaching in service water through use of lead free copper alloy casting and surface treatment. Sokeizai, March, 2003.

3.7 Free-cutting brass

3.7.1 Lead supply for free-cutting brass

There are no data regarding free-cutting brass in the Demand and Supply Statistics for lead. An estimation of the amount of lead consumption from the total production of brass bars, and the consumption of lead described in copper products statistics will be discussed in the following section.

3.7.2 Lead consumption for the production of free-cutting brass

(1) Trends demand for free-cutting brass

Copper products of free-cutting brass include bars and sheets, but bar production is the largest. Demand for brass bars includes valves and cocks for use in gas equipment, as well as a wide range of applications. Production of brass bars started to decline in 1998, with a

Table 3-7-1 Brass bar production and lead consumption (units: t)

Year	Brass bar prod.	Lead content	Lead supply	Lead supply (statistics)	Lead	Recycled lead	Lead scrap	Compar. rate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
		(1)×0.027	(2)×1.2	(5)+(6)+(7)				
1988	312753	8601	4300	3333	2273	256	804	0.7751
1989	326285	8973	4486	3171	2432	80	659	0.7068
1990	325431	8949	4475	3028	2333	87	608	0.6767
1991	344278	9468	4734	3235	2482	98	655	0.6834
1992	294259	8092	4046	2907	2087	170	650	0.7185
1993	293581	8073	4037	3077	2343	171	563	0.7622
1994	313667	8626	4313	3321	2516	169	636	0.7700
1995	321750	8848	4424	3240	2518	167	555	0.7324
1996	316686	8709	4354	3362	2449	173	740	0.7721
1997	314172	8640	4320	3364	2550	167	647	0.7787
1998	250090	6877	3439	2552	1788	152	612	0.7421
1999	260174	7155	3577	2833	1751	47	1035	0.7919
2000	291032	8003	4002	2821	1856	148	817	0.7050
2001	257512	7082	3541	2486	1665	86	735	0.7021
2002	238032	6546	3273	2291	non	non	non	
average								0.7369

Source: Annual report of Resource Statistics for years 1989 to 2001. For 2002, steel, non-ferrous metals, and metallic product statistics annual report.

Note 1) Production of brass bars in column (1) taken from copper products statistics in the Resource Statistics.

Note 2) PbO content in free-cutting brass bars, is 1.8 to 3.7% in C3601 to C3604, and 3.5 to 4.5% in C3605. A medium value of 2.75% has been selected.

Note 3) Assuming that approximately half of the lead supply (calculated in column (3)) shipped as bar products returns as cutting scrap, half of this amount is demanded as fresh mineral.

Note 4) Lead supply in column (4) (statistics) is taken from copper products statistics of the Resource Statistics. No data available from year 2002.

Note 5) Composition rates between the estimation of lead consumption from production of brass bars and lead consumption from copper products statistics are shown in the rightmost column. Lead consumption in copper products decreased in the years 1990 and 1991, but the reason for this decline is not clear. In years 2000 and 2001 there is also a decrease, attributed to the reduction of lead consumption in the automotive industry. There are no data regarding copper products statistics for year 2002, and the composition rate has been kept at 0.7, as shown.

recovery in year 2002 triggered by IT related applications, but is currently decreasing again.

Usually, cutting scrap from free-cutting brass processing is returned, so it is used again as a material of copper products. To assess the amount of lead required, column (3) in Table 3-7-1 assumes that half of the free-cutting brass bars go back as processing scrap, but the amount is larger than the amount of lead as raw material for copper products in column (4).

The figures could be interpreted as that 60% of the processing scrap is recycled, indicating a large rate of saving. Unfortunately, data for lead consumption in the production of copper products in column (4) have disappeared. The decrease in the amount of lead containing products was not so large in 2002, so it was possible to try to make an estimate of the lead content, but if there are no objective data, it will be difficult to estimate the consumption of lead in copper products.

(2) Environmental problems

Consumption of free-cutting brass containing lead is being reduced, with the automotive industry at the core of this trend. Substitute brass as shown in the table below are being developed, manufactured and sold, but JIS standards have not been set yet.

Table 3-7-2 Free-cutting brass excluding lead

	Alloy	Cu	Bi	Si	Sn	P	Pb	Zn	Fe(1	Fe(2	Others	Mfr.ers
Tradition	C3601-05	56.0-63.0	-	-	Fe+Sn≦0.05	-	1.8-4.5	remnant	≦0.3	≦0.5		
Lead-free	C6801	57.0-64.0	0.5-4.0	-	0.2-2.5	≦0.2,	≦0.01	remnant	≦0.05			*2
	C6802	57.0-64.0	0.5-4.0	-	0.2-2.5	≦0.2	0.01＜,≦0.1	remnant	≦0.7			
	C6803	57.0-64.0	0.5-4.0	-	0.2-2.5	≦0.2	≦0.01	remnant	≦0.5		*1	*3
	C6804	57.0-64.0	0.5-4.0	-	0.2-2.5	≦0.2	0.01＜,≦0.1	remnant	≦0.7		*1	
	C6931	69.0-80..0	-	2.0-4.0	≦0.2	0.02-0.15	≦0.01	remnant	≦03		Mg ≦0.1	*4
	C6932	69.0-80..0	-	2.0-4.0	-	0.02-0.15	0.01＜,≦0.1	remnant	≦0.3		Mg ≦0.1	

Source: Japan Copper and Brass Association
Note 1): *1→Se+Al+Sb+Te 0.02-0.6
Note 2): (Product development manufacturers) *2→Sanetsu, *3→Kitz, *4→Sanbo Shindo (license granted to: Nippon Shindo Co., Ltd, Shinnihon Brass (group of Dowa Mining Co., Ltd))

3.7.3 Discard and recycling of free-cutting brass

A large portion of scrap from cutting after forging during the production of valves and cocks is returned for recycling. As for the collection of waste products, it must be investigated.

3.8 Free-cutting steel

3.8.1 Lead supply for free-cutting steel

There are no data regarding the supply of lead in the Demand and Supply Statistics or Production Statistics of free-cutting steel. Accordingly, an estimation of the lead supply will be discussed in the next section.

3.8.2 Lead consumption for the production of free-cutting steel

(1) Demand trends for lead containing free-cutting steel

Combined or independent addition of phosphorous, sulfur, lead, selenium, tellurium, bismuth, and calcium impart free-cutting characteristics to steel.[1)]

Through addition of sulfur to steel, the cutting characteristics can be improved using the notch cutting effect of MnS. Lead addition further improves these cutting characteristics, calcium being the next in this sequence of betterment of cutting characteristics. As shown in Table 3-8-2, sulfur and lead addition for free-cutting steel are covered by the JIS standards.

Uses for free-cutting steel include products that require complex machining such as bolts, nuts, crank shafts, gear connecting rods, and dies.

As shown in Table 3-8-1, the annual production of free-cutting steel is in the vicinity of 1,000,000 t.

The main applications of free-cutting steel include power transmission equipment and assembly parts for the key industries in Japan: automobile and industrial machinery, as well as metal casts for plastic injection and pressing. It can be said, then, that the status of free-cutting steel is closely related to the general status of industry in Japan .

The above graph[2)] shows that lead free-cutting steels account for 50% of the total free cutting steel. This share has not changed during the last 10 years. From Table 3-8-2, it is found that the content of lead in free-cutting steel is 0.225%. The amount of lead consumed is calculated by multiplying by 0.00225 the production of free-cutting steel, as shown on the right side of Table 3-8-1. The amount of lead in free-cutting steel is in the order of 1000 t.

Table 3-8-1 Free-cutting steel production and Pb content

Year	Free-cutting steel prod.	Pb content
	Units: 1000 t	Units: t
1988	1327	1,493
1989	1263	1,421
1990	1245	1,401
1991	1233	1,387
1992	1070	1,204
1993	1021	1,149
1994	1031	1,160
1995	1063	1,196
1996	1005	1,131
1997	1092	1,229
1998	870	979
1999	911	1,025
2000	1037	1,167
2001	945	1,063
2002	971	1,092

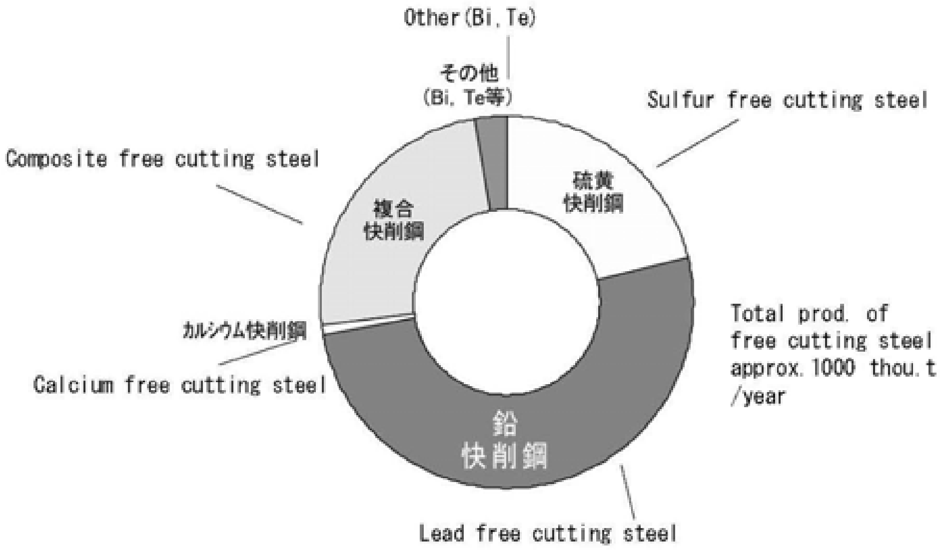
Source: Japan Iron and Steel Federation: Handbook iron and steel statistics 2003. From "Production of hot rolled special steel"
Note: Pb containing free-cutting steel comprises 50% of the total of free-cutting steel. To estimate the Pb content, a value of 0.225%, medium value between 0.10 and 0.35% found in Table 2 under the SUM (L) column, was used (multiplying by 0.00225).

Table 3-8-2 Chemical content standards(containing Sulfur) free-cutting steel (units: %)

code of class.	C	Mn	P	S	Pb
SUM 22 L	0.13and less	0.70〜1.00	0.07〜0.12	0.24〜0.33	0.10〜0.35
SUM 23 L	0.09and less	0.75〜1.05	0.04〜0.09	0.26〜0.35	0.10〜0.35
SUM 24 L	0.15and less	0.85〜1.15	0.04〜0.09	0.26〜0.35	0.10〜0.35
SUM 31 L	0.14〜0.20	1.00〜1.30	0.04以下	0.08〜0.13	0.10〜0.35

Source: Japanese Standards Association; JIS G 4804 (1999) of the JIS handbook for iron and steel I

Figure 3-8-1 Domestic status of free-cutting steel production[2)]



(2) Environmental problems

Due to the facts that will be explained below, demand for free-cutting steel containing lead is being reduced, with the automotive industry at the core of this trend.

(a) Lead reduction target (METI: May, 1997, Japan Automobile Manufacturing Association)

- Lead content in new models (excluding the battery) has to be reduced to less than 1/3 of the level of 1996 by the end of 2005.

(b) Aichi Steel

To improve the technology of free-cutting steel for eco-friendly automobiles, and to develop fuel-efficient automobiles (low CO_2 emission), parts for automobile should be made lighter. For lighter parts, stronger steel is required, but high strength steel is difficult to cut, and costs are increased. Accordingly, to produce light parts it is necessary to develop free-cutting steels with still better cutting properties.

Against this background, Aichi Steel has engaged in a research project for the development of lead-free steel with superb cutting properties. This project was carried out from 1997 to 1998 in cooperation with Toyota Central R&D Laboratories Inc. and Sanyo Special Steel. Afterwards, in 1999, Aichi Steel developed its own refining and molding technologies, as well as heat casting technology for mass production. In order to promote the use of Ecoscut-Steel, the mass production technology and know-how for heat casting, as well as the steel itself, will be available to the market.

Ecoscut-Steel has been used in Toyota vehicles since August 2001, after the auto manufacturer examined the durability and its commercialization as a crankshaft.[2)] As described above, The Japan Automobile Manufacturing Association decided to reduce the amount of lead to 1/3 of the 1996 level by 2005, suggesting that consumption of lead will continue to decrease. It seems that the data for lead contentsin Table 3-8-1 should be revisited for, at least, until after 2003.

3.8.3 Disposal and recycling of free-cutting steel

There are no data available, and investigation on this regard remains topic for future studies.

References:

1) Dictionary of ferrous materials

2) http: www.aichi-steel.co.jp/ TOPICS/pdf/topics146.pdf

3) http: www.aichi-steel.co.jp/ TOPICS/pdf/topics146.htm