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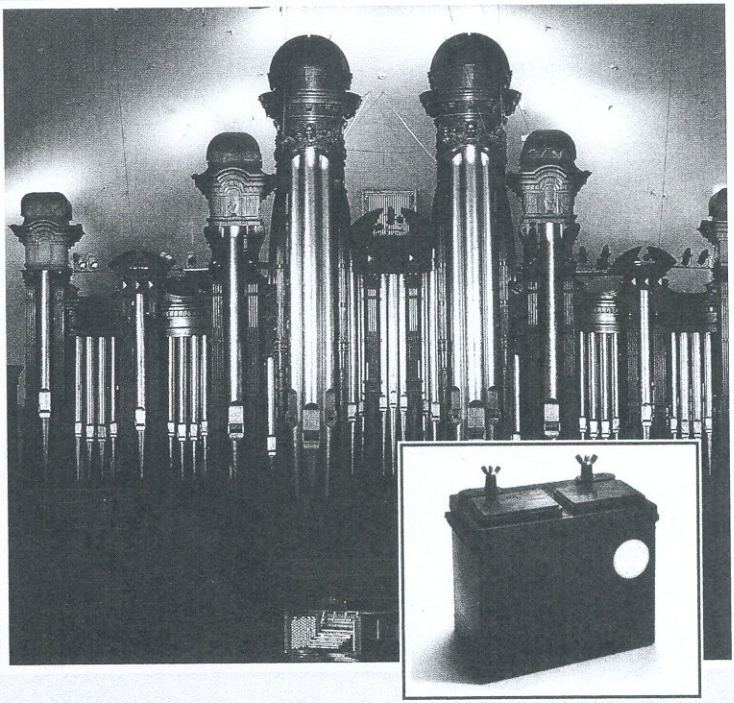

Sivaraman Guruswamy

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Sivaraman Guruswamy

University of Utah
Salt Lake City, Utah

Prepared for the International Lead Zinc Research Organization, Inc.
Research Triangle Park, North Carolina

MARCEL DEKKER

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Table 5 Assigned Number Ranges for Lead and Its Alloys [28]. (Courtesy of Lead Industries Association, New York.)

Designated No.	Lead-alloy system	Designated No.	Lead-alloy system
L50000–L50099	Pure leads	L53000–L53099	Pb–(5.0–5.99)Sb
L50100–L50199	Pb–Ag	L53100–L53199	Pb–(6.0–6.99)Sb
L50200–L50299	Pb–Al	L53200–L53299	Pb–(7.0–8.99)Sb
L50300–L50399	Pb–As	L53300–L53399	Pb–(9.0–10.99)Sb
L50400–L50499	Pb–Au	L53400–L53499	Pb–(11.0–12.99)Sb
L50500–L50599	Pb–Ba	L53500–L53599	Pb–(13.0–15.99)Sb
L50600–L50699	Pb–Bi	L53600–L53699	Pb–(16.0–19.99)Sb
L50700–L50799	Pb–Ca	L53700–L53799	Pb–(>20%)Sb
L50800–L50899	Pb–Ca	L53800–L53899	Pb–Se
L50900–L50999	Pb–Cd	L53900–L53999	Pb–Si
L51000–L51099	Pb–Co	L54000–L54099	Pb–(<1.0%)Sn
L51100–L51199	Pb–Cu	L54100–L54199	Pb–(1.0–1.99)Sn
L51200–L51299	Pb–Fe	L54200–L54299	Pb–(2.0–3.99)Sn
L51300–L51399	Pb–Ga	L54300–L54399	Pb–(4.0–7.99)Sn
L51400–L51499	Pb–Hg	L54400–L54499	Pb–(8.0–11.99)Sn
L51500–L51599	Pb–In	L54500–L54599	Pb–(12.0–15.99)Sn
L51600–L51699	Pb–K	L54600–L54699	Pb–(16.0–19.99)Sn
L51700–L51799	Pb–Li	L54700–L54799	Pb–(20.0–27.99)Sn
L51800–L51899	Pb–Mg	L54800–L54899	Pb–(28.0–37.99)Sn
L51900–L51999	Pb–Mn	L54900–L54999	Pb–(38.0–47.99)Sn
L52000–L52099	Pb–Na	L55000–L55099	Pb–(48.0–57.99)Sn
L52100–L52199	Pb–Ni	L55100–L55199	Pb–(>58%)Sn
L52200–L52299	Pb–O	L55200–L55299	Pb–Sr
L52300–L52399	Pb–P	L55300–L55399	Pb–Te
L52400–L52499	Pb–S	L55400–L55499	Pb–Tl
L52500–L52599	Pb–(<1.0%)Sb	L55500–L55599	Pb–Zn
L52600–L52699	Pb–(1.0–1.99)Sb	L55600–L55699	Pb–Zr
L52700–L52799	Pb–(2.0–2.99)Sb	L55700–L55799	Miscellaneous alloys not included above.
L52800–L52899	Pb–(3.0–3.99)Sb		
L52900–L52999	Pb–(4.0–4.99)Sb		

anisms of plastic flow that are operative at room temperature and at elevated temperatures, to which lead alloys will be subjected.

In a perfect crystal, the plastic deformation can occur by a slip process in which simultaneous translation of one plane of atoms over another occurs. No dislocations are involved in this case. This occurs at a stress level that is referred to as the ideal strength above which the deformation is no longer elastic and becomes catastrophic. The ideal shear strength is about 0.06 μ

Table 6 Listing of Lead Alloys as per the Unified Numbering System [28]. (Courtesy of Lead Industries Association, New York.)

Unified No.	Description	Chemical composition[a]	Cross-referenced specifications
L50001	Zone Refined Lead	Pb 99.9999 min	
L50005	Refined Soft Lead	Pb 99.999 min	
L50010	Refined Soft Lead	Pb 99.99 min	Canadian CSA HP21958 Type 1 Australia AS-8 1975 Soft Pb
L50011	Refined Soft Lead	Pb 99.99 min	India 99.99 IS-27-1965
L50012	Refined Soft Lead	Pb 99.99 min	
L50013	Refined Soft Lead	Pb 99.99 min	UK BS 334 Chemical A Germany Pure Pb DIN 1719
L50014	Refined Soft Lead	Pb 99.99 min	
L50020	Refined Soft Lead	Pb 99.985	Germany Pure Pb DIN 1719
L50025	LME Grade Pure Lead	Pb 99.97	LME
L50035	Refined Soft Lead	Pb 99.95 min	Australia AS-1812-1975 Soft
L50040	Refined Soft Lead	Pb 99.94 min	India 99.94 IS-27-1975
L50041	Refined Soft Lead	Pb 99.94 min	Germany Smelter Lead DIN 1719
L50042	Corroding Lead	Ag 0.0015 max Bi 0.050 max Cu 0.0015 max Fe 0.002 max Pb 99.94 min Zn 0.001 max (Cu + Ag) 0.0025 max. (As + Sb + Sn) 0.002 max	ASTM B29 (Corroding Lead); FED QQL-171
L50045	Common Lead	Ag 0.005 max Bi 0.050 max Cu 0.0015 max Fe 0.002 max Pb 99.94 min Zn 0.001 max. (As + Sb + Sn) 0.002 max	ASTM B29 (Common Lead)
L50050	Grade A Lead	Pb 99.90 min Total other elements 0.10 max	FED QQL-171 Grade A

Table 21 Thermal Properties of Lead Alloys [28]. (Courtesy of Lead Industries Association, New York.)

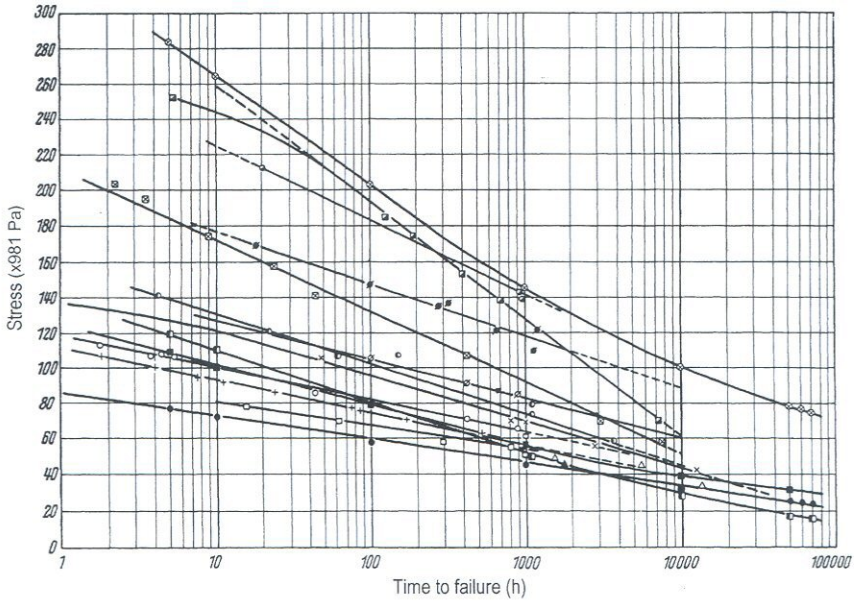
Alloy composition[a]	Common name	UNS No.	Liquidus (°C)	Solidus (°C)	Coefficient of expansion ($\times 10^{-6}$/K)	Specific heat (J/kg/K)	Latent heat of fusion (kJ/kg)	Thermal conductivity (W/m K)
Pure lead								
Pb >99.94	Corroding Lead	L50001–L50042	327.4	327.4	29.3	129	23	35
Pb–Ag alloys								
Pb–(1.3–1.7)Ag	Solder Alloy—Grade Ag 1.5	L50132	310	309				
Pb–1.5 Ag–5 Sn	Solder Alloy—Grade 5S	L50134	301	296				
Pb–(2.3–2.7)Ag	Solder Alloy—Grade Ag 2.5	L50150	304	304				
Pb–(2.3–2.7)Ag	Solder Alloy—Grade Ag 2.5	L50151	303	—				
Pb–2.5 Ag–2 Sn	Solder Alloy	L50152	304	299				
Pb–5 Ag	Solder Alloy	L50170	364	305				
Pb–5 Ag–5 Sn	Solder Alloy	L50171	292	—				
Pb–5 Ag–5 In	Solder Alloy	L50172	310	290	27			25
Pb–(5–6) Ag	Solder Alloy—Grade Ag 5.5	L50180	366	304				
Pb–As alloys								
Pb–0.15 As–0.1 Sn–0.1 Bi	Arsenical Lead Cable Sheathing Alloy	L50310	327	302				
Pb–Bi alloys								
Pb–42 Bi–11 Sn–9 Cd	Fusible Alloy	L50605	88	70	24	168	23	21

Table 24 Mechanical Properties of Lead Alloys [28]. (Courtesy of Lead Industries Association, New York.)

Nominal alloy composition	Common name	Ultimate tensile strength (MPa)	Elongation (%)	Yield strength (MPa)	Shear strength (MPa)	Hardness Brinell/ Rockwell R[a]	Impact energy (J)	Creep strength	Fatigue strength	UNS No.
Pure lead										
Pb >99.94	Corroding Lead	12–13	30	5.5	12.5	3.2–4.5	14.1 Charpy V		3.2 MPa @ 10^7 cycles	50042
Pb–Ag alloys										
Pb–(1.3–1.7)Ag	Solder Alloy–Grade Ag 1.5	35						19.5 MPa (1000 h)		50132
		1.8 @ 100°C	28			13		7.5 MPa (1000 h)		
Pb–1.5 Ag–5 Sn	Solder Alloy–Grade 5S	30	20							50134
		19 @ 100°C	25							
Pb–5 Ag–5 In	Solder Alloy	40								50172
Pb–(5–6) Ag	Solder Alloy–Grade Ag 5.5	32	28							50180
Pb–As alloys										
Pb–0.15 As–0.1 Sn–0.1 Bi	Arsenical Lead Cable Sheathing Alloy	16–30	25–40			5–10		0.13%/yr @ 2.1 MPa		50310
Pb–Bi alloys										
Pb–42 Bi–11 Sn–9 Cd	Fusible Alloy	38	220			9				50605
Pb–44.7 Bi–5.3 Cd–8.3 Sn 19.1	Fusible Alloy	37				12				50620

Table 25 Mechanical Properties of Commonly Used Lead Alloys

Lead or lead alloy[a] (ConG. in wt.%)	Tensile strength (MPa)	Elongation (%)	Hardness[b]	Compression strength (25%) (MPa)	Yield strength (MPa)	Fatigue strength (MPa)	Creep strength (0.2%/year) (MPa)	Young's modulus (10 GPa)	Ref.
Pure lead [c]	13.1	45	#4.0	15.2	5.9	2.7[c]			167, 168
Pb 99.985	18.4	33	@28.5						169
Pb 99.95	18.2	35	@28.5		3.1				169
DSL	41.4	18.5	#13.5	44.8	40.0			2.0–2.2	170
Corroding [e]									167
Refined [r]	12.1	53	#3.8			3.2	1.2	2.0	167
Chemical [c]	17.9	45	#5.2	20.0	11.3				167
Chemical [r]	19.3	47	#5.5			6.9			167
Undesilverized [e]	17.2	50							167
Undesilverized [r]	16.5	51	#4.7	17.9	8.6	5.0	15.8	2.5	167
0.47 Ag + 0.18 Ca [e]	41.1	40							171
0.47 Ag + 0.18 Ca [a]	43.8	38							171
0.15 As + 0.1 Sn + 0.1 Bi						10.0[c]			168
0.77 Ba + 0.30 Ca [e]	51.2	38							171
0.77 Ba + 0.30 Ca [a]	58.5	32							171
0.88 Ba + 0.94 Ca [e]	61.1	44							171
0.88 Ba + 0.94 Ca [a]	55.5	40							171
0.1 Bi	21.6	45							169
0.2 Bi	20.6	33							169
0.025 Ca	25.1				17.7		1 hr at 20.7 MPa		172
0.050 Ca	37.2				29.0		30 h at 20.7 MPa		172
0.065 Ca	42.5				31.8		50 h at 20.7 MPa		172



□ Lead (99.89%) with 0.09% Bi
+ Commercial Lead 25.8°C
○ Commercial Lead 21.1°C
◐ Cable Sheathing 2% Sn
⊠ Cable Sheathing 0.75% Sb
Cable Sheathing 0.03% Ca
◪ 0.04% Ca Material 1
Material 2
} (According to MOORE and co-workers [184]).

⌀ Cable Sheathing 0.16% As + 0.113% Sn. (According to DOLLINS [207]).

• Refined Lead (stamped)
◧ Refined Lead + 0.06% Te (stamped)
■ Chemical Lead 0.059% Cu
⊗ Chemical Lead 0.05% Ca
} (According to GOHN and co-workers [208]).

× Lead Pipe 0.018% Ag (According to GOHN and ELLIS [209]).

△ Commercial Lead, Coarse Grained
▲ Commercial Lead, Fine Grained
} (According to MCKELLAR [210]).

Figure 59 Creep-to-rupture of lead and lead alloys [2,184,207–210]. (Courtesy of Springer Verlag, New York.)

those for some cable sheathing alloys. The superiority of lead–calcium alloys (Figure 66) is seen even at 65°C [219].

The copper addition does tend to increase the creep strength of lead, but the effect is neutralized by the finer grain of the specimens containing copper (Figure 67) [2,184,200,211,222,223]. Creep tests on commercial lead and on lead–copper alloys that have been extruded at two different temperatures show that lead–copper extruded at 120°C is markedly superior to