LEAD-FREE SOLDER

New Methodology and Perception

Christopher M. Carabello
Director of North American Operations
Redring Solder (M) Sdn. Bhd.
Selangor, Malaysia

Content

- Definition of Lead-Free Solder
- Solder Alloy Choices
- Changes in Perception and Methodology
- Equipment Issues
- Economic Issues

Definition of Lead-Free Solder

Allowable Lead Content in Solder (% max)			
Solder Bar/Wire/Paste			
IPC J-STD-006	**ISO 9453**	**JIS-Z-3282**	**High-Purity Tin 99.99%**
0.2% (Common) **0.1% (Variation E)**	**0.1%**	**0.1%**	**0.002%** **(20 ppm)**
Solder Anodes for Electroplating			
American/European Customers		Japanese Customers	
500 ppm (max)		1,000 ppm (max)	

Lead-Free Alloys

Problems

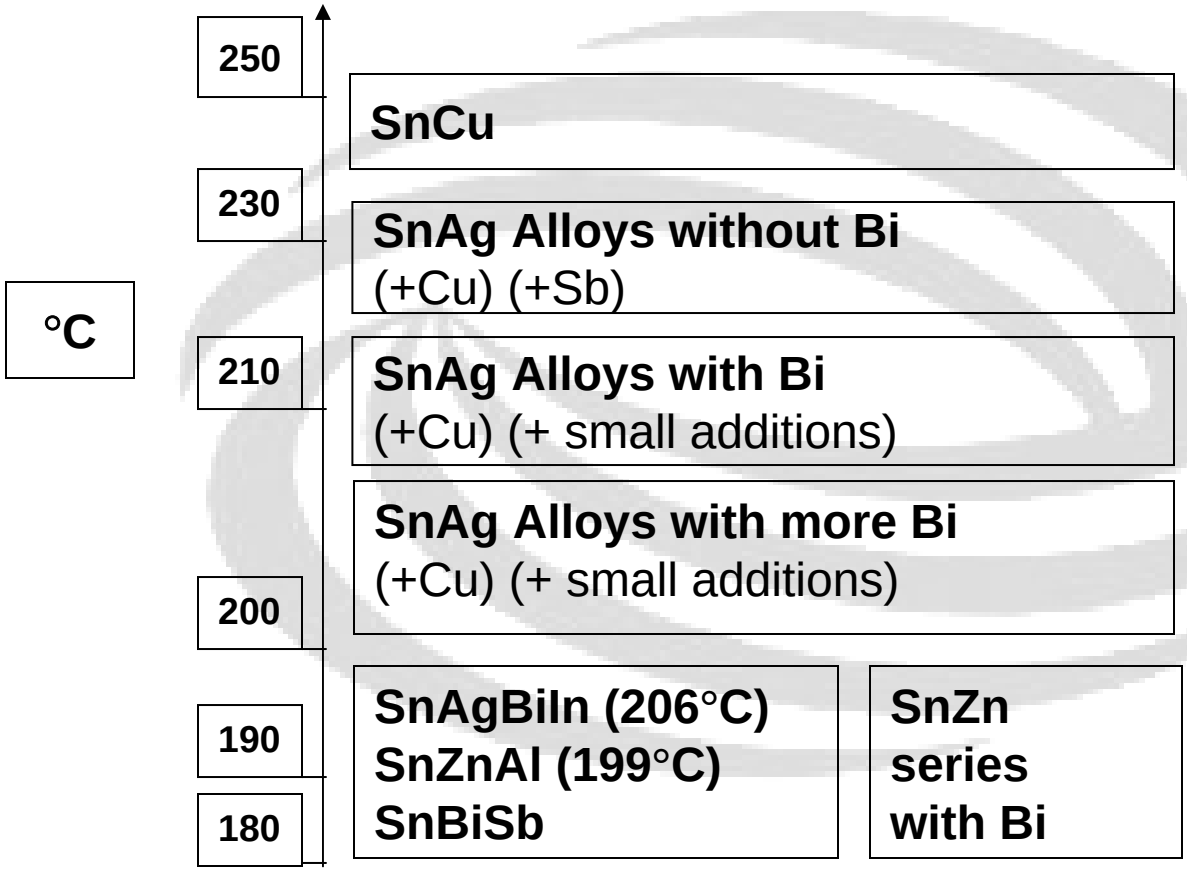
- Numerous Lead-Free Alloys available
- Potential cross-contamination problems
- Effect on equipment

Alloy choices based on specific applications

- SnAgCu as a primary alternative
- SnBiAg for Surface Mount Technology
- SnCu for Wave Soldering and Hot Air Leveling

Alloy Compositions

Typical Lead-Free Solder Alloys



SAC Alloys (Sn/Ag/Cu)

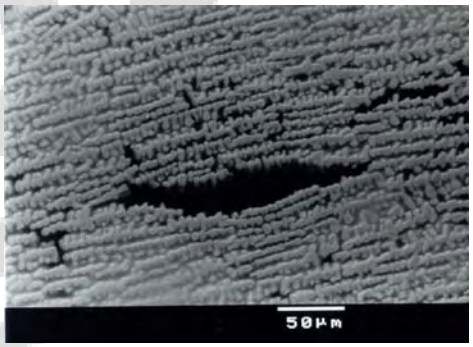
Sn95.5/Ag3.8/Cu0.7 (Typical Alloy)

Advantages

- High Reliability
- Good Solderability
- Greater ability to cope with Lead contamination

Disadvantages

- Higher Melting Temperature
- Cost of Silver content
- Micro-Cracking
  - Depends on Composition
- Some patent issues, particularly outside Europe



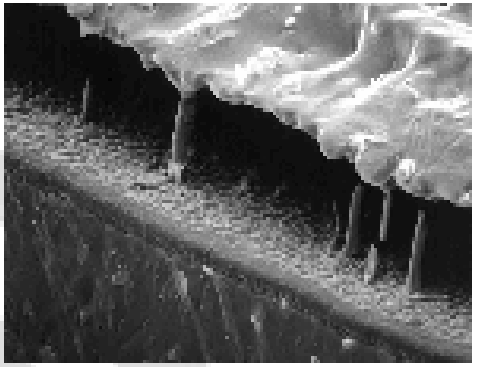
Current Uses

- Automotive and Video

Bismuth Alloys (Sn/Bi/Ag)

Advantages

- Lower Melting Temperature
- Excellent Solderability



Fillet Lifting

Disadvantages

- Cost of Silver content
- Strength reduction with Lead contamination
- Fillet lifting considerations
- Fatigue performance more dependant on conditions

Current Uses

- Camcorders, PC's, Walkmans, and Headphones

Tin Copper (Sn/Cu)

Sn99.3/Cu0.7 (Typical Alloy)

Advantages

- Lower Cost
- Dissolves less Copper in coating process
- More stable intermetallic layer
- Less attack on Solder Pot

Disadvantages

- Higher melting temperature
  - May not be suitable for all wave soldering
- Poor Wetability
- Low thermal resistance

Current Uses

- VCR's and HASL

Tin Copper (Sn/Cu)

Sn/Cu (Ni) at initial start-up and Pure Tin to replenish bath

Easily Contaminated

- New Solder Pot and Working Parts

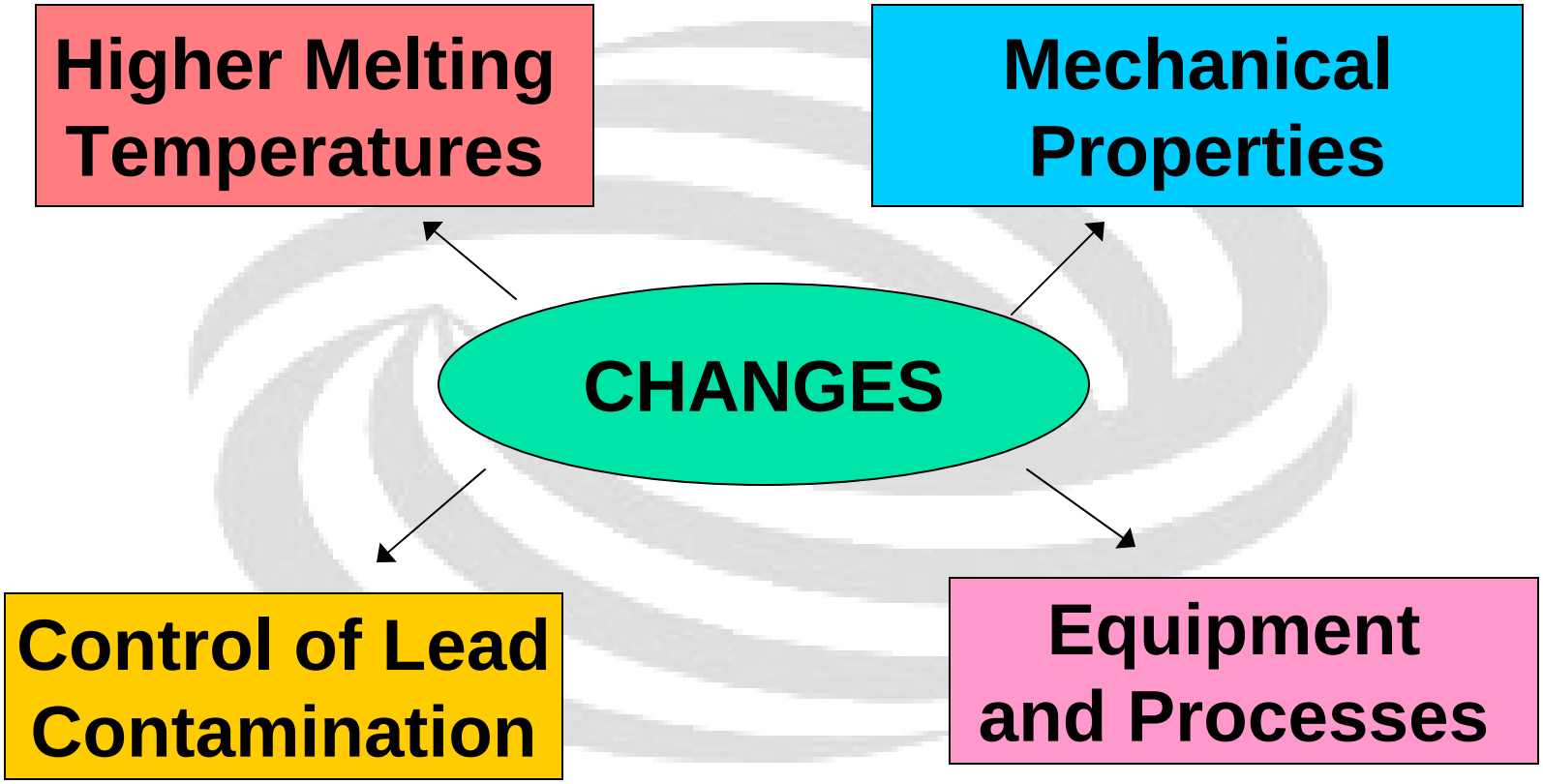
Operating Temperature in Vertical HASL

- 500^{o}F (current operation in Texas)

Causes Corrosion in Equipment

- High concentrations of Tin attack and dissolve protective coatings that are typically resistant to corrosion. Wetting occurs and underlying material dissolves in Solder bath causing severe pitting and corrosion.

Changes in Perception and Methodology



Changes in Perception and Methodology

Higher Melting Temperatures (in melting furnace)

Melting Temperature for Leaded Solder: 280 to 380°C
Melting Temperature for Lead-Free Solder: 400 to 500°C

Higher temperature increases formation of dross.

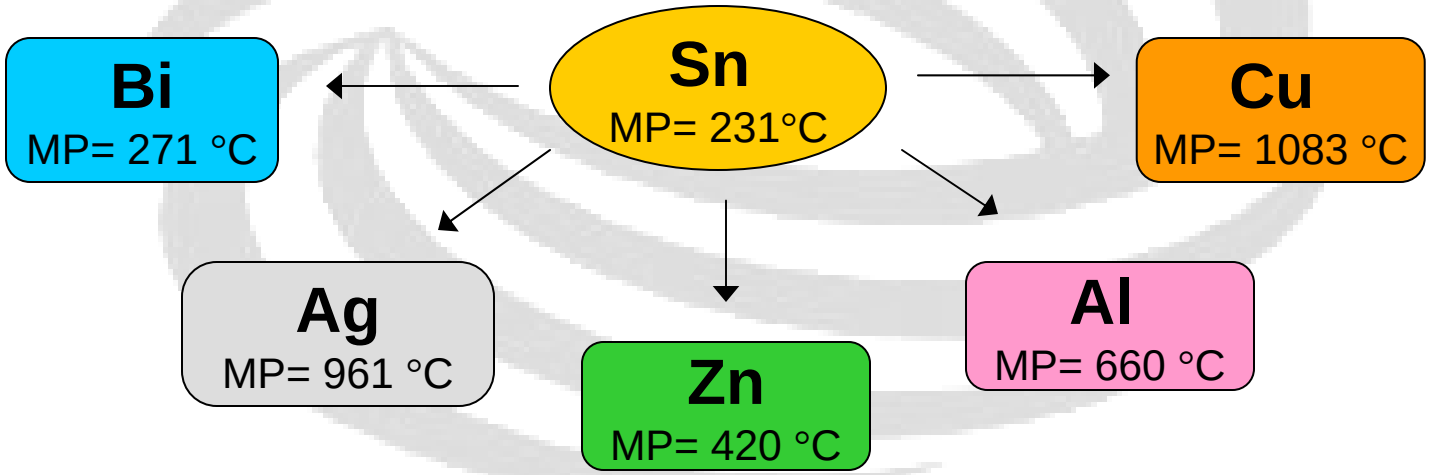
CONTENT			LIQUIDUS TEMP (°C)	SOLIDUS TEMP (°C)	FURNACE TEMP (°C)
Sn	Pb		183 (e)	183	280 - 380
Sn	Ag		221 (e)	221	400 - 500
Sn	Cu		227 (e)	227	400 - 500
Sn	Ag	Cu	215 - 221	215 - 221	400 - 500

Typical Lead-Free Solder Melting Temperature

Changes in Perception and Methodology

Melting Temperatures for Replacement Elements

Difficult to melt metals that replace Lead due to high melting temperatures (Lead 327^{o}C)



Changes in Perception and Methodology

Physical Properties of Replacement Elements

Metal	Melting Point (°C)	Specific Gravity (kg/m³)
Nickel (Ni)	1453	8.9
Copper (Cu)	1083	9.0
Silver (Ag)	961	10.5
Aluminium (Al)	660	2.7
Antimony (Sb)	630	6.6
Zinc (Zn)	420	7.1
Lead (Pb)	327	11.4
Tin (Sn)	232	7.3
Bismuth (Bi)	271	9.8
Indium (In)	156	7.3

Manufactured with High-Purity Tin

Manufactured solely with high-purity Tin (99.99%) Pb <20 ppm

Lead is a natural trace Element in Tin.

Can not use scrap or reclaimed material.

Changes in Perception and Methodology

Control of Lead Contamination during the Manufacturing Process

Permitted Level: 0.05 to 0.10 % Pb

Solder bath prone to lead contamination from production floor, testing equipment, handling, atmosphere, etc.

Need to have new production and testing equipment.

Need to have a special designated closed system/area for Lead-Free production line.

Production staff wearing anti-static uniform, gloves, and shoes.

Equipment Issues

New Equipment Needed for Lead-Free HASL

- Solder Pot
- Heat Exchanger
- Air Knives (must be heated)
- Testing Equipment
  - Accurate and Precise
- Calibrated with new methods and standards
  - Analyze Lead as low as 1 ppm
  - Higher Tin and Silver levels

Effect on HASL Equipment

- High Concentrations of Tin
- More Aggressive Fluxes
- Higher Temperatures (Preheat, Pot, and Air Knives)
  - Air Knives Heated to 540^{o}F

Economic Issues

Cost Comparison (of Alloys)

Sn63/Pb37	US$ 3.25/lb.
Sn99.3/Cu0.7	US$ 4.83/lb. (+48%)
Sn95.5/Ag3.8/Cu0.7	US$ 8.50/lb. (+161%)

Higher Value for Scrap!$!$!$

RedringSolder®

Contact Us:

Europe
Tel: 32 3 227 73 06
E-Mail: sven.jantzen@sogemnet.com

North America
Tel: 215 887 7190
E-Mail: carabello@aol.com

Asia–Pacific
Tel: 603 6138 5757
E-Mail: info@redringsolder.com

www.redringsolder.com

IPC MEMBER
ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

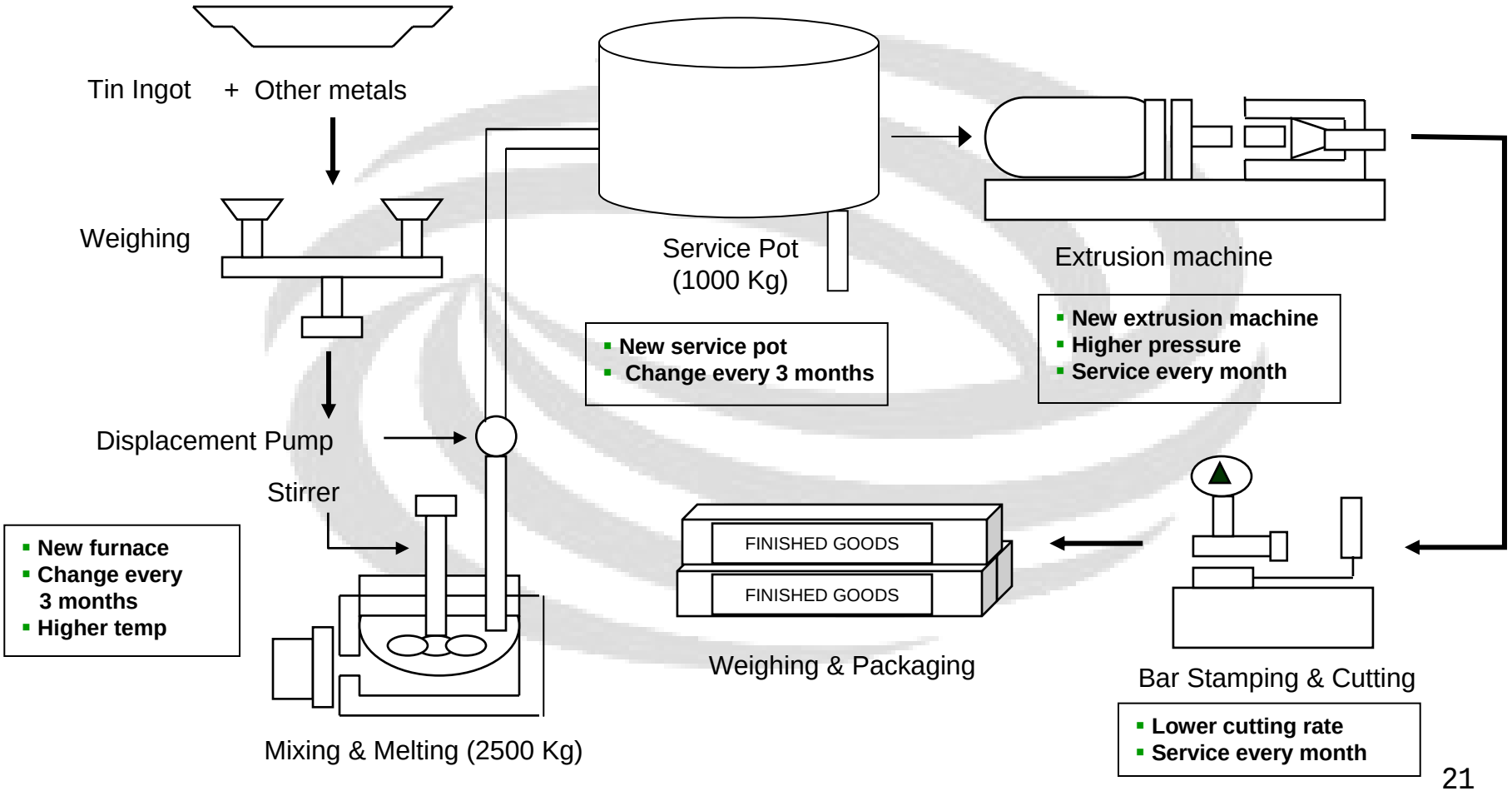
TIN TECHNOLOGY
FOR A CLEANER FUTURE

Since 1993 ISO 9001
MS ISO 9001 (AR0235)

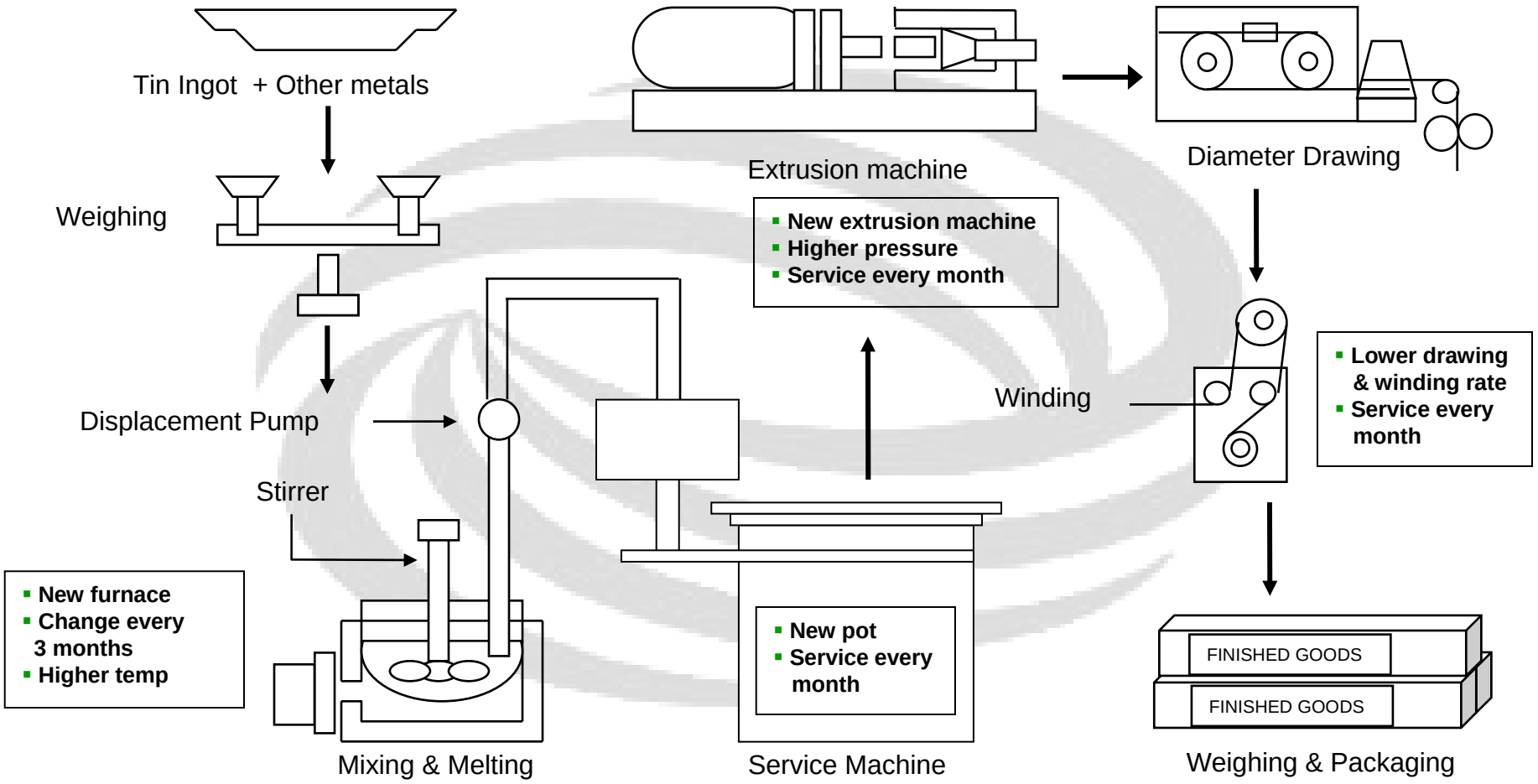
Since 2001 ISO 14001
MS ISO 14001(R0005-1031)

Towards OHSAS 18001
TARGET: 2005

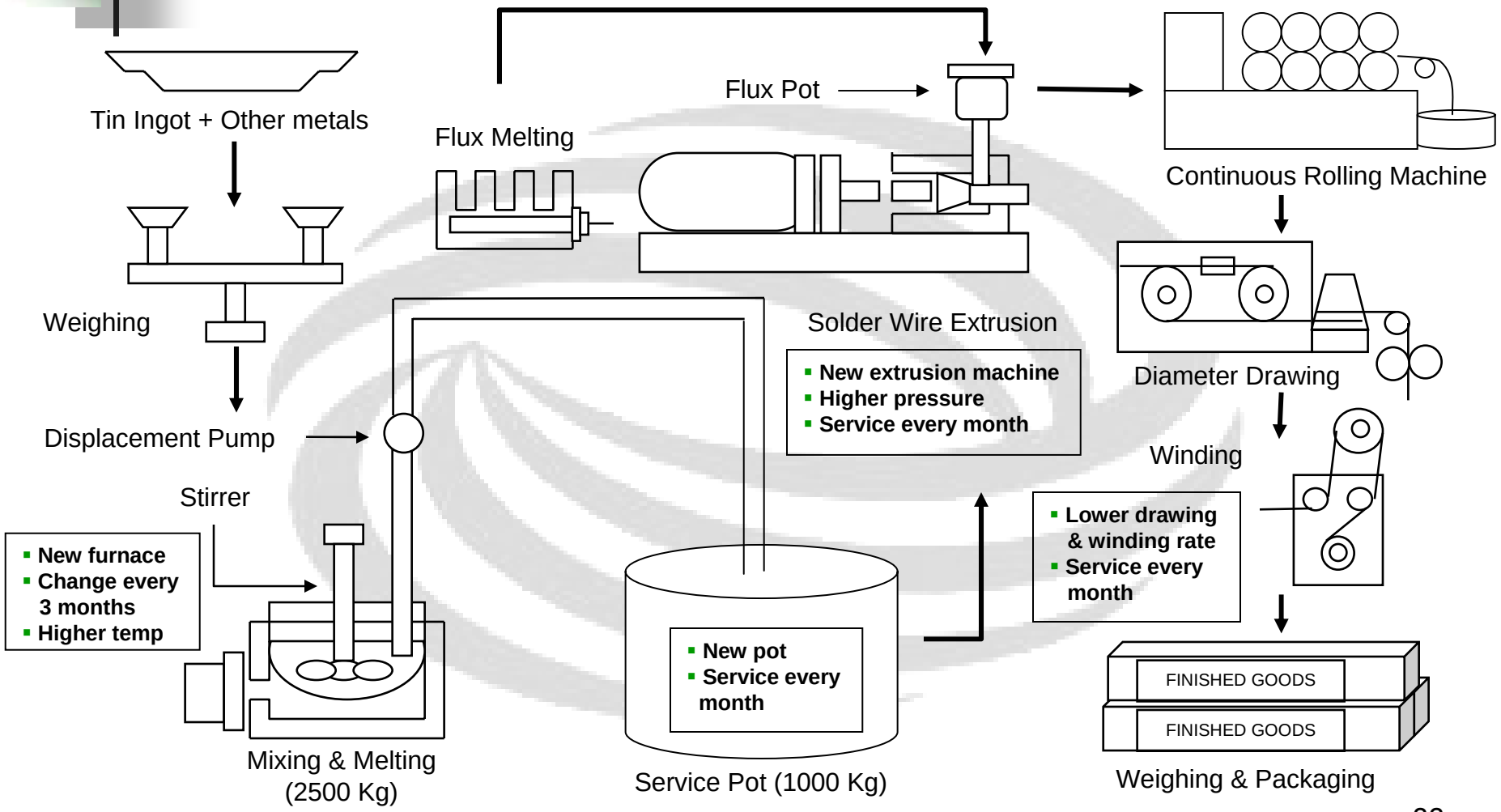
Manufacturing Process for Lead-Free Solder Bar



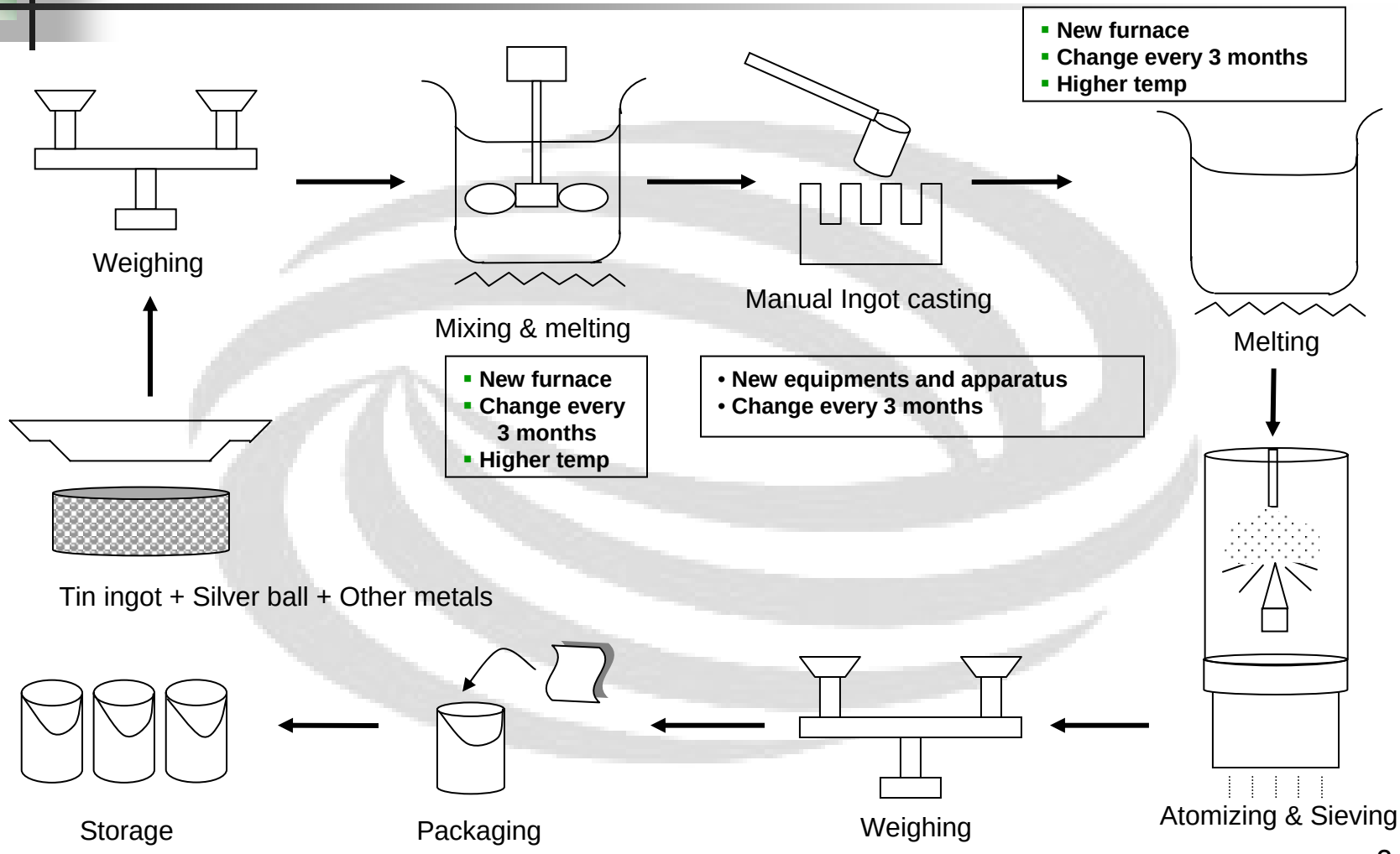
Manufacturing Process for Lead-Free Solder Wire



Manufacturing Process for Lead-Free Solder Wire



Manufacturing Process for Lead-Free Solder Powder



Manufacturing Process for Lead-Free Solder Paste