Secondary Lead Smelting

Secondary Lead Smelting Objectives

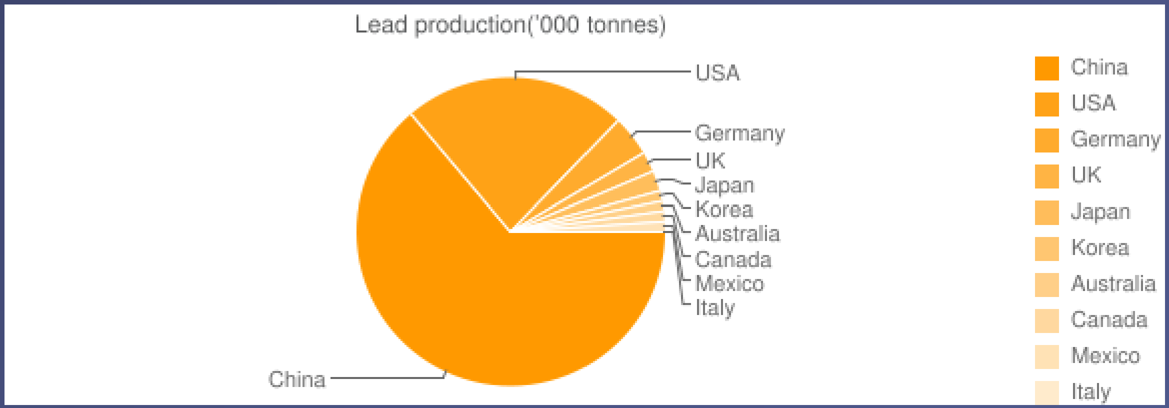
- Describe the basic smelting process terms: smelting, refining, and alloying
- List key chemicals associated with secondary lead smelting
- Define volatility temperature, volatile metals, and metals partitioning

Secondary Lead Smelting Objectives (cont.)

- List major modes of release to the environment
- Identify analytical methods useful for detecting secondary lead smelting contaminants in the environment

Process Overview

- SIC: 3341; NAICS: 331492
- U.S. lead consumption: 1.8 million metric tons per year (2004)
  - 62% of which is met by secondary lead industry
- Worldwide consumption: 9.6 million metric tons per year (2010)
  - 51% of which is met by secondary lead industry



Process Overview

- SIC: 3341; NAICS: 331492
- U.S. lead consumption is 1.4 million metric tons per year (1993)
- 72% of demand is met by secondary lead industry

Process Overview (cont.)

- Total employment: 2300 (1993)
  - 1700 by secondary smelters and refiners
- 53 active secondary lead smelters in U.S. (1991)

Process Overview (cont.)

- Largest worldwide use of lead is for batteries (80%)
  - 95% of which are recycled
- 15 active secondary lead smelters in U.S. (2011)
  - In 1991, there were 53

Process Overview (cont.)

Smelting: Conversion of oxidized metal species into metallic (zero valence) form

Process requires:

- High temperatures (1260°C)
- Reducing agents
- Exclusion of oxygen

Process Overview (cont.)

Refining: Separation of impurities from primary metal

Process requires:

- Melting temperatures (327.5°C)
- Refining agents
- Physical separation of insoluble layers

Process Overview (cont.)

Alloying:

Addition of ingredients to obtain desirable product properties

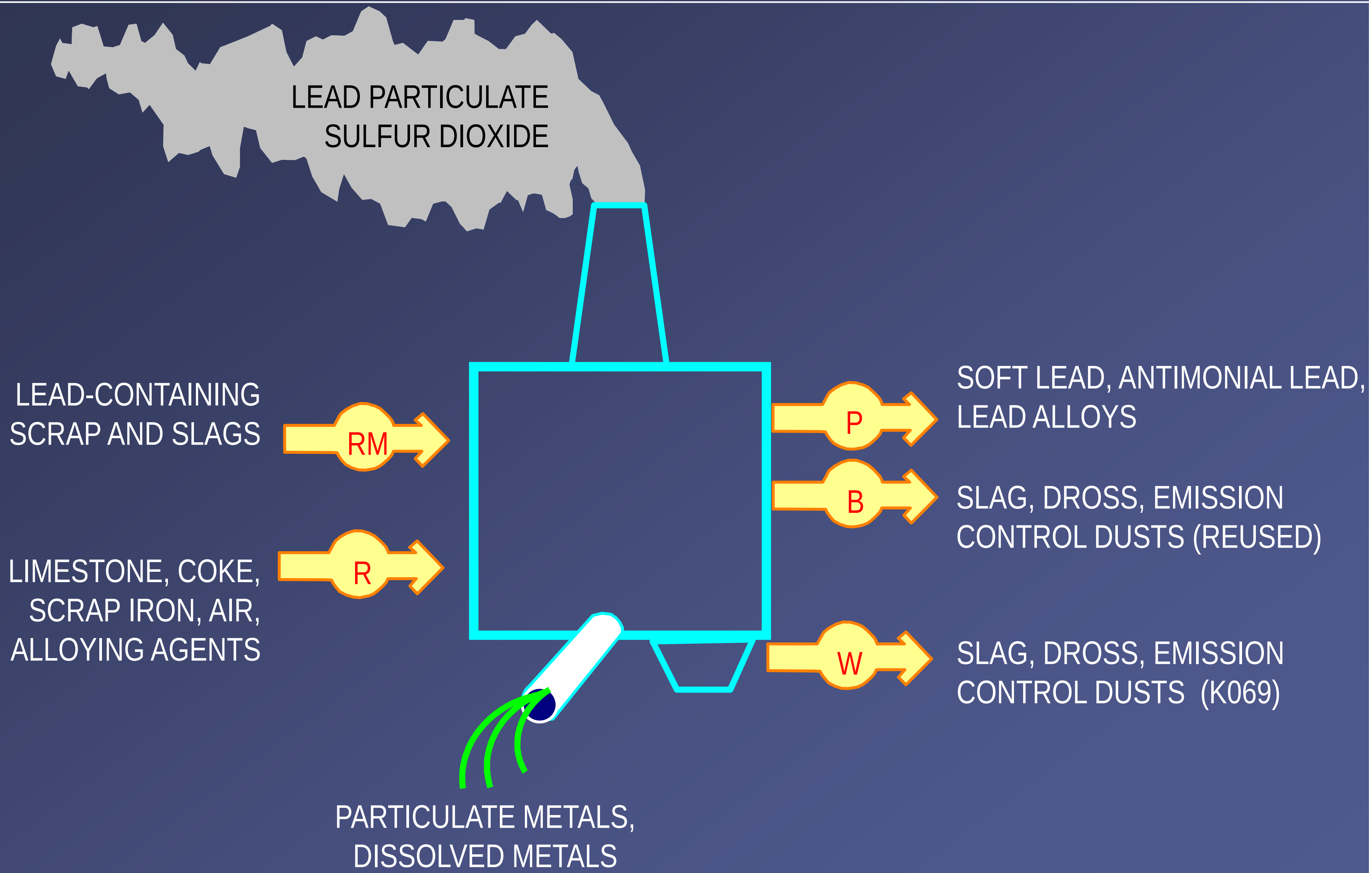
Process requires:

- Melting temperatures
- Alloying agents
- May occur during refining step

Key Chemicals

	2011 ATSDR Rank
Arsenic	1
Lead	2
Cadmium	7
Zinc	75
Antimony	>100
Copper	>100
Tin	>100

Standard Process Schematic



Process Details

Reverberatory or blast furnace

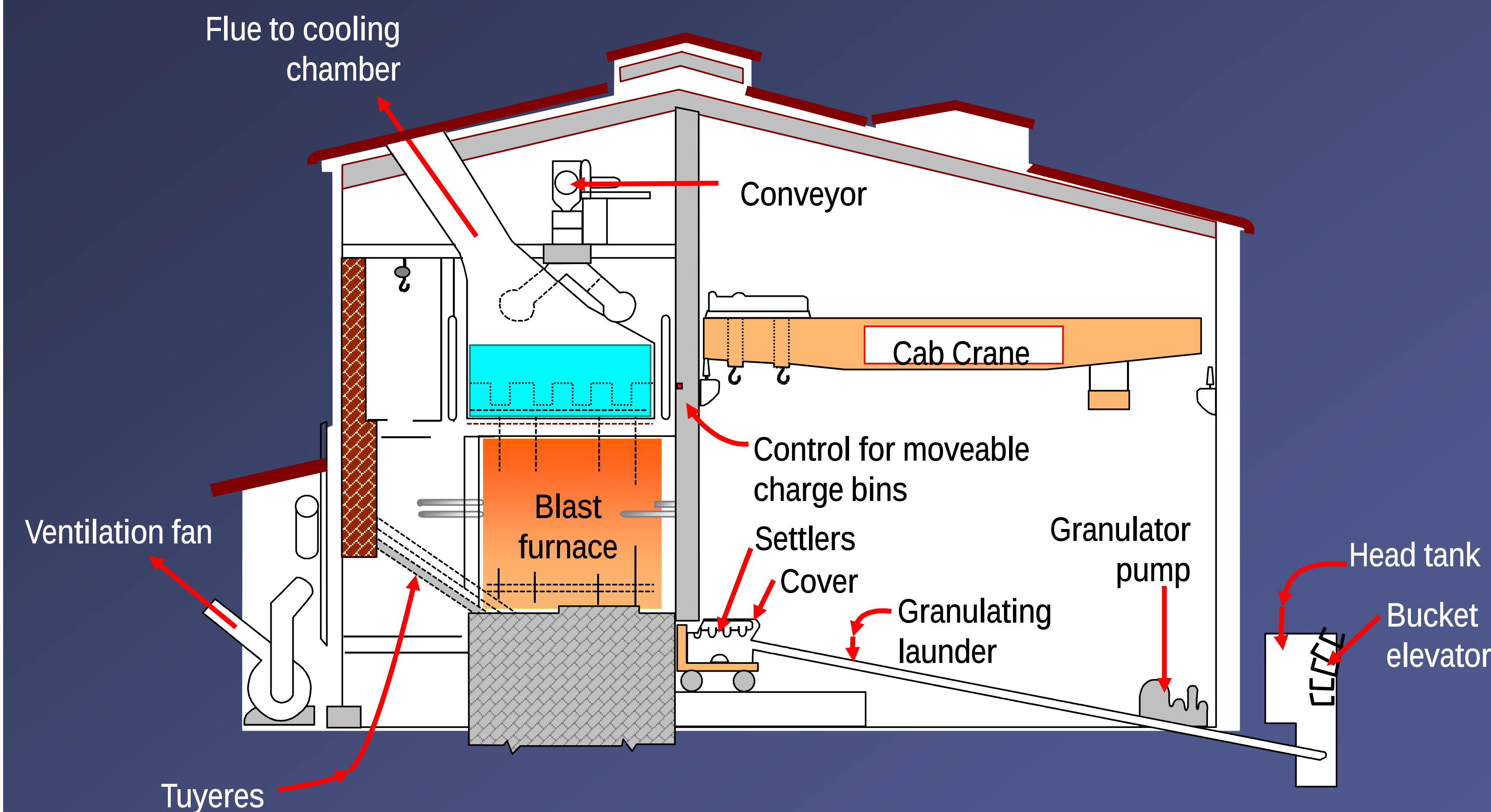
– 1260°C

– Burnout

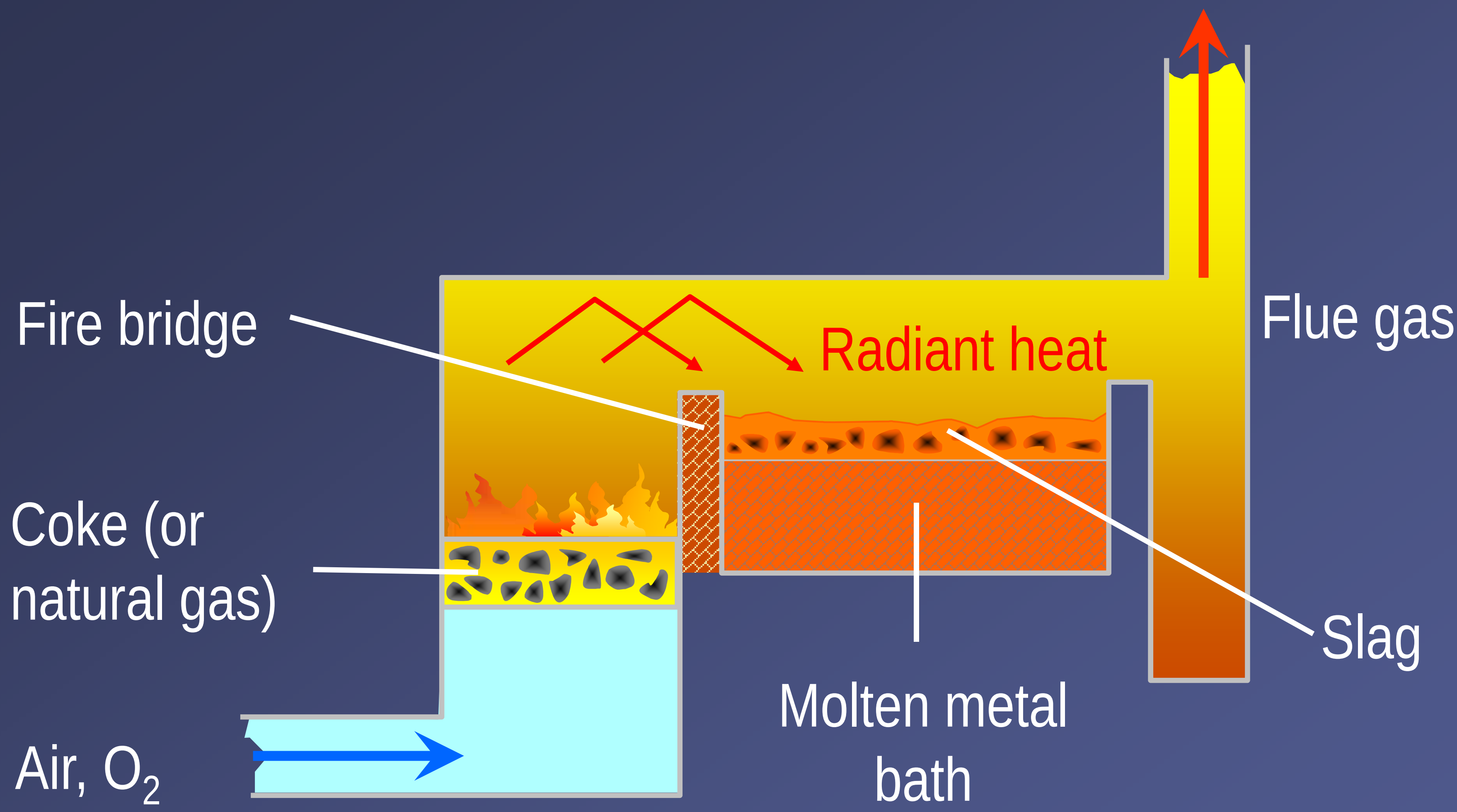
– Sweating

– Slagging

Process Details (cont.) Blast Furnace Schematic

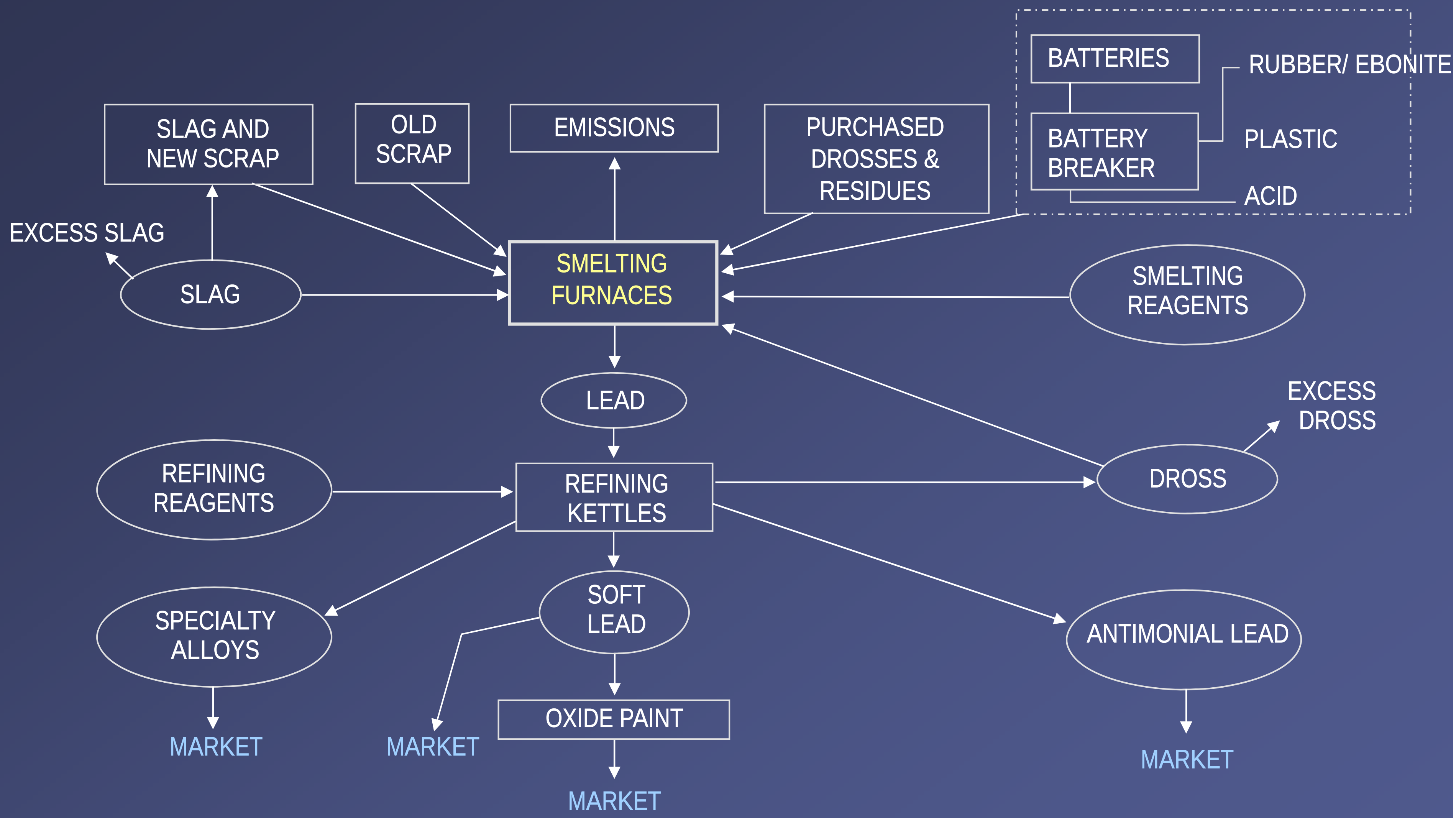


Process Details (cont.) Reverberatory Furnace Schematic



Reverberatory Furnace

Generalized Secondary Lead Refining Process



Refining Casts

Environmental Chemistry

Metals partitioning

- Volatility temperature (VT)
- Vapor pressure >10^{-6} atm
- Chlorine effect
- Volatile metals ~ VT <900°C

Predicted Metals Volatility Temperatures

	With 0% Chlorine		With 10% Chlorine	
Metal	Volatility Temperature (°C)	Principal Species	Volatility Temperature (°C)	Principal Species
Chromium	1613	CrO_2/CrO_3	1610	CrO_2/CrO_3
Nickel	1210	$Ni(OH)_2$	693	$NiCl_2$
Beryllium	1054	$Be(OH)_2$	1054	$Be(OH)_2$
Silver	904	Ag	627	AgCl
Barium	849	$Ba(OH)_2$	904	$BaCl_2$
Thallium	721	Tl_2O_3	138	TlOH
Antimony	660	Sb_2O_3	660	Sb_2O_3
Lead	627	PbO_2	B15	$PbCl_4$
Selenium	318	SeO_2	318	SeO_2
Cadmium	214	Cd	214	Cd
Osmium	41	OsO_4	41	OsO_4
Arsenic	32	As_2O_3	32	As_2O_3
Mercury	14	Hg	14	Hg

Source: EPA 1992

Modes of Release

Continuous emissions

- Stack emissions
- Emission control dusts/sludges
- Slag, dross (K069)

Fugitive emissions

- Fugitive dust
- Seal leakage
- Washdown dust and water

Modes of Release (cont.)

Soils

- Direct placement or burial
- Air deposition

Groundwater

- Limited migration potential

Surface water

- Mobilized particulate
- Limited solubility

Analytical Considerations - Laboratory Methods for Lead

Medium	Method	Detection Limit
Water	Atomic absorption, ICP	0.001-0.1 mg/l
Soil	Atomic absorption, ICP	0.1-1.0 mg/kg
TCLP	Atomic absorption, ICP	0.001-0.1 mg/l

Analytical Considerations - Field Screening Methods for Lead

Medium	Method	Detection Limit
Soil	X-ray fluorescence (XRF)	~10 mg/kg
Water	Photometric, Colorimetric test kits	1 ppm

Summary

- Secondary smelting utilizes secondary resources to convert or recover lead metal
- Smelting furnaces and refining kettles are employed to reduce metallic species and to separate impurities
- Air emissions of volatile metals and particulate dusts
- Soils and surface water are primarily environmental receptors