PRIMUS®

Recycling of Residues and Wastes from Ironmaking, Steelmaking and Non-Ferrous Metallurgy
The PRIMUS® Process, developed by Paul Wurth, provides an innovative solution for

- **recycling iron and steelmaking dust and sludge**
  - and recovering valuable iron, zinc and other non-ferrous metals,
- **recycling non-ferrous residues**, and recovering valuable metallic contents.

This process is based on the combination of an advanced multiple-hearth furnace (MHF) and a specially designed electric arc furnace (EAF), serving as PRIMUS® Pre-Reduction Unit, resp. PRIMUS® Melting Unit.

Reduction and melting technologies are complemented by:

- simple material preparation for treating very fine dry material such as dust, if required,
- a simple blending step when treating sludge,
- specifically designed off-gas treatment, enabling …
  - minimized use of external gas,
  - efficient recovery of non-ferrous metal oxides.
Iron & Steelmaking Dust and Sludge

The PRIMUS® Process permits the treatment of all typical iron and steelmaking residues which cannot normally be recycled within the existing plant, such as EAF dust, BF sludge, steelworks sludge and oily mill sludge.

Recycling of such residues through the PRIMUS® Process provides the best solution to:

- mini-mill operators who want to reduce waste disposal costs,
- operators (steel, non-ferrous or wastes) who want to efficiently recycle residues with a zero waste process.

In addition to zinc, lead and other volatile metal oxides collected in the PRIMUS® oxide, this innovative process recovers separately the iron fractions from residues, and converts all gangue materials into inert slag, e.g. usable for road construction.

Thanks to the combination of MHF and EAF, the PRIMUS® Process achieves total recovery of zinc and lead, as opposed to other recycling processes.

Non-Ferrous Residues

The PRIMUS® Process provides an efficient solution for recovering non-ferrous metal content from residues. Such residues could be generated by the primary refining stage or by the transformation or use of refined metals at various manufacturing stages. The PRIMUS® Process solves the environmental issues inherent to the disposal of these materials.

Traditionally, in the zinc hydrometallurgical process, residues from the leaching steps must be stored in special ponds, which are becoming more expensive to maintain, if still permitted. Manufacturing and coating industries also generate waste and sludge which contain metallic fractions. These metals can be recovered through the PRIMUS® Process. For example, zinc, nickel or manganese included in alloys used for surface coating.

Depending on the materials to be treated and on the metals to be recovered, the valuable fractions will be obtained either at the outlet of the melting furnace i.e. HM or Ferro-Nickel or in the PRIMUS® Oxide out of the off-gas treatment i.e. zinc, lead, silver or gold. Additionally, hydrometallurgical treatment can be coupled to the PRIMUS® Process for producing metals of high purity.
**PRIMUS® Material Preparation**

**EAF dust**

EAF dust has to be pelletized before being charged to the PRIMUS® Pre-Reduction Unit, while the coal (economical, non-coking, wet) is charged separately.

**Iron & Steelmaking Sludge and wet Non-Ferrous Residues**

All iron & steelmaking sludge as well as wet residues from the non-ferrous industry are delivered to the PRIMUS® Plant where they are blended prior to being charged into the MHF.

---

**PRIMUS® Pre-Reduction Unit**

The PRIMUS® Pre-Reduction Unit is a specially designed multiple-hearth furnace (MHF) that achieves the following metallurgical steps: drying, heating, cracking of carbonated and hydrated components and pre-reduction.

The mechanical components and the refractory lining have been specifically designed for high off-gas temperature and corrosion. The gas flow has been optimized for efficient post-combustion and process control.

The raw materials and coal, initially charged on the top hearth level of the furnace, are carried along on each hearth level by rabble arms fixed to the rotating shaft. The process materials drop to the next hearth level located directly below until they are discharged at the bottom of the furnace and directly fed to the PRIMUS® Melting Unit.

During transfer through the MHF, the intense mixing of the input materials promotes their rapid heating and hence maximises process productivity. Metal oxides undergo pre-reduction by CO and H₂.

The energy requirement for the pre-reduction process is basically supplied by combustion of coal volatiles and post-combustion of CO evolved during pre-reduction.
**PRIMUS® Melting Unit**

The PRIMUS® Melting Unit, combined with the PRIMUS® Pre-Reduction Unit for producing hot metal, is a specially designed 3-phase AC arc furnace realizing final reduction, including dezincing, carburization and desulphurization (through the generated slag), as well as continuous melting of hot DRI fines.

The high specific power ratio, possible with the intense process, permits a compact design of the furnace vessel and hence investment is minimized.

The hot DRI produced by the PRIMUS® Pre-Reduction Unit is continuously fed to the PRIMUS® Melting Unit, which gives a very efficient energy balance for the PRIMUS® Process.

The final products are
- a high quality hot metal with approx. 4% carbon,
- an inert slag, comparable to BF slag, e.g. usable in road construction.

**PRIMUS® Off-gas Treatment System**

The off-gas treatment system is specifically adapted to the input materials and complies with the most stringent environmental regulations.

In case of recycling of iron & steelmaking dust or sludge or non-ferrous residues, the volatile metals extracted from the PRIMUS® Pre-Reduction and Melting Units are recovered as metal oxides in a bag filter unit.

The PRIMUS® Oxide is a premium input material for further hydrometallurgical processing leading to the production of pure zinc, lead and other non-ferrous metals.

**PRIMUS® Process reduces complexity of sludge processing**

The PRIMUS® Process is a compact and integrated technology avoiding several processing stages usually required for sludge.

Depending on residue features and local conditions, Paul Wurth can propose a tailor-made solution which may include alternative Paul Wurth technologies.
1. Laboratory Furnace
- Single-hearth furnace for 10-15 kg batch operation
- Built in 1998 in Luxembourg

2. Pilot Plant
- MHF for 1-2 t/h continuous operation combined with a 1.8 MW arc melting furnace, equipped with a full off-gas treatment system
- Built in 2000 in Luxembourg

3. Industrial Plants
- First industrial plant, commissioned in 2003 for Primorec S.A. (now ArcelorMittal Woiber–Differdange, Luxembourg)
  - Key plant features:
    - For processing 60,000 t/a EAF dust and rolling mill sludge: 8 hearth MHF and 3-phase AC arc melting furnace, equipped with a full off-gas treatment for zinc recovery.
    - Primus plant operated since 2009 by Dragon Steel in Taiwan for processing 85,000-120,000 t/a EAF dust and integrated steelworks residues

---

a. ArcelorMittal Woiber – Luxembourg
b. PRIMUS® Shaft with rabble arms
c. PRIMUS® Melting unit
d. Dragon Steel Plant – Taiwan
Advantages of the PRIMUS® Process

**Low Operating Costs:**

- Very low energy costs
  - Non-coking coal fines serve as a unique reductant and energy source for MHF.
- No natural gas consumption for processing dust and non-ferrous residues
- Some natural gas consumption is required for initial heat-up of MHF and for processing sludge
- Low material preparation costs:
  - Sludge and residues: only blended
  - EAF dust: pelletized (no firing)
  - Coal: no grinding, no fines separation, no drying

**High Efficiency of PRIMUS® Process**

- Efficient energy balance
  - Solid-gas counter-flow
  - Off-gas post-combustion is undertaken in the MHF and in a post-combustion chamber
  - CO containing EAF off-gas is used to minimize external gas output in the gas treatment line
- Almost **100% recovery yield**
  - of zinc, lead and other non-ferrous metals from sludge, dust and non-ferrous residues
- Direct feeding of hot DRI into the PRIMUS® Melting Unit

**High Product Quality**

- Hot Metal
  - Carbon ~ 3.5-4.5%
  - Silicon < 0.1%
  - Sulphur: depending on sulphur inputs
- PRIMUS® Oxide
  - Zinc > 55%
- Slag
  - Inert slag, similar to BF slag (e.g. usable in road construction)

**Reliability and Safety of the PRIMUS® Process:**

- Use of proven technologies
  - MHF, EAF, pelletizing, off-gas treatment...
- Multiple-hearth furnace working at atmospheric pressure
- Low temperatures for pre-reduction process
  - Max. 1000°C
The Paul Wurth Group is today one of the world leaders in the design and supply of complete plants, systems and processes as well as specialised mechanical equipment for

- **the iron & steel industry:**
  - Blast Furnaces & Auxiliary Plants
  - Coke Making Plants
  - Agglomeration Plants
  - Direct Reduction Plants
  - Environmental Protection, Recycling & Energy-Saving Technologies

- **other industries:**
  - Systems & Equipment for Non-Ferrous Pyrometallurgy, Electrometallurgy & Residue Treatment
  - Intralogistics Solutions for Heavy Loads
  - Engineering & Project Management for Civil Construction and Infrastructure Projects


© Copyright 2008-2015 Paul Wurth S.A. – all rights reserved

Non Contractual Data: Paul Wurth believes that the data contained in this folder are correct and accurate, but cannot guarantee same or better performances for any specific site without a detailed quote. Patents and Patents pending. — Paul Wurth equipment and processes are protected in many countries by patents.

Paul Wurth, the Paul Wurth Logo and Primus are trademarks of Paul Wurth S.A. and may be registered in your jurisdiction.