Explosion at Blast Furnace

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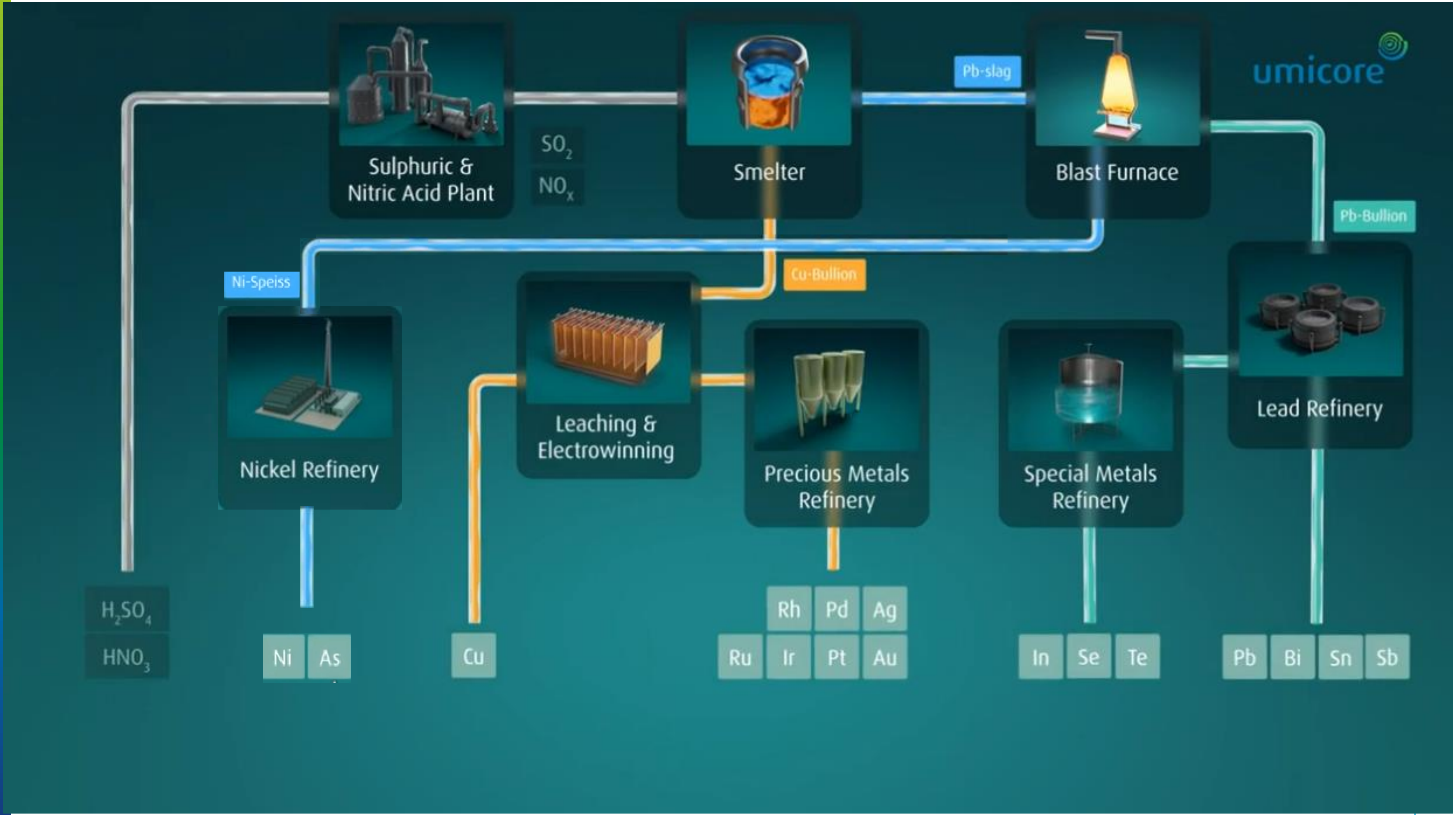
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Sulphuric & Nitric Acid Plant
SO2
NOx
Smelter
Pb-slag
Blast Furnace
Pb-Bullion
Ni-Speiss
Cu-Bullion
Nickel Refinery
Leaching & Electrowinning
Precious Metals Refinery
Special Metals Refinery
Lead Refinery
H2SO4
HNO3
Ni
As
Cu
Rh
Pd
Ag
Ru
Ir
Pt
Au
In
Se
Te
Pb
Bi
Sn
Sb

Explosion at Blast Furnace

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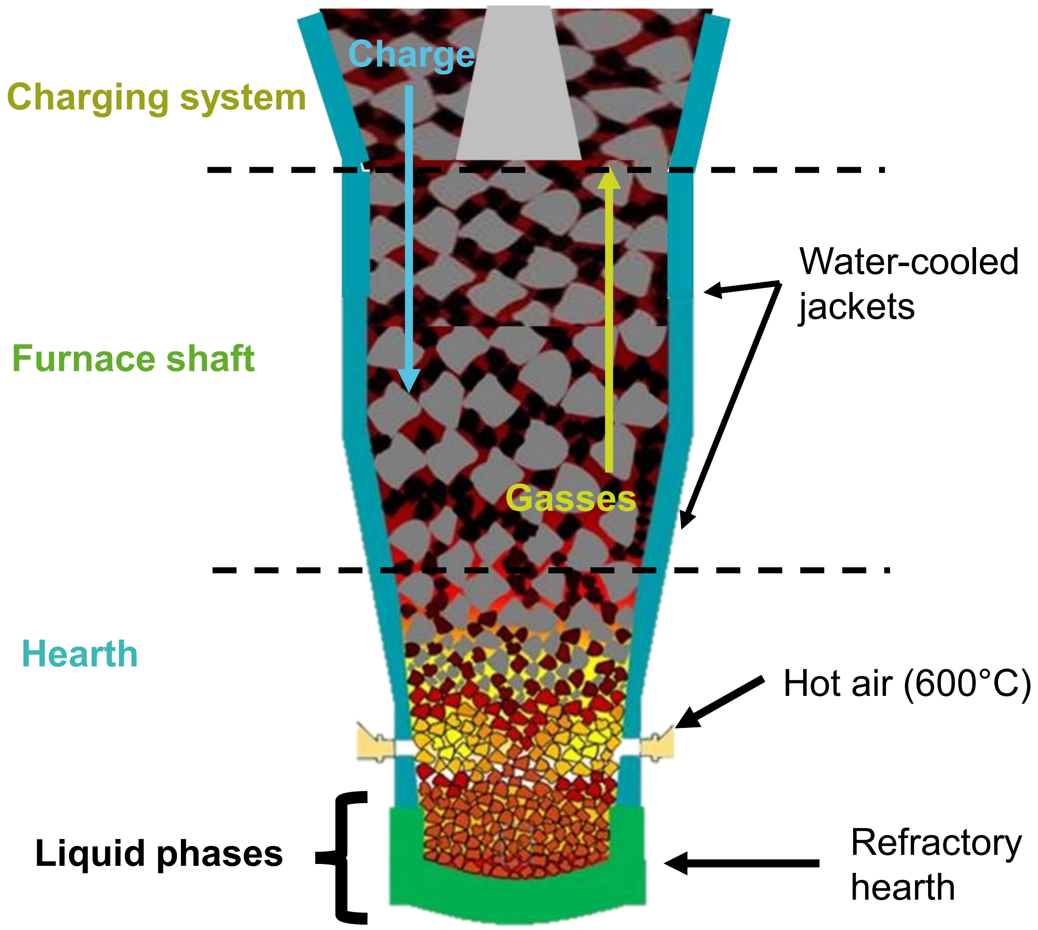
Introduction – Blast furnace process



Continuous process were lead slags are reduced to a lead bullion

- **Charge**:
  - Solid feed (25°C) mainly lead slag
  - Reducing agents**:** Cokes and **iron** scrap
  - Bed needs to have sufficient strength and permeability
- **Furnace shaft**:
  - Pre-heating zone (25 – 1000°C)
  - Solid charge – solid cokes
  - Water-cooled jackets
- **Hearth**:
  - Collecting liquid phases (1100 – 1250 °C)
  - Refractory hearth

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Timeline

4/4/'25	8/4/'25	9/4/'25	11/4/'25	2/5/'25
Stable process	Unstable process	Stable process	Shutdown	

New charge recipe
(every week)

Difficult operations (1)
- Release of hot process gas through taphole
- Fluctuations in bath height

Temperature parameters beyond known operating window

Changing to
emergency charge

(2) **Explosion in furnace**

Explosion at Blast Furnace

Incident classified as PSE Level 2

- Unexpected, uncontrolled or unplanned event? ✗ → No Process Safety Event
- ✓ (Chemical) substance/material or (chemical) process directly involved? ✗ → No Process Safety Event
- ✓ Incident in production, distribution, storage, lab, utilities, pilot plants? ✗ → No Process Safety Event
- ✓ Release of material, fire or ex/implosie? ✗ → No Process Safety Event
- ✓ Classification Process Safety Event

	Level 1	Level 2	Level 3	Level 4	Level 5
Injury:	FATs	FAT	LTA	RI_NLT	FA
Direct damage:	≥ 25M€	**250k-25M€**	25k-250k€	2.5k-25k€	<2.5k€
Evacuation/shelter	>24h	12-24h	3-12h	<3h	no
Release: Acute release during one hour	≥ 640xTQ	160-640xTQ	40-160xTQ	1-40xTQ	<TQ

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1 Cause of unstable operations

Due to an incorrect delivery, aluminum scrap was charged instead of iron scrap.

Process consequence:

- **Extremely high temperatures** as 15 times more energy is released with Al oxidation compared to Fe oxidation

Why not detected:

- No control on incoming goods for iron scrap on the presence of aluminium
- Difference between Al and Fe scrap is visually difficult to distinguish
- Scenario of wrong input of Al was not identified during risk assessment (Al scrap is not used on site)

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❶ **Impact of working outside known operational window**

Wear of cooling plates

- Extreme temperatures causing **martensite transformation** in microstructure of cooling plates → **embrittlement**
- Fluctuations in bath height due to drops in counter pressure resulting in contact of Pb-alloy/matte phase with cooling plates → **corrosion**

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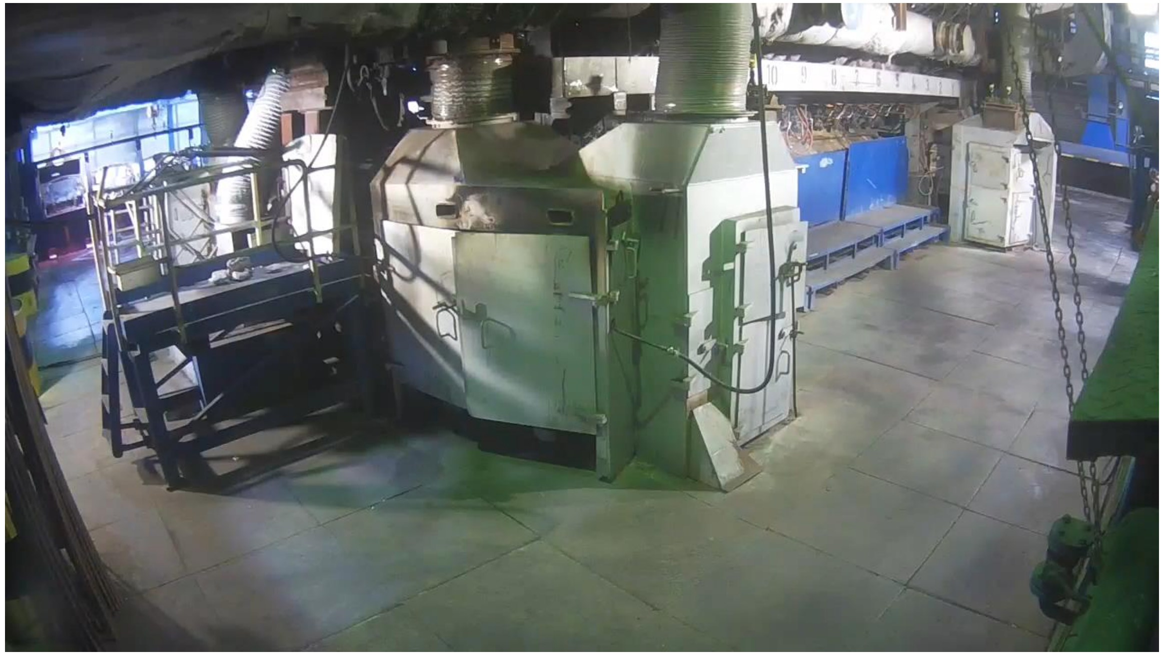
2 **Explosion of cooling plate due to reaction of cooling water and liquid metals**



2

Wear of cooling plates 1

⇩

Cooling water enters furnace

⇩

Steam explosion due to reaction water with liquid metals

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Why did this water leakage had a much greater impact than previous instances?

Previous water leakages

- Corrosion creates small leaks (l/day)
- **Water evaporates** in contact with hot slag
- Detected by **“sweating” of cooling plates** and gradual decrease in **level of leak detection vessel**
- Cooling plate replaced without incident

Current incident

- Martensite formation made cooling plates **brittle**
- Small corrosion leak was **easily enlarged by brittle cooling plates**
  → large amounts of liquid water in the oven (m^3/min)
- Pressure build-up due to rapid expansion of water (1700 times volume)
- → **explosion**

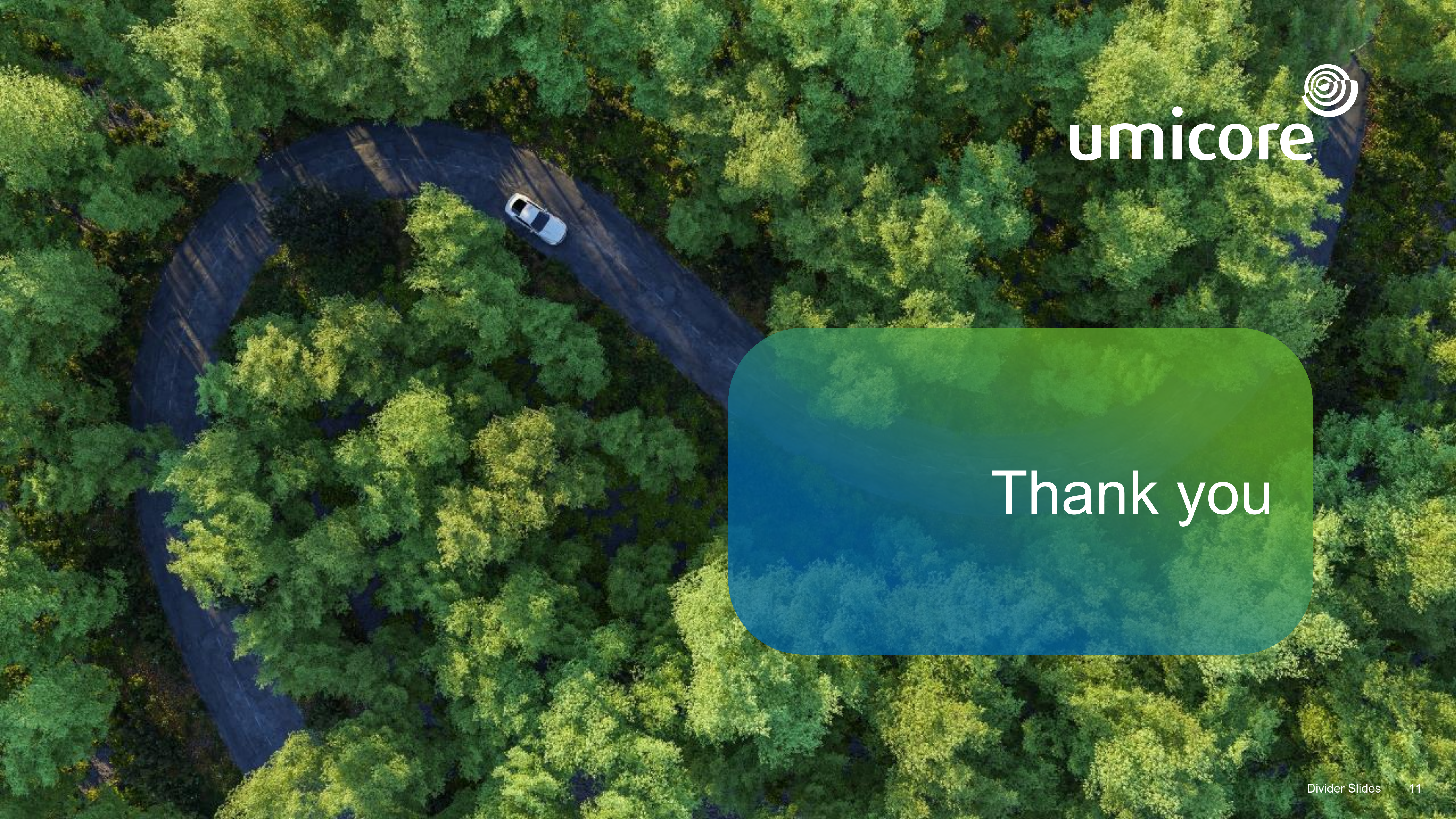
Actions & key learnings

Direct actions

- MOC to increase height of the liquid bed
- Check on magnetism for incoming Iron scrap
- Segregation of iron scrap from different suppliers (traceability and quality control)
- Mix deliveries of iron scrap from different suppliers
- Replacement of cooling water by a mixture of MEG/water – reduces impact

Key learnings

- Review Hazop for deviations of individual feeds (involve suppliers)
- Review acceptance criteria for all incoming material
- Include the scenario of steel embrittlement in the PHA of other cooling systems


Thank you