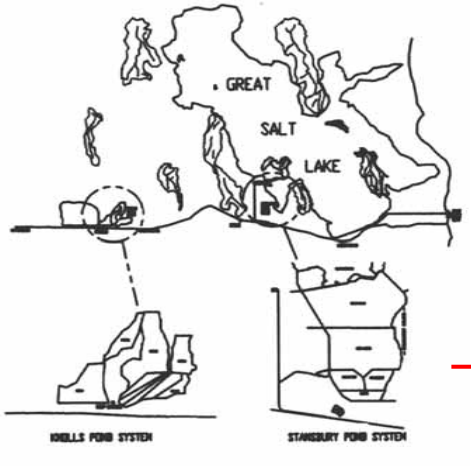
SF6 Replacement Consideration for Primary Magnesium Producers

Tom Tripp – US Magnesium

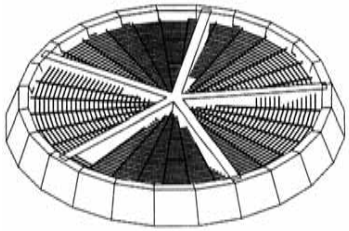
US Magnesium

- Member of The Renco Group family of industrial companies that include assets in magnesium, steel, lead, energy and specialized vehicle production (AM General).
- Only producer of primary magnesium in the United States.
- Operate a 43,000 metric tpy production facility 60 miles west of Salt Lake City, Utah, USA.
- The manufacturing process has been in operation for over 30 years under various owners.

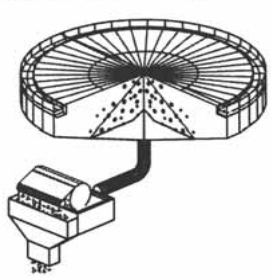
Process Flow Diagram



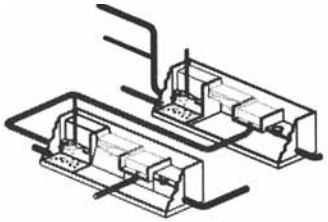
SOLAR PONDS



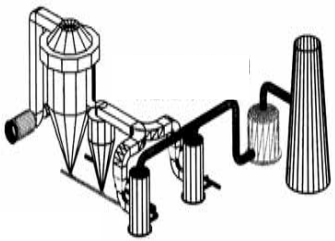
HOLDING PONDS



DESULFATION

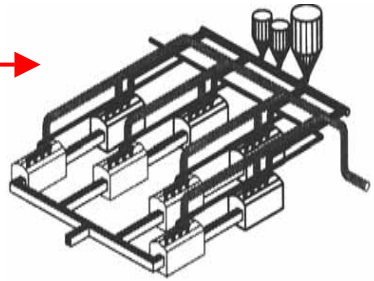


DEBORONATION

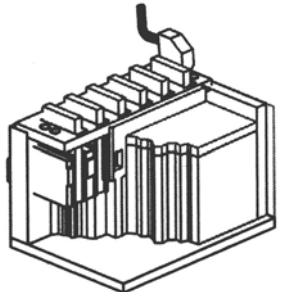


SPRAY DRYING

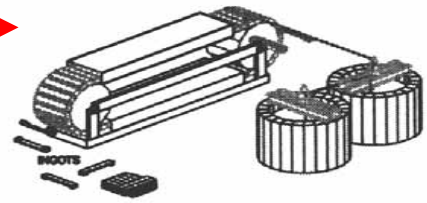
CONCENTRATE/PREHEAT



MELTING/PURIFICATION



ELECTROLYTIC



CAST HOUSE

What is a Primary Magnesium Producer?

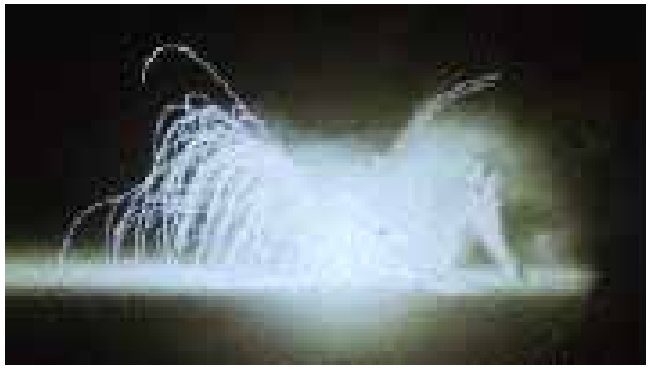
- For the purposes of this discussion – a place where:
  - Ingots produced from native materials
  - Ingots produced from scrap
  - Ingots produced from secondary materials

Why Do We Like Cover Gas?

- While solid magnesium is fairly safe -

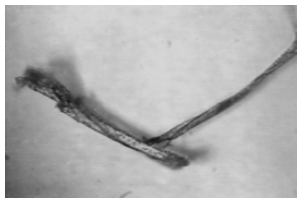
Why Do We Like Cover Gas?

- Fire control
  - Molten magnesium burns spontaneously

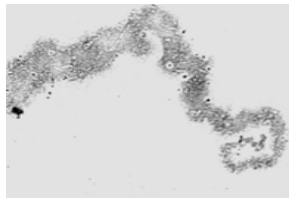


Why Do We Like Cover Gas?

- Metal Purity
  - Lack of protection introduces oxides



400x



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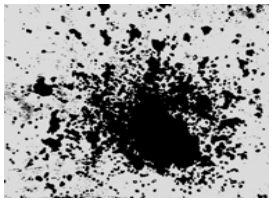

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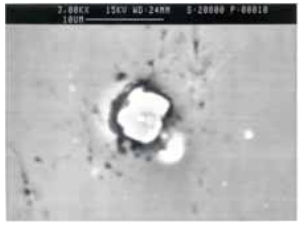


Uses for Cover Gas in Magnesium Ingot Production

- Furnace Protection

Uses for Cover Gas in Magnesium Ingot Production

- Casting Protection

Uses for Cover Gas in Magnesium Ingot Production

- Protection of recycle materials

SF_6 – The Perfect Cover Gas?

- Non-toxic
- Odorless
- Robust performance
- Readily available
- Moderate cost (usually)

SF_6 – The Perfect Cover Gas?

- Very high global warming potential
  - **23,900 times CO_2**
- Global Environmental Attention
- Subject to cost swings based on fluorine value
  - SF_6 Price has ranged from $4 to $75 in the last 15 years.

Protective Gases (non –SF6)

- Most Common
  - Sulfur Dioxide (SO_2)
  - Argon (Ar)
  - Nitrogen (N_2)
  - Carbon Dioxide (CO_2)
  - BF_3

- Recent Additions
  - Novec612
  - HFE 7100
  - Freon (HFC-134a)
  - Others ??

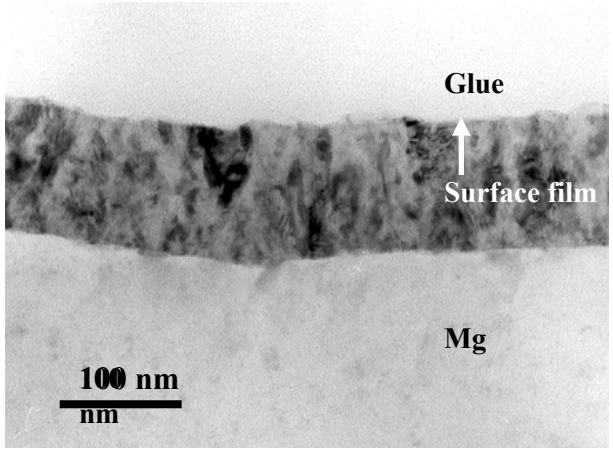
Protective Gases (non –SF6)

- Oxygen Excluders
  - Argon (Ar)
  - Nitrogen (N_2)
  - Carbon Dioxide (CO_2)
  - Others

- Considerations
  - Require tightly sealed systems
  - Very poor performance in extinguishing fires
  - Subject to pyrophoric Mg deposition

Protective Gases (non –SF6)

- Oxide Film Stabilizers
  - Novec 612
  - HFE 7100
  - Freon (HFC-134a)
  - Others ??



- Considerations
  - Possible industrial hygiene considerations (HF and others)
  - Ease of conversion
  - Cost/Supply/etc.

US Magnesium SF_6 Replacement Testing

- Nitrogen – Routine use in certain non-casting applications

US Magnesium SF_6 Replacement Testing

- Novec 612 – Successfully tested in Direct Chill Casting

US Magnesium SF_6 Replacement Testing

- 134a – Successfully tested as a furnace cover and small ingot casting

Considerations in Replacement

- Toxicity/Industrial Hygiene
  - Some replacements may generate toxic breakdown by products
  - Byproducts may be difficult to detect
- The obstacles are very manageable via
  - Proper planning
  - Good operating practices

Considerations in Replacement

- Cost
  - Annual purchase costs
  - Capital investment in new equipment
  - Indirect costs related to product quality
  - Indirect costs related to operating difficulties
- There are opportunities for savings compared to SF_6

Considerations in Replacement

- Other Considerations
  - Annual Supply; Number of suppliers
  - Technical support
  - Ease of use
  - Global warming potential
  - Indirect costs related to operating difficulties
  - Ease of conversion

Conclusion

- There are already viable options for conversion
- There may be cost incentives to conversion
- It’s widely recognized that a quick conversion will be good for the magnesium industry.

The Intergovernmental Project on Climatic Change - IPCC

The United Nations Project for controlling
“global warming” and “ozone depletion”

The Kyoto Protocol

- Signatory countries agreed to reduce emissions of greenhouse gas (GHG) to 1990 levels by 2012
- The IPCC assist tracking of progress to making the goals
- Annual inventories of GHG are filed by the signers of the Kyoto Protocol

The IPCC is divided into five task groups for GHG Inventory development:

- Energy
- Industrial Process and Product Use (IPPU)
  - Metals including Mg are in this group
- Agriculture, forestry and Other Land Use
- Waste
- Cross-cutting Issues

GHG Inventory Guidelines

- First Issued in 1996
- To be Updated every 10 yrs
- GHG of Special Interest e.g. SF_6 were added to the inventory system in 1998
- Good Practices for estimating SF6 emissions from the “magnesium sector” were added at that time

The IPCC began the process to revise GHG inventory guidelines for 2006 this year with meetings of the various task groups

- Energy - Tanzania
- Industrial Process and Product Use - Washington D.C.
- Agriculture, forestry and Other Land Use - Mauritius
- Waste - Canada
- Cross-cutting Issues

Industrial Processes and Product Use

- Met in Washington D.C. - July 2004
- Divided into six “break out groups”
- One of the groups was metals

IPPU Metals Group

- The Metals Group Inventory to cover "major metals"
- Major metals largely focused on steel, cast iron, aluminum and magnesium.
- A total of about 20 metals were considered
- Group composed of 12 people from eight countries

Magnesium Guidelines

- Guidelines developed by Gabriella Trannel of SINTEF (Norway) and Tom Tripp (US Magnesium)
- Based on the 1998 guidelines previously developed by the IPCC's IPPU
- Per IPCC direction include other GHG besides SF_6

Magnesium Guidelines

- The guideline allows three options for estimating emissions based on the available data
- Guides will be edited in 2005
- Revised guidelines will be published in 2006