A Replacement for SF_6: The MagShield System

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Hatch

Acknowledgement

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- Helmut Brandt—President
- George Calder—Special Project Engineer

Presentation Overview

- Magnesium protection—prior art
- Use and limitations of SF_6
- The MagShield system
- Industrial trials—results
- Conclusions
- Future plans

Magnesium Protection History

- 1910's–1970's
  - Salt fluxes:
    - Hygroscopic
    - Corrosive
    - Flux contamination of metal
    - Environmental pollution
- 1948
  - Addition of 0.0005% Be
    - Burning inhibitor

Magnesium Protection History (cont'd)

- 1930's–1970's
  - SO_2
    - Used quite universally
    - Good protective film
    - Corrosive and toxic
- 1970's–present
  - SF_6
    - Forms thin protective elastic film
    - Prevents oxidation and evaporation
    - Non-corrosive and non-toxic

SF_6—General

- Synthetic
- Non-toxic, odorless
- Safe to handle
- Effective protection

Cover Gas Comparison

Description	SO_2	SF_6	BF_3
Presently Used?	Yes	Yes	Test Trials
Mechanism of Melt Protection	Protective Film	Protective Film	Protective Film
Amount Required (% vol.)	0.5–5.0	0.6–1.5	0.4–0.8
Corrosiveness	Yes	Yes (in high %)	Yes
Toxicity	Toxic	Non-toxic	Toxic
Greenhouse Effect	No	Yes*	No

* 1 kg SF_6 = 23,900 kg CO_2, 3,200 years of atmospheric life

SF_6—Environmental

Potent Greenhouse Gas

1 kg SF_6 = 23,900 kg CO_2

Long Lasting

3,200 Years Atmospheric Life

Unacceptable

Major End Users and Regulators

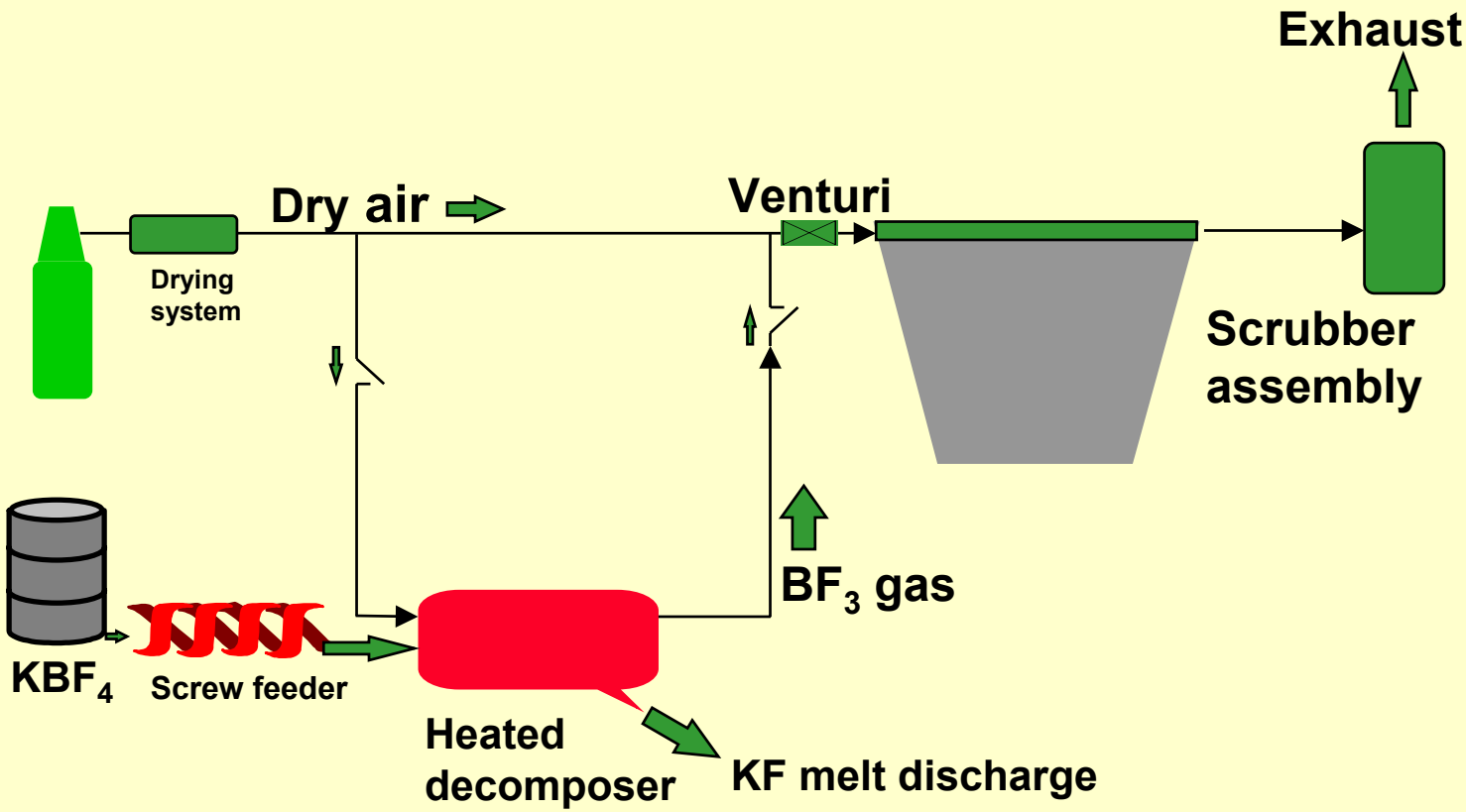
Why Not BF_3?

- BF_3 is equally effective in protecting molten magnesium BUT!
  - SF_6 availability and transportation
  - Toxicity/corrosiveness concerns
  - Dry carrier gas requirements
  - Compressed gas—costly/special storage
  - Storage—potentially serious hazard

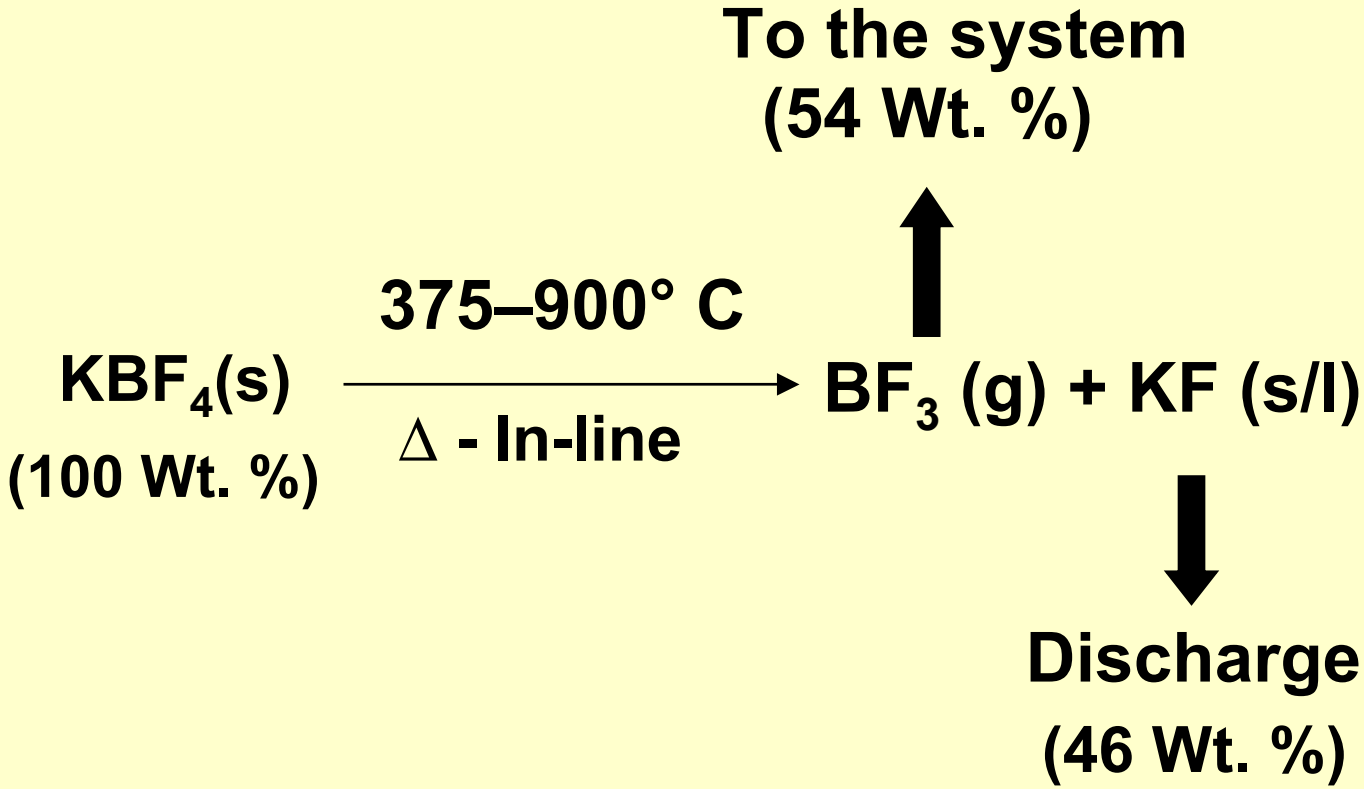
What Is MagShield ?

- MagShield—the in-line generation of BF_3 by efficient thermal decomposition of a low cost and inert material

MagShield System Schematic



MagShield Reaction Chemistry



MagShield
Estimated Operating Data

Basis	KBF_4 required	BF_3 produced	KF-waste generated
1.0 MT Mg	1.1 kg (2.4 lb)	0.6 kg (1.3 lb)	0.5 kg (1.1 lb)
5,000 MT Mg	5,500 kg (12,100 lb)	2,970 kg (6,500 lb)	2,530 kg (5,600 lb)
50,000 MT Mg	55,000 kg (121,300 lb)	29,700 kg (65,500 lb)	25,300 kg (55,800 lb)

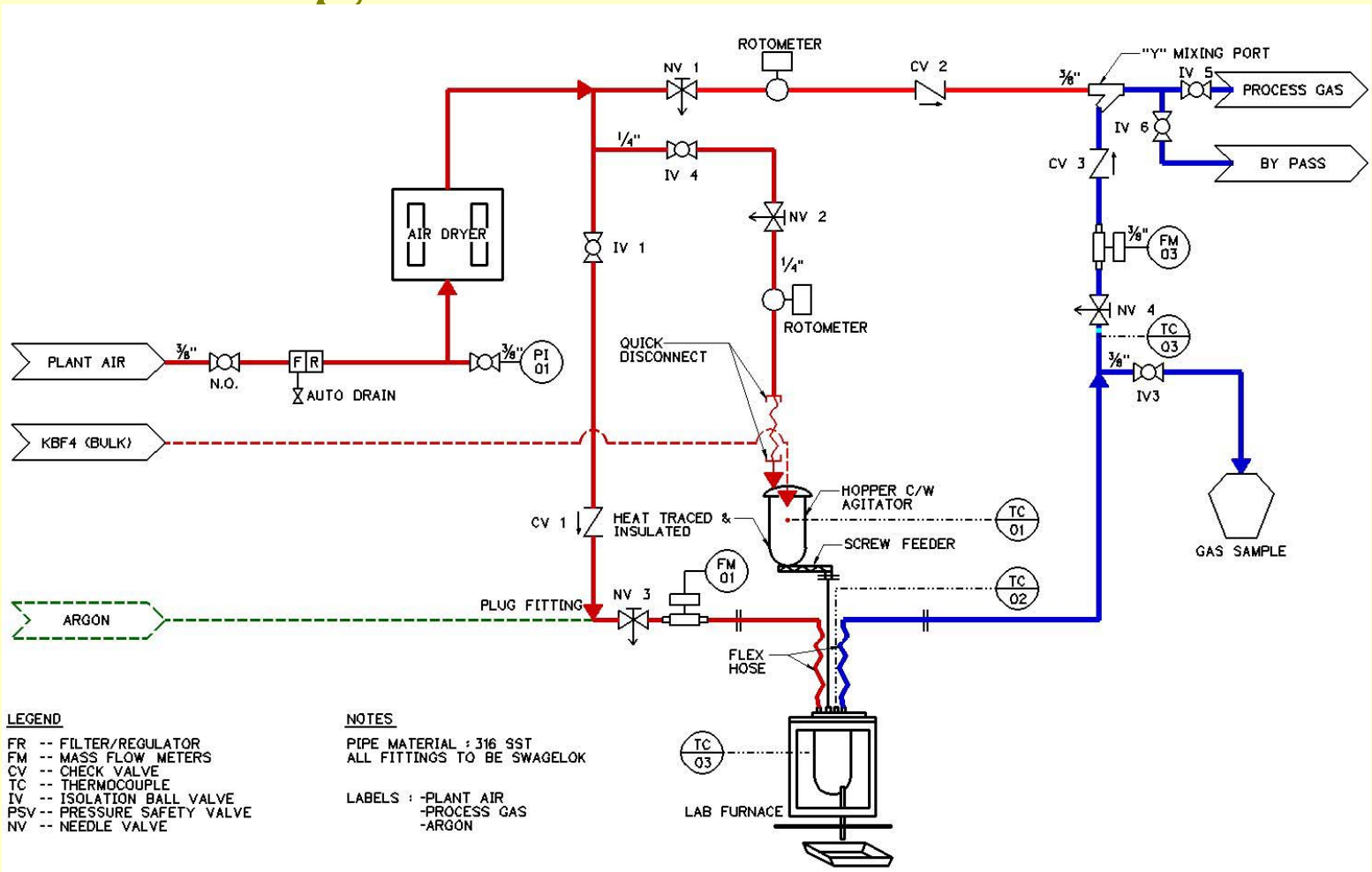
MagShield—Advantages

- Environmentally friendly
- Cost effective
- Safe
  - In-line generation of dilute gas mixture
  - Elimination of compressed gas storage
- Highly effective (approx. 0.5% by volume)
- Available raw material
- Simple process

Industrial Trials—Objectives

- Process validation
- Operational evaluation
- Health and safety assessment
- Equipment reliability
- Product quality confirmation

MagShield—Flow Sheet



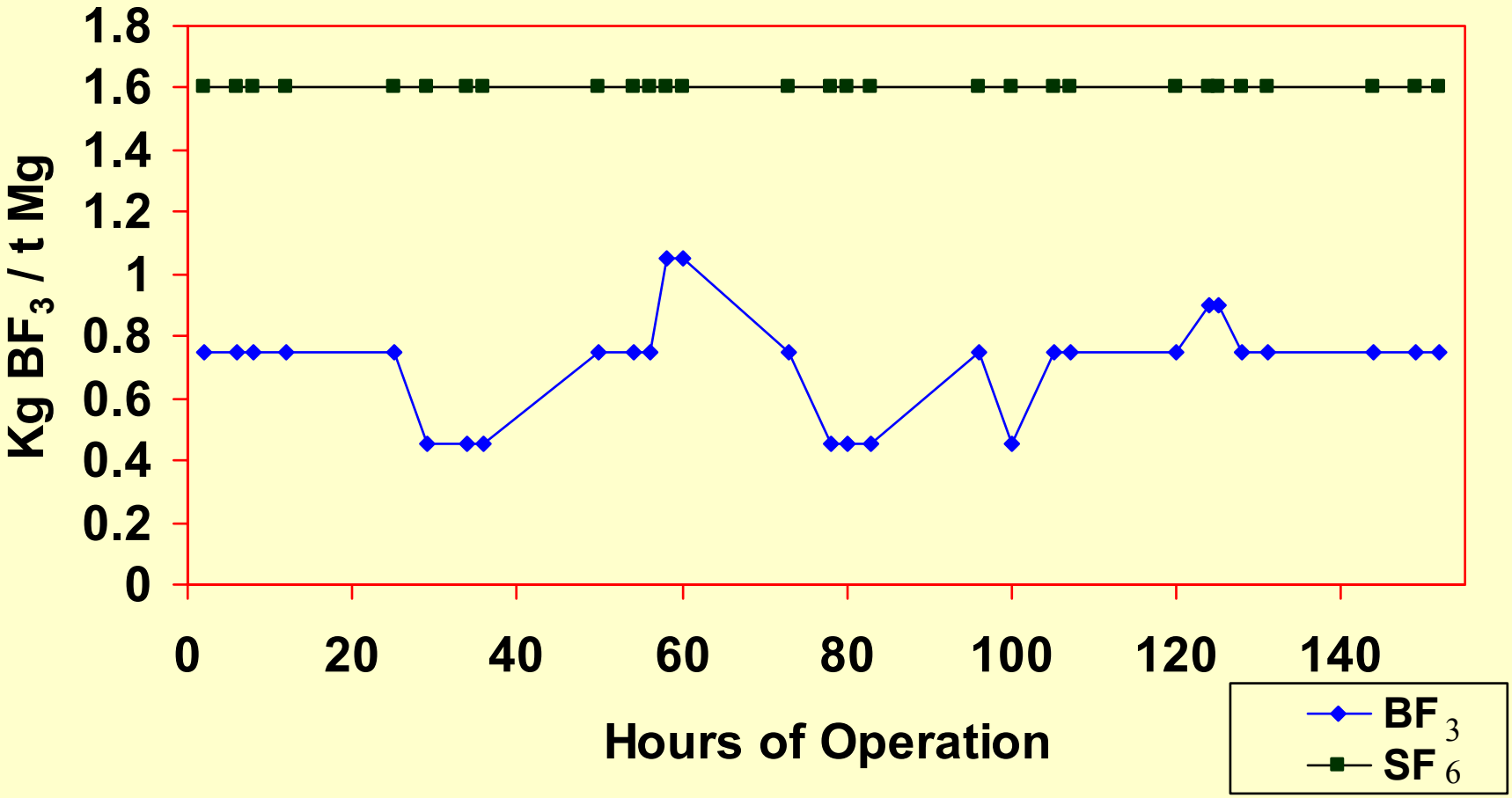
MagShield—Prototype

Industrial Trials—Observations

• Decomposition	Consistent
• Gas generation	Constant
• Gas concentration	0.1–0.7 vol.% (in dry air)
• Gas consumption	Varied with temperature
• BF_3 utilized*	0.12–0.8 kg/MT Mg
• KBF_4 consumed*	0.2–1.3 kg/MT Mg

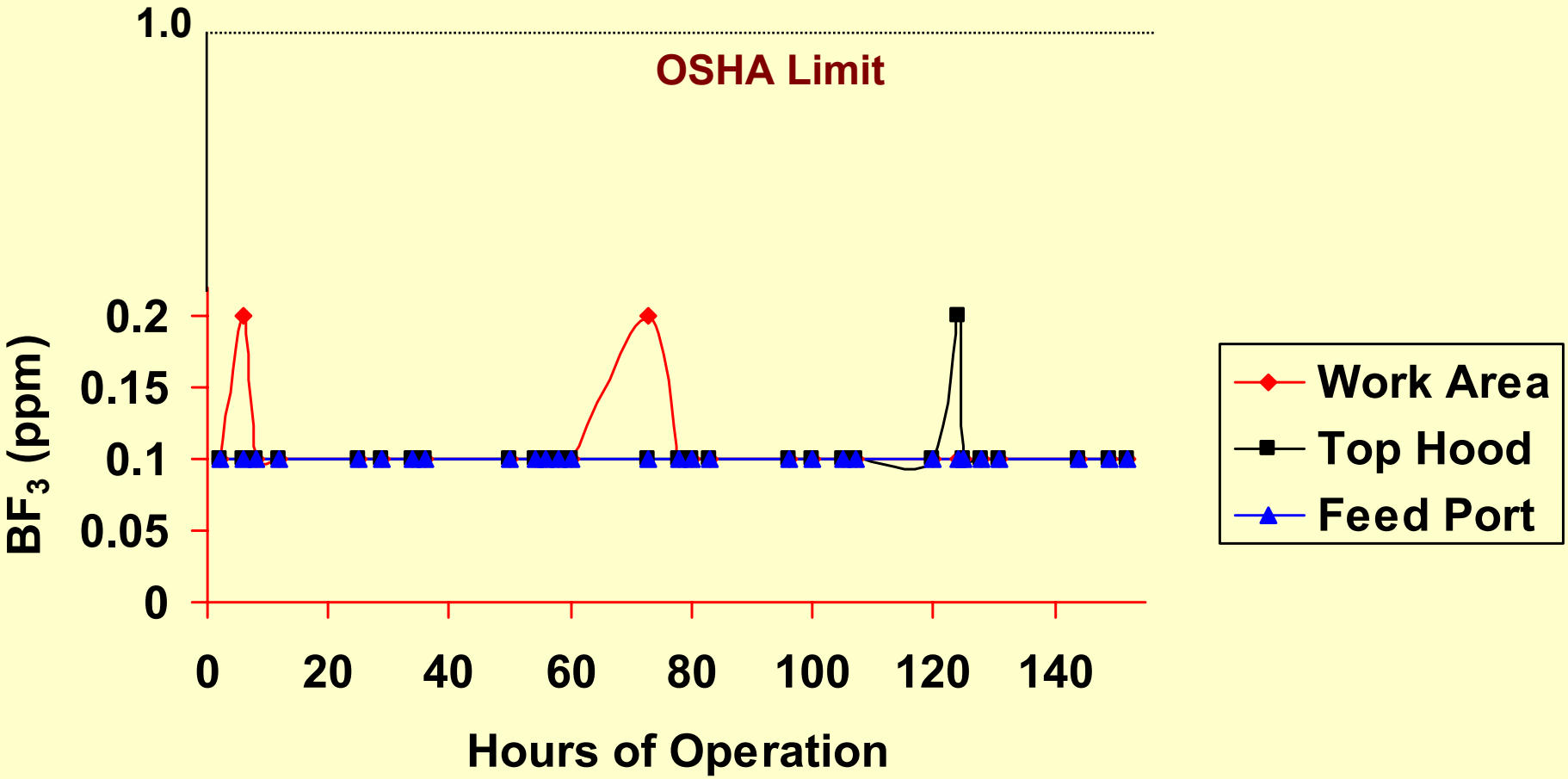
* Calculated values

Industrial Trials—Gas Utilization



Fugitive BF_3 Monitoring

BF_3 Fugitive Emissions



KBF_4—Safety Data

- KBF_4 (potassium fluoroborate) is <u>not</u> listed as <u>hazardous compound</u>
- Chemically stable under normal conditions
- Decomposition starts at 350^{o} C
- TLV: 2.5 mg/m^3

Cover Gas—Safety Data

Description	SO_2	SF_6	BF_3
Toxic Threshold Limit Value (TLV), ppm	2	1,000	1
$LC_{50}inhal_{(rat)}$, ppm (1.0 hr exposure)	2,520	N/A	387

Industrial Trials—Conclusions

- Volume consumption < SF_6
- Mass consumption ~ ½ SF_6
- Lower cost of operation ~ ½ SF_6
- Emissions ~ 1/10 OSHA limit
- No observed system corrosion

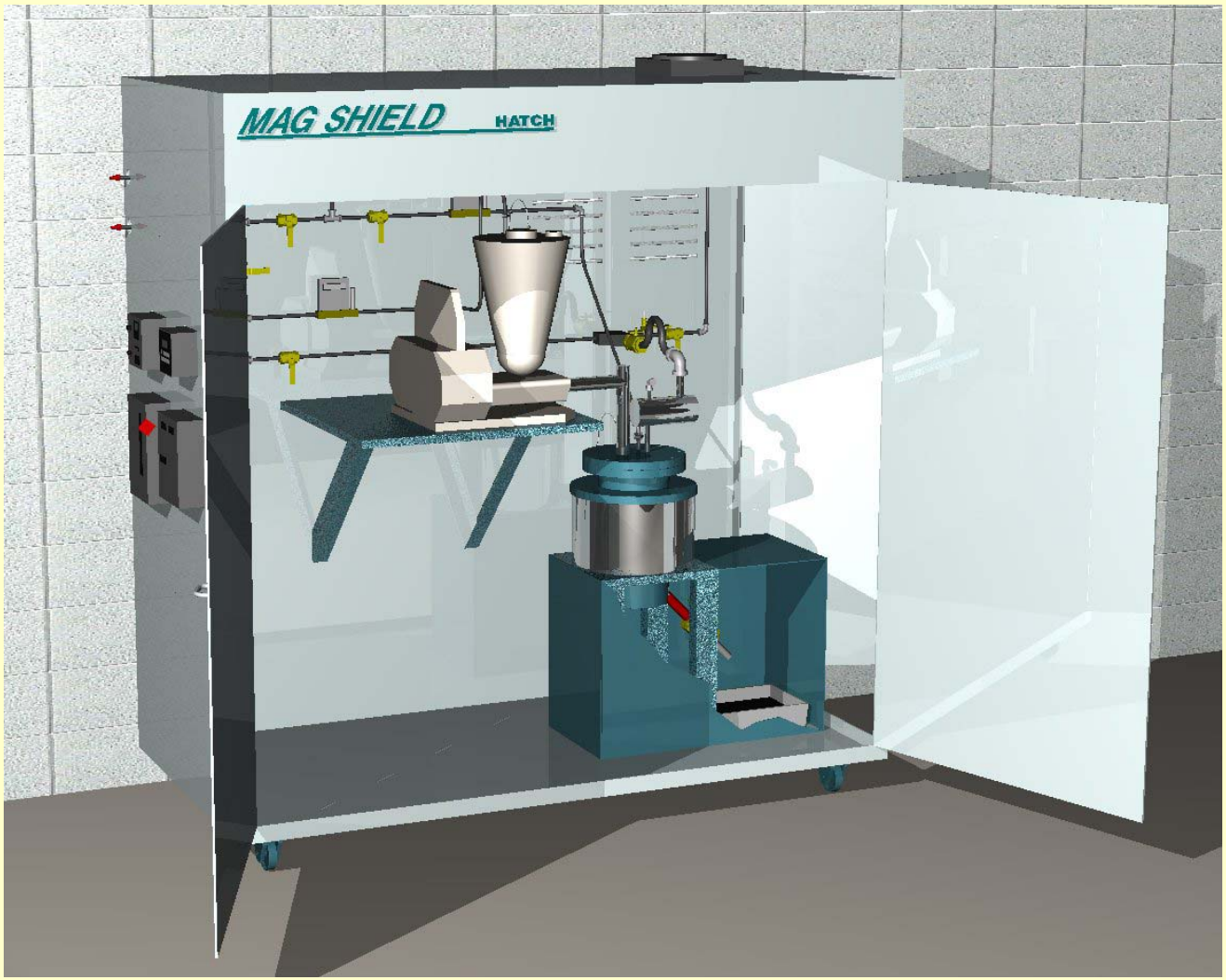
Reagent Cost Comparison (basis: 5,000 MTPY Mg)

Operating costs	Unit	SF6	KBF4
Nominal consumption	kg/tonne Mg	1.1	1.1
Reagent consumption	kg/yr	5,500	5,500
Reagent cost	US$/kg	22.60	3.60
Annual reagent cost	***US$/yr***	***124,300***	***19,800***

Summary

- Controlled gas generation and supply
- Good process reliability
- Uniform thin film melt protection
- Successful during emergency operations
- Clean, odorless, safe work environment

MagShield Commercial Prototype Unit



Future Plans

- Commercial demonstrations to be completed in early 2001

Proposed Commercial Methodology

- Equipment supply
- Direct license
- Technology transfer
- Training/start-up