Handling and Use of Sulfur Dioxide for Magnesium Melt Protection

SF_6 and the Environment: Emission Reduction Strategies November 2-3, 2000

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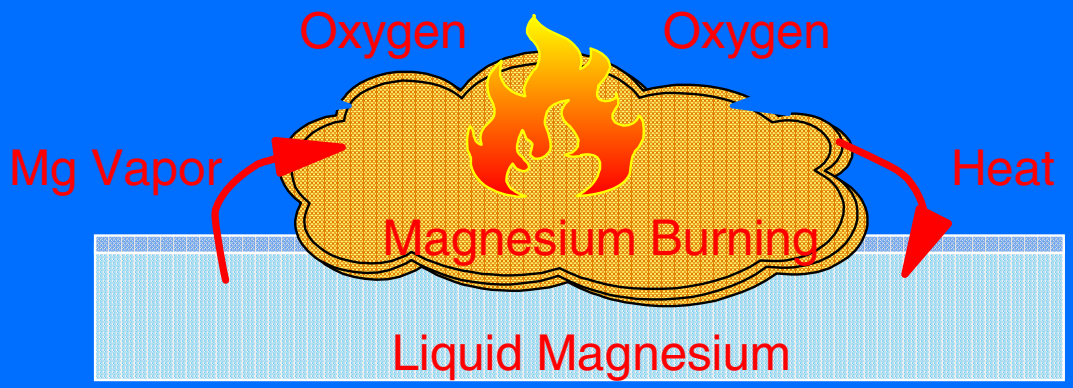
Without Proper Protection, Molten Magnesium Will Evaporate and Burn

- Due to its high vapor pressure, magnesium will evaporate from an unprotected molten magnesium surface
- In an atmosphere of air/oxygen, magnesium vapor will react or burn, forming oxides
- This reaction will generate heat and thereby increase the evaporation, thus accelerating the burning



History of Magnesium Melt Protection

- A US patent from 1934 cited several gases, including SF_6, BF_3, and SO_2
- A combination of salt-based fluxes and SO_2 was commonly used until the introduction of SF_6
- R&D in the late 60's and 70's formed the basis for using SF_6 as melt protection in magnesium melting and casting
- During the late 70's and 80's most producers and die casters adopted SF_6 in production
- SF_6 was considered a major improvement for the working environment in the magnesium industry, since SO_2 is both toxic and corrosive

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Using SO_2 for Melt Protection

- Proven and reliable technology
  - More than 50 years experience in Europe
  - Recent experience in North America and Japan
  - Concentration and flow parameters established
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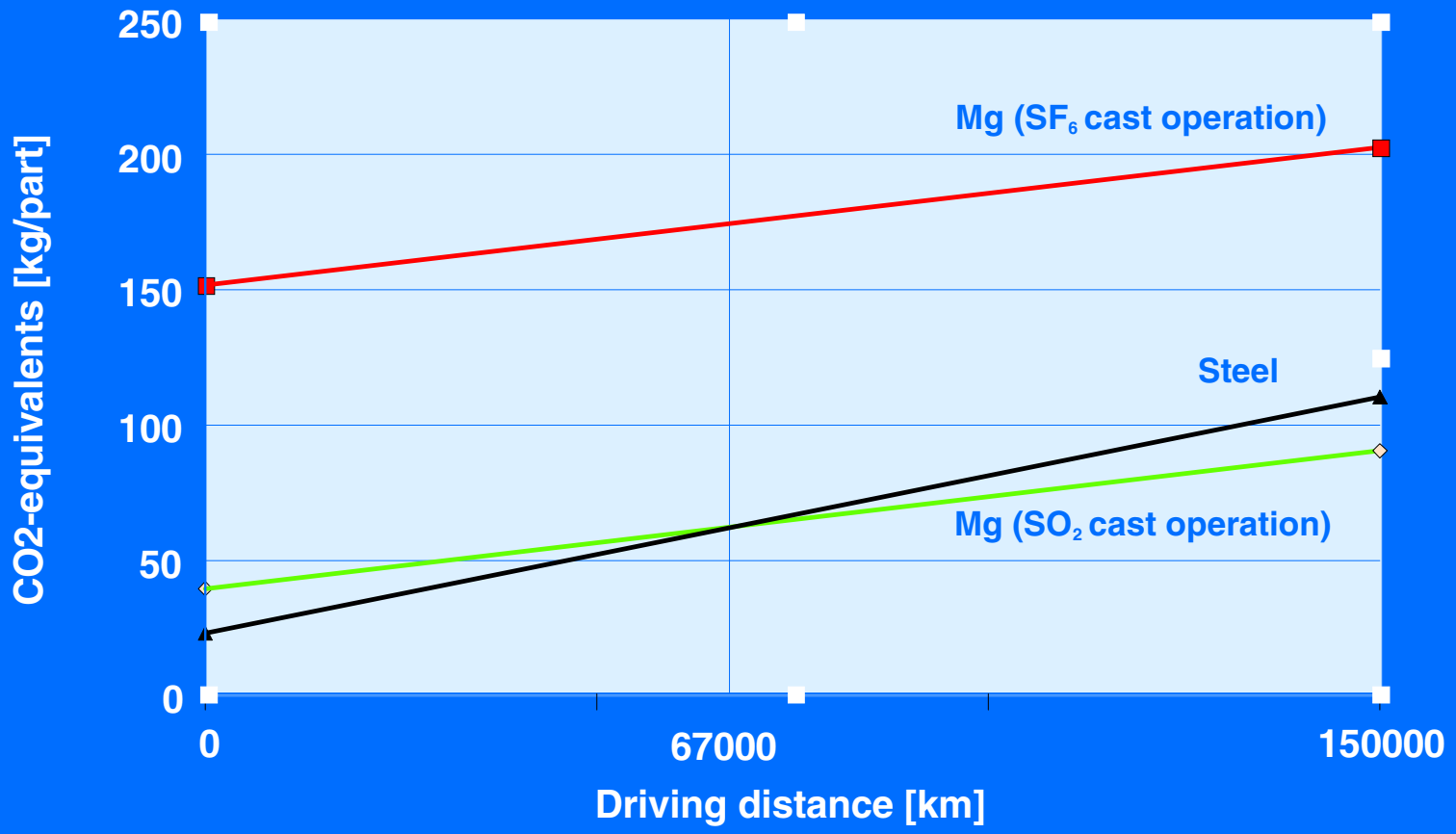
SO_2 Creates a Life Cycle Advantage for Magnesium Components

Life Cycle Study of Cross Car Beams



Reference: Opel/Hydro Magnesium

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- Cost-effective solution
- Disadvantages
  - Toxic (2 ppm occupational exposure limit in 8 hr)
  - Potential acidic precipitation (H_2SO_4)

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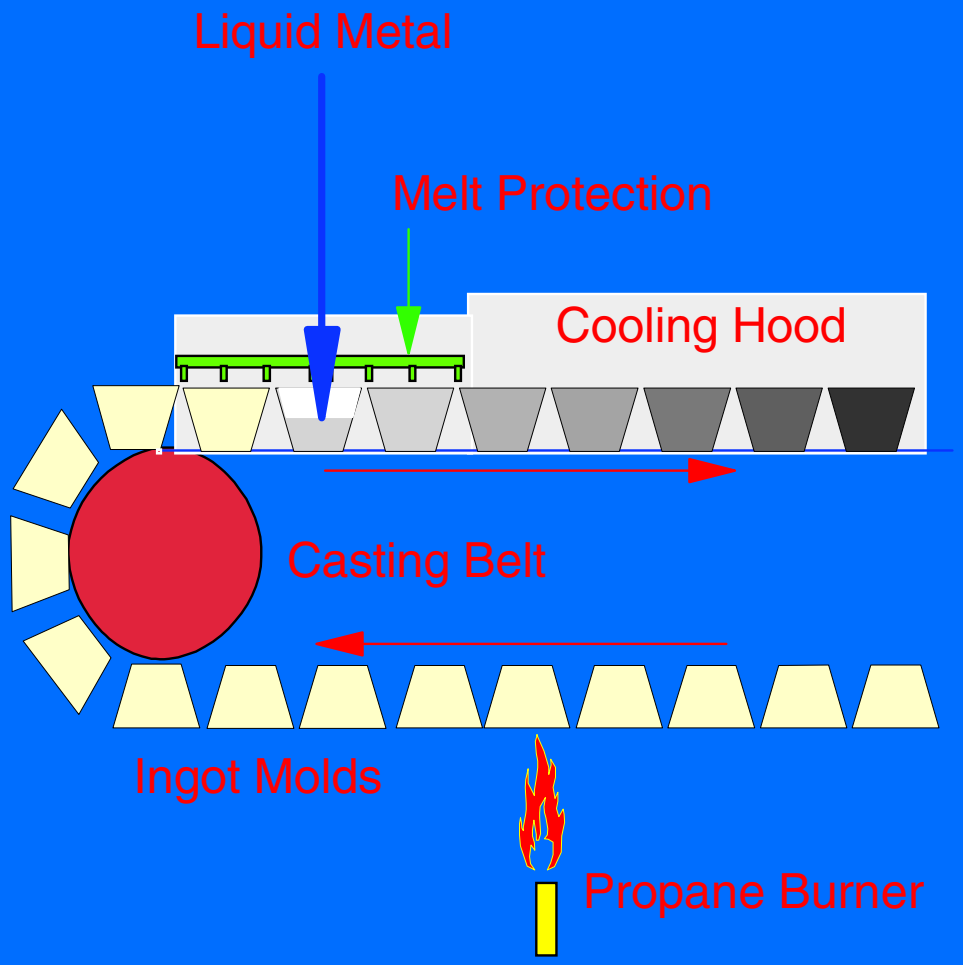
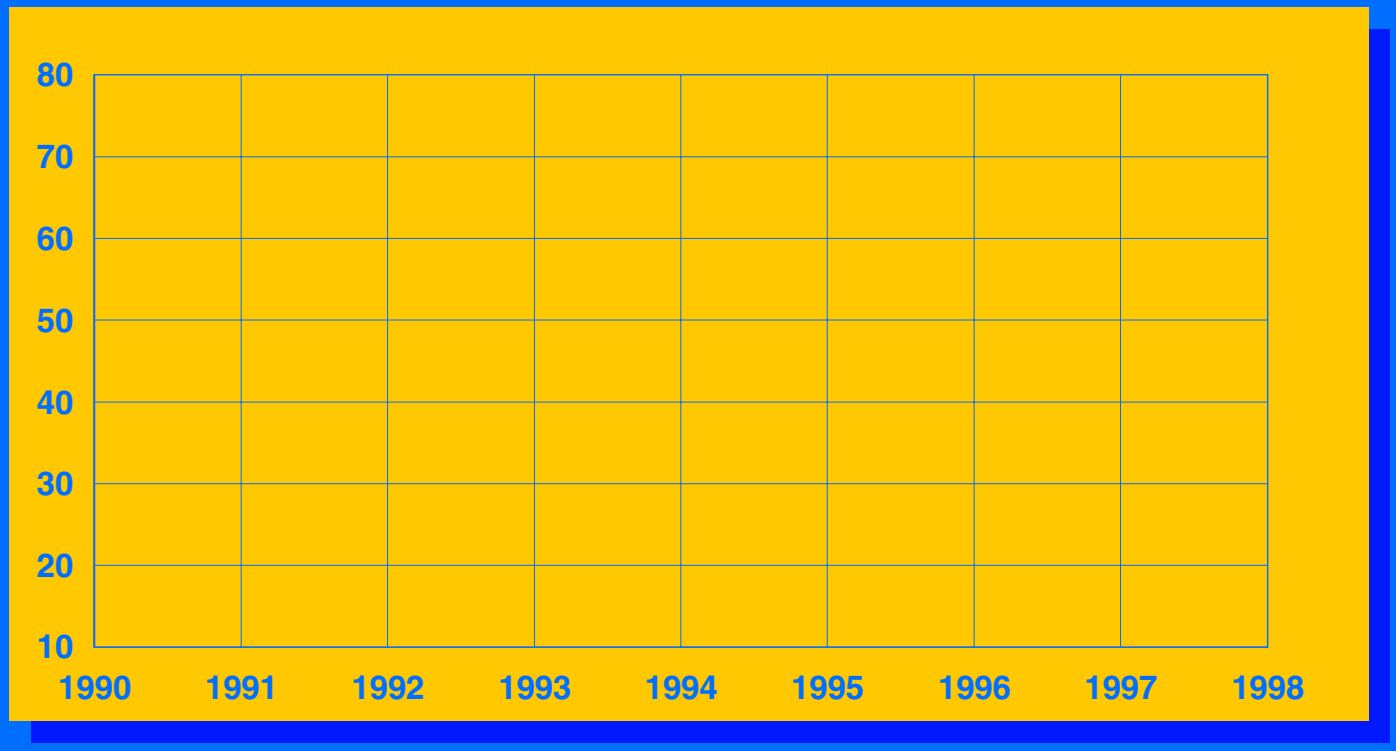
Casting of Ingots Requires Melt Surface Protection



✓ Hydro Magnesium Systematically Reduced SF_6 Usage in Ingot Casting Lines

CO_2-eq. [kg/kg Mg]



Hydro Magnesium Plants Are Replacing SF_6 with SO_2

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  - "Tightening" furnaces and casting equipment to minimize the use of sulfur dioxide

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  - "Tightening" furnaces and casting equipment to minimize the use of sulfur dioxide
  - Developing established procedures for safe gas management
  - Verifying that sulfur dioxide can be used for effective melt protection while still achieving an acceptable and safe working environment

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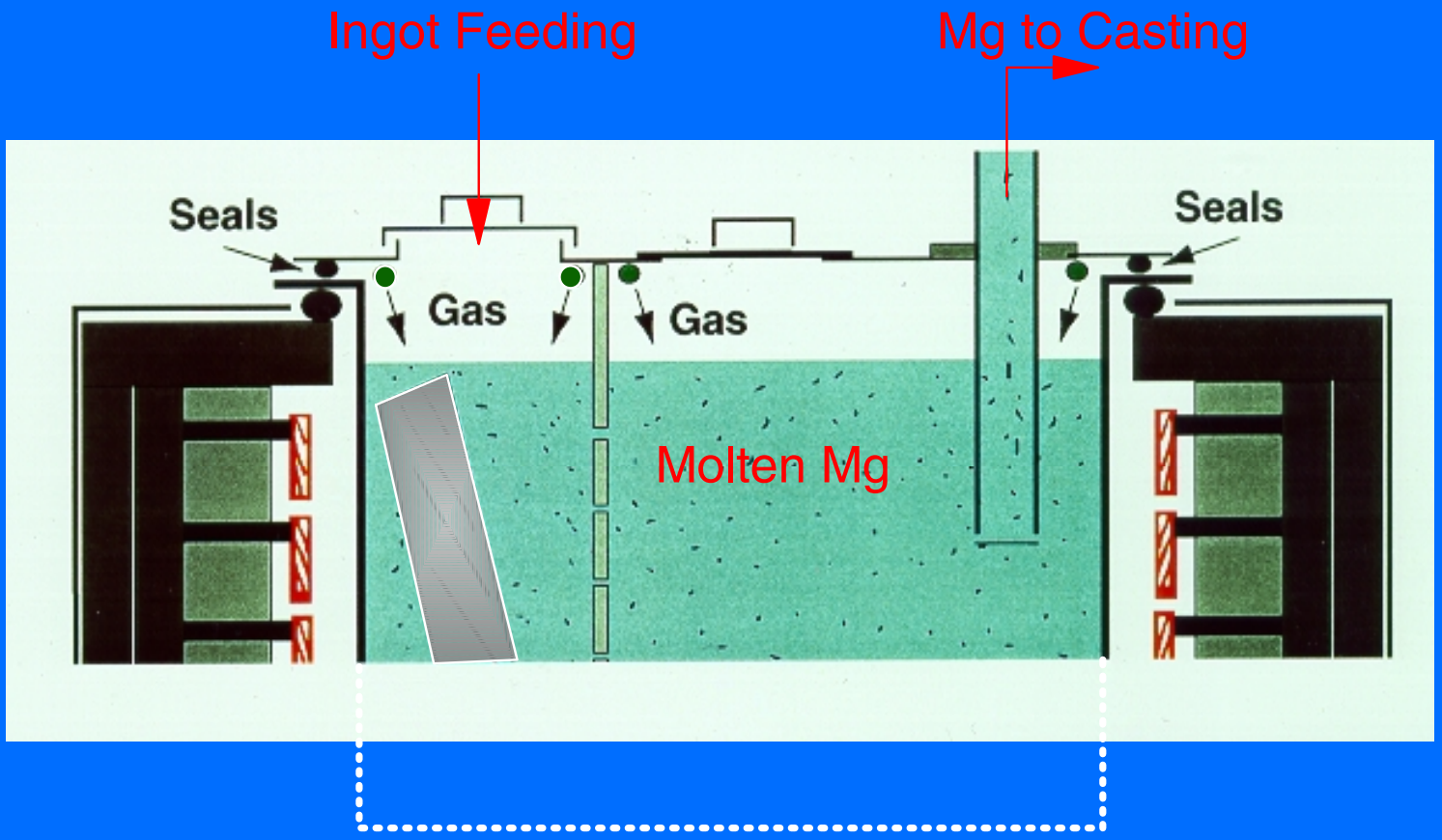
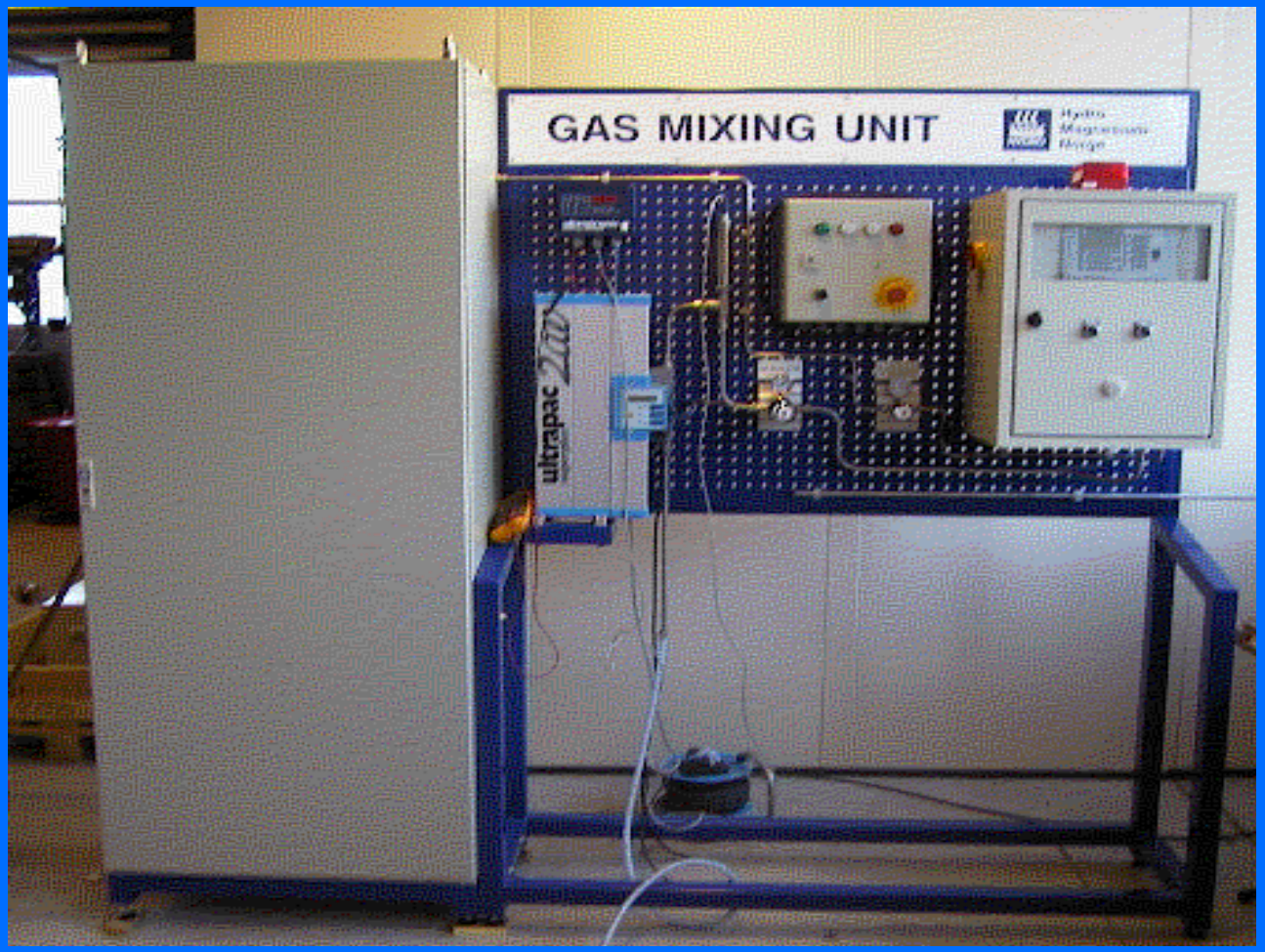
Magnesium Diecasting Requires Protection of the Melt Surface



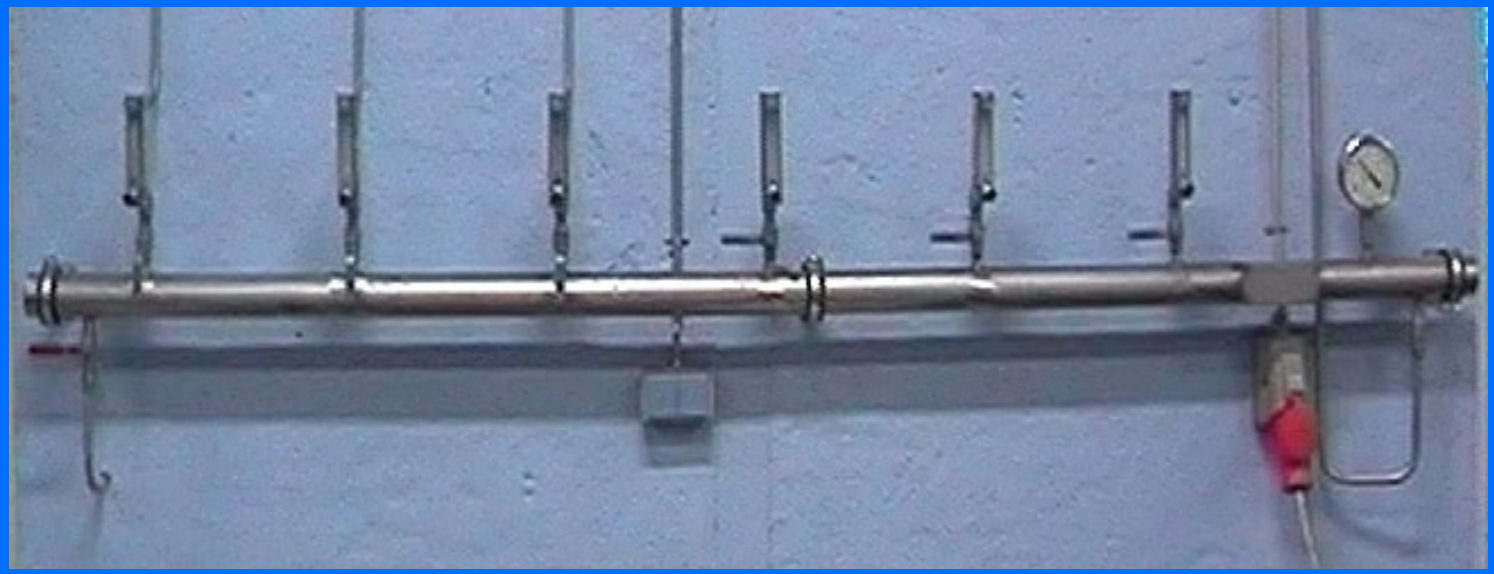
Hydro Magnesium Approach for Diecasting

- Encourage diecasters to consider SO_2
  - Developed a gas mixing unit for air-sulfur dioxide

Gas Mixing Unit



Manifold for Gas Distribution



Design Data for Gas Distribution

- Distance between metal level and lid/gas manifold
  - 100-150 mm
- Size of gas supply and distribution manifold
  - 1.0-1.5 cm^2 (internal diameter of 12-15 mm)
- Total outlet area
  - 0.15-0.30 cm^2 (20-40 outlets of 1 mm diameter)
- Recommended gas flow
  - Approximately 10 Nl/min (gas outlet velocity of 5-10 m/s)

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Hydro Magnesium Approach for Diecasting

- ✓ Encourage diecasters to consider SO_2
  - Developed a gas mixing unit for air-sulfur dioxide
- ✓ Continuing education - papers/presentations
  - Use of SF_6 in the Magnesium Industry - An Environmental Challenge (1996)
  - Protection of Molten Magnesium from Oxidation (1996)
  - Gas Protection of Molten Magnesium Alloys; SO_2 as a Replacement for SF_6 (1996)
  - Diecaster Bulletin (1997)
  - Progress to Eliminate SF_6 as a Protective Gas in Magnesium Die Casting (1998)
  - Use of SO_2 as Protection Gas in Magnesium Diecasting (2000)

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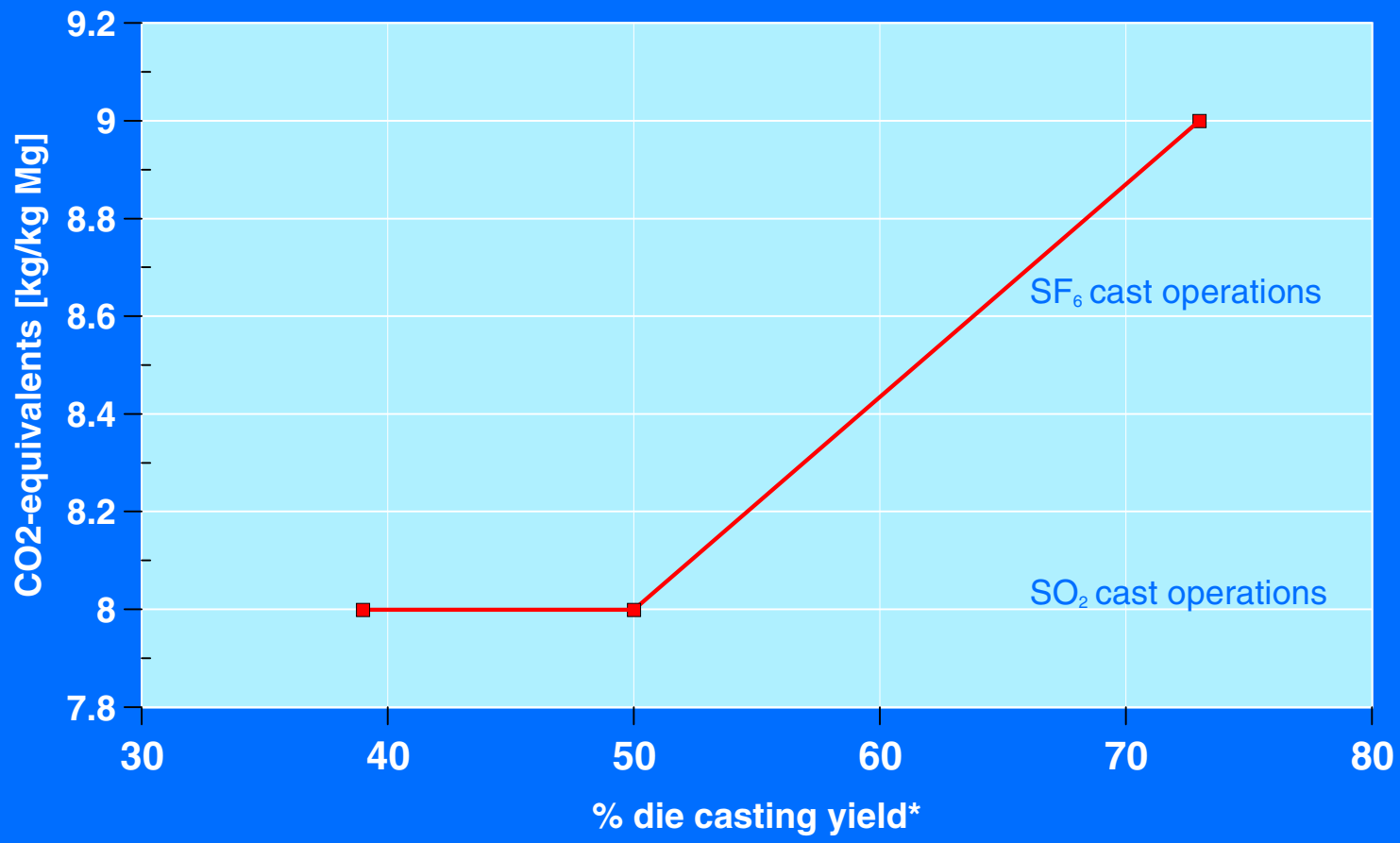
Cost Impact

SF_6 vs. SO_2

			SF_6	SO_2
Number of machines		3		
Running operation	[days / year]	300		
Running operation	[hours / day]	24		
Flow rate of gas to each machine	[Nl / min]		10	10
Concentration of gas	[%]		0.4	0.7
Price	[NOK / kg]		270	33
Volume / weight	[Nl / kg]		153	350
Consumption of gas	[kg / year]		339	259
Cost / year	[NOK]		91500	8500

Environmental Impact



(*component weight/shot weight)

Local Impact - Health & Safety

- Sulfur dioxide is toxic
  - Occupational exposure limit of 2 ppm
  - Odor detectable at 0.1-0.3 ppm
  - Safe practice record established

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- Sulfur dioxide contributes to acid rain
  - Use determined by local agencies
  - Related to annual consumption (50-500 kg/yr)
  - Dependent on operating environment

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