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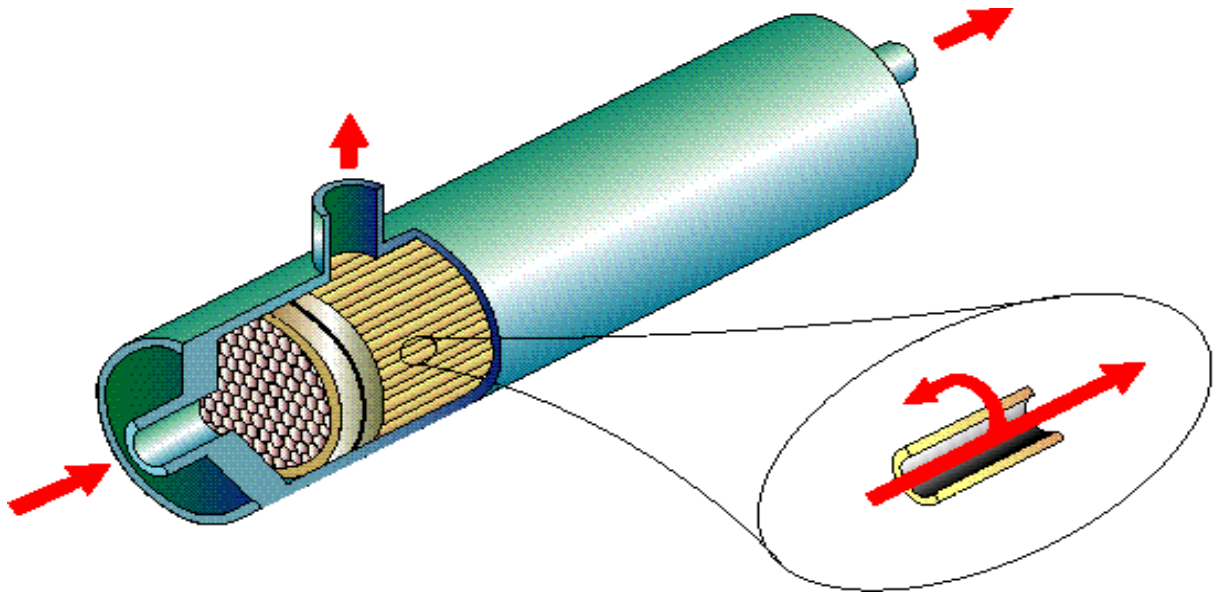
MagCorp & Air Liquide

CAPTURE AND RECYCLING OF SULFUR HEXAFLUORIDE



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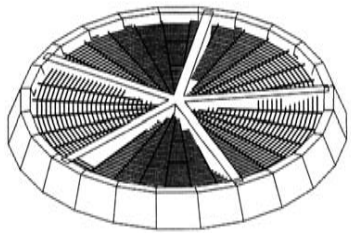
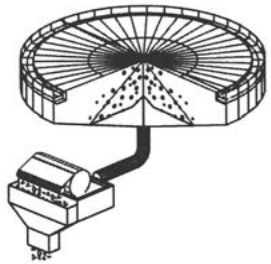
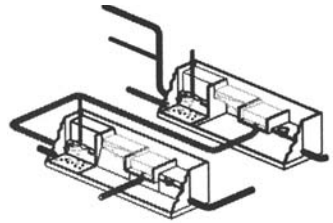
SOLAR PONDS



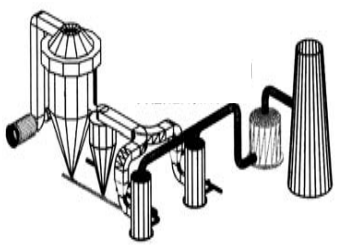
HOLDING PONDS



DESULFATION

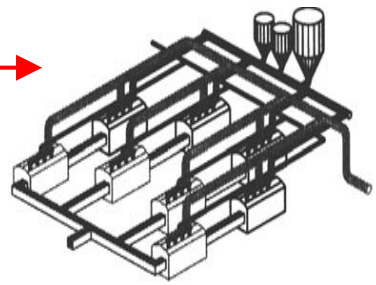


DEBORONATION

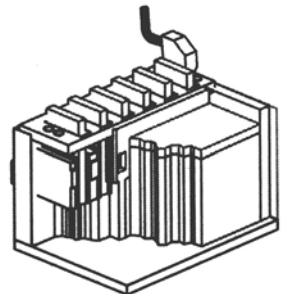


SPRAY DRYING

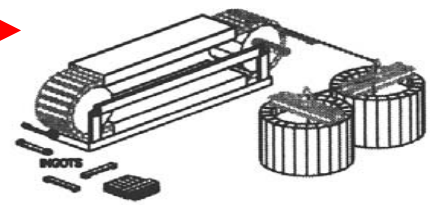
CONCENTRATE/PREHEAT



MELTING/PURIFICATION



ELECTROLYTIC



CAST HOUSE

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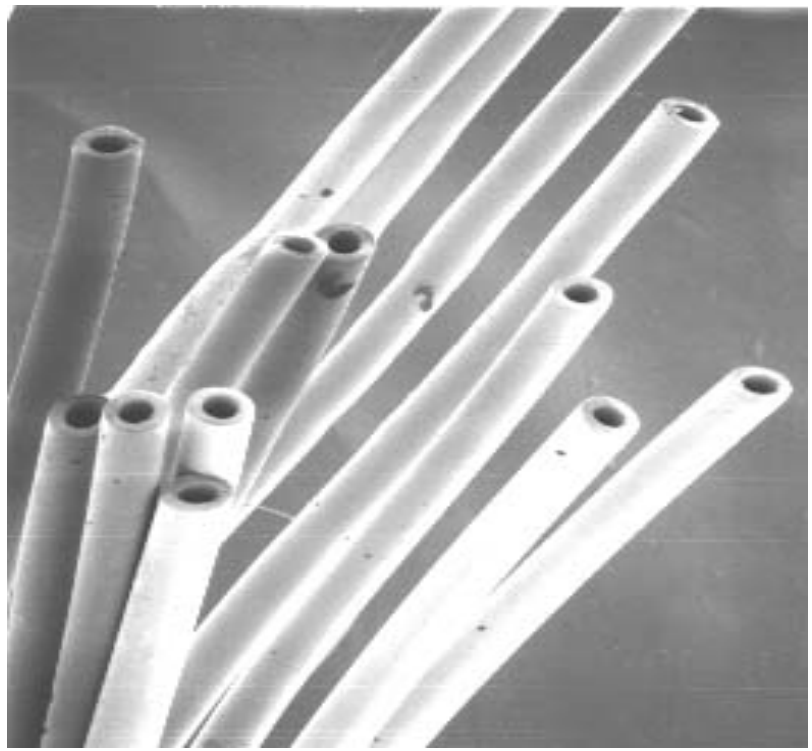
Membrane Air Separation

- Hollow fibers allow:
  - high packing densities
  - operation at elevated pressures
- Permeable gases migrate across the fiber wall



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Membrane Air Separation

- Fibers produced from polymers
- Diameter of a human hair
- Up to 750 miles of fibers are assembled in a membrane module
- Thin skin at the outside of each fiber acts as a membrane to separate the constituents of a gaseous stream

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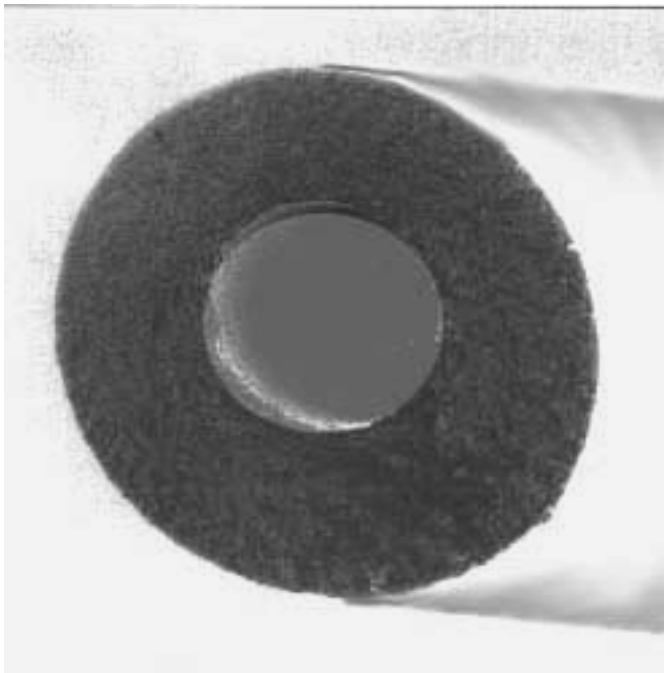
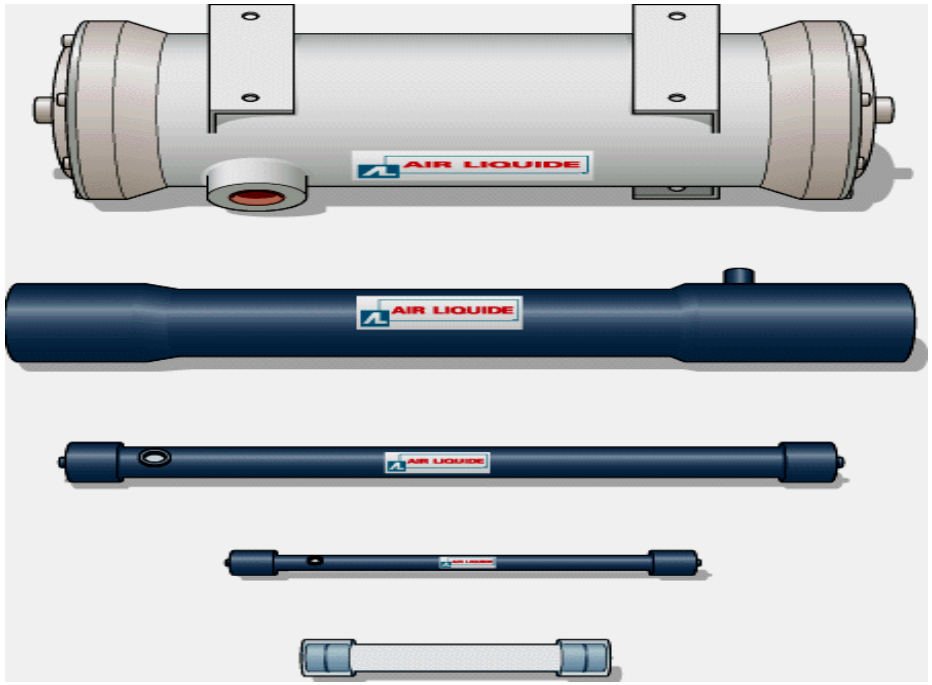
Membrane Air Separation



Cut of a hollow fiber



Membrane modules

1”, 2”, 6”, and 12” diameter

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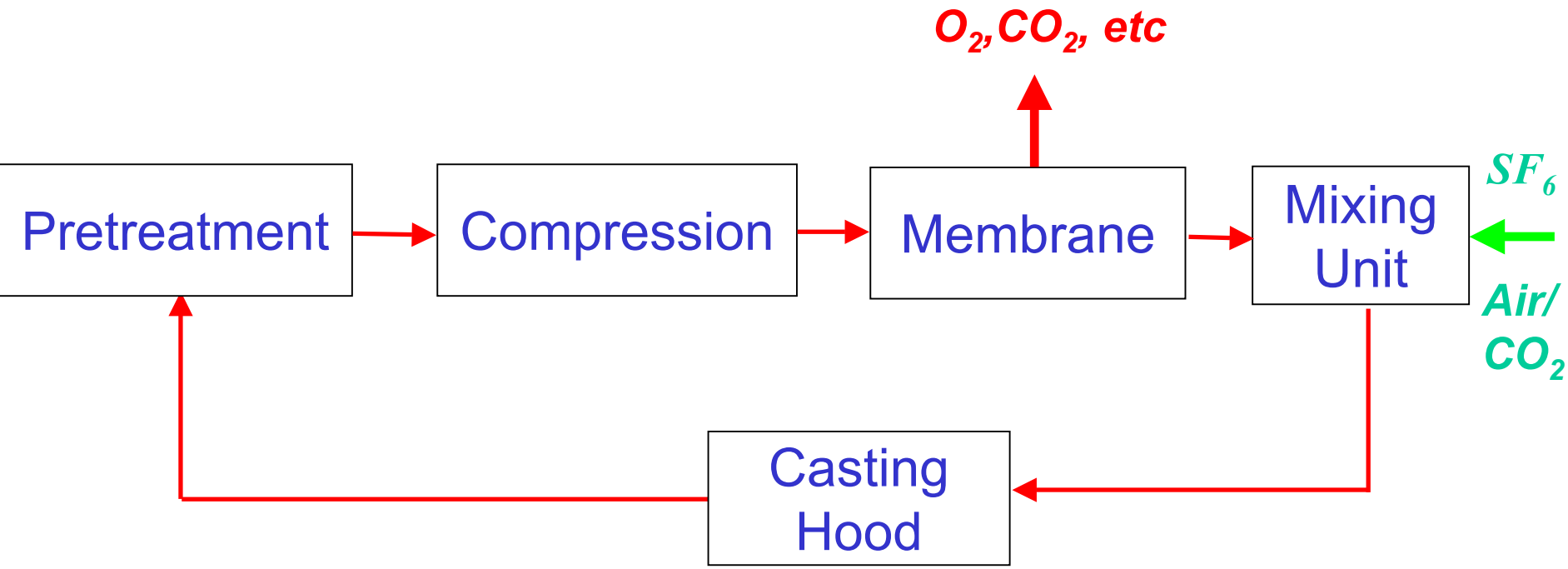
Floxal SF_6 Recycle System



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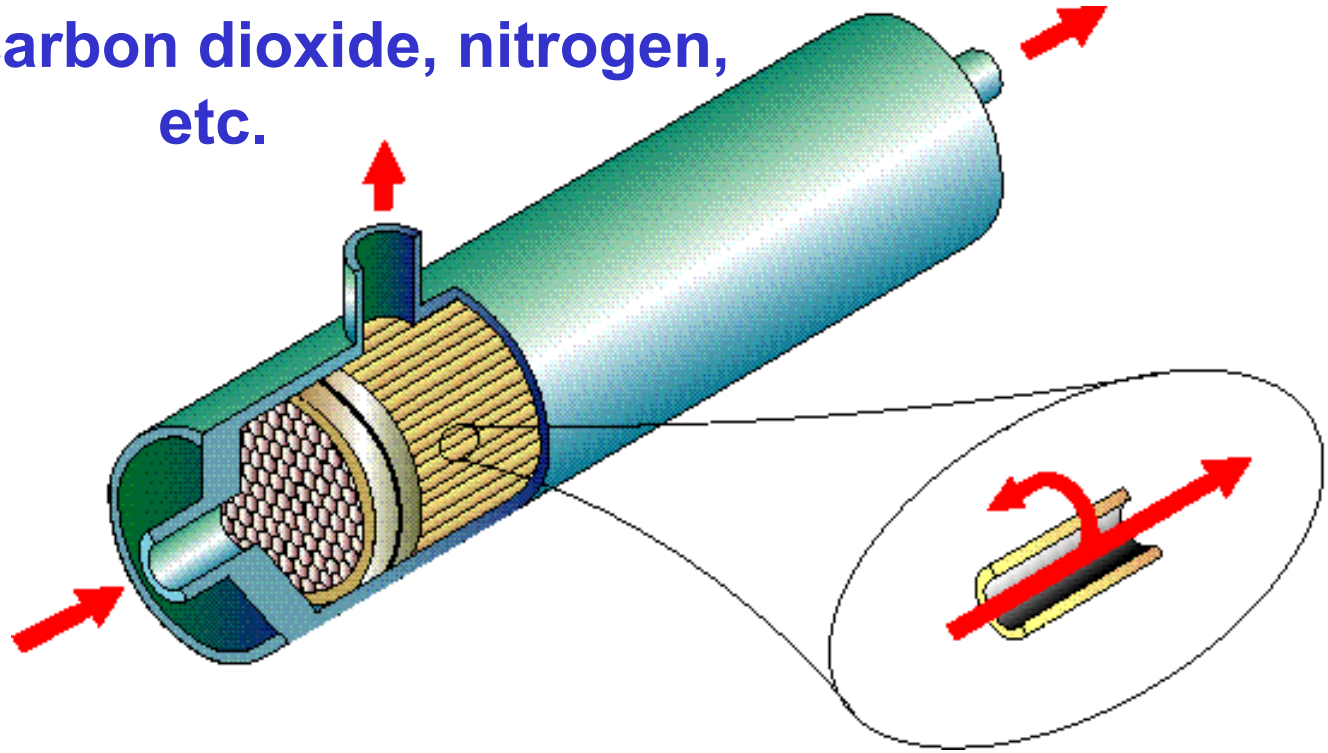
Concentrated SF_6
Balance nitrogen

Oxygen, carbon dioxide, nitrogen, etc.



Exhaust gas

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Pilot Unit Used at MagCorp

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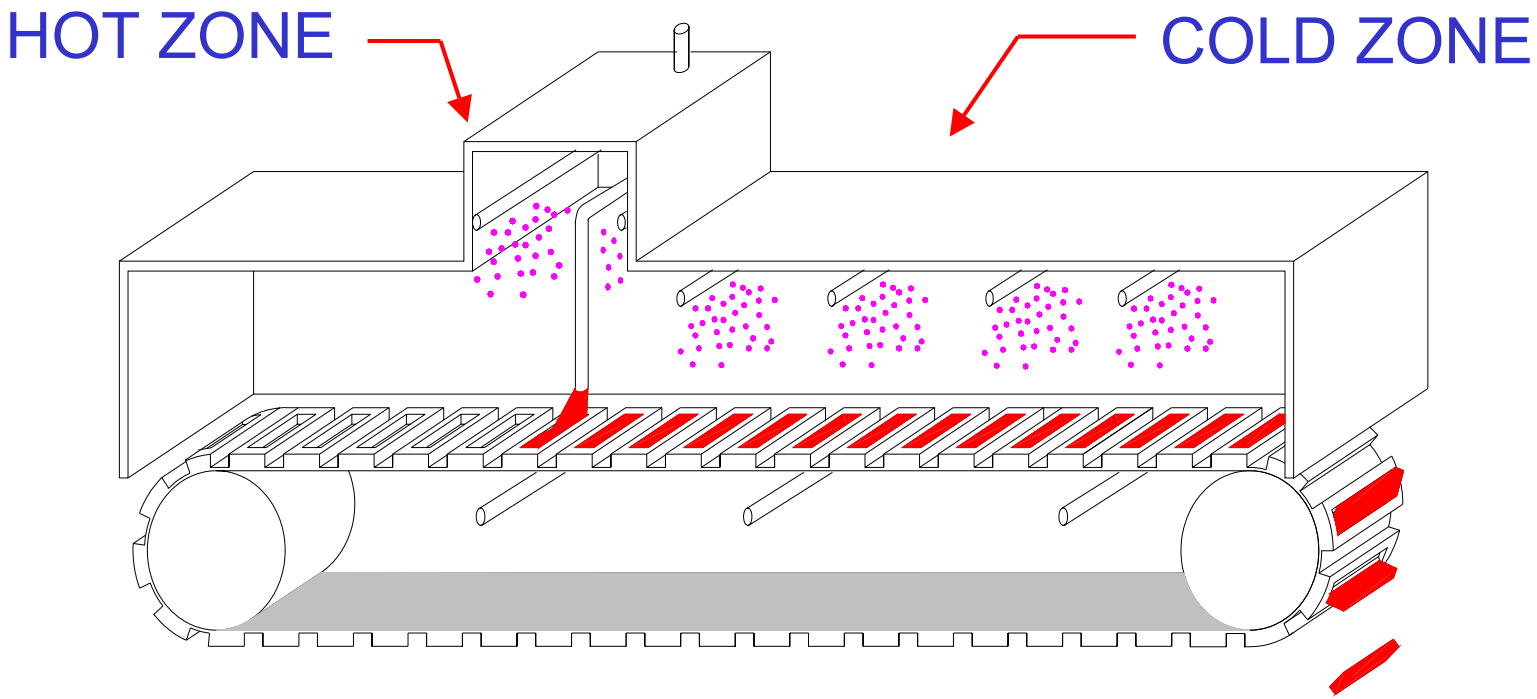
MAGCORP'S CASTING SYSTEM



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Air Liquide's Preliminary Testing

- Measurement of exhaust gas
  - composition
  - temperature
  - pressure
  - particulate
- Determine maximum suction flow rate using a simulated compressor apparatus

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Air Liquide's Analytical Equipment

- FT-IR
  - all compounds aside from Cl_2, F_2, and SF_6
- UV-Vis
  - only for Cl_2 and F_2
- ND-IR
  - only for SF_6

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Air Liquide's Findings

- Concentrations of SO_2, CO, and HCl were detected
- Neither HF or F_2 were detected
- Particulate
  - 10 μm filter exposed for 15 hours at 60 scfm
    - size ranged from 5 - 350 μm
    - composed of C, Mg, O, S, and Fe

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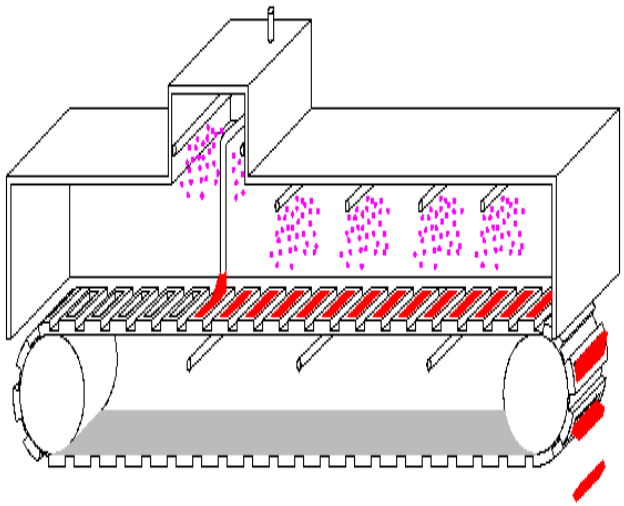
Air Liquide's Findings



- Cover gas diluted by a factor of 10
- Maximum suction rate of 60 scfm
- Increased amount of SF_6 for recovery from 33% to 46% with addition of 3 bottom suction ports

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Floxal SF_6 Recycle System

- Makes it possible to adjust the purity of the gas
- The lower the purity, the higher the quantity of gas produced
- C and G membrane bundles available
  - C bundle - 90% plus recovery
  - G bundle - 95% plus recovery

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Performance of Pilot Floxal SF_6 Recycle System

- Concentrated exhaust gas by 10 times
- Demonstrated 90% plus recovery of SF_6
- Test unit stream data

Streams	SF_6	Flow Rate (scfm)
Inlet Line	0.04%	17.6
Permeate, Vent Line	0.003%	16.0
Product Line	0.4%	1.6
SF_6 Recovery Rate	+90%	-

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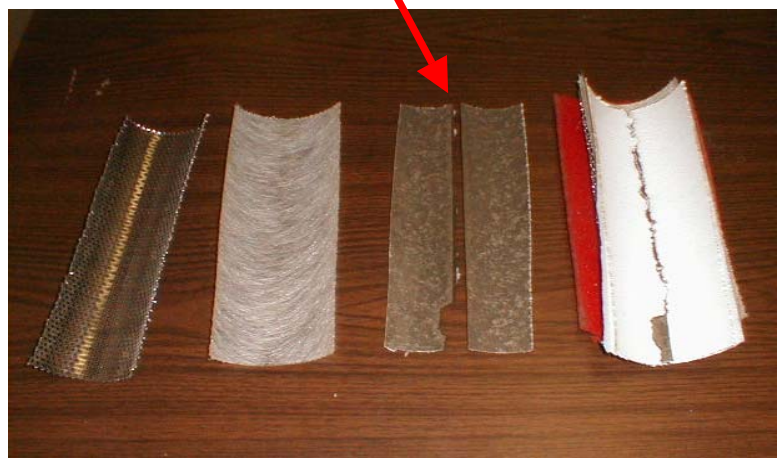
Minor Issues

- Pretreatment
  - Packed tower and inlet filtration pluggage



  - Corrosion of compressor hoses and fittings

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Pretreatment Options

- Packed tower alternatives
  - inlet filtration before packed tower
  - replace major components with corrosion resistant materials
  - zeolite impregnated with $KMnO_4$
  - activated carbon impregnated with NaOH or KOH
  - wet scrubber
- Inlet filtration alternatives
  - self-cleaning filters
  - electrostatic precipitator

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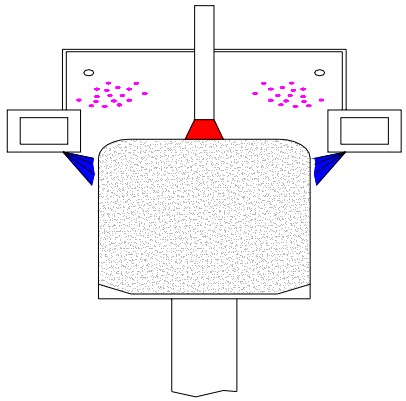
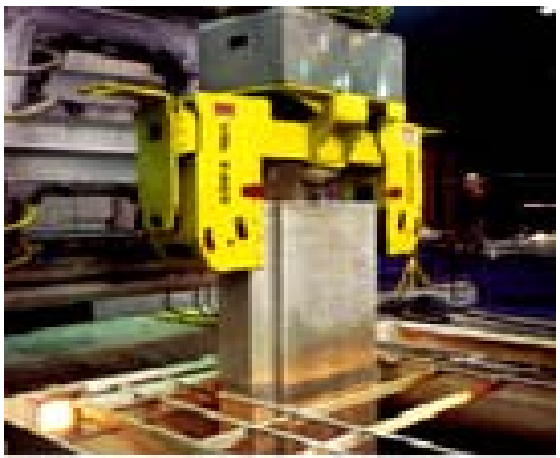
Future Experimentation





- Empirical determination of SF_6 reduction
- Expanding use
  - conventional cast machines
  - direct chill (DC) casting of magnesium

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Conclusion

- Indicated to be low maintenance and nearly a trouble free unit
- 90% plus recovery was obtained of captured gas
- Exhaust gas concentration of SF_6 was increased by 10 times
- Capable of reducing SF_6 consumption by 41%
- Neither HF or F_2 was detected
- Successful project with further experimentation