Managing the Health Impacts of Aluminum Smelters

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Managing the Health Impacts of Aluminum Smelters

- **Objectives**
  - Present the major health issues associated with aluminum smelters in workers and communities in the vicinity of the smelters
  - Discuss strategies to prevent adverse health effects in workers and communities in the vicinity of smelters

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Yale-Alcoa Partnership

- January 1997 – Agreement between Alcoa and Yale University
- Research & consultative services in environmental, health & safety
- Occupational & Environmental Health Advisory Council (OEHAC)

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Worker vs. Community Health

- **Worker's Health**
- Healthy workforce, 17-65 yrs
- Higher exposure to substances
- More options for control within the plant
- Employees can be monitored easily

- **Community Health**
- Children, pregnant women, elderly
- Much lower exposure to substances
- Main control is to limit air emission, waste and water discharge
- General public less easily monitored

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Aluminum Production

Mining of bauxite

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Bauxite refining to produce Alumina

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Alumina smelting to produce Aluminum

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Aluminum Smelting

- Alumina smelting to aluminum by Hall-Héroult process (1886)
- Smelting technology
  - Söderburg smelters uses anodes baked in pot
  - Pre-bake smelters uses anodes pre-baked in separate facility

Aluminum Smelting

- Alumina dissolved in molten cryolite (sodium aluminum fluoride) in large carbon lined steel pot
- Electric current flows between carbon anode made of petroleum coke & pitch and cathode formed by pot lining
- Molten aluminum deposited at the bottom of the pot & siphoned off for casting ingots.

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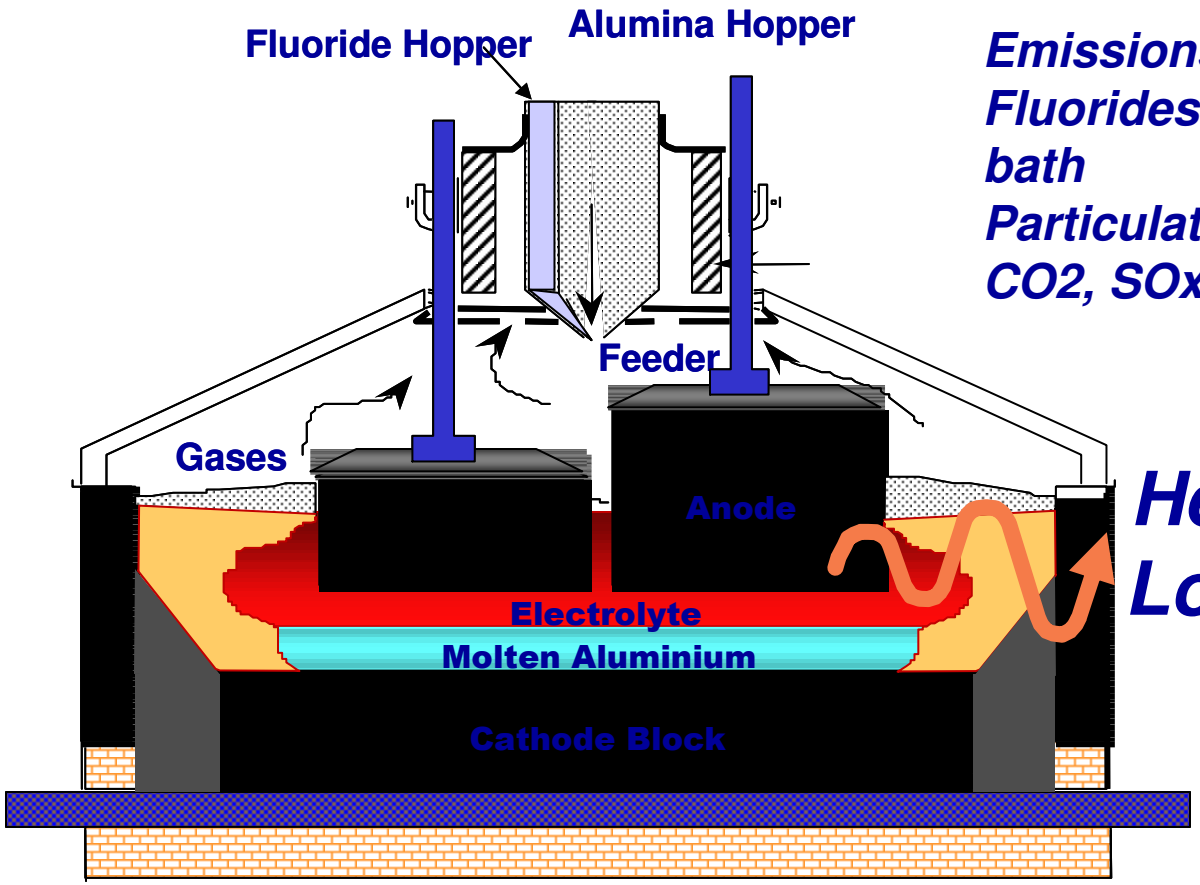
Aluminum Smelting



Emissions
Fluorides from bath
Particulates,
CO2, SOx, PAHs,

Heat Loss

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Primary Emissions from Aluminum Smelters

- Coal Tar Pitch Volatiles (PAHs)
- Fluorides
  - Gaseous fluorides
  - Particulate fluorides
- Sulfur dioxide (SO_2)
- Alumina dust

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Coal Tar Pitch Volatiles

Health Effects

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Coal Tar Pitch Volatiles (CTPV)

- Distillation product from coal
- Made up of chemicals called polycyclic aromatic hydrocarbons (PAHs)
- Sources in Aluminum industry
  - Carbon anode: Petroleum coke & pitch
  - Carbon or graphite pot lining

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Polycyclic Aromatic Hydrocarbons: PAHs

- PAHs are formed from incomplete burning of almost any fuel

- **Common Sources**
  - Forest fires
  - Domestic heating
  - Vehicle exhaust
  - Waste incinerators

- **Industrial activities**
  - Aluminum, coke, gas, asphalt, iron & steel plants, transportation industry

  - Other activities using materials from organic matter like coke, coal tar, pitch, creosote, asphalt, diesel, heavy oil

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Aluminum Workers & Cancer Risk

- Lung & bladder cancer reported in Canadian Söderberg Smelters workers (1950-1979) exposed to large levels of coal tar pitch volatiles over long periods

- Similar observation reported in smelter workers in other countries. Other studies have also reported pancreas & kidney cancer

- These studies have shown levels of exposure to CTPV that causes cancer & levels that did not cause cancer

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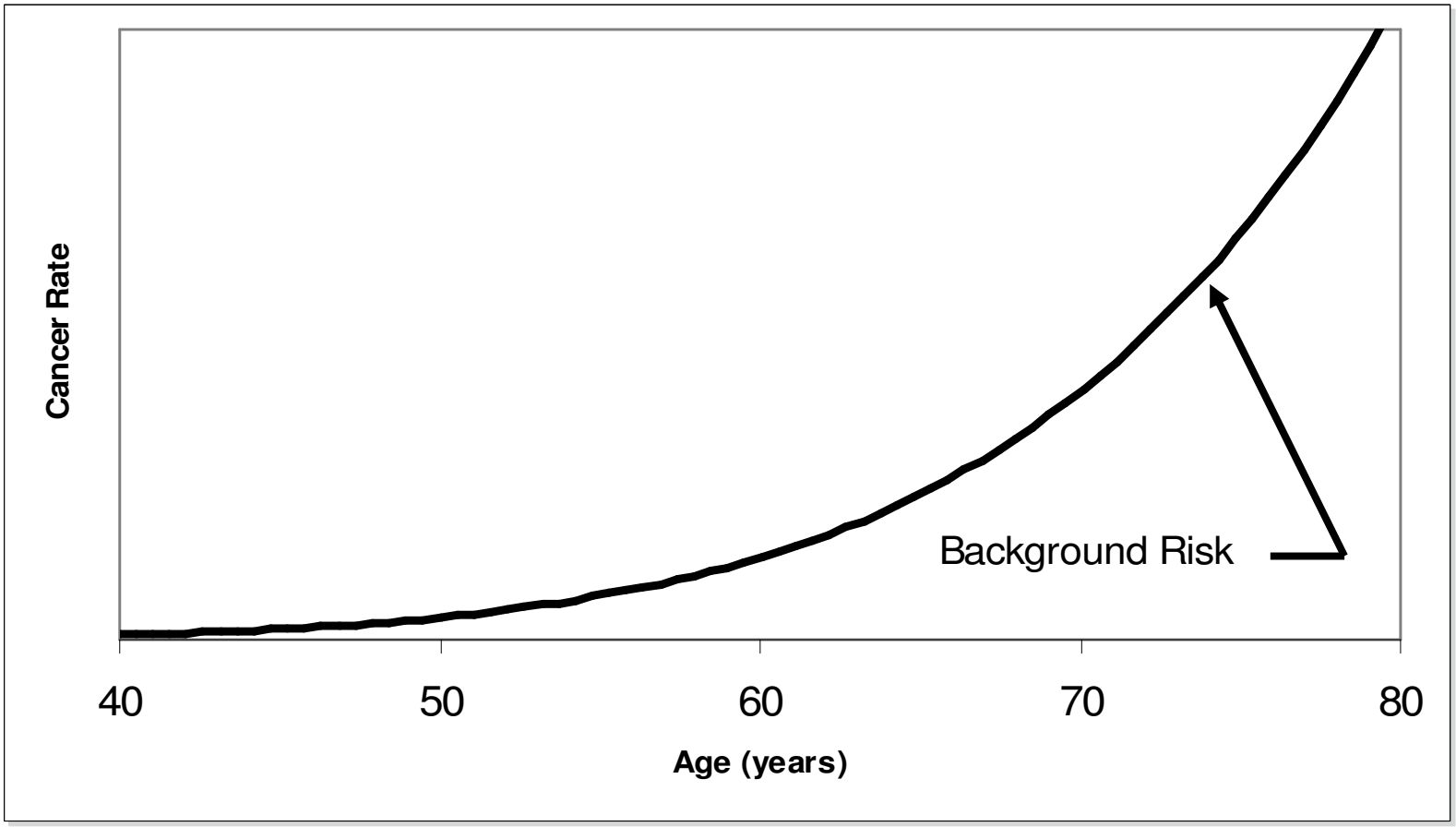
Cancer Risk



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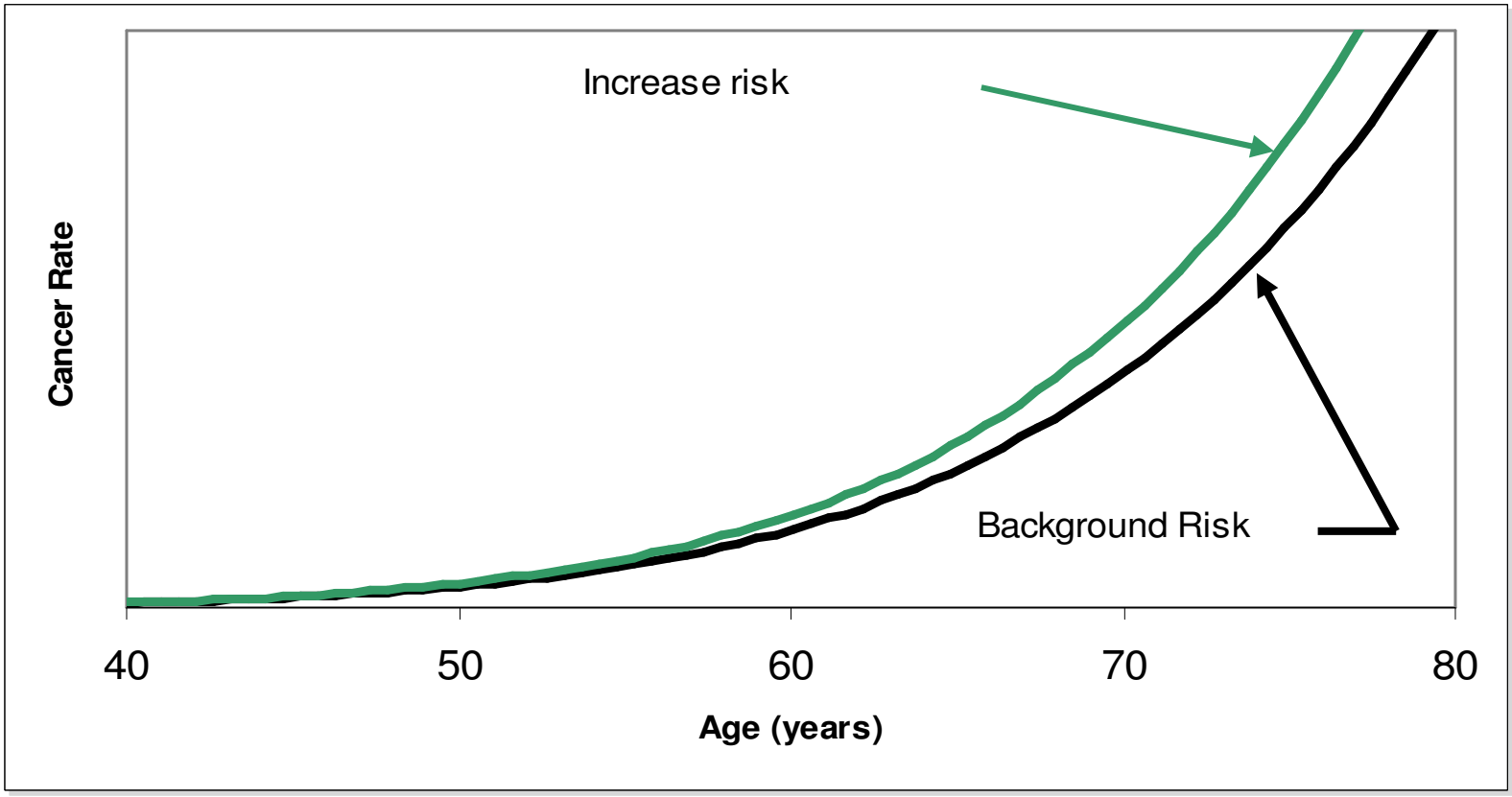
Cancer Risk



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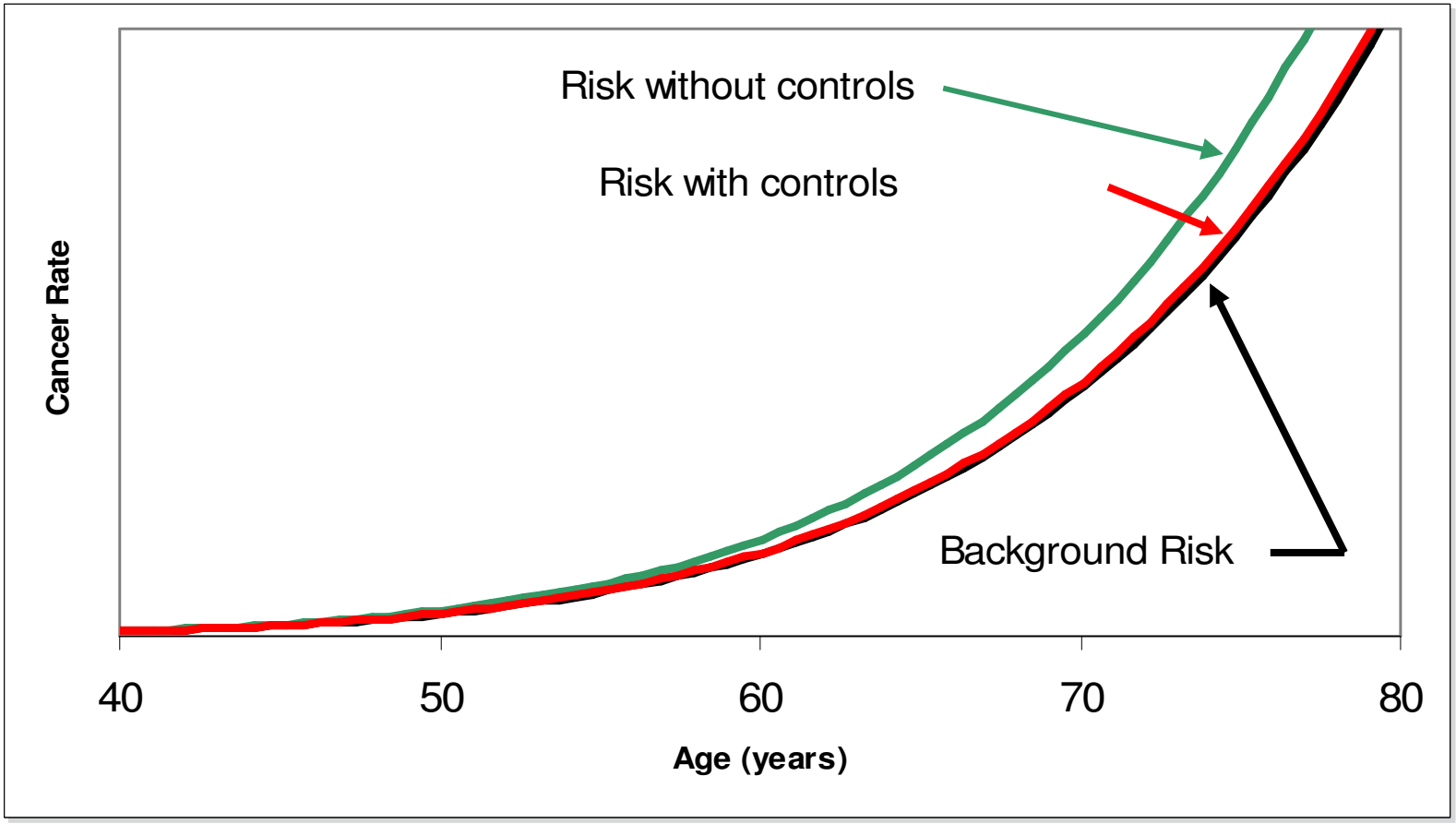
Management of Cancer Risk



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Strategies to Prevent Cancer Risk in Workers

- Establish safe levels of exposure limits for workers
- Engineering control
  - Prebake (newer technology); anode made in separate facility with automated process & emission control
  - Cell hooding & ventilation in potroom
  - Automated cranes & equipment to minimize worker activity near cells
- Use of personal protective equipment for certain tasks
- Education and training of workers
- Medical surveillance of workers

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Cancer Risk From Studies of Aluminum Smelter Workers

Cumulative Exposure BaP ug/m3 year	Relative Risk
0	1
10	1.03
20	1.06
50	1.15
100	1.29
150	1.43
200	1.58
250	1.73
300	1.87
350	2.02
400	2.16
450	2.31

Range of exposures for workers in Armstrong study

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Cancer Risk From Studies of Aluminum Smelter Workers

Range of exposures expected for workers in modern Prebake smelter

Range of exposures for workers in Armstrong study

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Strategies to Prevent Cancer Risk in Workers

- More recent study following workers from Prebake smelters in Victoria, Australia (1984-present) with changes in technology and work practices have not shown increase risk of cancer

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Risk of Cancer in Communities in the Around Aluminum Smelters

- PAHs are widely distributed in environment
- Levels higher in urban vs. rural areas
- Söderberg smelters release more PAHs compared to Prebake smelters
- Levels of PAHs in communities around aluminum plants especially Söderberg smelters can be high
- Levels of PAHs at the boundary of smelters much lower compared to levels inside the plant

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Risk of Cancer in Communities in the Around Aluminum Smelters

- Norwegian study of cancer in communities surrounding 4 aluminum smelters which had been operating for more than 30 years

- New cases of cancer diagnosed between 1960-1991 was compared to the expected numbers of cancer for the same population based on national averages

- Incidence of cancer was not different in the communities studied compared to the rest of the country

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Risk of Cancer in Communities in the Around Aluminum Smelters

- Safe air limits for PAHs have been developed by regulatory agencies
- If PAH emission is kept below the safe limits at the boundary of the facility, the community should be safe
- This can be achieved by emission controls using appropriate technology within the plant

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Fluorides

Health Effects

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Health Effects of Fluorides

- Ingestion of fluorides at low levels prevents dental cavities and useful for the treatment of osteoporosis
- Exposure to very high levels of fluoride through breathing or drinking water may cause fluorosis:
  - Teeth discoloration
  - Bone pain & decrease spine mobility
- Exposure to fluorides can also cause irritation of upper airway & asthma

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Fluoride Exposure in Workplace: Fluorosis

- 1932 in cryolite workers in Denmark
- Also reported in aluminum and fertilizer workers
- Fluorosis occurs when exposure in the workplace is over 3.8 mg/m^3 of fluoride
- Workplace standards to prevent fluorosis was implemented many years ago
- Fluorosis has not been reported in smelter workers in over 30 years where fluoride exposure was controlled $\leq$ 2.5 mg/m^3

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Fluoride Exposure in Community: Fluorosis

- Reports of fluorosis in communities in the vicinity of aluminum smelters in China (1981) & Russia (1993)

- No similar reports from smelters in Western Europe, North America, Australia, South America

- Fluorosis unlikely to occur in the vicinity of a modern Prebake smelter

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Fluoride Exposure in Workplace: Asthma

- There continues to be a modest increase risk of asthma among workers from exposure to lower levels of fluorides and other irritants in the workplace

- Control measures that prevents fluorosis not adequate for prevention of asthma in workers

- Lower exposure levels to prevent asthma 0.4-0.6 mg/m^3 has been recommended and implemented by countries like Norway and some companies

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Fluoride Exposure to Community: Asthma

- No reports of increase incidence of respiratory diseases in residents of communities living in vicinity of Prebake smelters

- Asthma and other respiratory diseases can be prevented in the vicinity of a modern Prebake smelter by controlling fluoride, dust & SO_2 emissions using:
  - Low emission technology designed to capture and recycle most of the emissions
  - Adequate buffer zone

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Conclusion

- Successful control of health hazards can be achieved in a properly run modern aluminum smelter by:

- **Workplace**
  - Modern technology
  - Engineering
  - Personal protective equipment
  - Medical Surveillance

- **Community**
  - Controlling emissions below established standards
  - Ongoing monitoring & audits of air, water and soil

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End

- **Questions?**

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