Carbon Monoxide Poisoning at a Surface Coal Mine ... 

A Case Study

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Anatomy of the CO Poisoning

- Spatial Relationships
- CO Levels
- Chronology
- Blasting
- Geology
- Residential Entry Points
CO Poisoning — April 1, 2000

- Carboxyhemoglobin levels
  - Infant -------- 31 %
  - Husband ------ 28 %
  - Wife ---------- 17 %
Carboxyhemoglobin Levels

- 10% Asymptomatic or may have headaches
- 20% Dizziness, nausea, and syncope
- 30% Visual disturbances
- 40% Confusion and fainting
- 50% Seizures and coma
- 60% Cardiopulmonary dysfunction and death
CO Standards — Workplace

- **Immedialtely Dangerous to Life and Health (IDLH)**
  - 1,200 ppm (NIOSH)
  - 1,500 ppm (OSHA)

- **Short Term Exposure Limit (STEL) 15 Min.**
  - 200 ppm (NIOSH and OSHA)

- **Time Weighted Average (TWA) 8 Hours**
  - 50 ppm (OSHA)
  - 35 ppm (NIOSH)
  - 25 ppm (AIGIH)
CO Standards — Homeplace

- Environmental Protection Agency (EPA)
  - 25 ppm — 1 hour
  - 9 ppm — 8 hours

- Consumer Product Safety Commission (CPSC)
  - 25 ppm — 1 hour
  - 15 ppm — 8 hours
Chronology

- February 2000 - mining began.
- March 7, 2000 - the first of twenty blasts.
- March 31, 2000 - two blasts are detonated in the afternoon.
- April 1, 2000 - in the early morning, later diagnosed with carbon monoxide poisoning.
- April 2, 2000 - the furnace contractor finds 650 ppm in a floor drain, 450 ppm on the first floor, and 400 ppm on the second floor.
Chronology

- April 2-7, 2000 - The family stays at their parents’ home. Install two CO detectors.
- April 17, 2000 - two blasts are detonated (430 and 475 feet).
- April 20, 2000, one blast was detonated at 13:45. One hour later -73 ppm in the basement -46 ppm in the upstairs of the home.
- On April 21, 2000 - the DEP ER - 200 ppm in a floor drain - 160 ppm in the well. Note negative air pressure in floor drain.
Chronology

- April 24, 2000 - DEP Blasting Inspector ceases blasting on the mine in the absence of a readily explainable source other than blasting.
- May 31, 2000 - DEP and OSM jointly conduct geologic profiling, find CO in the ground.
- July 7, 2000 - DEP writes an order for failure to prevent injury to people outside the permit area. States Industries decides to reclaim the site.
Blasting and In-Pit Observations
ANFO (3.4% FO)

\[5\text{NH}_4\text{NO}_3 + \text{CH}_2 \rightarrow 11\text{H}_2\text{O} + \text{CO}_2 + 4\text{N}_2 + 2\text{NO}\]

ANFO (5.5% FO)

\[3\text{NH}_4\text{NO}_3 + \text{CH}_2 \rightarrow 7\text{H}_2\text{O} + \text{CO}_2 + 3\text{N}_2\]

ANFO (8.0% FO)

\[2\text{NH}_4\text{NO}_3 + \text{CH}_2 \rightarrow 5\text{H}_2\text{O} + \text{CO} + 2\text{N}_2\]
Blasting Fumes

1. Poor product formulation
2. Inadequate priming
3. Insufficient water resistance
4. Lack of confinement
5. Reactivity of the explosive with the rock
6. Incomplete product reaction.
30' overburden, 6' sandstone 3' above coal
16 to 89 holes
6 1/4 inches in diameter
16' X 16' pattern
Powder column 1 ½ to 15 feet
ANFO with 1 lb booster
Non-electric initiation
Stemming 13 to 24 feet
Blasting Data

Charge per Hole (lbs)

Powder Factor (lb/yd3 x 100)
May 31, 2000

Four holes

Hole number 2 - 28 - 33 feet sandstone w/ 1' crevice
Borehole Gas Data
Borehole #4

36" Well

Residence #1
Cap rock and soil semi confining aquifer below

Affected House and Well

Vadose Zone

Seasonally fluctuating water level

Saturated

Jointing in the gray shale and brown sandstone carrying water and fumes

Note: Drawing is a characterization only, scale is approximate
Conclusions

- Flyrock control - Primary focus of the blaster
- Inadvertently contained gases in the ground
- Blast holes were aligned with the fracture system
- Site geology provided a “pipeline and reservoir”
- A large diameter well collected the gases
- The french drain was openly connected to the floor drains
- ALL of these combined to cause the poisoning
Blasting was conducted to minimize displacement,
Broken overburden was not immediately excavated,
Carbon monoxide had a pathway to enter the basement, and
Adequate or positive ventilation was not provided.

The only IME circumstance not existing at this site was that the blasts be “very close” to the residence.