

Toxicity of Conveyor Belt Combustion Products

Charles D. Litton

**National Institute for Occupational Safety and Health
Pittsburgh Research Laboratory**







Some Definitions

Any “substance” that comes into contact with the human body and produces an adverse health effect is said to be *toxic*.

For conveyor belt combustion products, the “substances” that affect the human body are gases and smoke, primarily via breathing and contact with the skin.

Each combustion product gas can produce some **toxic** effect.

Gases that are **most toxic** produce adverse health effects at very **low concentrations** and vice versa.

Terminology Related To Toxicity

- Permissible Exposure Limit (PEL)
- Time Weighted Average (TWA)
 - PELs and TWAs are the Time Weighted Average concentrations that are deemed to be safe for an 8-hour working period.
- Short Term Exposure Limit (STEL)
 - STELs are the concentrations that are deemed safe for a 15-minute exposure.
 - For some gases, up to four 15-minute exposures may occur within an 8-hour working period.
- Immediately Dangerous To Life And Health (IDLH)
 - IDLH concentrations are those that typically produce some immediate adverse health effect.

Principal Toxic Gases

- **Carbon Monoxide (CO)**
 - STEL – 200 ppm
 - IDLH – 1200 ppm
- **Hydrogen Chloride (HCl)**
 - STEL – 5 ppm
 - IDLH – 50 ppm
- **Nitrogen Dioxide (NO₂)**
 - STEL – 5 ppm
 - IDLH – 20 ppm
- **Hydrogen Cyanide (HCN)**
 - STEL – 4.7 ppm (skin)
 - IDLH – 50 ppm (skin)

Experimental Measurements

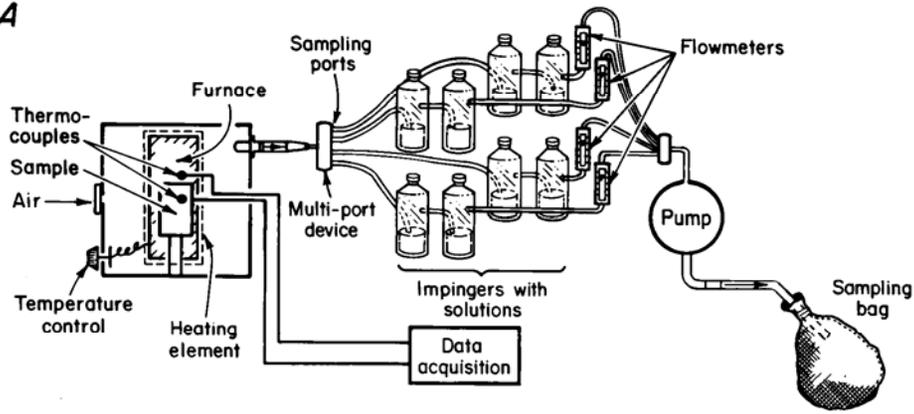
- Thermally decompose a sample in a high temperature (800 deg C) furnace, or
- Burn a sample in a ventilated tunnel
- For each configuration, measure the
 - Mass loss of the sample, m_s
 - Mass of gas produced, m_x
- Define the yield of gas, x , by
 - $Y_x = m_x/m_s$
- The concentration is then calculated from
 - $[X] = (Y_x \cdot M'_s) / V_0 A_0$

where: M'_s is the mass loss rate, for instance during a fire

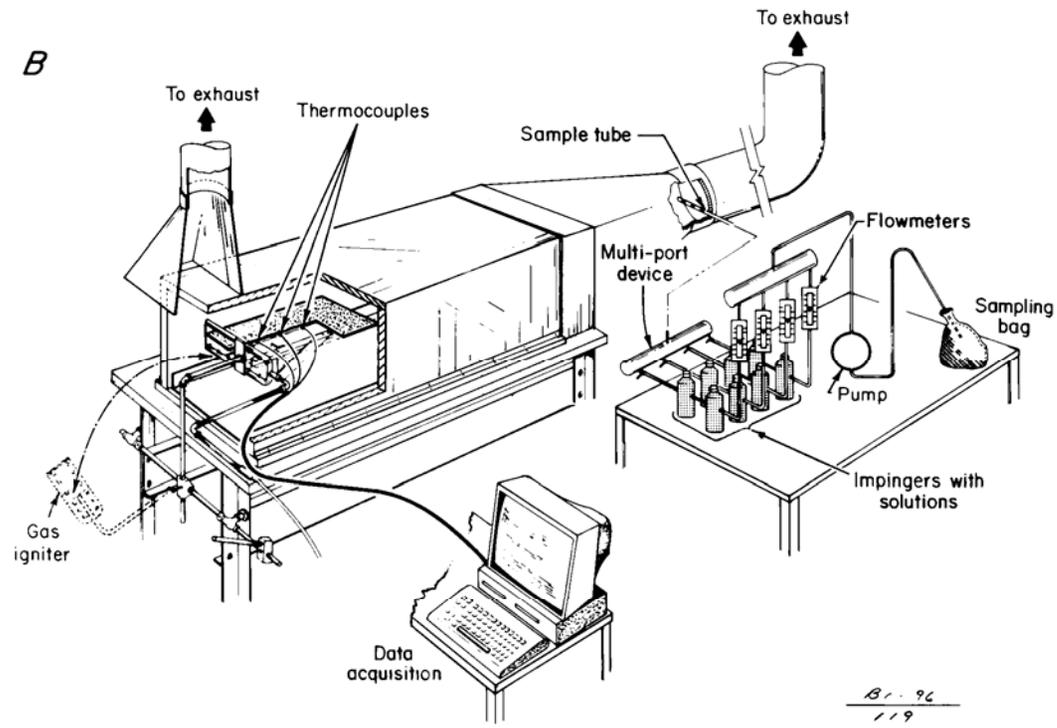
Two Experimental Configurations

- Two Stages of Combustion
 - Non-flaming, smoldering combustion
 - Flaming combustion

A



B



B1-96
119

Experimental Program

- Tests were conducted for 16 different conveyor belt samples
 - Three tests for each sample for reproducibility
 - Basic belt materials
 - Polyvinyl chloride (PVC)
 - Chloroprene rubber (CR)
 - Styrene butadiene rubber (SBR)
- Of the 16 samples
 - 10 had passed a rigorous flame spread test
 - 6 had failed a rigorous flame spread test

Flame Spread Experiment



Clearly, Gas Concentrations can vary Dramatically

- How to normalize results so that they make sense when comparing the gases produced from one material to the next?
- Ratio the concentration produced for each gas to its respective IDLH value
- Results in a toxicity index $(TI)_x$ for that gas and combustible sample because the yield is specific to that sample
- For a given sample, simply sum the four individual gas TIs to arrive at a TI for that sample

Results

- Average **TI** for 10 belt samples that passed the rigorous flame spread test was 0.61 ± 0.24
- Average **TI** for 6 belt samples that failed the rigorous flame spread test was 0.62 ± 0.20

Conclusion

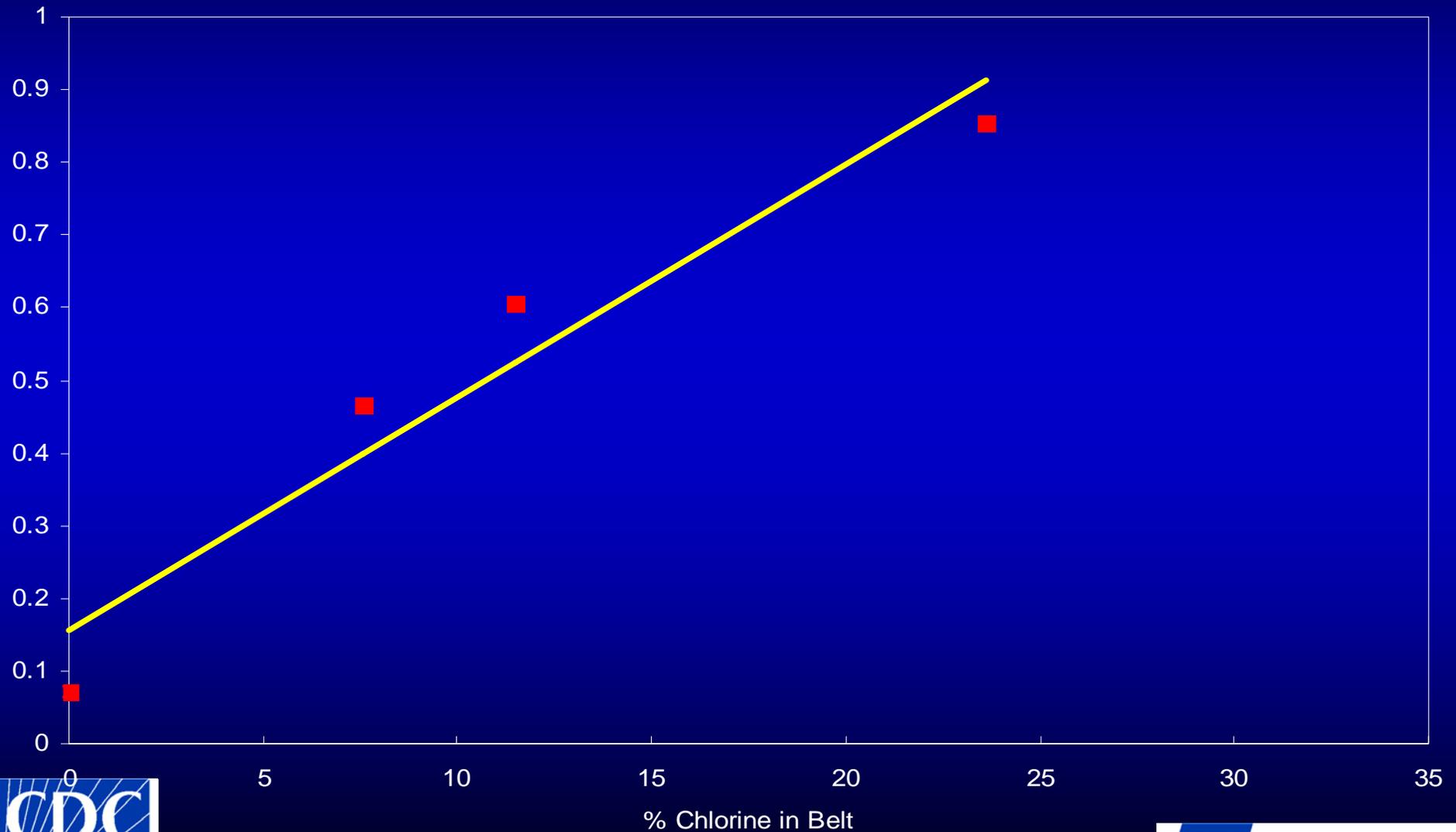
- On average, the relative potential toxic hazard is independent of whether or not the belt is fire resistant

Results Based Upon Type Of Belt

- SBR belts
 - Average TI = 0.49 ± 0.12
- CR belts
 - Average TI = 0.53 ± 0.20
- PVC belts
 - Average TI = 0.77 ± 0.21

Belt Cl Content and Toxicity

Toxicity Index (TI)



Discussion

- Gas-phase HCl deposits readily on roof and ribs; concentrations may rapidly decrease downstream of point of generation
- Because of this possible effect, an average **TI** can be calculated, assuming no HCl present
- Without HCl, result is:

$$\mathbf{TI = 0.069 \pm 0.014}$$

- Depending upon the rate at which HCl is lost from the flow, average **TI** should lie within the following range:

$$\mathbf{0.069 \leq TI \leq 0.610}$$

Discussion (Continued)

- In a conveyor belt fire, toxic hazard (TH) is defined in terms of gas concentrations that result
- Mathematically, TH defined by:

$$TH = TI \cdot (M'_S / V_0 A_0)$$

Discussion (Continued)

- The potential, or probability, that a conveyor belt fire will create a significant toxic hazard also depends upon the probability for flame spread to occur, and we can write
 - $P(TH) = P(FS) \cdot TI \cdot (M'_s / V_0 A_0)$
 - where $P(FS)$ is the probability, for a given belt, that flame spread will occur

Flame Spread Probability

- The best method to assess values for $P(\text{FS})$ is to:
 - conduct large scale experiments to determine whether or not flame spread occurs
 - assess the rate of flame spread proportional to M'_s , should it occur, or conduct smaller scale experiments that reliably mimic large scale experiments.
- The potential to create a toxic hazard, $P(\text{TH})$, depends upon both parameters.

Toxic Hazard Potential

- Three possible situations result, with increasing potential for the fire to create a significant toxic hazard
 - No flame spread, so $P(\text{FS})$ is very close to zero as is the potential for a toxic hazard to occur
 - Slow flame spread, so that $P(\text{FS})$ is unity, but the mass loss rate is low, so that the potential for a toxic hazard is greater than zero, but not too large
 - Rapid flame spread, so that $P(\text{FS})$ is unity, and the mass loss rate is high, so that the potential for a toxic hazard is also high

Conclusions

- The potential for conveyor belt fires to produce a significant toxic hazard does exist, but
- The magnitude of this potential depends upon the probability for flame spread and the rate of flame spread, should it occur
- In general, conveyor belts with good fire resistance characteristics can be expected to present less of a potential toxic hazard than conveyor belts with poor fire resistance properties.

Questions, Discussion