THE OXYGEN COST OF A MINE ESCAPE

J.G. Kovac, Jr. (NIOSH)
Dr. J.H. Kravitz (MSHA)
T. R. Rehak (NIOSH)
March, 1997
Background

- Joint MSHA/NIOSH Project
- Involving 99 mines in six states
- 700 miners
- Currently there are approximately 900 active underground coal mines in the United States employing approximately 50,000 miners
- Data was collected on the escape route as well as each participating miner
Objectives

• To gather in-mine data on escape times, distances and heart rates in order to predict how much oxygen is needed for a mine escape
• To compare oxygen consumption bare-faced versus using an SCSR
• To provide a scientific basis for practical escape planning involving all major factors
Protocol

• Escape means taking a miner on foot and under oxygen from the deepest point of penetration in the mine to the surface
• Day 1 - 5 miners make a mock escape barefaced while wearing a recording pulse-rate monitor
• Day 2 - At least one miner escapes using an SCSR
Analysis

- Histograms
  - Age
  - Weight
  - Escape Distance
  - Escape Time
  - Speed
  - Oxygen Uptake
  - Oxygen Cost
  - Oxygen used
Miner's Weight

WEIGHT (kg)
Escape Distance (All Mines)
Escape Time (w/ SCSR)
Average VO₂ (w/ SCSR)
Oxygen Consumption Rate

- **HR** = Heart Rate (beats per minute)
- **VO₂** = Rate of Oxygen consumption (liters of oxygen per minute)
- **HR** = b + m * **VO₂**
- **VO₂** = b₁ + m₁ * **HR**
  - Straight line relationship
  - Intercepts (b & b₁) and slopes (m and m₁) are known
  - Oxygen consumed = Area under VO₂ vs. time curve
  - Oxygen consumed = Average VO₂ x Escape Time
Relationships from Research

• HR = 36 VO$_2$ + 66 (Penn State, 1977)
• HR = 39 VO$_2$ + 68 (Bureau of Mines, 1981)
• HR = 37 VO$_2$ + 66 (Bureau of Mines, 1995)
$O_2$ Used (w/ SCSR)

Relative Frequency

$O_2$ Used (Liters)
Conclusions

• The study demonstrated that it is possible to project, on a mine-by-mine basis:
  – The difficulty of the mine escape
  – The amount of oxygen that would be required for a mine escape knowing the body weight and heart rates of the escaping miners
  – This would provide a practical way of optimizing the mine escape plan so that there would be enough SCSRs for miners to make the mine escape
Conclusions

- Escape speed - 15% slower while using an SCSR
- Travel time - 15% longer while wearing an SCSR
- Weight - a miner consumes oxygen in proportion to his/her weight
- A practical, scientific approach for planning