



Mine Ventilation Laboratory

Department of Mining and Minerals Engineering

A REVIEW OF ATMOSPHERIC MONITORING SYSTEMS IN UNDERGROUND COAL MINES: IMPLICATIONS FOR EXPLOSION PREVENTION

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Outline

- Introduction and Motivation
- Select international regulation
 - China and Australia
- US Regulation
- Regulatory Atmosphere in the U.S.
- AMS Technology
 - Continuous Monitoring
 - Tube Bundle Systems
- Developing Technology and Recommendations



Introduction

April 5th, 2010

The Upper Big Branch Mine Explosion occurred in Montcoal, WV resulting in 29 fatalities.

November 19th, 2010

The Pike River Mine Explosion occurred in New Zealand resulting in 27 fatalities.

Numerous other explosions occurred in developing countries.

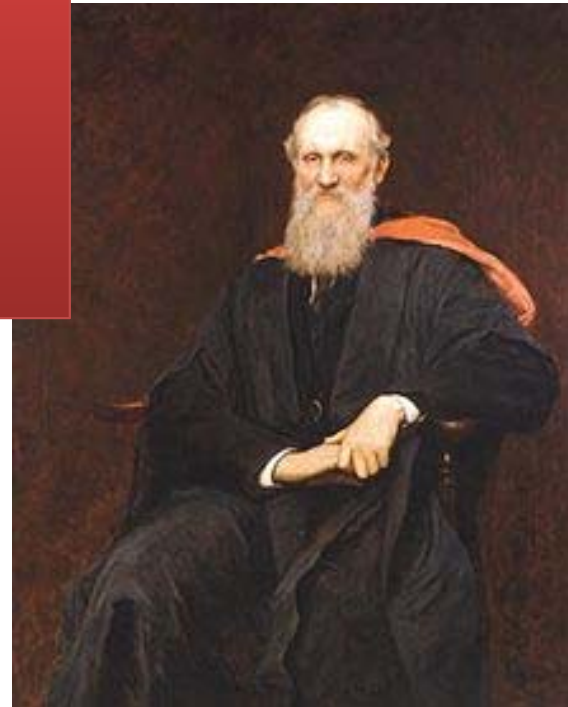


Motivation

“If you cannot measure it, you cannot improve it.”

AMS Systems

- Real-time
- Comprehensive
- Continuous



Current US Regulation

30 CFR §75.156 AMS Operators

30 CFR §75.350 Installations in Belt Air

30 CFR §75.351 Monitoring of Returns

30 CFR §75.362 Monitoring of Returns maintained under 1.5%

30 CFR §75.323 Allows intrinsically safe AMS to be energized

30 CFR §75.352 Actions taken



Select International Regulations

Australia

- Continuous AMS Systems (typically major return nodes and other areas.)

China

- Gassy underground mines must monitor immediate returns in addition to working face.



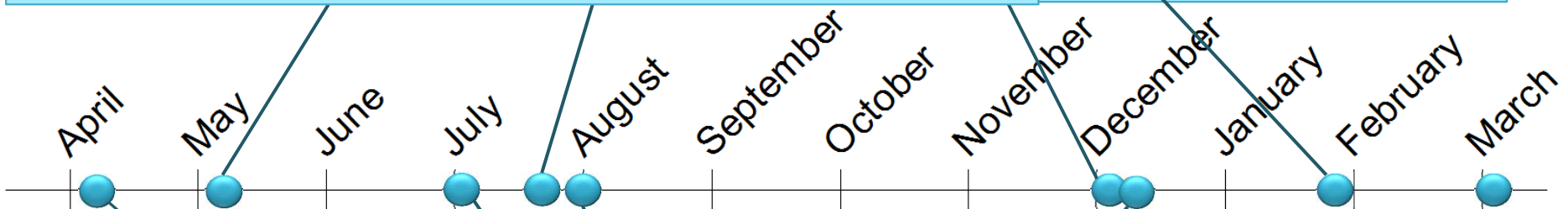
Regulatory Atmosphere in the US

January 25, 2011: Senate

Rockefeller (D-WV) introduces the Robert C. Byrd Mine and Workplace Safety and Health Act of 2011 (S 153, 3 co-sponsors)

House

proposes a mine safety bill (H 5788, 0 co-sponsors)



December 8, 2010: House

The Robert C. Byrd Mine Safety and Health Act of 2010 fails under a suspended vote (yeas-214, nays-193)

Senate

Rockefeller (D-WV) introduces the Robert C. Byrd Mine and Workplace Safety and Health Act of 2010 (S 3671, 3 co-sponsors)



Robert C. Byrd Mine and Workplace Safety and Health Act of 2011

Atmospheric Monitoring

Section 503

- **6 months** after enactment of the Robert C. Byrd Mine and Workplace Safety and Health Act of 2011, NIOSH will issue recommendations-
 - Ensuring best utilization of AMS for health and safety
 - “the implementation of redundant systems, such as the bundle tubing system, that can continuously monitor the mine atmosphere following incidents such as fires, explosions, entrapments, and inundations.”
- **270 days** after recommendations are received regulation will be promulgated requiring AMS:
 - protect miners where the miners normally work and travel;
 - provide real-time information regarding methane and carbon monoxide levels, and airflow direction, as appropriate, with sensing, annunciating, and recording capabilities; and
 - can, to the maximum extent practicable, withstand explosions and fires.

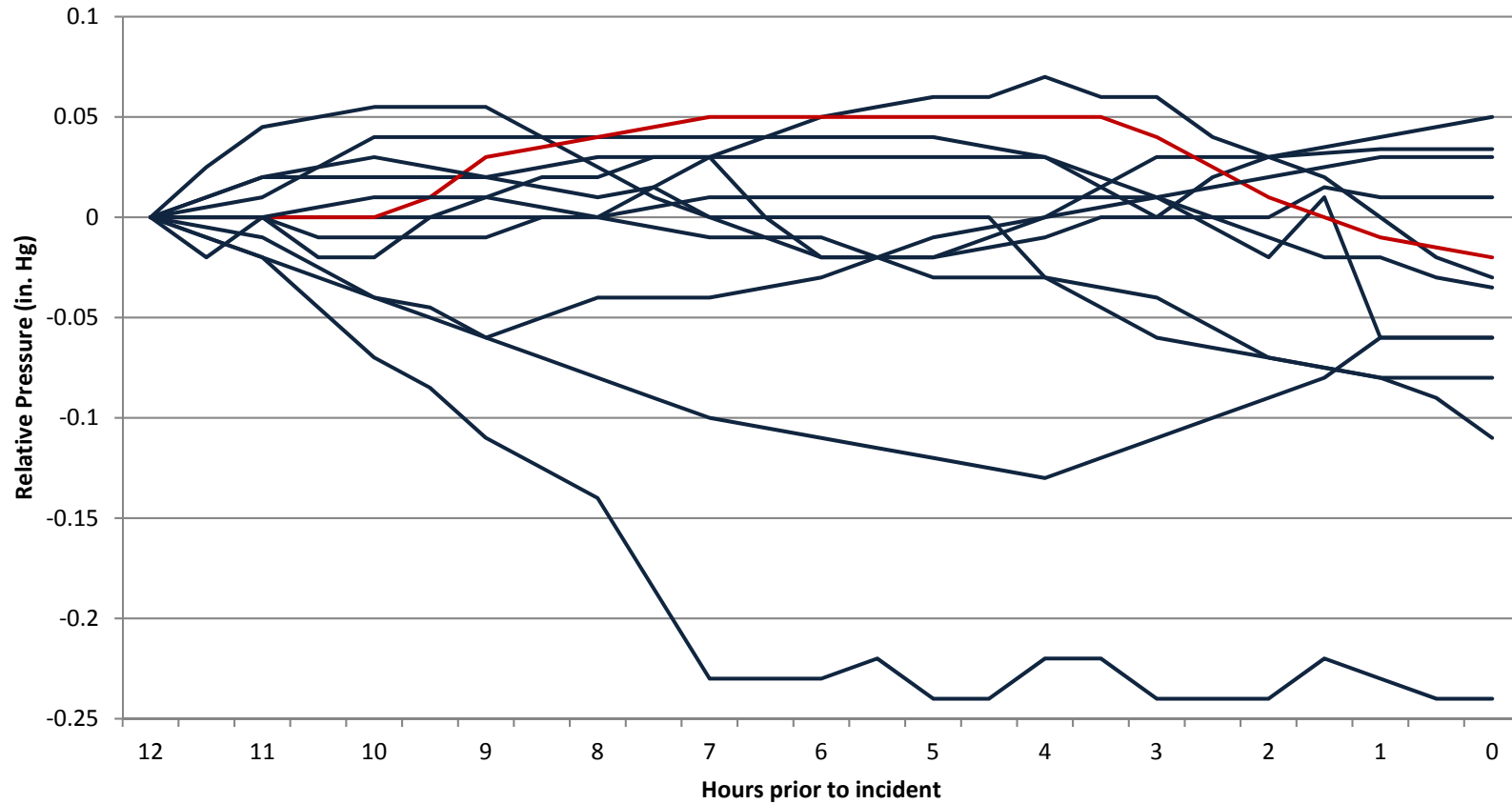


AMS Technology

- Continuous Monitoring
 - Barometric Pressure
 - Gas and velocity sensing
- Tube Bundle Systems
- Developing Technology
 - Fiber optics
 - Wireless monitoring



Barometric Pressure



Velocity Sensing

- Ultrasonic Sensing
- Thermal Mass Flow
- Vortex Shedding
- Differential Pressure Measurement

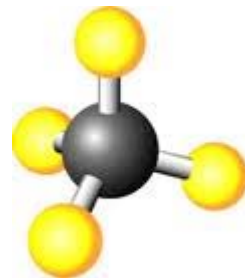


Gas Sensing

Primary Interest

Methane, Carbon Dioxide, Carbon Monoxide,
Oxygen

Also:



Fire Gases

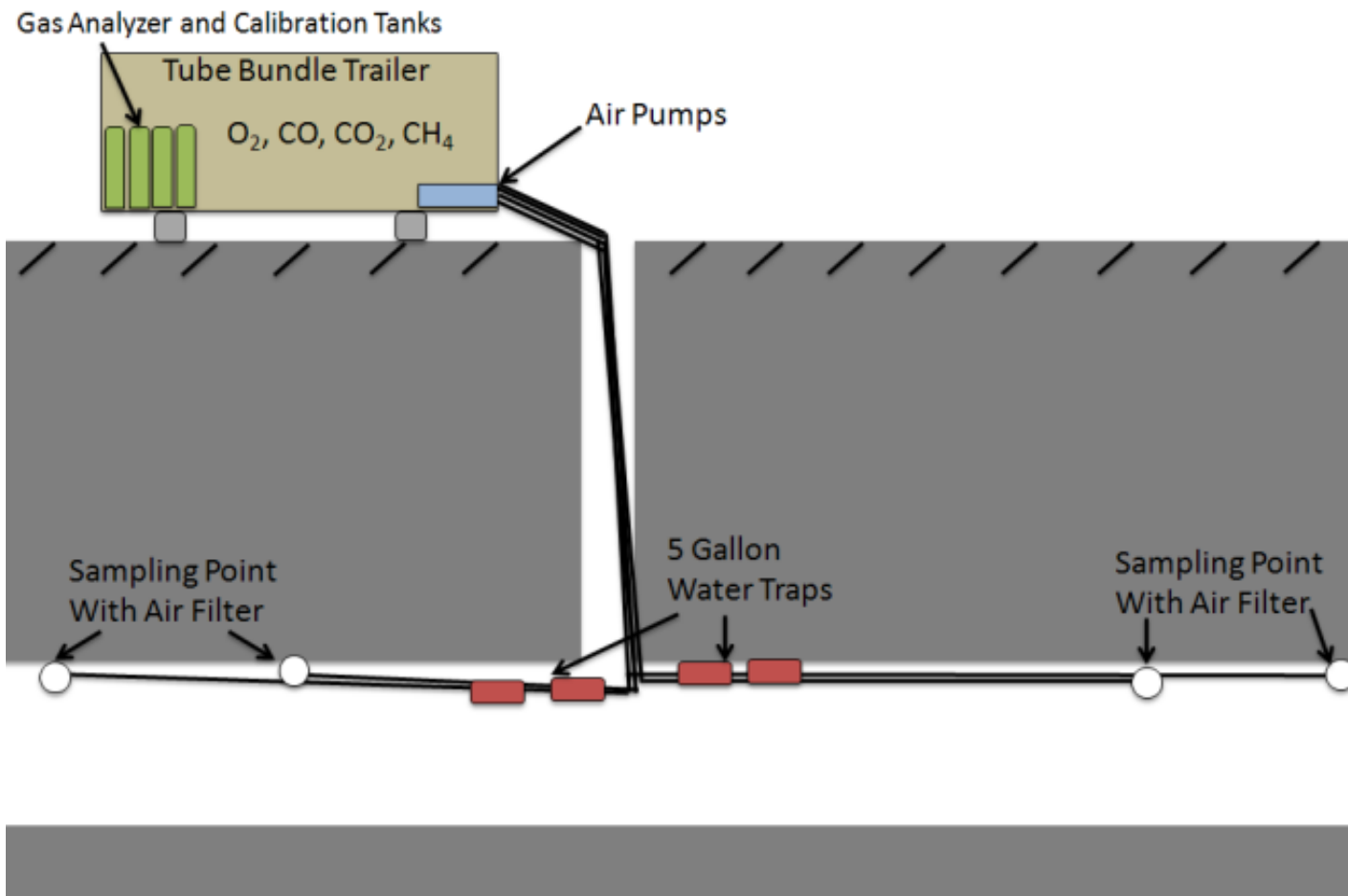
(Acetylene, Ethane, Ethylene, Hydrogen)

Nitrogen and Argon

Others such as Hydrogen Sulfide



Tube Bundle Systems



Tube Bundle Systems



Best Practice

- Multiple levels of detection
 1. Personal detection
 2. Fixed detection
 3. Continuous real time monitoring
 4. Remote monitoring (tube bundle systems)
 5. Bag sampling and analysis by GC



Weaknesses of Current Technology

- Interference from dust and other gases
- Measurement is often only 0 to LEL (or small range)
- Frequent calibration required
- Maintenance intensive



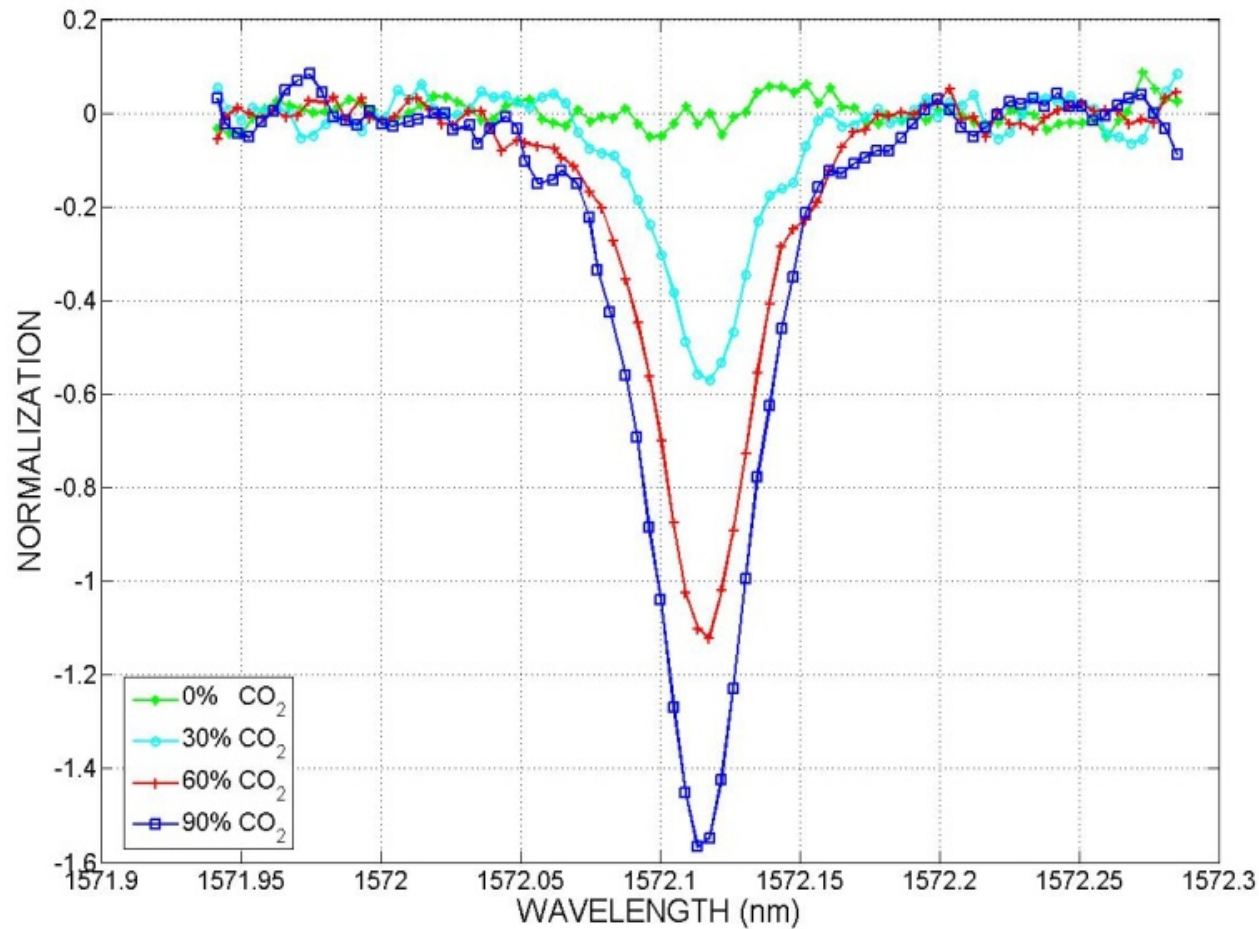
Developing Technology

Optical Fiber Sensing

- Self-calibrating
- Excellent sensitivity and resolution over a full range
- No interference from other gases
- Safe



Fiber Optic Sensing



Courtesy of the Center for Photonic Technology. Anbo Wang and Evan Lally, 2010.

Explosion Prevention

- Must bring multiple system/sensors together and display data in real time in a useful format.
- An attractive investment
- Systems must be intelligent
 - Able to assess multiple parameters and give timely warning of the development of dangerous atmospheres



Recommendations

- Thorough review of recent explosions
 - What would have been necessary to sense the development of an explosive atmosphere?
 - How far in advance can that development be forecast?
 - Could a system withstand or partially withstand the incident?
 - Development of novel sensing technology.
 - Full scale field trials.



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