



Office of  
Mine Safety and  
Health Research

# System Implementation

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# Outline

- **System Safety**
  - Permissibility
- **EM (electromagnetic) Radiation Safety**
  - Personnel
  - Explosive Atmosphere
  - Blasting Caps
- **EM Compatibility and Interference**
  - EM Interference (EMI)
  - EM Compatibility (EMC)
- **Standards and Regulations**

# System Safety

- **Intent of MINER Act is to have CT systems operational following an emergency incident**
  - Mine power may be shut down
  - To remain operational, CT systems will have to be MSHA permissible
  - Will need battery operated equipment
- **Permissibility**
  - Intrinsically Safe (IS)
  - Installed in eXplosion Proof (XP) container

# EM Radiation Safety

- **EM radiation is everywhere**
  - TV, radio, cell phone, satellite, garage door opener, remote car lock, ...
- **Most surface EM radiation does not penetrate overburden**
- **CT systems will introduce EM radiation underground**
- **Need to assess EM radiation hazards (RADHAZ)**
  - Personnel
  - Explosive atmosphere
  - Blasting caps

# **RADHAZ - Personnel**

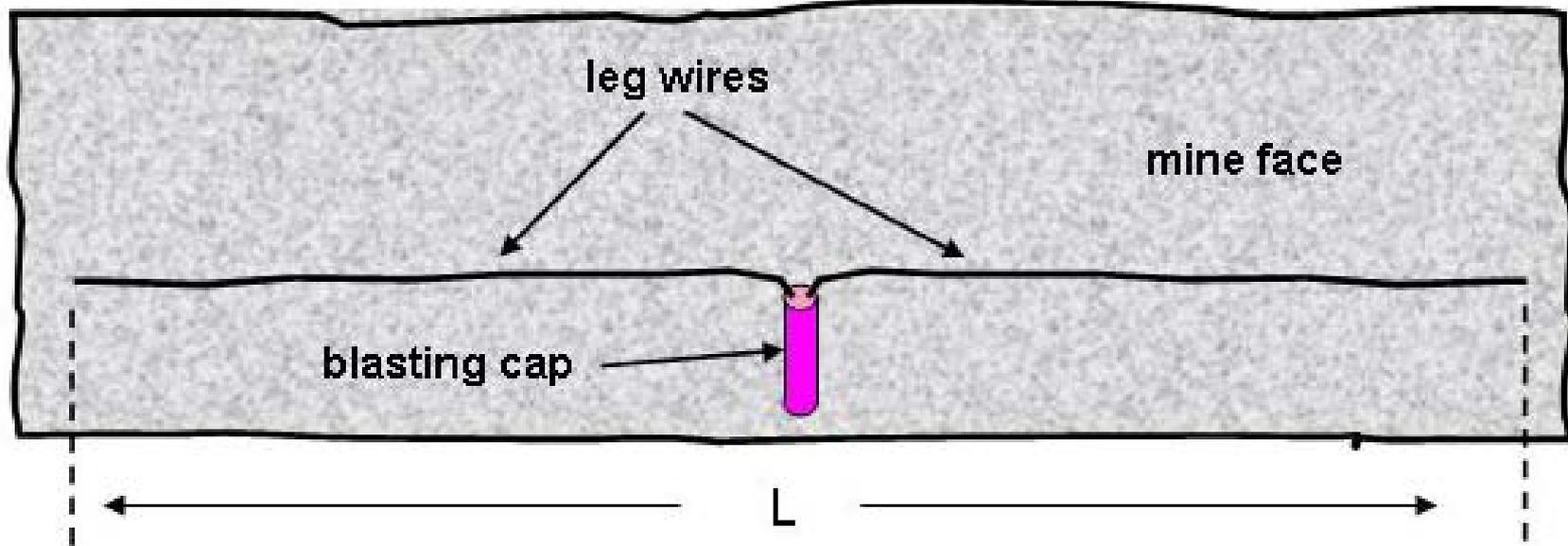
- **EM energy may pose health risk**
- **There are well-established national and international standards for acceptable exposure levels**
- **Acceptable levels depend on frequency of operation, radiated power level, distance of separation source-to-person (exposure decreases with increasing distance)**
- **No hazard except possibly high power (4-5 watt) devices transmitting close to head for more than 6 minutes continuous transmission (not expected usage)**

# **RADHAZ – Explosive Atmosphere**

- **EM radiation induces currents in metal structures which can cause spark igniting fire or explosion in methane or coal dust atmosphere**
- **There are well-established standards addressing this issue**
- **Induced currents pose no hazard if effective isotropic radiated power (EIRP) is less than 6 watts**

# RADHAZ – Blasting Caps

- Leads (leg wires) can act as receive antenna
- Incident radiation can induce RF power in leads causing inadvertent ignition



# RADHAZ – Blasting Caps: Transport

- There are regulations covering RF safety for over-the-road
- There are regulations covering RF safety for transport underground
- Recommend RF shielding during underground transport



# **RADHAZ – Blasting Caps: Deployment**

- **There are standards to specify minimum separation distance between transmitter and blasting cap leads (do not fully address underground mine issues)**
- **There is a threshold power for ignition of caps**
- **Induced RF power in leads depends on:**
  - Effectiveness of leads in capturing RF energy: Layout of leads, Length of leads, Frequency of incident radiation
  - RF energy incident on leads: Transmitter(s) power, Antenna gain, Reflections, Separation Distance
- **Unless calculated or measured compliance with standards, use**
  - RF frequencies: minimum separation 200 feet
  - MF: turn off

# **RADHAZ – Blasting Caps: RFID Separation**

- **Miner may have RFID device on helmet near blasting cap**
- **National standards that specifically address RF Safety when using Electric Blasting Caps**
  - 40 mW no-fire average power for electric blasting caps (DC or RF power)
- **No MSHA-approved RFID tags exceed 40 mW**
- **No minimum separation distance need be observed**

# Electromagnetic Interference (EMI)

- **Undesired RF energy interferes with reception or processing of desired signal**
- **RF interference:**
  - Intentional emitter – e.g., handheld radio  
(EMI: radios on different channels may introduce static when operated simultaneously)
  - Un-intentional emitter – e.g., continuous miner  
(EMI: radio operated near continuous miner may have static)
- **Mitigation**
  - Frequency management
  - Twisted wires, coaxial cable, shielding ...
  - Reduce transmitter power
  - Increase separation between transmitter and receiver

# Electromagnetic Compatibility (EMC)

- **Desired quality – systems operate in their EM environment without causing (*source*) or experiencing (*victim*) degradation**
- **EM Spectrum managed by**
  - Federal Communications Commission (FCC)
  - National Telecommunications and Information Administration (NTIA)
- **FCC not much on susceptibility (*victim*)**
- **Military Standard MIL-STD 461F for susceptibility and radiated EMC tests (*tailor*)**

# Standards and Regulations

## Surface Operation

	Frequency	Reference	Comment
node-based	WiFi, Zigbee, UWB 902 – 928 MHz 2400 – 2483 MHz 5 – 6 GHz portions	47 CFR Part 15	No FCC license needed if meet power (and other) requirements
leaky feeder	150 – 174 MHz 450 – 470 MHz	47 CFR Part 90	Requires FCC license as Land Mobile Radio
MF	300 – 800 kHz	Maritime Mobile, Aeronautical Mobile	No spectrum available for mobile radio

Underground: 47 CFR Part 15, tunnel radio, no license required if emissions from mine are less than specified.

# Summary

- **System Safety**

- Mine power off => permissible => batteries

- **EM Radiation Safety**

- Personnel (possible concern 4-5 W devices, 6 min.)
- Explosive Atmosphere (keep EIRP power less than 6 W)
- Blasting Caps (measured, calculated, UHF – 200 feet separation; MF – turn off)
- RFID tags less than 40 mW no minimum separation

- **EM Compatibility and Interference**

- EMI and EMC, MIL-STD 461F tailored

- **Regulations on licensing**

# Survivability & Reliability Safety

- **Competitive Bidding**
- **Foster-Miller awarded 3 contracts (Aug 2008)**
  - System Reliability and Environmental Survivability
  - Performance and Safety Investigation of Emergency Backup Batteries and Battery Charging Systems
  - Development of Guidelines for Safely Managing Electrical Equipment and Systems