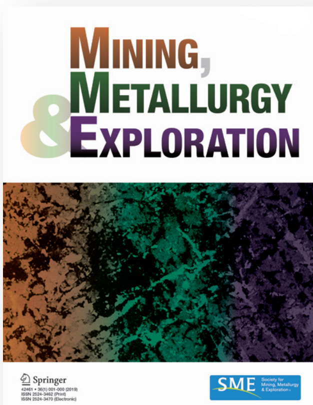
Extended abstracts from the SME journal
Mining, Metallurgy & Exploration



Take full advantage of your SME membership. As a member, you can read and download for free all of the full-text papers in *Mining, Metallurgy & Exploration* (**MME**) and the archives of *Minerals & Metallurgical Processing* (**MMP**). Log in to the SME website as a member, and enter the MME Springer website through our dedicated SME link:

1. Log in at smenet.org with your email address and password.
2. Click on "Publications" in the top banner and choose "Mining, Metallurgy & Exploration journal" in the pull-down menu.
3. Scroll down and click on the "Read the MME Journal Online" link. This takes you to the MME Springer website as an SME member with free access.

To see a specific paper, use the search function or use the paper's https://doi link.

For assistance at any time, email Chee Theng at theng@smenet.org. ■

IMPACT FACTOR 1.695

Submit your paper by clicking on the "Submit manuscript" box at springer.com/42461
Get Table of Contents (ToC) email alerts by clicking on "Sign up for alerts"

MME is abstracted and indexed in Web of Science, Current Contents, Science Citation Index Expanded, Scopus, Google Scholar, EBSCO, ProQuest and many more.

An overview of existing EMI standards applicable to mining

Matthew Girman*, Miguel Reyes and Chenming Zhou
CDC NIOSH, Pittsburgh, PA, USA
*Corresponding author email: MGirman@cdc.gov

Full-text paper:
Mining, Metallurgy & Exploration (2022) 39:77–88, https://doi.org/10.1007/s42461-021-00502-y

Keywords: Electromagnetic interference, EMI/EMC standards, Underground mining, Mine safety

Electromagnetic energy emitted from electronic devices has been known to interfere with other electronic systems, hindering their ability to function properly. Mines have many electronic devices critical to the health and safety of mine workers that could be negatively affected by electromagnetic interference (EMI). To ensure that devices are electromagnetically compatible, tests must first be conducted to measure emissions and check for immunity. Standards are available across multiple industries that prescribe emission limits and test methods for electronic devices. A literature review was conducted in this study, and an overview of EMI standards in other industries is provided. Also, an example of how a standard can be applied to mining equipment is presented.

Introduction

Globally, electromagnetic interference (EMI) has been implicated in many accidents that led to injuries and fatalities. It has caused weapons systems to fire unexpectedly, flight instruments to malfunction, and antilock braking systems on automobiles to fail. EMI presents a critical challenge in mining as health and safety devices such as proximity detection systems and personal dust monitors have been introduced to enhance mine worker safety. An underground mine is a unique environment with tight spaces, low roof heights and long tunnels with a variety of electronic devices and machinery working in close proximity. The mining industry has made progress in understanding the impacts of EMI through research and development efforts. One example is the Mine Safety and Health Administration's (MSHA) program policy letters dealing with potential EMI produced by communication and electronic tracking systems on blasting circuits. Although efforts have been made to summarize existing EMI standards and to compare military and international standards, there is a need to examine how EMI standards can be adapted to a mining environment. It is important for the mining industry to identify existing EMI standards, assess their applicability to mining and develop solutions to any gaps between mining and other industries. A literature review was conducted in this study on existing EMI standards so that mine workers and technology manufacturers can continue to build the knowledge base on how other industries achieve electromagnetic compatibility (EMC) and to develop solutions to ensure that the critical safety systems in mines work as intended.

Background

What information do these standards contain? Electronic devices can be characterized in terms of how much energy they emit and how much EMI they can withstand while still working as intended. As a result, an EMI standard typically contains requirements for two key elements: (1) emissions and (2) susceptibility/immunity.

Existing standards usually include test methods and limits of emission and susceptibility for specific environments. An assessment of standards in other industries was a primary focus of this study.

EMI standards and organizations. As more electronic devices are introduced to mines, it is expected that more EMI instances will occur, which can lead to serious safety issues. Accordingly, there exists a need to investigate similar challenges in other industries and to specifically draw guidance from existing standards.

In this paper, we provide an overview of EMI standards in other industries and discuss their applicability to mine environments. Table 1 lists the EMI standards cited.

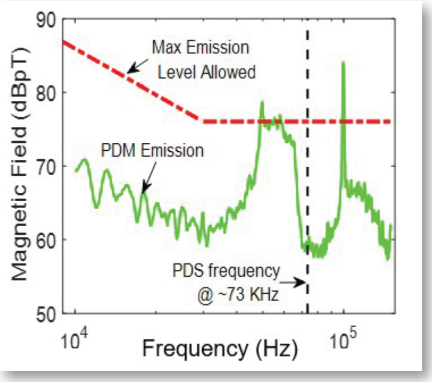


Fig. 1 Radiated emission test result of a personal dust monitor (PDM) based on RE101 of MIL-STD-461G.

Table 1 — Summary of EMI standards cited in this paper.

Organization/industry	Relevant standards
Military	MIL-STD-461G
FCC	47 CFR 15
IEC	IEC 61000-6-4:2018, IEC 61000-6-2:2016, IEC 61000-4, IEC 61326-3-1:2017
CISPR	CISPR 11:2015
ANSI	C63.4-2014, C63.10-2013, C63.15-2017
IEEE	Std 299-2006, Std 1848-2020
Automotive	SAE J1113, SAE J551, SAE J1752, ISO 11452, ISO 13766-1:2018, ISO 7637-2:2011, ISO 16750-2:2012
Medical	IEC 60601-1-2:2014
Nuclear	IEC 62003:2020, IEEE P2425
Aviation	RTCA DO-160G

Discussion

By investigating EMI in other industries, we can learn how they address similar problems. In each of the industries discussed in this paper, a malfunction in an electronic device can have major consequences.

Characterizing electronic systems used in coal mines based on existing EMI standards — a case study. EMI has caused issues in mining when emissions from one electronic device interfere with emissions from another device, causing it to malfunction. One example is that of personal dust monitors (PDM) and powered air-purifying respirators interfering with proximity detection systems (PDS), which exposes miners to striking and pinning hazards from continuous mining machines. We present a case study related to the applicability of the military standards to assess that interaction.

Figure 1 shows the measured magnetic fields from the PDM based on the measurement method specified in RE101 of MIL-STD-461G. The maximum emission level, allowed per the military standard for U.S. Navy applications, is also plotted in Fig. 1 for comparison. At 73 kHz, which is the frequency at which the PDS operates, the emission from the PDM is about 18 dB below the given maximum emission limit. In practice, the application of this standard highlights the need to consider the mining environment to better represent the emission and susceptibility threshold levels of different electronic devices used in underground coal mines.

This paper also presents the susceptibility of a proximity detection system component based on RS101 of MIL-STD-461G and an evaluation of the potential impacts of the measured emissions and susceptibility on the functionality of the device.

Conclusion

As new technologies are introduced to mines, the number of potential sources of EMI will increase. Investigating this topic is especially critical because EMI poses challenges that may lead to injuries and fatalities to mine workers. There are questions that need to be considered, such as: What is the intended use for each device? What are the consequences if a device stops working? What are the allowable emissions limits before it may interfere with other devices? What is the susceptibility threshold before a device stops working as intended? Further research is required to investigate mining-specific applications and conditions that may point to the need for an EMC standard to be created specifically for mining applications. Mining industry stakeholders can use the information presented in this paper to gain insight into how other industries approach electromagnetic interference and electromagnetic compatibility and explore the applicability of existing standards to address challenges encountered in underground mines. ■

Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC). Mention of any company or product does not constitute endorsement by NIOSH.

References

A list of all references is available in the full-text paper.

Near-technical limit gold recovery from a double refractory Carlin-type ore after pretreatment by high-temperature pressure oxidation

Devy Dyson[1], Steve Yopps[2,*], John Langhans[2], Stamen Dimov[3] and Brian Hart[3]
[1]FLSmidth, Midvale, UT, USA
[2]Nevada Gold Mines, Elko, NV, USA
[3]University of Western Ontario, Canada
*Corresponding author email: swyopps62@gmail.com

Full-text paper:
Mining, Metallurgy & Exploration (2022) 39:1563–1570, https://doi.org/10.1007/s42461-022-00638-5

Keywords: Pressure oxidation, Catalyzed oxidation, Carbonaceous gold ore, Carbonaceous matter, Subcritical water oxidation

A recent Nevada Gold Mines research program focused on the pressure oxidation (POx) pretreatment of a Carlin-type double refractory ore from the Turquoise Ridge Mine. The research team found that both arsenian pyrite and carbonaceous matter were highly oxidized within an hour at 300 °C using a bench-top autoclave reactor and that the gold recovery from the residues after cyanide/carbon-in-leach (CIL) approached the technical limit set by the amount of gold encapsulated by silicate minerals. Although the 60-min pretreatment at 300 °C yields robust performance when treating a whole ore, copper additives can catalyze the oxidation rate of carbonaceous matter and reduce the residence time needed at elevated temperatures. Certain gangue minerals are susceptible to dissolution in acidic solutions at 300 °C, and this may cause poor gold recovery. This recovery challenge is mitigated by keeping free acid in the discharge solution below a key threshold.

Introduction

Nevada Gold Mines and FLSmidth's Minerals Testing and Research Center based in Salt Lake City, UT, developed an acidic POx program to oxidize more than 80 percent of carbonaceous matter in Nevada Gold Mines' Turquoise Ridge Stockpile O ore. The goal was to achieve these oxidation levels within 20 min, the expected practical limit for high-temperature, high-pressure plug-flow reactor designs.

Background

Subcritical water oxidation of carbonaceous matter. Existing studies for similar ores achieved carbonaceous-matter oxidation as high as 40 percent when treating a 20-µm feed at 225 °C for 120 min. Gold recovery averaged 86 percent on the representative composite sample evaluated. Copper sulfate was also tested as a catalyst for carbonaceous-matter oxidation, which enhanced results as well [1]. Flotation concentrates have also been processed by POx at 240 °C with a residence time of less than 360 min [2]. Mass reduction by flotation was key in keeping the POx circuit capital cost within reason.

Characterization, results and discussion

Characterization and diagnostic leaching exemplified the refractoriness of the ore. Baseline POx-CIL tests with complete oxidation at 225 °C showed significant refractoriness, resulting in 71 percent gold recovery. Preg-robbing characterization tests then identified a preg-rob value of 84 percent, which again indicates high levels of gold loss by the carbonaceous matter. Problematic gangue minerals, such as muscovite, were also identified that were determined to play a critical role in recovery during testing. Results concluded that approximately 95 percent of the gold should be recovered if all gold associated with sulfides and carbonaceous matter are recovered.

Considering carbonaceous-matter oxidization was the greatest challenge and focus of the program, detailed characterization of the carbonaceous matter was undertaken with Surface Science Western (SSW), a consulting and research laboratory. Various morphologies and compositions of carbonaceous matter were found to be present in the ore. The average submicroscopic gold concentration of all the carbonaceous matter, irrespective of morphology, was 45 ppm gold (Au) and was positively correlated with iron (Fe), arsenic (As) and sulfur (S) concentrations in the carbonaceous matter. This correlation suggests that the gold carrier was microfine arsenian pyrite encapsulated within the carbonaceous matter. Consequently, there was a need to oxidize the carbonaceous matter to liberate the encapsulated gold to achieve the highest gold recovery.

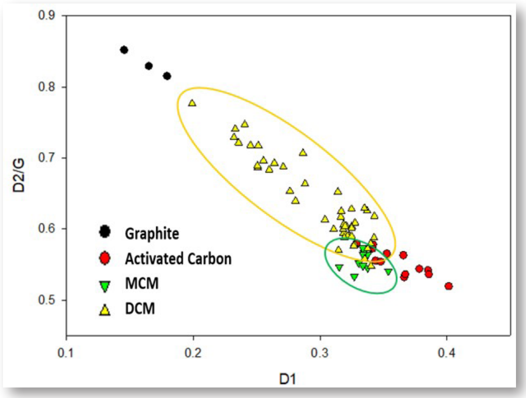


Fig. 1 Comparison of the carbonaceous-matter morphologies against the Raman ratios of standard materials.