National Institute for Occupational Safety and Health

Comments to the Mine Safety and Health Administration

Formal comments from the National Institute for Occupational Safety and Health (NIOSH) to the Mine Safety and Health Administration (MSHA) on Testing, Evaluation, and Approval of Electric Motor-Driven Mine Equipment and Accessories proposed rule; request for comments

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The National Institute for Occupational Safety and Health has reviewed the Mine Safety and Health Administration (MSHA) proposal to revise its regulations on "*the testing, evaluation, and approval requirements for electric motor-driven mine equipment and accessories intended for use in gassy mines. Under this proposal, MSHA will accept voluntary consensus standards (VCS) that are suitable for gassy mining environments and that provide protection against fire or explosion dangers, to replace approval requirements in its regulations. This proposal is intended to promote the use of innovative and advanced technologies that lead to improvements in mine safety and health and to improve the efficiency and effectiveness of MSHA's approval process.*"

NIOSH supports the proposed rule change as it represents a much needed and significant step forward in the approval of explosion protected equipment, and potentially increases the availability of equipment which could improve worker health and safety. NIOSH understands the difficulty in implementing any changes in this area as reflected in the discussion on the NIOSH webpage Electrical Equipment Explosion Protection Research [NIOSH 2020]. The adoption of voluntary consensus standards (VCS) should reduce much of the uncertainty introduced by the existing equipment approval requirements of the MSHA Approval and Certification Center. This likely will make it more attractive to equipment manufacturers to invest in mine safety and health-related technologies and expand the pool of available equipment. Supporting background information has been included in Appendix 1.

The MINER Act of 2006 permanently established the Office of Mine Safety and Health Research (OMSHR) to enhance the development of new mine safety technology and technological applications as well as to expedite the commercial availability and implementation of such technology in mining environments. NIOSH has long recognized that U.S. coal mines can use only a small fraction of the explosion protected equipment available worldwide due to U.S. approval requirements [Industry ARC 2013; Snyder et al. 2018], and this likely limits their use by mining companies.

While some new safety and health technologies have been introduced in mines [Snyder et al. 2016], many of the barriers to implementing technologies in gassy mines are not fully understood by NIOSH researchers. NIOSH contracted with the RAND Corporation to perform a blind survey of the mining community to identify and better understand these barriers [Federal Register 2017]. The survey results, while in draft form, indicate that two large barriers to implementing technologies in gassy mines are the relatively small equipment market and unique approval requirements. A copy of the RAND barrier taxonomy from that effort, prepared in advance of a draft report, is attached as Appendix 2.

NIOSH commends MSHA for publishing this proposed rule which builds multiple layers of engineering and administrative controls into the system of health and safety protections for U.S. miners. NIOSH supports the intent of such a layered safety approach and offers MSHA comments for consideration. These comments, while not rooted in NIOSH published empirical research, are based on considered expert judgment of our scientists and engineers working in this area through the intent of NIOSH's charge in the MINER Act.

The NIOSH comments are as follows:

1) NIOSH supports including VCS to remove barriers that prevent the use of mining equipment used internationally so that the U.S. can take advantage of all available safety and health technologies that provide adequate protection for miners.

Adoption of VCS for equipment certification was identified as a way to reduce the barriers to using new technologies in the RAND taxonomy. This solution could be applied to all types of electrical and electronic equipment used in mines. The proposed rule applies only to Part 18, so to address all equipment other parts of 30 CFR might be considered:

Part 19 Electric Cap Lamps

Part 20 Electric Mine Lamps other than Standard Cap Lamps

Part 22 Portable Methane Detectors

Part 23 Telephones and Signaling Devices

Part 27 Machine-Mounted Methane Monitoring Systems

In addition to the standards listed in the proposed rule, other International Electrotechnical Commission (IEC) standards that may apply to several 30 CFR Parts are listed below. A complete list of IEC Ex standards can be found at https://www.iecex.com/publications/standards/.

IEC 60079-2 Part 2: Equipment protection by pressurized enclosure 'p'

IEC 60079-7 Part 7: Equipment protection by increased safety 'e'

IEC 60079-29-1 Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases

IEC 60079-29-2 Part 29-2: Gas detectors - Selection, installation, use and maintenance of detectors for flammable gas and oxygen

IEC 60079-29-4 Part 29-4: Gas detectors - Performance requirements of open path detectors for flammable gases

IEC 60079-33 Part 33: Equipment protection by special protection 's'

IEC 60079-35-1 Part 35-1: Caplights for use in mines susceptible to firedamp - General requirements - Construction and testing in relation to the risk of explosion

IEC 60079-35-2 Part 35-2: Caplights for use in mines susceptible to firedamp - Performance

2) MSHA should consider including language in the rule that states that Mb protection is acceptable, subject to additional ventilation monitoring with integrated power cutoff or other supplementary safety measure acceptable to MSHA. Appendix 3 has been included with further background and references on the possible use of the Mb designation.

A significant limitation of the proposed rule is that 30 CFR Part 18 pertains to higher power motor- driven equipment, whereas the Ma levels of protection within the IEC/ANSI standards pertain primarily to lower power instrumentation and control circuits. Level of protection Mb pertains to higher power motor-driven equipment and appears to be most applicable to 30 CFR Part 18. While the proposed rule provides greater access to low powered intrinsically safe equipment, the proposed regulation does little for higher powered mining machinery. To increase the availability of higher-powered machinery equipment, MSHA should consider including equipment designated "Mb" (IEC 60079-0 Part 0: Equipment - General requirements). The additional measures would be included in the MSHA approved ventilation plan and NIOSH is willing to work with MSHA in developing guidelines for the additional monitoring requirements.

3) It would be helpful if MSHA clarified allowable and expected changes of the testing and approval process as a result of the rulemaking.

While accepting VCSs is a start, some requirements of the MSHA approval process may still constitute barriers to implementing technologies. While MSHA must approve equipment, the mining community has expressed a strong preference for MSHA to accept testing and certification of equipment by Nationally Recognized Test Laboratories (NRTLs) as the basis for the approval. This might allow MSHA to assist and audit the NRTLs; facilitating oversight of the testing and certification of mining equipment. Additionally, MSHA could audit manufacturing and distribution to ensure compliance with the approved designs and verify authenticity of products. Enhanced oversight could improve the safety integrity of the manufacturing and deployment process of explosion protected equipment [ANSI 2015; Calder 2014].

In the draft RAND taxonomy, it is noted that manufacturers cite as a specific barrier their reluctance to provide their proprietary information to MSHA for certification. That barrier might be reduced or eliminated by adopting parts of the OSHA NRTL approach. Manufacturers routinely provide their proprietary information to NRTLs as the manufacturers have a much clearer understanding of how those labs treat proprietary information and much better legal options for protecting the information than they have with a Government entity (Calder, 2014). Another barrier identified in the draft Rand taxonomy that might be alleviated is the inconsistency between reviewers of the applications submitted for approval. If MSHA were to provide oversight and auditing of laboratory facilities and personnel, they could include measures within their NRTL requirements such as the IEC requirements for Certification of Personnel Competencies (CoPC). (IEC, 2017)

4) NIOSH suggests that MSHA consider accepting either the VCS or the current MSHA criteria for five years or more for new applications and indefinitely for modifications.

The one-year transition period to mandatory use of VCS may be problematic for some manufacturers. The proposed rule states that a modification can use either the existing MSHA regulation or the VCS without a time limit; it appears that the determination of a modification as opposed to a new submittal is based on the application status. In particular, businesses involved in rebuilding and overhauling equipment could be negatively impacted. Our understanding of the proposed rule is that if a third-party equipment rebuilder overhauls and updates a piece of mining machinery they must receive new MSHA approval. It is unclear if this is considered a new

application or a modification. If it is considered a new application, the manufacturer may have to modify components to meet the VCS requirements which would make the work either cost or logistically prohibitive. Another potential issue arises when a small company needs to make extensive changes to a product due to component obsolescence. If the changes are extensive, they may prefer to submit a new design. If the manufacturer already understands and builds their equipment to the existing MSHA requirements , they may not have the resources or the willingness to transition their product engineering to the VCS and potentially redesign their product for such limited applications.

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Appendix 1

Additional supporting information regarding NIOSH research supporting IEC and ANSI/UL 60079 standards:

The proposed rule cites the IEC and ANSI/UL 60079-28 ed 2 standards which specify requirements for equipment emitting optical radiation intended for use in explosive atmospheres. These standards reference NIOSH studies that characterize optical ignition mechanisms. Dubaniewicz (2006a, 2006b) and Dubaniewicz, Cashdollar, Green and Chaiken (2000) observed that threshold igniting optical powers for several straight chain hydrocarbon-air mixtures (including methane, propane, and butane) were approximately proportional to beam diameter for beam diameters ranging from 0.1 to 2 mm. Optical igniting powers were lowest for small beam diameters and optical igniting power densities were lowest for the largest beam diameters studied. Igniting powers tended to level off for beam diameters < 100 μm. Threshold ignition delays for these hydrocarbons were approximately proportional to the inverse square of the igniting power using targets attached to optical fibers. These findings support optical power and power density limits and beam shutoff provisions within the IEC and ANSI/UL 60079-28 ed 2 standards.

The proposed rule cites the IEC and ANSI/UL 60079–0 Ed. 7 standards which provide the general requirements for the construction, testing, and marking of electrical equipment intended for use in explosive atmospheres. These general requirements apply to all of the standards in the 60079 series unless modified by any particular standard. The IEC and ANSI/UL 60079–0 Ed. 7 standards reference NIOSH studies that characterize lithium and lithium-ion battery thermal runaway ignition mechanisms. Dubaniewicz and DuCarme (2013, 2014, 2016) observed methane-air mixtures ignited by certain lithium and lithium-ion batteries when the batteries were subjected to internal short circuit that produced battery thermal runaway. They also observed that pressures generated by lithium-ion battery thermal runaway may exceed pressure containment specifications for flameproof enclosures. Recommendations from the studies are noted in the IEC and ANSI/UL 60079–0 Ed. 7 standards, and NIOSH researchers continue to work with the IEC Technical Committee 31 to develop equipment specifications to prevent explosive atmosphere ignition by lithium and lithium-ion batteries.

References

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Appendix 2

Draft RAND Barrier Taxonomy

Draft Taxonomy of Barriers to the Commercialization and Adoption of New Technologies in the U.S. Underground Coal Mining Industry

Draft barriers were identified in 73 anonymous interviews conducted by the RAND Corporation in 2020 with representatives of stakeholder organizations in the underground coal mining industry, including technology suppliers; mining companies; mine engineering, design, construction, and consulting firms; researchers; professional associations; legal firms; labor organizations; regulatory agencies; and standards development and testing organizations. Barriers are divided into classes and groups for convenience; there is no significance to the order in which barriers are listed. This draft taxonomy does not reflect a consensus; some barriers were mentioned in more interviews than others. Draft barriers are presented as characterized by interview participants and have not necessarily been verified with other sources. This draft taxonomy reflects a work in progress, has not been peer-reviewed, and is subject to change.

Barrier Class	Barrier Group	Barrier
Cultural	Risk Aversion	Mine operators are risk averse and resist change
Economic	Insufficient Demand	Small U.S. market makes it difficult for suppliers to recoup investments in new technology
Economic	Insufficient Demand	Shrinking market leads to incumbent dominance
Economic	Insufficient Demand	Mine operators lack funds to invest in new technology
Economic	Insufficient Demand	Worker safety not an important driver beyond regulatory requirements
Economic	Insufficient Supply	Technology developers lack resources to commercialize
Economic	Specialized market	Harsh physical environment in mines dissuades potential developers
Legal	Liability	Greater liability risk in U.S. compared to other countries acts as disincentive to enter market
Regulatory	MHSA Approval Cost	Technology approval is disproportionately expensive for smaller companies
Regulatory	MSHA Approval Duration	Technology approval takes much longer than in other countries
Regulatory	MSHA Approval Duration	Poor coordination between MSHA & NIOSH
Regulatory	MSHA Approval Duration	Reapproval of technology is required for small design or part changes
Regulatory	MSHA Approval Duration	Technology approval applications are sent to end of queue when discrepancies are found
Regulatory	MSHA Approval Duration	Lack of transparency about technology approval application status
Regulatory	MSHA Practices	MSHA is conservative and risk averse

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Regulatory	MSHA Practices	MSHA-industry relationship is adversarial
Regulatory	MSHA Practices	New inspector (e.g., for a RAMP application) can overturn prior approvals
Regulatory	MSHA Practices	Going beyond regulatory requirements opens mine operators to citation for failure of non-required features
Regulatory	MSHA Practices	Inconsistent application of standards among applicants
Regulatory	Currency of MSHA Regulations	MSHA standards are embedded in regulations, so difficult to change
Regulatory	Currency of MSHA Regulations	Standards often require obsolete features and capabilities
Regulatory	Currency of MSHA Regulations	MSHA regulatory environment is unequipped to address new technology
Regulatory	Performance vs Prescriptive MSHA Standards	Prescriptiveness creates disincentive for new technology that may improve safety and health but not get "counted" under current standards
Regulatory	Performance vs Prescriptive MSHA Standards	Prescriptiveness crowds out novel approaches- regulations may be too specific to the incumbent technology, dissuading new entrants
Regulatory	Performance vs Prescriptive MSHA Standards	Sometimes suppliers must create separate versions of technology for the U.S. underground coal mining market
Regulatory	Performance vs Prescriptive MSHA Standards	MSHA won't accept voluntary consensus standards, despite having the flexibility to do so
Regulatory	Performance vs Prescriptive MSHA Standards	MSHA approval requires revealing proprietary information; some firms won't participate for that reason
Regulatory	Operator Burden	The regulatory burden of operating some approved technologies dissuades operators from using them
Regulatory	Operator Burden	Going beyond regulations opens mine operators to citations for violations that may not have been discovered without non-required features
Federal Support	Technical Support	MSHA and NIOSH both focus on safety and health only; no agency is addressing overall mining technology needs

MSHA = Mine Safety and health Administration, NIOSH = National Institute for Occupational Safety and Health, RAMP = Revised Approval Modification Program

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Appendix 3

Background of recommendation for use of Mb equipment:

The most fundamental difference between U.S. mining machinery and machinery made in other countries is the MSHA requirement for the use of XP (Explosion Proof) enclosures built to unique U.S. requirements as compared with "flameproof" enclosures built to international standards. These types of enclosures are used for electrical motors and other higher-powered equipment [Groh 2004a].

Internationally, flameproof enclosures are considered as a Mb explosion protection level suitable for Zone 1 areas (explosive atmosphere likely to occur in normal operation occasionally). Active mining operations are considered Zone 1 areas and therefore Mb is applicable to active mining areas. Internationally, the combination of auto shutoff and Zone 1 techniques such as flameproof enclosures are considered in the determination of the Mb EPL (IEC 60079-0 Part 0: Equipment - General requirements) (IEC 60079-33 "s" Part 33: Equipment protection by special protection 's'). Both machine-mounted and external methane monitors located elsewhere in the mine integrated with the auto shutoff are considered in evaluating the Mb EPL. Similarly, combinations of Zone 1 techniques can be used to provide the higher level of protection Ma, formerly called M1, which is suitable for Zone 0 applications [Groh 2004b]. Internationally, the EPL considers all protection mechanisms as they apply to the explosion risk, including machine mounted and in-mine engineering controls, which is appropriate from a safety engineering perspective [Mageson 1998a].

In the U.S., MSHA XP enclosures are used instead of flameproof enclosures, which are very similar, but slightly more conservative than the standards used for flameproof enclosures. Active methane monitoring and auto shutoff is also required with the use of XP boxes as used on machines used to "extract or load coal within the working place" [30 CFR 75.342]. However, only machine mounted active methane monitoring is considered in the approval of U.S. mining equipment. There is no requirement and no consideration of auto shutoff based on methane monitors elsewhere in the mine. The lack of consideration of in-mine explosion protection controls in the approval of explosion protected equipment is a fundamental difference in U.S. versus international practices [30 CFR 27, 1987].

There is a lot of confusion relative to the appropriateness of either MSHA XP or flameproof enclosures for Zone 0 environments. Most explosion protection experts, as reflected in IEC standards, do not consider the enclosure technique appropriate for Zone 0 (an environment where the atmosphere is continually or frequently explosive). Either enclosure is designed to allow the explosion to occur inside of the enclosure while quenching the flames to the external environment. One rationale for not accepting such enclosures alone is that, in a true Zone 0 environment, if the equipment is energized explosions may occur frequently inside the enclosure, eventually leading to failure of the equipment and enclosure [Bottrill G et al. 2005].

Due to a comparison of flameproof versus MSHA XP [NIOSH 2020], combined with the issue of MSHA regulations and the allowance of a two-tiered Division system in the National Electric Code (NEC) versus a three-zone categorization, a mistaken belief has arisen by some stakeholders that

MSHA XP requirements are so much more conservative than flameproof enclosures that MSHA XP is suitable for Zone 0 and flameproof enclosures are not. As stated in the previous paragraph, the opinion of experts is that neither enclosure would be acceptable, as the technique alone is not suitable for a true Zone 0 environment. The reality is the active mining section, which includes a functioning ventilation system, is more appropriately considered a Zone 1 environment [Magison 1998b]. The international community has recognized this by designating the Mb, formerly called M2, level of protection as appropriate for the active mining environment [Groh 2004c].

In the IEC and ANSI standards cited, Equipment Protection Level (EPL) Mb applies to electric motor-driven equipment and accessories. EPL Mb is defined in UL 600790-0 as equipment for installation in a mine susceptible to firedamp, having a "high" Level of Protection, which has sufficient security that it is unlikely to become a source of ignition in normal operation or during expected malfunctions in the time span between there being an outbreak of gas and the equipment being deenergized. The intent to deenergize equipment designed to EPL Mb appears to be consistent with 30 CFR 75.342 “Methane monitors” requirements to deenergize mechanized equipment used to extract or load coal within the working place when excessive methane levels are detected or when the methane monitor malfunctions.

NIOSH researchers support the international practice of using equipment approved to the Mb EPL, and appropriate inclusion of methane monitors and auto cutoff external to machine, which can provide a level of protection for the miner better than the current U.S. regulations and practices. Specifically, by adding upstream and/or downstream methane monitors, combined with flameproof enclosures and current practices, it can readily be determined that such an approach would provide a better level of protection afforded the miners than the current MSHA requirements. To do so, would require a systems level analysis approach and MSHA would have to recognize mine specific factors and in-mine engineering controls, such as methane monitors with integrated shutoff in the approval process. NIOSH suggests that these additional controls should be identified in the mine ventilation and electrical plan, and that guidelines should be established for implementation. However, there is no doubt that allowing flameproof enclosures with an additional methane monitor/shut off would yield a higher overall level of protection for the miner, as this can be substantiated through accepted engineering principles applicable to multiple independent protection layers and integrated auto shutoff [Magison 1998b; Sammarco 2002].

Another basis for the NIOSH recommendation to accept Mb equipment protection level is that equipment manufacturers individually or collectively may decide not to build equipment approved for the U.S. market. The number of active underground gassy mines has decreased substantially over the last ten years and is not likely to recover to prior levels. As identified in the RAND barrier taxonomy, equipment manufacturers have little incentive to build U.S. specific mining equipment given the potential market size. Reduction in the number of manufacturers for U.S. specific equipment could lead to higher equipment prices for whatever remaining equipment is manufactured, the increased use of re-built equipment with potentially inferior capabilities or lagging technologies, and the inability to deploy new technologies in U.S. mines. This would negatively affect the industry’s ability to keep the U.S. miners employed as well as their ability to improve safety and health.

References

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