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Response to MSHA re proximity detection systems

1. Please provide information on the most effective protection to miners that you believe proximity detection systems could provide, e.g., warning, stopping the equipment, or other protection. Include your rationale.

Vehicle to vehicle (V2V) or vehicle to person (V2P) interaction in both opencut and underground mines is currently seen as one of the largest safety risks in the Australian mining industry. While proximity detection is at best an engineering control (in the hierarchy of controls ranging from elimination to personal protective equipment) the Queensland Government strongly supports development and implementation of these systems across the mining sector. Analysis of Australian accident has shown that appropriate proximity detection systems would most likely have eliminated most of the collision accident events.

Systems should be both vehicle mounted and personnel-based and include a range of escalating alerts depending on the proximity to a hazard/likelihood of collision.

Systems should also consider the possibility of equipment shutdown.

Overall 'system' design (the safety and health management system that supports proximity detection) MUST also include other non-proximity detection technology and solutions (ie traditional approaches) such as signeage, visual alerts, hard barriers (eg haulroad separation), and strict training and refresher training regimes (to focus on the human element). The latter is particularly challenging given a range of human variability and human error issues.

Workplace design must actively consider effective controls to minimise V2V or V2P interaction through road layout, intersection design, gradients etc.. The design must be enabling.

Equipment designers, modifiers and maintainers must actively consider effective controls so achieve cabin and machine layout that eliminates proximity hazards.

Human unreliability – human error: Reliance on 'a human being doing the right thing' should be minimised in the above 'design' approaches, ie procedural controls ought to be minimised as the only control.

In our view it is important to have a mixture of the above to ensure some redundancy in the overall system, in case of 'failure' of one or more system components. The most suitable system for the mine should be established by risk assessment utilising a proper cross section of the workforce including a sufficient number of operators intimately familiar with the task.

It is equally important to scrutinise and test the actual control effectiveness of the system (in contrast to reliability) to ensure the chosen control will provide a sound defence against collision hazards.

Apart from mobile equipment interaction hazards, there may be scope to use proximity detection system in fixed plant applications to prevent operators/maintainers entering hazardous areas, or other areas of mine optimisation

Proximity detection technology should also consider functionalities that prevent operators from operating equipment they are not authorised for, log operator hours spent on equipment, measure operating efficiency etc. (see comments further on).

Note: Proximity detection system must be compared to electrical safety devices such as fuses or circuit breakers – they cannot and should never be solely relied on to provide safety when performing electrical work - such work should always be preceded by isolation of the energy source and testing.
Similarly proximity detection systems must not be seen as the only control against V2V or V2P incidents – they are there to stop interaction as a last resort.(like an electrical circuit breaker that trips the energy source if accidental contact is made.)
Having said that an effective proximity detection system must incorporate prox detection technology as relying on humans only (to do the right thing) has shown to be ineffective.

A lot of thought ought to be putt into creating the linkage between proximity detection and collision avoidance systems. OEMs do not like their equipment being interfered with by third party systems (for alleged reasons of warranty, safety etc.)

2. Other than electromagnetic field based systems, please address other methods for effectively achieving MSHA's goal for reducing pinning, crushing, and striking hazards in underground mines.

Other solutions could be radar, GPS (open cut), work environment design, rule based solutions (weak and human error prone).

On board camera systems are also available but should not be considered as primary collision avoidance system (cameras are glorified mirrors!)

3. In general, reliability is defined as the ability of a system to perform when needed. Please provide information on how to determine the reliability of a proximity detection system. The Agency would appreciate information that describes reliability testing, how reliability is measured, and supporting data.

There are several proven statistical techniques available to test electronic reliability of such units (refer to military standards on electronic systems).

Strong consideration also needs to be given to the reliability of software used in the these systems, and manmade and natural interference of the working environment.

Accidental and deliberate interference by the operator (eg to disable the system) also needs to be considered.

System operating performance must be logged and analysed, this in fact should be part of the system design and functionality.

4. Manufacturers should design their systems to be fail-safe. Please provide information on how miners would know when a proximity detection system is not working properly. Include suggestions for what works best, including your experience, if applicable.

System must provide a continuous self-check capability interlocked to machine controls ie if prox system not working properly – machine should not be operated.

5. Please describe procedures that might be appropriate for testing and evaluating whether a proximity detection system is functioning properly. Include details such as the frequency of tests and the qualifications of persons performing tests; include specific rationale for your suggestions.

All tests/verification tools/methods must refer back to the hazards identified in the risk assessment done.. Tests/verification tools must ensure the system (control) is effective and achieves the aim of reducing and controlling risk effectively.

New learnings from malfunctions, mishaps, incidents and accidents must be viewed in light of the risk assessment which therefore gives opportunity to review the effectiveness of the system.

Malfunctions of one system installation (on site, by manufacturer, within industry) should automatically trigger examination of all (local) proximity detection systems and components.

System self test – continuous while equipment is operating. Malfunction should alert operator, no override, strict protocols on fault response.

Basic test - minimum prestart check by operator at beginning of shift – operator responsible for his equipment, and immediate working environment. A clear response must be established and communicated e.g. if system not working, machine to be removed from service until problem rectified and machine recommissioned into service.

Checks by supervisors – to ensure systems are working and demonstrate safety leadership – various system checks and scenario based checks. Also supervisor to check if the system is used in the way it is intended to be used.

Regular system checks at set maintenance intervals, and after any equipment accidents/damage – to ensure integrity of system – must include all hardware as minimum. A minimum checklist to ensure full system integrity must be established, and kept up to date.

Management of change - the system must be checked each time there has been a modification to the equipment or working environment (e.g. a new two way radio is fitted to the machine – its effects on the prox system need to be established, change in geology etc.)

OEM checks – these ought to include checks on modifications of machine that may interfere with prox system.

Malfunctions must be logged and investigated and used as a key performance indicator (warning – just because the system does not malfunction occasionally does not mean it works properly).

Investigations into all near misses, incidents, accidents incl damage events, and malfunctions must be carried out to ensure ongoing functionality. Focus of these should be to verify (or otherwise) the control effectives of the system in use. (Note: the fact that an incident occurred indicates that the system is not effective!!!!)

Regular audits of proximity system usage, operator acceptance, improvement opportunities, innovations and developments of hard/software.

6. Some proximity detection systems provide a warning before the equipment shuts down. An excessive number of warnings can cause miners to become complacent and routinely ignore them as nuisance alarms. Please describe any experience you have had with nuisance alarms and how you addressed these alarms to assure an appropriate level of safety for miners. In addition, please provide suggestions for minimizing nuisance alarms.

Properly designed/engineered system should not cause too many (if any) nuisance alarms. It may also be worthwhile to look at the other sources/reasons of nuisance alarms on the equipment (not prox system related, eg high temp alarms etc.) and or behaviour of people that may cause nuisance alarms.

Equipment OEMs seem to have a real issue with their equipment being 'interfered' with (e.g. slowed, stopped or shut down) by a third party system. Sound risk assessments must be carried out before equipment shutdown should be considered. OEM issues need to be resolved ideally at the purchasing stage.

System must be tamperproof to ensure operators/maintainers do not disable the system. Disabling should only be allowable by an appointed person.

7. How should the size and shape of the area around equipment that a proximity detection system monitors be determined? What specific criteria should be used to identify this area, e.g., width of entry, seam height, section type, size of equipment, procedures for moving equipment, speed of equipment, and related information? Please provide any additional criteria that you believe would be useful in identifying the area to be protected.

Could/should be done using a risk assessment and consider speed at which system alerts operator, reaction time of operator and number of people in area. If system relies on operator to react to an alarm, area must be considerably larger to provide safety margin.

8. Proximity detection systems can be programmed and installed to provide different zones of protection depending on equipment function. For example, a proximity detection system could monitor a larger area around the RCCM when it is

being moved and a smaller area when the machine operator is performing a specific task, such as cutting and loading material. How should a proximity detection system be programmed and installed for each equipment function?

Suggest thorough risk assessment of all scenarios including those that have resulted in accidents locally/at other means to determine optimum system design. Critical issue is to establish and quantify the reliability and effectiveness of the control.

9. Since 1983, six fatalities occurred while miners performed maintenance on RCCMs. The fatalities involved three miners crushed in the machine and three miners pinned between the machine and mine wall or roof. Please provide specific information, including experience, on how a proximity detection system might be used to protect miners during maintenance activities and why the system would be effective in each situation.

Proximity devices should not be considered as an (energy) isolation device. Maintainers and operators must consider proper equipment isolation methods as main control and accidental 'powering up' while maintenance is performed.

10. Some proximity detection systems include an override function that allows the system to be temporarily deactivated. Please provide information on whether an override function is appropriate and, if so, please provide information on the circumstances under which such a function should be used. Please provide information on the types of procedures or safety precautions that could be used to prevent unauthorized deactivation of a proximity detection system.

System should only be overridden by an appointed person, exposure and risk to others must be considered.
<u>Change management</u> and control of new hazards and risk her is paramount. If this is not possible, it is suggested that system cannot be overridden.

11. MSHA found, in its field testing experience, that the use of some new technology for controlling motor speed, like variable frequency drives, could result in nuisance or false alarms (shutdowns) from the proximity detection system. Please provide information on other sources of interference, if any, that might affect the successful performance of proximity detection systems in underground mines. In addition, please provide information on whether a proximity detection system might adversely affect other electronic devices, such as atmospheric monitoring systems. used in underground mines. Please provide specific circumstances including: (1) Types of equipment; (2) adverse effect; and (3) how the adverse effect could be minimized.

Near misses, incidents and accidents have shown that any electronic devices are susceptible to interference from other electronic systems, or particular characteristics of the working environment. Programmable electronic systems must be designed accordingly considering the appropriate Safety Integrity Level (SIL) to provide a reliable system and effective method of control.

Application to RCCMs

MSHA's experience with proximity detection technology and proximity detection systems has focused on RCCMs. An RCCM often has auxiliary equipment, such as roof bolting machines and mobile bridge conveyors, attached to it. The interconnection of this equipment can introduce additional pinning, crushing, or striking hazards.

12. Commenters who have experience with RCCMs, please describe: (1) any experience with pinning, crushing, and striking hazards, including accidents and near misses; and (2) any unique experience with an RCCM with auxiliary equipment attached.

No comment.

13. How should the area that a proximity detection system monitors be determined on an RCCM interconnected with auxiliary equipment?

Could be achieved through risk assessment involving designers, management, supervision, safety professional and importantly coal mine workers with experience of RCCM and auxiliary equipment – Note: working practises will vary from mine to mine so one solution/system may not be applicable between mine!

Applications to Underground Equipment Other Than RCCMs

MSHA requests information on whether proximity detection technology might be applicable to reducing the risk of accidents involving other types of underground equipment.

14. Describe whether there are safety benefits from applying proximity detection systems to underground equipment other than RCCMs. Describe your experience with pinning, crushing, or striking accidents and near-misses involving other underground equipment. Please provide examples identifying the specific types of equipment involved and how proximity detection systems may help provide an additional margin of safety to miners. Also describe any experience you have with respect to obtaining MSHA or other agency approval for systems designed for underground equipment other than RCCMS.

Yes, there have been several UG pinning/crushing accidents in Australia involving non RCCM equipment e.g. shuttlecars, small front end loaders and the like.

15. How might a proximity detection system for remote controlled equipment be different than one for non-remote controlled equipment?

Proximity detection system for remote controlled equipment should have a higher integrity. Accidental interference with other remote controlled equipment must be considered and effectively controlled/eliminated.

16. Manufacturers are evaluating the use of proximity detection systems on multiple pieces of equipment that operate near each other, such as RCCMs and shuttle cars. In your experience, what are the safety considerations of coordinating proximity detection systems between various types of underground equipment?

Not sure if it matters if there are multiple machines in workplace, it is the one closest to the person that will cause the pinning/crushing accident. Therefore suggest a set of basic principles (~ 'no go 'red' zone approach') is agreed on eg persons presence within say 2m of machine will trigger machine alarm irrespective of which machine it is .

However interaction of one machine on the other machines must be established to check rigour and effectiveness of approach.

17. Describe your experience with the state-of-the-art of proximity warning technology. Include any experience related to whether the current technology is able to accurately locate and protect workers from all recognized hazards.

In Australia, the technology is readily available for open cut mines – Radar, RFID tags, GPS etc., and underground metalliferous mines. (Cameras are also used widely.)

Own personal experience with mining truck GPS systems suggests that technology is mature.

Stand alone camera systems should not be considered as proximity detection systems per se.

The issue remains with UG coal mines due to requirement for equipment to be intrinsically safe. A number of trials are being conducted here in Australia and results need to be reviewed before comment can be made.

Training

18. What knowledge or skills would be necessary for miners to safely operate equipment that uses a proximity detection system? What knowledge or skills would other miners working near the equipment need?

All mine personnel - managers, supervisors, operators, miners, maintenance personnel, trainers, contractors etc. need to be given a high level of awareness training that working in proximity of any machine can result in fatal outcomes irrespective of proximity detection 'system' provided.

Key to education is to highlight the <u>correct safe behaviours and actions</u> around such machine, and highlight the limitations of the proximity detection system.

The Training must stress that proximity detection systems are not a 'silver bullet' and should not be relied on as the only control against collision hazards

Management must ensure that their safety systems encourages and enables safe behaviours and action, including peer review of each others actions and behaviours.

19. Please provide suggestions on how to effectively train miners on the use and dangers of equipment that uses a proximity detection system. Please include information on the type of training (e.g., task training) that could be used and on any evaluations conducted on the effectiveness of outreach and/or training in the area of proximity detection (e.g., red zone warning materials). How often should miners receive such training?

Key to education is to highlight the <u>correct safe behaviours and actions</u> around such machine, and highlight the limitations of the system.
Management must ensure that their safety systems encourages and enables safe behaviours and actions.
Hands-on training in safe behaviours around machines should be done. Must highlight that proximity detection systems are not a 'silver bullet' and should not be relied on as the only control against collision hazards.
Previous accidents should be re-enacted (where safe to do so).
Refresher training at least 6 monthly.

Benefits and Costs

MSHA requests comment on the following questions concerning the costs, benefits, and the technological and economic feasibility of using proximity detection systems in underground mines. Benefits would include an increased margin of safety for miners working near machines equipped with proximity detection systems resulting in the reduction in pinning, crushing, and striking accidents. Your answers to these questions will help MSHA evaluate options and determine a course of action.

20. Please provide information on the benefits of using proximity detection systems with RCCMs. Please be specific in your response and, if appropriate, include the benefits of using proximity detection systems with other types of underground equipment. Include information on your experience related to whether proximity detection systems cause a change in the behavior of an RCCM operator. For example, would the operator need to operate the machine from a different location, such as one that might introduce additional hazards, to remain outside of a predefined danger zone? Please explain your answer in detail and provide examples as appropriate.

Suggest that proximity detection systems are not used to modify operating practises per se as they can never be totally relied on as a control. Instead it is suggested to modify practises/mine layout/design in such a way as if proximity detection system were not available.

21. Please provide information on the costs for installing, maintaining, and calibrating proximity detection systems on underground equipment. What are the feasibility issues, if any, related to retrofitting certain types of equipment with proximity detection systems?

Unable to comment. GPS systems for open cut operations can be fitted within a few hours.

22. What is the expected useful life of a proximity detection system? Please provide suggested criteria for servicing or replacing proximity detection systems, including rationale for your suggestions.

Unable to comment

23. Some proximity detection systems automatically record (data logging) information about the system and the equipment. Are there safety benefits to having a proximity detection system automatically record certain information? If so, please provide specific details on: (1) Safety benefits to be derived; (2) information that should be recorded; and (3) how information should be kept.

1. *Safety benefits could include:*
    a. *possible to verify if equipment operated in its safe operating envelope.*
    b. *Personnel and machinery location (personnel and machine tracking in case of mine emergency).*
    c. *System may be used to improve communications capabilities between operator and mine office/supervision.*
    d. *Operator education – what and where operation rules re exceeded.*
    e. *System could be used to monitor production and or maintenance status of machine.*
    f. *System should be able to read if operator is authorised to operate the equipment.*
    g. *Training enhancements possible based on personal record – i.e. where/how is the equipment operated outside normal parameters.*
    h. *Operating parameters may be used to later automate certain parts of the activity.*
    i. *System may permit equipment use in low visibility situations eg mine emergency – rather than walking out and getting lost on foot, system may be adaptable to a safe drive-out option.*
    j. *Info can be used to optimise haulage circuit and check likely collision scenarios and locations in advance.*
2. *Info to record –*
    a. *exceedances of operating envelope,*
    b. *proximity occurrences – mishaps, incidents & accidents, equipments failures (hardware and softweare)*
    c. *and locations & times, cycle times, speeds productivity info*
    d. *which persons are involved (to get a personal profile on good operators and not so good operators.)*
3. *How info should be kept:*
    a. *Should be able to provide say a month of data to enable retrospective analysis.*
    b. *Would be nice if data could feed into mine and production design software*
    c. *Direct feed into maintenance planning and analysis software would be great.*

24. Please provide information on whether small mines or mines with special mining conditions, such as low seam or mine entry height, have particular needs

related to the use of proximity detection systems. Please be specific and include information on possible alternatives.

Unable to comment, but all remarks provided here by others should also be used/considered for mines with normal working conditions as there may be some overlap/relevance.

25. What factors (e.g., cost, nuisance alarms) have impeded the mining industry from voluntarily installing proximity detection systems on mining equipment?

The unavailability of UG coal proximity detection systems has prevented industry from adopting them here in Australia so far. A modest take up is evident in OC and UG metalliferous mines.

Limited history, misperception that 'a proximity incident could not happen at this site', unfamiliarity, resistance by workers, supervisor and management, initial and ongoing cost and limited range of suppliers (support and spares) may also be an issue.

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