

Surface Mobile Equipment Safety Program

Mobile Equipment Technology Resources

The Surface Mobile Equipment Safety Program Rule requires mine operators to identify currently available and newly emerging feasible technologies that can enhance safety at the mine and evaluate whether to adopt them.

There are numerous ways that mine operators can achieve and demonstrate compliance with this portion of the rule. Included are:

- Participating in industry, NIOSH or MSHA meetings on emerging technologies.
- Attending mine safety and health conferences or other events that include vendor exhibits and equipment demonstrations.
- Requesting, researching, and reviewing vendor materials or sales quotations.
- Interviewing engineers or viewing equipment demonstrations.
- Testing technologies on mine property to determine their effectiveness in improving safety.

MSHA provides the following list of example resources to help mine operators identify mobile equipment technology that potentially may be applicable and feasible at their mine. This list is not all-inclusive and is for informational purposes. MSHA does not endorse any of the products, suppliers, or manufacturers listed.

Collision Avoidance

- Global Navigation Satellite Systems (GNSS)
 - Global Positioning Systems (GPS-US), Galileo – European Union
 - Tracks equipment in relation to one another
 - “Geo-fence” areas to restrict equipment and set boundaries
- RADAR, LIDAR, Ultrasound, or Infrared
 - Detects other equipment, objects, or pedestrians using time of flight measurements.
- Electromagnetic or Radio Frequency Identification (RFID)
 - Detects sensors mounted on other equipment, objects, or pedestrians.

- Cameras
 - Rear-facing
 - Forward-facing
 - 360-degree multiple view stitching
 - Object detection
- Geofencing - electromagnetics (EM), RFID, GPS and bi-directional radar recognize vehicles or personnel. GPS receivers permits surface tracking and setting defined no-go perimeters around potential danger zones.
- [Geofencing: a key tool in zero-harm objectives](#), Connectivity, 2020.
- [How Geofencing Is Shaping the World Around You](#), Toward Data Science
- [Collision Avoidance and Collision Warning Systems](#) - MSHA Technical Support slide presentation, 2019
- [Proximity Detection and Collision Avoidance and Collision Warning Systems](#) - includes links to 16 manufacturer websites for collision avoidance/warning equipment for surface mining vehicles - MSHA Safety Information post
- [Proximity Detection - Surface and Underground Mining](#) - NIOSH Mining Program, 2015
- [Validating Collision Warning/Avoidance System Detection Performance](#) - NIOSH slide presentation, 2021
- [Validating Collision Warning and Avoidance System Detection Performance for Surface Mining Haul Trucks](#) - NIOSH Mining Program, 2023
- [Recommendations for Evaluating & Implementing Proximity Warning Systems on Surface Mining Equipment](#) - NIOSH Mining Program, 2012
- [Recent Advancement in Collision Avoidance Systems in Mining](#) - AZO editorial, 2022
- [Lidar, radar and camera technologies](#), Fleet Equipment, 2023

Equipment Visibility

- [Construction Equipment Visibility](#) - NIOSH blog 2022
- [Visibility Diagrams](#) for 13 categories and 43 specific types of equipment - NIOSH information posting 2022

Autonomous, Semi-autonomous and Remote-controlled Equipment

- Haul trucks, loaders, drills, dozers, etc.

Dozers – surge piles and spoil piles

- High strength glass and SCSR
- Remote stop for feeder
- Autonomous, semi-autonomous and remote-controlled dozers

Small Unmanned Aerial Systems (sUAS – Drones)

- Picture and video for examinations of difficult or hazardous locations
- Measuring - Photogrammetry and LiDAR
- Highwall and dump point monitoring
- Roadway condition and berm monitoring

Fleet Management Systems and Software

- Asset location tracking
- Scheduling and route planning to minimize collision potential
- Integrated Collision Warning
- Integrated Driver Fatigue monitoring
- Enforce maintenance schedules – predictive maintenance
- Monitor speed, payload

Virtual Reality Training

- Mobile equipment blind spot VR training – Gillette College, Wyoming, State Grant Program, <https://gillettecollege.org/academics/mshatraining/>
- Light Duty pickup pre-operation inspection VR training - Gillette College, Wyoming, State Grant Program, <https://gillettecollege.org/academics/mshatraining/>
- Machine-specific controls training
- Task training

Fatigue Detection Technology

- Basic principles: 1) Dashboard-mounted camera monitors and software analyzes driver facial features (e.g. expression, yawns), eyelid position, pupil brightness and dilation, head pose, gaze direction; 2) Doppler radar measures and software analyzes driver's eyelid position, heartbeat, respiration and pulse rate; 3) measurement of steering wheel movement - precision and amplitude
- [Fatigue Monitoring and Detection Technology](#) – NIOSH science blog, 2021
- [The Who, What, How and When of Implementing Fatigue Monitoring and Detection Technologies](#) - NIOSH science blog, 2021

- [Setting Objectives for Fatigue Detection Technology](#) - NIOSH science blog, 2022
- [How to Choose the Right Fatigue Detection Technology for Your Workplace](#) - NIOSH poster, 2022

Advanced Seating and Seatbelt Systems

- Machine Interlocks
- Rollover and impact detection
- Seat mounted airbags
- Automatic seat height drop and belt tensioning
- Seat belt monitoring
 - [Seat Belt Use in Mobile Equipment](#) - MSHA Safety Alert
 - Numerous firms market a variety of seat belt monitoring and reporting systems. Mines can search the internet for themselves.

Predictive Maintenance

- [A guide to predictive maintenance for the smart mine](#), Mining.com, 2020
- [Predictive Maintenance in the Mining Industry](#), Soofastaei Publications, via LinkedIn, 2022
- [The benefits of predictive maintenance in the mining and minerals industry](#), WorldRef, via LinkedIn, 2023
- [Predictive Maintenance](#), an overview by Rockwell Automation
- [Predictive Maintenance \(PdM\)](#), an overview by Rockwell Automation

Fire Protection Systems

- Electrical monitoring and activation
- Wet systems and water mist (Petitions required for diesels though)

Wearable Technology

- Smart beacon systems with Bluetooth sensors record data wirelessly based on proximity. They consist of a radio, processor and battery and continuously transmit Bluetooth low-energy signals. These sensors can track miners entering and exiting mines at a set location in real time. From [Geofencing: a key tool in zero-harm objectives](#), Connectivity, 2020

Lighting and Illumination

- LED equipment lights and light towers
- Brighter and more extensive work area and dump point illumination

Disclaimers

MSHA is providing best practices, methods, lists of equipment, templates and example programs as guidance to assist operators in developing and updating a surface mobile equipment safety program. This guidance is not all inclusive and is for informational purposes. Because each mine has unique conditions and features, each operator is responsible for tailoring its surface mobile equipment safety program to meet its individual mine's needs. (30 U.S.C. § 952(b))

As part of the agency's cooperative programs with its Alliance partners, State grantees, and others, MSHA is providing mining industry-developed templates as guidance in developing and updating your mine-specific surface mobile equipment safety program. (30 U.S.C. §§ 952(b), 962)

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