1.0 PURPOSE

1.1. Many types of heavy equipment are engaged in construction projects. All have the ability to cause serious injury or property damage when they come into contact with people or objects in Areas of Risk (AOR). Using best efforts for heavy equipment to be fitted with Maneuvering Risk Mitigation Measures (MRMM) specified in this Safe Work Guideline, is an attempt to minimize these types of incidents and provide guidance on minimum requirements for these systems.

1.2. This Safe Work Guideline defines the expectations for and how to equip, utilize, and maintain proximity sensors and camera monitor systems on heavy equipment used at project worksites.

1.3. The guidelines in this document are not meant to supersede or replace regulatory requirements, nor are they intended to be all-inclusive of the applicable regulatory, site-specific hazard assessments/safety plans or company requirements. Rather, they are intended to be supportive and complimentary to such requirements.

2.0 DEFINITIONS

2.1. **Area(s) of Risk (AOR)** – An area of obstructed view that would be part of the heavy equipment's direction of movement, where a person or object cannot be seen by the heavy equipment operator in the normal operating position, either by direct line-of-sight or indirectly, using mirrors.

2.2. **Blind spots** – An area of the equipment an operator cannot see.

2.3. **Camera monitor system** - Includes a monitor and camera(s) to provide the operator with a clear view of a defined area.

2.4. **Critical work** – work required to be performed as soon as reasonably practicable to prevent harm to people, property damage or an environmental impact and will add more risk to people, property or the environment if not completed

2.5. **Emergency work** – work required to be performed immediately to provide medical care, rescue, fire suppression or environmental mitigation, to prevent further harm to people, property damage or an environmental impact.

2.6. **False alarm** – A warning signal due to the detection of anything other than a person or object in the AOR.

2.7. **Longer duration** – a period from months to years

2.8. **Maneuvering Risk Mitigation Measures (MRMM)** – Systems or products specified for installation on heavy equipment to reduce a defined risk. For the purpose of this guideline these systems should include proximity sensors and camera monitor systems.

2.9. **Hazard zone** – See Area(s) of Risk.

2.10. **Heavy equipment** – Includes but not limited to the following: dozers, excavators, side booms (pipelayers), skid steers, rock trucks, loaders, tele-handler forklifts, graders, compacting equipment, piling equipment, tractors, and cranes.

2.11. **Identify** – Being able to distinguish a shape on the screen as that of a person. It is part of the sequence: detection, identification, and recognition.

2.12. **Proximity sensor system** – A transmitter and receiving system which detects a person or object in an AOR and alerts the heavy equipment operator by an audio signal and visual display of the approximate distance of the person from the heavy equipment.

2.13. **Reasonable time period** – a period of days to weeks.

3.0 RESPONSIBILITIES

3.1. Project Owner *(Includes, as appropriate, Pipeline Owner/Operator, EPC Prime Contractor, etc.)*

3.1.1. Serves as the custodian of the Safe Work Guidelines for Heavy Equipment Equipped with Proximity Sensors and Camera Monitor Systems and works with stakeholders to ensure these safe work guidelines continue to meet business needs.

3.1.2. Provides support and guidance to the construction management team in the implementation of the MRMM on heavy equipment, as specified in this Safe Work Guideline.

3.1.3. Recommends changes to this Safe Work Guideline, based on industry best practice and industry trends.

3.1.4. Provides feedback and recommendations on the effectiveness of this Safe Work Guideline.

3.1.5. Regularly audit active projects to ensure the guideline contents are readily available, known, understood, and consistently applied.

3.1.6. Endorses the use of heavy equipment equipped with MRMM on projects in accordance with this Safe Work Guideline.

3.1.7. Ensures that the Safe Work Guideline is communicated to contractors during the bidding process and/or Construction Management Team.

3.1.8. Suggests heavy equipment equipped with MRMM is used on project work sites.

3.1.9. Conducts site inspections and includes MRMM in the inspection when applicable.

3.2. Construction Management Team *(Includes all construction-related personnel with a supervisory and/or oversight role, however named.)*

3.2.1. Will use best efforts to have heavy equipment equipped with MRMM meeting the specifications in this Safe Work Guideline operating on work sites.

3.2.2. Ensures workers are trained in the use and maintenance of MRMM fitted to heavy equipment if used on the project.

3.2.3. Ensures all personnel who work with heavy equipment are educated on the purpose, benefits, and limitations of the systems. e.g., operators, service technicians, spotters, etc.

3.2.4. Ensures incidents are investigated when there is evidence of intentional disabling or tampering, making the MRMM inoperable or function differently than intended by the manufacturer, and would have or did place a worker, property, or the environment in harm's way. In such cases, disciplinary action, up to and including removal from the project worksite may occur for performance issues.

4.0 SUGGESTED PERFORMANCE REQUIREMENTS

4.1. Camera Monitor System

4.1.1. To let heavy equipment operators have a clear image of a person or object in the AOR.

4.1.2. The image of a person or object in the AOR must be rapidly identifiable.

4.1.3. The system must reliably perform in adverse climatic and weather conditions.

4.2. Proximity Sensors

4.2.1. To detect and alert the heavy equipment operator of a person or object in the AOR.

4.2.2. Person detection must be reliable and uniform throughout the AOR.

4.2.3. False alarms must be minimized by careful programming to ensure the false alarm rate is as low as achievable.

4.2.4. The system must reliably perform in adverse climatic & weather conditions.

5.0 SUGGESTED MINIMUM SPECIFICATIONS

5.1. Monitor

Panel Size	Sufficient size for equipment operator to easily identify persons or objects.
Resolution	800 x 480 to provide sufficient detail for visual detection
Contrast Ratio	500:1 to ensure a good image in bright light.
Viewing Angle	Side 70° x Top 50° x Bottom 70° to allow the operator to see a clear image even when the monitor is adjusted to avoid bright reflections.
Brightness	Open cab: 500 cd/m2 Closed cab: 400 cd/m2
Operating temperature range	Open cab: - 40 to + 70°C Enclosed cab: - 20 to + 70°C
IP rating	Open cab: monitor & connectors IP69K (Waterproof) Enclosed cab: IP30
Mechanical Vibration	Non-suspension or tracked: 10 G Suspension: 4 G
Electromagnetic compatibility	ISO 13766:2006 - Earth-moving machinery -- Electromagnetic compatibility
	ISO - 16750 1,2,3,4,5 (Climatic Loads) Road vehicles — Environmental conditions and testing for electrical and electronic equipment
EMI & RF signal levels	ANSI C63.4 - American National Standard for Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz FCC 47 CFR Part 15 Subpart B - Unintentional Radiators

5.2. Camera

Visual Resolution	420 TV Lines
Illuminating Distance	5 meters
Mechanical Shock	50 G
Mechanical Vibration	10 G in all 3 axis's, minimum 24 hours
Camera IP Rating	IP69K
Connector IP Rating	IP67
Operating Temperature:	-40° to +70°C

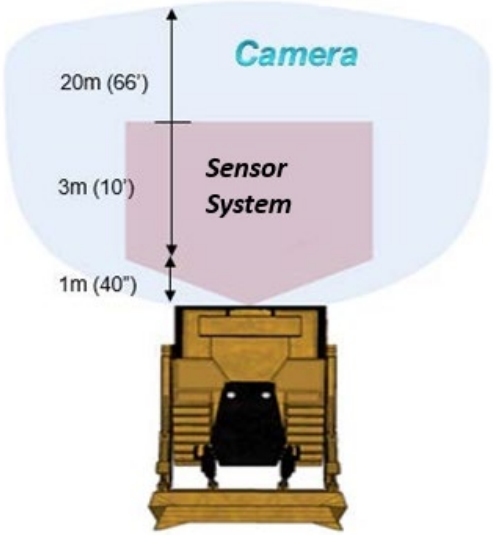
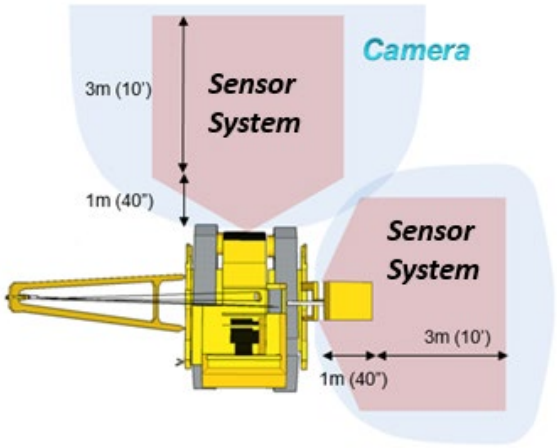
5.3. Proximity Sensor

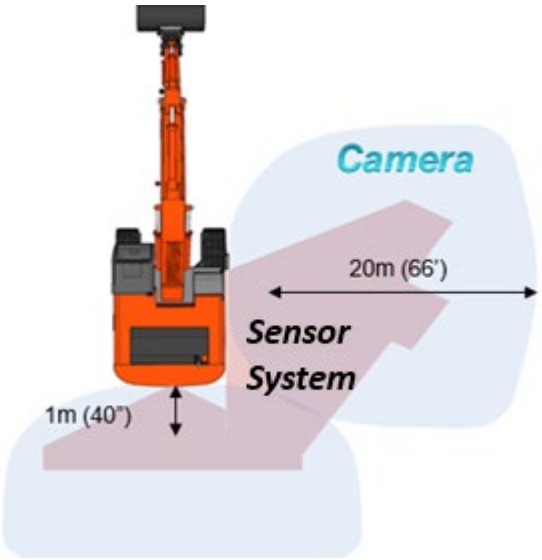
Programmable	Adjustable detection zones with independent width and distance detection zones Configurable to ignore detections from heavy equipment parts and shape detection area
Operating conditions	Maintains operational performance when covered in at least 0.5 cm of snow, ice, or mud
Operating temperature	-40 to + 80° C
Mechanical vibration	8G
Mechanical shock	4 G in all 3 axis's, min 24 hours
Radio frequency devices	FCC 47 CFR Part 15 Subpart B & C Unintentional & Intentional Radiators
Electromagnetic compatibility	ISO 13766:2006 - Earth-moving machinery -- Electromagnetic compatibility

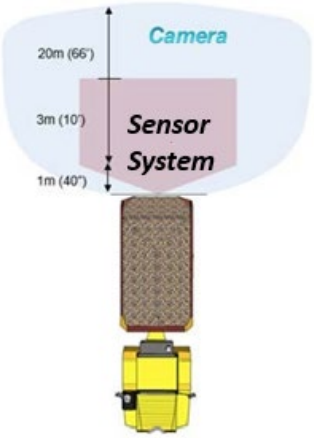
5.4. Proximity Sensor Operator Display

Audio alarm	Buzzer must remain loud enough to alert the operator regardless of the noise created by the equipment or other sources on the work site.
Display zone light brightness	> 300 cd/m2 but not so bright as to be a distraction or cause night blindness
External feed trigger	Programmable detection with programmable trigger distance
Reaction time	< 0.5 seconds (500 milliseconds)
Operating temperature	-20 to + 70°C
Self-diagnostic function	Indicator to alert when system is not working correctly

5.5. Camera & Detection on Typical Construction Equipment

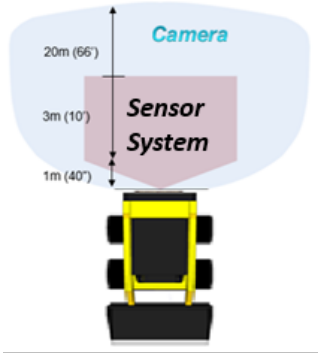
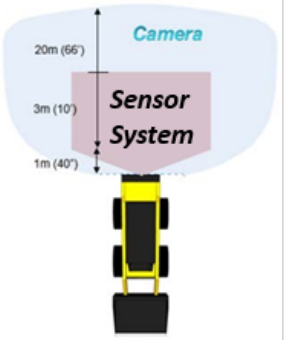
Dozers	
A proximity sensor system capable of detecting a person or object within 1m (~3') of the rear of the dozer to a point at least 3m (~10') out from the rear of the dozer.	
A camera and monitor system to view the AOR as a whole at ground level from the foreground field of view immediately to the rear of the dozer to a point at least 20m (~66') to the rear.	
Side booms	
Two (2) heated camera systems, Two (2) programmable detection systems and one (one) 1-monitor:	
Cameras: One (1) forward facing and one (1) on the counterweight side of the heavy equipment.	
Monitor: The monitor and detection display positioned in clear view of the operator and forward of the operator's normal head position. Sunshades must be installed to prevent direct sunlight on to the monitor screen spoiling clear vision of monitor display.	
Proximity Sensor System: Forward facing; capable of detecting a person or object to the front of the sideboom from a point within 1m to a point at least 3m (10') to the heavy equipment front.	

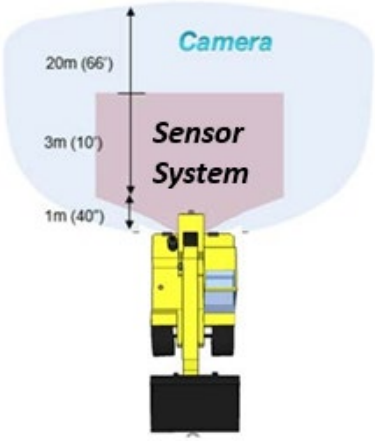
Side facing; A programmable system capable of detecting a person within the whole of the blind area to the side of the side boom from a point within 1m (40”) to a point at least 3m (10’) to the side.	
Excavators	
2 -heated camera systems, 2-programmable detection systems	
1- camera and detection combination rear facing system and 1-facingto the right side of the heavy equipment.	
Monitor (1): The monitor and detection display positioned in clear view of the operator and forward of the operator’s normal head position. Both camera views and detection areas must overlap to the rear right of the heavy equipment.	

Rock Trucks	
One (1) heated camera system, one (1) programmable detection system both rear facing. The monitor and detection display positioned in clear view of the operator and forward of the operator's normal head position. Sunshades must be installed when this factor prevents clear vision of monitor display.	

6.0 INSTALLATION

6.1. Monitor position

Skid steers	
One (1) heated camera system, one (1) programmable detection system both rear facing.	
The monitor and detection display positioned in clear view of the operator and forward of the operator's normal head position.	
Loaders	
One (1) heated camera system, one (1) programmable detection system both rear facing.	
The monitor and detection display positioned in clear view of the operator and forward of the operator's normal head position.	

Telehandler/RT Fork Truck .	
One (1) heated camera system, one (1) programmable detection system both rear facing.	
The monitor and detection display positioned in clear view of the operator and forward of the operator's normal head position. Sunshades must be installed when this factor prevents clear vision of monitor display.	

6.1.1. Ergonomically for easy viewing during normal operation forward of the operator's normal head position.

6.1.2. A heavy equipment operator requiring glasses must be able to clearly identify a person or object displayed on the monitor. Ideally the monitor should be positioned below the operator's head providing for the near/far accommodation of operators with multi-focal glasses.

6.2. Camera position

6.2.1. As high as practicably possible, with the adjacent lower heavy equipment edge being displayed in the bottom of the monitor screen, providing a distance reference.

6.2.2. Ideally centrally located along the side on which positioned.

6.3. Detection receiver (Radar head)

6.3.1. Needs to be able to detect throughout the AOR at between 0.5m and 1.2m above ground level.

6.4. Detection display

6.4.1. Ideally located beside the monitor

6.5. Wiring/cabling

6.5.1. As these are safety systems, particular care should be taken to protect cables from damage; e.g., crushing, and sharp edge chaffing.

7.0 TRAINING

7.1. The contractor and/or Construction Management Team should ensure and demonstrate workers have received training in the care, use and limitations of MRMM systems.

7.2. Training to cover the following:

7.2.1. Pre-use inspections and documentation.

7.2.2. General use, care, limitations, and maintenance

7.2.3. Review of location and availability of manual and other technical data

7.2.4. Contractor specific safety rules and policies regarding proximity sensors and camera monitor systems.

8.0 MAINTENANCE

8.1. The Contractor and/or Construction Management Team to ensure an effective maintenance program is in place covering the following elements:

8.1.1. Pre-use inspections and documentation.

8.1.2. Clear criteria for identifying when equipment is malfunctioning.

8.1.3. A system for placing heavy equipment with defective systems “out of service” unless a written exemption is provided by COMPANY as per 7.4 of this Safe Work Guideline.

8.2. When a malfunction occurs, repairs or replacement must be made as soon as practicable. Heavy equipment may be used in the interim, when a written exemption is provided from the COMPANY, hazard assessment and mitigation is in place to allow work to continue in the same controlled manner as with MRMM system.

9.0 REFERENCES & LEGISLATION

9.1. **ISO-5006: Earth-moving machinery** — operator's field of view — Test method and performance criteria

9.2. **Safer By Design**: Research shows even though meeting international safety standards, a significant proportion of incidents involving mobile equipment are due to poor design. Safer by Design helps to address this design vacuum/time lag existing between many manufacturers and users of heavy equipment. http://www.safequarry.com/safer_by_design.aspx.

9.3. **ISO-16505:2015**: although a standard for use of camera monitor systems as an alternative to mirrors on cars and commercial vehicles, there are some requirements applicable to mobile equipment.

9.4. **UN ECE R46**: based on ISO-16505:2015