Collision warning and avoidance systems
Expectations of the construction industry – Revision 2

Preamble

The requested system shall comply with NF EN ISO 13849-1 :2016 "General principles for the design of safety-related control systems".

The system requested is a collision warning system (*CWS*) and a *collision* avoidance *system* (CAS) as defined in ISO 21815-1 "Earth-moving *machinery — Collision warning and avoidance — Part 1: General requirements*", not translated into French in 03/2023,

Whether or not the mobile machinery equipped with this system is an earthmoving machine, **this system shall comply with ISO 21815-1:2022**, and with the performance requirements defined in Chapter 4 of this standard, except for the provisions mentioned below, which apply instead of or in addition to the provisions of the standard.

These specifications do not apply to road-rail machines, which are subject to SNCF approval and are the subject of particular specifications established with the Syndicat des Entrepreneurs de Travaux de Voies Ferrées de France (SETVF).

The tenderer must inform the applicant whether any of the requirements of these specifications have a significant impact on the level of price of his proposal. Where applicable, it must provide an estimate of the financial impact.

The tenderer must also specify the points of the tender specifications which he is unable to comply with, using the document attached as Annex C.

In addition, we recall that ISO 21815-1 mentions that a *risk analysis for a machine equipped with a CxS device must be carried out in accordance with the principles of ISO 12100 by the system integrator* (paragraph 4.1.15).

Requirements

It.	Description	Mandatory	Optional
1	**Compliance with standards** The system meets the NF EN 13847-1:2016 standard with:		
1.1	1. a Performance Level required (PLr) greater than or equal to D in terms of pedestrian detection.	1	
1.2	2. a Performance Level (PLr) required greater than or equal to A in terms of collision warning.	1	
1.3	3. a Performance Level required (PLr) greater than or equal to D in terms of collision avoidance.	1	
1.4	The system complies with ISO 21815-1:2019, except for the following provisions which apply instead of or in addition to the provisions of that standard.	1	
2	**Objects to detect** As a reminder, ISO 21815-1:2019 defines (paragraph 3.5) an object to be detected as an object, *such as a person, machine, vehicle or obstacle, that must be detected by a collision warning system (CWS) or a collision avoidance system (CAS) when it is in the collision risk zone.*		
2.1	The requested system must detect at least people, whatever their posture: standing, sitting, squatting, lying down, ...	1	
2.2	Note: "All obstacles" detection is possible, however the tenderer's attention is drawn to the risk of unwanted action of the system (blocking of the machine) if necessary, in the case of mounting on a trailer, for instance.		1
3	**Information of the driver in case of malfunction of the system or departure from the range of use** As a reminder, ISO 21815-1:2019 states (paragraph 4.6) that**:** - *Throughout operation, the system must carry out self-diagnosis at a frequency determined by the manufacturer's risk assessment,* - *When CxS capability is detected as unavailable because it is outside the specified usage limits (e.g., speed), the operator must be notified.*		
3.1	The customer specifies that the requested system must have a frequency of self-diagnosis and verification of the operating range of less than one second.	1	

It.	Description	Mandatory	Optional
	Note: The range of use is to be defined in the instruction manual of the system. See point 1 2.3.		
3.2	This unavailability of the system must not block the operation or use of the machine.	1	
4	**Provisional conditions of use** ISO 21815-1:2019 states that collision *warning and avoidance systems that have limited capabilities (e.g., limited speed and distance) may have different usage limits depending on the use cases defined in the other parts of the ISO 21815 series (*paragraph 4.2.4).		
	The customer specifies that the requested system must operate under the following conditions:	1	
4.1	• Ambient temperature: Between **X** and **Y** °c,		
4.2	• Brightness: Between **X** and **Y** lux,		
4.3	• Environment with fog, rain, snow, dust,		
4.4	• Speed less than or equal to the maximum speed of the equipment,		
4.5	• Slope less than or equal to the permissible slope of the machine.		
5	**Protection against unauthorized modification of system functions** ISO 21815-1:2019 states that *a* CxS *must be designed to prevent unauthorized changes to internal settings or CxS software. EXAMPLE Protections against unauthorized changes such as passwords, key locks* (Paragraph 4.7).		
	The client specifies that the system must have been analyzed the main cybersecurity risks related to its implementation and specify the security devices and controls compared to these risks. They must include, at a minimum:	1	
5.1	• Hardware Secure Boot,		
5.2	• State-of-the-art encryption, encryption of firmware stored in memory,		
5.3	• Anti-burglary mechanisms,		
5.4	• No physical debugging interface available,		
5.5	• Secure patch application procedure,		
5.6	• Prevention of cloning,		
5.7	• Principle of least privilege (POLP) (each user must have access according to his needs),		
5.8	• Secure software interface: authentication requirement,		
5.9	• Unique identity and password for the device,		

It.	Description	Mandatory	Optional
5.10 5.11 5.12	• Secure management of access rights according to POLP, • Logging system (recording of each action on the system – historization) / Historization of version changes, program, etc. • Clear roles and responsibilities.		
6	**Data recording and retrieval** ISO 21815-1:2019 does not address the subject of data logging.		
6.1	The client specifies that the requested system must record different events: • Outputs of range of use, • Malfunctions • Detection by the CWS, • Action by CAS.	1	
6.2	The requested system must allow the extraction of the recorded data.	1	
7	**Possibilities of override** ISO 21815-1:2019 states that *a CxS can have different operating modes: normal mode, sleep mode and override mode* (paragraph 4.7). The client specifies the following:		
	If there is a possibility of inhibition, there must be: • Possibility of manual reactivation at any time, and automatic reactivation after X min. and information to the driver before reactivation. • Automatic reactivation on restart if the machine was in inhibition mode at the time of shutdown.	1	
7.1	The warning to the driver must be able to be override by the driver, to avoid excessive alerts in case of necessary proximity to an obstacle or a person. The duration of this warning deactivation should be in the range of **X** to **Y** minutes. This override period must not be able to be changed by an unauthorized person.	1	

It.	Description	Mandatory	Optional
7.2	The collision avoidance system shall not be capable of being override in the event of proximity to a person.	1	
7.3	It shall be possible to deactivate the collision avoidance system in the event of proximity to an obstacle.	1	
7.4	The system must ask the driver for confirmation before entering override mode.	1	
8	**Pedestrian alert** ISO 21815-1:2019 states that the warning - defined as the *transmission of alert information by visual, audible or other signals* - is intended for the operator *and may also be intended for persons in the vicinity of the machine in addition to the operator* (paragraph 3.2).		
8.1	The requested system must alert the pedestrian in the event of proximity to the machine.		1
9	**Pedestrian instrumentation** ISO 21815-1:2019 states that a CxS may *have passive detection (e.g. camera, radar) of intended objects that are not instrumented, or a CxS may require the intended object to be instrumented (e.g. by an RFID badge) (paragraph* 3.2).		
9.1	The tenderer may propose pedestrian instrumentation, to improve the performance of the system or to distinguish a "friendly" pedestrian (instrumented) from an "intruder" pedestrian (not instrumented).		1
9.2	On the other hand, it should not be necessary for the people to be detected to be instrumented (for example, by an RFID badge) for them to be detected, and for the collision avoidance system to be effective.	1	

It.	Description	Mandatory	Optional
10	**Possible actions** The system can act in different ways: • Locking or stopping (TIC) of forward travel[1] • Blocking or stopping (TIC[1]) of the reverse travel • Blocking or stopping (SIC) rotation,[2] • Blocking or stopping the movement of equipment: bucket, tool, bucket, balance, arm, ...		
10.1 10.2 10.3 10.4	Annex B defines the actions required for different families of equipment and specifies the cases where deceleration must be gradual.	1	
11	**System initialization** ISO 21815-1:2019 does not specify a system initialization time, nor does it prohibit movements when the system is in the initialization phase.		
11.1	The client specifies that the system initialization time must be less than one minute.	1	
11.2	The various movements of the machine must be neutralized during the initialization phase of the system.		1
12	**Instructions manual** ISO 21815-1:2019 provides an example of the content of instructions manual (Annex 3) in the annex.		
	The customer specifies that the instructions manual must include the following points:	1	
12.1	• <u>Description of the system</u> General and descriptive characteristics of system components		
12.2	• <u>Areas of operation</u> - Detection area(s) by the system, - Driver warning zone(s), - Zone(s) in which the system triggers an automatic action, in case of pedestrian presence. Note 1: The shape and size of the detection volumes shall be shown in explicit diagrams showing different views of the equipment.		

[1] : TIC = Take-Off Inhibition CxS

[2] : SIC = Swing Inhibition CxS

It.	Description	Mandatory	Optional
	Note 2: The distances of driver warning and automatic action depend on the speed of the machine or its equipment.		
12.3	• <u>Limitations on system usage and factors that may degrade its performance</u> Like what: - Temperatures - Luminosity - Opacity related for example to fog, rain, snow or dust, - Unladen speed, or at nominal load (for the equipment concerned), - Slope. - **…**		
12.4	• <u>Measures to be taken and recommendations to minimize hazards</u>, especially in relation to conditions that could degrade system performance. Examples: lighting, speed limit, clamping, sensor cleaning...		
12.5	• <u>Instructions for use</u> - Instructions for getting started, - Information on the different modes (initialization, operation, ...) and visual, audible or aptic signals, ... - Checks to be carried out before use, - …		
12.6	• <u>Maintenance instructions</u> - Instructions for periodic system performance checks. - Preventive maintenance to be implemented. - Instructions to follow in case of failure. - …		
12.7	• <u>Regulatory Compliance</u> The machine equipped with the system must comply with the regulatory requirements applicable to it and in particular with the Machinery Directive 2006/42/EC.		

Annex A – Determining the Performance Level required (PLr)

<table>
<tr><th></th><th>Severity of injury</th><th>Frequency and/or duration of exposure to the hazard</th><th>Avoidance of the hazardous phenomenon or limitation of possible damage</th><th>PLr</th></tr>
<tr><td rowspan="8">Starting point for the level of determination of the Performance Level required (PLr)</td><td rowspan="4">Minor injury S1 (normally reversible)</td><td rowspan="2">Rare to frequent and/or short-lived F1</td><td>Possible under certain conditions P1</td><td>PLa</td></tr>
<tr><td>Rarely possible P2</td><td rowspan="2">PLb</td></tr>
<tr><td rowspan="2">Frequent to continuous and/or long-lasting F2</td><td>Possible under certain conditions P1</td></tr>
<tr><td>Rarely possible P2</td><td rowspan="2">PLc</td></tr>
<tr><td rowspan="4">Serious injury (normally irreversible) and death S2</td><td rowspan="2">Rare to fairly frequent and/or short-lived F1</td><td>Possible under certain conditions P1</td></tr>
<tr><td>Rarely possible P2</td><td rowspan="2">PLd</td></tr>
<tr><td rowspan="2">Frequent to continuous and/or long-lasting F2</td><td>Possible under certain conditions P1</td></tr>
<tr><td>Rarely possible P2</td><td>PLe</td></tr>
</table>

Annex B – Actions required for various equipment families

	Forward Translation Inhibition (TIC) or stop	**Reverse** Translation Inhibition (TIC) or stop	**Steering** change inhibition or stop	**Swing** inhibition (SIC) or stop	**Attachements movements** inhibition or stop
Wheel or crawler loader	Option	Mandatory	Forward : Option Reverse : Mandatory	N/A	Option
Forklift without turret	Option	Mandatory		N/A	Mandatory
Forklift with turret	Option	Mandatory		Mandatory	Mandatory
Compactors (excluding waste) (earthmoving, tandem, tyres)	Option	Mandatory		N/A	
Mini wheel loader or track loader (skid steer)		Mandatory	Mandatory	N/A	
Hydraulic excavator up to 6 t		Mandatory		Mandatory	Option
Hydroskip dumper	Mandatory	Mandatory		N/A	
Motograder	Option	Mandatory	Option	N/A	
Hydraulic excavator (tracks, tyres)		Mandatory		Mandatory	Option
Soil stabilizer	Option (suivant modèle)	Mandatory		N/A	
Rigid or articulated dump truck	Option	Mandatory	Forward : Option Reverse : Mandatory	N/A	Option
Bulldozer	Option	Mandatory	Option	N/A	

Families of machines not listed:

- Motoscrapers
- Pavers
- Drilling machines
- Extrusion Machines
- Rail-Road Machines
- Milling Machines
- Agricultural tractors
- Side-boom

Annex C – Specification Compliance Matrix

Requirement Number	Requirement	OK	Not OK	Tenderer comments	Client comments
1	**Compliance with standards**				
1.1	- Performance level D mini for detection				
1.2	- Performance level A mini for warning				
1.3	- Performance level D mini for avoidance				
1.4	- ISO 21815-1:2022 compliance				
2	**Object to detect**				
2.1	- People detection				
2.2	- Detection of any obstacle				
3	**Information in case of malfunction or departure from the range of use**				
3.1	Frequency of self-diagnosis and verification of operating range				
3.2	Equipement not blocked if system is not available				
4	**Provisional conditions of use**				
4.1	- Temperature				
4.2	- Luminosity				
4.3	- Fog, rain, snow, dust				
4.4	- Speed				
4.5	- Slope				
5	**Protection against unauthorized modification of system functions**				
5.1	- Hardware Secure Boot				
5.2	- State-of-the-art encryption				
5.3	- Anti-burglary mechanisms				
5.4	- No physical debugging interface available				
5.5	- Secure patching procedure				
5.6	- Prevention of cloning				
5.7	- Principle of least privilege (POLP)				

Requirement Number	Requirement	OK	Not OK	Tenderer comments	Client comments
5.8	- Secure Software Interface				
5.9	- Unique identity and password for the device				
5.10	- Secure management of access rights according to POLP				
5.11	- Logging system / Historization of version changes, program, etc.				
5.12	- Clear roles and responsibilities				
6	**Data recording and extraction**				
6.1	Recording of the following events: Operating range deviations, malfunctions, CWS detections, CAS actions.				
6.2	Possibility of data extraction				
7	**Possibilités for override**				
7.1	Possible deactivation of the driver warning				
7.2	Non-deactivation of the CAS in case of proximity to a person				
7.3	Possible deactivation of the CAS in case of proximity to an obstacle				
8	**Pedestrian warning**				
9	**Pedestrian instrumentation**				
9.1	Possible pedestrian instrumentation				
9.2	Pedestrian instrumentation not necessary				
10	**Actions**				
10.1	Forward inhibition or stop				
10.2	Reverse inhibition or stop				
10.3	Swing inhibition or stop				
10.4	Attachements inhibition or stop				
11	**System initialization**				
11.1	Maximum initialization time				
11.2	Blocking movements during initialization				

Requirement Number	Requirement	OK	Not OK	Tenderer comments	Client comments
12	**Instructions manual**				
12.1	Description of the system				
12.2	Definition of operating areas				
12.3	Usage limits and factors that may degrade performance				
12.4	Measures to be taken to minimize hazards				
12.5	Instructions for use				
12.6	Maintenance instructions				
12.7	Regulatory Compliance				