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EUROPEAN MATERIALS HANDLING FEDERATION

Product Group Cranes and Lifting Equipment

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Position Paper Assistance Systems on Cranes & Lifting Equipment

Contents

1 Introduction

Currently, there exists uncertainty regarding the classification of assistance systems. As a result, the requirements for assistance systems and their functions on cranes and lifting equipment need clarification. FEM Product Group Cranes and Lifting Equipment is concerned that uncertainty may result in unrealistic expectations and requirements related to these systems and functions. This position paper was developed to give guidance on assistance systems and the functions realised thereby.

In general, machines and systems consist of several components which interact with each other and ensure the functionality of a machine or system. Such systems provide functions that allow the operators to use and operate the machine as intended by the manufacturer.

A distinction must be made between different types of functions: Those which are needed to perform basic operating functions, functions dedicated for safety (protective measures for risk reduction), functions to warn and inform the operator and lastly assistance functions which support the operator by improving ergonomics, reducing energy consumption, or increasing efficiency when used. The latter are increasingly being offered to the market by the manufacturers of cranes and lifting equipment. In contrast to the other three types of functions, assistance functions can be overruled or deactivated at any time.

2 Scope

This position paper focuses on the domain of cranes and lifting equipment and differentiates between different types of functions, excluding functions falling under road regulations for travel on public roads.

3 Cranes and lifting equipment functions

3.1 General

Control functions to safely operate cranes and lifting equipment (in the following text “crane functions”) are distinguished into following types:

1. Operating functions
2. Safety functions
3. Warning and indicating functions
4. Assistance functions:
    a. providing information
    b. influencing motion

3.2 Operating functions

Operating functions are functions of the machine which are necessary to fulfil the intended use of the machine.

For cranes and lifting equipment typical operating functions are lifting/lowering of loads, slewing left/right of rotating upper works, boom hoisting (luffing) up/down, and travelling forward/backward of the trolley or the entire crane.

3.3 Safety functions

Safety functions are necessary to reduce the risk of operating machines within their limits.

According to EN ISO 13849-1, a safety function is a function of a machine whose failure and/or faulty behaviour can result in an immediate increase of the risk(s) to the operator and/or persons in the machine environment.

The necessity for safety functions is determined in the risk assessment and covered in product standards. A typical safety function for cranes and lifting equipment is for example the overload protection function.

3.4 Warning and indicating functions

Warning and indicating functions provide necessary information to the operator, enabling him to safely operate the equipment. They are part of the designer's contribution to risk reduction, informing the operator about possible emerging risks and get him prepared to avoid or mitigate these risks (see EN ISO 12100).

3.5 Assistance functions

Assistance functions are either supporting the operator with information or by influencing motion in the operating process to achieve improved ergonomics and efficient operation (e. g. reduction of energy consumption). Assistance functions are not designed to serve as a risk reduction measurement.

At all times, the operator of the crane has control of the crane and is able to override or deactivate the assistance function. When utilizing assistance functions, the responsibility for supervision and safe operation of the crane remains with the operator. The operator must always follow the manufacturer's instructions.

Operators may become accustomed to the comfort of applying the available assistance functions. Especially when training and instructing, it is necessary to point out on a regular basis that the crane operator nevertheless remains responsible for safe operation.

Contrary to safety functions, performance levels according to EN ISO 13849-1 are not specified for assistance functions.

It must be emphasized that the assistance functions considered in this guidance document only correspond to a low to medium level of automation when comparing to SAE J3016 “Levels of Driving Automation” used in the automotive industry. More information can be found in [2,3].

4 Properties of different types of crane functions

To distinguish between the different crane functions, their properties are described in Table 1. The questions below can serve as a guidance to classify the different types of crane functions:

- Is a control interaction possible?
- What is the purpose of the function?
- When is the function available for the operator?
- Is an activation of the function foreseen or needed?
- Can the operator manually overrule the function?
- Can the function be overridden or muted?
- Which priority has the function?
- Can the function’s parameter be modified by the operator?
- Which standard was considered for the function deployment?

Annex A provides several examples of different crane functions and their classification by applying the properties of Table 1.

Table 1: Properties of different types of crane functions

	Function types				
Properties	**Operating functions**	**Safety functions**	**Warning and Indicating functions**	**Assistance functions**	
				providing information	**influencing motion**
Control Interaction	Can actively influence the crane behaviour by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency and ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on.			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn.	Activated when a defined operational threshold is reached or activated by the operator.	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop.	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledge-ment. [3]	The operator can intervene and overrule assistance functions at any time.	

Table 1: Properties of different types of crane functions
(*continued*)

	Function types				
Properties	**Operating functions**	**Safety functions**	**Warning and Indicating functions**	**Assistance functions**	
Function's Override	Overriding by the operator is not needed.	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable.		Lowest priority
Parameter settings	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote 2

Annex A: Examples of crane functions

Typical examples of different crane's functions for different crane types:

Classification / function type	Function title	Crane type
Assistance function, influencing motion	A.1. Load-Sway-Reduction (LSR)	Industrial EOT-Cranes
	A.2. Working Range System (WRS)	Mobile Cranes
	A.3. ECO Mode	Mobile Cranes
	A.4. Side-Pull Control (SPC)	Tower Cranes
Assistance function providing information	A.5 Surround View System ('Bird View')	Mobile Cranes
Safety function	A.6 Overload protection	Industrial EOT-Cranes
	A.7 Anti-Collision System (ACS)	Tower Cranes

A.1. Load-Sway-Reduction function

Function-Name	Load-Sway-Reduction (LSR)
Purpose	Load-Sway-Reduction is a useful assistance function for the damping of load sway and easier handling of loads. Especially for beginners without previous experience and training the exact positioning of a swinging load is a time-consuming task.
Description of the main principle	The LSR-Function of EOT-Cranes is integrated in the crane control system: The drives for crane and trolley travel of the cranes with load sway damping are infinitely speed-controlled via a frequency inverter. The main task is performed by the crane control system in combination with a sensor that detects the deflection of the rope at the rope anchorage point (including inclined pull) and actively counteracts it if it detects a load sway. Since the LSR-control measures the actual rope angle deflection, the oscillation of the load is effectively minimized in every operating situation. Also load oscillations that existed before the start of a movement are detected and thus actively compensated.
Classification According to Table 1	See next Page of this document
Result	Assistance function (influencing motion)

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INPUT:

Properties of **„LSR function“**

OUTPUT:

The LSR is an **Assistance Function** (influencing motion)

	Function types				
	Operating functions	Safety functions	Warning and Indicating functions	Assistance functions	
Properties				providing information	influencing motion
Control Interaction	Can actively influence the crane behaviour by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency, reduce energy consumption or improve ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on.			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn	Activated when a defined operational threshold is reached or activated by the operator.	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop.	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledgement. [3]	The operator can intervene and overrule assistance functions at any time.	
Function's Override	Overriding by the operator is not needed.	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable.		Lowest priority
Parameter setting	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote 2

A.2. Working Range System (WRS)

Function-name	Working Range System (WRS)
Purpose	The Working Range System is used by the crane operator to restrict the working range of the crane. It is a helpful system when working on cramped job sites.
Description of the main principle	The crane operator can restrict the total height, radius, angle of rotation and hoisting rope path. The maximum approved speed of movement depends on the distance from the set boundary. The movement is reduced continuously until standstill at the boundary. If the boundary is reached, the movement is switched off. All movements that exceed the boundary are blocked. The shutdown is retained even if you turn off monitoring. In order to release movements again, you must initiate a movement away from the boundary in the opposite direction. The Working Range System can be switched on or off by the crane operator.
Classification according Table 1	See next Page of this document
Result	Assistance function (influencing motion)

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INPUT:
Properties of **„Working Range System“**

OUTPUT:
The WRS is an **Assistance Function** (influencing motion)

Properties	Function types: Operating functions	Safety functions	Warning and Indicating functions	Assistance fun: providing information	Assistance fun: influencing motion
Control Interaction	Can actively influence the crane behaviour by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency, reduce energy consumption or improve ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on.			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn	Activated when a defined operational threshold is reached or activated by the operator.	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop.	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledgement. [3]	The operator can intervene and overrule assistance functions at any time.	
Function's Override	Overriding by the operator is not needed.	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable.		Lowest priority
Parameter setting	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote 2

A.3. Eco Mode - Fuel saving system

Function-Name	ECO Mode
Purpose	The system automatically adjusts the engine speed to save fuel and reduce energy consumption.
Description of the main principle	The ECO-Mode can be turned on and off by the operator. When activated the system automatically increases engine speed to operator specified working speed when functions are operated, and then decreases the engine speed to idle speeds when no functions are being operated for a certain period of time.
Classification According to Table 1	See next Page of this document
Result	Assistance function (influencing motion)

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INPUT:

Properties of „ECO Mode“

OUTPUT:

The ECO Mode is an **Assistance Function** (influencing motion)

Properties	Function types: Operating functions	Safety functions	Warning and Indicating functions	Assistance functions: providing information	Assistance functions: influencing motion
Control Interaction	Can actively influence the crane behaviour by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency, reduce energy consumption or improve ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on.			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn	Activated when a defined operational threshold is reached or activated by the operator.	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop.	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledgement. [3]	The operator can intervene and overrule assistance functions at any time.	
Function's Override	Overriding by the operator is not needed.	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable.		Lowest priority
Parameter setting	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote 2

A.4 Side-Pull Control (SPC)

Function-Name	Side-Pull Control (SPC)
Purpose	The Side-Pull Control (SPC) is a function to avoid side pull and reduced swinging when lifting a load from the ground by an automatic alignment of the jib and the trolley above the load.
Description of the main principle	The Side-Pull Control (SPC) function for tower cranes is integrated in the crane control system and can be switched off or overruled at any time. When made available by the operator, the SPC can be activated or de-activated by means of a push button. The function is performed by the crane control system in conjunction with a sensor that detects the deviation of the hook block relative to the rotation angle of the jib and the radial position of the trolley and actively counteracts during the lifting operation. Since the SPC measures the actual deflection of the hook block, the deflection of the hook block is reduced to a minimum during the lifting of the load.
Classification according to Table 1	See next page of this document
Result	Assistance function (influencing motion)

INPUT:
Properties of SPC

OUTPUT:
The SPC is an **Assistance Function**
(influencing motion)

Properties	Function types				
	Operating functions	Safety functions	Warning and Indicating functions	Assistance functions	
				providing information	influencing motion
Control Interaction	Can actively influence the crane behaviour by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency and ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on.			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn.	Activated when a defined operation threshold is reached or activated by the operator	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledgement.[3]	The operator can intervene and overrule assistance functions at any time.	
Function's override	Overriding by the operator is not needed	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable		Lowest priority
Parameter setting	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote [2]

A.5. Surround View System (‘Bird View’)

Function-Name	Surround View (‘Bird View’)
Purpose	The surround view system (‘Bird View’) provides a video signal that shows the crane and its immediate surrounding ambient area from an elevated viewpoint. This allows the crane operator to perceive the crane´s surroundings and to recognise people or obstacles around the crane. In addition, the maximum outrigger position and the slewing radius of the counterweight can be projected into the surround view signal as an augmented reality. In this way, the crane operator is supported in efficiently position or relocated the crane in narrow working areas.
Description of the main principle	The surround view system (‘bird view’) consists of several cameras installed at different locations on the crane. The signals of all cameras are processed by dedicated software and combined into a video signal that shows the current crane position from a bird’s perspective. The crane operator can watch the crane´s surroundings to detect people or obstacles when positioning the crane on the job site. In addition, the software can project the possible outrigger reach and the tail swing of the counterweight on the display which supports the crane operator to detect possible collisions with obstacles before crane operation.
Classification According to Table 1	See next Page of this document
Result	Assistance function (providing information)

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INPUT:
Properties of SVS
„Surround View System“

OUTPUT:
The SVS is an **Assistance Function**
(providing information)

Properties	Function types: Operating functions	Safety functions	Warning and Indicating functions	Assistance functions: providing information	Assistance functions: influencing motion
Control Interaction	Can actively influence the crane behaviour by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency, reduce energy consumption or improve ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on.			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn	Activated when a defined operational threshold is reached or activated by the operator.	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop.	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledgement. [3]	The operator can intervene and overrule assistance functions at any time.	
Function's Override	Overriding by the operator is not needed.	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable.		Lowest priority
Parameter setting	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote 2

A.6. Overload protection

Function-Name	Overload protection
Purpose	According EN 14492-2, hoists with a rated capacity of 1.000 kg or more shall be fitted with a rated capacity limiter. The rated capacity limiter shall be designed to prevent overloading of the hoist. It shall also limit the forces transmitted to the supporting structure. Overloading means exceeding the designed operating forces.
Description of the main principle	The Overload protection Function is a direct acting capacity limiter and is integrated in the crane control system. A load sensor provides the load-value. If the limit value is exceeded, the drive will be stopped with a safety-related stop function of category 0 or 1 according to EN 60204-32.
Classification According to Table 1	See next Page of this document
Result	Safety function

INPUT: Properties of **„Overload protection function “**

OUTPUT: The Overload protection function is a **Safety Function**

Properties	Function types				
	Operating functions	Safety functions ✓	Warning and Indicating functions	Assistance functions	
				providing information	influencing motion
Control interaction	Can actively influence the crane behavior by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency, reduce energy consumption and ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on. .			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn.	Activated when a defined operational threshold is reached or activated by the operator.	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop.	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledgement.[3]	The operator can intervene and overrule assistance functions at any time.	
Functions Override	Overriding by the operator is not needed.	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable.		Lowest priority
Parameter settings	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote 2

A.7. Anti-Collision System (ACS)

Name	Anti-Collision System (ACS)
Purpose	In an Anti-Collision System (ACS) for tower cranes, a safety function is implemented to prevent collisions between cranes and/or obstacles in the working range of the respective cranes.
Description of the main principle	In an Anti-Collision System (ACS), the control systems of the cranes involved are connected via a network in which their respective status, position and speed data are exchanged in real time. This is usually done by means of Anti-Collision Devices (ACD) that are additionally mounted on each crane and linked to the respective crane control system. The Anti-Collision Function (ACF) is implemented in these devices as a safety function and interacts with the crane's control commands to slow down or stop movements in dangerous directions to prevent a collision with another crane or an object in the crane's working range. Before operation, when commissioning the Anti-Collision Function (ACF), crane- and site-specific parameters are considered, e. g. deformation of the crane, expected size of the load, possible pendulum angle of the load (due to crane acceleration and/or wind) or required safety distance. NOTE: Requirements for anti-collision systems for tower cranes are specified in the product standard EN 17076:2020 which refers to EN ISO 13849-1.
Classification according to Table 1	See next page of this document
Result	Safety function

INPUT: Properties of **„ACS"**

OUTPUT: The ACS is a **Safety Function**

Char	Function types				
	Operating functions	Safety functions	Warning and Indicating functions	Assistance functions	
				providing information	influencing motion
Control Interaction	Can actively influence the crane behaviour by interaction with the control system.		Cannot actively influence the crane behaviour by interaction with the control system but requires user attention and action.		Can actively influence the crane behaviour by interaction with the control system.
Purpose	Necessary to operate the crane as intended.	Necessary to reduce the risk of hazards during operation.	Function providing proper information for the user and is part of the designer's contribution to risk reduction. With this information the user must implement the necessary protective measures.[1]	Additional functions for the operator to improve efficiency and ergonomics when operating the crane. Not necessary to operate the crane or fulfil safety requirements.	
Availability	Are available when an operating mode is switched on.			Are available when an operating mode is switched on and the assistance function is selected by the operator. It can be unselected by the crane operator at any time.	
Activation	Activated by the crane operator by a control device.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. an emergency stop.	Activated by the crane control when a defined safety-related limitation is exceeded or manually by a switch, e. g. activating the horn.	Activated when a defined operational threshold is reached or activated by the operator.	
Intervention by operator	In general, not applicable. In case of malfunction operator uses emergency stop.	The operator cannot overrule safety functions.	The operator cannot overrule. Some warning and indicator functions allow an acknowledgement.[3]	The operator can intervene and overrule assistance functions at any time.	
Function's override	Overriding by the operator is not needed.	Overriding of a safety function is not allowed.[2]	Overriding by the operator is not allowed.[3]	Overriding by the operator is not needed – the assistance function may be activated or deactivated at any time.	
Priority	Operational functions have priority over and can overrule assistance functions.	Safety functions have the highest priority and can overrule operational functions and assistance functions.	Not applicable		Lowest priority
Parameter settings	Setting of parameter values of properties of operating function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties cannot be changed by the operator.	Setting of parameter values of properties (i. e. threshold values) of assistance function is allowed and can be changed by the operator within the limits foreseen by the manufacturer.	
Designed and built according to	Applicable product standard.	EN ISO 13849-1 and applicable product standard.	Applicable product standard.		

[1] See EN ISO 12100, Clause 4, Figure 2
[2] Muting: Temporary automatic suspension of safety functions is possible but safe conditions must be provided by other means (in accordance with EN ISO 13849-1).
[3] Muting of warning and indicating functions is also allowed analogous to Footnote [2]

Bibliography

[1] DGUV, Fachliche Stellungnahme des FB HM zu Sicherheitsanforderungen an Assistenzsysteme von Maschinen, 03.11.2017, Mainz, Germany

[2] SAE J3016, LEVELS OF DRIVING AUTOMATION, sae.org/standards/content/j3016_202104

[3] Tobias Englert, Lastpendeldämpfung für Turmdrehkrane - Ein erster Schritt zur Kranautomation, 30. Internationale Kranfachtagung 2022, Magdeburg, Germany

[4] EN ISO 13849-1 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for

[5] EN ISO 12100 Safety of machinery - General principles for design - Risk assessment and risk reduction