

# Kalmar ESC straddle carrier technical specification



## TECHNICAL SPECIFICATION OF 8<sup>th</sup> GENERATION KALMAR ESC CONTAINER STRADDLE CARRIER

### 1 Versatility

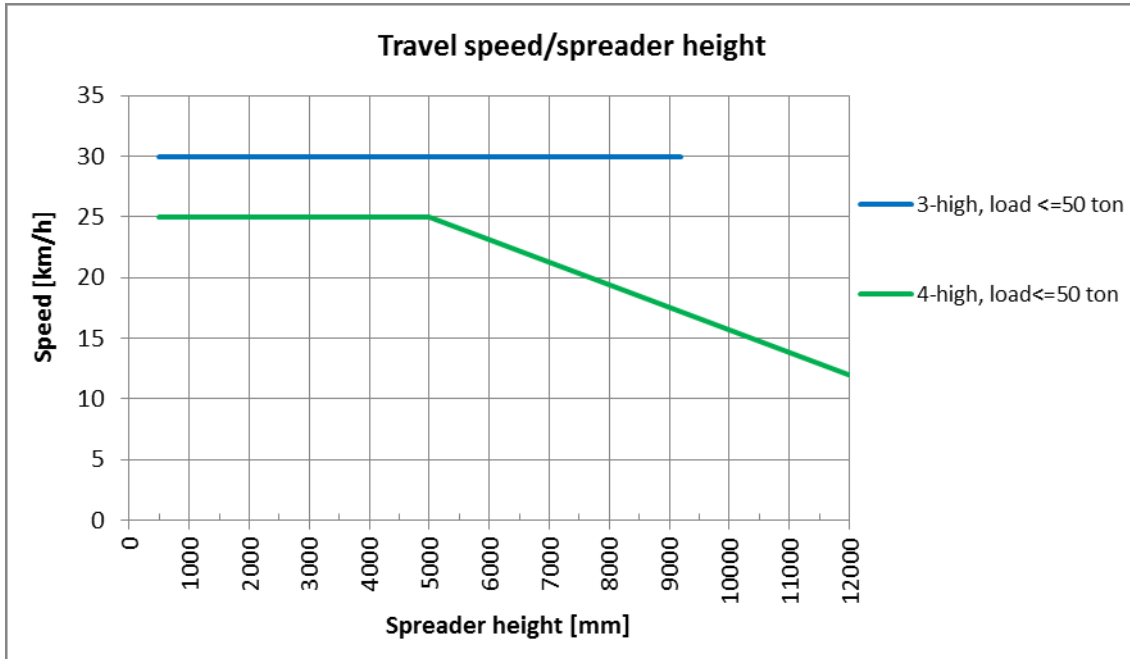
The 8<sup>th</sup> generation Kalmar ESC container straddle carrier is designed for efficient and safe container handling. Thanks to wide range of various configurations available Kalmar ESC straddle carrier is capable of:

	3-high single lift	3-high twinlift	4-high single lift	4-high twinlift
1.1. Stacking maximum number of 9'6" high containers	3	3	4	4
1.2. Travelling empty over maximum number of 9'6" high containers in stack	3	3	4	4
1.3. Travelling with one 9'6" container over maximum number of 9'6" high containers in stack	2	2	3	3
1.4. Handling 20 ft and 40 ft ISO containers	+	+	+	+
1.5. Handling longer than 40 ft containers with corner castings in 40 ft position	+	+	+	+
1.6. Handling 45 ft containers with corner castings in 45ft position with - single lift spreader - fixed twinlift spreader - extendable twinlift spreader	option n/a n/a	n/a option +	option n/a n/a	n/a option +
1.7. Handling 2x20 ft ISO containers simultaneously	-	+	-	+
1.8. Handling ISO containers of all heights	+	+	+	+
1.9. Handling cargo flats as low as 500 mm (20 in)	+	+	+	+
1.10. Handling other heavy loads using wire rope hooks	+	+	+	+

## 2 Performance

### 2.1 Travel speed

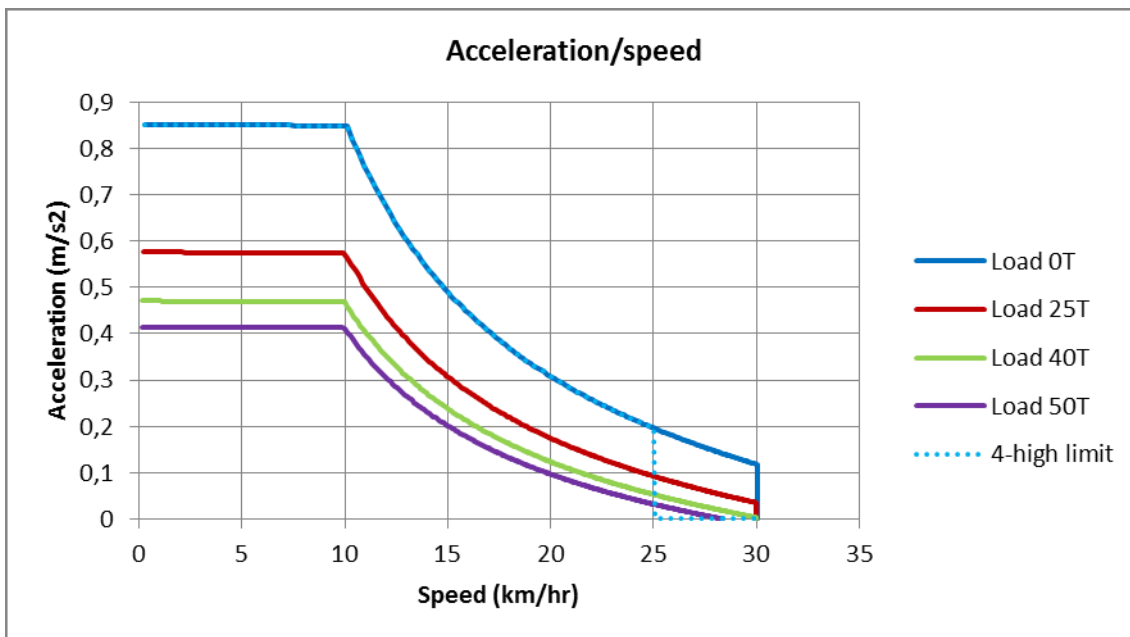
Maximum travel speed

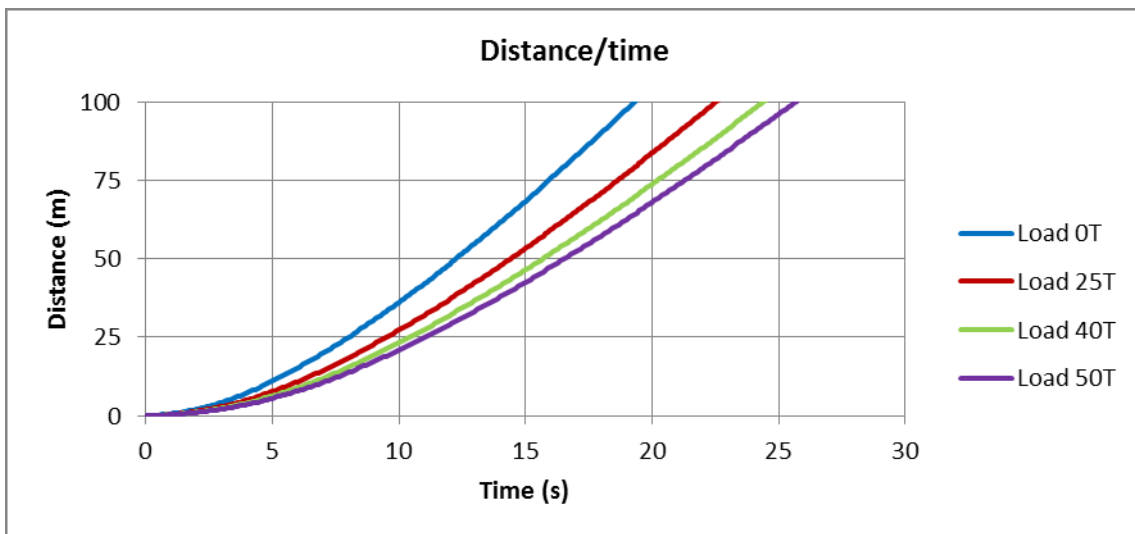
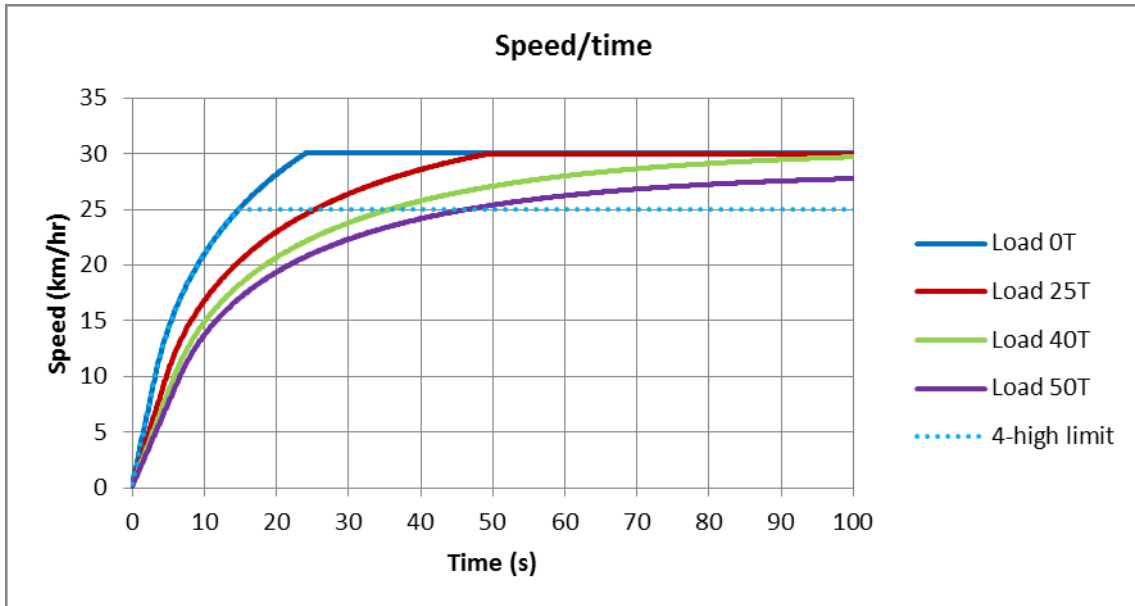
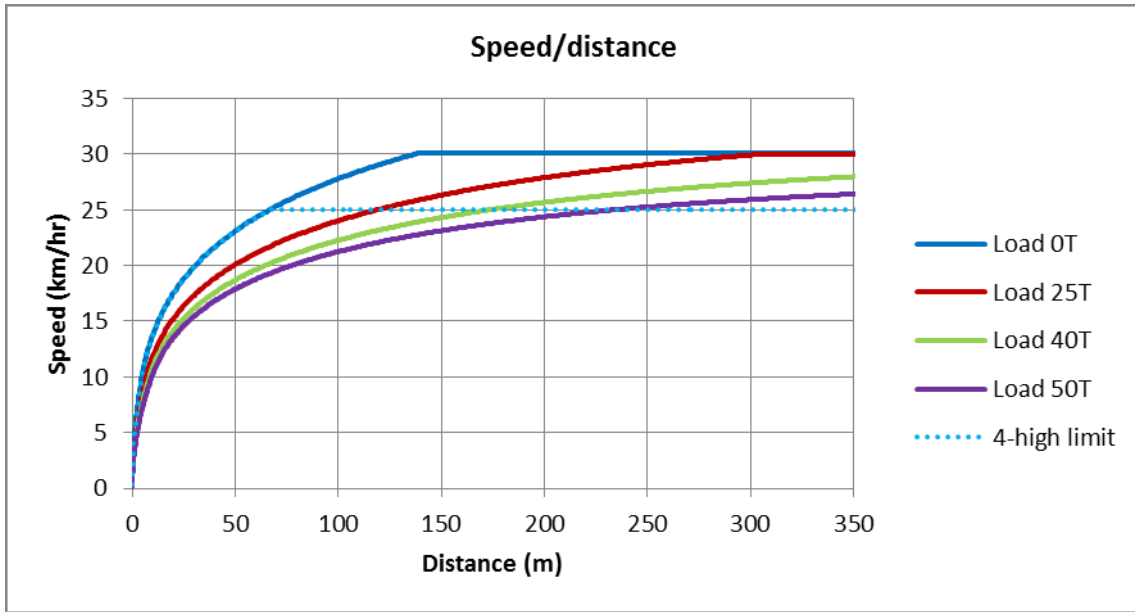


Travel speeds are valid both in forward and reverse direction.

### 2.2 Acceleration

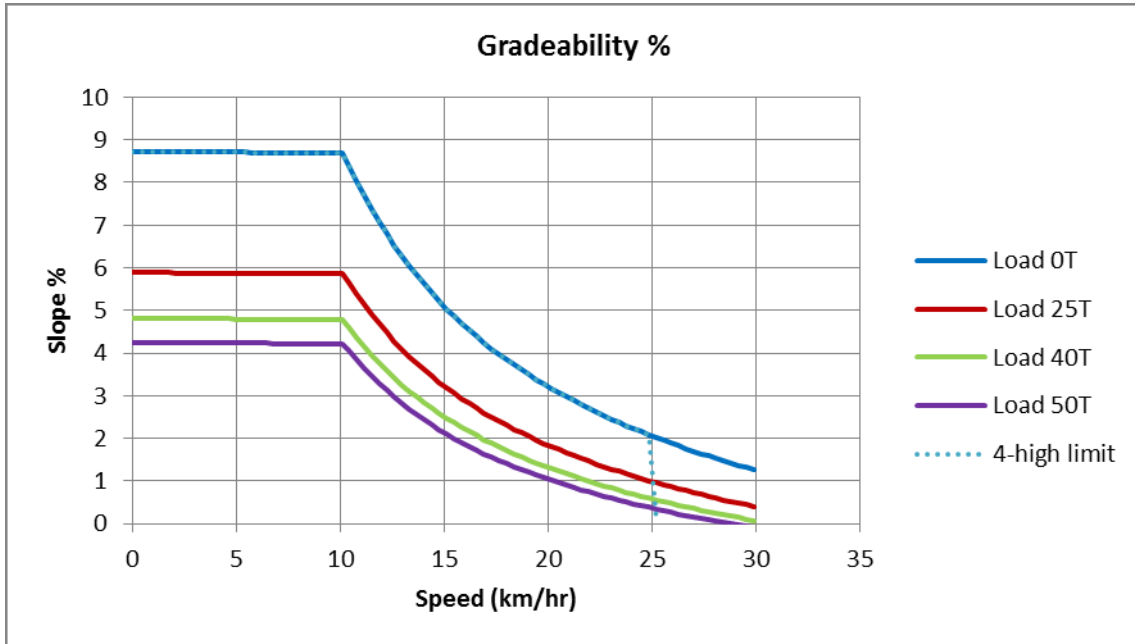
Maximum acceleration





### 2.3 Gradeability

Maximum gradeability

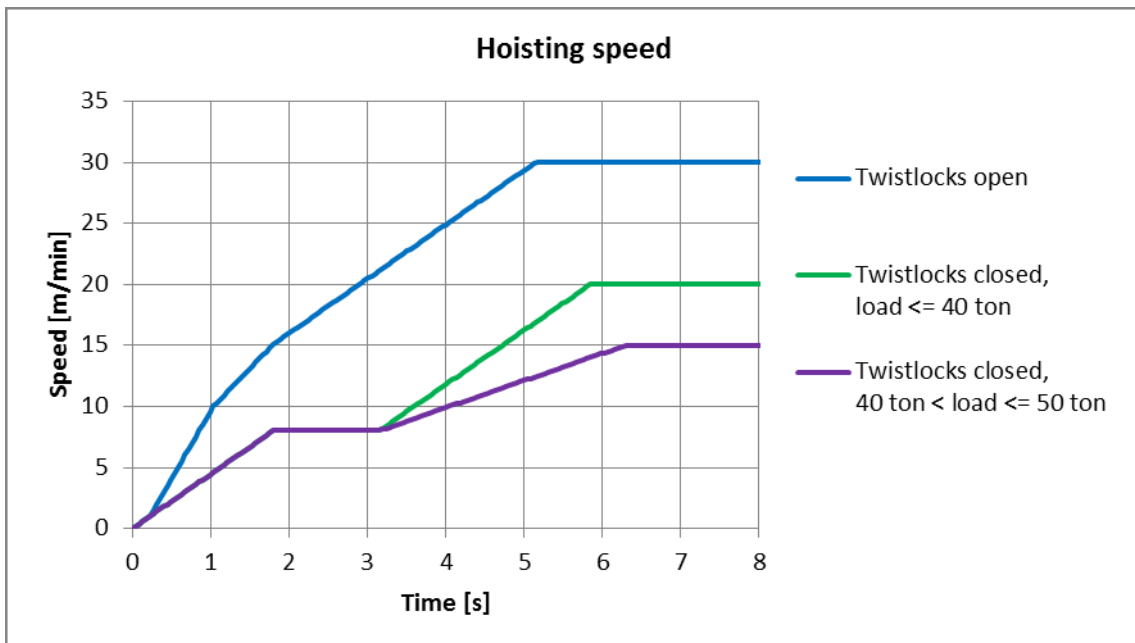


### 2.4 Hoisting and lowering speeds

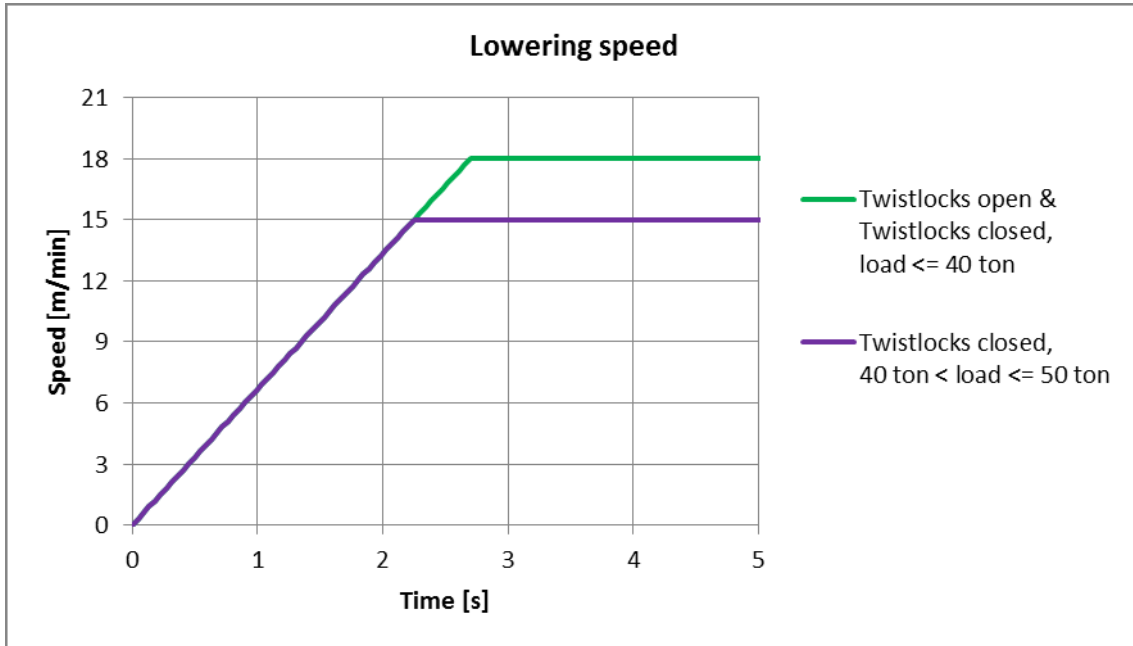
Hoisting and lowering speeds are controlled according to load situation for optimised performance and life time.

- twistlocks open speed is controlled based on no load situation
- twistlocks closed speed is controlled based on load weight

#### 2.4.1 Maximum hoisting speed



### 2.4.2 Maximum lowering speed



### 2.5 Wind speed

Maximum operating wind speed

3-high	25 m/s	(90 km/h; 56 mph)
4-high	20 m/s	(72 km/h; 45 mph)

### 2.6 Boundary conditions

The nominal performance values are based on theoretical calculations assuming normal conditions, like paved level surface and wind speed less than 5 m/s. The nominal performance values are valid for the ambient temperature range of -20 °C...+40 °C.

All performance data values have +/- 5% tolerance compared to nominal values.

Hoisting/lowering and travelling can be performed simultaneously. When hoisting and driving simultaneously, the hoist movement will influence the drive movement, but the drive movement is prioritised. Maximum speeds and/or accelerations can be achieved one at the time.

## 3 Nominal dimensions and weight

Nominal dimensions and weight are according to a separate dimensional drawing. The nominal dimensions are based on an unloaded machine. The maximum load reduces vertical dimensions by approx. 100-125 mm (4-5 in) due to deflection of tyres and suspension.

## 4 Power Train

### 4.1 General Description

Kalmar ESC straddle carrier is built with a reliable and energy efficient diesel-electric power train. Power unit is placed on the top frame where it is not exposed for collisions to obstacles on ground level.

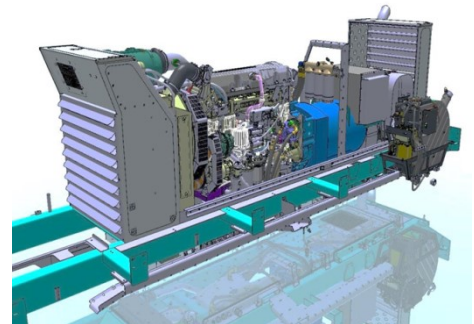
System includes:

- variable speed diesel engine-AC generator set
- hydraulic pump for steering, braking and spreader functions
- frequency controlled electric motors for travel and hoist functions
- energy regeneration from deceleration and spreader lowering providing reduced fuel consumption
- electronic traction control system

#### 4.2 Engine-generator set

Kalmar ESC straddle carrier is equipped with one piece of modern low emission and low specific fuel consumption liquid cooled turbocharged and air to air intercooled in-line 6-cylinder Volvo Penta 10.8 litre displacement diesel engine with electronic control via CAN bus.

Diesel engine drives a three-phase-current generator, which powers the main functions hoist drive and travel drives and supporting systems. The generator is a heavy duty air cooled AC type with single bearing construction, mounted directly to engine rear end.



The diesel engine-generator set compartment is protected against harsh weather conditions by a cover with easy-to-open sliding doors for maintenance access. Bottom cover is hinged and formed as a drip pan with a hand valve enabling easy draining of penetrated washing or rain water.

#### 4.3 Drive line

To obtain reliable and efficient drive line as well as maximum traction on all travel surface conditions and equal wheel loading a 4-wheel drive system (centre wheels driven) is built up with:

- four AC type air cooled electric motors with standard dimensions, one for each driven wheel, installed on top of side frames and protected by columns
- single propeller shaft between AC motor and wheel hub gear
- bevel gear and planetary reduction at driven wheel hubs

#### 4.4 Traction control

Machine control system controls rotation speed of each drive motor individually and in case of excess tyre slip on slippery surface decreases speed of too fast running motor and thus prevents shock loads for each individual drive line. System monitors and controls

- speed differences between drive motors
- acceleration rate of each drive motor

#### 4.5 Hydraulic system

The hydraulic system is of the load-sensing (LS) type in which the pump output is adjusted by the signal pressure coming to the pump. Variable displacement axial piston pump located at the front end of the engine produces hydraulic power for all hydraulic systems of the machine. The pump is equipped with a pressure relief valve that acts as the safety valve for the pump.

Hydraulic oil circuit has an on-line pressure filter after the pump and a return filter at the oil tank.

Hydraulic oil tank of 124 litres volume is placed on top frame in proximity to pump unit. Drain cock under hydraulic oil tank as well as sewerage for top frame oil drainage at ground level is included for easy oil drain. Oil tank is equipped with sight glass and low oil level limit sensor for oil level monitoring.

#### 4.6 Fuel system

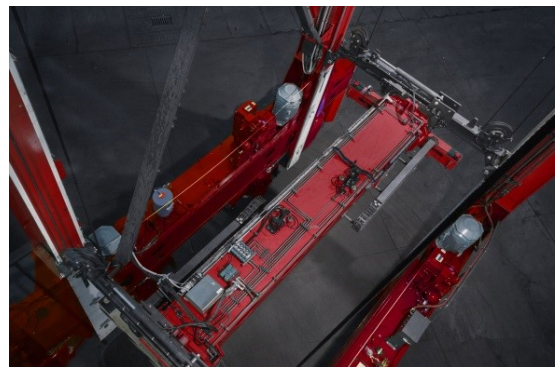
Fuel tank with capacity of 1,400 litres (370 US gal) is integrated in the left side frame. Fuel is transferred from the fuel tank to the supply tank located on top frame through prefilter-water separator by a feed pump. From the supply tank, the fuel flows to the engine fuel pump through filters.

Through the drain cock at the fuel tank sump possible condensation water and sediment can be taken out quickly and easily from the fuel tank.

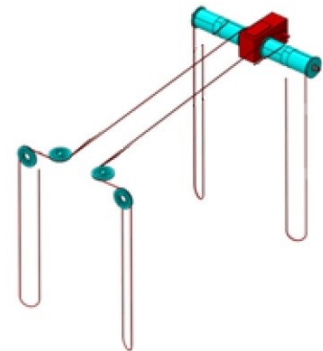
## 5 Lift System

### 5.1 General Description

For maximum life combined with low maintenance demand, environmentally friendly electric motors driven winch hoist system with reduced number of hydraulic components is built in with the following features:



- two hoist motors of AC type air cooled low-voltage squirrel-cage electric motor with standard dimensions, mounted directly to hoist gear
- two hoist brakes of spring loaded hydraulically operated safety type dry disc brake with PLC monitored wear control in brake pads, mounted on primary side of hoist gear
- one hoist gear of heavy duty multi stage helical reduction gear
- two hoist drums of 440 mm diameter, fitted to secondary side of hoist gear and outer ends equipped with support bearings
- four hoist ropes, double rope reeving per corner, adjustable fixed ends on top frame, slack rope indicator and prevention system, rain covers over hoist ropes on top frame
- hoist rope reeving system with eight 440 mm diameter sheaves, 4 on top frame and 4 on lifting beams
- lifting beams are guided by columns
- electric overload protection for hoisting

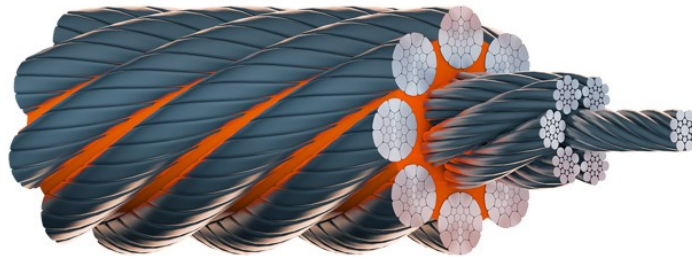
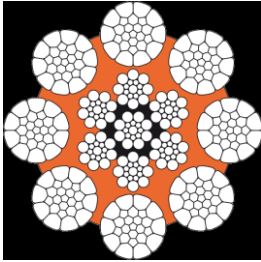




## 5.2 Hoist rope

### 5.2.1 Description

High breaking force 8-strand non-rotation-resistant type rope Veropro 8 with a plastic layer between the independent wire rope core (IWRC) and 8 compacted outer strands is provided. The hoist rope doesn't require continuous lubrication but regular maintenance according to basic maintenance intervals thus leading to cleaner machine and more environmentally friendly operation.



### 5.2.2 Technical data

- Nominal diameter: 22 mm (0.87 in)
- Construction: 1+6+P+8
- Type of lay: Ordinary
- Finish: Galvanised
- Type of core: Steel
- Tensile grade of steel wire: 1,960 N/mm<sup>2</sup>
- Minimum breaking load: 433,600 N
- Mass/metre: 2.177 kg/m
- Lubricated during manufacture

## 5.3 Toplift spreader

Kalmar telescopic spreader's length positions are selected with control buttons from cabin (if cabin is installed) and automatically set. Hydraulic cylinders are used to expand and to retract the spreader. Separate mechanic position locking devices safeguard the spreader length position.

Extensive side shifts/skewing are independent adjustable at both ends, and automatic spreader centring device is a standard feature. With some machine configurations a spreader side shift limitation at driver's cabin height is applicable which is then indicated in dimensional drawing.

Spreader is equipped with floating, ISO type twistlocks. Twistlock latching is automatic and working hydraulically. Accidental opening of twistlocks is prevented by electrical safety system and also by mechanical locking to container's corner pockets with square base of twistlocks. Lifting of container is prevented electrically, if all four corners are not properly engaged.

Twinlift spreader is equipped with detecting system for single or twinlift hoist. Handling of single 20 ft container at one end of twinlift spreader in 40 ft position is allowed with certain limitations.

Spreader control is executed with CanOpen bus and mobile I/O modules. Field devices are connected to I/O modules with cables having molded M12-connectors.

## 6 Wheels, brakes, steering, suspension

### 6.1 Wheels

The machine is travelling on 8 wheels with radial tyres mounted on multi-piece web plate rims made of steel and having tyre inflation pressure of 10 bars (145 PSI). Wheel guards are included for reducing dirt splattering to machine frame.

### 6.2 Brakes

#### 6.2.1 Service brakes

The machine is equipped with a double-circuit brake system. The interconnected brake circuits have been divided so that one circuit affects the left side brakes and the other circuit the right side brakes. The brake pressure for operating the brakes is received from the machine's hydraulic system, which means that the brake system and hydraulic system share the pump and oil tank.

Service brakes are hydraulically operated wet disc brakes with forced cooling. Brake cooling is built with separate cooling oil circuits on both side frames with electric driven oil pump, oil tank with 60 litres volume, cooling radiator with fan and oil filters. Brake oil coolers are located on top of each side frame.



#### 6.2.2 Electrical braking

Electrical braking is executed through drive motors utilizing energy regeneration and brake resistor package.

#### 6.2.3 Parking brakes

Parking brakes are spring-loaded fail safe type and integrated in service brakes on four centre wheels. The springs press through brake pistons the friction discs of the service brakes together and thus prevent the wheels from rotating. The parking brakes are released by hydraulic pressure.

### 6.3 Steering

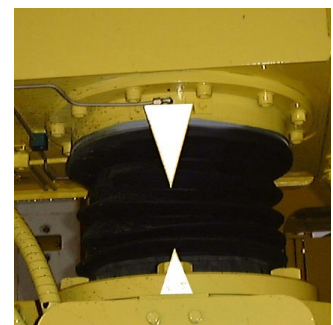
Machine is equipped with hydraulically operated, two axis Ackerman type all-wheel steering. Steering cylinder at each side frame turns the wheels through the steering linkage consisting of steering levers and four similar, straight steering rods. Aligning arrows are included for easy wheel alignment inspection.

### 6.4 Suspension

All wheel suspension is built up to even out the ride and to equalize the wheel loads.

Rubber bellows are provided to protect the lower ends of wheel arms from dirt.

- bellows are built with a press stud joint for easy replacement



without need to remove the wheel arms

## 7 Electrification

### 7.1 AC electrical system

Diesel engine-generator set delivers a 3-phase alternating current which is converted by a rectifier into direct current distributed to inverters via DC bus. Inverters deliver an adjustable 3-phase AC voltage to the electric motors of the drive and hoisting functions. However at idle RPM of diesel engine the generator does not produce power.

### 7.2 Inverters

Travel and hoist functions of Kalmar ESC straddle carrier are driven with mobile inverters which are especially made for vehicle applications. Structure of the liquid cooled mobile inverter is extremely robust providing excellent class of protection against harsh ambient conditions. Each drive and hoist motors are controlled by its' own inverters which are equal among themselves. Inverters together with cooling radiator are installed on top frame.



### 7.3 24 VDC electrical system

Kalmar ESC straddle carrier is equipped with 24 V electrical system having

- 2 pieces 12 V/220 Ah engine starting batteries
- 2 pieces 12 V/220 Ah batteries for secure power supply of control system
- battery isolator switch at battery casing
- alternator mounted to diesel engine
- main switches on ground level and in the cabin (if cabin installed)
  - Automatic switch off of the main switch after 60 minutes if machine is left unattended

Kalmar ESC straddle carrier meets Electromagnetic Compatibility (EMC) requirements according to EN 55012, EN 61000-4-2 and ISO 7637-2.

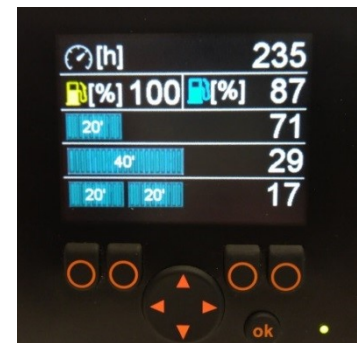
### 7.4 Instrumentation

On the left side frame there are operating hourmeter and panel meter in the electric cabinet. Ground level main switch and start/stop switches are located next to the electric cabinet. A shore power isolator switch exists in vicinity of the shore power connector socket.



On panel meter display are shown values of:

- Engine hours (total)
- Fuel level
- AdBlue level (if applicable)
- Number of 20ft containers (trip)
- Number of 40ft containers (trip)
- Number of twin containers (trip)



## 7.5 Lights

### 7.5.1 General

Lighting is built with LED lights providing

- Long lifetime
- Maintenance-free, no changing of the bulbs
- Energy savings
- Increased lighting performance for night time operation

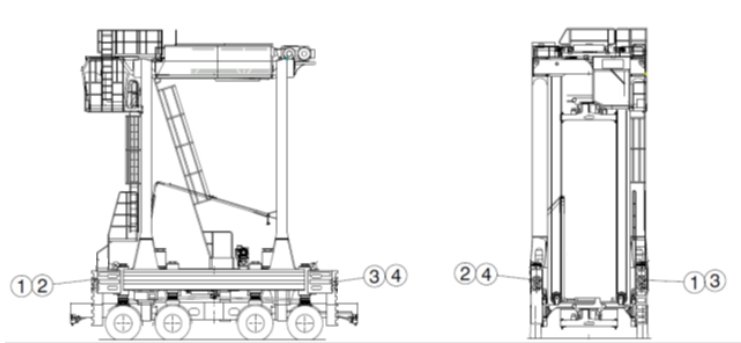
### 7.5.2 Driving lights

Driving light system is provided with headlights and three chamber rear lights consisting of tail light, brake light and turn signal at front and rear, total 4 sets.

Headlight (light position numbers 1-4)

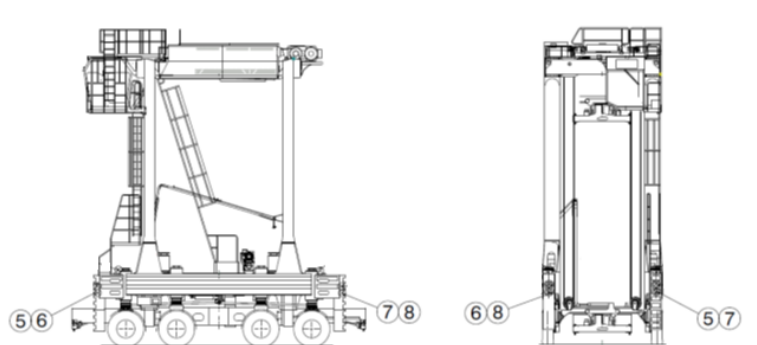
- Lumen output: 3,800 lm
- Voltage & power: 24V / 40W
- Single beam (i.e. no separate low beam/high beam)





Tail light (light position numbers 5-8)

- Three chamber light (tail light, turning signal, braking light)
- Voltage & power: 24V / <5W



### 7.5.3 Work lights

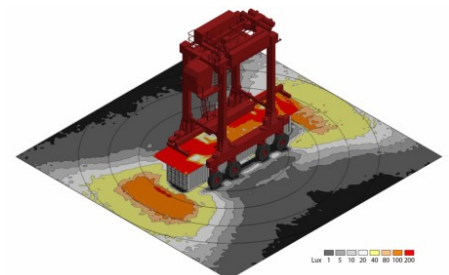
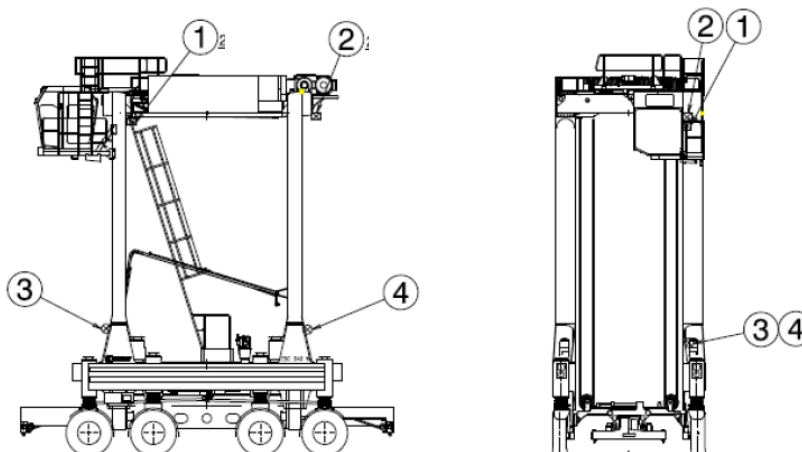
On top frame

- Work lights 2 pieces (light position numbers 1 and 2)
  - Lumen Output: 15000 lm
  - Voltage & Power: 24V / 150W



On left side frame

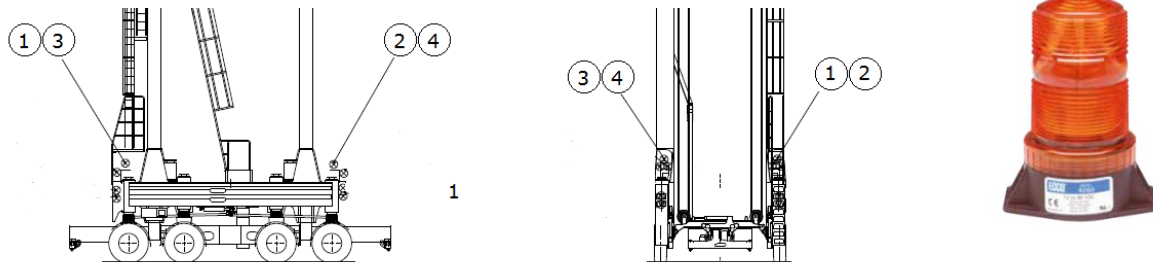
- Work lights 2 pieces (light position numbers 3 and 4)
  - Lumen Output: 1800 lm
  - Voltage & Power: 24V / 22W



#### 7.5.4 Flashing beacons

Flashing beacons are active always when the parking brake is controlled open and also for 3 seconds before the diesel motor starts when the engine start button is pressed.

- Amber beacon strobe at each end of side frames , 4 pieces (light position numbers 1-4)
  - SAE Class III, UL, CE, R10, IP66/67
  - Voltage & Power: 12-80V / <5W



### 7.6 PLC specification

Machine operation is comprehensively controlled and monitored by Omron programmable logic controller (PLC) covering all main functions of the equipment. PLC central unit is located in top frame electric cabinet. Control system composition is distributed I/O system with CanOpen communication.

#### 7.6.1 Monitoring

PLC system is continuously supervising machine functions extensively and providing corresponding information of machine status to the operator enabling effective and safe operation. PLC system has also self-monitoring feature ensuring proper functioning.

#### 7.6.2 Statistics

As PLC is used to control electrical functions of a straddle carrier, it enables to store monitored events widely, including operation statistics, into memory of the PLC. Recorded events can be checked afterwards, for instance weekly. Standard PLC system composition includes connection interface via Ethernet for optional StradMonitor diagnostic software.

An equipment telematics gateway is built in the Kalmar straddle carrier control system.

#### 7.6.3 Maintenance features

Kalmar PLC control system has built in maintenance and diagnostics tools

- operated through PLC touch type screen
- no additional tools needed

PLC maintenance pages are in easy to use menu format.

Maintenance features of the PLC system make it easier to maintain and test the straddle carrier. Various characters can be monitored and/or controlled using maintenance features of the PLC system.

Also default parameters for PLC can be set from the PLC display which is particularly handy when testing the straddle carrier or when changing the CPU of the PLC. All adjustable parameters are definite, thus wrong or dangerous values cannot be set.

Connection interfaces for optional portable PLC display unit are in the left side frame electric cabinet and in the top frame electric cabinet.

#### 7.6.4 Designed for automation

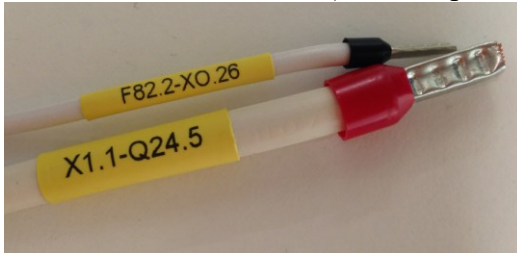
Kalmar is involved in extensive container handling equipment automation projects around the world. This enables Kalmar to equip all Kalmar straddle carriers with the latest technology that is ready to accept future automation updates immediately when they are available. All Kalmar straddle carriers include:

- CAN based fieldbus for remote unit control
  - fieldbus that can easily accept new automation modules without the need of complicated rebuilding the whole electrical system
- fly-by-wire control systems in the whole straddle carrier
  - PLC controls most of the functions of the machine. Also brakes and steering can easily be updated to be electrically controlled

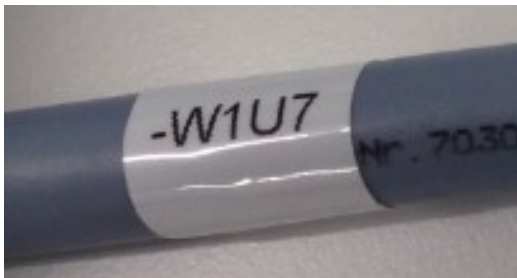
### 7.7 Cable and wire marking

Standard marking for cables and wires of Kalmar straddle carriers covers:

- Single wires are marked according to the connection points and markings are in line with the technical documentation (for example F82.2-XO.26).



- Molded cables are marked in line with technical documentation (for example -W1U7).



- Wires of molded cables are marked by the cable manufacturer typically by color or number. These markings are in line with technical documentation.



Marking method of single wires and molded cables is black printing on white or yellow label.

In the wiring harnesses single wire marking is consistent but marking is printed directly on the wire. Distance between the markings is about 10 cm.

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Markings are in accordance with standard 60204-32 *Electrical equipment of machines. Requirements for hoisting machines.*

## 7.8 Heaters

Machine is equipped with accessories enabling stand still heating of generator, hoist and drive motors and main electric cabinet with shore supply for avoiding condensation due to ambient temperature changes in humid atmosphere while machine is not used.

## 8 Cabin

### 8.1 General

Manually operated Kalmar straddle carrier is built with an ergonomic cabin mounted in front left hand upper corner inside the machine profile. Automated straddle carrier is typically built without cabin but still with possibility for manual driving on board.

The cabin is built with large windows all round including large floor and upper windows for good visibility out to working area. Remote controls are ergonomically placed on the arm rest of the seat. Hoist controller is electrical. All necessary instruments and special warning and control devices are easily accessible and located in a way that provides clear vision to them without obstructing the all-round visibility from cabin.

Features in the front cabin:

- wide cabin frame, spacious interior
- adjustable, comfortable, ergonomically designed operator's seat with seat belt
- adjustable right arm rest with all necessary controls
- adjustable steering column
- adjustable angle of accelerator and brake pedals
- ventilation fan
- heater
- air conditioning
- interior light
- windscreen wipers with interval switch and washers on front, right side and rear windows
- tinted cabin side glasses and clear floor glasses for better visibility
- opening upper (front and rear) windows for ventilation and better visibility towards cranes
- one floor window can be opened from inside for easier cleaning as well as for emergency exit
- low equivalent noise level in the cabin with doors and windows closed, due to good noise insulation.

### 8.2 Instrumentation

Main instruments provided in the cabin are:

- controls for load handling and driving
- electric main switch and engine start/shutdown switch
- PLC display showing various information, like speedometer, stability indicator, engine rpm and alarm information
- emergency stop switch and spreader stop switch



- hoist prevention bypass key switch

## 9 Corrosion protection and colours

### 9.1 Corrosion protection

A proper surface preparation for all steel structure is carried out prior to paint coating.

Painting system of outer surface of structural frame and spreader is project specific.

Painting system of outer and inner surfaces of cabin meets ISO 12944 expected durability C4-H and consists of:

- Zinc phosphate dipping, dry film thickness 1-2  $\mu\text{m}$  (0.04-0.08 mil)
- E-coat epoxy primer dipping, dry film thickness 15-20  $\mu\text{m}$  (0.59-0.79 mil)
- One coat of polyester powder paint finishing, dry film thickness 60-80  $\mu\text{m}$  (2.36-3.15 mil)

Painting system of outer surface of small parts and accessories meets ISO 12944 expected durability C3-L and consists of:

- One coat of epoxy primer, dry film thickness 80  $\mu\text{m}$  (3.15 mil)
- One coat of polyurethane finishing, dry film thickness 50  $\mu\text{m}$  (1.97 mil)

Walking platform gratings are hot dip galvanized and not painted.

Main electric cabinet on top frame and electric cabinets at side frames as well as power unit compartment cover are stainless steel and not painted.

All pressure pipes in hydraulic and brake system are treated with CrVI free thick film passivation method and not painted.

Certain small components in the machine and on the spreader, like hydraulic valves, base plates for hydraulic valves, small shafts and washers are not painted but they are corrosion protected with anti-corrosive agent.

### 9.2 Colours

The colours of main frame, spreader and cabin outside are project specific.

Rims, wheel hubs and bottom part of gliding plates are Kalmar white (RAL 7047). Markings and safety striping are either Kalmar white (RAL 7047) or Kalmar black (RAL 7021) depending on background colour. All AC electric motors are painted to supplier's standard colour (grey/blue).

Following stock components are painted to Kalmar black (RAL 7021) if they are painted (stainless steel and plastic parts are not painted): battery box, hoist winch, covers and housings of hoist ropes and rope sheaves, propeller shafts, small parts and accessories, lifting beams, spreader scissors, hydraulic cylinders, brackets for lights, cabin supports and frames of walking platforms.

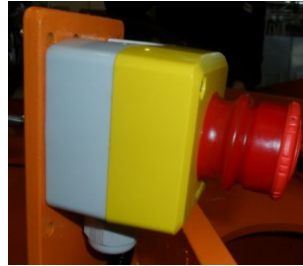
## 10 Safety

### 10.1 General

Kalmar ESC straddle carrier meets the requirements of the European directive 2006/42/EC Safety of machinery.

Kalmar ESC straddle carrier is equipped with:

- ladders with safeguard and non-skid surface walkways and platforms giving access to the machine itself and all major mechanical components
- gates at entrances of access ladder openings on top frame and cabin platform
- handrails on all elevated walkways
- attachment points for safety harness on top frame area
- portable fire extinguisher 6 kg (13 lbs.)
- emergency stop switches with red push button on top frame and on both side frames facing outwards
  - button diam. 40 mm, button with locking system, returning by turning



## 10.2 Stability control device

### 10.2.1 General description

The stability control device monitors and indicates the stability of the vehicle and, when the residual safety margin of stability starts to deteriorate, the active control feature limits the operation of the machine in order to resist the stability situation to become worse. Stability control device is integrated in the PLC system.

### 10.2.2 Safety principle

The driver is always responsible to slow down the driving speed when approaching the cornering situation. The driving speed in corners is normally less than half of the maximum straight driving speed.

The active stability control device is assisting the driver to keep the adequate safety margin when cornering but it cannot prevent tipping over of the machine if critical speed/turning radius ratio is exceeded. The alarm situation is to be avoided. The latest ten alarm cases are registered with time stamps into the logbook of the machine for enabling safety processing later on.

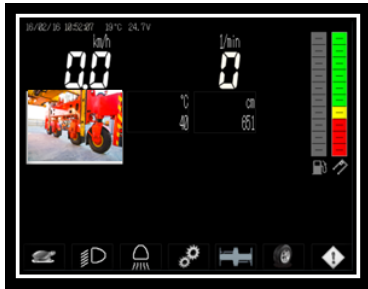
### 10.2.3 Monitoring and indication operation

The system continuously monitors driving speed, turning radius and spreader height and calculates the safety margin in each case. System provides both visible and audible indications to the operator.

The safety margin indicator beam is shown on PLC display. The residual safety margin is 100 % in straight driving situation. The indicator beam appearance colour changes according to the residual safety margin of stability:

- green > 40 % indicating normal driving situation
- 40 %  $\geq$  yellow > 30 % indicating warning situation
- red  $\leq$  30 % indicating alarming situation

Audible warning and alarm signals are given in the cabin correspondingly.

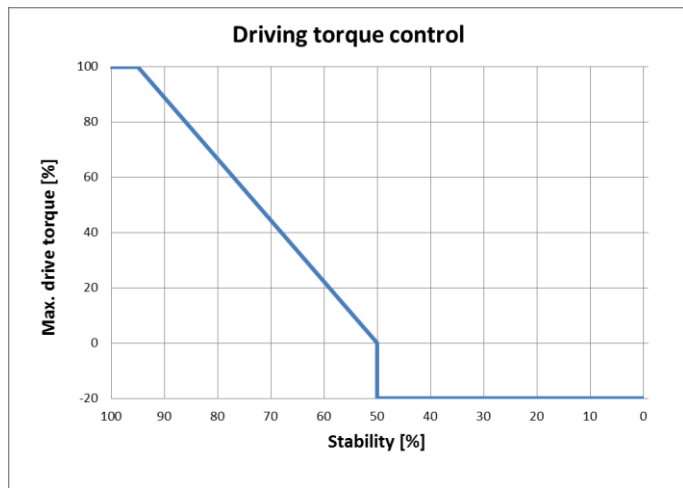


	Signal	Safety margin	Status
1	constant buzzer sound	$\leq 30\%$	<b>Alarm:</b> critical danger of tipping over
2	buzzer sound is repeated at regular intervals, cycle 0,2 s	$> 30\%$ $\leq 40\%$	<b>Warning:</b> danger of tipping over
3	no buzzer sound	$> 40\%$	normal driving situation

10.2.4 Active control operation

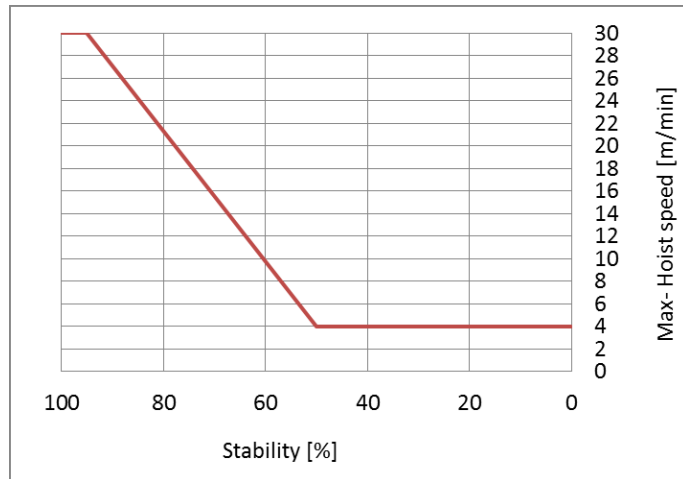
Driving torque control based on stability

- Stability over 95% - full driving torque
- Stability 95%...50% - control on
- Stability below 50% - mild electrical braking



Hoisting speed control based on stability

- Stability over 95% - full hoisting speed
- Stability 95%...50% - control on
- Stability below 50% - speed reduced to 4m/min



Automatic centering of spreader sideshift

- Conditions for automatic centering checked once after picking or placing container
- automatic centering done when following conditions are met
  - Driving speed exceeds 10km/h
  - Driving straight (to prevent automatic side-shifting towards outer side when cornering)

### 10.3 Warning devices and indicators

- audible sound signal when machine starts to move
- manual electric horns
- indicator lights in the cabin for "open" and "closed" position of twistlocks as well as for "container contact" and "centred" position of spreader
- parking brake indicator light in the cabin

### 10.4 Interlocks

Among other functions the PLC system also takes care of the interlocks which are protecting the machine and assisting the operator in safe container handling.

Driving prevention is activated and indicator light is on when shore power feed is on

- prevents using of the machine accidentally if shore power is connected

## 11 Maintenance interval

Basic maintenance interval excluding lubrication points is 1,000 operating hours.

## 12 Documents

Operator's manual, maintenance manual and spare part catalogue in electronic Adobe Acrobat format is included in machines delivery project scope. A printed paper copy of operator's manual is provided in each machine.

## 13 Training

Client's operator and maintenance staff instructors will be always properly trained. Upon successful attendance the trainees will receive a certificate.