





DUTY CYCLE CRANES
THE GUIDE

Philosophy, design and operations

VERSION 2.0

SENNEBOGEN

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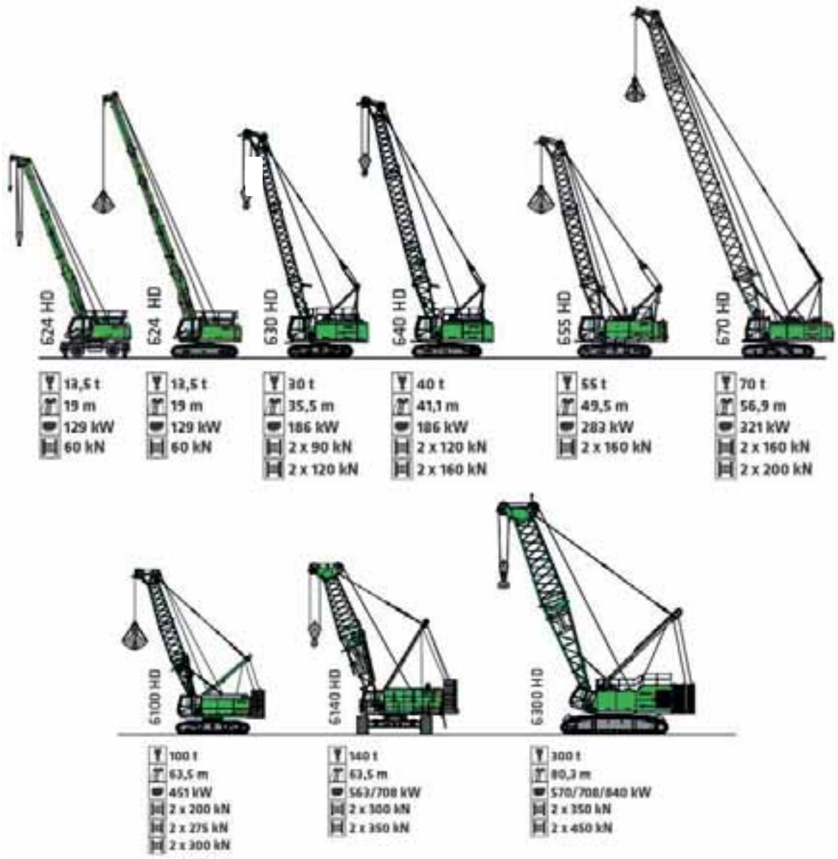


SENNEBOGEN Duty Cycle Cranes – Philosophy

SENNEBOGEN Duty Cycle Crane [source: SENNEBOGEN]

What is a duty cycle crane?

A **duty cycle crane** is an extremely robust construction machine for removing and transporting soil and stone, for which almost all excavator tool movements are executed with winch mechanisms and wire ropes. Duty cycle crawler cranes are in the machine class of excavators and differ from other machines in this category through the rope/mechanical transmission of force.

[Source: http://de.wikipedia.org/wiki/Seilbagger]

Duty cycle cranes are excavators (see ISO 6165:2006) equipped with an uppercarriage driven by wire rope. They are primarily designed for digging with dragline buckets, load buckets, or grabs, for compacting material with a compaction plate, for demolition tasks with a hook or ball, and for hoisting operation with special work devices and equipment.

[Source: DIN EN 474-12:2006]

INFO

Duty cycle cranes are used for dynamic, material-stressing operations, where the engine power, hydraulic power, and winch capacity of a crawler crane no longer suffice

What sets apart Made in Germany duty cycle cranes from SENNEBOGEN?

SENNEBOGEN duty cycle crawler cranes are robust, easy to maintain, and have a long service life!

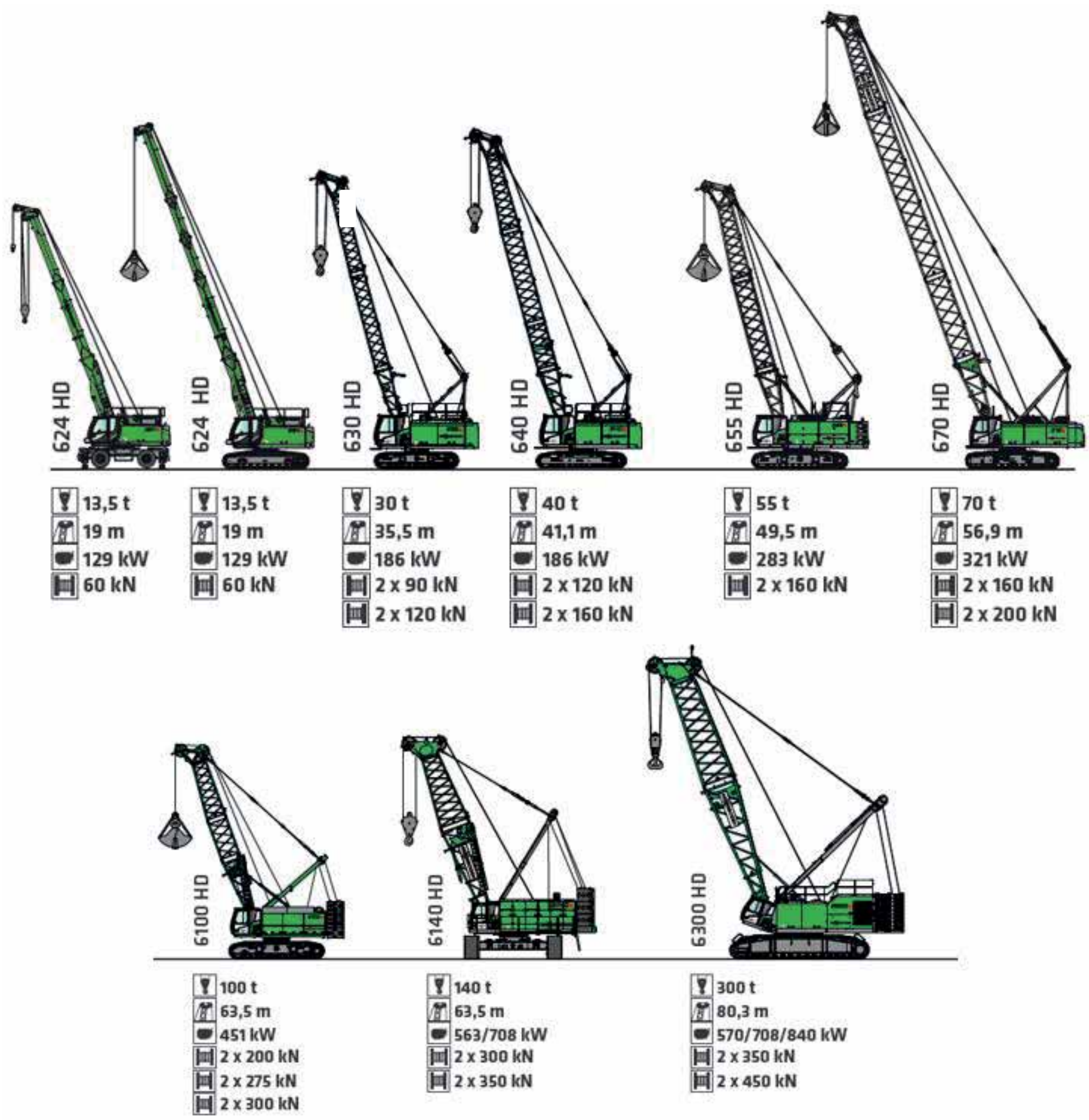
From more than 65 years of experience in mechanical engineering, a design philosophy has been developed that can be described using these key words. Our decades of experience and our successes in the crane industry confirm us in this philosophy.

Customers esteem the robustness and the ease of service of all components. SENNEBOGEN duty cycle cranes can be serviced on site with minimal effort. Often problems can be resolved without the assistance of our worldwide service organization. This worldwide availability demonstrates an additional strength of SENNEBOGEN: **Proximity to customers**.

SENNEBOGEN – There's no such thing as can't.

Essential characteristics of a SENNEBOGEN duty cycle crane

SENNEBOGEN offers decades of experience in the manufacturing of duty cycle crawler cranes. In the late 1960s, SENNEBOGEN developed the world's first fully hydraulic duty cycle crane. This innovative drive continues to this day and is demonstrated by an extremely wide product range with duty cycle cranes from 13.5 t to 300 t.

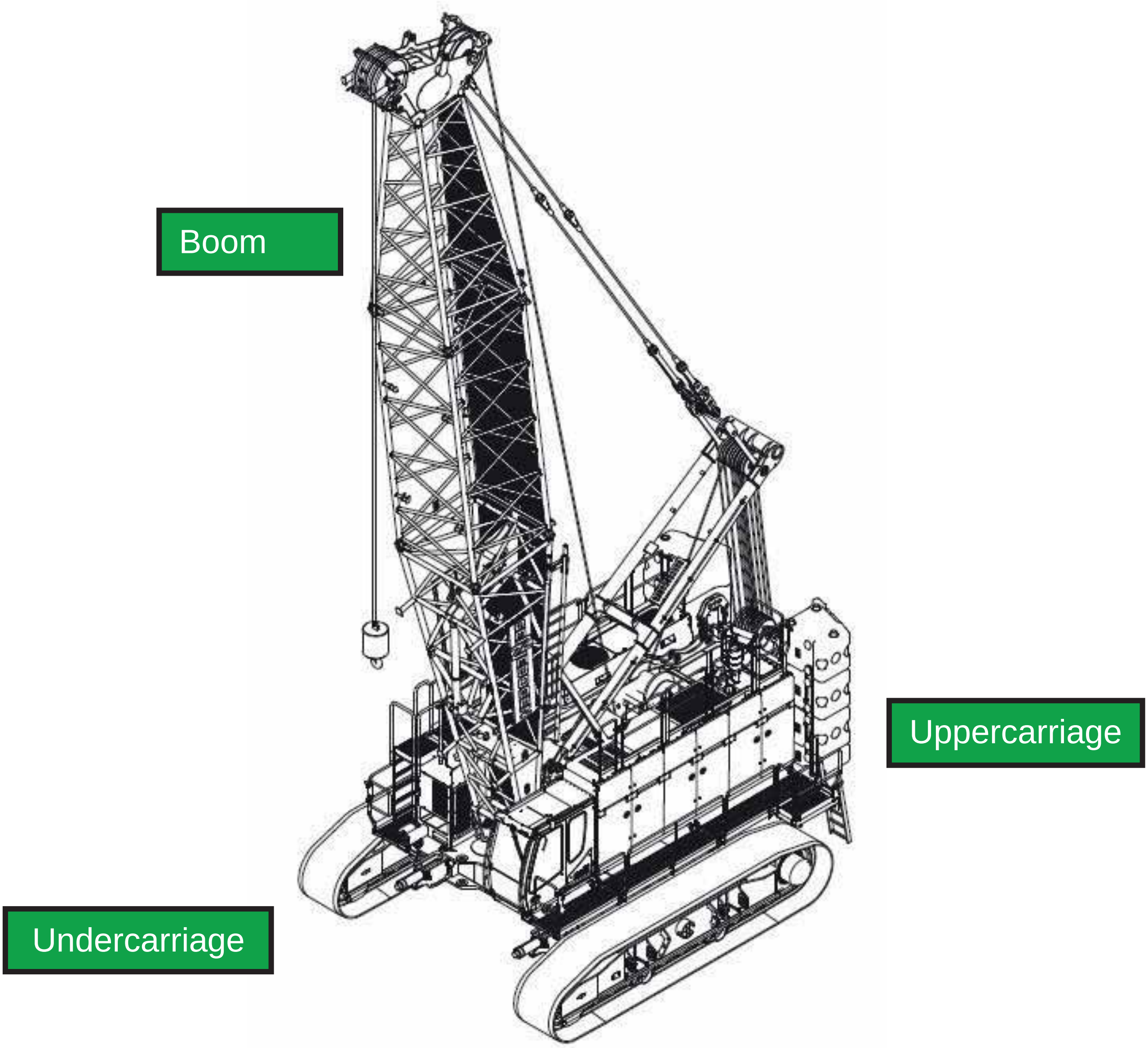


SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

The overall design of the SENNEBOGEN HD series is configured for loads arising from dynamic operations, making it absolutely in line with today's customer demands.

Duty cycle cranes are equipped with crane freefall winches. There is also a wide range of variation in component configuration (depending on the size of the machine) like for example engine capacities of up to 840 kW, winches pulling forces of up to 45 t, additional hydraulic systems etc.

The reinforced sheet thickness of the steel components and boom components also takes account of the dynamic forces in heavy-duty operation.



Structure of a SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

UNDERCARRIAGE – SENNEBOGEN duty cycle crane

SENNEBOGEN offers different undercarriage types for its duty cycle cranes depending on the machine size: Rigid undercarriages (624 HD), telescopic undercarriages (630 HD – 6100 HD), and Starlifter undercarriages (6100 HD – 6300 HD). All undercarriage types ensure a high level of machine stability thanks to the wide track, meaning that the machine is reliable even when rigorous requirements are imposed on the handling capacity.

Telescopic undercarriages (630 HD – 6100 HD) provide the option of varying the track width, which significantly facilitates machine repositioning. This applies to construction sites, as well as to truck transport between two construction sites.

Starlifter undercarriages (6100 HD – 6300 HD) offer first-class stability and a large track width, while also providing optimal transportability thanks to the self-mounting mechanism.

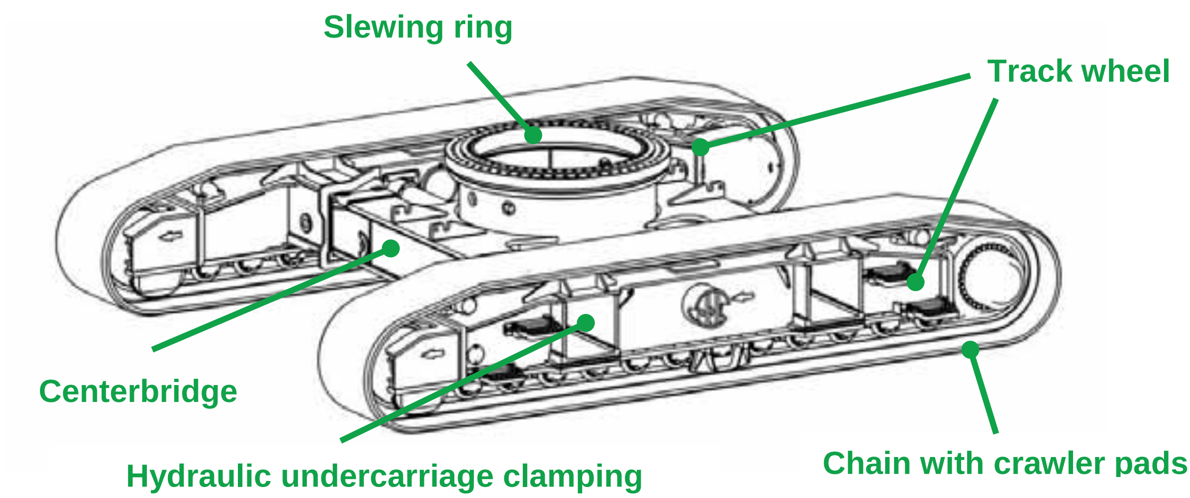
Overview of undercarriages for SENNEBOGEN duty cycle cranes

“S” = series production, “O” = option

Model	Type	SENNEBOGEN designation	Travel-ing gear	Length	Base plates										Track width re-tracted	Track width tele-scoped out (ex-tended)
				[mm]	600 3-bar	700 3-bar	700 flat	800 3-bar	800 flat	900 3-bar	900 flat	1000 2-bar	1200 flat	1500 flat	[mm]	[mm]
624 HD	Fixed	R25/240 (S) R25/215 (O)	B4HD	4.440	S	O									2.400 2.150	2.400 2.150
630 HD	Tele	T27/355	60b	4.815		S	O	O							2.280	3.550
640 HD	Tele	T41/380-2	60b	5.300		S	O	O							2.300	3.800
655 HD	Tele	T47/370	6b	5.735		S		O							2.400	3.700
670 HD	Tele	T83/390	7b	6.002		S	O	O							2.300	3.840
6100 HD	Tele/ SL	T107/420	B7 (S) B8B (O)	6.440				S	O	O	O				3.480	4.200
6140 HD	Starlifter	T140/550	B9HDS	7.180								S	O		4.600	5.500
6300 HD	Starlifter	R300/680-V	S10	9.500									S	O	6.800	6.800

duty cycle crawler crane	Type	SENNEBOGEN designation	Support leg track width retracted	Support leg track width extended
			[mm]	[mm]
624 HD	Mobile	MP26E	2.910	3.910
630 HD	Mobile	MS30-2	2.834	5.620
640 HD	Mobile	MS40-2	3.029	6.000

Overview of undercarriages for SENNEBOGEN duty cycle cranes [source: SENNEBOGEN]



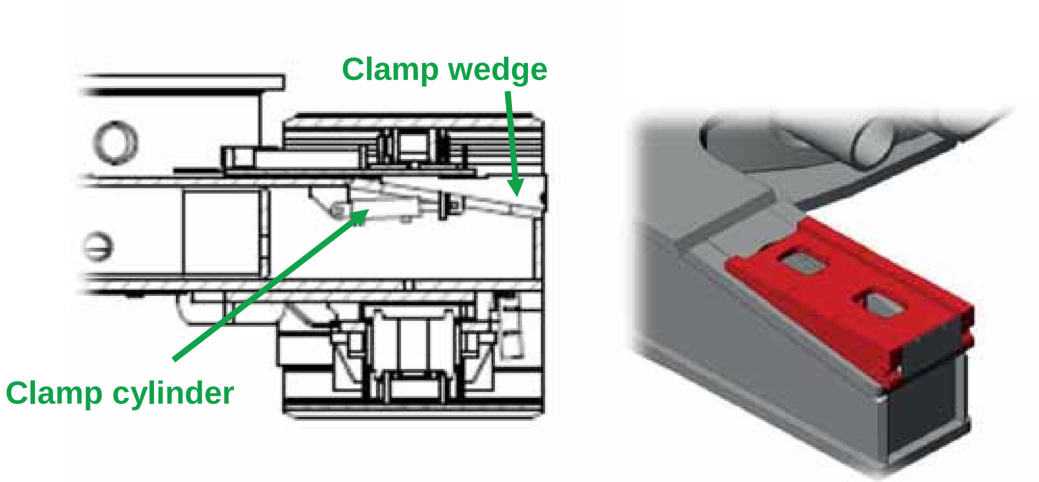
Detail graphic of undercarriage – SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

SENNEBOGEN duty cycle crane undercarriages generally consist of the following main components:

- Center bridge
- Track wheel carrier on the left and right
- Chain on the left and right with base plates
- Hydraulic undercarriage clamping (for telescopic undercarriages)
- Slewing ring

Different **crawler pads** can be offered for all duty cycle cranes with a crawler chassis. The wider the base plates that are selected, the more optimal is the ground pressure distribution thanks to the enlarged contact area. There is also the option to choose between 2-bar / 3-bar base plates and flat shoes. Base plates with welded-on bars are particularly well-suited for difficult terrain. Flat shoes, on the other hand, are primarily suited for substrates where damages need to be avoided.

The **hydraulic undercarriage clamping** works with cylinders integrated in the middle bridge – exclusively in extended state. The cylinders pull the clamping wedges with a constant force of 30 bar in the opposite direction to the telescoping direction. The telescopic undercarriages therefore provide maximum stability and torsion-resistance. This allows a precise positioning of the duty cycle crane and does not require a constant re-tensioning associated with mechanical undercarriage clamping.



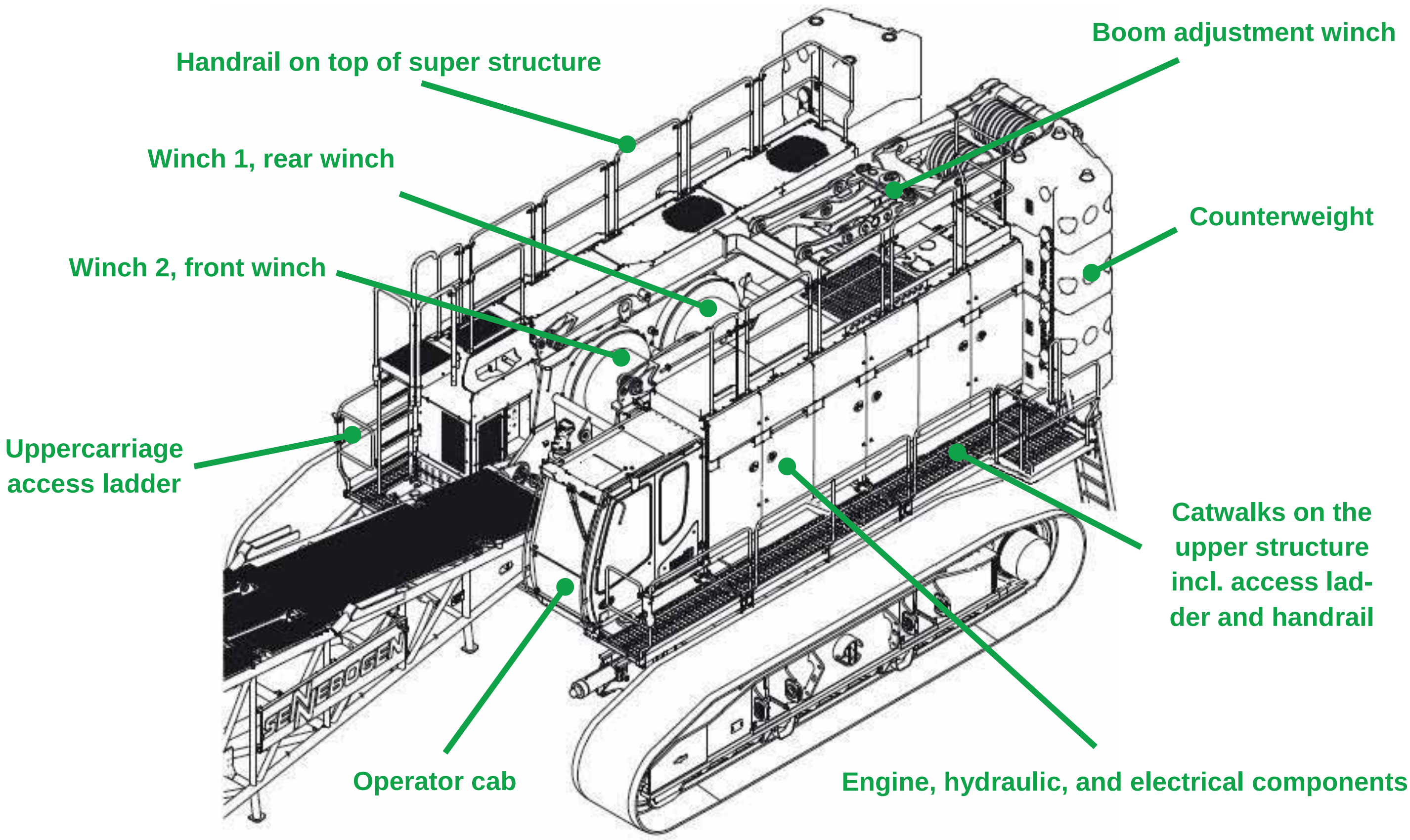
Detail graphic of undercarriage clamping of SENNEBOGEN duty cycle cranes [source: SENNEBOGEN]

The **slewing ring** is the connecting point between the undercarriage and uppercarriage and must be generously dimensioned as the interface for force transmission. SENNEBOGEN uses a 3-row sheave slewing ring starting from the 100 t duty cycle crane (6100 HD).

Optimal slewing force and maximum power are ensured via strong dimensioned slewing drives. As many as three slewing drives can be installed per duty cycle crawler crane, depending on the size of the machine.

UPPERCARRIAGE – SENNEBOGEN duty cycle crane

All the core components, such as the engine, winches, counterweight, and cab with complete control of the duty cycle crane, are integrated into the uppercarriage of SENNEBOGEN HD cranes. Due to the various dynamic loads on the machine, the uppercarriage needs to be very robust. At the same time, an efficient and well-structured / clear design is essential for simple operation and maintenance.



Detail graphic of uppercarriage – SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

The **operator cabs** of the HD cranes – the SENNEBOGEN Multicab (624 HD) and SENNEBOGEN Maxcab (from 630 HD) – allow the operator to perform even extremely protracted and strenuous deployments without problems thanks to their optimal ergonomics, the all-round view and diverse other equipment variations.

Detail graphic of SENNEBOGEN Maxcab [source: SENNEBOGEN]

To ensure an optimal view and handling for the operator, some duty cycle cranes can be optionally equipped with tiltable cabs. In addition, SENNEBOGEN offers other designs that are adapted to the respective customer and work requirements, for example, a cab that can be hydraulically elevated by 2.70 m. Optional bulletproof glass and additional protective gratings provide protection for every application.

The standard version of a SENNEBOGEN HD crane is always equipped with 2 **winches** and a **boom adjustment winch**. The winches are freefall winches. SENNEBOGEN offers freefall winches with a pulling force between 6ton and 45ton. This rope pulling force is the determining factor for the working capacity of the machine since many tasks are executed single-strand with maximum pulling force, which makes the winches one of the most stressed components of the duty cycle crane.

The **counterweight** is optimally adapted to the respective machine size. Some duty cycle cranes have the option of increasing the load capacity with additional counterweight in the undercarriage or at the rear. This allows higher load capacities in crane operation or higher stability in HD applications. For 624 HD – 670 HD, the counterweight consists of cast concrete blocks. Starting from the SENNEBOGEN 6100 HD, counterweight plates are used.

HD crane	engine				freefall winches	counter-weight	optional counterweight options	design of CW	cabin type	cabin options
	supplier	[kW]	[kW]	[kW]	[t]	[t]				
624 HD	CUMMINS	129			6	5,80		block	MultiCab	
630 HD	CUMMINS	172	186		9 / 12	6,50		block	MAXCAB	tiltable by 15° / elevatable by 2,7m
640 HD	CUMMINS	172	186		12 / 16	8,20		block	MAXCAB	tiltable by 15° / elevatable by 2,7m
655 HD	CUMMINS	254	283		16	18,00		block	MAXCAB	
670 HD	CUMMINS	261	321		16 / 20	22,00		block	MAXCAB	tiltable by 15° / elevatable by 2,7m
6100 HD	CUMMINS	433	451		20 / 27.5 / 30	28,00	35,00 OW + 17,00 UW	Ground plate and counterweight plates	MAXCAB	tiltable by 15° / elevatable by 2,7m
6140 HD	Caterpillar	563	708		20 / 30 / 35	34,00	45,00 OW	Ground plate and counterweight plates	MAXCAB	tiltable by 15° / elevatable by 2,7m
6300 HD	Caterpillar	563	708	840	35 / 45	85,00	105,00 OW + 40,00 UW 135,00 OW + 40,00 UW	Ground plate and counterweight plates	MAXCAB	tiltable by 15°

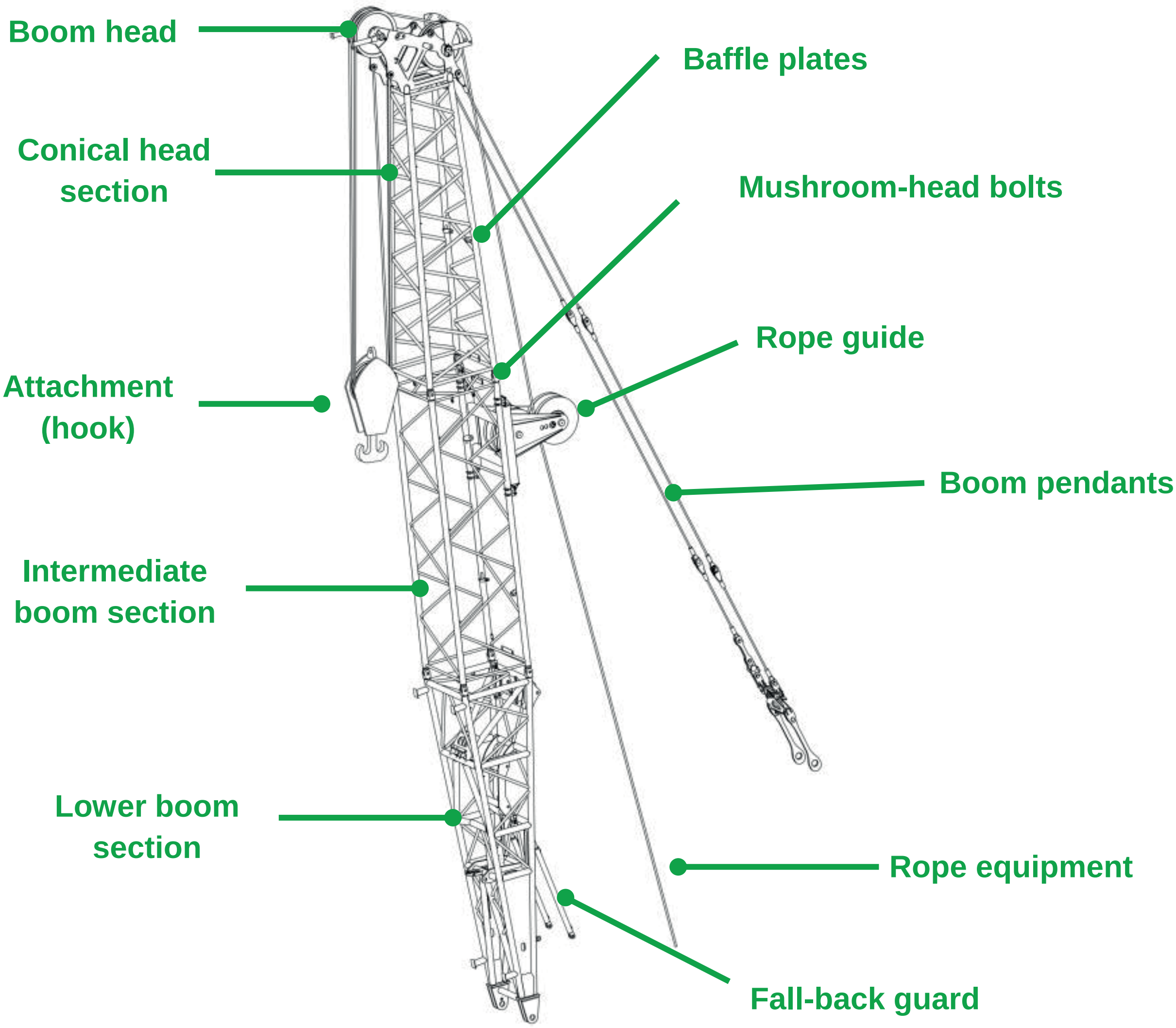
Detail graphic of uppercarriage – SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

The **drive unit** (engine) of the SENNEBOGEN duty cycle cranes is matched to the operation conditions and the power required to operate all hydraulic components. SENNEBOGEN exclusively uses engines from well-known manufactures, such as Caterpillar and Cummins. All engines offer an optimal combination of maximum efficiency and long service life, with low diesel consumption. SENNEBOGEN provides an 840 kW diesel engine for the 6300 HD as the current maximum engine size.

INNOVATION: **SENNEBOGEN also offers electric motors for its duty cycle cranes upon request. However, unlike machines with diesel engines, machines with an electric motor require a pylon to house the electronics.**

BOOM – SENNEBOGEN duty cycle crane

The boom of the SENNEBOGEN duty cycle crawler crane has been specially designed for the hard requirements of the various dynamic uses. Incredible robustness and stability are responsible for maximum load-bearing capacity and efficiency.



Example diagram of boom – SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

The boom of the SENNEBOGEN duty cycle crane generally consists of the following main components: Lower boom section, intermediate boom sections (different sizes), boom head, fallback protection, and boom pendants. Baffle plates, rope guides, and mushroom-head bolts are additionally mounted on the boom sections. The rope equipment runs from the winches, along the boom via the boom head to the attachment.

The **boom head** is designed for the maximum dynamic load. Depending on the application, this can be optionally equipped with steel sheaves and a sheave shield or HD sheaves on the front axle. The sheave shield guarantees optimal rope guidance on the boom head for highly dynamic applications. This prevents the rope from slipping off the sheaves.

Detail graphic of SENNEBOGEN boom head with sheave shield [source: SENNEBOGEN]

Steel sheaves and HD sheaves have the advantage of higher wear-resistance over plastic sheaves, meaning longer use, especially for dynamic loads.

SENNEBOGEN offers the following **boom configurations** for its duty cycle cranes:

duty cycle crawler crane	Length HA	Length HA dynamic Use	Length Boom sections	Auxiliary jib	Length Fly boom	Capacity Fly boom
	[m]	[m]	[m]	[t]	[m]	[t]
624 HD	14.0 - 19.0	14.0 - 19.0	---	---	---	---
630 HD	10.3 - 35.5	13.1 - 24.3	2.8 / 5.6	8.5	6.0 - 18.0	8.5
640 HD	10.3 - 41.1	13.1 - 24.3	2.8 / 5.6 / 11.2	12	6.0 - 18.0	12.0
655 HD	10.3 - 49.5	13.1 - 27.1	2.8 / 5.6 / 11.2	12	6.0 - 15.0	12.0
670 HD	12.1 - 56.9	14.9 - 28.9	2.8 / 5.6 / 11.2	12	6.0 - 18.0	14.0
6100 HD	13.1 - 69.1	18.7 - 29.9	2.8 / 5.6 / 11.2	12 / 24	---	---
6140 HD	13.1 - 63.5	13.1 - 41.1	2.8 / 5.6 / 11.2	12 / 24	---	---
6300 HD	18.7 - 80.3	24.3 - 52.3	5.6 / 11.2	48	---	---

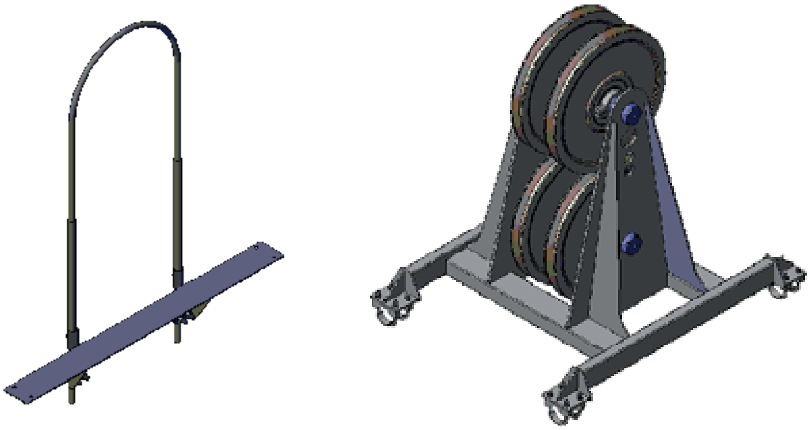
Boom details – SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

The **boom pendant** is guaranteed via pendant-ropes due to the dynamic loads arising during duty cycle crane operation (unlike crawler cranes with guy bars). The length is always adapted to the size of the boom sections used. This is necessary in order to allow a flexible variation of the boom length for the respective use.

Detail graphic of SENNEBOGEN guying rope [source: SENNEBOGEN]

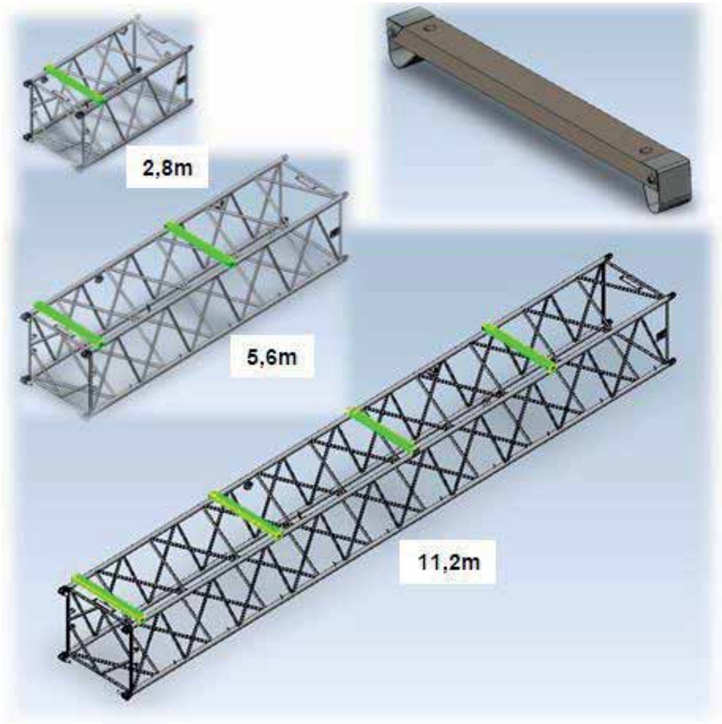
The boom pendants on the SENNEBOGEN 6300HD consists of aramid ropes. This is necessary for weight-saving reasons since conventional guying made of steel ropes is no longer feasible at this machine size.

Rope guidance on the boom can be ensured by rope guides or rope guide sheaves. The rope guide is used to avoid slack rope and prevents lateral slip-off of the rope and thus associated damage to the rope or to the boom. The number of rope guides used varies from use to use and can also be modified on customer request.



Detail graphic of rope guide – rope grab (left) and rope guide sheaves (right) [source: SENNEBOGEN]

The top side of the boom is fitted with **baffle plates** to prevent damage from the ropes. The baffle plates are made of hard plastic. The number of baffle plates varies depending on the length of the intermediate boom section. In the standard version, SENNEBOGEN uses one plate for an intermediate section 2.8 m in length, two baffle plates for an intermediate boom section 5.6 m in length, and four baffle plates for an intermediate boom section 11.2 m in length. For some applications (e.g. demolition) other baffle plates may be recommended.



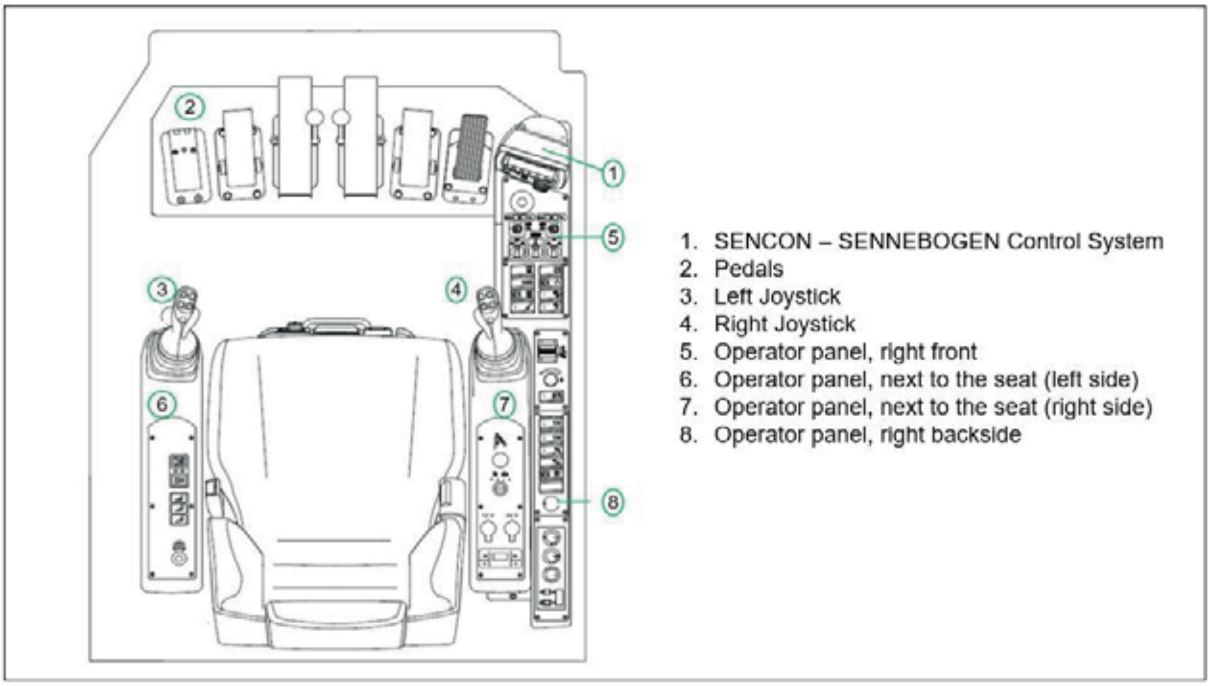
Impact strip detail graphic and baffle plates on various boom sections [source: SENNEBOGEN]

SENNEBOGEN duty cycle cranes are equipped with **mushroom-head bolts** in the upper bolt points of the intermediate boom sections. They prevent the ropes that laterally slip off the boom from catching on the bolts, which could cause damage to the rope, as well as to the boom bolts.

Mushroom-head bolts [source: SENNEBOGEN]

CONTROL ELEMENTS – SENNEBOGEN duty cycle cranes

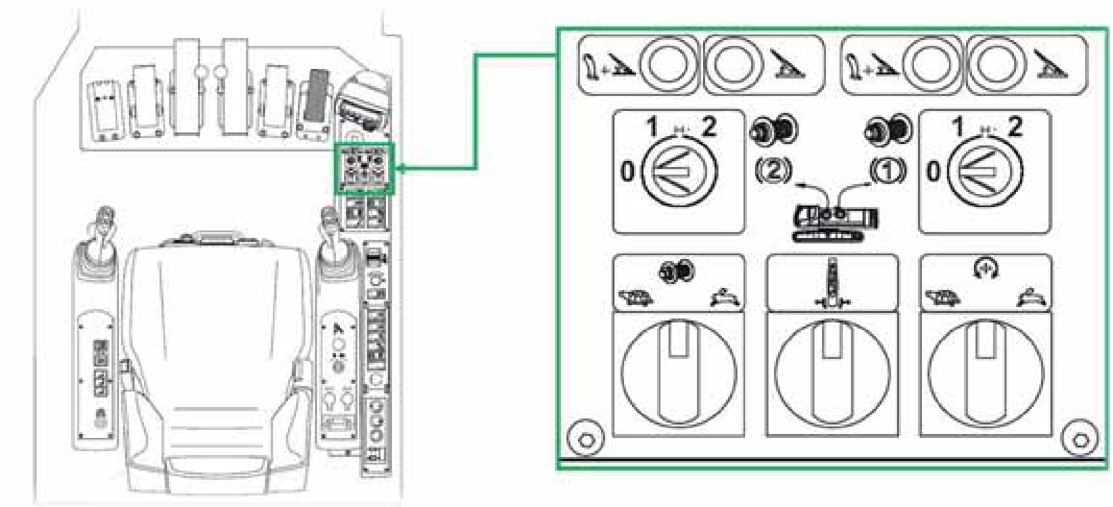
SENNEBOGEN offers technical innovations for its duty cycle crawler cranes that guarantee more efficiency and optimal handling of the machine. The control system, adapted to the respective operation conditions, comprises the winch control module, SENCON, and other technical components which will be discussed in more detail below.



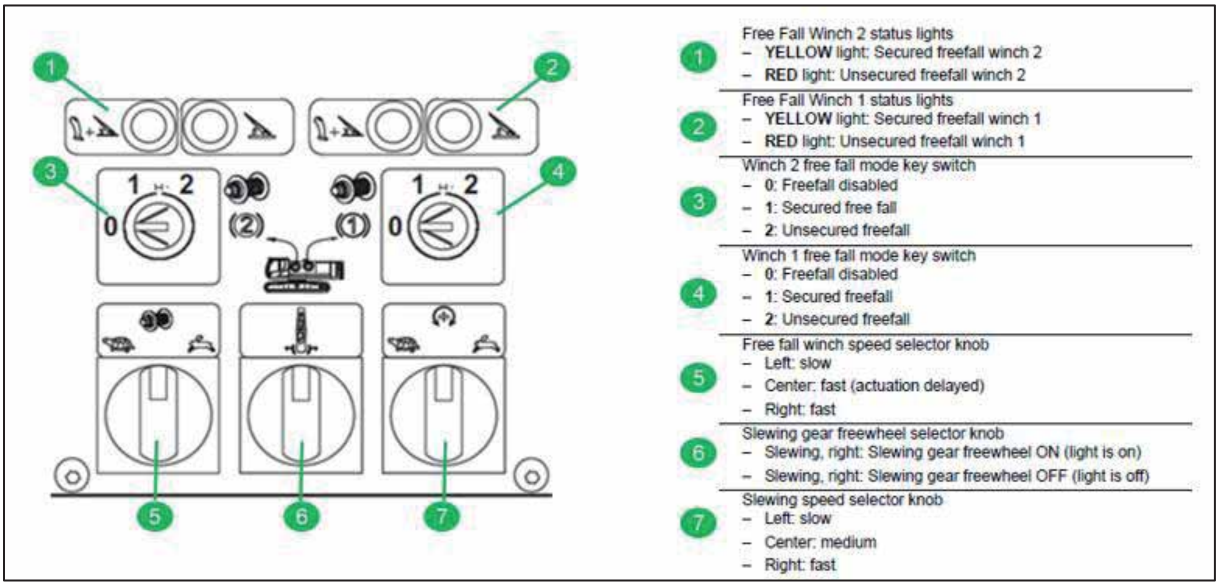
Control elements in the cab [source: SENNEBOGEN]

Key switches: Crane operation / freefall secured + unsecured

The key switches (see item 5 in the graphic above) can be used to select the crane mode (0), secured freefall (1), or unsecured freefall (2) operation mode. In hoist operation (0), the winch or the load can only be moved up or down by operating the joystick.



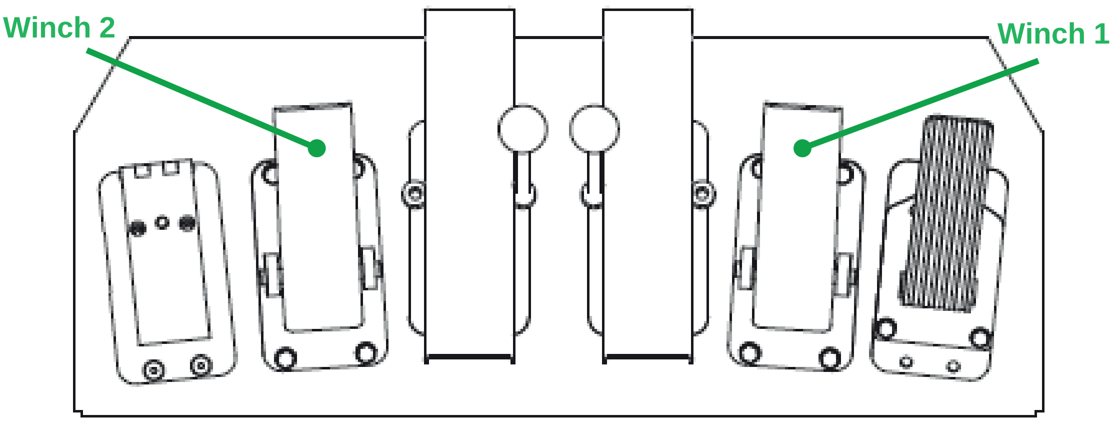
Key switches: Control panel, front right [source: SENNEBOGEN]



Key switches: Control panel, front right [source: SENNEBOGEN]

In secured freefall (1), the winch or load is braked or allowed to fall uncontrolled using the respective foot pedal. For this the foot pedal must first be pressed down to the floor and held in this position. Freefall is now activated. Then the appropriate control lever / joystick must be pushed forward and held in place. The freefall can be controlled with sensitive and slow release of the foot pedal (Attention: Do not fully release the foot pedal, otherwise the load moves in complete freefall and cannot be subsequently braked). The brake is reactivated by reapplying pressure to the foot pedal (stepping on it). Braking and off-loading occur proportionally in each case. Only return the control lever to neutral position once the load has been brought to a standstill.

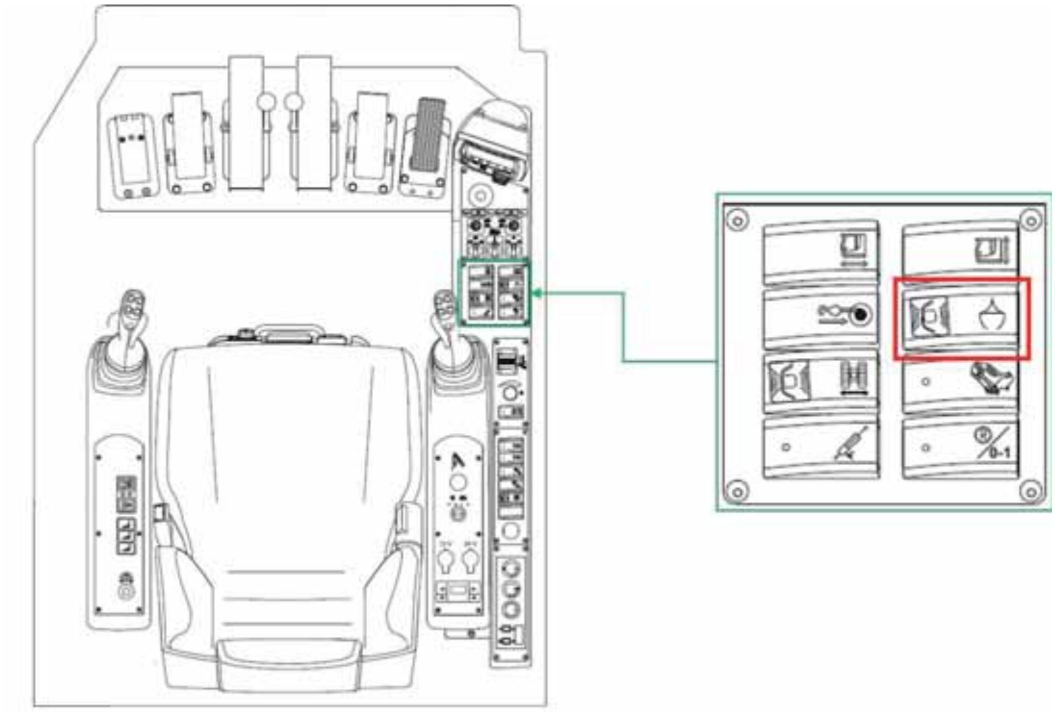
The freefall of the winch or load is also controlled using the foot pedal in “unsecured freefall (2)” operating mode. For this the foot pedal must first be pressed down to the floor and held in this position. Freefall is now activated. Unlike in secured freefall mode, in this mode it is not necessary to use the appropriate control lever / joystick in addition to the pedals.



Foot pedals – freefall control for the relevant winch [source: SENNEBOGEN]

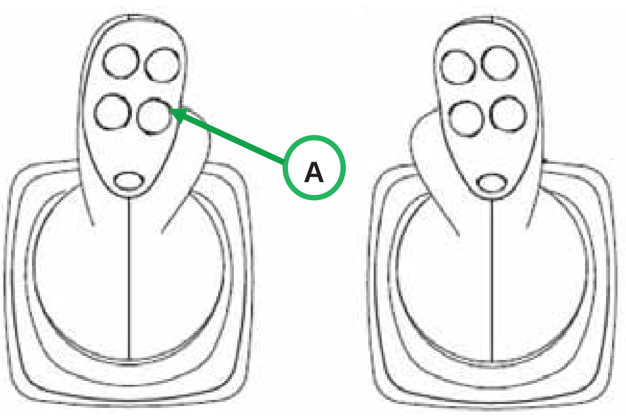
Grab autofill: Winch freewheeling for optimal grab filling, winch 1

The grab autofill function is used for operation with 2-rope grabs (diaphragm wall grab, casing oscillator, dredging, etc.). To enable this function, first the freewheeling of the rear winch (winch 1) with the grab hoist rope needs to be activated by pressing the corresponding switch on the front right control panel.



Switch for grab autofill: Control panel, front right [source: SENNEBOGEN]

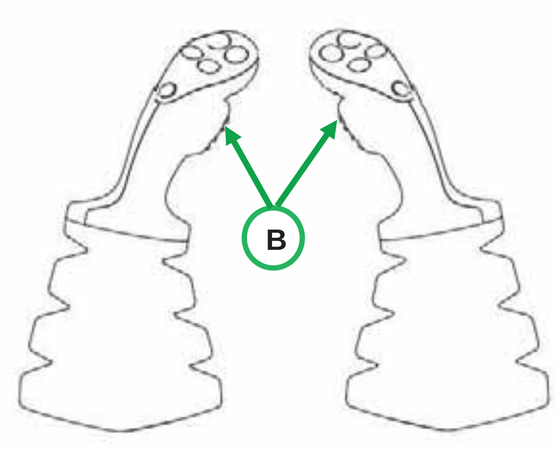
To fill the grab, it needs to be open and facing the bulk material. Then the freewheeling can be executed by pressing and holding the "A" button on the left joystick. The grab penetrates down into the material through the switched-on winch freewheeling and the deadweight of the grab. In parallel, the grab is closed by activating winch 2, which results in optimal filling. Once the grab is completely closed, button A needs to be released. This deactivates the winch freewheeling. Then the filled grab can be lifted using both control levers (winch 1 and winch 2).



Activation of winch freewheeling for winch 1 using the left joystick button [source: SENNEBOGEN]

Combi-Link: Crane operation / freefall operation changeover via joystick

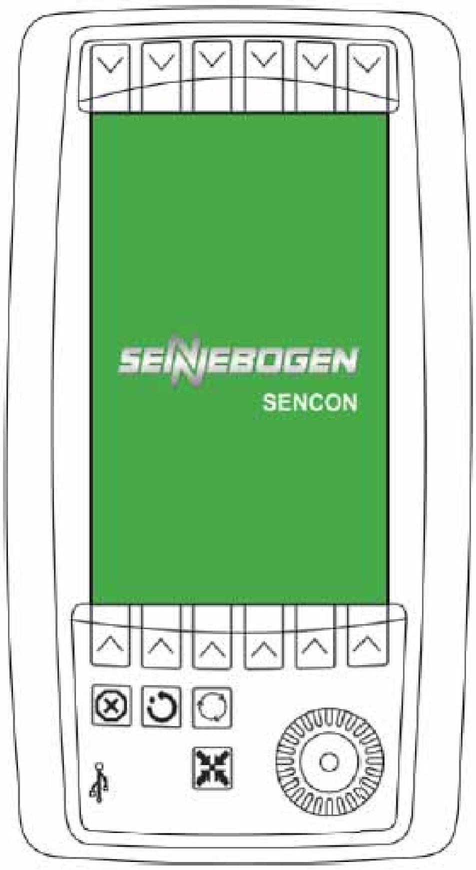
If a duty cycle crane is equipped with freefall winches, it may be necessary to temporarily switch the winches from freefall mode to the hois (crane) mode for certain operations using the joystick button. This function is provided on SENNEBOGEN duty cycle cranes by the so-called Combi-Link and is part of the standard equipment of every duty cycle crane. If the winches are in freefall mode, pressing and holding the "B" button on the joystick activates friction-locking operation for the winches until the button is released. This may be necessary, for example, for operations with diaphragm wall grabs. In friction-locking operation, the grab is initially fed into the slot and then lowered in freefall mode to enable it to dig into the material. This function is also required for dragline bucket, demolition, and casing tasks.



Combi-Link button for winch 1 and winch 2 [source: SENNEBOGEN]

SENCON 2.0: SENNEBOGEN control system 2.0

Another tool for crane operators is the diagnostic and control system installed as standard in all new machines – the SENCON (**SEN**nebogen **CON**trol system). This control and monitoring unit enables current machine operating data to be recorded and statistically evaluated as required. The system also allows the operator to configure various machine parameters and to conduct troubleshooting. The system's display and operation options are on a small screen in the front right area of the cab.



SENNEBOGEN control system – SENCON [source: SENNEBOGEN]

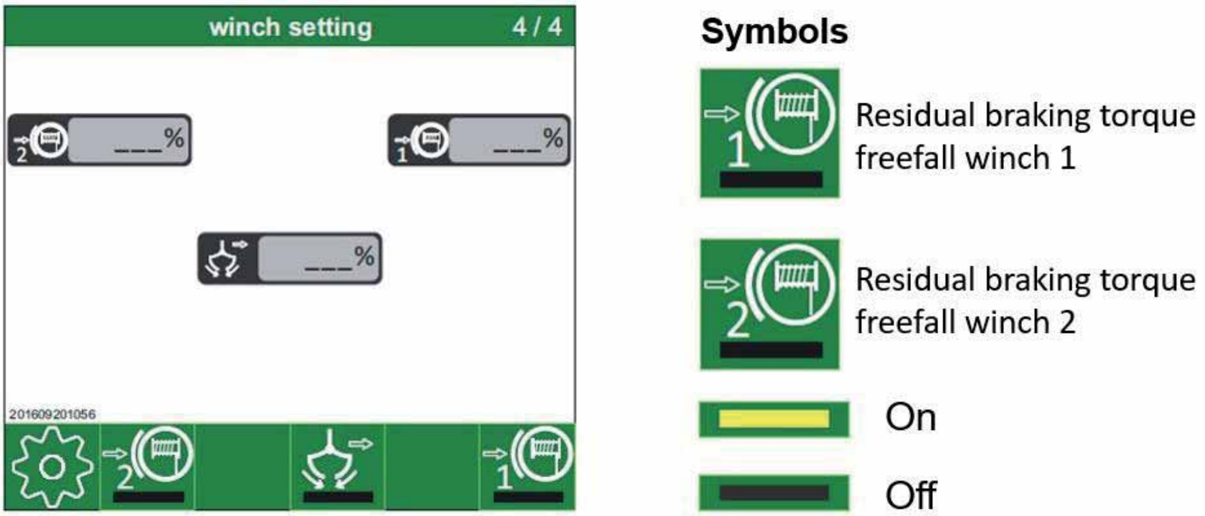
The main priority of the SENCON functions is local diagnostics, such as engine, CAN bus, or cooling diagnostics. The machine operator also receives all current machine data, such as consumption, speed, and load in a clearly compressed format on the small monitor.

There is also an option to install SENtrack^{DS} on the machines. With this system, SENNEBOGEN is providing an option for remote diagnosis with the main purpose of simplifying service planning. For example, it is possible to monitor the energy efficiency or maintenance condition of the machine. The system can also be expanded to include a remote shutdown option if required.

If the duty cycle crane also needs to be used in hoist operation, the machine needs to be fitted with a so-called load moment indicator (LMI). If a machine is equipped with an LMI, this can be set and operated via the SENCON or via an additional LMI display. The LMI uses sensors to monitor crane functions and provide the machine's capacity data to the crane operator in real time. If the machine approaches the maximum load capacity, the LMI warns the operator via an acoustic and visual signal. If the machine reaches an inadmissible operating range despite the warnings, all machine movements that increase the crane's load moment are shut down by the LMI. If this happens, only the “lower winch” function can be used to relieve the load on the machine. The system is intended to prevent accidents and damage to the machine due to overload. Even when there is an LMI installed in the machine, experience, caution, and good judgment on the part of the operator are essential to ensure safe machine operation.

Thanks to the modular structure of the system, the functionality can be enhanced by additional features. These can be easily installed via a USB stick.

SENCON is the only way to **set the residual braking torque (freefall velocity)** of the respective freefall winch. Under the "winch setting" tab, the residual braking torque can be set separately and independently for each winch. The value 0% means that the freefall will be executed at maximum speed. Increasing the value partially engages the freefall brake and reduces the freefall velocity. This prevents the occurrence of slack rope and enables better monitoring/control for freefall tasks.

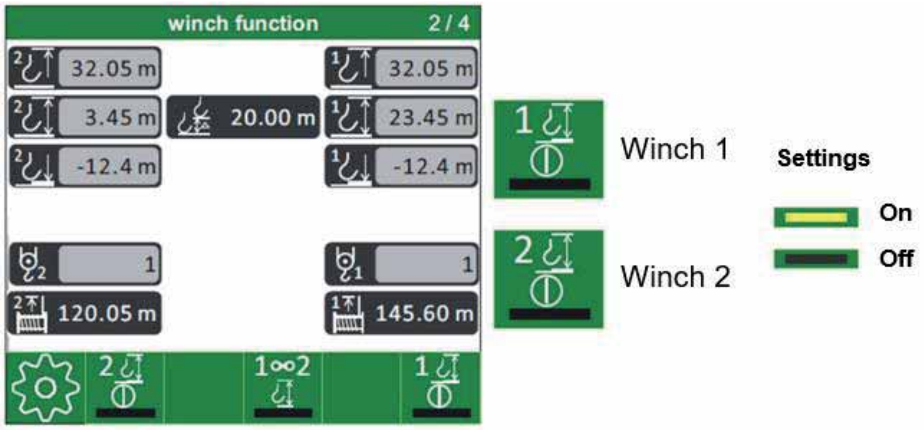


SENCON – setting the residual braking torque [source: SENNEBOGEN]

The **joystick toggle button** can be used to swap the assignment of the two control levers / joysticks, and therefore the control of the winches. The button is underneath the quick-selection symbols in the SENCON console. If the toggle switch is deactivated, the standard settings are valid (see the respective operating manual). Selecting and confirming the symbols shown below activates the swap and switches the assignments of the control levers. This is indicated visually by the button lighting up yellow.

SENCON – joystick toggle button [source: SENNEBOGEN]

The **depth indicating device** is a tool for the machine operator that displays the height of the load / work equipment (for example, grab). The height depends on a zero point that can be set by the operator via the display. When the function is activated, sensors on the machine monitor the current operating conditions and transmit the measurement results to the depth indicating device. After analysis, the values are presented on the SENCON screen automatically or by the touch of a button.



SENCON – depth indicating device [source: SENNEBOGEN]

The depth indicating device with shut-off also includes shut-off of the winches at a specific depth.

Winch synchronization, winch 1 / winch 2

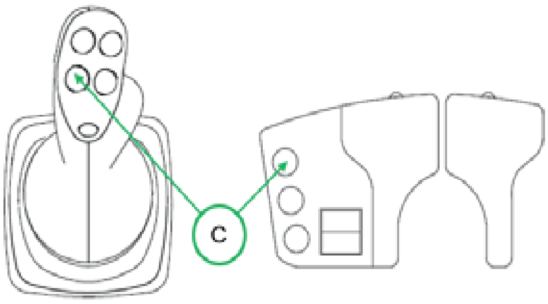
In some application areas, especially in 2-rope grab operation, it may be necessary to control both winches synchronously, for example to lift a grab. In order to facilitate precise synchronous operation of the winches, SENNEBOGEN duty cycle cranes are equipped with two different winch synchronization functions: hydraulic and electronic winch synchronization. Winch synchronization is activated/deactivated in the SENCON or by pressing the push button on the control lever. To use this function, the two winches need to be in the same operating mode (see the key switch section).

Hydraulic winch synchronization

Hydraulic winch synchronization is part of the basic equipment of each SENNEBOGEN duty cycle crane. When this is activated, the two hydraulic pumps for winch 1 and winch 2 are interconnected, which means that there is pressure equalization in the supply line for the two control valve sections of winch 1 and winch 2.

The parallel circuit provides the following functionality:

- Activation of hydraulic synchronization via a push button [C] in the joystick
- The system only functions with the LIFT function
- Both control levers for winch 1 and winch 2 need to be moved equally (the load distribution on the winches needs to be the same)
- This provides just one useful feature for practical application in rope grab operation



Activation of hydraulic winch synchronization [source: SENNEBOGEN]

Electronic winch synchronization

With electronic winch synchronization, the respective position of the winch is detected by sensors (angular position encoders). At activation of electronic winch synchronization, the control lever / joystick of winch 2 is deactivated. The joystick of winch 1 controls now both winches.

In the background: With the joystick of winch 1, winch 1 is controlled, and winch 2 is readjusted via winch positioning detection.

Electronic winch synchronization can be run in 2 operating modes:

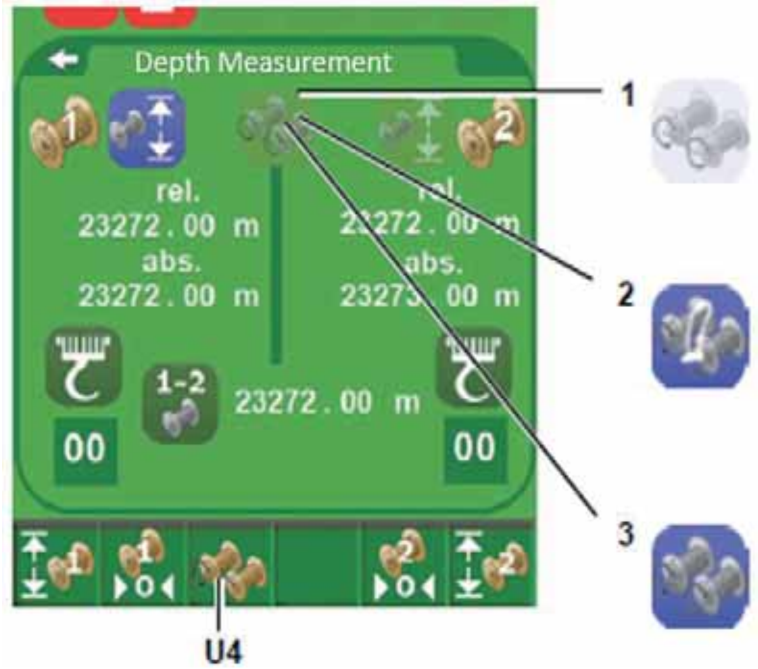
A. Temporary operation – activation via SENCON

In temporary mode synchronization is only activated if the associated button on the joystick is activated. For example, this is suitable for 2-rope grab operation, as in this case synchronization is only required for the lifting (hydraulic synchronization) and lowering (electronic synchronization) function. The synchronization must be switched off again for opening and closing the grab.

B. Continuous operation – activation via SENCON

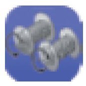
In this mode electronic winch synchronization is continuously activated. This synchronization mode is used for applications where both ropes are used synchronously for the lift or lower function, for example, for traverse operation, in operation with hydraulic diaphragm wall grabs, in drop-ball operations, or for dynamic intensive compaction. In this case opening and closing occur via an additional hydraulic controller.

In general, it must be noted that the depth indicating device, which must be installed in the machine, is one prerequisite for electronic winch synchronization. This is because the synchronization is based on the hardware system of the depth indicating device, in other words, the sensors of the depth indicating device are used



Depth measurement [source: SENNEBOGEN]

Winch synchronization is activated or deactivated in SENCON with the lower quick selection button U4.

Quick-select button	***Checking***	***For operating mode***
No action U4 (1) **No** winch synchronization (electronic) possible Winch synchronization (hydraulic) possible		• Friction-lock winch function **for hoist operation** • Winch function freefall secured **for excavator operation** • Winch function freefall unsecured **for excavator operation**
Press U4 (2) 1x - temporary operation: Winch synchronization deactivated *Press push button (15) on control lever* – Winch synchronization activated		• Friction-lock winch function **for hoist operation** • Winch function freefall secured **for excavator operation** • Winch function freefall unsecured **for excavator operation**
Press U4 (3) 2x - continuous operation		**Crane mode only!**

Depth measurement [source: SENNEBOGEN]

Operation with Dragline Bucket

SENNEBOGEN 6140 with dragline bucket [source: SENNEBOGEN]

Definition of terms

Dragline bucket excavators are the most important machines for quarrying and extraction tasks.

A dragline bucket excavator is equipped with an open drag bucket. This is connected to a hoist rope that is routed via the boom head, to winch 1, and to a pull-in rope, that runs frontally through the basic boom and is connected to winch 2. Both winches are crane freefall winches.

A wide variety of materials can be conveyed using this technology, for example sand, gravel, loam, or clay. To convey material, the dragline bucket pull-in rope pulls the tossed-out drag bucket through the material to be extracted until the bucket is full. This process can take place under water or onshore. Slewing the uppercarriage and simultaneously pulling up the dragline bucket transports the extracted material to the unload point and unloads it.

For operations with dragline buckets the boom working range is 30° to 50°.

Work cycles of dragline operation

Images – SENNEBOGEN 655HD in dragline operation in France [source: SENNEBOGEN]

Image 1: Tossing out the empty bucket

- Winches are in freewheeling mode
- Uppercarriage slews forcefully from the unload point to the extraction point

Image 2: Lowering the bucket

- Winches are initially in freefall and are subsequently braked to avoid slack rope
- Uppercarriage has reached position

Image 3: Recovering the bucket

- Winches up
- Uppercarriage position is fixed

Image 4: Lifting the loaded bucket

- Winch 1 lifts the bucket and winch 2 follows with friction-locking via Combi-Link
- In parallel, the uppercarriage starts to slew

Image 5: Emptying the bucket

- Winch 1 is braked
- Winch 2 is unloaded in freefall via Combi-Link
- Uppercarriage slews out and then immediately slews in the other direction

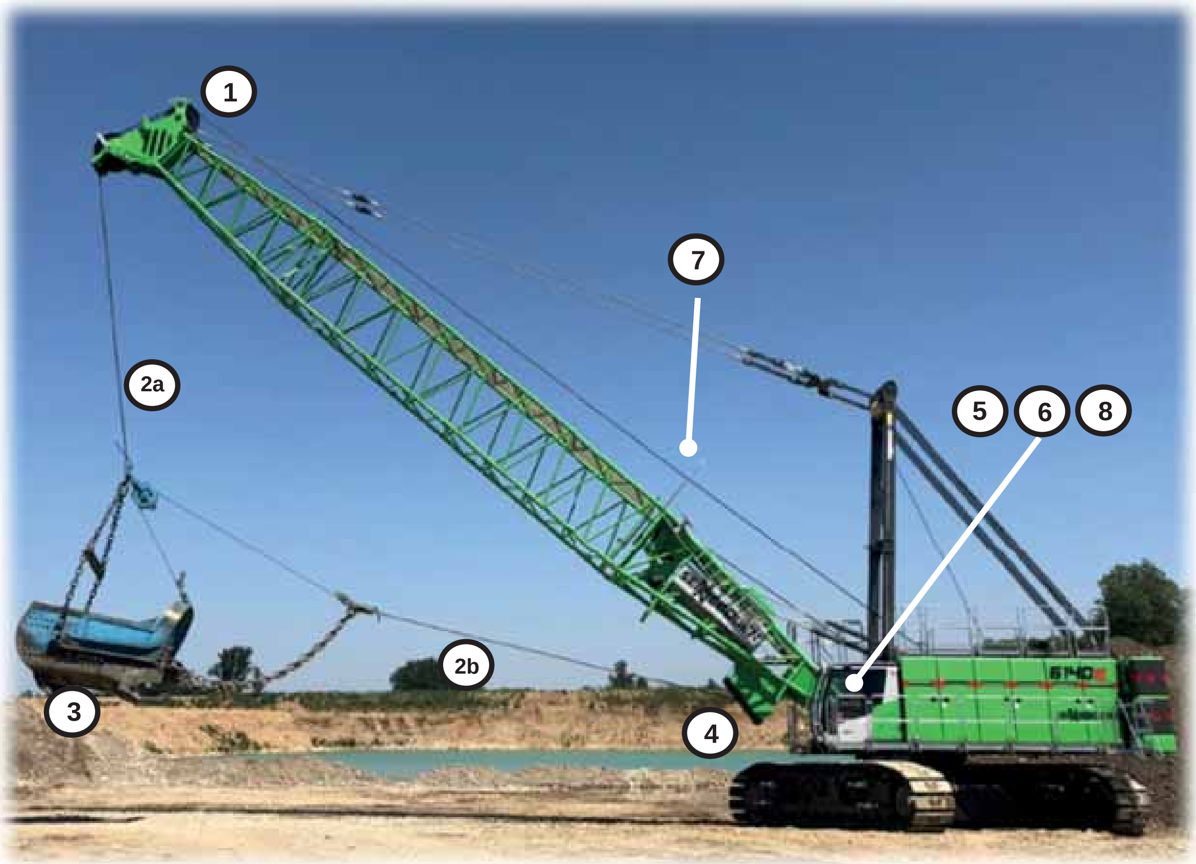
ATTENTION: When extracting material that is not underwater (onshore), the dragline bucket is let down in a controlled manner to prevent damage to the bucket

SENNEBOGEN 6180HD in dragline operation [source: SENNEBOGEN]

SENNEBOGEN technology – dragline operation

SENNEBOGEN duty cycle cranes for dragline operation are equipped with first-class technical equipment for this dynamic application and have been 100% adapted to the operating conditions.

SENNEBOGEN dragline machines are high-performance machines with maximum efficiency and handling capacity and at the same time offer low fuel consumption.



SENNEBOGEN duty cycle crane version with dragline bucket [source: SENNEBOGEN]

1. Boom head with steel sheaves and sheave shield
2. Dragline bucket hoist rope (a) and dragline bucket pull-in rope (b)
3. Dragline bucket / drag bucket
4. Fairlead
5. Combi-Link
6. Pre-adjustable residual braking torque (freefall velocity)
7. Rope guide on the boom / rope guide sheaves
8. Dragline automatic (SENCON)

1. Boom head with steel sheaves and sheave shield

SENNEBOGEN recommends equipping HD cranes in dragline operation with steel sheaves or HD sheaves on the boom head because these are more wear-resistant under dynamic loads than plastic sheaves. Installing a sheave shield on the front axle of the boom head is also recommended. This is used as rope guide of the hoist rope on the boom head to prevent the rope from slipping off the rope sheave.

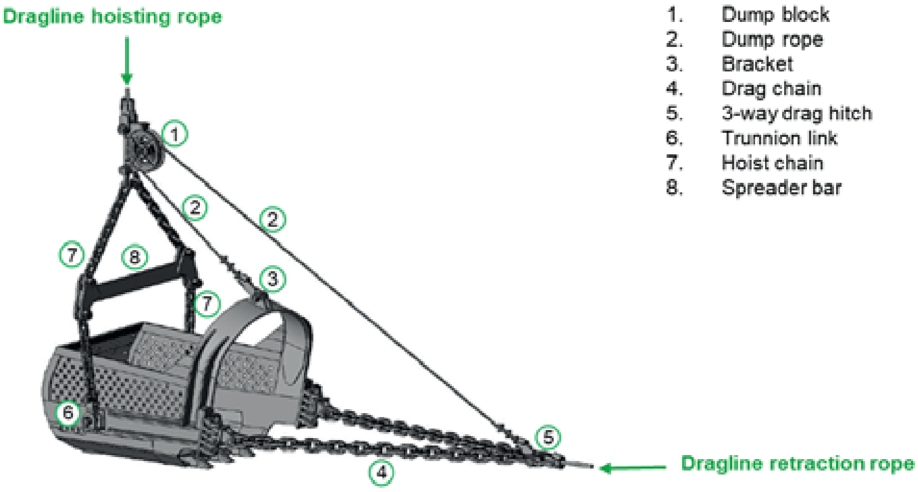
Detail graphic of SENNEBOGEN boom head with sheave shield [source: SENNEBOGEN]

2. Rope equipment

The SENNEBOGEN dragline ropes have been specially developed for the dynamic forces in dragline operation. The hoist rope is routed via the boom head of the machine to the rear winch (winch 1), while the pull-in rope is pulled onto the front winch (winch 2) via the fairlead. For this, two special dragline ropes Z-laid with the same diameter are used.

3. Dragline bucket

The dragline bucket is used as grab and means of material conveyance. There are different dragline bucket designs – light, moderately heavy, and heavy – that are selected according to the material to be excavated. Dragline buckets can be perforated or non-perforated. The grab teeth are replaceable wear parts.



Drag bucket [source: Rädlinger]

4. Fairlead

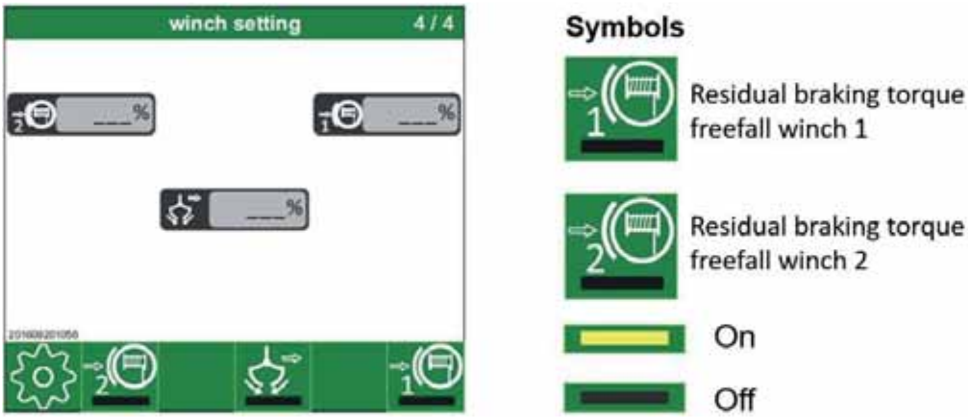
The fairlead is used to guide the dragline bucket pull-in rope. It is integrated in the basic boom or attached in front of the uppercarriage.

The fairlead reduces rope wear and ensures optimal winding of the pull-in rope on the winch drum of winch 2.

Fairlead detail graphic – left: 670 HD; right: 640 HD [source: SENNEBOGEN]

5. Pre-adjustable residual braking torque (freefall velocity)

SENCON is the only way to set the residual braking torque (freefall velocity) of the respective freefall winch. Under the “winch setting” tab, the residual braking torque can be set separately and independently for each winch. The value 0% means that the freefall will be executed at maximum speed. Increasing the value partially engages the freefall brake and reduces the freefall velocity. This prevents the occurrence of slack rope and ensures better monitoring/control for freefall tasks.



SENCON – setting the residual braking torque [source: SENNEBOGEN]

6. Combi-Link

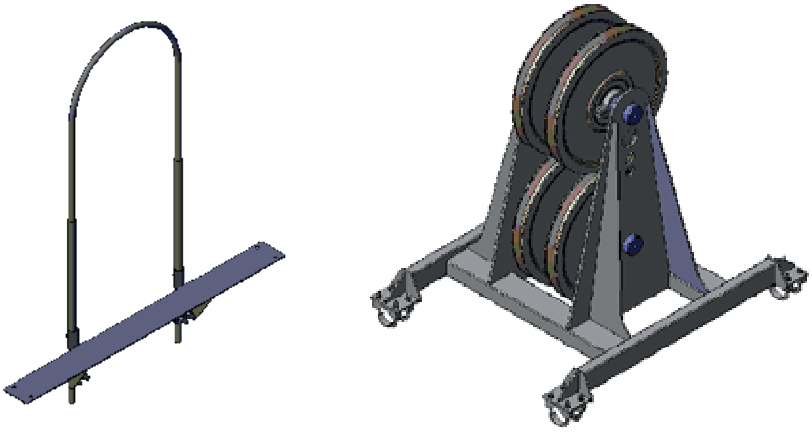
The Combi-Link ensures winch changeover between freefall mode and friction-locking operation. In dragline operation, the Combi-Link is required for the front winch (winch 2) with the pull-in rope. Pressing the front left button on the left joystick enables friction-locking advance of the pull-in rope when the drag bucket is lifted.

Activation of Combi-Link via joystick [source: SENNEBOGEN]

7. Rope guidance on the boom

The rope guide on the boom is used to guide the rope in order to prevent it from laterally slipping off. This should prevent damage to the boom, the boom bolts, and to the rope. It should also prevent the occurrence of slack rope.

In dragline machines, the rope is often guided by means of rope guides along the boom. The number of guides depends on the length of the boom. Alternatively, the ropes can be guided by a rope guide sheave on the boom. This is fastened on the chord with clips approximately in the middle of the boom.



Detail graphic of rope guide – rope guide (left) and rope guide sheaves (right) [source: SENNEBOGEN]

Rope guide sheaves on the boom 6130HD [source: SENNEBOGEN]

Rope guide on the boom 640 HD [source: SENNEBOGEN]

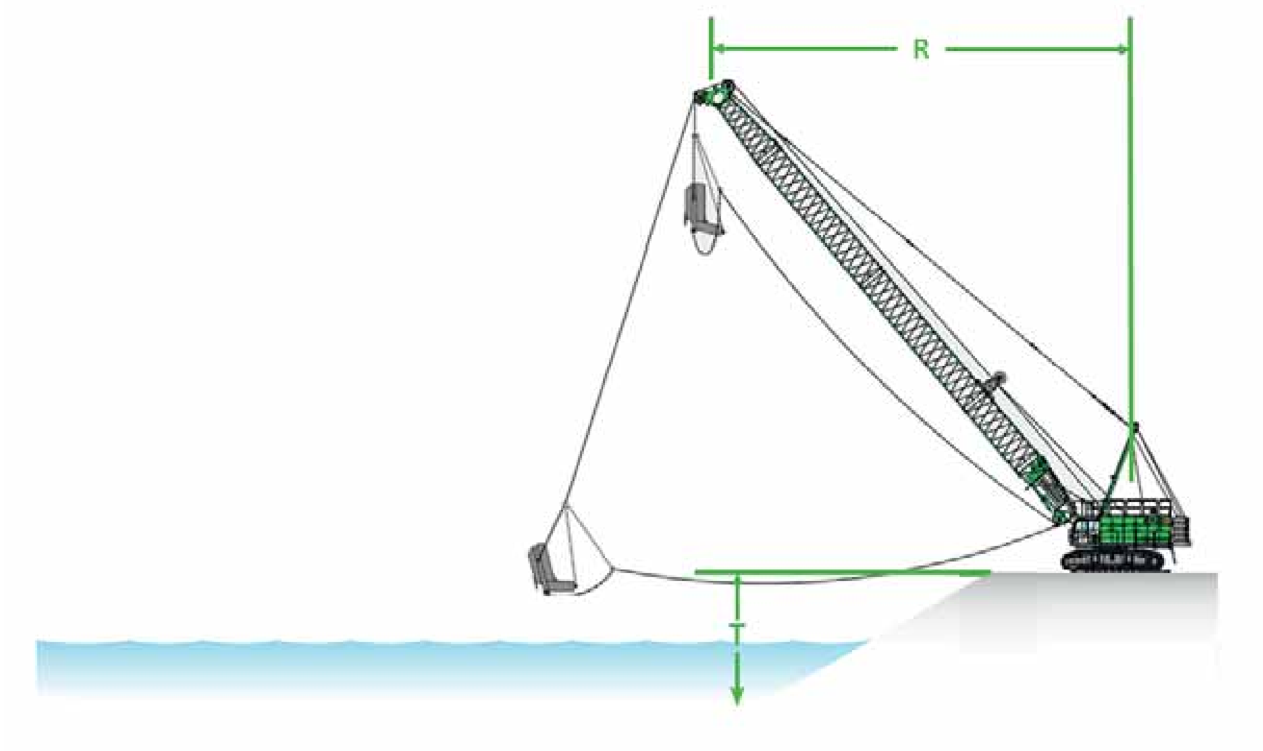
8. Dragline bucket automatic system

The SENNEBOGEN dragline bucket automatic system via the SENCON module allows the dragline bucket to be pulled in by operating the winch 1 joystick. This means, the drag bucket is pulled in via winch 1 (hoist rope) and winch 2 (pull in rope) follows automatically.

Handling capacities – dragline operation

The calculation of handling capacity in dragline operation depends on many different factors. Material and ground condition along with lift, emptying and slewing factors need to be considered, as well as the working time and particularly the qualification and experience of the operator.

Machine	Motor [kW]	Winches [t]	Boom [m]	Dragline bucket [m³]	Grab depth [m]
630 HD	186	2 x 12	13.1 - 24.3	2.1	12
640 HD	186	2 x 16	13.1 - 24.3	2.3	12
655 HD	261	2 x 16	13.1 - 27.1	3.0	13
670 HD	261 / 321	2 x 20	14.9 - 28.9	3.4	14
6100 HD	451	2 x 30	18.7 - 29.9	4.6	15
6140 HD	570 / 708	2 x 35	13.1 - 41.1	5.4	17
6300 HD	570 / 708 / 840	2 x 45	24.3 - 52.3	10.0	25
ATTENTION: The values cited above are provided as approximate information only and must be adapted to the actual conditions on site. Subject to change.					



Parameters of dragline operation 6140 HD [source: SENNEBOGEN]

Calculation of the theoretical dragline bucket capacity L_S

L_s = theoretic dragline bucket capacity = $t_0 * f_0 * V_{SK}$ [m³/h]

$f_0 = f_1 * f_2 * f_3 * f_4 * f_5 * f_6 * f_7$ [-]

t_0 = 120 theoretical load cycles per hour [h^{-1}]

V_{SK} = volume of drag bucket [m³]

f_1 **Fill factor** depending on the soil class

Soil class	bulk factor f1	soil class	bulk factor f1
sand / fine gravel	1.1 – 1.2	sandy loam, dry	0.95 – 1.0
sand / fine gravel (earthmoist)	1.0 – 1.1	cohesive loam, dry	0.90 – 0.95
sand / fine gravel (wet)	0.8 – 0.9	cohesive loam, hard	0.88 – 0.90
Soil with sand / gravel, dry	0.85 – 0.88	topsoil, sandy loam	0.82 – 0.85
loam with sand / gravel (earthmoist)	0.75 – 0.80	topsoil, lean loam (earthmoist)	0.80 – 0.82
slaty rock, coarse gravel	0.72 – 0.75	gravel with loam, dry	0.70 – 0.72
debrised loam (earthmoist)	0.68 – 0.70		

f_2 **Grab factor** depending on the boom length

boom lenth	[m]	12,00	15,00	18,00	21,00	24,00	27,00	30,00	33,00	36,00	39,00	42,00
dig-factor f_2	[-]	0,86	0,83	0,79	0,75	0,72	0,69	0,65	0,61	0,58	0,55	0,51

f_3 **Lift factor** depending on the boom length

boom length	[m]	12,00	15,00	18,00	21,00	24,00	27,00	30,00	33,00	36,00	39,00	42,00
lift-factor f_3	[-]	0,95	0,93	0,92	0,91	0,9	0,88	0,87	0,86	0,85	0,83	0,82

f_4 **Slewing factor** depending on the slewing angle

slewing angle	[°]	90,00	120,00	180,00
slewing-factor f_4	[-]	0,98	0,95	0,91

f_5 **Emptying factor** depending on the loading device

Dumped to	[-]	Truck	Hopper	Landfill
emptying-factor f_5	[-]	0,96	0,96	1

f_6 **Worktime factor** depending on the effective working time

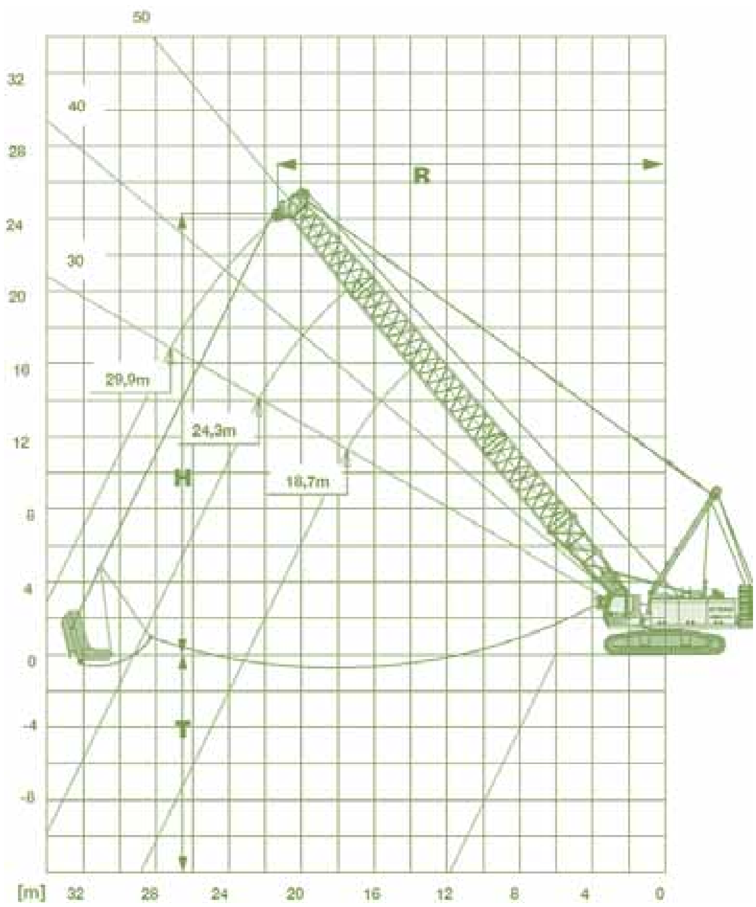
worktime	[min/h]	60,00	55,00	50,00	45,00	40,00
worktime-factor f_6	[-]	1	0,92	0,83	0,75	0,67

f_7 **Operating factor** depending on the experience of the operator

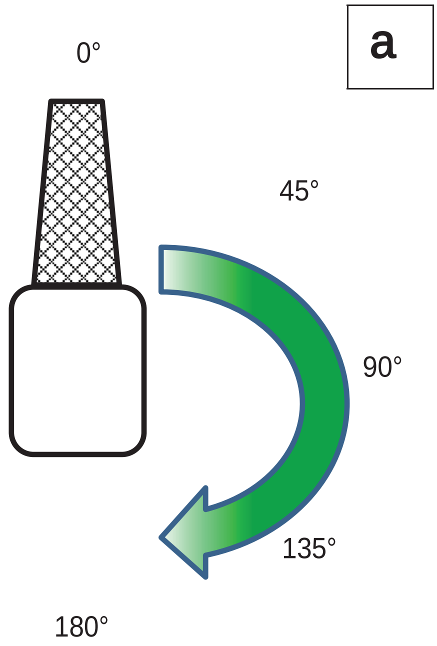
Operation	[-]	experienced	moderate experience	inexperienced
operating-factor f_7	[-]	1	0,95	0,85

Dragline operation questionnaire

Existing material:	______________________	[-]
Density:	______________________	[t/m³]
Extraction under water:	______________________	[yes/no]
Slewing angle α:	______________________	[°]
Maximum grab depth T:	______________________	[m]
Maximum radius R:	______________________	[m]
Dragline bucket present / size:	______________________	[m³ or yd³]
Required handling capacity:	__________ / __________	[t or m³]
Work hours per day / days per month	__________ / __________	[h] / [d]



Top view



SENNEBOGEN HD cranes in dragline operation

SENNEBOGEN 640HD with 1.7 m³ dragline bucket – Germany [source SENNEBOGEN]

SENNEBOGEN 655HD with dragline bucket – New Zealand [source SENNEBOGEN]

SENNEBOGEN 655HD with dragline bucket – France [source SENNEBOGEN]

SENNEBOGEN 6130HD with dragline bucket – Austria [source SENNEBOGEN]

SENNEBOGEN 640HD with dragline bucket – France [source SENNEBOGEN]

SENNEBOGEN 6180HD electric motor with 6.0 m³ dragline bucket – Great Britain [source SENNEBOGEN]

SENNEBOGEN 6140HD diesel engine with dragline bucket – France [source SENNEBOGEN]

Operation with Diaphragm Wall Grab [DWG]

SENNEBOGEN 6100 HD with mechanical diaphragm wall grab [source: SENNEBOGEN]

Definition of terms – diaphragm wall

A **diaphragm wall** is a construction element that is used for securing deep excavation pits or for deep foundation work.

Diaphragm walls are wall constructions in the substrate made from concrete or reinforced concrete that are produced in fluid-supported, open vertical slots in the ground. They are stabilized by a constantly topped-up stabilizing slurry (betonite suspension = betonite + water). They are produced by excavating the ground material in the slot.

Diaphragm walls can have a static and/or a shielding function. In their static function, they absorb ground pressure and water pressure forces, for example as a building pit wall, and transfer these forces to the ground via anchoring or via the earth resistance on the base support. Vertical forces are introduced into the ground through point pressure and pile friction. Individual diaphragm wall elements are also used as foundation elements that accommodate heavy stresses instead of bored piles.

The diaphragm wall technology can be used down to maximum depths of 100 m and more (with duty cycle cranes up to approximately 50m). It is an extremely gentle construction method because tasks can be executed virtually without any intermediate space to existing buildings or foundations. Also an extremely low level of vibration occurs.

Diaphragm walls are characterized by extremely low deformation compared with other shoring walls. At depths greater than 25 m, reinforced concrete diaphragm walls are significantly more precise and secure than pile walls.

Two-phase diaphragm wall

With two-phase diaphragm walls, the support suspension is replaced by a different wall material, such as concrete, once the final depth has been reached. If the suspension is replaced by concrete, this is referred to as an in-situ concrete diaphragm wall because the concrete is introduced “in situ”. If the concrete gets steel reinforcement a steel reinforced concrete diaphragm wall is produced.

Single-phase diaphragm wall

Unlike two-phase diaphragm walls, the support suspension remains in the ground with this diaphragm wall type and is not replaced. However, hardened materials, such as cement are added. Subsequently reinforced prefabricated concrete parts or sheet piling profiles are installed in the slot. This is referred to as a pre-cast concrete diaphragm wall. Previously a foundation is erected in the base area of the prefabricated parts. This occurs through replacement of the suspension with concrete on the floor of the slot.

Construction site with diaphragm wall

Work cycles for diaphragm wall production

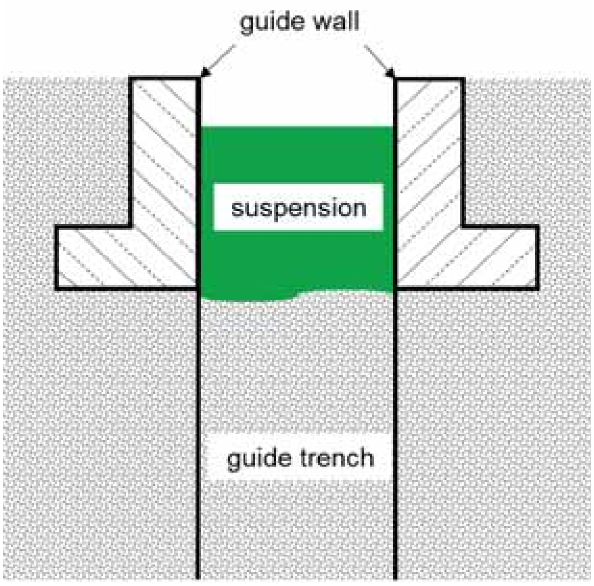
A diaphragm wall consists of multiple diaphragm wall elements produced adjacent to each other – also referred to as diaphragm wall lamellas. The length of an element is between 2.5 m and 7.5 m – depending on the excavation tool used and the stability of the slot (with duty cycle cranes, the length is approximately 2.5 m – 3.5 m).

The following work cycles are necessary:

1. Production of the guide walls and preparation of the suspension fluid
2. Excavation of the slot and simultaneous feed of the stabilizing slurry
3. Installation of the joint constructions (stop end pipe, water stop, or pre-fabricated reinforced concrete element) on the edge of the lamellas
4. Installation of the reinforcement
5. Replacement of the stabilizing slurry with concrete

1. Production of the guide walls and preparation of the suspension fluid

Guide walls are installed along the longitudinal sides of the slot to be excavated as in-situ concrete walls or prefabricated parts. They are used to support the upper area of the slot, to guide the excavating tool, and to maintain a supply of suspension fluid.



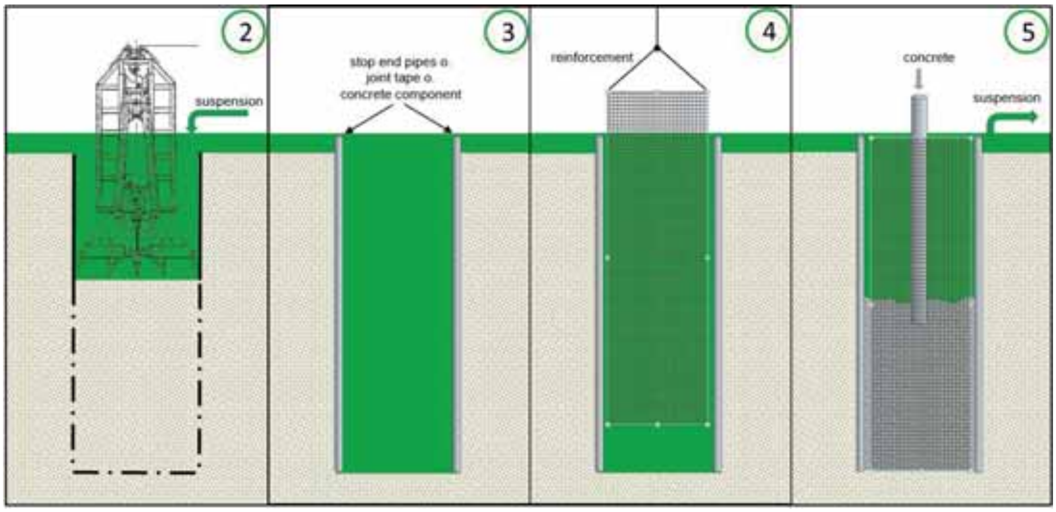
Guide wall [source: SENNEBOGEN]

Guide walls have a height of approximately 1.0 m – 1.5 m.

The stabilizing slurry is normally a mixture of betonite and water - referred to as betonite suspension. This is adapted to the ground conditions (type and proportion of betonite can be varied)

2. Excavation of the slot and simultaneous feed of the stabilizing slurry

The ground is excavated using the diaphragm wall grab or a diaphragm wall cutter. In this process, the width and depth of the diaphragm wall, as well as the ground conditions must be considered in order to define the suitable operating equipment.

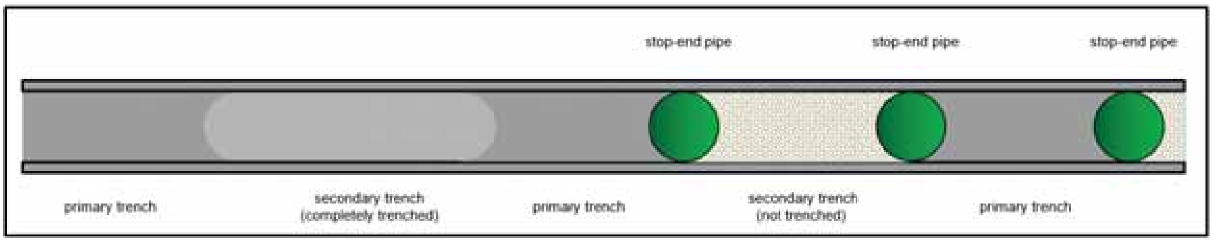


Work cycles for diaphragm wall [source: SENNEBOGEN]

To produce a complete diaphragm wall, first the primary slot is completed, and after hardening, the secondary slot is completed. In this process, the primary slots are produced in gaps and the secondary slots are placed between them.

3. Installation of the joint construction (stop end pipe, water stop, or prefabricated reinforced concrete element) on the edge of the lamellas

The sides of the lamellas are limited by joint constructions. Usually stop end pipes made of steel (diameter = wall thickness) are used. These are pulled again before producing the secondary slot. Through this measure a clean closure that is as sealed as possible is achieved between the lamellas. Instead of the stop end pipes, elements that remain in the slot can also be installed (water stop, prefabricated reinforced concrete parts).



Primary and secondary trenches [source: SENNEBOGEN]

4. Installation of the reinforcement

For steel reinforced concrete walls, reinforcement is installed after completing a slot. This is delivered to the construction site pre-assembled for a lamella size. For particularly deep slots, multiple reinforcement baskets are mounted in the slot hanging on each other.

The reinforcement is used to increase the overall stability of the diaphragm wall, and particularly to accommodate pull forces.

5. Replacement of the stabilizing slurry with concrete

Concrete is introduced with the aid of concreting pipes. These must be connected to each other so that they are sealed. The concrete is filled in the slot from bottom to top. The suspension fluid that then rises is simultaneously pumped off and reconditioned. An additional lifting machine is required on the construction site for insertion of reinforcement and the concreting pipe.

SENNEBOGEN HD cranes for diaphragm wall grab operation

Duty cycle crawler crane in diaphragm wall operation are the most important devices for foundation work and compaction tasks. SENNEBOGEN duty cycle crawler cranes are used as carriers for the diaphragm wall grab.

There are mechanical diaphragm wall grabs (mDWG) and hydraulic diaphragm wall grabs (hDWG) (see the section “SENNEBOGEN technology – diaphragm wall grab operation”, paragraph 4). The individual work cycles for producing a diaphragm wall are explained below.

Images – SENNEBOGEN 690HD in diaphragm wall grab operation [source: SENNEBOGEN]

Image 1: Moving grab into the slot

- Winches are run in crane mode via Combi-Link; grab bucket closed
- mDWG – hoist rope is let down and close rope is advanced
- hDWG – both hoist ropes are run in parallel via electronic winch synchronization

Image 2: Trenching

- Grab is stopped a few meters before reaching the ground, grab buckets are opened, and winches are switched to freefall
- Grab moves into the ground with momentum from its own deadweight (if necessary, use the chisels installed in the grab – for harder ground)
- Grab is closed
  mDWG – via close rope (winch 2)
  hDWG – via hydraulic cylinder in the grab
- Winch freewheeling for winch 1 ensures optimal grab filling

Image 3: Lifting the grab

- Winches are run in hoisting mode
- mDWG – hoist rope and closing rope are run in parallel via hydraulic winch synchronization
- hDWG – both hoist ropes are run in parallel via electronic winch synchronization

Image 4: Emptying the grab

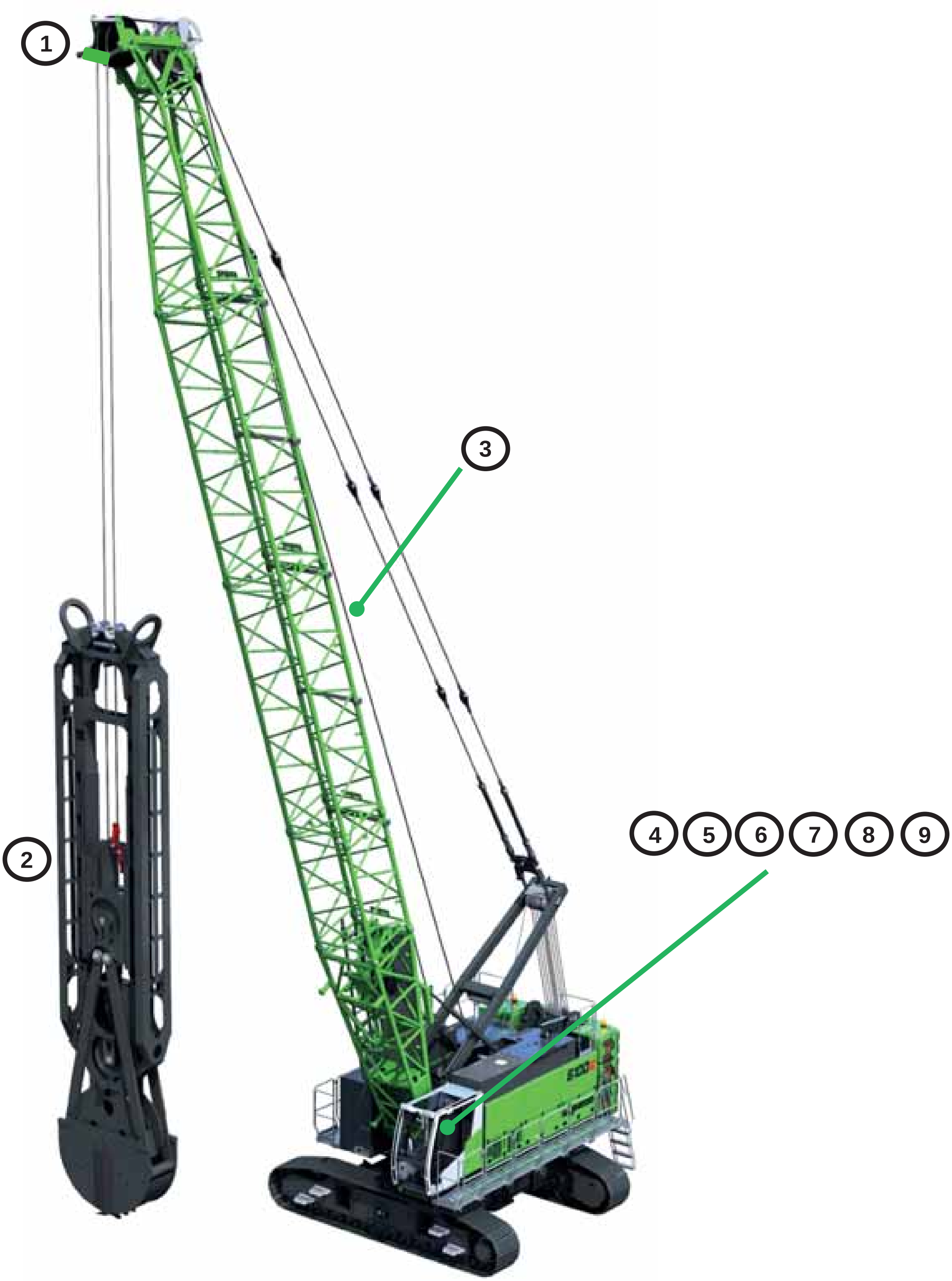
- Uppercarriage slews to the unloading point
- Winches move with friction-locking
- Grab is opened
  mDWG – via close rope (winch 2)

  hDWG – via hydraulic cylinder in the grab

SENNEBOGEN technology – diaphragm wall grab operation

SENNEBOGEN duty cycle cranes are equipped with first-class technical equipment for dynamic operation with diaphragm wall grabs and have been 100% adapted to the operating conditions.

SENNEBOGEN HD cranes are high-performance machines with maximum efficiency and slotting capacity and at the same time offer low fuel consumption.



SENNEBOGEN duty cycle crane equipment for diaphragm wall grab [source: SENNEBOGEN]

1. Boom head with steel sheaves and sheave shield
2. Diaphragm wall grab
3. Rope equipment
4. Depth indicating device
5. Double-T control
6. Winch synchronization (hydraulic/electronic)
7. Winch freewheeling, winch 1 / grab autofill
8. Pre-adjustable freefall speed for winch 1 and winch 2
9. Combi-Link winch 1 and winch 2

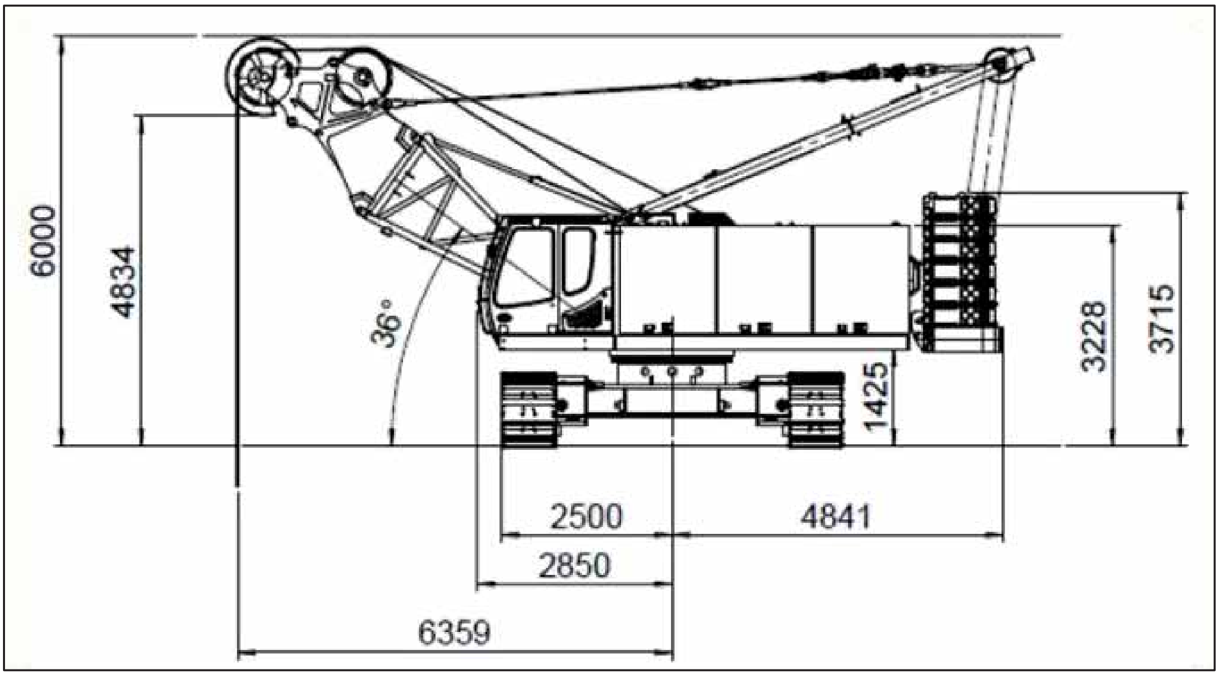
1. Boom head with steel sheaves and sheave shield

SENNEBOGEN recommends equipping duty cycle cranes for operation with diaphragm wall grabs with steel sheaves on the boom head because these are more wear-resistant than plastic sheaves under dynamic loads and for that reason have longer durability.

Detail graphic of SENNEBOGEN dragline bucket head with sheave shield [source: SENNEBOGEN]

To enable operations with diaphragm wall grabs under bridges or at other construction sites with limited height, SENNEBOGEN also offers special solutions with a “low head room” boom and boom head. However, in addition to this machine adaptation, the diaphragm wall grab needs to be adapted to the operating conditions with height limitation.

SENNEBOGEN 690 HD with “low head room” boom and boom head [source: SENNEBOGEN]



Drawing of SENNEBOGEN duty cycle crane with “low head room” boom [source: SENNEBOGEN]

2. Diaphragm wall grab

Diaphragm wall grabs are used to pick up and convey material. There are different design depending on material or local conditions (for example under bridges). The grab buckets are replaceable and easy to change (for example for a different diaphragm wall width or in case of wear).

SENNEBOGEN duty cycle cranes are used as carriers for both mechanical and hydraulic diaphragm wall grabs.

The mechanical diaphragm wall grab (mDWG) is always a two-rope grab with one hoist rope and one close rope. The width of the grab shells defines the thickness of the diaphragm wall. The opening width is between 2.50 m and 3.50 m. Above the grab shells, there is a guide frame that has the same thickness as the diaphragm wall which guides and stabilizes the grab in the slot. In addition, the guide frame provides the required deadweight, in order to loosen the material at the base of the slot. Mechanical diaphragm wall grabs can be used to a diaphragm wall depth of approximately 50 m.

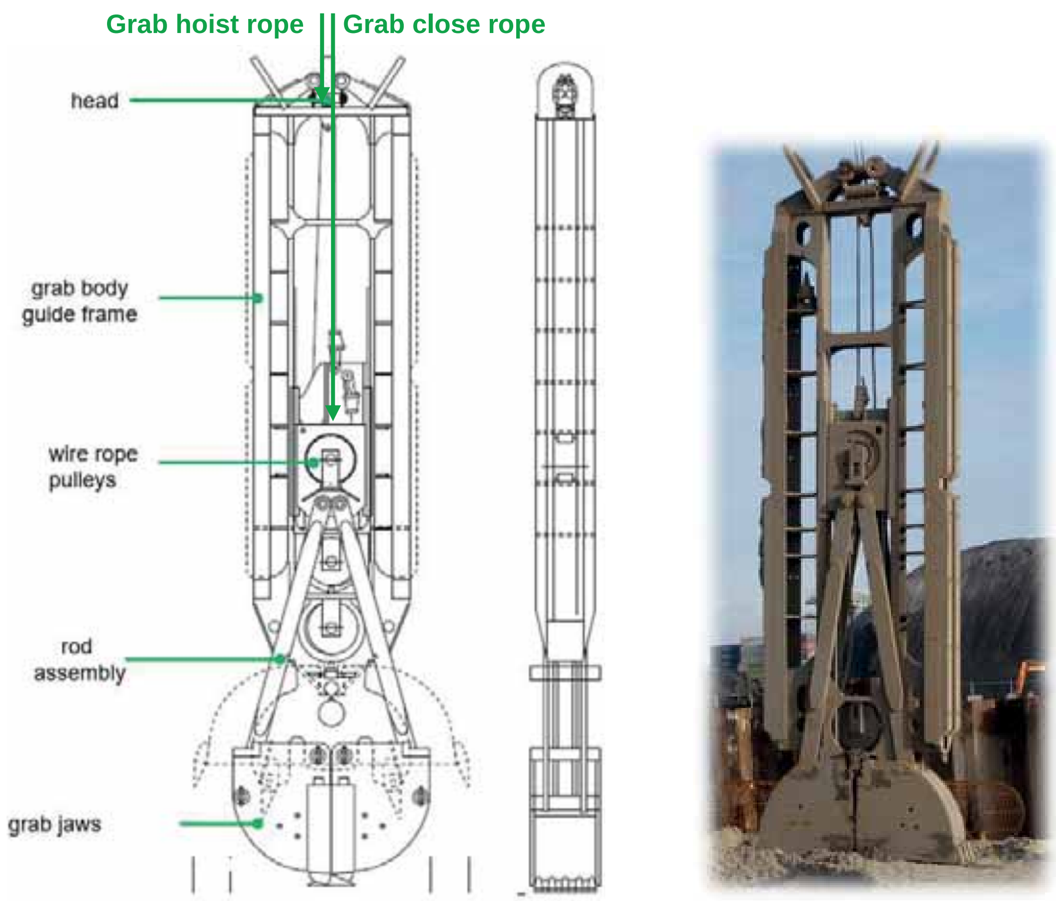


Diagram and image of a mechanical diaphragm wall grab [source: SENNEBOGEN]

The hydraulic diaphragm wall grab is a grab for which opening and closing is executed by a hydraulically powered linkage. The hydraulic system required for this is provided by the duty cycle crane (carrier). The advantages of the hydraulic diaphragm wall grab is greater accuracy (due to constant measurement and control mechanisms) and more effective cycle duration. Both ropes are used as hoist ropes (each single reeved) for hydraulic diaphragm wall grabs.

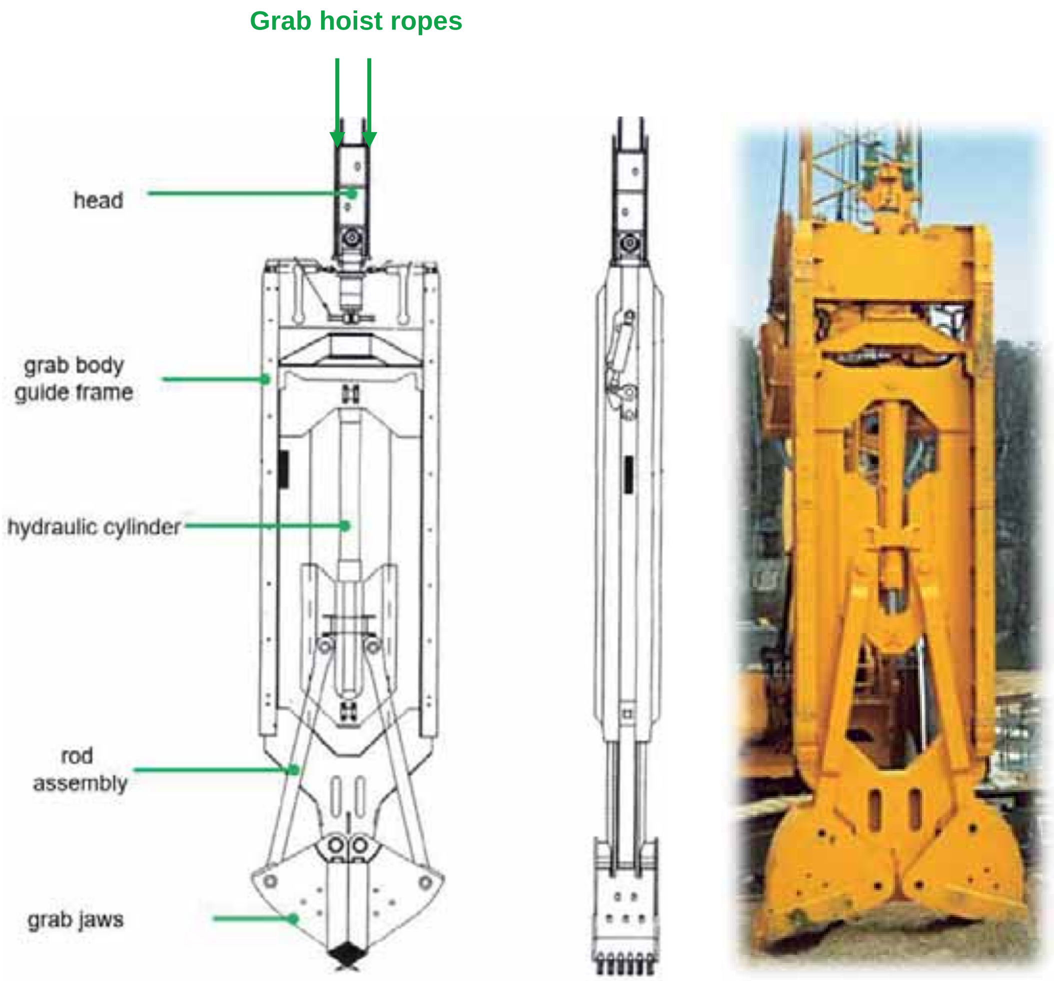


Diagram and image of a hydraulic diaphragm wall grab [source: SENNEBOGEN]

3. Hoist rope(s) for diaphragm wall operation

The SENNEBOGEN diaphragm wall grab rope equipment has been specially developed for the dynamic forces in slotting operation.

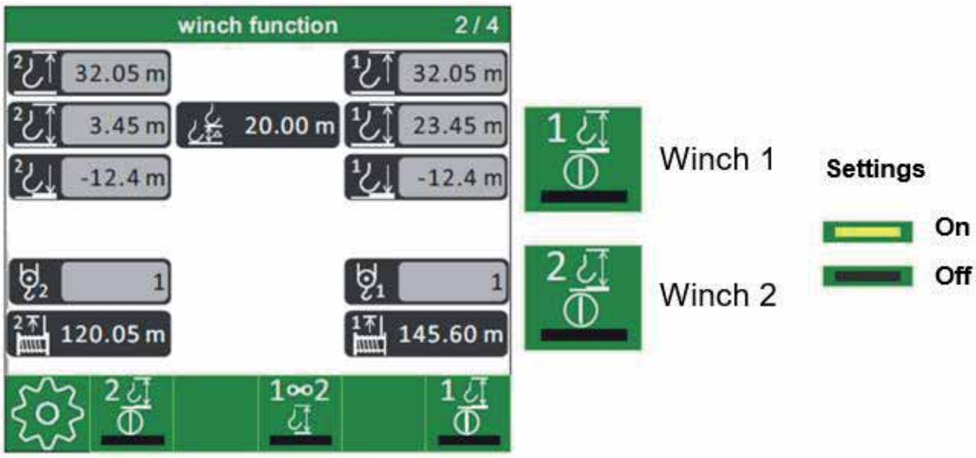
With the mechanical diaphragm wall grabs, one hoist rope (on winch 1) and one close rope (on winch 2) with opposite rotation directions are used. For the hydraulic diaphragm wall grab, on the other hand, two hoist ropes are used, each with single reeving.

4. Depth indicating device

The depth indicating device is a tool for the machine operator that displays the height of the operating equipment (in this case: Diaphragm wall grab) on the screen in the cab. This is necessary to monitor whether the required diaphragm wall depth or the height at which the grab is opened and switched to freefall has been reached.

This is monitored and measured for both winches via sensors and incremental encoders on the winch drums. The results are transferred to the depth indicating device. This is where analysis takes place, which is automatically displayed on the SENCON screen. Position compensation – i.e. the two winches are in different positions and windings – is executed automatically.

Switch-off points in both directions can also be programmed via the display.



Detail graphic of SENCON depth indicating device [source: SENNEBOGEN]

5. Double-T control

Both winches can be run exclusively using the right joystick, which is designed as a double-T variant. (Standard: Winch 1 via right joystick and winch 2 via left Joystick). The advantage is that both winches can be activated simultaneously via a combined joystick. Operation via 2 joysticks (left and right) results in different activations.

Through use of the double-T joystick, hydraulic synchronization can be more easily operated when lifting the grab.

Detail graphic of double-T control [source: SENNEBOGEN]

6. Winch synchronization, winch 1 / winch 2

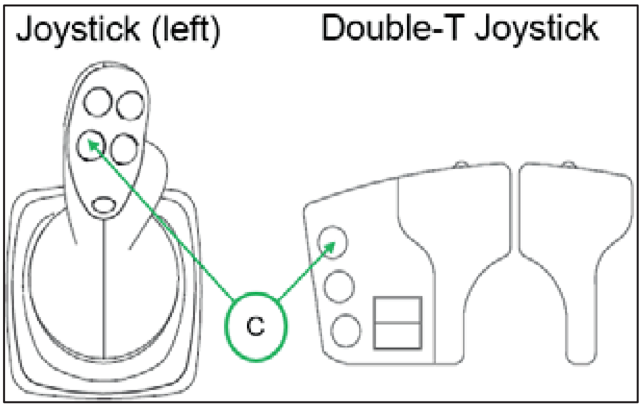
In some application areas, especially in 2-rope grab operation, it may be necessary to control both winches synchronously, for example to lift a grab. In order to facilitate precise synchronous operation of the winches, SENNEBOGEN duty cycle cranes are equipped with two different winch synchronization functions: hydraulic and electronic winch synchronization. Winch synchronization is activated/deactivated in the SENCON or by pressing the push button on the control lever. To use this function, the two winches need to be in the same operating mode (see the key switch section).

Hydraulic winch synchronization

Hydraulic winch synchronization is part of the basic equipment of each SENNEBOGEN duty cycle crane. When this is activated, the two hydraulic pumps for winch 1 and winch 2 are interconnected, which means that there is pressure equalization in the supply line for the two control valve sections of winch 1 and winch 2.

The parallel circuit provides the following functionality:

- Activation of hydraulic synchronization via a push button [C] in the joystick
- The system only functions with the LIFT function
- Both control levers for winch 1 and winch 2 need to be moved equally (the load distribution on the winches needs to be the same)
- This provides just one useful feature for practical application in rope grab operation



Activation of hydraulic winch synchronization [source: SENNEBOGEN]

Electronic winch synchronization

With electronic winch synchronization, the respective position of the winch is detected by sensors (angular position encoders). At activation of electronic winch synchronization, the control lever / joystick of winch 2 is deactivated and controlled with the joystick of winch 1, both winches are now controlled.

In the background: With the joystick of winch 1, winch 1 is controlled, and winch 2 is readjusted via winch positioning detection.

Electronic winch synchronization can be run in 2 operating modes:

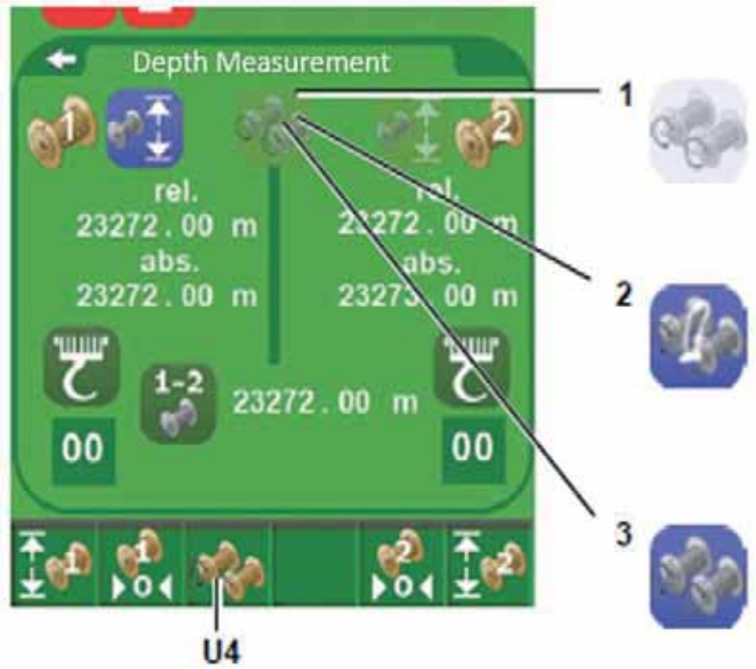
A. Temporary operation – activation via SENCON

In temporary mode synchronization is only activated if the associated button on the joystick is activated. For example, this is suitable for 2-rope grab operation, as in this case synchronization is only required for the lifting (hydraulic synchronization) and lowering (electronic synchronization) function. The synchronization must be switched off again for opening and closing the grab.

B. Continuous operation – activation via SENCON

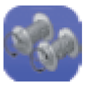
In this mode electronic winch synchronization is continuously activated. This synchronization mode is used for applications where both ropes are used synchronously for the lift or lower function, for example, for traverse operation, in operation with hydraulic diaphragm wall grabs, in drop-ball operations, or for dynamic intensive compaction. In this case opening and closing occur via an additional hydraulic controller.

In general, it must be noted that the depth indicating device, which must be installed in the duty cycle crawler crane, is one prerequisite for electronic winch synchronization. This is because the synchronization is based on the hardware system of the depth indicating device, in other words, the sensors of the depth indicating device are used



Depth measurement [source: SENNEBOGEN]

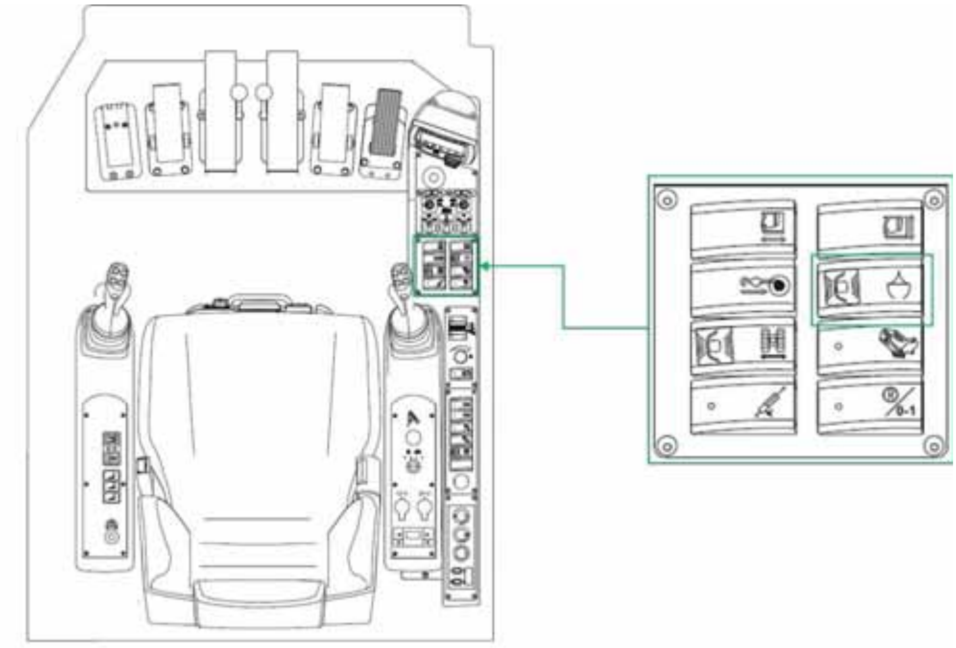
Winch synchronization is activated and deactivated in the SENCON using the lower quick selection button U4.

Quick-select button	*Checking*	*For operating mode*
No action U4 (1) **No** winch synchronization (electronic) possible		• Friction-lock winch function **for hoist operation** • Winch function freefall secured **for excavator operation** • Winch function freefall unsecured **for excavator operation**
Winch synchronization (hydraulic) possible		
Press U4 (2) 1x - temporary operation: Winch synchronization deactivated		• Friction-lock winch function **for hoist operation** • Winch function freefall secured **for excavator operation** • Winch function freefall unsecured **for excavator operation**
Press push button (15) on control lever – Winch synchronization activated		
Press U4 (3) 2x - continuous operation		**Crane mode only!**

Detail graphic of winch synchronization activation on the winch control panel [source: SENNEBOGEN]

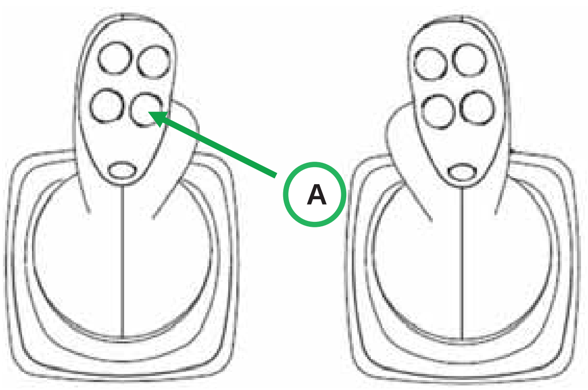
7. Winch freewheeling winch 1 / grab filling automation

The grab autofill is used for operation with mechanical diaphragm wall grabs. Winch freewheeling for winch 1 ensures optimal filling of the grab. To enable this function, first the freewheeling of the rear winch (winch 1) with the grab hoist rope needs to be activated by pressing the corresponding switch on the front right control panel.



Switch for grab autofill: Control panel, front right [source: SENNEBOGEN]

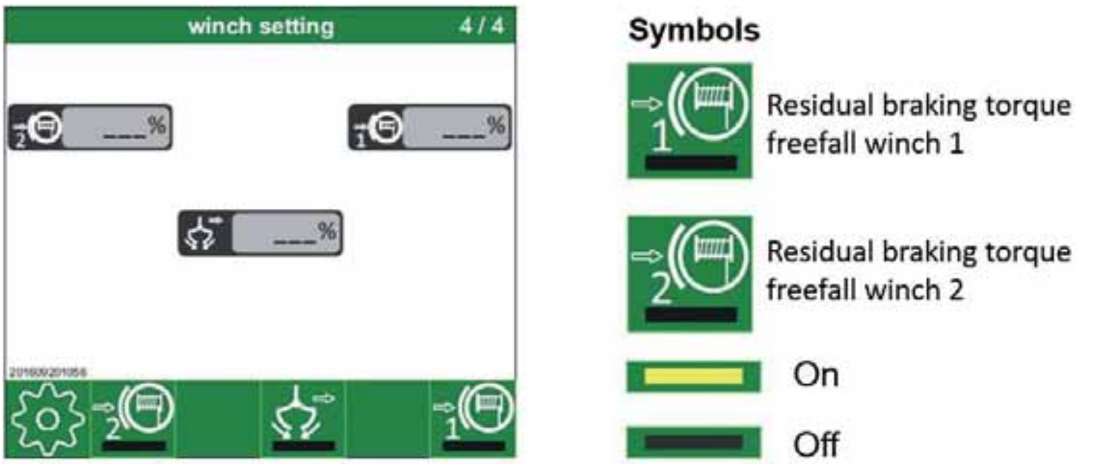
To fill the grab, it needs to be open and facing the bulk material. Then the freewheeling can be executed by pressing and holding the "A" button on the left joystick. The grab penetrates down into the material through the switched-on winch freewheeling and the deadweight of the grab. In parallel, the grab is closed by activating winch 2, which results in optimal filling. Once the grab is completely closed, button "A" needs to be released. This deactivates winch freewheeling. The filled grab can then be lifted by operating both control levers (winch 1 and winch 2).



Activation of winch freewheeling for winch 1 using the left joystick button [source: SENNEBOGEN]

8. Pre-adjustable freefall speed

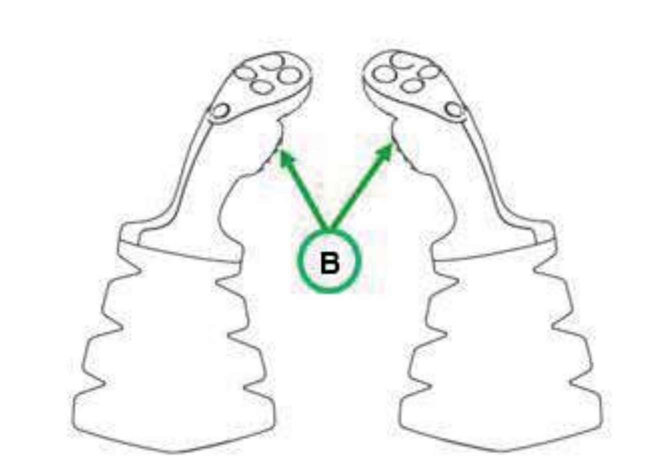
SENCON is the only way to **set the residual braking torque (freefall velocity)** of the respective freefall winch. Under the "winch setting" tab, the residual braking torque can be set separately and independently for each winch. The value 0% means that the freefall will be executed at maximum speed. Increasing the value partially engages the freefall brake and reduces the freefall velocity. This prevents the occurrence of slack rope and enables better monitoring/control for freefall tasks.



SENCON – setting the residual braking torque [source: SENNEBOGEN]

9. Combi-Link: Crane operation / freefall operation changeover via joystick

The Combi-Link ensures changeover between freefall and friction lock operation. In diaphragm wall grab operation, Combi-Link is necessary for both main winches. By activating the button on the joystick (winch 1 via the right double-T and winch 2 via the left joystick) the grab can be guided with friction-locking into the slot. This significantly reduces fuel consumption.



Detail graphic: Activation of Combi-Link via joystick [source: SENNEBOGEN]

Capacity calculation in diaphragm wall grab operation

For calculation of the capacity in dwg-operation there are many different factors, such as material, ground condition, operating resources, quality and experience of the operator, that must be considered.

The capacity is always described and calculated in square meters. The area is determined from the slot depth and the width of the entire diaphragm wall.

Diaphragm wall grab operation questionnaire

Existing material:	……………………………………	[-]
Density:	………..……………………………	[t/m³]
Ground water / height under ZERO:	………..…………………………	[yes/no] [m]
Diaphragm wall depth:	………..……………………………	[m]
Diaphragm wall width:	………………………………….....	[m]
Grab width of the grab:	……………………………………	[m]
Mechanical diaphragm wall grab / type:	………..…………/………………	[yes/no] / [-]
Hydraulic diaphragm wall grab / type:	………..…………/………………	[yes/no] / [-]
Working pressure for hDWG:	……………………………………	[bar]
Flow rate for hDWG:	……………………………………	[l/min]
Required capacity:	……………………………………	[m² / h]
Work hours per day / days per month	………..…………/………………	[h] / [d]

SENNEBOGEN duty cycle cranes in diaphragm wall grab operation

SENNEBOGEN 690HD with mechanical diaphragm wall grab / Germany [source: SENNEBOGEN]

SENNEBOGEN 690HD with mechanical diaphragm wall grab / Germany [source: SENNEBOGEN]

SENNEBOGEN 6130HD with mechanical diaphragm wall grab / Germany [source: SENNEBOGEN]

SENNEBOGEN 6140HD (special) with hydromill / France [source SENNEBOGEN]

Operation with Casing Oscillator

SENNEBOGEN 624HD with casing oscillator [source: SENNEBOGEN]

Definition of terms

One of the oldest underground engineering applications for removing and conveying ground material with duty cycle cranes is operation with rope-driven grabs. **Grab drilling** with a casing oscillator is a special kind of grab operation. A casing oscillator and a pile grab are used for this. This is not a drilling tool, rather it is an excavating tool. Drill pipes are drilled into the ground using the casing oscillator which is then excavated with the pile grab. The grab is fed into the pipe and released in freefall to penetrate the ground. The grab is then closed and the loosened material is lifted out of the drill pipe. The respective excavation capacity depends on the weight of the grab, its fall velocity, the stability of the ground, and the volume of the grab shells.

The main applications for this method are bores for the production of weight-bearing foundations or for obtaining resources (for example, water, oil, etc.).

There are specific distinctions between the following applications using pile grabs and casing oscillators:

1. Production of bored piles with casing
2. Production of bored piles with stabilizing slurry without casing
3. Insertion of steel profiles or prefabricated concrete parts into the bore
4. Well drilling for obtaining drinking water or service water
5. Well drilling for lowering the ground water level
6. Bores for gas wells in landfills

A cased bore using the grab method is the most frequently used dry drilling method. For the production of large diameter bores, in particular, difficult ground conditions or in special local situations, the pile grab method takes priority over rotational drilling equipment. In the case of unstable ground conditions or water-soaked soils, casing installation must be employed, to avoid or reduce loosening of the ground in the vicinity of the bore. For water-free and stable substrates, casing can be performed without additional pipes. However, the upper part (approximately 2 m) must always be secured with a support pipe and guide pipe.

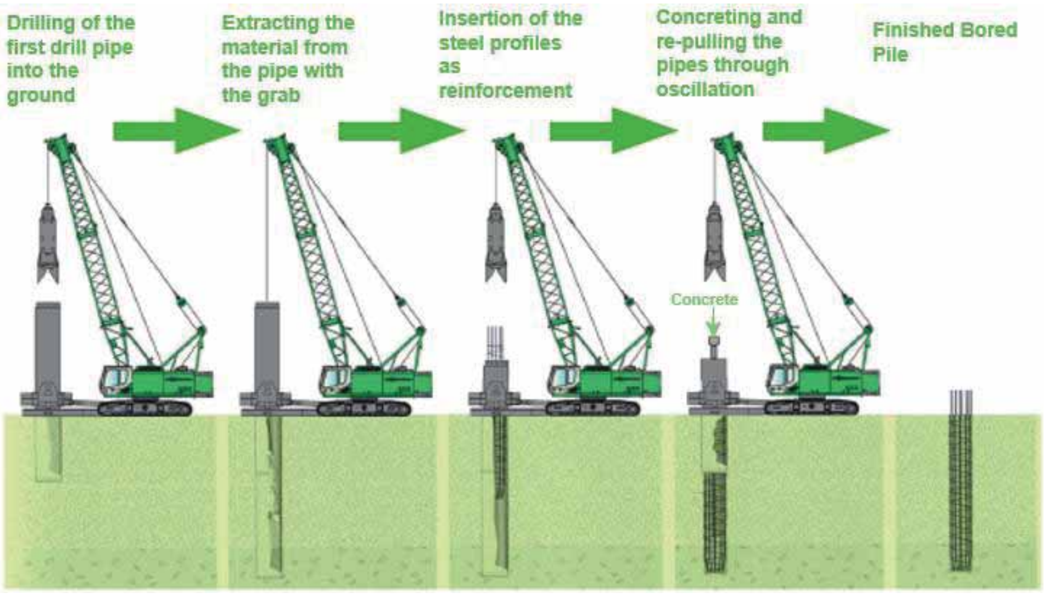
1. Production of bored piles with casing

The grab method for producing bored piles is the most frequently used dry drilling method for larger bore diameters, difficult ground conditions, and special local situations.

Bored pile wall [source: SENNEBOGEN]

Production of a bored pile in the grab method is executed as follows:

- The first drill pipe is clamped in the casing oscillator with the cutting attachment and is drilled into the ground
- The pipe is then extracted (bored out)
- If a drill pipe is driven in far enough, a new, friction-locking and positive-locking fit is established
- It should be noted that the casing always precedes drilling to ensure that there is no loosening of the ground underneath the drill pipes
- Once the required drilling depth has been reached, the casing is filled with the pile material (for example, reinforcement and concrete)
- The casing can subsequently be re-pulled out of the ground through oscillating rotation and pulling with the casing oscillator



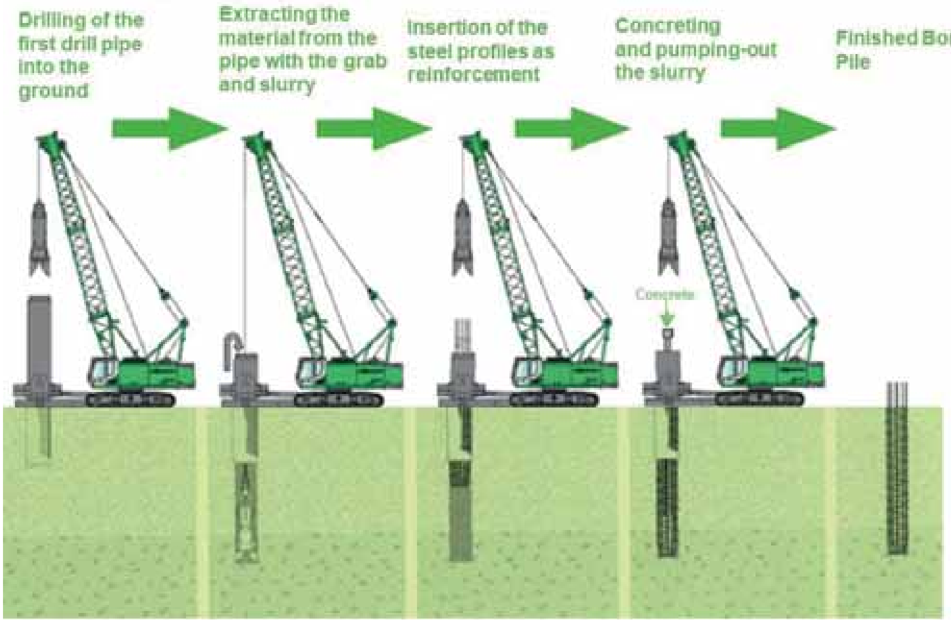
Production of a bored pile [source: SENNEBOGEN]

2. Production of bored piles with stabilizing slurry without casing

As opposed to the procedure described in point 1, for production of bored piles with stabilizing slurry without casing, the driving in of drill pipes is dispensed with. The stability of the inner drill hole is established through a stabilizing slurry that generates a fluid overpressure.

Production of a bored pile using the grab method without casing is executed as follows:

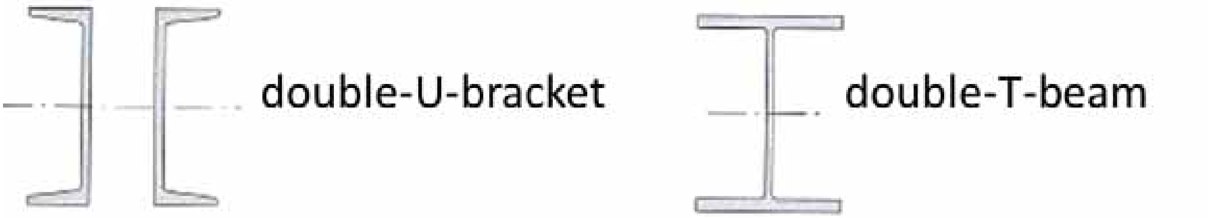
- The first and only drill pipe (protective pipe) is clamped in the casing oscillator with the cutting attachment and is drilled into the ground. The protective tube is used to guide the grab as it enters the borehole and to supply stabilizing slurry / concrete
- The protective tube is then extracted (bored out)
- The stabilizing slurry is supplied before the protective tube is completely dredged
- After reaching the required drilling depth, the reinforcement is inserted into the stabilizing slurry and then the suspension is exchanged for concrete. The concrete is introduced from below and the stabilizing slurry is suctioned out from above
- The upper suspension level always needs to be above the lower edge of the protective tube, both during the drilling process and during the pouring of the concrete, so that the overpressure in the drill pipe remains constantly stable
- After the concrete has been poured in, the protective tube is pulled out of the ground through oscillating rotation with the casing oscillator



Uncased bore [source: SENNEBOGEN]

3. Introducing steel profiles or prefabricated concrete parts into the bore

In addition to ramming or vibrating steel profiles into the ground, the introduction of steel profiles in bores is a frequent method for building ground foundation work.



Steel profiles for insertion [source: SENNEBOGEN]

Initially the procedure is identical to the procedure described under point 1 “Production of bored piles with casing”, however, after reaching the bore hole depth, the steel girder is inserted into the borehole. Before the casing is pulled, any construction material (soil, concrete, gravel, self-hardening suspension, etc.) can be incorporated if necessary. Pulling of the casing is executed by the casing oscillator.

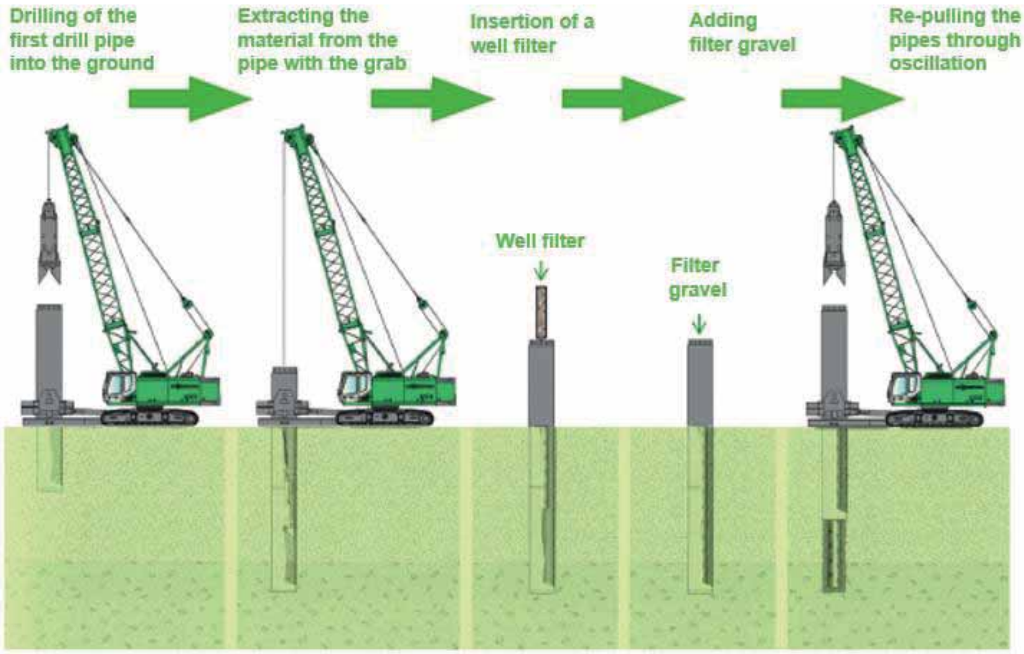
The complete procedure can also be executed without casing, but rather with stabilizing slurry.

4. Well holes for obtaining drinking water and service water or for lowering the ground water level

Well holes are always produced with casing using the grab method. They are created to convey ground water present in the soil. Depending on the task, it’s used for obtaining drinking water/service water or for lowering the ground water level (drawdown wells). A casing oscillator is also used for this application.

Production of a bored pile in the grab method is executed as follows:

- The first drill pipe is clamped in the casing oscillator with the cutting attachment and is drilled into the ground
- The pipe is then extracted (bored out)
- If a drill pipe is driven in far enough, a new, friction-locking and positive-locking fit is established
- It should be noted that the casing always precedes drilling to ensure that there is no loosening of the ground underneath the drill pipes
- Once the required drilling depth is reached, the borehole bottom is cleaned and then the well pipe is inserted centrally (through spacers) into the casing
- With the simultaneous supply of filter gravel, the drill pipe is then re-pulled out of the ground through oscillating rotation and pulling with the casing oscillator



Well drilling [source: SENNEBOGEN]

5. Bores for vent shafts in landfills

Landfill gas develops within landfills due to bacterial decomposition of the organic waste components. The main components of this gas are methane (CH4) and carbon dioxide (CO2). Because reclamation of old landfills has been hindered for decades due to the outflowing biogases, extraction of landfill gas is required for environmental protection reasons alone. “Gas wells” are used for this purpose – these are grab bores in the landfill body that are accompanied by special HDPE filters and full-wall pipes so that the landfill gas can be suctioned out. This can then be used economically in district heating plants.

The drilling process is as described in the previous sections. However, different filter elements are inserted into the drill pipe.

SENNEBOGEN 624HD grab bores in the landfill body [source: SENNEBOGEN]

SENNEBOGEN duty cycle cranes in pile grab operation with casing oscillator

Duty cycle crawler cranes in pile grab operation with casing oscillators are important devices for foundation work and extraction tasks. SENNEBOGEN duty cycle crawler cranes are used as the carrier for the pile grab and the casing oscillator and can take over the entire control of the attachments.

For this, the duty cycle crawler crane must be mechanically and hydraulically adapted to the selected casing oscillator. There are a number of casing oscillator manufacturers on the market that all specify different connection data. This is why this data must be discussed and defined in detail with the customer in advance.

Various connections for casing oscillator on SENNEBOGEN duty cycle cranes [source: SENNEBOGEN]

Likewise, the control system of the attachments must be specified. For example, the pile grab can be a one-rope grab, two-rope grab or hydraulic grab. The casing oscillator can be operated directly on the device, via remote radio control, or from the cab of the duty cycle crane.

SENNEBOGEN 630HD for grab bores for foundation work [source: SENNEBOGEN]

The following measures and work cycles are run with the SENNEBOGEN duty cycle crawler crane for casing operation:

Images – SENNEBOGEN 624 HD in casing operation with two-rope pile grab [source: SENNEBOGEN]

Image 1: Set-up of the operating equipment

- Duty cycle crane is moved into position
- Casing oscillator is lifted in front of the machine by the duty cycle crane.
- The casing oscillator is then connected mechanically (and hydraulically) to the front of crane
- Attaching a rope suspension gear to the rope of winch 1 for lifting the pipe sections

Image 2: Installation of the first pipe section in the casing oscillator

- Duty cycle crane is moved to the drilling position and operates in crane mode
- The first pipe section with cutting edge is lifted into the casing oscillator using a rope suspension gear and clamped via its hydraulic cylinders.
- The drill pipe is then oscillated* into the ground while rotating and pushed in parallel using the deadweight of the casing oscillator
- The duty cycle crane drops the rope suspension gear and picks up the pile grab

*counter-rotating, reciprocal rotation of the casing

Image 3: Grab and casing installation in parallel

- Duty cycle crane operates in freefall mode; the winches are initially run with friction-locking via Combi-Link; grab buckets open
- After inserting the grab into the casing section, freefall is activated and the pile grab digs into the material using its deadweight and the fall velocity (use a chisel if necessary)
- Opening and closing several times (two-rope and hydraulic grab) can optimally fill the grab
- Closing mechanisms:

One-rope grab:	Locking mechanism of the grab shells is released in the event of an impact
Two-rope grab:	Close rope (winch 2) closes the grab
Hydraulic grab:	Hydraulic mechanism

- The depth indicating device monitors the current drilling depth. Simultaneously, the drill pipe is further jacked via the control system of the casing oscillator so that it is always ahead of the pile grab

Image 4: Emptying grab and parallel casing installation

- Winches are run with friction-locking to lift the grab out of the bore hole
- Pile grab is emptied using the following opening mechanisms:

One-rope grab:	Locking mechanism in the trigger crown
Two-rope grab:	Close rope (winch 2) opens the grab
Hydraulic grab:	Hydraulic mechanism

- The drill pipe is oscillated further into the ground in parallel via the casing oscillator control

Image 5: Lifting the next pipe section

- Winches are run with friction-locking in crane mode
- Grab is set down and rope suspension gear is attached to connect the next section of the casing to the section already drilled in with positive-locking and friction-locking fit
- Then the drilling process starts again as described in image 3 and 4 until a new pipe section is attached or the required drilling depth is reached

After reaching the required drilling depth, the interior of the drill pipe is converted using the appropriate construction or fill material, such as:

- Concrete and reinforcement
- Steel profiles
- Prefabricated concrete parts
- Well pipes
- Filter gravel

The casing is then removed. This in turn is executed with the aid of the casing oscillator, which through oscillation and simultaneous pulling, conveys the casing sections out of the drill hole, one after the other.

SENNEBOGEN technology in use: Pile grab with casing oscillator

SENNEBOGEN duty cycle crawler cranes are equipped with first-class technical equipment for dynamic operation with casing machines and pile grabs, and have been optimized 100 % for the implementation conditions.

SENNEBOGEN HD cranes are high-performance machines with maximum efficiency and pile grab capacity, and at the same time they offer low fuel consumption.

SENNEBOGEN duty cycle crane equipment for pile grab with casing oscillator [source: SENNEBOGEN]

1. Mechanical and hydraulic connection for casing oscillator
2. Comb-Link winch 1 and winch 2
3. Pre-adjustable free-fall speed winch 1
4. Depth indicating device
5. Rope guidance on the boom
6. Rope equipment
7. Boom head with sheave shield
8. Pile grab
9. Casing / drilling pipe
10. Casing oscillator

1. Mechanical and hydraulic connection for casing oscillator on the duty cycle crane

A mechanical connection of the casing oscillator to the duty cycle crane is necessary because the casing oscillator rotates in the opposite direction for oscillation and must be held / stabilized by a “counterweight” (counterweight = duty cycle crane). The connection is established on the middle bridge of the undercarriage. It is always designed in such a manner that the casing oscillator can be quickly and easily mounted or dismounted because the casing oscillator is always transported separately from the duty cycle crane.

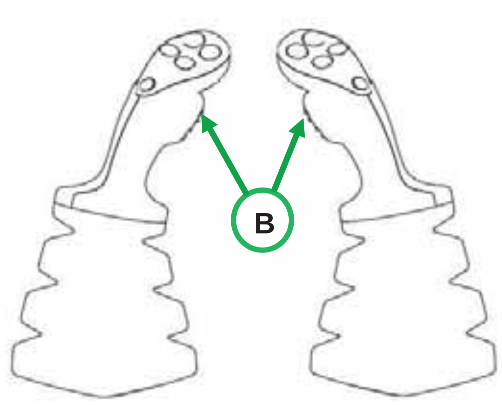
Mechanical connection for casing oscillator – middle bridge of the undercarriage SENNEBOGEN 690HD [source: SENNEBOGEN]

The hydraulic connection of the casing oscillator is also established on the middle bridge of the undercarriage. For this it is necessary to know the required hydraulic connection data of the casing oscillator. The number of connections (flow, return, and leakage oil lines) with the respective flow rate of the hydraulic oil in liters per min, the working pressure of the hydraulic oil in bar, and possibly the electrical connection data need to be clarified in particular.

Hydraulic connection – casing oscillator on the middle bridge of the undercarriage SENNEBOGEN 630 HD [Source: SENNEBOGEN]

2. Combi-Link: Crane operation / freefall operation changeover via joystick

The Combi-Link ensures active changeover between free-fall and friction-locking operation by the operator of the duty cycle crane. In pile grab operation, this function is required for both main winches. When both winches are switched to freefall mode, pressing the respective button on the joystick activates friction-locking operation and guides the grab precisely into the borehole. You can then switch back to freefall mode by releasing the respective button and the pile grab can be lowered into the material to be excavated in freefall.



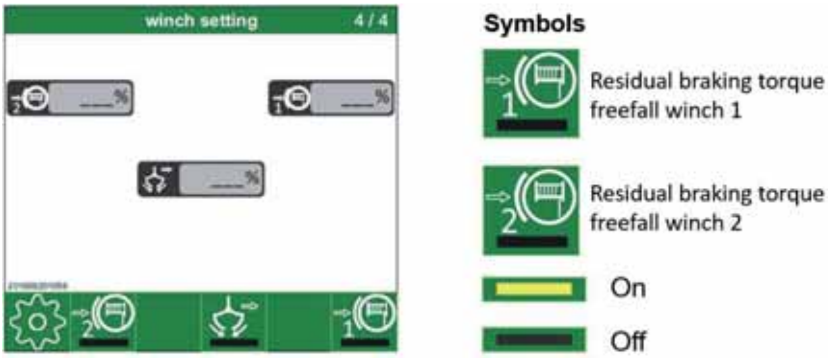
Detail graphic: Activation of Combi-Link via joystick [source: SENNEBOGEN]

The Combi-Link push button ("B") is on the right joystick for the front winch (winch 1) and on the left joystick for the rear winch (winch 2).

3. Pre-adjustable residual braking torque ("freefall velocity") for winch 1

The option of pre-adjusting the residual braking torque or the "freefall velocity" for winch 1 is required to vary the speed at which the pile grab penetrates the ground in freefall mode. This allows the operator to respond to different ground characteristics and optimizes the penetration behavior of the grab.

SENCON is the only way to set the residual braking torque (freefall velocity) of the respective freefall winch. Under the "winch setting" tab, the residual braking torque can be set separately and independently for each winch. The value 0% means that the freefall will be executed at maximum speed. Increasing the value partially engages the freefall brake and reduces the freefall velocity. This prevents the occurrence of slack rope and enables better monitoring/control for freefall tasks.

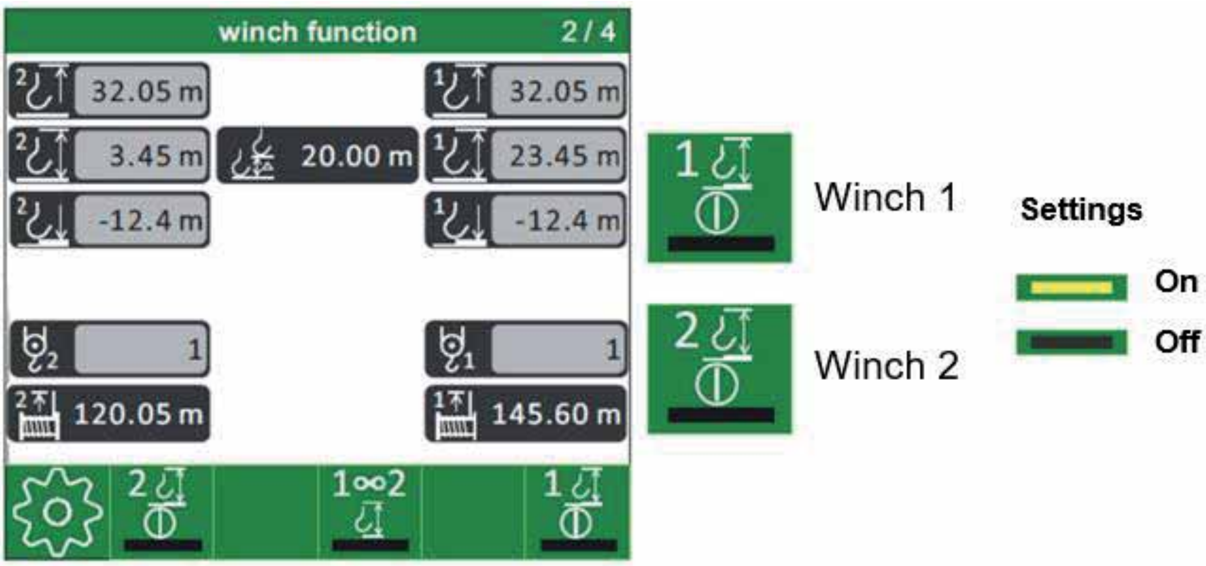


SENCON – setting the residual braking torque [source: SENNEBOGEN]

4. Depth indicating device

The depth indicating device is provided as a tool for the machine operator that displays the height of the load / operating equipment (here: pile grab) on the screen. This is needed to monitor whether the required bore depth has been reached. The height at which the grab is opened and switched to freefall mode can also be recorded.

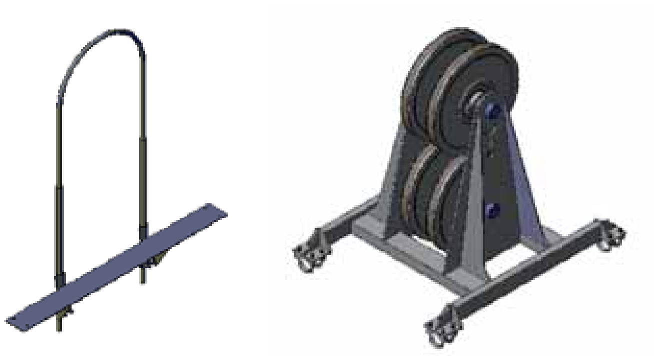
The height depends on a zero point that can be set by the operator via the display. Sensors on the machine monitor the current operating conditions and transmit the measurement results to the depth indicating device. After analysis, the values are presented on the SENCON screen automatically or at the touch of a button. Position compensation – i.e., the two winches are in different positions and windings – is executed automatically. Switch-off points for the winches can also be programmed via the depth indicating device.



SENCON – depth indicating device [source: SENNEBOGEN]

5. Rope guidance on the boom

Rope guidance on the boom can be ensured via rope catch brackets or rope guide sheaves. The rope guide is used to avoid slack rope and prevents lateral slip-off of the rope and thus associated damage to the rope or to the boom. The number of rope guides used varies from use to use and can also be modified on customer request.



Detail graphic of rope guide – rope grab (left) and rope guide sheaves (right) [source: SENNEBOGEN]

6. Rope equipment for pile grab operation

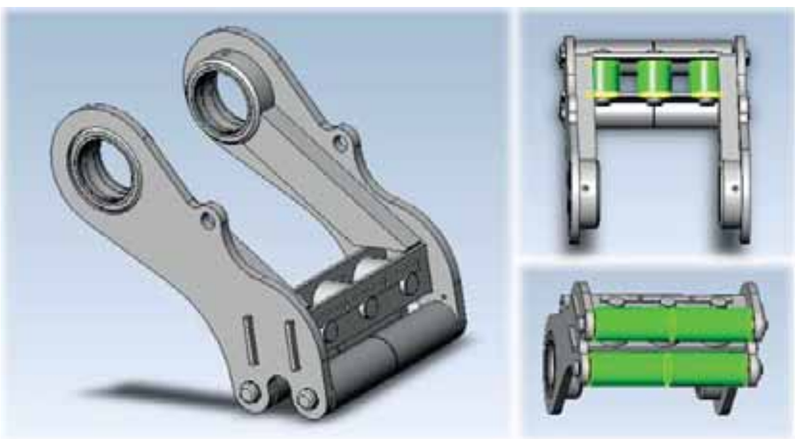
The SENNEBOGEN rope equipment for pile grab operation has been specially developed for the dynamic forces in casing operation.

Two grabs ropes are always used for this underground engineering technique, regardless of whether a mechanical or hydraulic grab is used. For the mechanical pile grab (one-rope or two-rope grab), one rope (winch 1) is used for lifting the pile grab and one rope (winch 2) is used for the close mechanism of the grab. In operation with a two-rope grab, the closing mechanism is activated directly via the rope of winch 2. For one-rope guides, this rope is connected to the trigger crown above the one-rope grab. Unlike mechanical pile grabs, with hydraulic grabs, both ropes (winch 1 and 2) are used to lift the grab since the close mechanism is controlled hydraulically.

All ropes used have a rated strength of 1,770 N/mm².

7. Boom head with sheave shield

Rope guidance of the lift and closing rope is optimized through use of a sheave shield attached to the boom head. The sheave shield consists of moveable sheaves in a longitudinal and transverse arrangement. This prevents reciprocal jamming of the two ropes and also stops the rope from slipping off the sheaves of the boom head. Steel sheaves are recommended in the boom head instead of plastic sheaves to minimize rope wear



Sheave shield on the boom head [source: SENNEBOGEN]

8. Pile grabs

Pile grabs are used to pick up and convey material. There are different designs depending on material, locale and carrier. The grab buckets are wear parts and consequently are easy to replace.

The conveying capacity of the pile grab that is not used as a drilling tool, but rather as an excavating tool, is highly dependent on the grab weight, its fall velocity, the stability of the ground, and the volume of the grab shells.

There are mechanical, as well as hydraulic pile grabs. Mechanical grabs can be one-rope or two-rope guides. The main components are the basic body that ensures guidance into the drill pipe and the lower part of the grab with the grab shells.

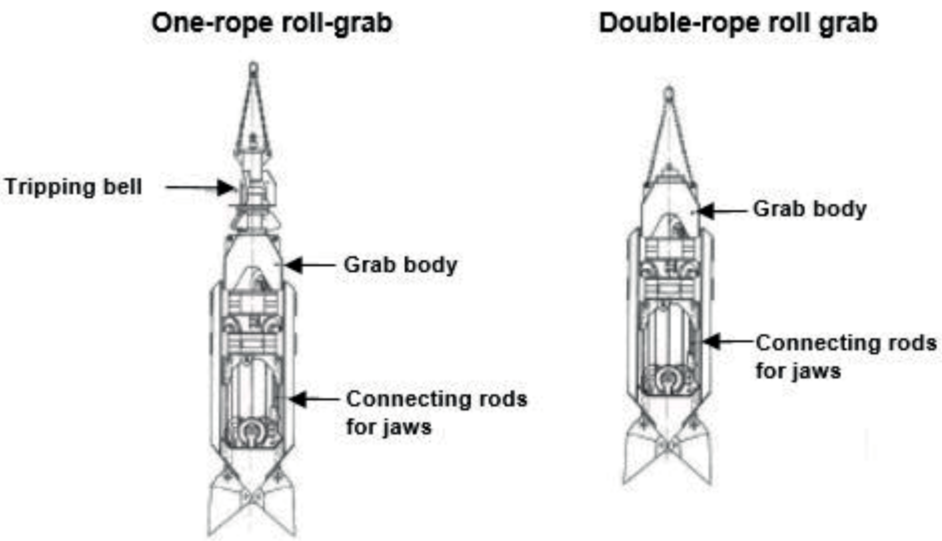


Diagram of a mechanical one-rope and two-rope pile grab [source: SENNEBOGEN]

The opening mechanism for the one-rope grab is activated via a trigger crown that hangs fixed in place on the rope of winch 2 a short distance below the boom head.

For the hydraulic pile grab the close and open mechanism is activated via a hydraulically operated mechanism. The required hydraulic system is provided by the SENNEBOGEN duty cycle crane as a carrier.

The spherical grab is another pile grab. This can be a mechanical grab (two-rope system), as well as a hydraulic grab. Thanks to the spherical design of the grab buckets, the spherical grab achieves an extremely high fill level. The single-grab behavior of the grab in the ground can be characterized as optimal due to its extremely high deadweight and the high closing forces, even without switching the spherical grab to freefall. This is primarily used if drilling needs to be executed without vibration.

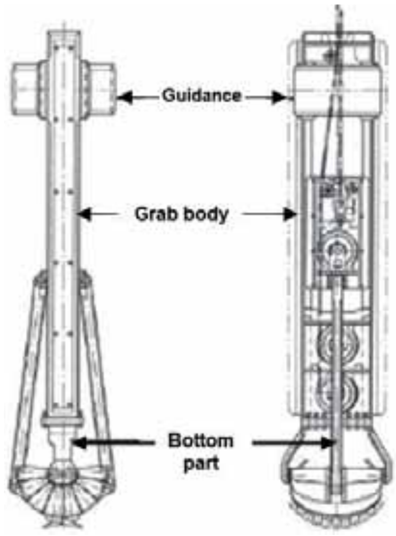


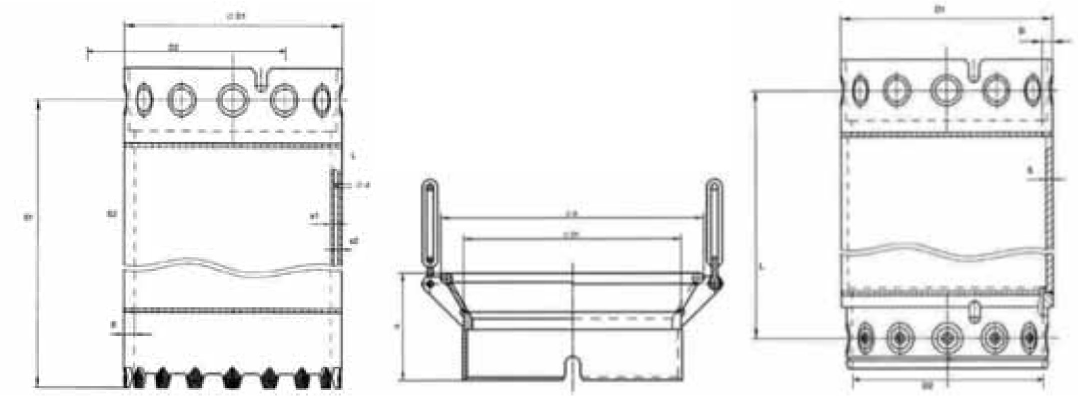
Diagram of a spherical grab [Source: SENNEBOGEN]

One-rope guides and two-rope guides are suitable for drill pipes with an outer diameter of 600 mm to 3,000 mm – the spherical grab even up to 3,200 mm. The deadweight of a pile grab can be as much as 20 t.

9. Casing / drill pipes

Drill pipes are suitable for producing cased bores to a depth of 100 m. The precision-fit pipe connections guarantee fast fitting and bolting of the pipes, particularly for pile production. Moreover, the transmission of force is optimal.

Double-wall pipes should be used to a drill pipe diameter of 1,500 mm. For larger diameters, single-wall drill pipes are used to reduce the lifting weight. In general, drill pipes with diameters from 600 mm to 3,300 mm are used for casing oscillators.



Diagrams – bottom pipe – drill pipe – funnel – of a drill [source: SENNEBOGEN]

Other casing elements include:

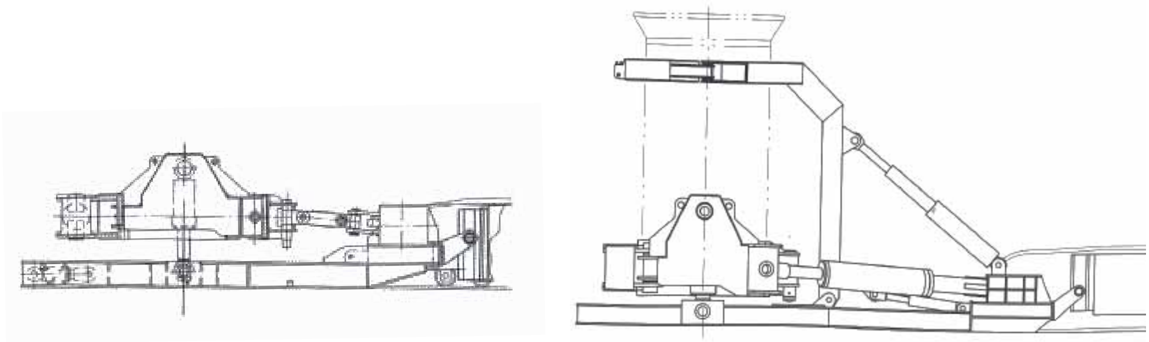
- The cutting edge (bottom pipe) is guaranteed with the propulsion
- The drill funnel as protection for the pipe connection and guide for the pile grab
- Drill pipe connection for precision-fit connection of individual drill pipes
- The drill suspension gear for fast fitting and severance of the drill pipes

10. Casing oscillator incl. control system

Casing oscillators are hydraulically powered jacking devices for the production of piles and wells. The extremely robust construction enables durable and cost-effective use. Casing oscillators must be mechanically permanently connected with the carrier (SENNEBOGEN HD crane). The great advantage when using the casing oscillator is the low height in front of the duty cycle crane. In addition, the duty cycle crane can be rotated 360° in coupled status (for example, to lift drill pipes or to empty the grab).

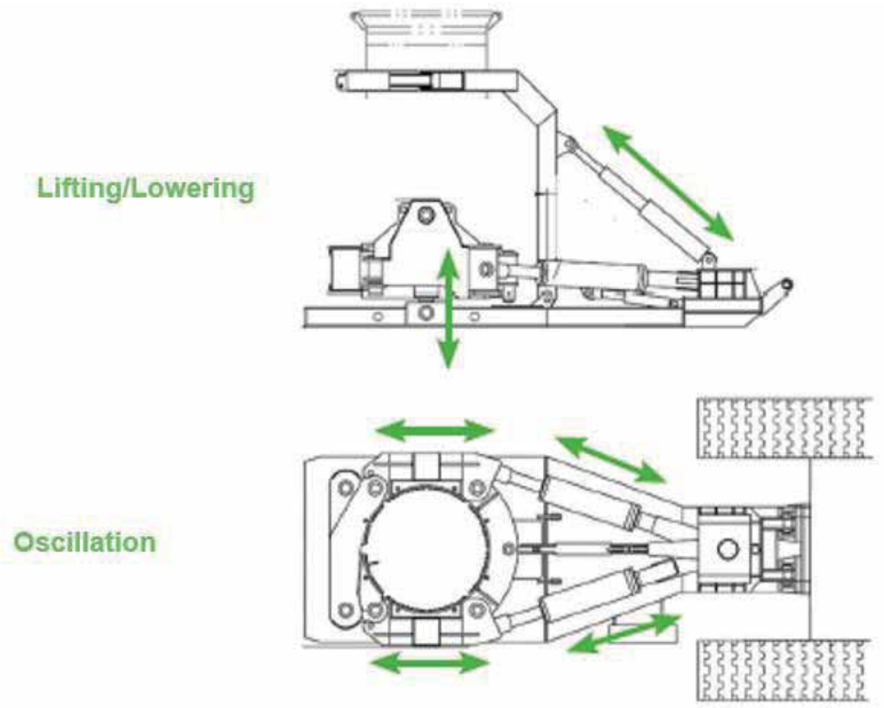
The hydraulic system required for the casing oscillator can either be provided by the carrier or by an additional hydraulic power unit.

The drill pipes are inserted into the ground using the casing oscillator through oscillation and pushing. In this case, usually the “short” design for pipes up to 1,200 mm is used. For drilling pipes longer than 1,200 mm, preferably casing oscillators with a high pipe guide are used.



Casing oscillator short design (left) and casing oscillator high pipe guide (right) [source: SENNEBOGEN]

After inserting the drill pipe it is clamped. The clamp consists of multiple elements that encircle the drill pipe like a chain so that constant pressure occurs on the pipe perimeter. In addition, the extensive height of the clamp (400 mm to 700 mm) ensures that any possibility of damaging the pipe is excluded.



Casing oscillator jacking mechanisms [source: SENNEBOGEN]

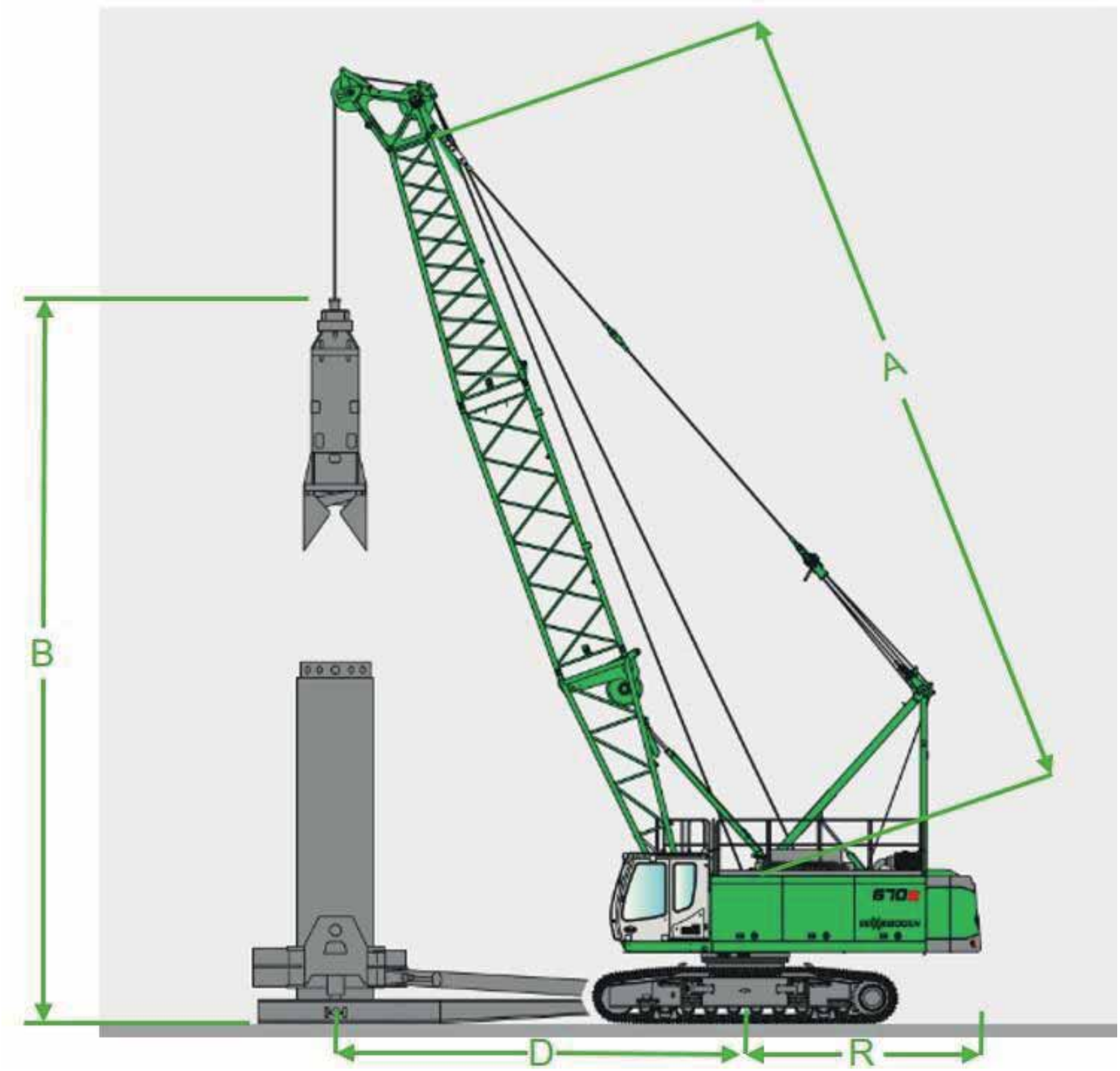
The casing oscillator can be controlled via:

- The operator cab of the duty cycle crane (joystick or control panel)
- A control panel directly on the casing oscillator
- Via remote control with a receiver part on the casing oscillator

Equipment recommendations – SENNEBOGEN duty cycle crane in grab operation with casing oscillator

Type	boom length max. [A]	hook height [B]	Distance to axis of rotation [D]	Swingtail [R]	hook load max.	bore diameter max.
	[m]	[m]	[m]	[mm]	[t]	[mm]
624HD	14.0	13.0	4.0	2.840	12	600 - 1.200
630HD	13.1	12.5	4.5	3.330	20	600 - 1.200
640HD	15.9	15.0	4.9	3.773	28	1.200 - 1.800
655HD	15.9	15.0	5.3	4.090	39	1.500 - 2.000
670HD	17.7	16.5	6.0	4.645	40	1.500 - 2.000
6100HD	18.7	18.0	6.5	5.210	69	2.000 - 2.500
6140HD	24.3	22.0	8.0	5.490	80	2.500 - 3.300
6300HD	29.9	28.0	10.0	7.320	150	3.000 - 3.500

Overview of SENNEBOGEN duty cycle crane with casing oscillator [source: SENNEBOGEN]



Dimensions of duty cycle crane with casing oscillator [source: SENNEBOGEN]

Pile grab with casing oscillator questionnaire

Available casing oscillator type: ________________________ [-]

Manufacturer of the available casing oscillator: ________________________ [-]

Data sheet included: ________________________ [yes/no]

Drawing of mechanical connection: ________________________ [-]

Working pressure of the casing oscillator: ________________________ [bar]

Pressure line flow rate: ________________________ [l/min]

Number of pressure lines: ________________________ [-]

Nominal diameter of the pressure line connection: ______________________ [-]

Flow rate of the return lines: ________________________ [l/min]

Number of return lines: ________________________ [-]

Nominal diameter of the return line connection: ________________________ [-]

Flow rate of leakage oil lines: ________________________ [l/min]

Number of leakage oil lines: ________________________ [-]

Nominal diameter of the leakage oil line connection: ____________________ [-]

Control of the casing oscillator from: ________________________ [-]

Electrical connection required: ________________________ [V]

Diameter of the drill pipes: ________________________ [mm]

Ground water/height under ZERO: ______________________ [yes/no] [m]

Maximum drilling depth: ________________________ [m]

Work hours per day / days per month ____________ / ___________ [h] / [d]

SENNEBOGEN duty cycle crane in pile grab operation

SENNEBOGEN 630HD with casing oscillator – France [source SENNEBOGEN]

SENNEBOGEN 624HD with casing oscillator – France [source SENNEBOGEN]

SENNEBOGEN 6130HD with casing oscillator – Hong Kong [source: SENNEBOGEN]

Operation with 2-Rope Grab / Dredging

SENNEBOGEN 630HD in grab operation – dredging tasks [source: SENNEBOGEN]

SENNEBOGEN duty cycle crawler cranes are machines that are ideally designed for grab operation. Thanks to the special design and numerous features, they can be used in almost all grab applications.

The particularly robust structure of the uppercarriage, the selection of materials, and the stress test of individual components provide years of high-performance use – even under harsh conditions. The stability of the undercarriage – due to the wide track – allows the machine to stand securely, meaning that the machine can be used reliably, even when high demands are placed on the handling capacity. The possibility of changing the track width for telescopic undercarriages also significantly facilitates machine repositioning. This applies to use on construction sites as well as to truck transport between two materials handling locations.

What does grab operation mean

Grabs are used for different activities. Here special mention should be made of grab operation for loading various goods, particularly in the area of materials handling, and the use of underwater grabs for dredging.

For tasks with grabs, both crane winches and freefall winches can be used. Crane winches are used in particular when a controlled lowering of the grab is required or if the operation of freefall winches is prohibited (for example, discharging shiploads). Freefall winches are used when the material to be loaded is compacted or extremely dense. In this case, freefall winches are more suitable since they can dig into the material better due to the high “impact speed”.

For work with load grabs, the grab is lowered down into the material to be loaded. If the material is compacted or highly dense, the grab can be run into the material in freefall if necessary. In this process the grab shells dig themselves deeper in right from the start so that a higher level of filling can be achieved. Closing of the grab is supported by Combi-Link (see the Combi-Link section).

Combined with a load moment indicator device (LMI) installed in the machine, the grab weight can be monitored. In the event of an overload, this switches the winches off, which ensures safe machine operation. Freefall winches can also be moved and monitored by the LMI in crane mode. However, in this case, the freefall function is not enabled.

An additional tool for reliable machine operation is the grab steadying winch (GSW). Depending on the type of duty cycle crane, this is installed in the basic boom, on the side of the boom, or on the front of the uppercarriage and is used to prevent oscillating grab motions. The pulling force of the GSW can be preset via the SENCON (SENNEBOGEN Control System). This ensures appropriate reaction to different grab sizes and conditions on site.

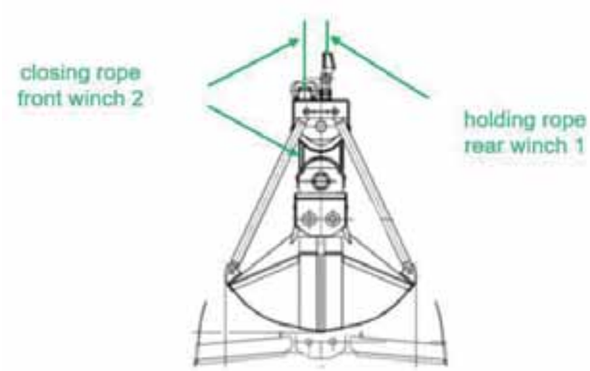
Grab operation and grab models

Typical grab implementations and the associated grab models are explained below.

a. Handling work with mechanical 2-rope grab
b. Special case – dredging

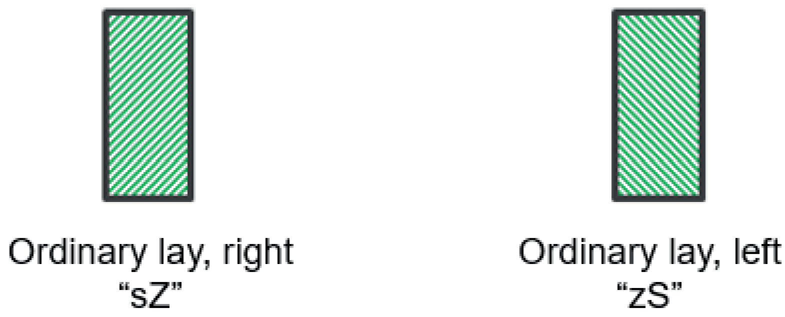
A. Handling work with 2-rope grab

A 2-rope grab is characterized by the fact that two ropes are required for the task. A hoist rope for lifting the grab and a close rope that operates the open and close mechanism of the grab.



Two-rope grab – schematic diagram [source: SENNEBOGEN]

The close rope is reeved several times between the attachment point on the grab and the moving grab shells in order to increase the closing force. To rotate the grab in a controlled manner, two ropes rotating in opposite directions are used. Thus SENNEBOGEN places on winch 1 a rope with ordinary lay right (sZ pitch) and on winch 2 a rope with ordinary lay left (zS pitch).



Regular lay – schematic diagram [source: SENNEBOGEN]

Both ropes are routed to the grab via the boom head and must each be able to hold the full load (grab + content). The so-called line pull required for this varies depending on the quality of the ropes and their diameter.

The following line pulls apply for SENNEBOGEN duty cycle crawler cranes:

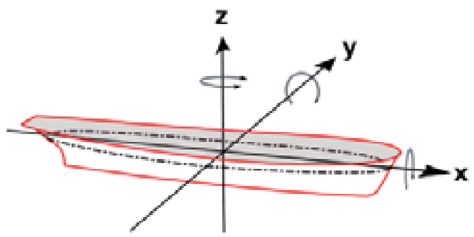
SENNEBOGEN HD crane	engine [kW]	winches [t]	rope-Ø [mm]	max. line pull [kg]	max. rope speed [m/min]
624HD	129	6	16	6.000	110
630HD	186	12 (9)	22 (18)	12.000 (9.000)	125 (120)
640HD	186	12 (16)	22 (26)	12.000 (16.000)	125 (120)
655HD	261	16	26	16.000	115
670HD	298/261/321	16 (20)	26 (28)	16.000 (20.000)	125 (110)
6100HD	447/451	200 (250/300)	28 (34/34)	20.000 (25.000/30.000)	95 (80/73)
6140HD	563/708	25 (30/35)	34 (36/36)	25.000 (30.000/35.000)	98 (98/87)
6300HD	570/708/840	35 (40)	36 (42)	35.000 (45.000)	80 (105)

Maximum line pull depending on winch size and rope diameter [source: SENNEBOGEN]

B. Special case – dredging

Dredging is defined as a duty cycle crane task with a grab that is used at least partially underwater. This is not a materials handling application, rather it is pure excavation of river beds or the sea floor. The objective of this work is usually the maintenance or development of waterways.

Duty cycle cranes are often built directly onto a ship for this purpose. Thus the hull of the ship is the undercarriage. For use of HD cranes on ships, the machines have to comply with special regulations. For example, a load moment indicator must be installed. Due to the degree of freedom of the ship, its heeling (lateral inclination in the direction of travel) must be manageable by means of special load charts.



Rotational movements: Rotation around the x-axis (static: Heeling – oscillation: Rolling)
Rotation around the y-axis (static: Trimming – oscillation: Stamping)
Rotation around the z-axis (course change: Rotation – oscillation: Yawing)

Heeling and trimming of ships [source: Wikipedia]

In special cases of high-seas implementation, maritime certifications, for example for the LMI or for the diesel engine must be obtained. These regulations must be clarified in advance because the component selection must meet more rigorous requirements and cannot be changed retroactively. Both the static and dynamic strength and stability of the entire machine are as a rule tested by an approved authority (for instance RINA: The Royal Institution of Naval Architects). In this area considerable reductions in load bearing capacity of to 30 % can occur. Thus reduction is not due to the selection of weaker materials, but rather is required to meet the extremely rigorous criteria required in maritime use.

To ensure smooth and faultless setup of duty cycle crawler cranes on the ship, the interfaces must be clearly defined. SENNEBOGEN always supplies the slewing ring, including screws. The required pylon can be provided by the customer. In this case, the boom forces and torques acting on the pylon are forwarded to the customer so that the pylon and the associated substructures can be configured for the machine. Because stationary machines are not complete machines SENNEBOGEN does not provide CE certification for the machine. In this case, a Manufacturer's Declaration is provided that cites all the relevant standards. The shipyard or the company that completes the machine is obligated to prepare a CE Declaration.

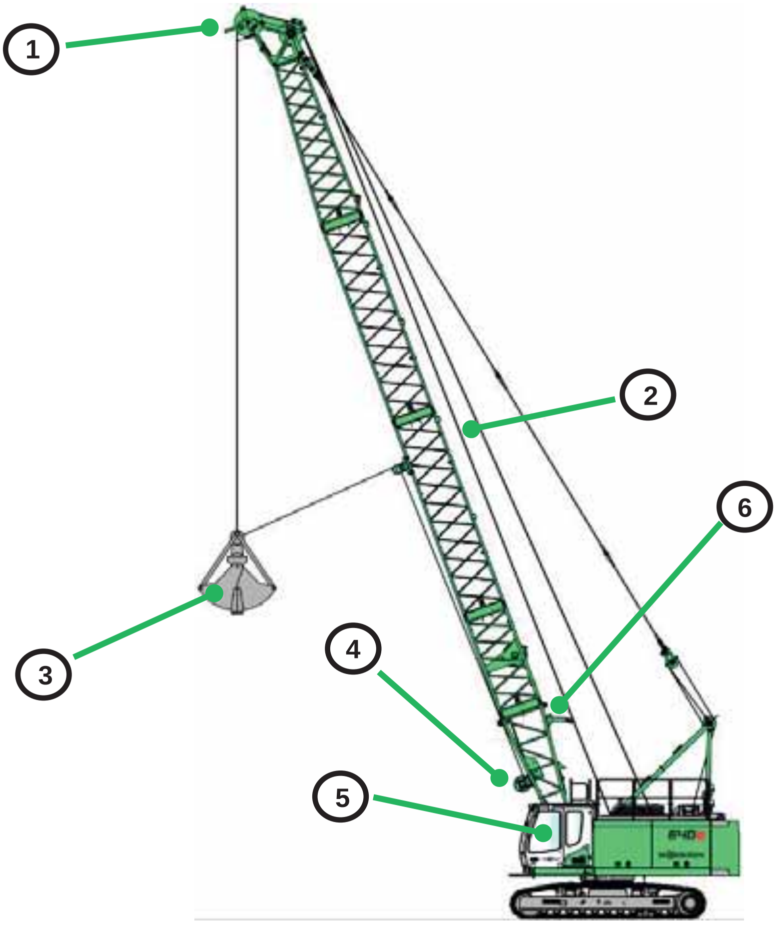
SENNEBOGEN 6180HD stationary on a ship in dredging operation [source: SENNEBOGEN]

Only special underwater grabs can be used for dredging. These must satisfy the requirements imposed on dredging (watertight lubricating points, drainage slots that allow the water to run off, etc.). For this application, rope guides, as well as underwater grabs that have been specially developed for this implementation are used.

Due to the typical implementation conditions associated with dredging, it may be the case that the grab adheres to the ocean floor and then jerks free. This imposes special requirements on the operator, the duty cycle crane, and the pontoon/ship as counter force. To maintain reserve capacity, SENNEBOGEN recommends that the duty cycle crawler cranes are configured slightly larger for dredging. Thus you can avoid the situation that the machines quickly reach their capacity limit.

SENNEBOGEN technology in grab operation

SENNEBOGEN duty cycle cranes are equipped with first-class technical equipment for dynamic applications with grabs and have been 100% adapted to the operating conditions. SENNEBOGEN duty cycle crawler cranes are high-performance machines with maximum efficiency and grab capacity, and at the same time they offer low fuel consumption.



SENNEBOGEN duty cycle crane with grab equipment [source: SENNEBOGEN]

1. Boom head
2. Grab rope equipment
3. Grab
4. Grab steadying winch with deflector sheave
5. Control: Pre-adjustable FF-speed, grab autofill, Combi-Link, Synchronization
6. Rope guidance on the boom

1. Boom head with steel sheaves and sheave shield

For operation with rope guides, SENNEBOGEN recommends fitting steel sheaves and a sheave shield on the boom head. The sheave shield in this combination ensures an optimal rope guide to prevent the rope from slipping off the sheaves. In addition, the use of steel sheaves instead of plastic sheaves prolongs the service life of components because the steel variant is significantly more wear-resistant than the plastic sheaves.

Detail graphic of SENNEBOGEN boom head 690 [source: SENNEBOGEN]

2. Rope equipment

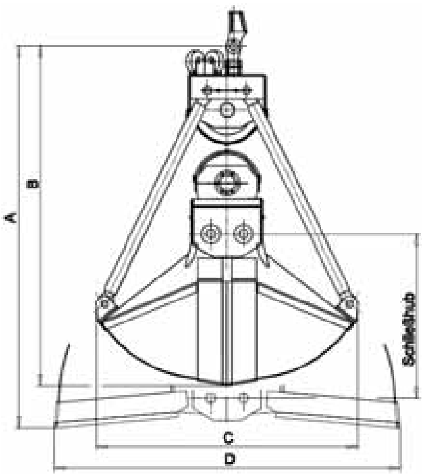
The SENNEBOGEN grab rope equipment has been specially developed for the dynamic forces that occur in grab operation. For the 2-rope grab, two grab ropes (1x for lifting the grab via winch 1 and 1x for closing the grab via winch 2) with opposite direction of rotation are used. This makes it possible to make minor corrections to the position of the grab. The minimum tensile strength of the rope used is crucial here. The maximum line pulls are specified on page 4 of this section.

3. Grab types

Types of grabs are differentiated according to the material to be loaded. Different requirements are taken into account by special grab shapes, particularly with the design of the grab shells. Grab types are essentially differentiated as follows.

Double shell grab

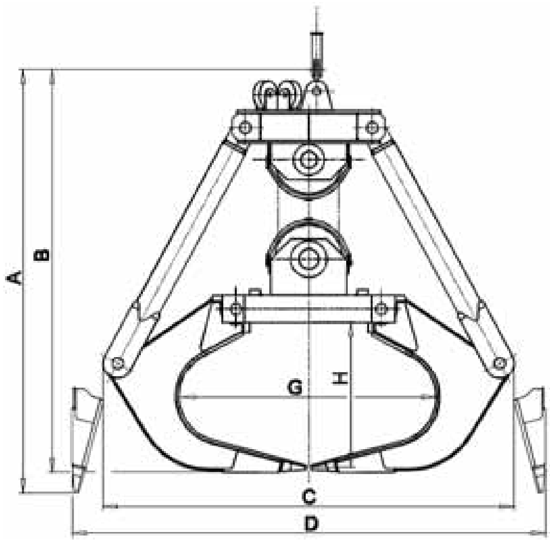
A double-shell grab has two shells that close to take up loose load material, usually powder-like bulk material. The shells can be used open on top, half open, or completely closed. Completely closed grab shells are required for the loading of chemicals, for example.



Double shell grab: Schematic diagram (left) and implementation graphic (right) [source: SENNEBOGEN]

Multi-shell grab

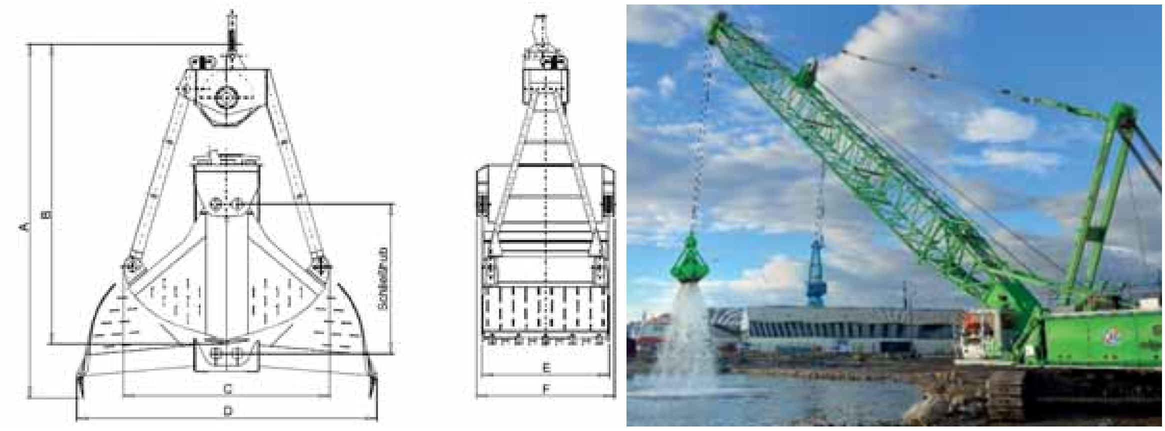
Multi-shell grabs are required if larger ballast material or scrap will be loaded. Compared with the double shell grab, careful handling of the material is not important.



Multi-shell grab: Schematic diagram (left) and multi-shell ballast grab (right) [source: SENNEBOGEN]

Underwater grab / dredging grab

Grabs for dredging operation must be built very robustly. This is due to the fact that high forces must be taken into account when the grab is torn loose as well as the pressure on the material that increases with increasing water depth. Dredging grabs always have drain slots for the water that is lifted up with the sludge.



Underwater grab: Schematic diagram (left) and implementation graphic (right) [source: SENNEBOGEN]

4. Grab steadying winch (GSW)

Via the grab steadying winch, a rope is fastened laterally to the grab, which stops the attachments from “wobbling”. During slewing, the grab is pulled forward via the grab steadying winch with a force that has been specified beforehand. This can prevent the attachment from protruding and consequently swinging once the slewing gear has stopped. With this activation, the grab can be positioned above a truck or other unloading aid with much greater ease.

Grab steadying winch 670HD installed in the basic boom section [source: SENNEBOGEN]

The GSW can be mounted in the basic boom, on the side of the boom, or on the front of the uppercarriage depending on the type of duty cycle crane. The associated rope is fed through a deflection sheave attached to the underside of the boom, which is used to prevent excessive pendulum movements of the grab. The winches are also equipped with rope and rope lock.

Since the grab capacity increases with higher machine capacity, it is necessary to adjust the GSW to the duty cycle crane size and to offer GSWs with varying strengths. SENNEBOGEN uses the following grab steadying winches for its duty cycle cranes:

Machine type	Tagline winch				
	9kN	18kN	30kN	60kN	120 kN
624 HD					
630 HD	x	x			
640 HD	x	x			
655 HD		x	x		
670 HD	x	x	x		
6100 HD		x	x		
6140 HD		x	x		
6300 HD				x	x

Overview of tagline winches – SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

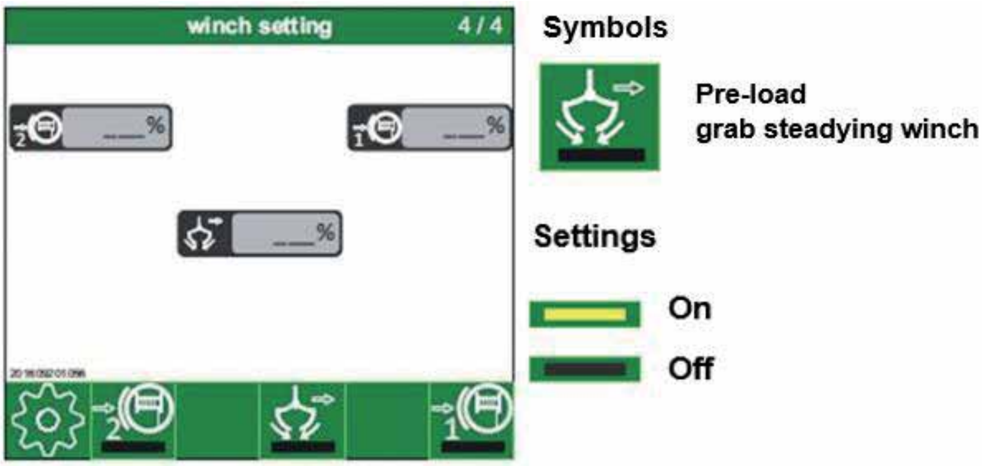
The grab steadying winch offers the following functions for optimal working:

- Proportional pull force adjustment of 0–100% during operation of the joy-stick/foot pedal
- Pull-force adjustment of 0–100% via potentiometer
- Immediate 100% winch pull force via button activation on the joystick
- Freewheeling function of the winch with button activation on the joystick

The pre-load of the GSW is set via the SENCON. Then the GSW can be controlled either via the foot pedal, with the joystick in general, or via the push button on the joystick.

Setting the pre-load of the GSW

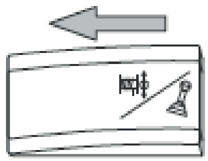
The pre-load of the grab steadying winch is set in the SENCON via the “winch setting” tab. In this menu, the residual braking torque (freefall velocity) can be set for each winch individually. The pre-load of the GSW can be entered as a percentage in the SENCON. By activating the relevant symbol, the entered value can be accepted and the GSW can be enabled. The GSW can then be switched on and off via the display.



SENCON – GSW pre-load setting [source: SENNEBOGEN]

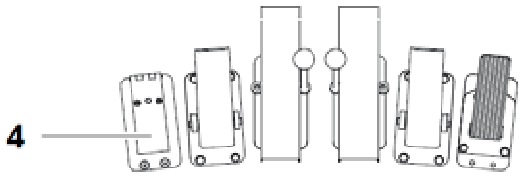
GSW operation via foot pedal

An additional switch in the control panel can be used to select control via foot pedal or joystick – this needs to be activated for pedal operation.



SENCON – grab steadying winch foot/hand switch [source: SENNEBOGEN]

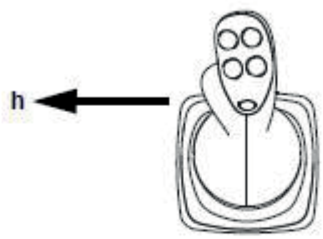
The pull of the grab steadying winch can be controlled (braked) via pedal 4.



GSW control via foot pedal [source: SENNEBOGEN]

GSW operation via joystick

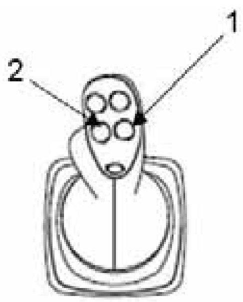
For operation using the joystick, the GSW foot/hand switch mentioned above needs to be set to manual operation. The GSW can now be controlled by moving the joystick in the direction of “h”.



GSW control via joystick [source: SENNEBOGEN]

GSW operation via joystick push button:

If the GSW foot/hand switch is set to manual operation, the pull force of the GSW can be controlled using the push button on the joystick. Pressing the “1” button tightens the rope with maximum pulling force. Conversely, button 2 can be used to release the rope in freewheel mode.

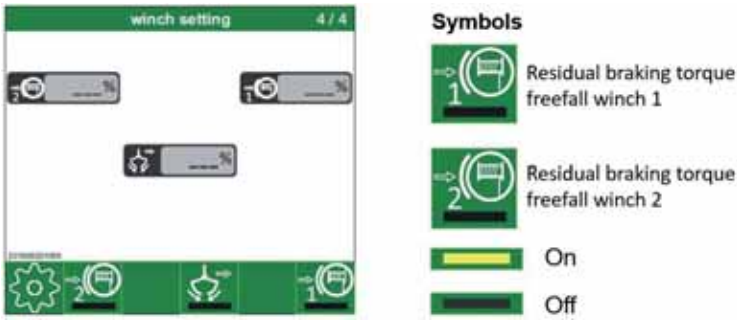


GSW control via joystick push button [source: SENNEBOGEN]

5. Control

Setting the residual braking torque:

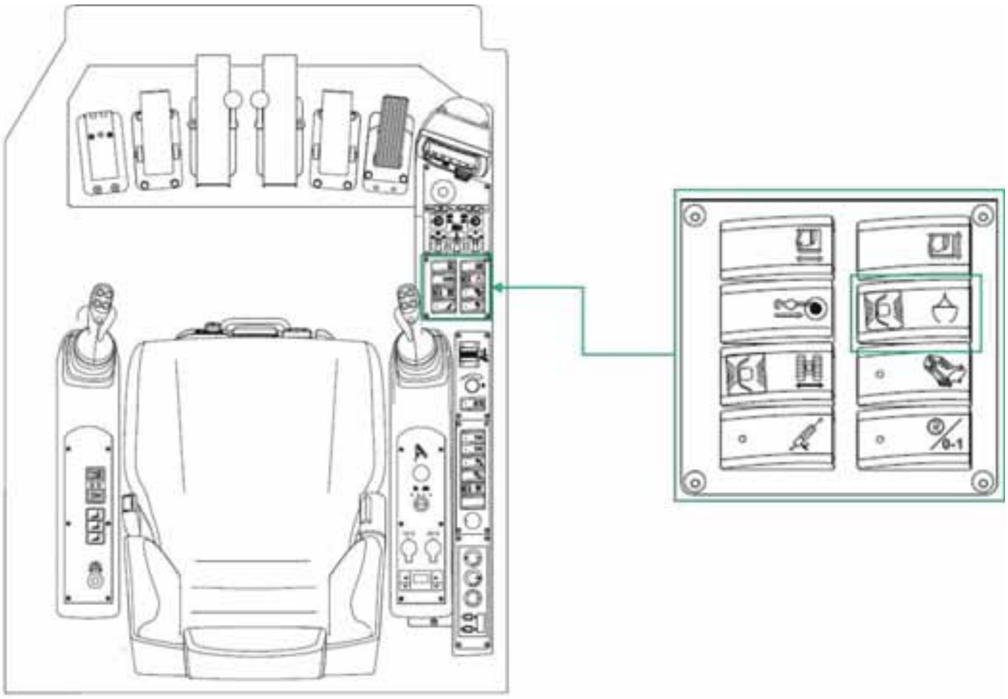
For operation with grabs, for example when loading bulk material, it may be necessary to let the grab drop into the material in freefall to achieve optimal grab filling. For this purpose, the residual braking torque or the “freefall velocity” can be preset using SENCON. Under the “winch setting” tab, the residual braking torque can be set separately and independently for each winch. The value 0% means that the freefall will be executed at maximum speed. Increasing the value partially engages the freefall brake and reduces the freefall velocity. This prevents the occurrence of slack rope and enables better monitoring/control for freefall tasks



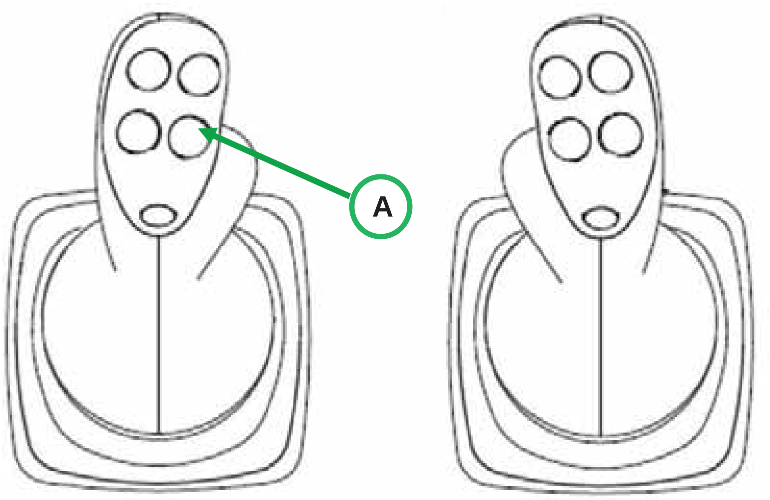
SENCON – setting the residual braking torque [source: SENNEBOGEN]

Grab autofill:

The grab autofill is used for operation with mechanical diaphragm wall grabs. Winch freewheeling for winch 1 ensures optimal filling of the grab. To enable this function, first the freewheeling of the rear winch (winch 1) with the grab hoist rope needs to be activated by pressing the corresponding switch on the front right control panel.


Switch for grab autofill: Control panel, front right [source: SENNEBOGEN]

To fill the grab, it needs to be open and facing the bulk material. Then the freewheeling can be executed by pressing and holding the "A" button on the left joystick. The grab penetrates down into the material through the switched-on winch freewheeling and the deadweight of the grab. In parallel, the grab is closed by activating winch 2, which results in optimal filling. Once the grab is completely closed, button "A" needs to be released. This deactivates winch freewheeling. The filled grab can then be lifted by operating both control levers (winch 1 and winch 2).

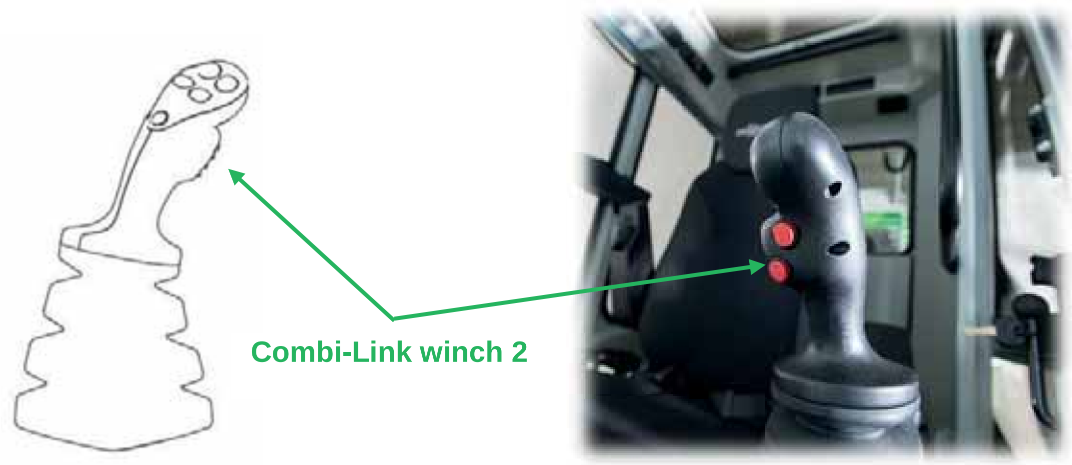


Activation of winch freewheeling for winch 1 using the left joystick button [source: SENNEBOGEN]

Combi-Link (for equipment with freefall winches):

The Combi-Link ensures changeover between freefall and friction lock operation. In grab operation, the Combi-Link is required for the front winch (winch 2) if freefall winches are used. Through activation of the button on the left joystick the friction lock advance of the holding rope (winch 2) is enabled in order to enable the grab to dig in. Through this measure the fill level of the grab can be increased.

The Combi-Link is activated via the left front button on the left joystick.

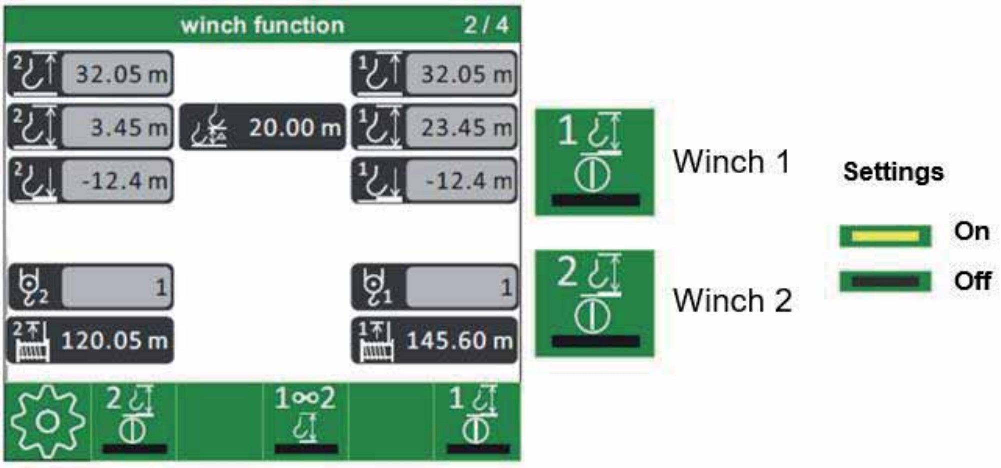


Activation of Combi-Link via joystick [source: SENNEBOGEN]

Depth indicating device:

The depth indicating device is a tool for the machine operator to display the height dimension of the operating equipment (here: grab) on the screen in the cab. This provides above all a visual aid in loading locations with an obscured view. For two-rope guides, the different unwinding of the ropes of the two main winches (winch 1 and winch 2) and the status of the grab (open/closed) can also be monitored. If both displays show the same rope end height, it is guaranteed that the grab is closed. In addition, switch-off points in both directions can be defined.

This is monitored and measured for both winches via sensors and incremental encoders on the winch drums. The results are transferred to the depth indicating device. This is where analysis takes place, which is automatically displayed on the SENCON screen. Position compensation – i.e., the two winches are in different positions and windings – is executed automatically.



Detail graphic of SENCON depth indicating device [source: SENNEBOGEN]

Winch synchronization, winch 1 / winch 2

In some application areas, especially in 2-rope grab operation, it may be necessary to control both winches synchronously, for example to lift a grab. In order to facilitate precise synchronous operation of the winches, SENNEBOGEN duty cycle cranes are equipped with two different winch synchronization functions: hydraulic and electronic winch synchronization. Winch synchronization is activated/deactivated in the SENCON or by pressing the push button on the control lever. To use this function, the two winches need to be in the same operating mode (see the key switch section).

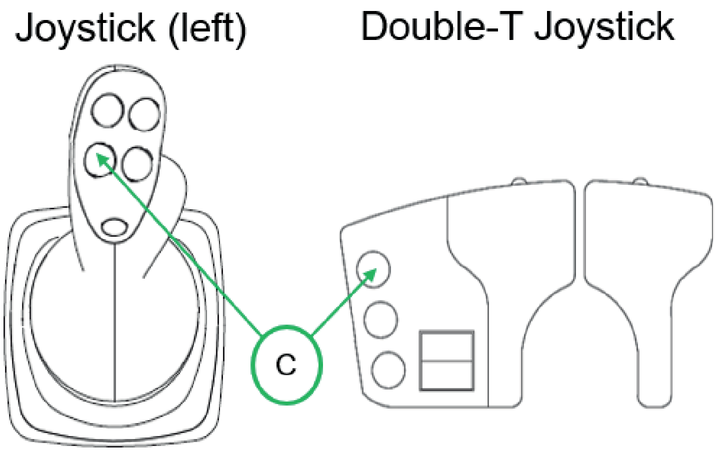
Hydraulic winch synchronization

Hydraulic winch synchronization is part of the basic equipment of each SENNEBOGEN duty cycle crane. When this is activated, the two hydraulic pumps for winch 1 and winch 2 are interconnected, which means that there is pressure equalization in the supply line for the two control valve sections of winch 1 and winch 2.

The parallel circuit provides the following functionality:

- Activation of hydraulic synchronization via a push button [C] in the joystick

- The system only functions with the LIFT function
- Both control levers for winch 1 and winch 2 need to be moved equally (the load distribution on the winches needs to be the same)
- This provides just one useful feature for practical application in rope grab operation



Activation of hydraulic winch synchronization [source: SENNEBOGEN]

Electronic winch synchronization

With electronic winch synchronization, the respective position of the winch is detected by sensors (angular position encoders). At activation of electronic winch synchronization, the control lever / joystick of winch 2 is deactivated and controlled with the joystick of winch 1, both winches are now controlled.

In the background: With the joystick of winch 1, winch 1 is controlled, and winch 2 is readjusted via winch positioning detection.

Electronic winch synchronization can be run in 2 operating modes:

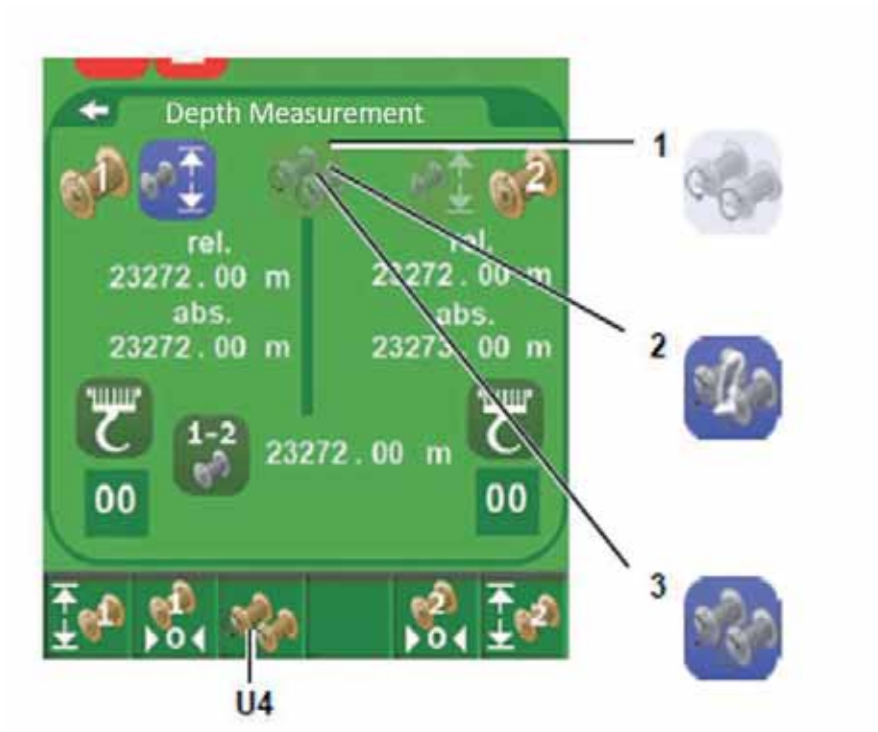
A. Temporary operation – activation via SENCON

In temporary mode synchronization is only activated if the associated button on the joystick is activated. For example, this is suitable for 2-rope grab operation, as in this case synchronization is only required for the lifting (hydraulic synchronization) and lowering (electronic synchronization) function. The synchronization must be switched off again for opening and closing the grab.

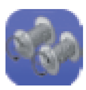
B. Continuous operation – activation via SENCON

In this mode electronic winch synchronization is continuously activated. This synchronization mode is used for applications where both ropes are used synchronously for the lift or lower function, for example, for traverse operation, in operation with hydraulic diaphragm wall grabs, in drop-ball operations, or for dynamic intensive compaction. In this case opening and closing occur via an additional hydraulic controller.

In general, it must be noted that the depth indicating device, which must be installed in the duty cycle crawler crane, is one prerequisite for electronic winch synchronization. This is because the synchronization is based on the hardware system of the depth indicating device, in other words, the sensors of the depth indicating device are used

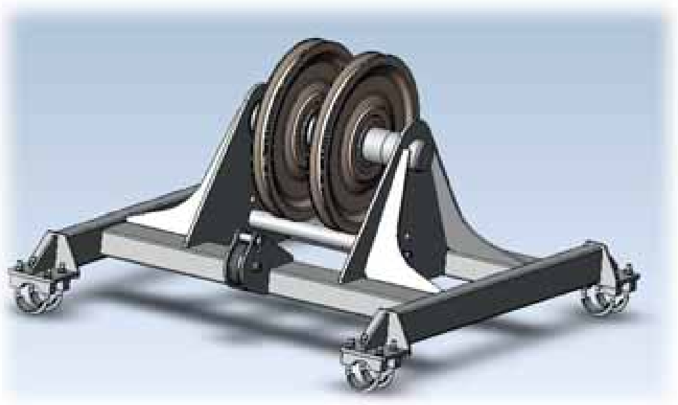


Winch synchronization is activated and deactivated in the SENCON using the lower quick selection button U4.

Quick-select button	*Checking*	*For operating mode*
No action U4 (1) **No** winch synchronization (electronic) possible		• Friction-lock winch function **for hoist operation** • Winch function freefall secured **for excavator operation** • Winch function freefall unsecured **for excavator operation**
Winch synchronization (hydraulic) possible		
Press U4 (2) 1x - temporary operation: Winch synchronization deactivated		• Friction-lock winch function **for hoist operation** • Winch function freefall secured **for excavator operation** • Winch function freefall unsecured **for excavator operation**
Press push button (15) on control lever – Winch synchronization activated		
Press U4 (3) 2x - continuous operation		**Crane mode only!**

6. Rope guide on the boom

Rope guidance on the boom is used to guide the rope to avoid lateral slip-off. This should prevent damage to the boom, the boom bolts, and to the rope itself. Moreover, the occurrence of slack rope should be suppressed.



Rope guide on the boom [source: SENNEBOGEN]

The rope guide for grab operation is fastened on chord with clamps approximately in the middle of the boom.

Calculation of the capacity in grab implementation

The calculation of the handling capacity in grab operation depends on many different factors (see table below). Material, filling, closing, slewing, emptying, and lifting factors must be considered, and so must the working time and particularly the quality and experience of the operator.

L_G = theoretical grab capacity = $t_0 * f_0 * V_G$ [m³/h]

$f_0 = f_1 * f_2 * f_3 * f_4 * f_5 * f_6 * f_7$ [-]

t_0 = 120 theoretical load cycles per hour [h^{-1}]

V_G = grab volume [m^3]

f_1 **Fill factor** depending on the soil class

Soil class	bulk factor f1	soil class	bulk factor f1
sand / fine gravel	1.1 – 1.2	sandy loam, dry	0.95 – 1.0
sand / fine gravel (earthmoist)	1.0 – 1.1	cohesive loam, dry	0.90 – 0.95
sand / fine gravel (wet)	0.8 – 0.9	cohesive loam, hard	0.88 – 0.90
Soil with sand / gravel, dry	0.85 – 0.88	topsoil, sandy loam	0.82 – 0.85
loam with sand / gravel (earthmoist)	0.75 – 0.80	topsoil, lean loam (earthmoist)	0.80 – 0.82
slaty rock, coarse gravel	0.72 – 0.75	gravel with loam, dry	0.70 – 0.72
debrised loam (earthmoist)	0.68 – 0.70		

f_2 **Close factor** depending on the grab size

grab size	[m³]	1,00	1,50	2,00	2,50	3,00	4,00	5,00	6,00
closing factor f_2	[-]	0,98	0,98	0,97	0,97	0,96	0,96	0,95	0,95

f_3 **Lift factor** depending on the grab depth (based on an average rope speed of 50 m/min)

Digging depth	[m]	5,00	7,50	10,00	12,50	15,00	17,50	20,00	22,50
lift-factor f_3	[-]	0,88	0,82	0,76	0,7	0,64	0,58	0,52	0,46

f_4 **Slewing factor** depending on the slewing angle

slewing angle	[°]	90,00	120,00	180,00
slewing-factor f_4	[-]	0,98	0,95	0,91

f_5 **Emptying factor** depending on the loading device

Dumped to	[-]	Truck	Hopper	Landfill
emptying-factor f_5	[-]	0,96	0,96	1

f_6 **Work time factor** depending on the effective working time

worktime	[min/h]	60,00	55,00	50,00	45,00	40,00
worktime-factor f_6	[-]	1	0,92	0,83	0,75	0,67

f_7 **Operating factor** depending on the experience of the operator

Operation	[-]	experienced	moderate experience	inexperienced
operating-factor f_7	[-]	1	0,95	0,85

Material densities

Material	t/m³
A	
Aluminium, fine	0,70-0,80
Aluminium, lumpy	0,95-1,05
Aluminium-silicate	0,8
Aluminium-splints, fine	0,21
Aluminium-spints, lumpy	0,16
Ash, dry	0,56-0,64
Ash, wet	0,72-0,80
Asphalt	1,0-1,3
B	
Bark	0,16-0,32
Bark-splints	0,13-0,24
Basalt	3
Basalt-quarry	2
Bauxite	1,2-1,36
Bauxite powdered, dry	1,09
Bauxite like extracted	1,4
Boulders	1,8
Brown coal, dry	0,72-0,88
Brown coal, wet	0,7-0,9
C	
Cellulose	0,37
Cement, brick chippings	2
Cement clinker	1,4
Cement DIN, loose	1,2
Cement DIN, vibrated	1,9
Chalk, lumpy	1,36-1,44
Chalk, powdered	1,12-1,20
Charcoal	0,2-0,36
Charcoal, drained	0,15-0,25
Charcoal, powdered	0,15-0,25
Clay, wet	2
Clay, dry, lumpy	1
Clay, excavated	1,3
Coal, dry, drained	0,83
Coal, dry, egg-coal	0,9
Coal, dry, lignite	0,65
Coal dust	0,45-0,5
Coal fines	0,8-0,9
Coal tar	0,72
Concrete / limestone concrete	2,0-2,2
Construction waste	1,8-2,0
Copper ore	3
Crude salt (0,72 - 0,83)	2,2
D	
Dust	0,5-0,6
F	
Fat lime, burnt, powder	0,5
Fat lime, fractured	0,80-0,96
Fine coal, washed	0,80-0,85
Fluorspar	1,31
Fly ash	0,45-1,0
Fly dust	1,6
Foundry sand	1,6
Fuller's earth, burnt	0,56-0,72
Fuller's earth, crude	0,56-0,64
Fuller's earth, drained	0,96-1,04

Material	t/m³
G	
Gas coke	0,45
Glass, broken	1,3-1,6
Granite	2,6
Granite, frained	1,52-1,60
Graphit	1,9-2,3
Graphite flakes	0,64
Graphite powder	0,45
Gravel, dry	1,5
Gravel, earthmoist	1,8
Gravel, fractured	1,5-1,8
Gravel, grit	1,5-1,6
Gravel, wet	2
Gypsum, burnt, drained	0,88-0,96
Gypsum, burnt, powdered	0,96-1,28
Gypsum, crude	1,44-1,60
H	
Hematite, loose	2,1-2,6
I	
Ilmenite	2,24
Iron ore	2,0-4,5
Iron ore, Fe 70 %	5,2
Iron ore, loose	2,0-2,4
Iron slag	2,75
L	
Lead-concentrate	2,7
Lime	0,96
Lime cement	0,7
Lime, drained	1
Lime, powdered	0,5-0,7
Limestone, grainy	1,09
Limestone, broken	1,36-1,44
Limonite	3,8
M	
Manure	0,8-1,0
Marble, fractured	2,7
Marble quarry	1,44-1,52
N	
Nickel ore	2,92
O	
Ore, fine	2,8
Ore, grained	2,4
Ore, crude	2,2
P	
Paper	0,7-1,2
Peat litter, pressed	0,21-0,34
Pitch, dry	0,8-1,0
Potash	1,1-,16
Potash-salt	1,3
PVC-powder	0,48
Q	
Quarry stone	2
Quartz	1,6-1,75
Quartz, powdered	1,4
R	
Raw meal	1
Raw sugar	0,88-1,04

Material	t/m³
Rayon	1,5
Rock salt	1,0-1,2
Rock salt, fractured	0,5
Rock salt, powdered	0,45
Run of mine coal	0,9-1,0
S	
Salt, dry, crude	0,7-0,8
Salt, dry, fine	1,1-1,3
Salt, granules (2,0 - 2,6)	1,2-1,45
Sand DIN, wet	2,1
Sand, dry	1,44-1,60
Sand, earthmoist	1,6-1,8
Sand, fine, wet	1,8-1,9
Sand + gravel, wet	1,75-2,1
Sand + gravel, dry	1,5-1,8
Sandstone (fractured)	1,35-1,55
Sewage sludge	0,72-0,88
Slack	0,7
Slack, pulverized	0,6-0,9
Slag, lumpy	1,2-1,3
Slag, fractured	0,7-1,04
Slag porous	0,6
Slate	2,7
Sludge	1,6-1,8
Sodium chloride	0,67-0,80
Soil, dry	1,6
Soil, wet	2
Stones, sorted	1,4-1,6
Stones, sorted, crude	1,3-1,6
Stones, unsorted	1,4-1,6
Stones, unsorted, crude	1,3-1,6
Sugar beet	0,55-0,65
Sugar cane	1,1-1,3
Sugar, crystalline	0,8-0,88
Sugar, powdered	0,6-0,8
Sugar, raw	0,88 - 1,04
Sugar, refined	0,8-0,9
Sulfur	0,8-0,96
Sulfur, crude	1,3
Sulfur, lumpy	1,3-1,4
Sulfur, powdered	0,8-0,96
T	
Titanium,grainy	2,4
Titanium, powdered	1,92
Topsoil	1,8
Turf, air-dry	0,32-0,9
Turf, dry	0,3-0,4
Turf, wet	0,5-0,6
W	
Waste (household)	0,8
Wooden chips (burning material)	0,24-0,40
Wooden chips (papermaking)	0,32-0,40
Wooden chips (softwood)	0,19-0,40
Wooden chips, wet	0,6-0,9

Grab sizes

The selection of the grab size depends on various factors:

- Grab material
- Machine size of the duty cycle crane
- Work environment (for example, above water/underwater)

Grab operation questionnaire

Project: ______________________

Machine type Sennebogen: __________

Boom length: ________________

Winch 1: ______ ton
Winch 2: ______ ton

Parameters:

A: ______m
B: ______m
C: ______m
D: ______m
E: ______m

Slewing angle: __°

Max. load: ____ton

Current load: ___ ton

Performance:

Handled material: __________

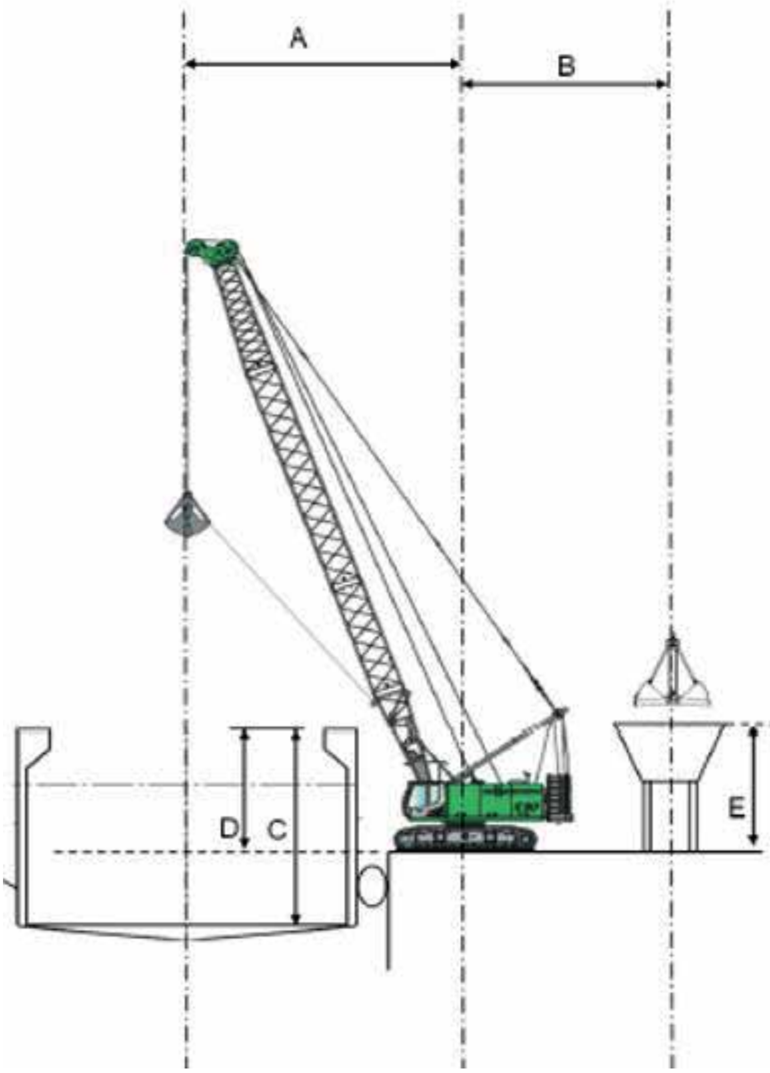
Density: _________ t/m³

Grab:

Grab content: _______ m³
Dead weight: _______ ton
Filling level: _______ %
Load (excl. grab): ______ ton
Load (incl. grab): _____ ton

Electrohydraulic grab:

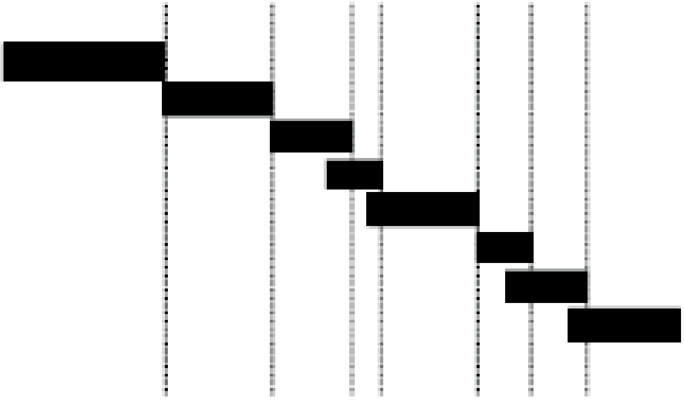
Closing time: ________
Opening time: ________



Calculation of cycle Time:

1st: electr. Hydr. Grab

filling of grab		s
lifting up		s
turning 135°		s
lowering		s
open grab		s
lifting up		s
turning 135°		s
lowering grab		s
working simult.		
total:	0	

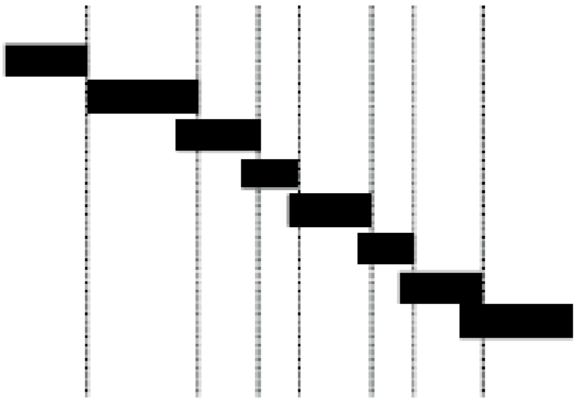


cycles per hour: 0

capacity/ hour **0** t/h

2nd: 2 rope clamshell

filling of grab		s
lifting up		s
turning 135°		s
lowering		s
open grab		s
lifting up		s
turning 135°		s
lowering grab		s
working simult.		s
total:	0	s



cycles per hour: 0

capacity/ hour **0** t/h

max. ground pressure:

outrigger plates: ______

shoes ______ ____________ t/m²

SENNEBOGEN duty cycle crane in grab operation

SENNEBOGEN 6180HD with multi-shell grab [source SENNEBOGEN]

SENNEBOGEN 6130HD with double shell grab [source SENNEBOGEN]

SENNEBOGEN 655HD with double shell grab [source SENNEBOGEN]

SENNEBOGEN 6180HD ship setup with double shell grab [source SENNEBOGEN]

Operation with Drop Ball

SENNEBOGEN 6100HD [source: SENNEBOGEN]

What does drop ball operation mean

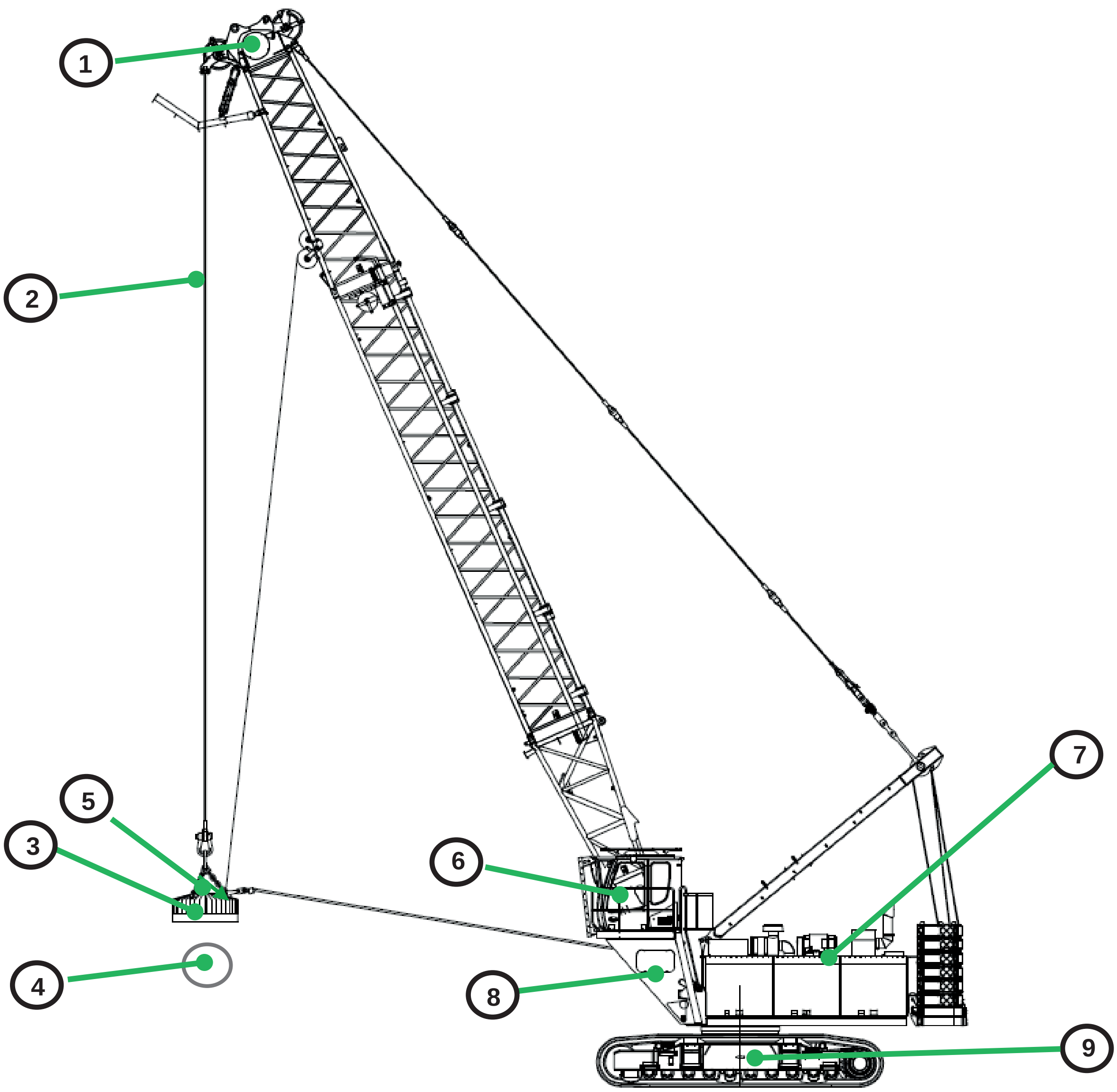
Drop ball operation is a standard, highly dynamic application type in the steel plant industry. Steel balls with a deadweight of up to 20ton are dropped from a great height onto slag residues from the smelting. Due to the kinetic energy of the impact, large chunks of slag are crushed into smaller pieces that are easier to transport.

This archaic process of crushing is still the most effective and cheapest method today. The determining factor in this regard is an extremely robust duty cycle crawler crane, that can withstand the loads of the highly dynamic implementation.

SENNEBOGEN HD cranes in drop-ball operation

SENNEBOGEN duty cycle cranes in drop ball operation are equipped with first-class technology for this dynamic application and have been 100% adapted to the operating conditions. SENNEBOGEN duty cycle cranes for drop ball operation are high-performance machines with maximum efficiency and low diesel consumption.

SENNEBOGEN 690 duty cycle crane, drop ball version [source: SENNEBOGEN]



SENNEBOGEN duty cycle crane, drop ball version [source: SENNEBOGEN]

1. Wide boom head for double winch
2. Hoist rope(s)
3. Magnet / magnet system
4. Drop ball
5. Lifting cross member
6. Special cab, Maxcab Industry, elevated 2 m
7. Winches
8. Positioning winch / pull-in winch (winch 2) with fairlead
9. Reinforced undercarriage

1. Widened boom head for double winch operation with steel sheaves

For heavy-duty operations, steel sheaves are used instead of plastic sheaves. The reason for this is the significantly lower wear and the accompanying extension of the service life. Steel sheaves are installed in a widened boom head which has been designed for use with a double winch and ensures clean parallel guidance of the two hoist ropes. The hoist ropes are guided on each side via the outer steel sheaves.

Detail graphic of SENNEBOGEN boom head for double winch [source: SENNEBOGEN]

2. Rope equipment

SENNEBOGEN recommends the following combination as rope equipment for drop ball applications:

Double winch (rear winch 1)	►	Crane hoist rope
Positioning and pull-in winch (front winch 2)	►	Grab and dragline bucket rope

The ropes are specially developed to pick up high loads and move them without rotation. When using a SENNEBOGEN 6100HD, rope lengths of 70 m for crane hoist rope and 40 m for pull-in rope are recommended.

3. Magnet / magnet system

In drop ball operation magnets / magnet systems are used. These are known from scrap handling applications. Unlike for scrap handling, strong magnets and magnet systems are installed consistently in drop ball operation. This is mainly due to the higher load capacity of the duty cycle crane which needs to be able to move drop balls with a deadweight of approximately 20 t safely.

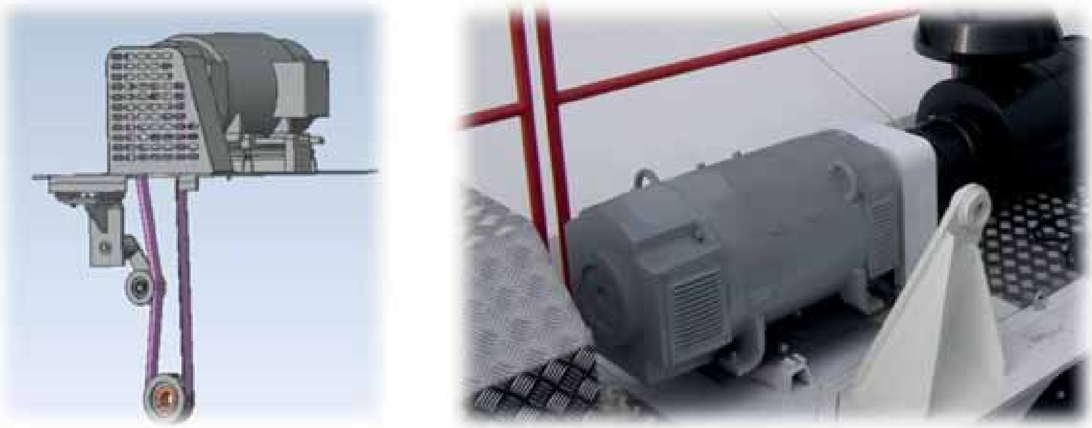
The magnets and the associated magnet system are arranged based on the deadweight of the drop ball. This in turn is directly dependent on the size and load capacity for the duty cycle crawler crane. The SENNEBOGEN 6100HD (100 t) has established itself as the standard size for duty cycle cranes for drop ball applications.

The magnet system consists of the following components:

- Generator (mechanically or hydraulically driven)
- Magnet control system (switch cabinet)
- Magnet

Generator (mechanically or hydraulically driven)

A mechanically powered generator can only be used if the positioning of the generator enables the mechanical drive via a V-belt from the engine.

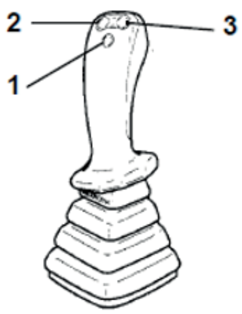


Mechanically powered generator – schematic diagram (left) and installed on the uppercarriage (right)
[Source: SENNEBOGEN]

If a solution like this is not achievable, a hydraulically powered generator is required. For this generator type, energy is supplied via a hydraulic motor flanged to the engine.

The generator capacity varies according to necessity, in other words, depending on the installation space available, the desired magnetic plate, and the size of the drop ball.

Magnet control system



Joystick buttons:

1. **Horn (magnet system deactivated/activated)**
2. **Magnet system activation**
3. **Magnet system deactivation**

Magnet control – activation via the right joystick and installation location of the switch cabinet
[Source: SENNEBOGEN]

The control system for the magnet consists of a switch cabinet (installed on the right front of the uppercarriage) and the integrated electrical system. The control unit can be activated/deactivated via a toggle switch on the control panel. After activation, the magnet can be switched on and off as required using a push button on the right joy-stick.

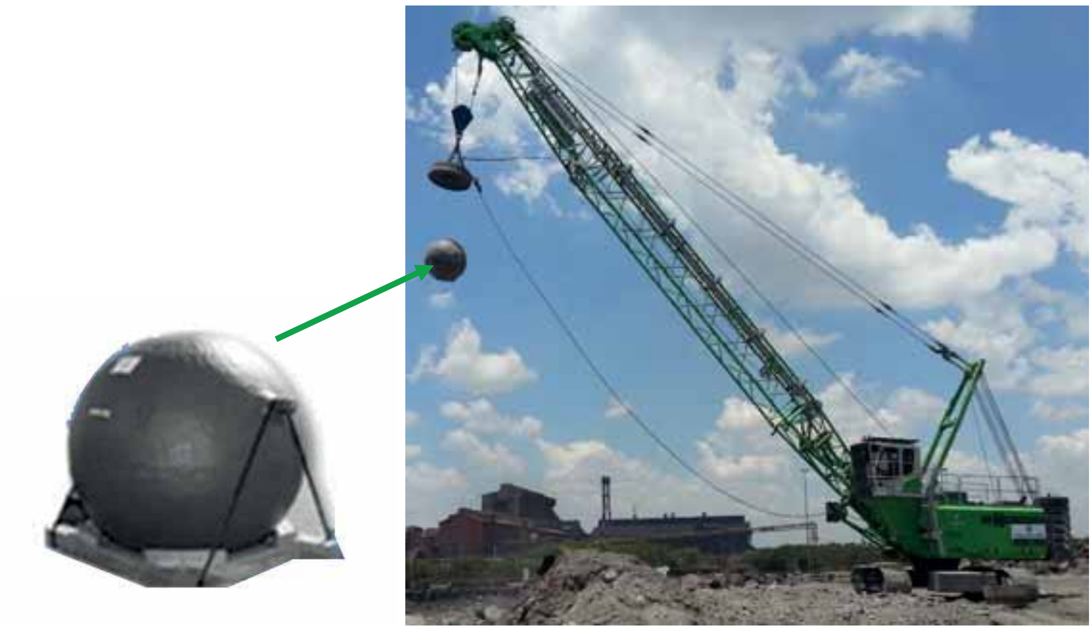
<u>Magnet</u>

The size of the magnet depends on the available generator power and the load-bearing capacity of the duty cycle crane used in conjunction with the drop ball used. For the SENNEBOGEN 6100HD in drop ball operation, at least one 22 kW magnet is used. However, ideally a magnet with an output of 25 kW or more is used.

4. Drop ball

In drop ball implementation "drop balls" are used. These are also used in quarries. Some manufacturers, offer drop balls in “standard sizes” for this purpose. However, the deadweight of these “standard balls” is only between 5,000 kg and 9,000 kg, which is not enough for efficient use with a duty cycle crane.

In steel plants, usually larger steel balls with a deadweight of up to 20 t are used for drop ball operation. Due to the low market volumes there are no standard in this area. This is why the drop balls are generally cast separately as custom-manufactured items and must be requested accordingly. Steel plants (≙ end customers) usually cast the drop balls to be used themselves.



Drop ball [source: SENNEBOGEN]

5. Lifting traverse 40 t

A 40 t lifting traverse is used to ensure that the magnets and the drop ball are lifted at a virtually horizontal level. This is intended to prevent the weight of both attachments from shifting to one side.

For this, a rope strand of the double winch is fastened onto the traverse with a rope lock. The line pull per rope is 20 t, which results in a maximum load-bearing capacity of 40 t. However, the maximum weight that can be attached to the lifting traverse depends on the type of duty cycle crane used. For example, the SENNEBOGEN 6100 HD can lift approximately 29 t (20 t drop ball + approximately 9 t magnet system) via the lifting traverse.

Lifting traverse 40 t [source: SENNEBOGEN]

6. Special cab, maXcab Industry

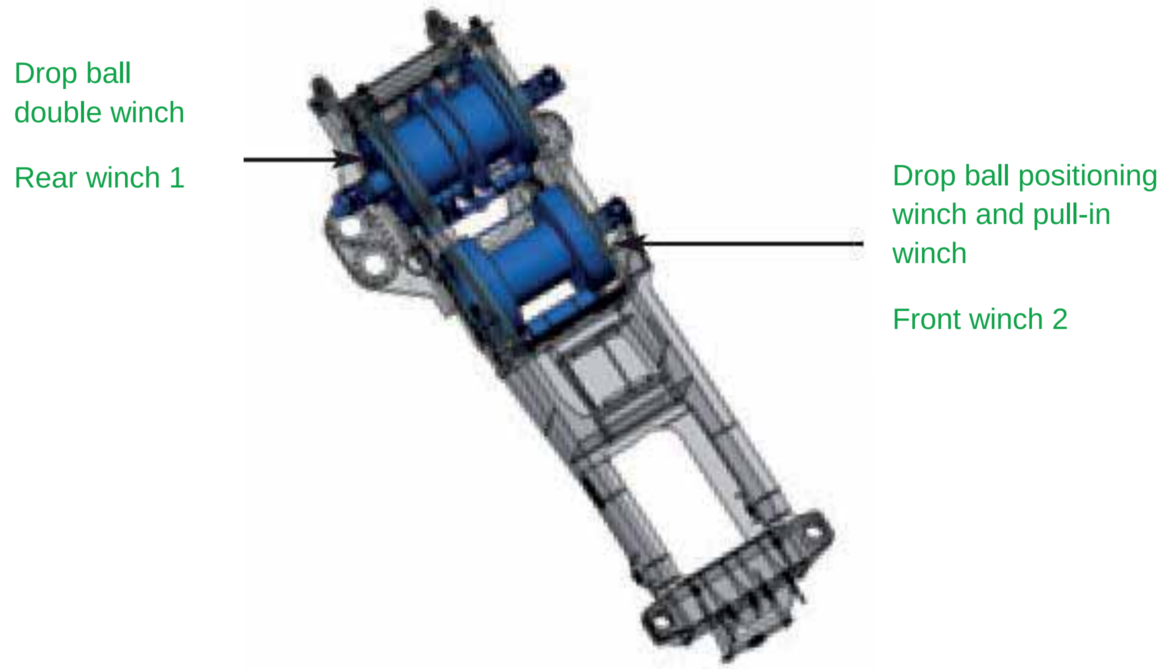
The MaXcab Industry is used for increased operator safety, particularly with regard to the high-energy flying splinters from the crushed material. For this purpose, bulletproof glass panes are installed in the front area (30 mm) and in the roof (20 mm). In addition, front protective grating and roof protective grating can be attached for protection against larger chunks of material.

The front protective grating protects the operator from larger broken fragments that are thrown up by the impact of the ball on the slag.

maXcab Industry [source: SENNEBOGEN]

7. Lifting unit

SENNEBOGEN HD cranes (6100) can be equipped with a double winch for drop ball operation. This is used as winch 1 (rear winch) / the main winch for lifting the attachments (magnet + drop ball). The capacity of the winch is 200 kN per rope winch; a maximum of 40 t in the first position.



Double winch positioning [source: SENNEBOGEN]

8. Positioning winch / pull-in winch and fairlead

In addition to the double winch, a positioning and pull-in winch (front winch) with LEBUS grooving is used in drop ball operation. This has a capacity of 20 t. It is used to position the magnet with the drop ball. This makes it possible to control the magnet when taking up and positioning the ball.

The front winch (winch 2) is driven via the boom adjustment pump and the so-called C-connection of the boom adjustment control block. The maximum speed Q_{max} is limited to 22 m/min.

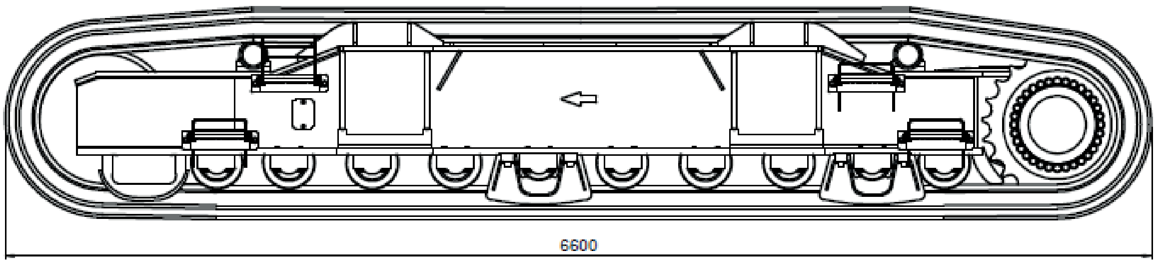
The rope of the positioning winch runs out of the uppercarriage on the front side. Consequently, a fairlead must be attached for ideal guidance of the pull-in rope. This is integrated in the basic boom or attached in front of the uppercarriage of the duty cycle crane as for dragline operation. It consists, horizontally, of sheaves supported by moving bearings and, vertically, of rollers supported by moving bearings that can be lubricated manually

The fairlead reduces rope wear and ensures optimal winding of the positioning rope on the winch drum of the front winch (winch 2).

Detail graphic of fairlead [source: SENNEBOGEN]

9. Reinforced undercarriage

In its drop ball machines, SENNEBOGEN uses a specially reinforced undercarriage that meets the requirements of the enormous dynamic load. For the SENNEBOGEN 6100HD, for example, a special undercarriage with B8b traveling gear is used. This is rigid and non-telescopic as in the standard version. The length is 6,600 mm in the reinforced design with a track width of 4,100 mm.



Undercarriage 6100HD drop ball [source: SENNEBOGEN]

Moreover, the undercarriage is equipped with a counterweight of 15 t (7.5 t in front and at the rear) to significantly increase the stability of the machine and thus ensure significantly more comfortable and durable working.

Drop ball operation questionnaire

Desired drop height H:	....	[m]
Required boom length:	....	[m]
Drop ball weight:	....	[kg]
Maximum radius R:	....	[m]
Magnet system (type):	....	[mechanical/hydraulic]
Connection data and weights:	....	[…]
	....	
	....	
	....	
Magnetic plate (type):	....	[-]
Connection data and weights:	....	[…]
	....	
	....	
	....	
Work hours per day / days per month:	....	[h] / [d]

SENNEBOGEN duty cycle crane in drop ball operation

SENNEBOGEN 6100HD diesel engine with double winch, Canada [source MULTISERV Canada]

SENNEBOGEN 6100HD diesel engine with double winch, USA [source SENNEBOGEN]

SENNEBOGEN 6100HD electric motor with double winch, USA [source: SENNEBOGEN LLC]

SENNEBOGEN 6100HD diesel engine with double winch, USA [source SENNEBOGEN]

SENNEBOGEN 690HD diesel engine with double winch, South Africa [source SENNEBOGEN]

Operation with Freefall Plate (Dynamic Compaction)

SENNEBOGEN 690 HD deep compaction [source: SENNEBOGEN]

Definition of terms – deep compaction

Deep compaction devices are generally used in geotechnically sensitive areas. The bulk density of the soil in-situ should be increased over a larger depth range to such an extent that the geotechnical risk is minimized.

This applies to both loosely piled geological layers and artificially backfilled soils, which, for example, are at risk of settlement or subsidence due to changes in groundwater, vibrations, or earthquakes, and therefore do not sufficiently meet the structure-specific requirements.

To ensure the success of deep compaction, the process parameters need to be matched to the soil properties since failures can quickly occur in larger soil areas (voids, loosening). Sufficient monitoring of the achieved status needs to be performed and documented.

Definition of terms – dynamic intensive compaction (DYNIV®)

Dynamic intensive compaction or dynamic deep compaction is one of the oldest methods for substrate improvement. The DYNIV® can be used to great depths thanks to the generation and introduction of optimal energy.

Compaction is achieved using a freefall plate.

The principle of compaction is based on the application of high energy by means of a drop weight, which is dropped from a great height onto the surface of a compressible substrate. This creates a dynamic compression effect upon impact. The shape of the compaction area resembles a frustum.

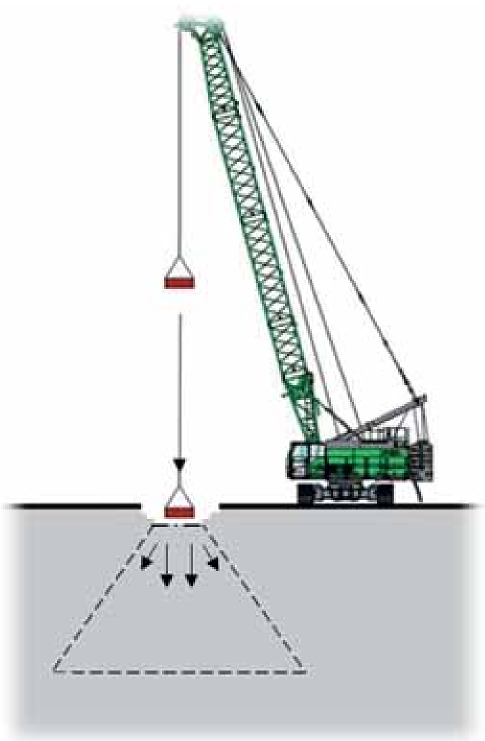


Diagram of DynIv® [source: SENNEBOGEN]

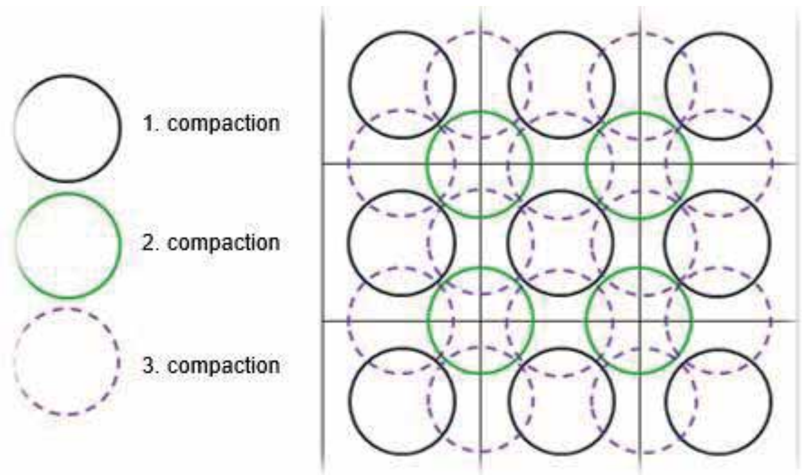
With every impact, an energy E = m*h is transferred to the ground, which can be used to specify the achievable profundity:

$$T = \alpha * (m * h)^{0.5}$$

T = profundity	[m]
α = ground coefficient = 0.3 – 1.0	[-]
m = mass of the drop body	[t]
h = drop height	[m]

For the coefficient α, smaller values are used for cohesive soils and larger values for granular soils – approximately 1.0 for gravel. With every impact for each compaction point, the profundity increases (for example: m = 1 t, h = 1 m, α = 0.5 → t = 0.5 m with one impact, t = 5 m with 100 impacts)

The drop process is repeated at various compaction points in line with a rectangular pattern. This also creates horizontal tension, which results in further compaction. The pattern of compaction points required for each application is defined according to the soil parameters and the degree of compaction that needs to be achieved.



Example of a DynIv® rectangular pattern [source: SENNEBOGEN]

The dynamic intensive compaction is implemented according to this pattern.

The first compaction run is started with a larger distance between the compression points. This starting distance should be approximately equivalent to the depth of the soil layers to be compacted. During the next compaction runs, other pattern points are selected, which means that as the runs increase, the distance between the impact points is steadily reduced and the soil is compacted evenly.

The main use of the DynIv® with freefall plate is compaction:

- With loosely piled formations (for example, sand, backfilling, rubbish, etc.)
- For immediate settlement
- To restructure the ground (increase the load-bearing capacity and shear strength)
- To minimize long-term settlements
- As a quick and cost-effective method for soil improvement

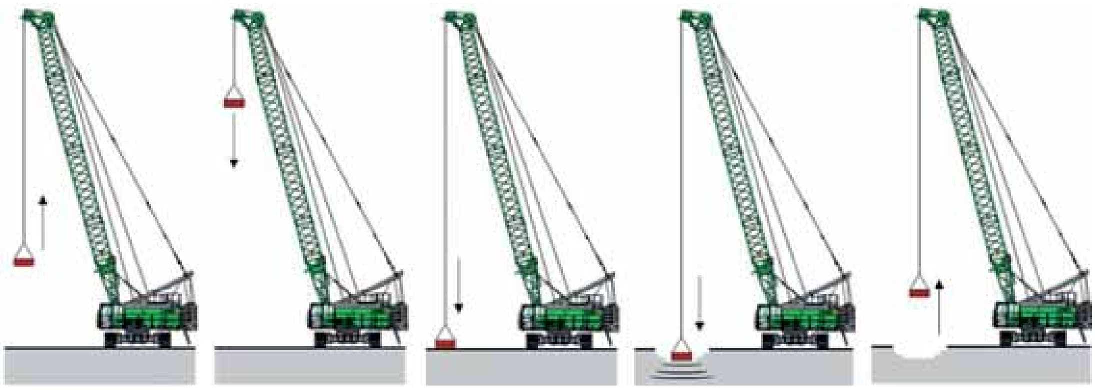
The DYNIV® has various uses from rock fill to malleable silt. Partially saturated and saturated soils can be compacted. The effectiveness for cohesive soils decreases with increasing impermeability to water.

Low load-bearing soils with a high water content are virtually impossible to compact. To improve the load transmission into these soils, rock fill should be laid on the ground before starting work.

Intensive sealing is widely used in existing landfill sites in order to make them useable again, for example for roads, tracks, leisure facilities, commercial areas.

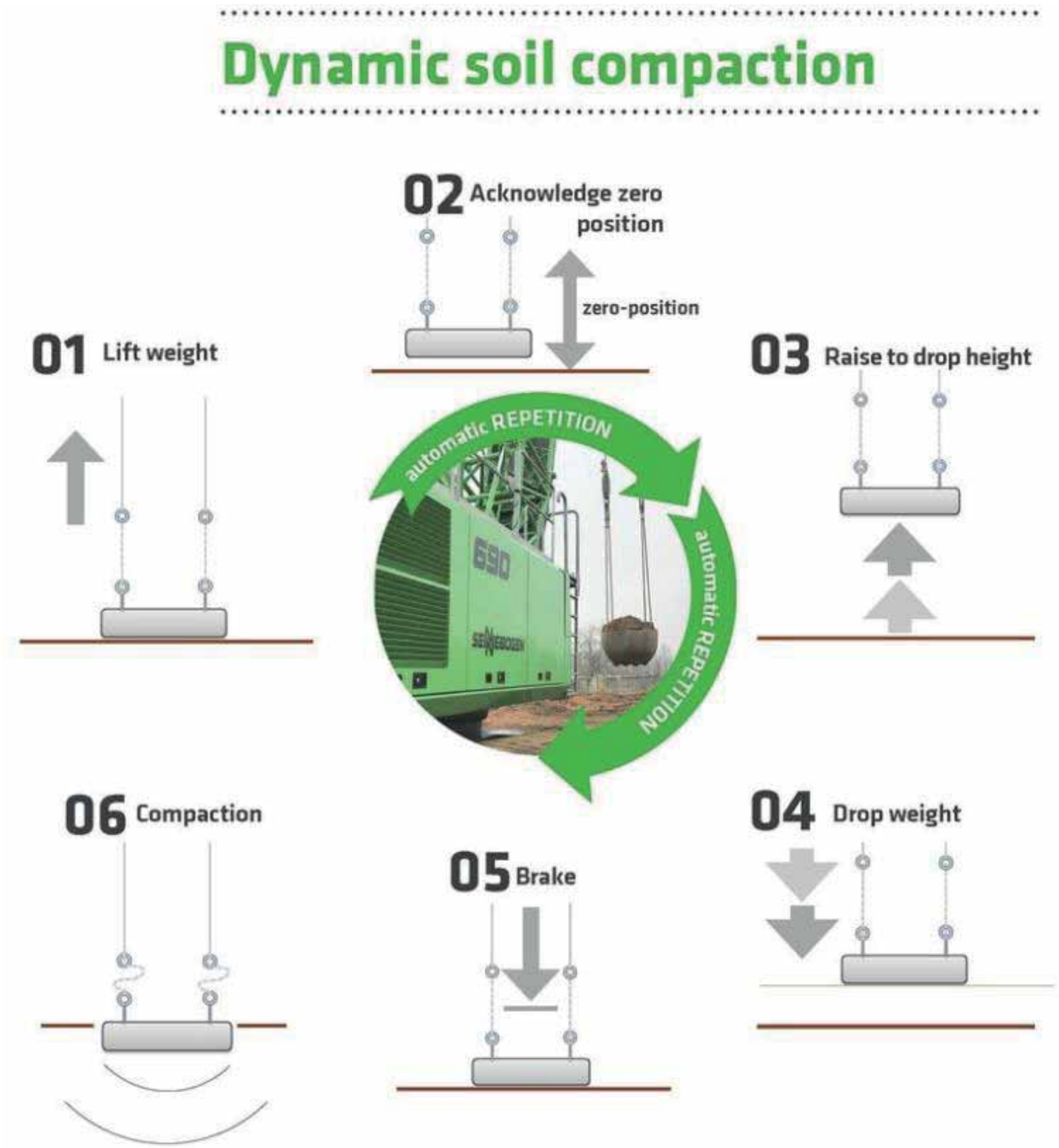
Duty cycle crane as a carrier in the DYNIV®

During operation with duty cycle cranes, the freefall plate hangs on the rope of the carrier. The drop plates have a weight of 10 to 30 tons and are dropped from heights between 5 and 25 m.



Functional principle of dynamic soil compaction with freefall plate [source: SENNEBOGEN]

The drop weight mostly consists of several interlinked steel plates that have a hexagonal or octagonal surface area of approximately 3–4 m². This is dropped repeatedly in the same place to compact the soil (approximately 5 – 20 times).



Functional principle of dynamic soil compaction [source: SENNEBOGEN]

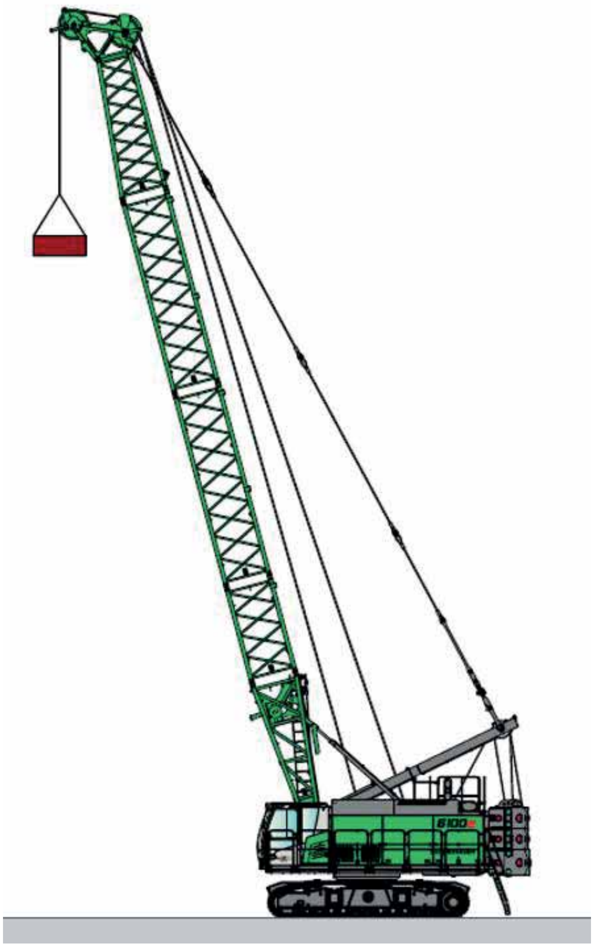
SENNEBOGEN 690HD in dynamic intensive compaction [source: SENNEBOGEN]

This usually takes place according to a rectangular pattern with point spacing of 4 to 8 m. In addition to the impact point, the neighboring areas are also compacted by wave propagation. The resulting impact funnels are always filled with new material. Gravel and crushed stone are particularly suitable for this because they penetrate the ground with every impact and also have a stabilizing effect.

The filling continues until the desired compaction depth is reached.

SENNEBOGEN duty cycle cranes in dynamic soil compaction

All SENNEBOGEN duty cycle cranes can be used in dynamic intensive compaction operation. The size of the machine used depends on the weight of the drop plate, the work radius, and the required drop height.



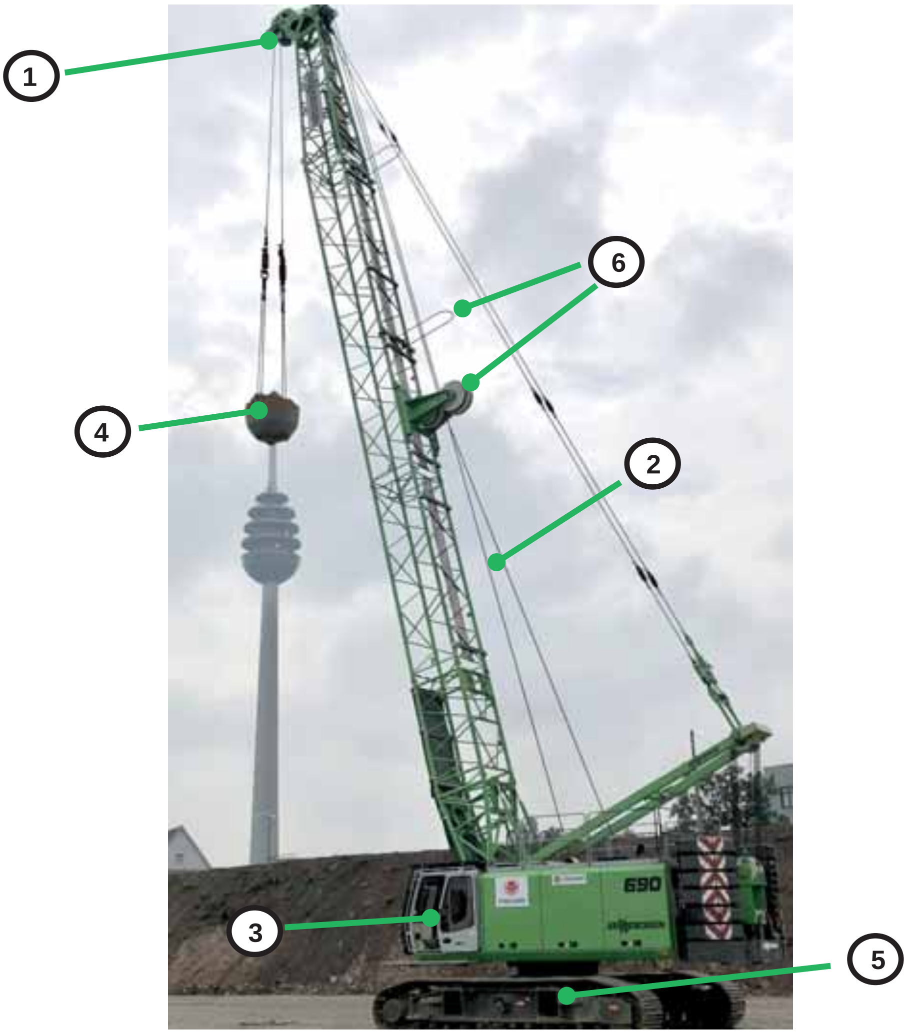
SENNEBOGEN duty cycle crane in dynamic soil compaction [source: SENNEBOGEN]

The use of duty cycle cranes in dynamic intensive compaction needs to be accompanied by extensive soil investigations and measurements. The use of drop plates creates different funnels depending on the ground condition. To guarantee the stability of the duty cycle crane, the distance between the device and the point of impact needs to be sufficiently large.

SENNEBOGEN duty cycle cranes are particularly suitable for this process because they are hard-wearing and have a very high stability due to a very wide crawler chassis. The lifting and dropping of the weight is controlled electronically via automatic freefall. This automatically controls the braking of the rope winch(es) to prevent slack rope and to reduce the load for all components.

SENNEBOGEN technology in dynamic soil compaction

SENNEBOGEN duty cycle cranes are equipped with first-class technology for use with drop weights for dynamic soil compaction and have been optimized 100% for the operating conditions. SENNEBOGEN duty cycle cranes are high-performance machines with maximum efficiency and low diesel consumption.



SENNEBOGEN duty cycle crane equipment for dynamic intensive compaction [source: SENNEBOGEN]

1. Boom head with steel sheaves and sheave shield
2. Rope equipment
3. Free-fall control
4. Drop weight / drop plate
5. Undercarriage
6. Rope guidance on the boom

1. Boom head with steel sheaves and sheave shield

For operation with drop weights, SENNEBOGEN recommends fitting the boom head with steel sheaves and a sheave shield. The sheave shield in this combination ensures an optimal rope guide to prevent the rope from slipping off the sheaves. In addition, the use of steel sheaves instead of plastic sheaves prolongs the service life of components because the steel variant is significantly more wear-resistant than the plastic sheaves.

Detail graphic of SENNEBOGEN boom head 690 [source: SENNEBOGEN]

2. Hoist rope(s) in DYNIV® operation

The SENNEBOGEN rope equipment in DYNIV® operation has been specially developed for the hugely dynamic forces that can occur in this application.

One or two crane hoist ropes are used to lift the drop plate. When using one hoist rope, a rope suspension gear also needs to be used, which is integrated between the crane hoist rope and drop plate.

When using two hoist ropes, these are both connected directly to the drop weight. It is necessary for both winches to work in 100% synchronization (see section 3, “Freefall control”).

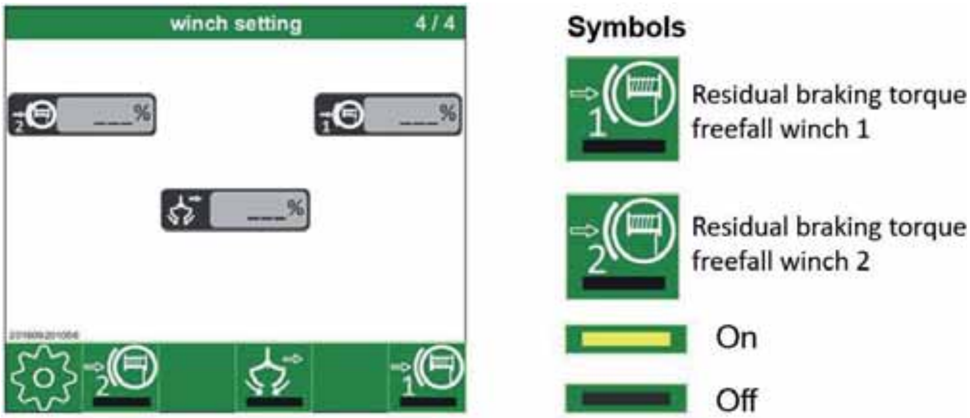
3. “Dynamic soil compaction” control

To control the dynamic soil compaction of SENNEBOGEN duty cycle cranes, the following components are required:

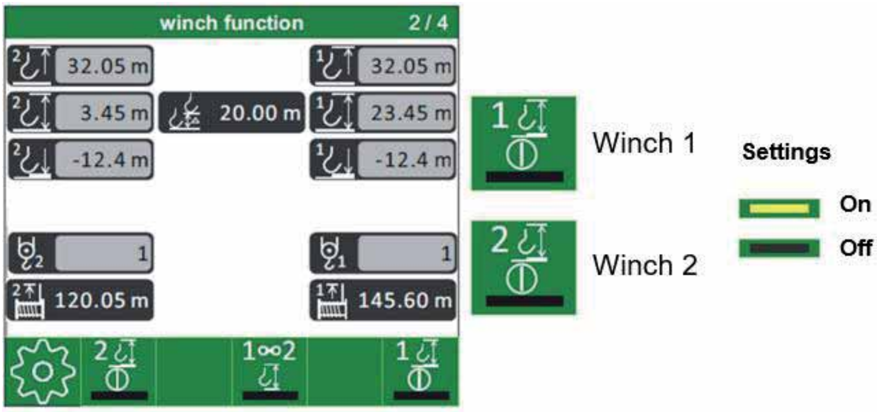
- Pre-adjustable freefall speed (standard equipment)

- Winch synchronization with depth indicating device via winch drum to both main winches, including position compensation; with switch-off points programmable in both directions via the display and incl. winch movement display
- SENCON system software for dynamic soil compaction

The **pre-adjustable freefall speed** can be controlled separately and independently for winch 1 and winch 2. This allows the freefall velocity of the drop weight to be varied, which enables you to react to different ground conditions. The greater the braking effect, the lower the freefall velocity.



SENCON – setting the residual braking torque [source: SENNEBOGEN]



SENCON – depth indicating device [source: SENNEBOGEN]

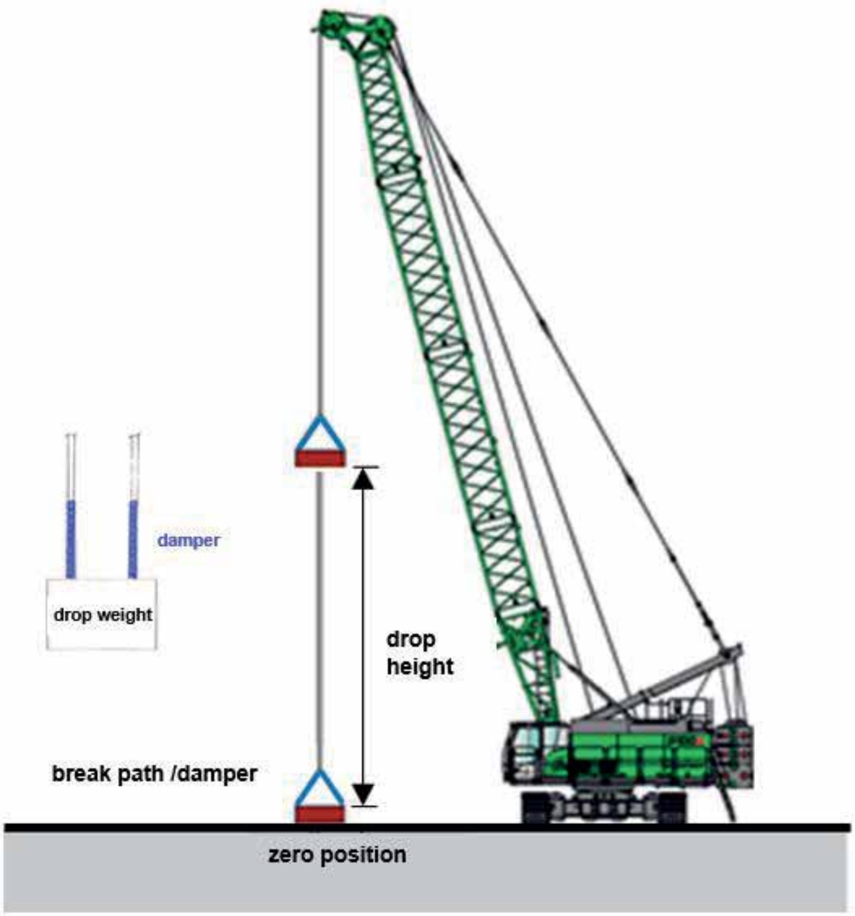
The **depth indicating device** is provided as a tool for the machine operator that displays the height of the load / of the operating equipment (here: Drop weight/plate). The height depends on a zero point that can be set by the operator via the display. When the function is activated, sensors on the machine monitor the current operating conditions and transmit the measurement results to the depth indicating device. After analysis, the values are presented on the SENCON screen automatically or at the touch of a button. Position compensation – i.e., the two winches are in different positions and windings – is executed automatically. Switch-off points in both directions can also be programmed via the display.

All SENNEBOGEN duty cycle cranes have hydraulic winch synchronization as standard, but this does not provide position compensation. The machines can also be equipped with electronic winch synchronization, which is significantly more precise and includes position compensation. The electronic winch synchronization fully synchronizes both main winches. For applications with drop weights, electrical winch synchronization is necessary for operation with two hoist ropes. The required data needs to be entered via the display in advance in the tab for the combined depth indicating device / winch synchronization.

SENNEBOGEN CONTROL SYSTEM – "dynamic soil compaction" control

In the **SENCON**, the operator can set the parameters for operating the duty cycle crane in dynamic soil compaction. In addition to the number of impacts required at one point, this also includes the drop height, the drop weight, and the braking-point.

The braking effect of the winches is set so that braking begins when the drop plate hits the ground. Dampers are used to keep the effects of braking on the machine as low as possible and also to prevent slack rope. These are installed between the rope end and the drop weight and determine the length of the brake path.



Dynamic soil compaction control parameters [source: SENNEBOGEN]

The operator must perform the following procedure:

A – Moving to the start position

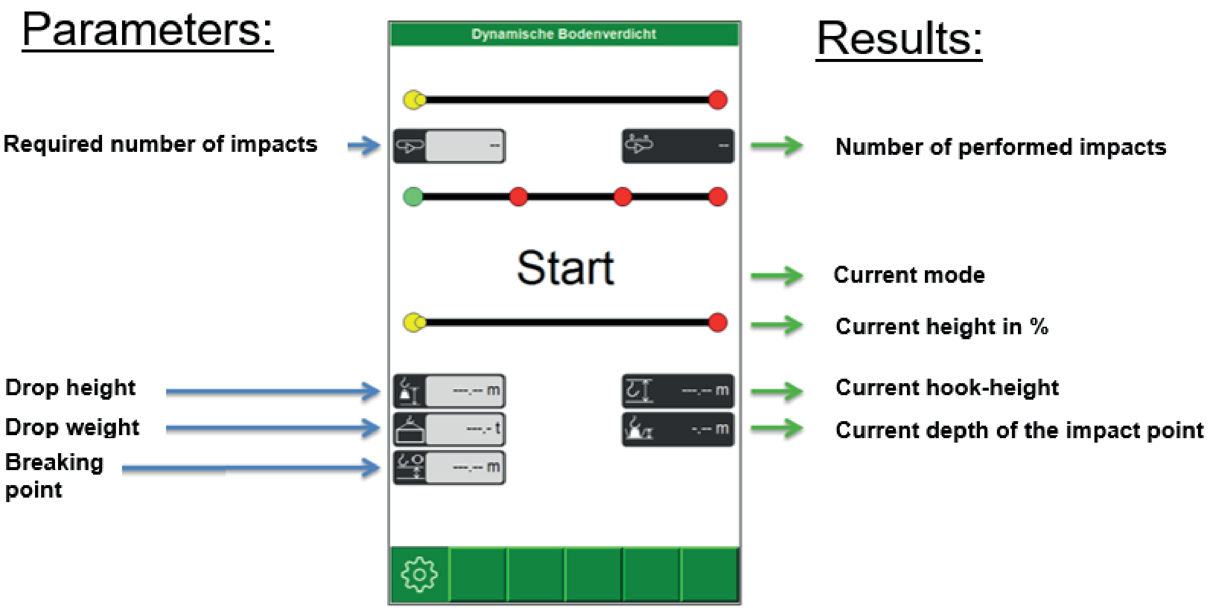
B – Placing the weight on the ground & defining the zero point

C – Entering parameters in the SENCON

D – Starting the dynamic soil compaction – AUTOMATIC!

1. Weight is lifted to drop height
2. Weight is released and drops
3. Soil compaction
4. Brake
5. New zero point positioning
6. Monitoring
7. Weight is lifted to new drop height (= old drop height – funnel depth)

This process is automatically repeated until the specified number of impacts has been reached.



Dynamic soil compaction control parameters [source: SENNEBOGEN]

4. Drop weight

The weight of the drop plate is between 10 t and 30 t. They are dropped from a height of 5 to 25 m.

DYNIV® drop weights [source: SENNEBOGEN]

The drop weight usually consists of several interlinked steel plates that have a hexagonal or octagonal surface area of approximately 3–4 m². The weight is dropped repeatedly in the same place (approximately 5 – 20 times).

There are no manufacturers of drop weights / drop plates. There are also no standards or specifications regarding what these attachments look like or how they are constructed. It is important that the drop weight and the duty cycle crane are compatible. The maximum rope pulling force is crucial.

5. Duty cycle crane undercarriage

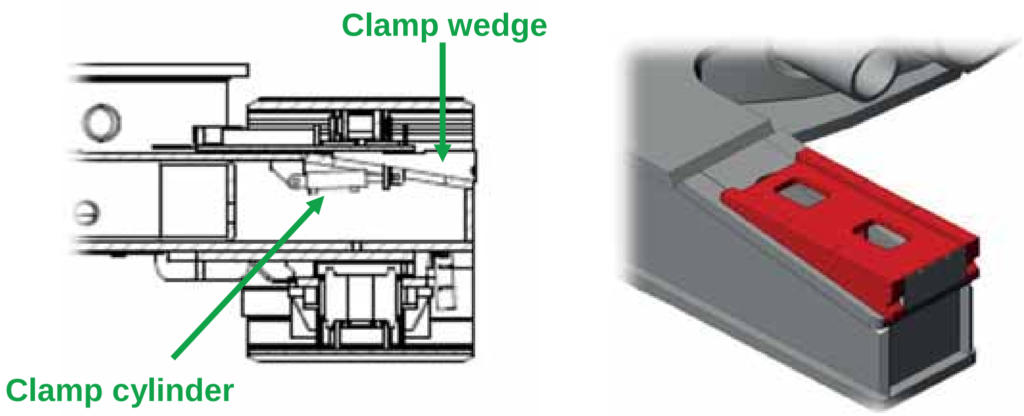
Model	Type	SENNEBOGEN designation	Traveling gear	Length	Track width retracted	Track width extended
				[mm]	[mm]	[mm]
624 HD	Fixed	R25/240 (S) R25/215 (O)	B4HD	4.440	2.400 2.150	2.400 2.150
630 HD	Tele	T27/355	60b	4.815	2.280	3.550
640 HD	Tele	T41/380-2	60b	5.300	2.300	3.800
655 HD	Tele	T47/370	6b	5.735	2.400	3.700
670 HD	Tele	T83/390	7b	6.002	2.300	3.840
6100 HD	Tele/SL	T107/420	B7 (S) B8B (O)	6.440	3.480	4.200
6140 HD	Starlifter	T140/550	B9HDS	7.180	4.600	5.500
6300 HD	Starlifter	R300/680-V	S10	9.500	6.800	6.800

SENNEBOGEN HD crane undercarriage – traveling gears and track widths [source: SENNEBOGEN]

The stability of the undercarriage is crucial during dynamic intensive compaction operation. SENNEBOGEN offers precisely this thanks to the extremely wide track and the huge length of the track wheel carrier. This stabilizes the machine and operates 100% reliably even with these high demands.

For telescopic undercarriages, SENNEBOGEN also offers hydraulic undercarriage clamping to ensure maximum stability of the undercarriage when it is telescoped out.

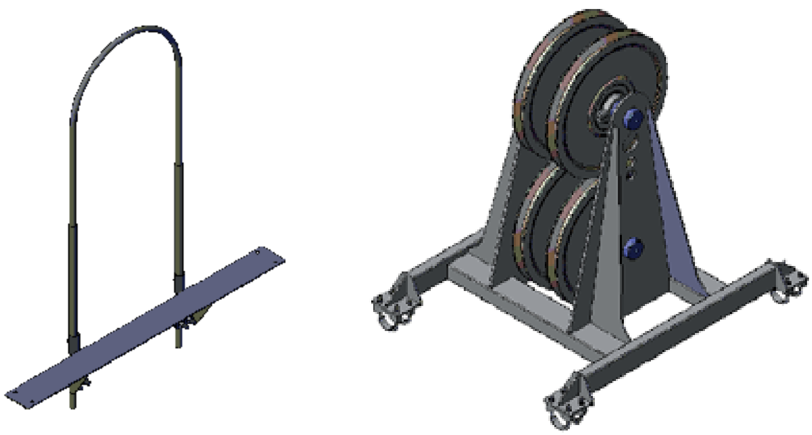
Hydraulic undercarriage clamping is established by cylinders integrated in the middle bridge – exclusively in telescoped-out status. The cylinders pull the terminal keys in the opposite direction to the telescoping direction with a constant pull of 30 bar for stabilization. The telescopic undercarriages therefore provide maximum stability and torsion-resistance. This makes precise positioning of the duty cycle crane possible and the constant re-tensioning associated with mechanical undercarriage clamping is no longer required.



Detail graphic of undercarriage clamping of SENNEBOGEN duty cycle cranes [source: SENNEBOGEN]

6. Rope guidance on the boom

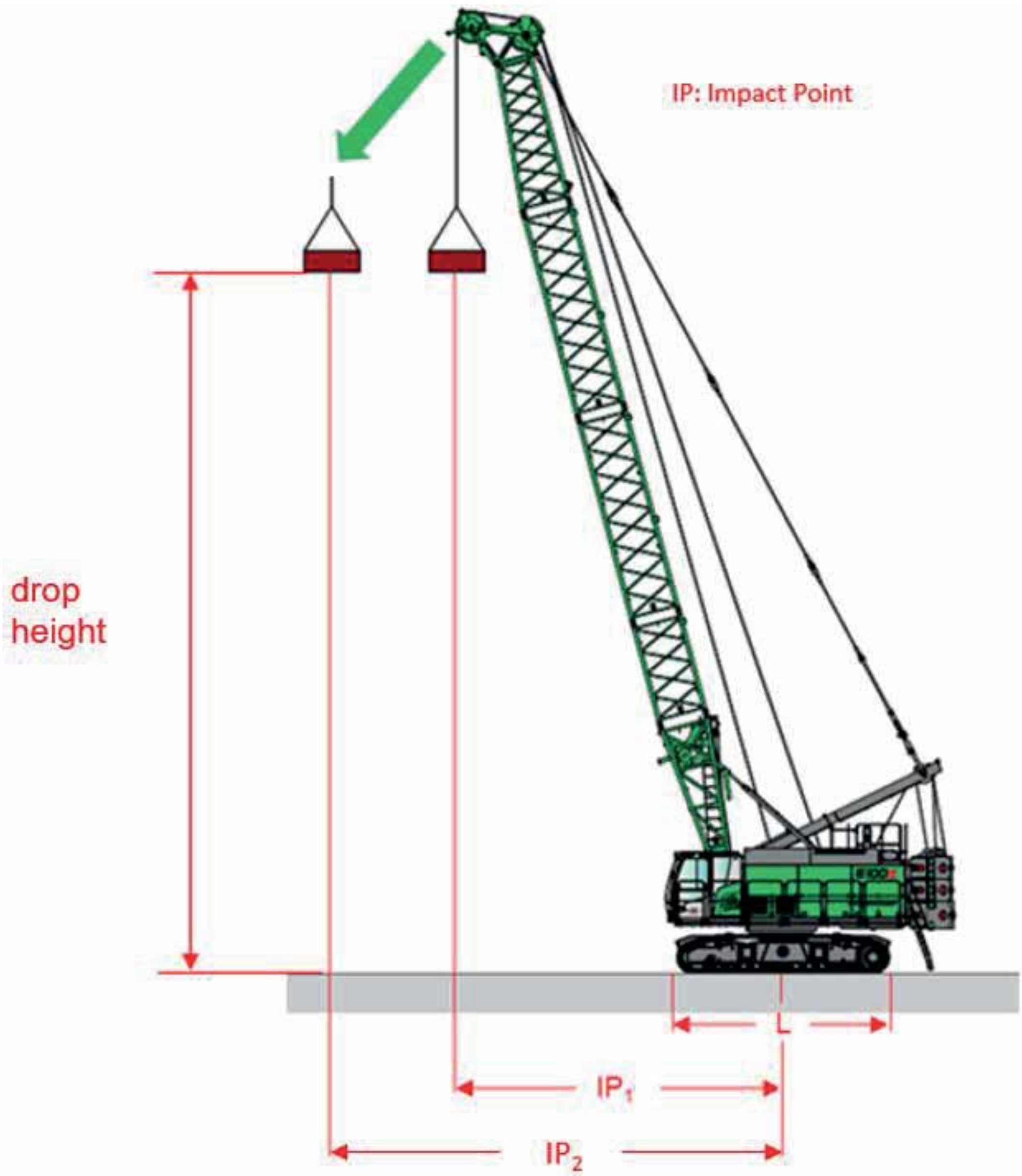
Rope guidance on the boom can be ensured by rope guides or rope guide sheaves. The rope guide is used to avoid slack rope and prevents lateral slip-off of the rope and thus associated damage to the rope or to the boom. The number of rope guides used varies from use to use and can also be modified on customer request.



Detail graphic of rope guide – rope grab (left) and rope guide sheaves (right) [source: SENNEBOGEN]

Duty cycle crane operation in the DynIv® questionnaire

Drop height of the drop plate:	....	[m]
Weight of the drop plate:	....	[t]
Height of the drop plate and suspension gear:	....	[m]
Required compaction depth:	....	[m]
MIN distance of impact zone [IP 1]:	....	[m]
MAX distance of impact zone [IP 2]:	....	[m]



Parameters of dynamic soil compaction [source: SENNEBOGEN]

SENNEBOGEN duty cycle crane in DynIv® operation

SENNEBOGEN 6130HD with drop plate [source SENNEBOGEN]

SENNEBOGEN 690HD with drop weight [source SENNEBOGEN]

Operation with Wrecking Ball

SENNEBOGEN duty cycle crane with wrecking ball in demolition operation
[source: SENNEBOGEN]

Definition of terms – demolition

In construction engineering, demolition refers to the complete or partial destruction and disposal of buildings and underground constructions of all types. Demolition is often undertaken to erect a new structure on the area that has become free. With partial demolition, often changes in the form and quality of the basic structure of a building are subsequently undertaken.

Particularly for concrete constructions, demolition can be a process that takes months with a lot of noise and dust development.

For most demolition tasks, special demolition permits are required in which the demolition procedure is precisely described. Because dangers occur not just during demolition, but also due to the structure or building intended to be demolished, safeguarding against unauthorized entry is particularly important. Difficult demolition projects (for example, demolition with large equipment, blasting, etc.) may only be started once a written demolition instruction from the demolition company is present on the construction site.

In addition to hydraulic demolition equipment, duty cycle cranes equipped with wrecking balls, loading grabs, or crane hooks, are also used.

Hydraulic excavators can be used with special equipment to a maximum working height of 30 m. In contrast, duty cycle cranes are primarily used for building demolition tasks with a height of more than 30 m. Duty cycle cranes are also more flexible in terms of their mode of operation and offer optimal transportability, whereas hydraulic excavators usually require special transport due to their special equipment.

As already mentioned, the duty cycle crane is equipped with a wrecking ball, loading grab, or hook for demolition purposes. For duty cycle cranes with wrecking balls, this is routed via the hoist rope of winch 1, which runs via the boom head. To enable precise ball impact, the duty cycle cranes are equipped with a grab steadying winch [GSW], which makes precise positioning of the ball possible. The rope of the grab steadying winch is routed via a deflection sheave positioned in the lower boom area. To break down the building parts to be demolished, the wrecking ball is accelerated towards the building by slewing the uppercarriage. Floors or ceilings can be demolished by allowing the wrecking ball to drop in freefall.

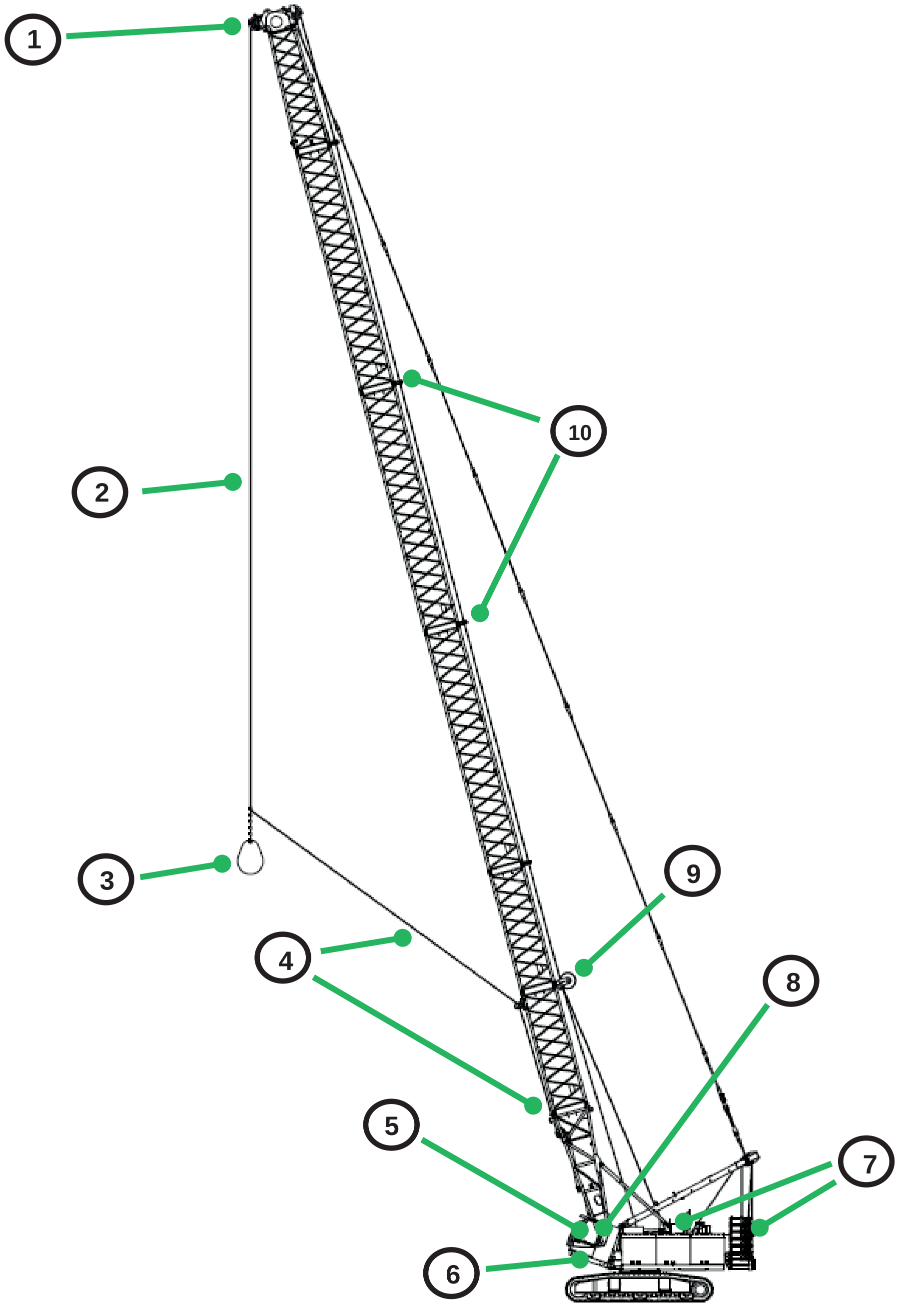
Demolition with rubble grab (left) and wrecking ball (right) [source: SENNEBOGEN]

Larger pieces that have broken off of the building are in some cases lifted off with the load hook to prevent them from falling and are crushed on the ground. A grab can be attached to winch 2 for the subsequent loading of rubble – subsequently, all work can be done with just one machine. In order to use the attached demolition tools as effectively as possible, the winches used (winch 1, winch 2, and GSW) are generally freefall winches.

SENNEBOGEN technology – demolition operation

SENNEBOGEN duty cycle cranes in demolition operation are equipped with first-class technical equipment for this dynamic application and have been optimized 100% for the operating conditions.

SENNEBOGEN duty cycle cranes for demolition are high-performance machines with maximum efficiency and low diesel consumption.



SENNEBOGEN duty cycle crane in demolition version [source: SENNEBOGEN]

1. Boom head for demolition operation
2. Rope equipment
3. Attachments
4. Grab-steadying winch with rope
5. Cab protection
6. Tiltable cab
7. Camera system
8. Pre-adjustable freefall speed
9. Rope guidance on the boom
10. Supplemental baffle plates

1. Boom head with steel sheaves and sheave shield

For operation with wrecking balls, SENNEBOGEN recommends fitting the boom head with steel sheaves and a sheave shield. The sheave shield in this combination ensures an optimal rope guide to prevent the rope from slipping off the sheaves. In addition, the use of steel sheaves instead of plastic sheaves prolongs the service life of components because the steel variant is significantly more wear-resistant than the plastic sheaves.

Detail graphic of SENNEBOGEN boom head with sheave shield [source: SENNEBOGEN]

2. Rope equipment

In demolition operation hoist ropes as well as grab ropes are used. The hoist rope is used in conjunction with the wrecking ball, and the grab rope is used in conjunction with the loading grab.

The SENNEBOGEN hoist rope, pulled on the rear winch 1, has been specially developed for taking up high loads and guiding them rotation-free. The SENNEBOGEN grab rope, hoisted on the front winch 2, has been specially designed for the dynamic forces in grab operation.

3. Attachments

Wrecking ball

A wrecking ball (also referred to as a demolition ball) is a tool used to demolish buildings. A wrecking ball is a pear-shaped or spherical iron weight with a dead weight of approximately 500 to 8000 kg. A wrecking ball is usually a custom-cast weight that is adapted to the respective operating conditions. There are no standard specifications regarding appearance and material characteristics. With regard to size and weight, the wrecking ball needs to be compatible with the duty cycle crane size used.

For demolition tasks, the wrecking ball is hung on the duty cycle crawler crane (single-strand via winch 1) and brought to the pendulum. As a result of the pendulum motion, it takes on kinetic energy, which causes the wall or ceiling to be torn down to become overloaded during impact, resulting in it being broken up by the wrecking ball. The use of wrecking balls is suitable for masonry whereas they are only of limited use for thick steel-reinforced concrete.

Different sizes and shapes of wrecking balls [source: SENNEBOGEN]

Today, wrecking balls are usually purchased second-hand as there is little demand for new ones, meaning there are no standard products or standard manufacturers. If a new wrecking ball is required then it is requested from steel plants and cast to customer specification.

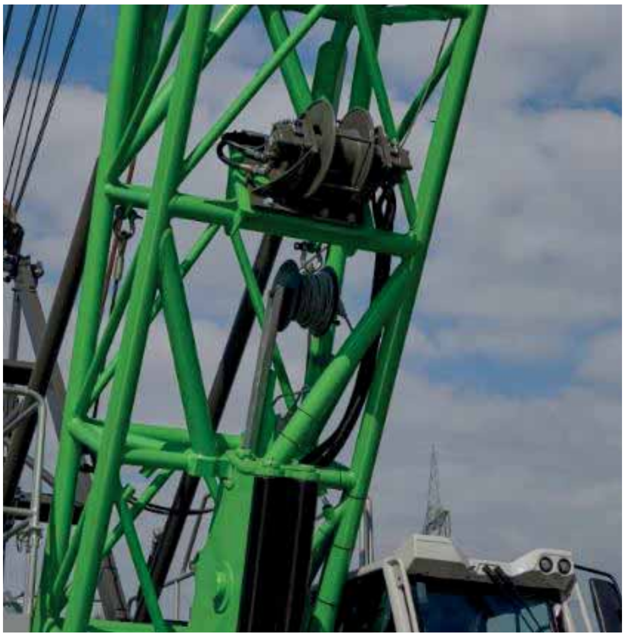
Loading grab

Loading grabs are always 2-rope guides: They can be delivered in different sizes and versions – with teeth and without teeth. The grab size used must be adapted to the duty cycle crane and its rope pulling force. “Standard grabs” that are suitable for loading rubble are typically used here.

6100HD demolition operation with loading grab [source: SENNEBOGEN]

4. Grab steadying winch

Via the grab steadying winch, a rope is fastened laterally on the grab or on the wrecking ball, which protects the attachments against “wobbling”. During slewing, the grab is pulled forward via the grab steadying winch with a force that has been specified beforehand. This can prevent the attachment from protruding and consequently swinging once the slewing gear has stopped. Through this activation the grab can be positioned above a truck or other unloading aid with much greater ease.



Grab steadying winch 670HD installed in the basic boom section [source: SENNEBOGEN]

The GSW can be mounted in the basic boom or on the front of the uppercarriage. The associated rope is deflected via a deflector sheave on the underside of the boom to prevent excessive pendulum movements of the grab. Since the grab capacity increases with higher duty cycle crane capacity, it is necessary to adjust the GSW to the duty cycle crane size and to offer GSWs with varying strengths.

SENNEBOGEN uses the following grab steadying winches for its duty cycle cranes:

Seilbagger	**Greiferberuhigungswinde**				
	9kN	18kN	30kN	60kN	120 kN
624 HD					
630 HD	x	x			
640 HD	x	x			
655 HD		x	x		
670 HD	x	x	x		
6100 HD		x	x		
6140 HD		x	x		
6300 HD				x	x

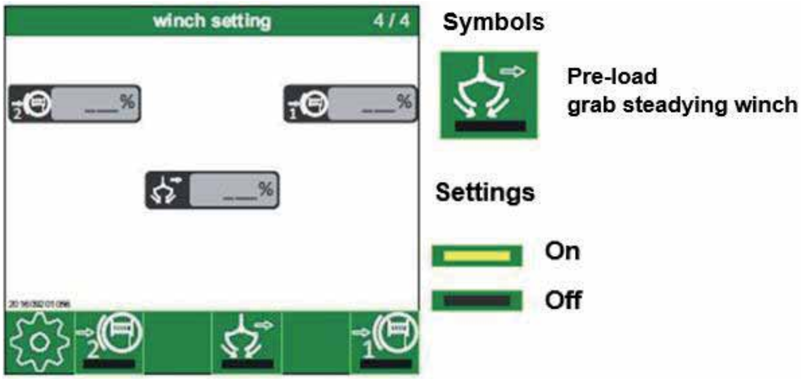
The grab steadying winch offers the following functions for optimal working:

- Proportional pulling force adjustment of 0–100% during operation of the joystick or foot pedal
- Pulling force adjustment of 0–100% in the SENCON
- Immediate 100% pulling force of the winch via button activation on the joystick
- Free-wheel function of the winch via button activation on the joystick

The pre-load of the GSW is set via the SENCON. Then the GSW can be controlled either via the foot pedal, with the joystick in general, or via the push button on the joystick.

Setting the pre-load of the GSW

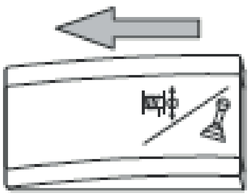
The pre-load of the grab steadying winch is set in the SENCON via the “winch setting” tab. In this menu, the residual braking torque (freefall velocity) can be set for each winch individually. The pre-load of the GSW can be entered as a percentage in the SENCON. By activating the relevant button via the touch display, the entered value can be accepted and the GSW can be enabled. The GSW can then be switched on and off via the display.



SENCON – GSW pre-load setting [source: SENNEBOGEN]

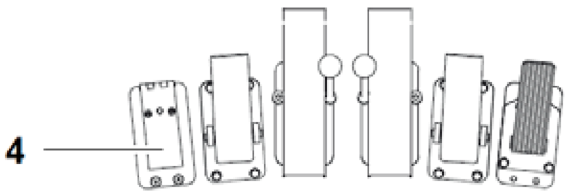
Operation by foot pedal

An additional switch in the control panel can be used to select control via foot pedal or joystick – this needs to be activated for pedal operation.



SENCON – grab steadying winch foot/hand switch [source: SENNEBOGEN]

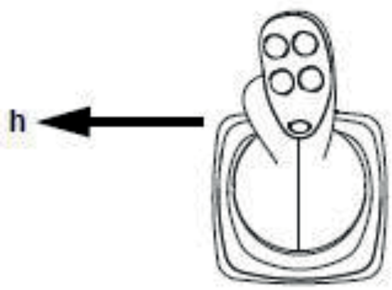
The pull of the grab steadying winch can be controlled (braked) via pedal 4.



GSW control via foot pedal [source: SENNEBOGEN]

Operation via joystick:

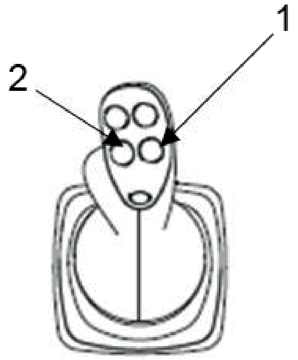
For operation using the joystick, the GSW foot/hand switch mentioned above needs to be set to manual operation. The GSW can now be controlled by moving the joystick in the direction of “h”.



GSW control via joystick [source: SENNEBOGEN]

Operation via joystick push button:

If the GSW foot/hand switch is set to manual operation, the pull force of the GSW can be controlled using the push button on the joystick. Pressing the “1” button tightens the rope with maximum pulling force. Conversely, button 2 can be used to release the rope in freewheel mode.



GSW control via joystick push button [source: SENNEBOGEN]

5. Cab protection

During demolition work, stones, smaller construction elements, etc. may fall down in an uncontrolled manner. This is why it is important to protect the cab – and the machine operator – during this operation scenario. SENNEBOGEN offers various optional protection options for its duty cycle cranes, such as bulletproof glass, protective grating, etc., that are explicitly recommended for demolition tasks. For example, FOPS protective grating on the cab roof or installed as front protective grating offers additional protection against flying construction elements from above or from the front.

Front protective grating and roof protective grating – SENNEBOGEN Maxcab II [source: SENNEBOGEN]

6. Tiltable cab

The 20° inclinable cab enables an ergonomic and fatigue-free operator position, particularly for longer periods of work at height. The result is increased safety and an improved view of the work location.

20° inclinable cab – SENNEBOGEN Maxcab [source: SENNEBOGEN]

7. Camera system

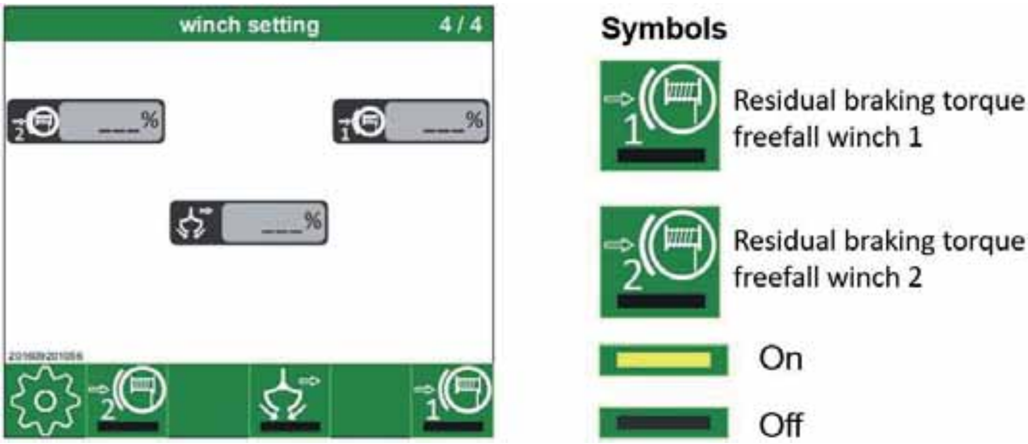
The SENNEBOGEN camera system offers safety at the highest level through the use of up to four cameras and a monitor with 4-way splitting.

In demolition operation, a camera is recommended for winch monitoring to detect and prevent slack rope. SENNEBOGEN also recommends a rear camera to prevent accidents thanks to better visibility of the zone behind the equipment.

Screen for camera system with up to 4-way splitting [source: SENNEBOGEN]

8. Adjusting the residual braking torque:

For operation with wrecking balls, for example for ceiling or story demolition, it may be necessary to let the ball drop onto the building parts to be demolished in freefall. For this purpose, the residual braking torque or the “freefall velocity” can be preset using SENCON. Under the “winch setting” tab, the residual braking torque can be set separately and independently for each winch. The value 0% means that the freefall will be executed at maximum speed. Increasing the value partially engages the freefall brake and reduces the freefall velocity. This prevents the occurrence of slack rope and enables better monitoring/control for freefall tasks.



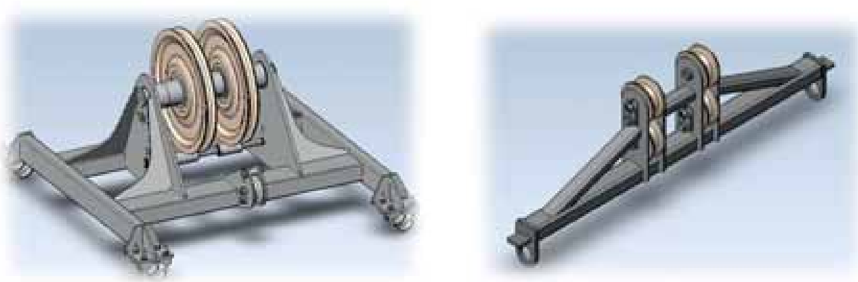
SENCON – setting the residual braking torque [source: SENNEBOGEN]

9. Rope guidance on the boom

The rope guide on the boom is ensured for duty cycle cranes in demolition operation via large or small rope guide sheaves. The rope guide is used to avoid slack rope and prevents lateral slip-off and thus associated damage to the rope or to the boom. The number of rope guide sheaves used varies from use to use and can also be modified upon customer request.

Large rope guide sheaves

Large rope guide sheaves are bolted on in the area of the basic boom section and ensure clean guidance of the rope in order to prevent lateral slip-off or striking of the rope. This prevents damage to the boom, the boom bolts, and the rope and optimal winding of the rope on the winch drum is achieved.



Rope guide on the boom – large rope guide sheaves (left) and small (right) [source: SENNEBOGEN]

Small rope guide sheaves

The small and lighter rope guide sheaves are bolted onto the upper section of the boom and are used to guide the rope in the upper boom area in order to prevent lateral slip-off and striking of the rope.

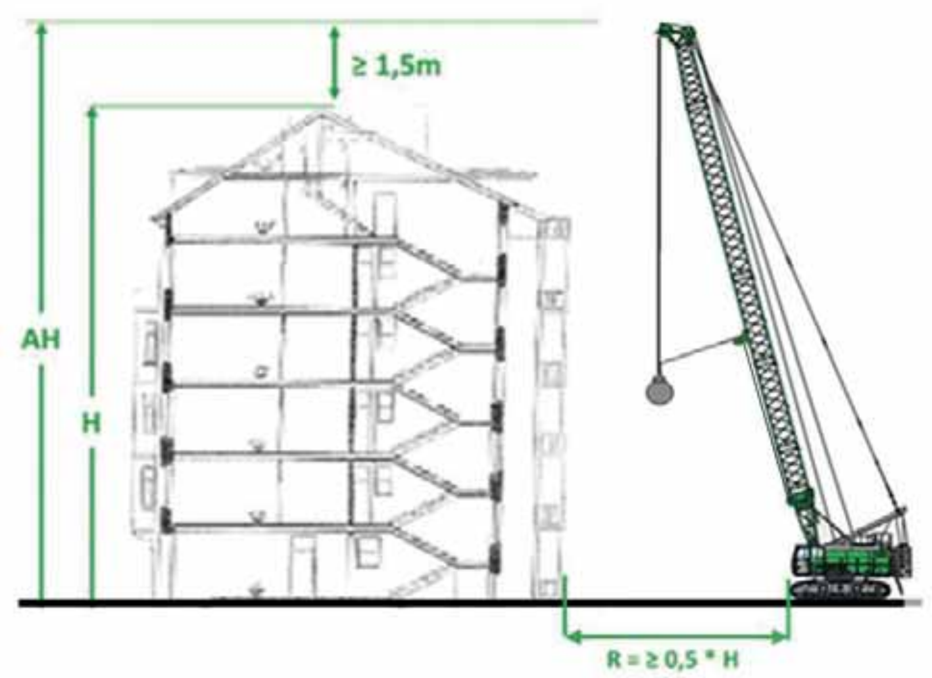
10. Supplemental baffle plates

Due to the extremely long boom lengths in demolition operation and the increased stress of the boom due to the striking rope, SENNEBOGEN use supplemental baffle plates on the boom sections:

- 11.2 m intermediate boom section: 4 supplemental baffle plates (8 in total)
- 5.6 m intermediate boom section: 2 supplemental baffle plates (4 in total)
- 2.8 m intermediate boom section: 1 supplemental baffle plates (2 in total)

Demolition operation questionnaire

Structure height:	……………………………………	[m]
Required boom length:	……………………………………	[m]
Maximum working height H:	……………………………………	[m]
Maximum radius R:	……………………………………	[m]
Attachment:	……………………………………	[-]
Connection data and weights	……………………………………	[…]
	……………………………………	
	……………………………………	
	……………………………………	
Work hours per day / days per month	……………………………………	[h] / [d]



Parameters for operation with wrecking ball [source: SENNEBOGEN]

SENNEBOGEN duty cycle crane in demolition operation

SENNEBOGEN 690HD with wrecking ball / Germany [source SENNEBOGEN]

Operation with Leader

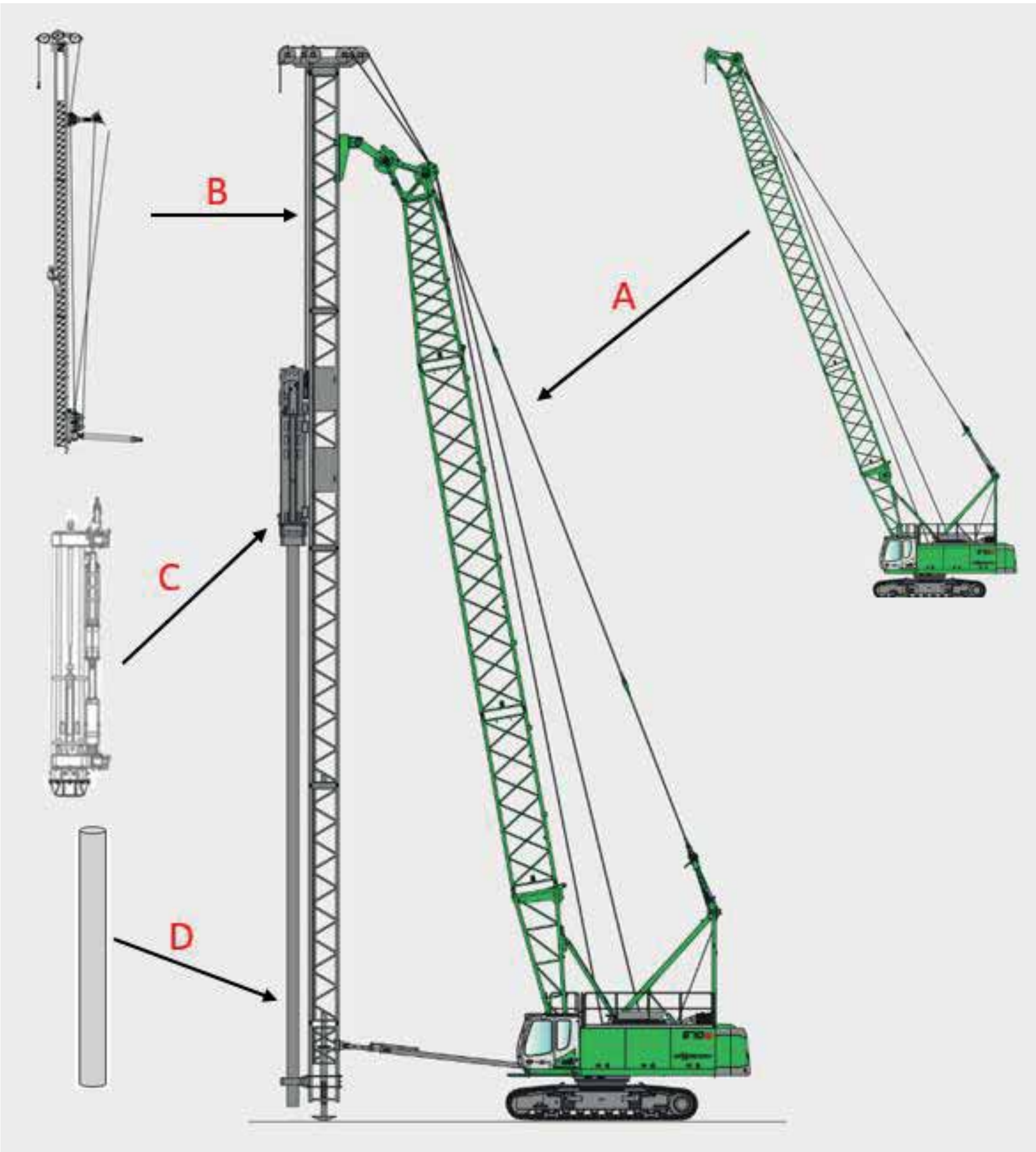
SENNEBOGEN duty cycle crane with leader system [source: SENNEBOGEN]

Definition of terms – leader

Depending on type, leaders can be used as equipment carriers for diesel pile hammers, hydraulic impact hammers, and for piling and extracting tools, as well as drilling tools. The lightweight construction and high level of stability are among the great advantages of leader systems. Replaceable guides permit adaptation to swinging, hanging, or fit-on leaders.

When using leaders, the overall system must be matched:

- **A** Capacity and type of carrier
- **B** Length, dimension, and type of leader
- **C** Capacity and type of attachment
- **D** Length, size, and type of pile element



Overall system – duty cycle crane in leader operation [source: SENNEBOGEN]

Duty cycle crawler cranes with leader systems are primarily used, if long and heavy profiles will be rammed or vibrated. The advantage in this regard is the increased stability due to the fixed connection of the leader to the carrier (duty cycle crane).

A variety of attachments can be operated with a leader. The most frequent uses include a diesel hammer or hydraulic hammer or an attached vibrator or drilling drive.

The heavy pile driving technology with diesel or hydraulic hammer is used for non-cohesive soils up to dense stratification or for cohesive soils up to maximum consistency. The silt and sand proportion should be greater than or at least equal to the clay proportion. Pile driving is not recommended for cohesive soils that are classified as firm, very firm or hard. In these cases, the necessary ground preparation can be provided through loosening bores with a leader-guided drilling drive with continuous flight auger.

For pile driving of steel tubes, steel girders, wood piles, concrete or reinforced concrete piles using diesel or hydraulic hammers, a helmet can be attached between hammer and the head of the pile element. This is adapted to the cross section shape of the pile driving element, which enables the impact energy to be applied as centrally as possible. Thus excessive energy loss or even the destruction / deformation of the pile element is prevented.

Due to the high noise level and environmental pollution more and more diesel piling hammers are disappearing from the European region. In most cases, use of these is no longer permitted today, particularly in built-up areas.

The vibrating in and pulling of heavy and long profiles with an attached vibrator, such as sheet pile wall profiles or steel profiles is also executed with the aid of a leader. Heavy-duty vibrator tasks with extremely long profiles and in exposed positions are usually executed with hanging leaders. Inclined vibrating and pulling can be executed with the hanging leader as well as the swinging leader. Specially equipped attached vibrators must be used for this.

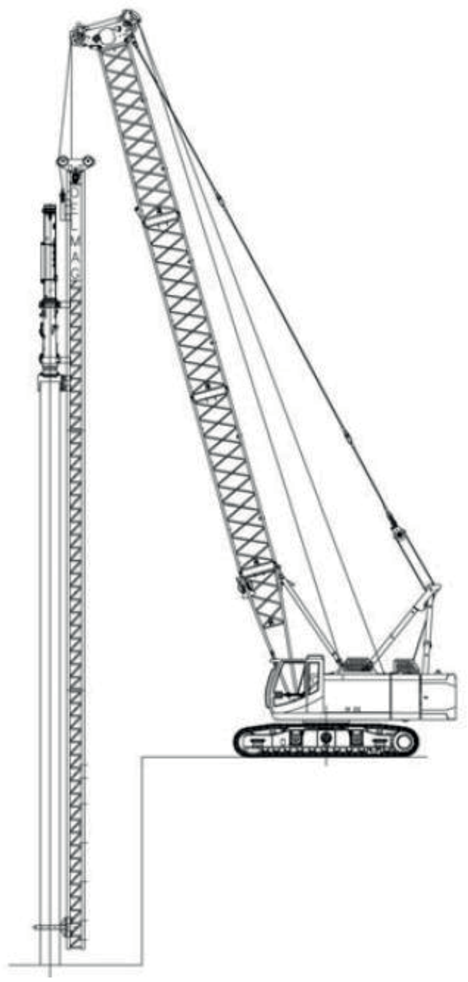
SENNEBOGEN duty cycle crane 655HD with leader system [source: SENNEBOGEN]

In soils that are basically poorly suited, it is necessary to execute loosening drilling for pile driving and vibration tasks. This is ensured with a drilling head with attached continuous flight auger routed on the leader. The diameter of the auger and the capacity of the drilling head depend on the ground, the carrier, and the leader used.

Leader types

Swinging leader

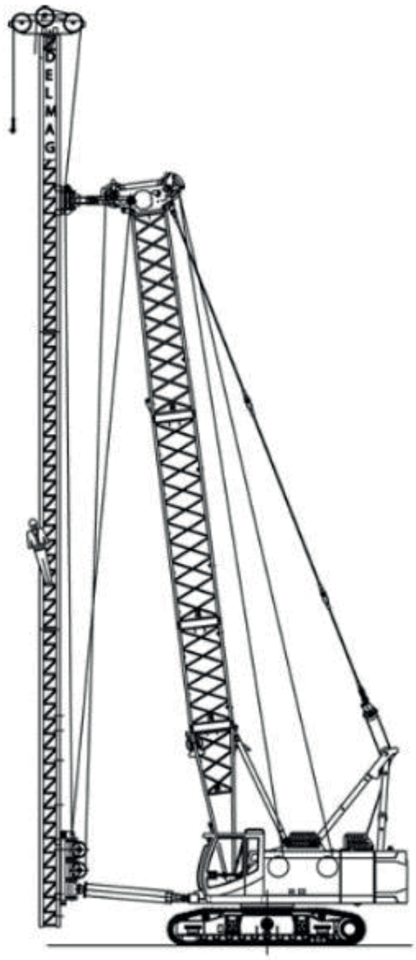
Swinging leaders can be mounted on every crane type with appropriate capacity. Because the leader is not connected to the crane uppercarriage, it can be rotated 360° around the vertical axis. When using a traverse, inclinations of up to 45° can be realized.



Duty cycle crane with swinging leader [source: SENNEBOGEN]

Hanging leader

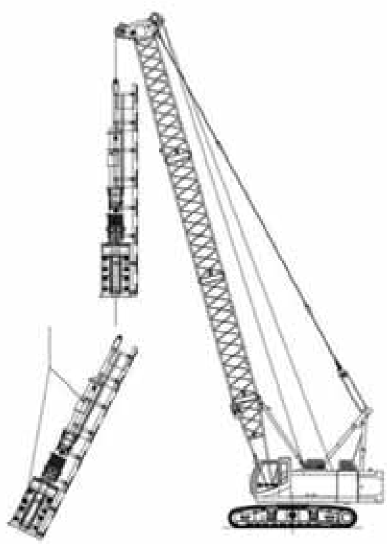
Hanging leaders are mounted on the boom arm of a duty cycle crawler crane. The lower part of the leader is usually connected with the uppercarriage of the duty cycle crawler crane for inclination control. In addition, the hanging leader is available with a pivot fixture for adjustments of ± 90° around the vertical axis and with a hydraulic mast lowering fixture for lowering to 8 m below ground surface. These components make it possible to drive in pile driving elements at the specified angle even under difficult conditions. Thanks to additional adapters, other equipment, such as drilling heads or vibrators can be used on the hanging leader.



Duty cycle crane with hanging leader [source: SENNEBOGEN]

Fit-on leader

Fit-on leaders sit free-riding on the pile driving element and are primarily used in the offshore sector. Different models are available on the market that enable pile driving of diameters of up to 4.2 m.

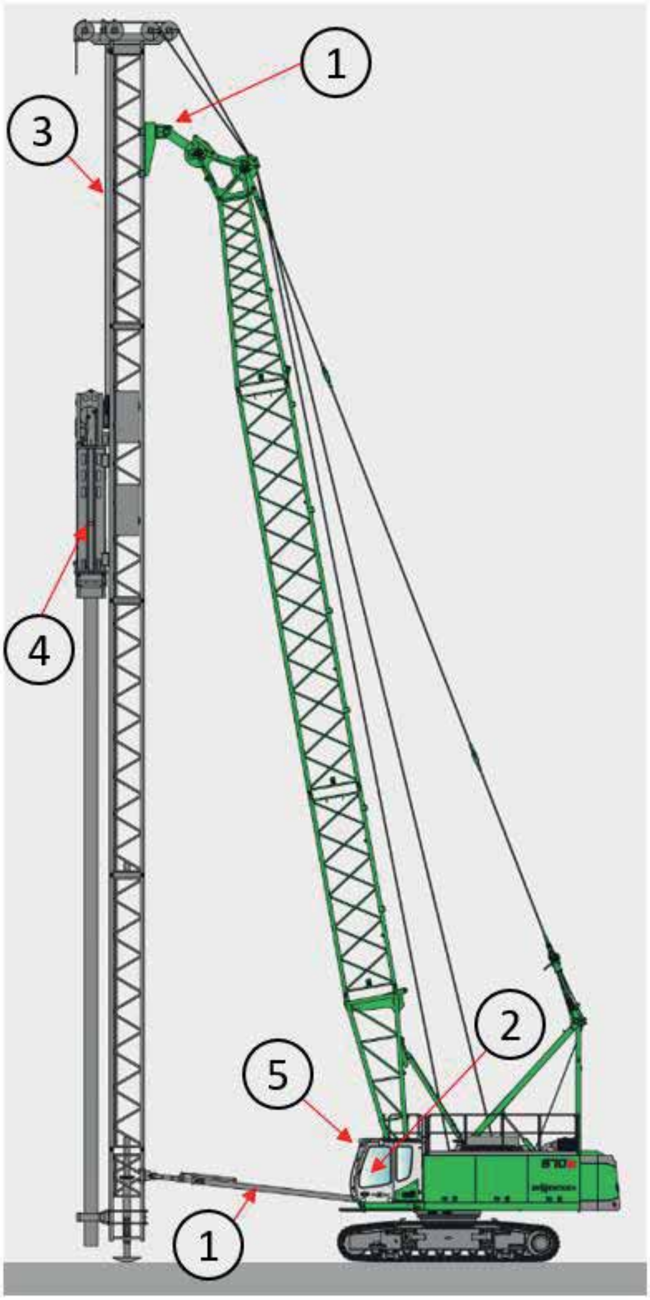


Duty cycle crane with fit-on leader [source: SENNEBOGEN]

SENNEBOGEN technology in leader operation

SENNEBOGEN duty cycle cranes are equipped with first-class technical equipment for this dynamic application and have been 100% adapted to the operating conditions.

SENNEBOGEN duty cycle cranes are carriers with maximum efficiency and low diesel consumption.



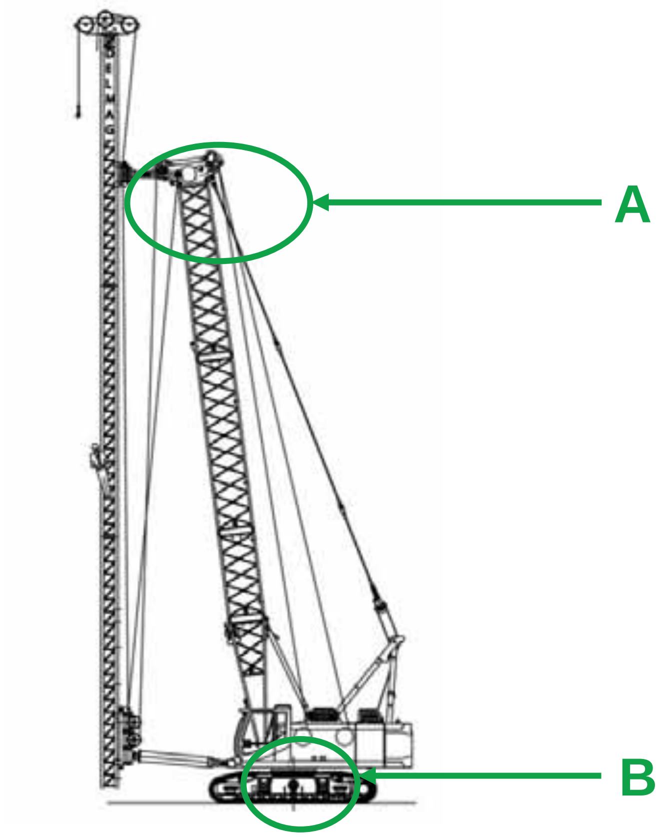
SENNEBOGEN duty cycle crane equipment for leader operation [source: SENNEBOGEN]

1	Mechanical connection of the leader on the HD crane
2	Leader control
3	Leaders
4	Attachment
5	Supplemental hydraulic system for attachment

1. Mechanical connection of the leader on the duty cycle crawler crane

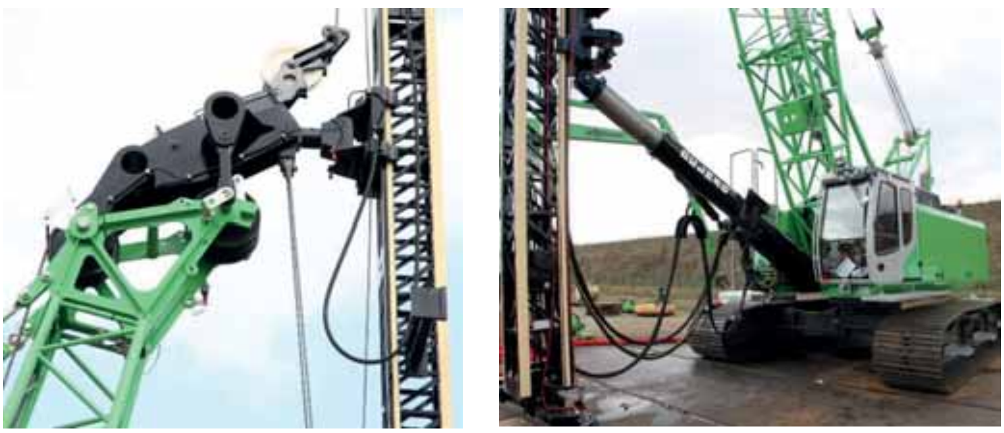
A mechanical connection on the duty cycle crane is necessary for attachment of a hanging leader. For this the leader is mechanically fixed in place at 2 points.

A) On the boom head
B) On the uppercarriage



Mechanical fixation of the leader on the SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

At the boom head, fixture is ensured by bolts on the left and right of the head. The mechanical connection has cardanic support. Thus the leader is bearing supported on the mechanical attachment part so that it is movable. The reason for this is so that the leader can be moved up and down, as well as tilted.



Detail graphic of mechanical connection of the leader on the SENNEBOGEN duty cycle crane [source: SENNEBOGEN]

In addition, the leader is mechanically connected to the uppercarriage of the duty cycle crane via the leader support. The leader support is used for fixation in the lower area of the leader. The leader support can be rigid or it can be retracted or extended via telescopic cylinder. This allows the leader to be tilted forward or back in the direction of travel. Moreover, it is possible to achieve a lateral inclination of the leader and thus of the pile element through cylinders attached on the side of the leader support.

2. Leader control

SENNEBOGEN, on customer request provides the supplemental hydraulic system and the control element for leader control. The required hydraulic system for operating the hydraulic functions of the leader are provided via an additional hydraulic pump with a maximum capacity of 60 l/min at 250 bar. Up to 6 functions can be controlled via the control panel. No standard can be defined in this regard. Depending on leader type, manufacturer, and customer request, the functions can vary in number and use.

The most frequently used functions are:

Function 1:	Extending or retracting leader support cylinder
Function 2:	Leader support up/down
Function 3:	Slewing the leader support cylinder on the right/left
Function 4:	Pile guidance right
Function 5:	Pile guidance left
Function 6:	Hydraulic pile holder

Additional or fewer functions can be implemented. However, detailed consultation and definitions with the customer and the leader manufacturer are necessary in advance.

Example of control panel of the leader control system [source: SENNEBOGEN]

The supplemental hydraulic system will be provided to the customer on the right side of the uppercarriage.

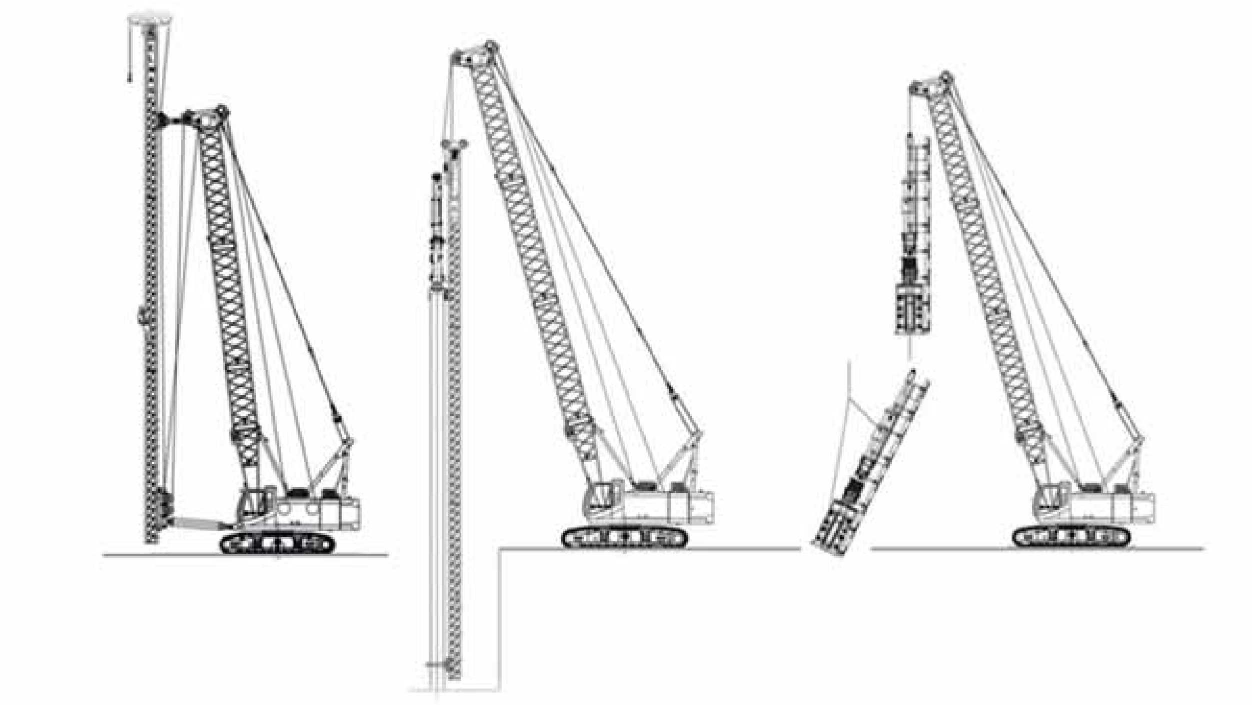
Hydraulic connection for leader control, uppercarriage front side [source: SENNEBOGEN]

3. Leaders

The leader is not a component of the SENNEBOGEN scope of supply. It serves as a carrier for various attachments. There are various leader manufacturers around the world and many leaders that have been constructed by customers in their own production. The length and the dimensions of the leader need to be compatible with ram elements used, the attachments used, and the size of the duty cycle crane.

Alongside the various manufacturers, there are also different types of leaders. The most frequent variant is the hanging leader that is mechanically fixed in place on the duty cycle crawler crane. The leader is adjusted via telescoping cylinders in the area of the leader support and can be adjusted forwards, backwards, or laterally.

Other variants are the swinging leader and the fit-on leader. Swinging leaders can be rotated 360° around the vertical axle. When using a traverse, inclinations of up to 45° can be achieved. The fit-on leader sits free-riding on the ram element and is primarily used in the offshore area.



SENNEBOGEN duty cycle crane with hanging leader, swinging leader, and fit-on leader [source: SENNEBOGEN]

Additional types of leaders are available depending on manufacturer. The adaptation to the SENNEBOGEN duty cycle crawler crane must be reconsidered and redetermined on a case-by-case basis.

4. Attachments

The leader is used as carrier for various attachments. In addition to diesel hammers and hydraulic hammers, vibrators and drilling drives can also be attached. These are all applications from the field of special underground engineering.

Size, capacity, and weight of possible attachments all depend on the selected duty cycle crane and leader and need to be adapted to these.

Attachments: diesel hammer, hydraulic hammer, vibrator, drilling drive [source: SENNEBOGEN]

5. Supplemental hydraulic system for attachments

Attachments can always be operated via external supplemental hydraulic power units or via the onboard hydraulic system of the SENNEBOGEN duty cycle crawler crane. For the latter, clear specifications and information concerning the attachments that will be operated are required. If the supplemental hydraulic system is provided via the duty cycle crane, the connection is made via special pins on the front right of the uppercarriage.

Control panel for control of leader and attachments – SENNEBOGEN 6100XLR [source: SENNEBOGEN]

SENNEBOGEN makes the required supplemental hydraulics available via additional hydraulic pumps. The attachments are operated via a control panel in the cab. When designing the supplemental hydraulic system and its control, the following parameters must be agreed with the customer/the manufacturer: Maximum hydraulic flow, maximum hydraulic pressure, connection sizes on the front of the uppercarriage, and the number of pressure, return, and leakage oil lines.

However, the hydraulic capacity that needs to be made available by the duty cycle crane greatly depends on the engine capacity and the cooling system capacity. This needs to be taken into account when selecting the duty cycle crane size.

Stability and increasing stability

From machine size 6100 HD, SENNEBOGEN offers the option of equipping the duty cycle crane with additional counterweights. This increase in the rear and undercarriage ballasts should ensure sufficient stability of the overall system.

Supplemental winches

In use with leader systems, due to the variety of attachments and use possibilities, it may be necessary to install supplemental winches. From duty cycle crane size 6100, these winches can be attached in the uppercarriage of the duty cycle crane, on the boom, or on the leader itself.

These winches are used for the following:

- Lifting cage operation
- Lifting reinforcement cages
- Lifting pile driving elements
- Cable feed winch
- Infeed winch

Duty cycle crane operation with leader questionnaire

Does the customer already have a leader: .... [yes / no]

If yes:

Manufacturer (data sheet): .... [-]

Type (hanging, swinging, or fit-on leader) .... [-]

If hanging leader:

Mechanical fixation on the boom head: .... [description]

Mechanical fixation on the uppercarriage: .... [description]

Leader control via duty cycle crane: .... [yes / no]

If yes - description of the functions that must be controlled, such as:

Leader support on / off: .... [yes / no]

If yes Hydraulic pressure: .... [bar]

Flow rate .... [l/min]

Slewing leader left / right: .... [yes / no]

If yes Hydraulic pressure: .... [bar]

Flow rate .... [l/min]

Other functions (for example, fixation of pile) .... [yes / no]

If yes Hydraulic pressure: .... [bar]

Flow rate .... [l/min]

Attachments

Diesel hammer: .... [yes / no]

If yes – make, model, and data sheet: .... [-]

Hydraulic hammer: .... [yes / no]

If yes – make, model, and data sheet: .... [-]

Hydraulic capacity and control via duty cycle crane: .... [yes / no]

If yes Hydraulic pressure: .... [bar]

Flow rate .... [l/min]

Attached vibrator: .... [yes / no]

If yes – make, model, and data sheet: .... [-]

Hydraulic capacity and control via duty cycle crane: .... [yes / no]

If yes Hydraulic pressure: .... [bar]

Flow rate .... [l/min]

Drilling drive: ....[yes / no]

If yes – make, model, and data sheet: .... [-]

Hydraulic capacity and control via duty cycle crane: .... [yes / no]

If yes Hydraulic pressure: .... [bar]

Flow rate .... [l/min]

Other attachments: .... [yes / no]

If yes – make, model, and data sheet: .... [-]

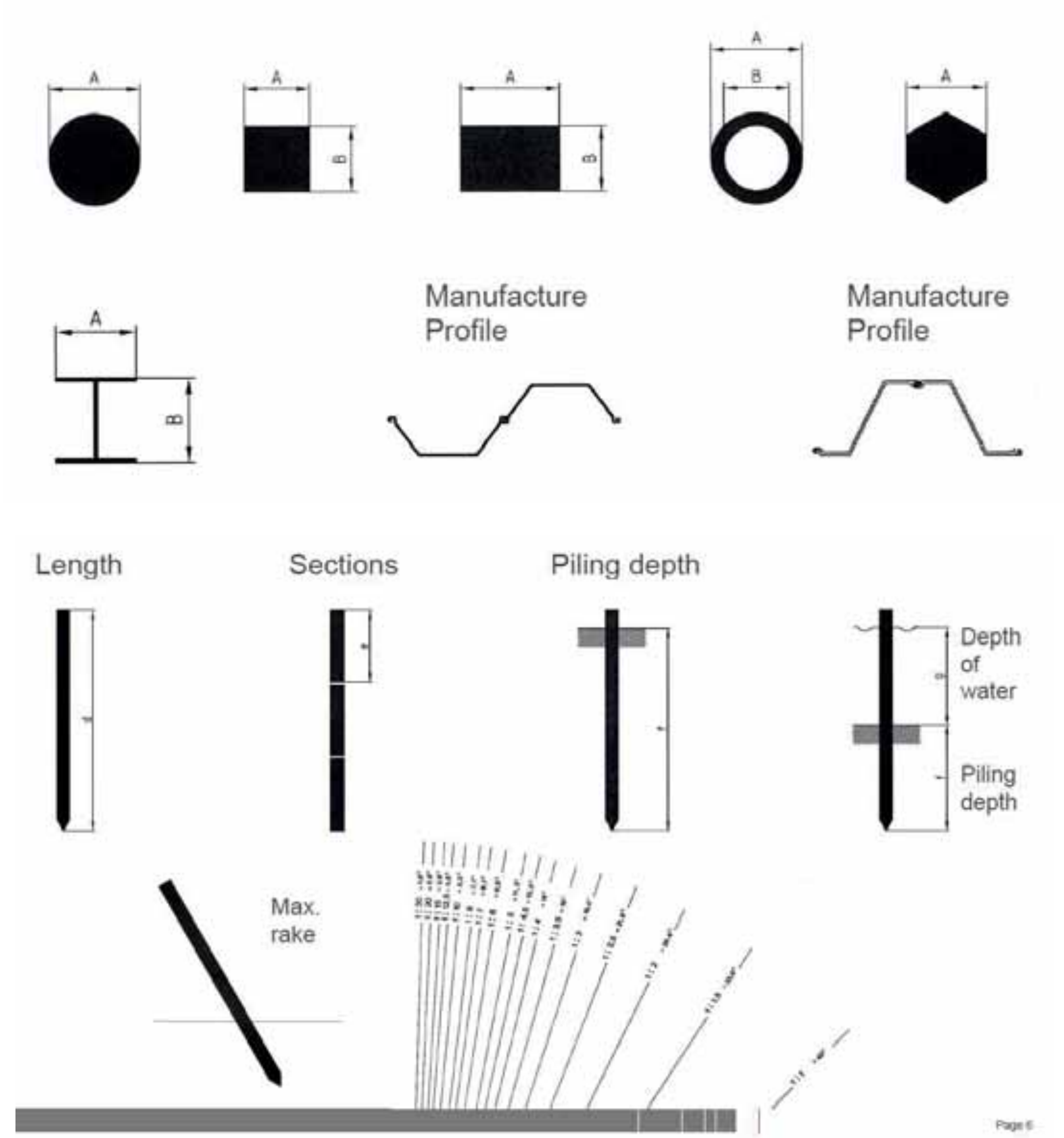
Hydraulic capacity and control via duty cycle crane: .... [yes / no]

If yes Hydraulic pressure: .... [bar]

Flow rate .... [l/min]

Pile driving element

Please check the profiles used and specify dimensions:



Steel

Concrete

Timber

SENNEBOGEN duty cycle crane in leader operation

SENNEBOGEN 6180HD with leader system [source: SENNEBOGEN]

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