

# Intelligent CST Drive Systems





## The Drive for Productivity

With constant pressure for greater productivity, improving the performance of longwall systems remains a key goal for mine operators. At Caterpillar, all aspects of longwall operation and machinery are continuously reviewed to find ways to improve productivity and reduce the overall cost of mining. The performance of the face conveyor system is continually improving.

### Improved Performance

Ever more powerful systems require ever more horsepower, heavier chains and faster conveyor speed with maximum availability. What was needed was a truly intelligent drive system for face conveyors, which led our engineers to develop the Cat® Controlled Start Transmission (CST) drive system meeting the following requirements:

- Currently available power up to 1,800 kW (2,447 hp @ 50 Hz, 2937 hp @ 60 Hz) per transmission unit
- Safe startup of the face conveyor
- Full utilization of the installed power
- Highly durable components
- Compact dimensions
- High level of efficiency

### The CST Drive System

Our engineers have been jointly developing the CST drive system for face conveyors with Baldor Electric since 1991.

The Cat CST drive is a planetary gearbox with an integrated infinitely variable multi-disc CST clutch. Also incorporating the proven PMC-D drive control unit featuring no-load motor startup, AFC soft start and synchronized heavy-load startup, it allows accurate load-sharing between up to three drive motors with excellent, extremely fast overload protection. While the CST115 is rated for 1800 kW (2937 hp @ 60 Hz), the CST65 offers 1200 kW (1,950 hp @ 60 Hz) per gearbox, the CST45 offers up to 800 kW (1305 hp @ 60 Hz) and the CST30 offers 500 kW (816 hp @ 60 Hz). The clutch delivers maximum efficiency with minimum operational slip. A compact drive system with integrated emergency operation, more than 500 CST systems were sold between 1991 and 2010 worldwide.



CST45 Drive System

## Modular Structure

CST gearboxes have a modular structure and are made up of three units. Thanks to this modular principle, identical supply and output units are used in all CST gearbox variants of the same parameter. The design as an angular gearbox (bevel helical planetary gearboxes; short: KP gearboxes) or as planetary gearboxes with coaxial input and output shafts (short: P gearboxes) is exclusively defined by the middle gearbox unit. Either a bevel spur gearbox or a planetary gearbox can be used for the middle gearbox unit. The bevel helical planetary gearbox is a four-stage gearbox, consisting of a bevel gear stage, two spur gear stages and a planetary output stage. The ratio is changed by exchanging the first and/or the second spur gear stage with the corresponding number of teeth of the gear and pinion. For parameters 30, 45 and 65, the P gearbox is a two-stage gearbox consisting of two planetary stages. For parameter 115, a third planetary stage is added.

## Oil Supply

A high-pressure pump supplies the oil to the clutch with the servovalve controlling the pressure that forces the clutch plates together. Power is transmitted with an efficiency of nearly 100% with no wear due to a running slip of 0.2%. A cooling oil pump provides a constant oil flow through the complete drive system—up to 2 000 L/min depending on the drive system size.

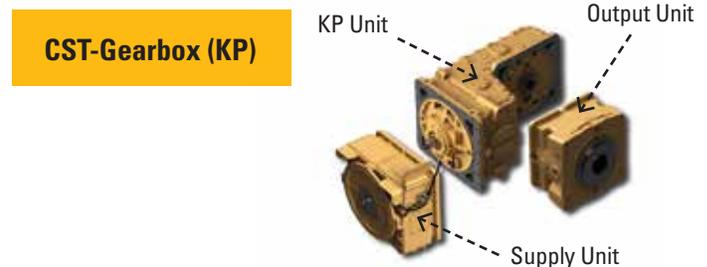
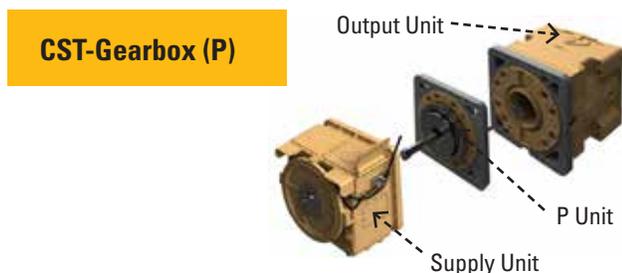
The CST gearbox is suitable as a conveyor gearbox for attachment to drive frames with a separate bearing-

supported shaft or, in the M version, also as a plow gearbox for attachment to the plow drive unit. It has one oil chamber. The added M in the designation of the gearbox parameter indicates that there is a pump unit with pump motor in the supply unit of the CST gearbox, which works independently of the gearbox drive motor speed, and therefore ensures that the gearbox is continuously supplied with oil. Thanks to the self-sufficient supply unit, there is also the option of using the Cat CST gearboxes in combination with a speed-variable drive, e.g. a frequency converter (FC) or a PU motor.

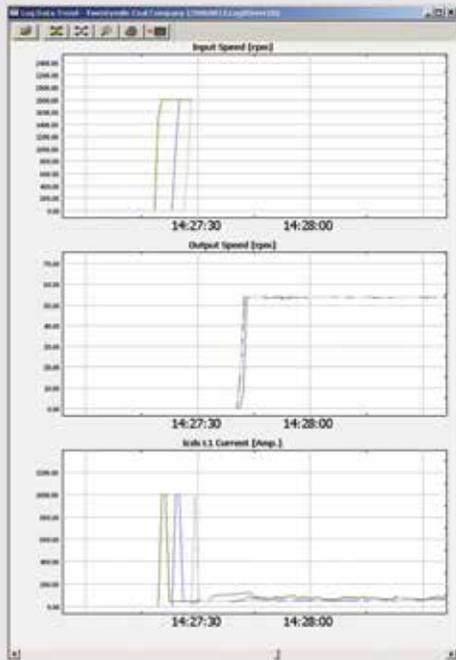
The CST is a closed system. A water hose for the heat exchanger and the 37-wire cable for the drive control unit and communication are the only external connections.

## Drive Control

A fast, real-time operating drive control unit controls all operations in the CST drive system via the integral servovalve. Each gearbox is equipped with a control unit interconnected via control cables. These units can communicate with mine-specific face control systems underground or on the surface. The tried and tested Cat hydraulic chain tensioner is used for safe operation during chain maintenance work.



Modular Principle of the CST Gearbox



## Startup

For soft-start and heavy-load startup, all drive motors run up to full speed at no load. Motors are always started sequentially, with the result that peak current and energy demand are very modest. When the last motor has reached full speed, pressure is applied to the CST clutch, increasing until the breakdown torque is reached if needed.

As a result, the increase in pressure and motor load is synchronized during the startup phase and continues as the conveyor accelerates.

## Benefits

- **Staggered no-load motor startup:**  
Minimum voltage drop in the electrical supply system
- **Soft start of the face conveyor:**  
Minimum stress on all drivetrain components at startup
- **Synchronized startup and use of motor kinetic energy:**  
Maximum total torque is available to facilitate startup of fully loaded conveyors

## Load-sharing

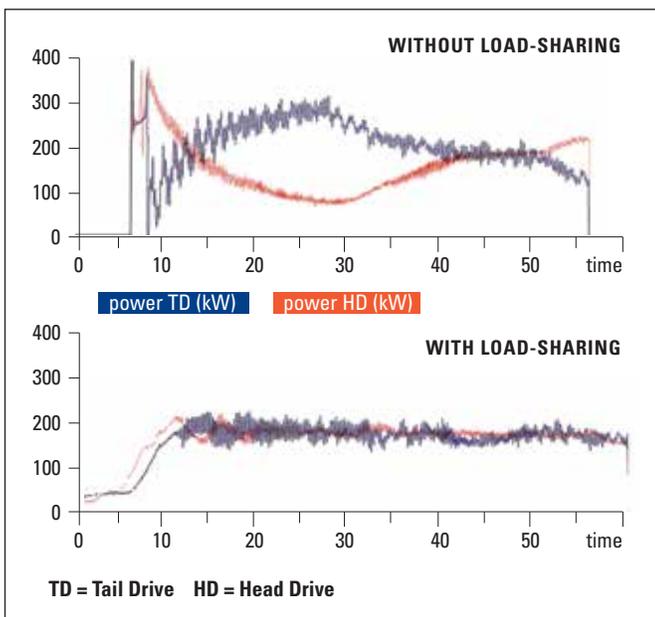
Power consumption of each motor is constantly monitored to allow load-sharing between the individual drives. If a preset value is exceeded, slip at the drive with the greater power consumption is increased, causing the other drives to draw more power and equalizing power distribution again. The typical operating slip is normally below 0.2%.

## Benefits

- **Accurate load-sharing between the drives:**  
Full utilization of available power, avoiding motor overheating and resultant downtime even with a chain showing different pitch along the face

## Overload Protection

If the chain is jammed by large pieces of rock or trapped iron, the CST clutch is opened rapidly and the motor is switched off. To achieve this, the output speed is constantly monitored. Within milliseconds, the rotating mass of the gearbox — and particularly of the asynchronous motor — is disconnected from the conveyor chain sprocket. Communication between the drive control units allows all clutches to be opened simultaneously.



*Load-sharing capabilities of the CST drive system*

## Benefits

- **Instant, effective overload protection:**

Excessive chain forces and the risk of instant chain failures are virtually eliminated. Chains, sprockets and transmission units incur less wear because shock loads are absorbed.

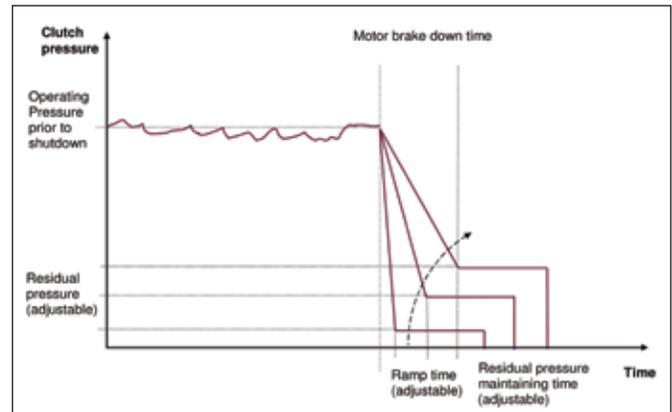
## Motor Braking Feature

Occasionally—even during regular shifts—there is a need to interrupt production and shut down the AFC motors. In order to restart the drives safely, the operator has to wait a considerable time (up to 3 minutes) until the motors come to a standstill. Motor braking leaves an adjustable residual pressure on the CST clutch, minimizing the time for the motor to stop and the resultant downtime.

## PMC-D and PMC-V

The PMC-D and PMC-V are members of the Cat PMC family of programmable mining controls. The PMC-D controls drive applications such as face conveyors and overload protection gearboxes. The PMC-V drives visualization. The PMC-D is typically dedicated to each gearbox or drive individually. It contains all necessary hardware to control all functions of a drive system effectively. The unit can be connected to an internal mounted distribution box as typically used in CST gearboxes for the connection of sensors and actuators.

The PMC-V contains 24 keys for easy operation and a 4" VGA display. Graphical trends, warnings and any error messages can be displayed. The interface is available in various languages such as English, Chinese, German and Russian. The PMC-V displays all available gearbox data including transducer values, status information, global and local parameters, network status, etc. Parameters can be easily changed using the 24-key numerical keyboard. Important system parameters are password protected.



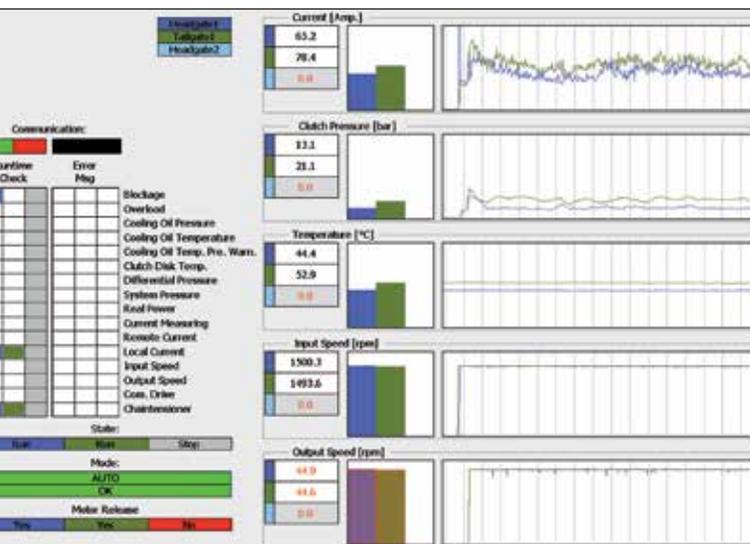
*Motor braking minimizes the time for the motor to stop and the resultant downtime.*



*PMC-D – used for measurement and control tasks*



*PMC-V – mainly for visualization of data and parameter settings*



Visualization of CST data by V-Drive



CAT30 gear train



P-45 CST drive system

## V-Drive Visualization Software

This software visualizes all CST, tail drive and chain tensioning data. It allows changes to drive system parameters and monitors load-sharing, conveyor speed, clutch sensors etc. The software also stores all CST data and undertakes analysis and trending of sensor values. It allows export of data to office applications such as electronic spreadsheets. Chinese, German and Russian versions of the software are also available.

## Field Experience

The CST drive system was applied for the first time in 1995 on a high production longwall face in the United States. Since then, well over 500 CST drive systems have been sold and are operating successfully in mines in the U.S., Mexico, Australia, Poland, China, Russia, Kazakhstan, the Czech Republic and Germany. The maximum total available power for the face conveyors is currently up to 5 400 kW. All components—particularly the vital components within the supply unit and the CST clutch—have proven their reliability in a range of applications. The world's highest capacity AFC (>6000 t/h) and the world's longest AFCs in operation (nearly 500 m/1,640 ft) have been equipped with the Cat CST drive system.

## Benefits

- Minimal slip during operation:**  
 Minimal energy and heat losses, maximum overall efficiency
- CST clutch mounted on low-speed output shaft:**  
 Ideal load discharge at the chain sprocket, very precise clutch control
- Integrated emergency operation feature:**  
 Fallback mode allows operation with semi-automatic mode and emergency mode
- Integrated CST drive system is considerably shorter than other drive systems:**  
 Less space required in narrow entries, very few external components
- High flexibility in operation:**  
 All parameters for startup, load-sharing and overload protection freely selectable

## Cat CST Gearbox Models

Cat CST gearboxes are suitable for use as conveyor gearboxes installed on drive frames and fitted to their input shafts. There are two designs available for most CST drive systems: an in-line gearbox design (the P gearboxes) and an angular gearbox design (the KP gearboxes). The CST45 M model is only available as a P gearbox. A CST gearbox comes in three parts: a supply unit, a first planetary gear stage and an output unit comprising a second planetary gear stage. The KP gearbox also comes in three parts. The supply unit and output unit are the same as the ones from the P gearbox, but the first planetary gear stage is replaced by a bevel helical gearbox unit. The KP gearbox design is available in a left-handed and in a right-handed version. It is also possible to mount the electro-hydraulic controller either inside or outside the supply unit.

The roller bearings of the bevel gear shaft are lubricated by forced lubrication via the built-in oil pump (usually responsible for cooling oil supply to the CST clutch). All other gearings and roller bearings are lubricated by means of splash lubrication.

### CST30

Reduction ratios of 24,4:1, 33:1, 39:1 and 50:1 are available; others are possible on request. Depending on the ratio, the permissible input power of the gearbox can be up to 500 kW/680 hp at a mains frequency of 50 Hz ( $\approx 1,485$  rpm) or 600 kW/816 hp at a mains frequency of 60 Hz ( $\approx 1,782$  rpm). The permissible output torque is 300,000 Nm (max for 3 sec.). The rated continuous output torque is 130,000 ( $i=50$ ).



### CST45

Reduction ratios of 24,4:1, 28:1, 33:1, 39:1, and 45:1 are available; others are possible on request. Depending on the ratio, the permissible input power of the gearbox can be up to 800 kW/1,088 hp at a mains frequency of 50 Hz ( $\approx 1485$  rpm) or 960 kW/1,305 hp at a mains frequency of 60 Hz ( $\approx 1,782$  rpm). The permissible output torque is 450,000 Nm (max for 3 sec.). The rated continuous output torque is 175,000 ( $i=39$ ).



### CST45 M

Can be used for driving armored face conveyors or for driving Cat automated plow systems. Reduction ratios of 16:1 and 33:1 are available, others are possible on request. The added M in the designation of the gearbox indicates that there is a pump unit with a separate pump motor in the supply unit, which works independently of the gearbox drive motor speed, and therefore ensures that the gearbox is continuously supplied with a constant flow of cooling and lubrication oil. In contrast to the standard CST45, the electro-hydraulic controller is installed on a drawer and not fixed inside or sideways outside of the supply unit. Like the CST45, this M version is able to sustain an input power of up to 800 kW/1088 hp at a mains



frequency of 50Hz ( $\approx 1485$  rpm) or 960 kW/1305 hp at a mains frequency of 60 Hz ( $\approx 1,782$  rpm). The permissible output torque is 450,000 Nm (max for 3 sec.). The rated continuous output torque is 170,000 Nm ( $i=33$ ). The CST45 M gearbox can be used in combination with a Cat variable frequency drive.

### **CST45 V**

The CST45 V gearbox is suitable for use as a conveyor gearbox to be installed on drive frames fitted to their input shafts. At present, only a reduction ratio 33:1 is available, but others are possible on request. In comparison with the standard CST45 design, the CST45 V gearboxes are able to endure higher input power. The permissible input power of the gearbox for the specific ratio of 33:1 is 1,050 kW/1,428 hp at a mains frequency of 50 Hz ( $\approx 1,485$  rpm) or 1,260 kW/1,713 hp at a mains frequency of 60 Hz ( $\approx 1,782$  rpm). The permissible output torque is 450,000 Nm (max for 3 sec.). The rated continuous output torque is 220,000 (standard CST45 175,000 Nm).



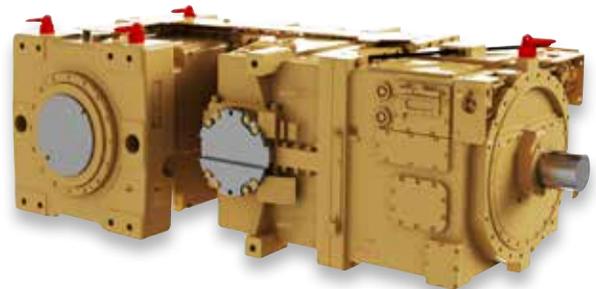
### **CST65**

Reduction ratios of 33:1, 39:1 and 50:1 are available; others are possible on request. In addition to the standard CST65 gearbox, we offer the CST65 S gearbox. The S version comes with a sideways mounted electro-hydraulic controller, an extra lube oil filter and two independent cooling circuits (including separate heat exchangers) instead of one. Depending on the particular ratio, the permissible input power of the gearbox can be up to 1200 kW/1632 hp at a mains frequency of 50 Hz ( $\approx 1485$  rpm) or 1440 kW/1958 hp at a mains frequency of 60 Hz ( $\approx 1782$  rpm). The permissible output torque is 650,000 Nm (max for 3 sec.). The rated continuous output torque is 255,000 ( $i=33$ ).



### **CST115**

At present, only a reduction ratio 39:1 is available; but others are possible on request. The permissible input power of the gearbox for the specific ratio of 39:1 is 1,800 kW/2,447 hp at a mains frequency of 50 Hz ( $\approx 1,485$  rpm) or 2,160 kW/2,937 hp at a mains frequency of 60 Hz ( $\approx 1,782$  rpm). The permissible output torque is 1,150,000 Nm (max for 3 sec.). The rated continuous output torque is 450,000 Nm.



## CST Drive Specifications

Technical Data	CST30	CST45	CST45 V	CST45 M	CST65	CST115
Application	AFC	AFC	AFC	AFC, Plow, VFD	AFC	AFC
Maximum output torque for a short duration (3 sec.)	300 000 Nm	450 000 Nm	450 000 Nm	450 000 Nm	650 000 Nm	1 150 000 Nm
Maximum input speed (motor speed)	1800 rpm	1800 rpm	1800 rpm	1800 rpm	1800 rpm	1800 rpm
Maximum installed power* at: i = 50:1 i = 45:1 i = 39.1 i = 33:1 - 16:1	400 kW (650 hp) 435 kW (700 hp) 500 kW (800 hp)	540 kW (880 hp) 700 kW (1,100 hp) 800 kW (1,300 hp)	1 050 kW (1,713 hp)	800 kW (1,300 hp)	800 kW (1,300 hp) 1 000 kW (1,600 hp) 1 200 kW (1,950 hp)	1 800 kW (2,937 hp)
Oil filling quantities: - in-line drive system - right/left-angle drive system	250 L (66 gal) 500 L (132 gal)	430 L (114 gal) 730 L (193 gal)	430 L (114 gal) 730 L (193 gal)	310 L (85 gal)	500 L (132 gal) 800 L (212 gal)	700 L (132 gal) 1300 L (212 gal)
Weight: (without oil) - in-line drive system - right/left-angle drive system	3 900 kg (8,600 lb) 5 800 kg (12,800 lb)	5 880 kg (13,000 lb) 9 700 kg (21,500 lb)	6400 kg (14,170 lb) 9700 kg (21,400 lb)	7200 kg (15,800 lb)	7 300 kg (16,100 lb) 10 880 kg (24,000 lb)	16 400 kg (36,145 lb) 23 980 kg (52,851 lb)
Dimensions In-line gearbox (P version) - height - length (without drive connection) - width	900 mm (35.5 in) 1 400 mm (55.2 in) 960 mm (37.8 in)	1 060 mm (41.7 in) 1 697 mm (66.8 in) 1 120 mm (44.1 in)	1 060 mm (41.7 in) 1 697 mm (66.8 in) 1 120 mm (44.1 in)	1 060 mm (41.7 in) 1 697 mm (66.8 in) 1 120 mm (44.1 in)	1 060 mm (41.7 in) 1 887 mm (74.3 in) 1 120 mm (44.1 in)	1 300 mm (51.1 in) 2 811 mm (110.6 in) 1 400 mm (55.1 in)
Dimensions Right-/left-angle gearbox (KP version) - height - length (without drive connection) - width	900 mm (35.5 in) 2 280 mm (89.8 in) 1 180 mm (46.5 in)	1 060 mm (41.7 in) 2 873 mm (113 in) 1 285 mm (50.6 in)	1 060 mm (41.7 in) 2 769 mm (109 in) 1 285 mm (52 in)		1 060 mm (41.7 in) 2 910 mm (114.6 in) 1 530 mm (60.2 in)	1 300 mm (51.1 in) 3 600 mm (141.6 in) 1 954 mm (77 in)

\*kW 1500 rpm @ 50 Hz (hp 1800 rpm @ 60 Hz)



Size comparison between CST30, CST45 and CST65





# Intelligent CST Drive System

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