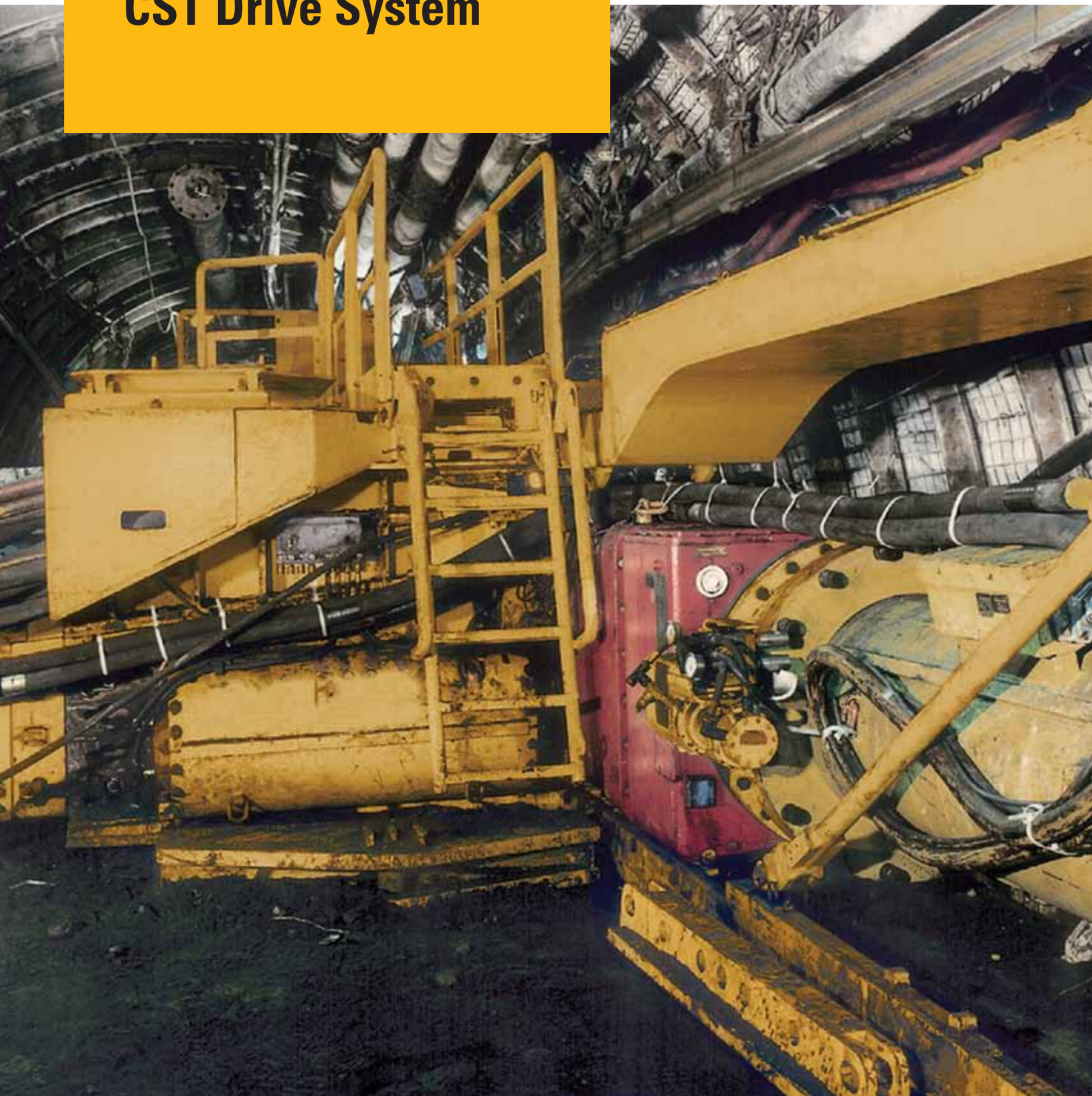


Intelligent CST Drive System





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 Controlled Start Transmission (CST) drive system meeting the following requirements:

- Currently available power up to 1 200 kW (1,950 hp) 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 CST65 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 CST65 is rated for 1 200 kW (1,950 hp) per gearbox, the CST45 offers up to 800 kW (1,250 hp) and the CST30 offers 500 kW (800 hp). 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 1995 and 2010 worldwide.

The CST drive system consists of two firmly-connected housings. The output stage of the gearbox encases the planetary and the integral CST clutch, the left or right angle drives, and the bevel helical gears. The clutch is a wet multi-disc type with special clutch plate material.

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 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.

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.



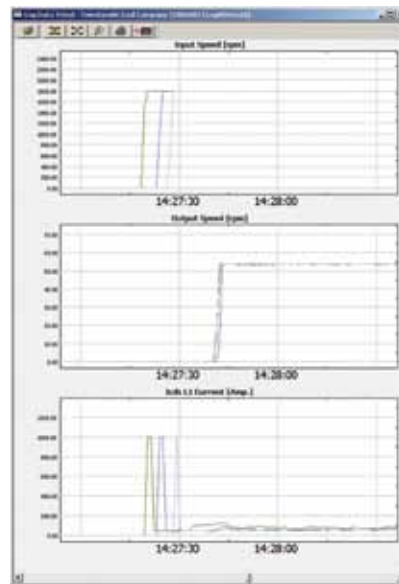
CST45 Drive System

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

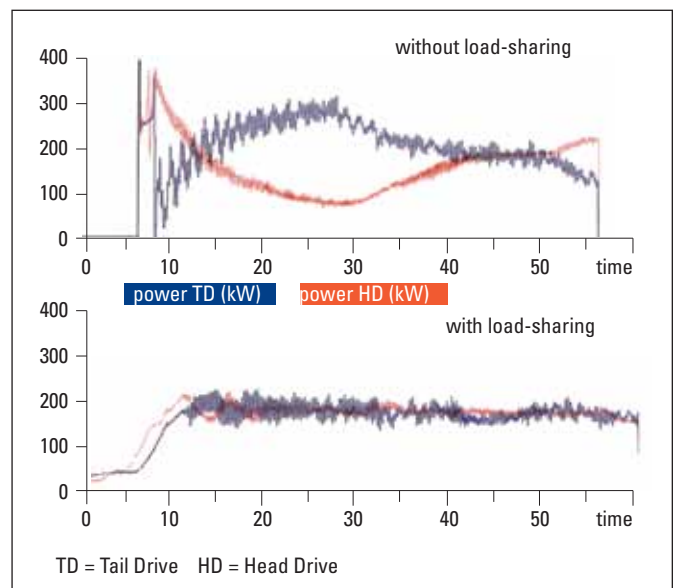


Load-sharing

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



Load-sharing capabilities of the CST drive system

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.

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.

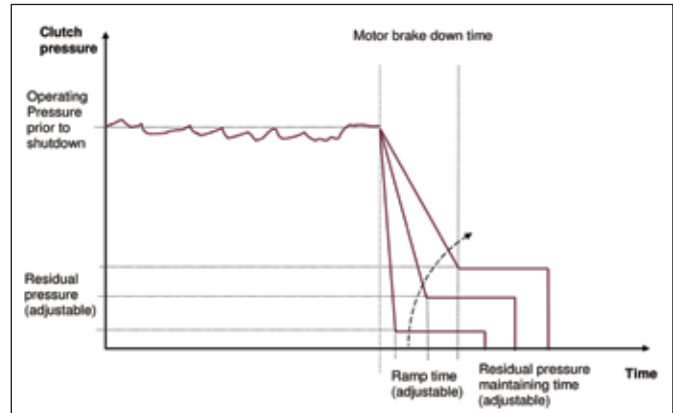
Motor Braking Feature

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.



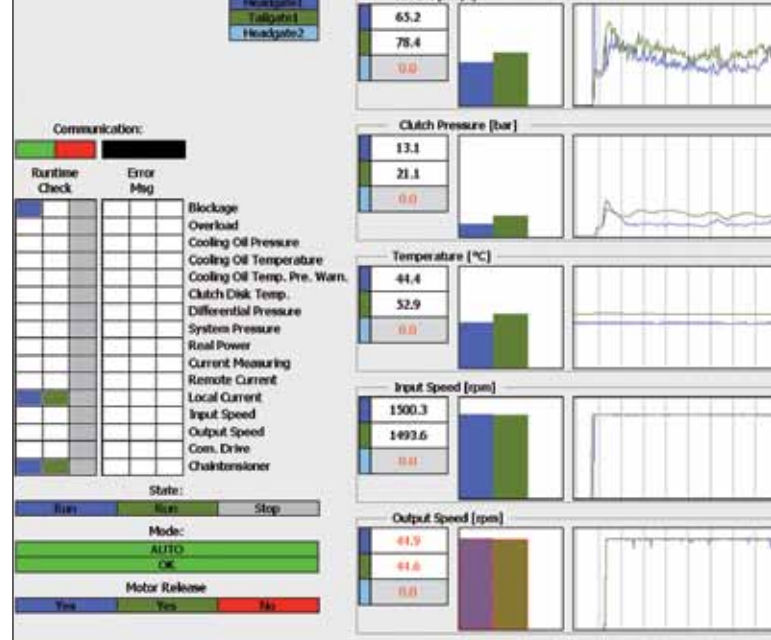
PMC™-D – used for measurement and control tasks



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

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.



Visualization of CST data by V-Drive

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 3 600 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



CST30 gear train



P-45 CST drive system

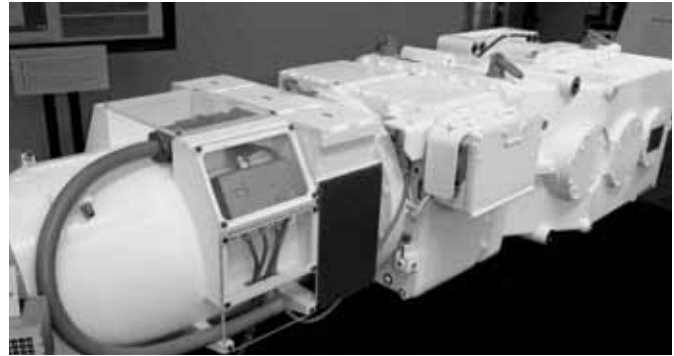
ICDS – Integrated CST Drive System

The ICDS is the result of continuing cooperation between Caterpillar and Baldor Electric Company. It combines the tried-and-tested CST drive system for face conveyors with a newly developed special Baldor Electric motor with our new PMC™-D drive control system.

The ICDS has a special asynchronous motor from Baldor Electric Company, with rated power of currently up to 1 200 kW (1,950 hp). The nominal motor running torque is 7 640 Nm (5,635 lb-ft) at full nominal speed. The maximum AFC starting torque (breakdown torque) is 3 x 19 100 Nm (14,090 lb-ft). Space is provided for integrated protected mounting of PMC™-D controls and other accessories. The power cable can be equipped with a Victor plug. The ICDS allows direct measurement of motor power at the PMC™-D controls.

ICDS Motor

- Full-load motor running torque
- Maximum AFC starting torque (breakdown torque)
- Power cable with Victor plug and socket (alternatively with a slip-fit packing gland)
- Integral mounting of PMC™-D controls and other accessories

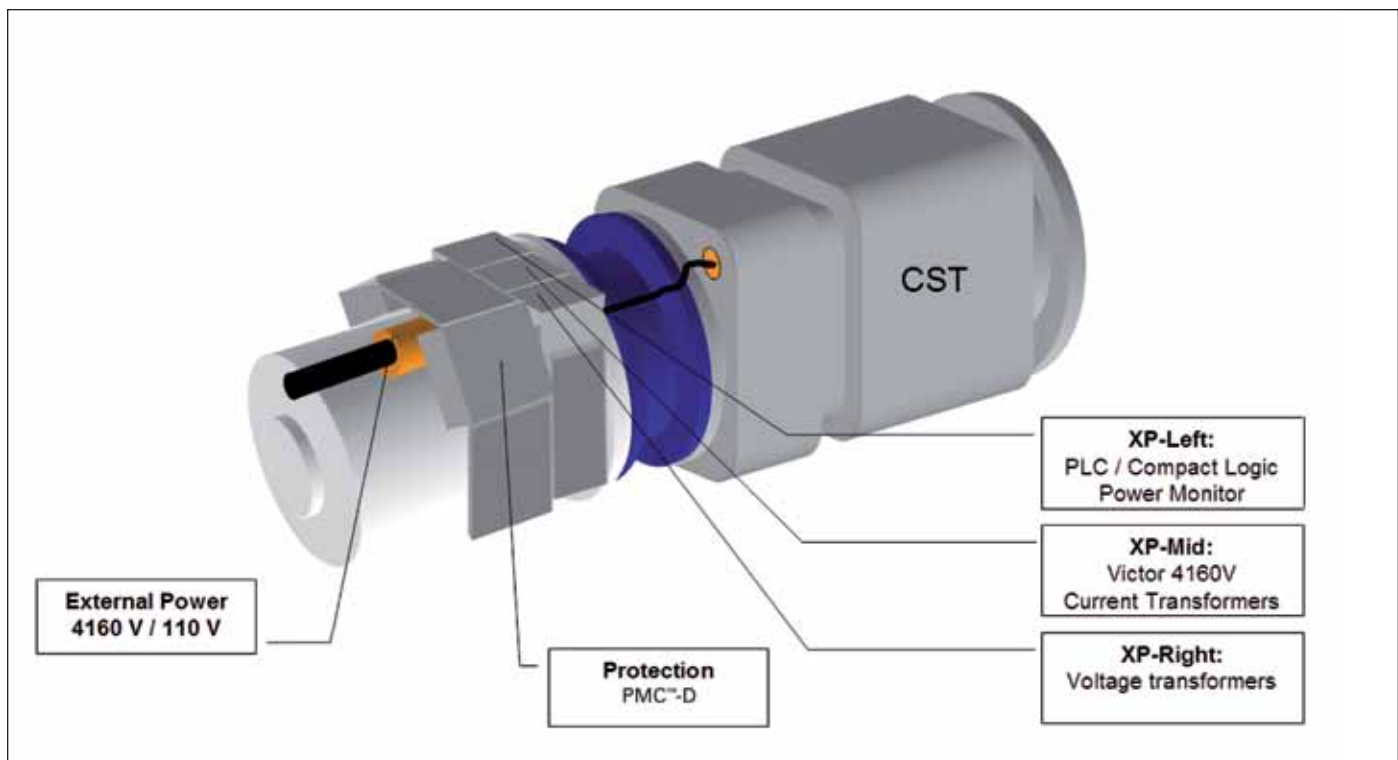


Prototype ICDS system

Features

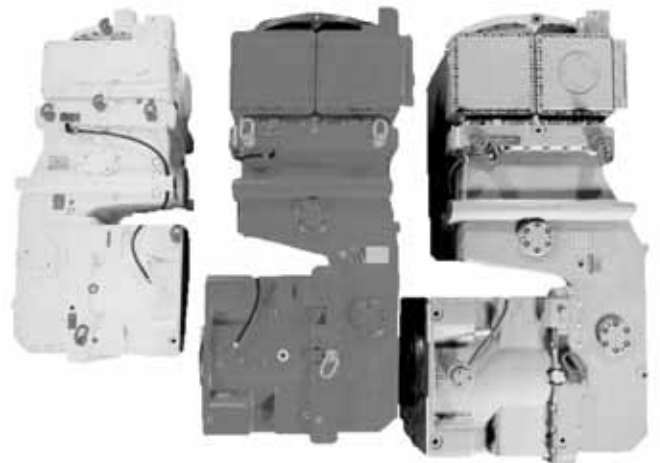
(compared to a CST gearbox with a regular motor)

- Real power measurement for accurate load-sharing
- Integrated control unit
- Capable of monitoring:
 - Winding temperature
 - Bearing temperature
 - Conduit box temperature
 - Water inlet/outlet temperature
 - Bearing vibration trending
- Compact design
- Less cabling due to integrated devices



Technical Data	CST30	CST45	CST65
Application	Chain type longwall machinery like face conveyors		
Maximum output torque for a short duration (3 sec.)	300 000 Nm	450 000 Nm	650 000 Nm
Maximum input speed (motor speed)	1500 rpm @50 Hz (1800 rpm @60 Hz)	1500 rpm @50 Hz (1800 rpm @60 Hz)	1500 rpm @50 Hz (1800 rpm @60 Hz)
Maximum installed power* at: - i = 50:1 - i = 39:1 - i = 33:1 - 16:1	400 kW (650 hp) 435 kW (700 hp) 500 kW (800 hp)	500 kW (800 hp) 700 kW (1,100 hp) 800 kW (1,300 hp)	800 kW (1,300 hp) 1 000 kW (1,600 hp) 1 200 kW (1,950 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)	500 L (132 gal) 800 L (212 gal)
Weight: (without oil) - in-line drive system - right/left-angle drive system	3 900 kg (8,600 lbs) 5 800 kg (12,800 lbs)	5 880 kg (13,000 lbs) 9 700 kg (21,500 lbs)	7 300 kg (16,100 lbs) 10 880 kg (24,000 lbs)
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) 1 887 mm (74.3 in) 1 120 mm (44.1 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) 2 770 mm (109.1 in) 1 285 mm (50.6 in)	1 060 mm (41.7 in) 2 910 mm (114.6 in) 1 530 mm (60.2 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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