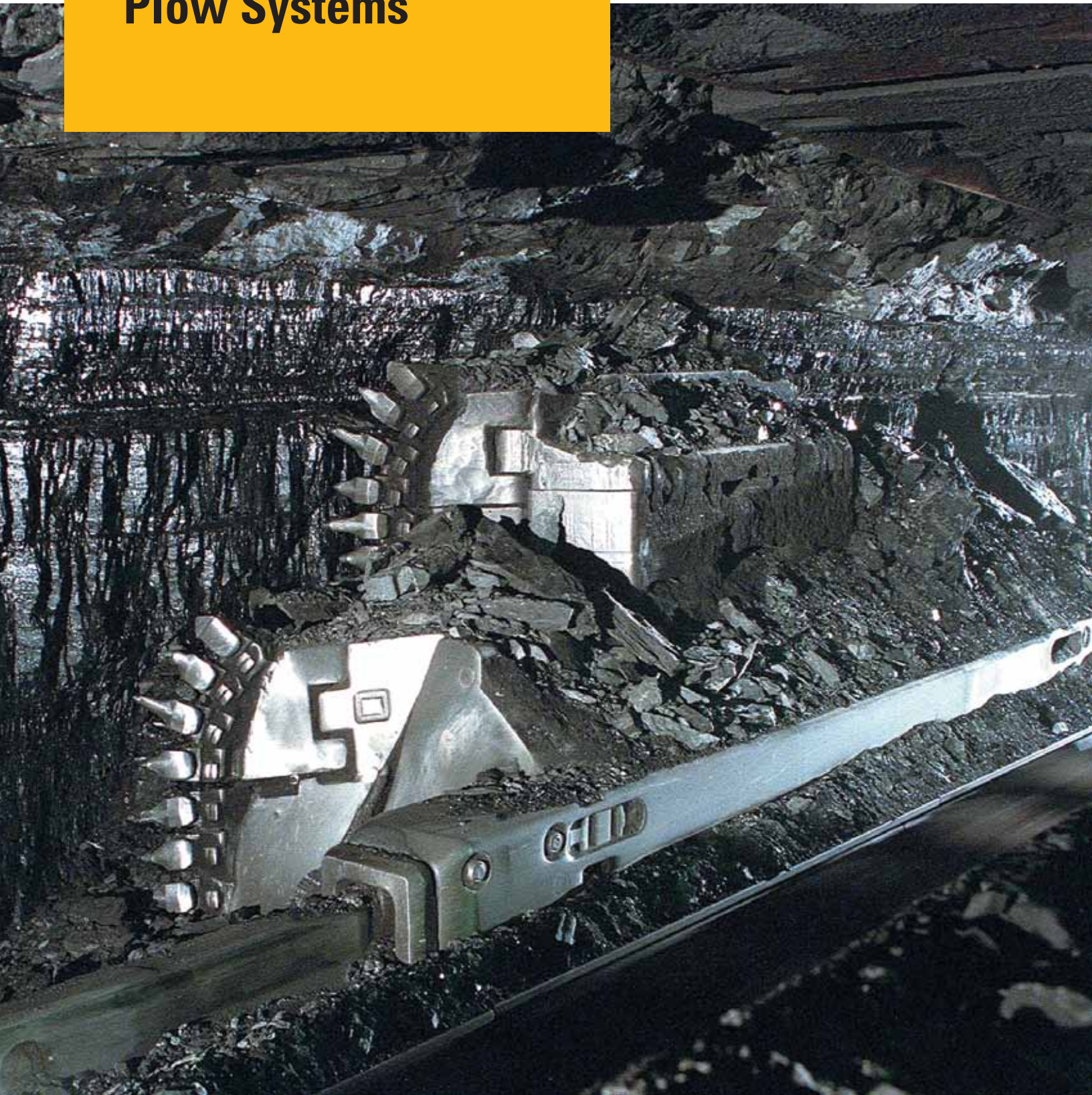


Automated Plow Systems





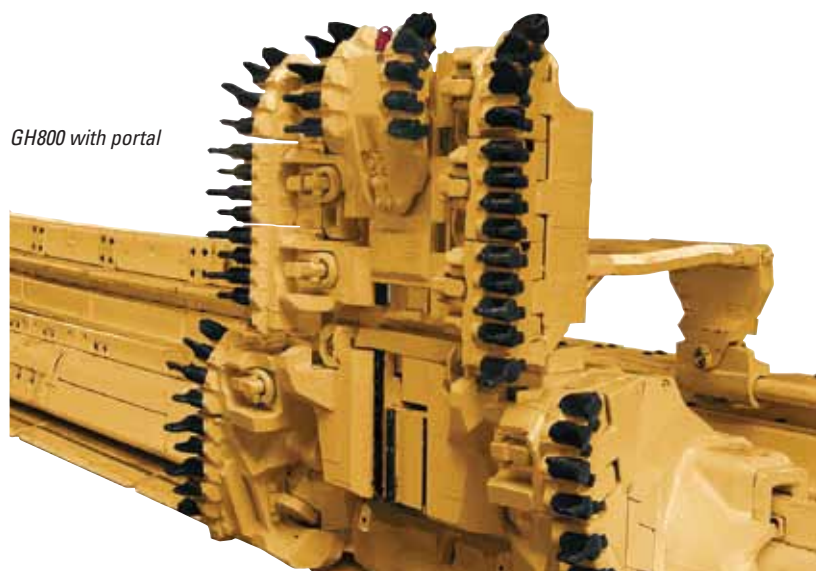
High-level Automation

We have been designing and building longwall plows since 1941 – and things have come a long way. Technical developments since 1990 have once again established plowing as the preferred longwall mining method for seams below 1.8 m (71 in) Cat® plows offer world-leading features that other manufacturers cannot and a cost of ownership that far outstrips the shearer when mining thin and medium seams. Their reliability, high-productivity and ability to mine in-seam make them the ideal choice for longwall mining medium and thin seams.

Cut any Coal

There was a time when the application of plows for longwall mining was limited by the type of coal to be cut. With Cat plows, this is no longer the case. Advancements in drive, control and transmission systems – with more powerful motors, stronger plow chain, increased plow speeds, higher advancing force provided by the roof supports, precise control of the cutting depth, and plow bit design improvements – all combine to allow Cat plows to be used for any coal hardness and with higher efficiency than other longwall extraction methods in low and medium heights. This is supported by greater installed power than any other manufacturer – up to 1 600 kW (2,160 hp) with the GH1600.

Incremental plowing means that Cat plows cut a precisely defined depth, regardless of coal hardness, seam structure and faults. On older-style systems, the cutting depth is typically controlled by adjusting the shield advancing ram pressure, with the result being that cutting depths vary with coal hardness.



GH800 with portal

Horizon control is provided by the hydraulic steering cylinders and allows exact control of the plowing angle, ensuring that the plow does not dive or climb unless required by the seam geology. This control capability also allows mining of seams with an inclination of up to 60°.

We offer plows systems as complete and fully-automated or semi-automated versions. Cat plows undergo constant development to meet special requirements for our customers.

How it Works

The plowing principle is simple: A sculpted steel plow body equipped with strategically-placed cutting bits is pulled along the face conveyor from one end of the face to the other by a continuous loop chain powered by drives located at the face ends. Cutting depth is electronically controlled by pushing the AFC toward the coal face in preselected increments after the plow has passed. The height of the plow body is easily and completely adjustable within a certain range, ensuring that only coal is cut. The plow body height can also be adjusted in larger increments by installing or removing additional bit blocks. Both adjustments can be performed quickly and easily from the gobside.

The plow body consists of mechanical components with all wear parts being replaced underground. Shields can be positioned to best suit the longwall's geology and normally advance automatically in concert with the cutting action of the plow. No operator is required within the longwall face itself. Operation can be controlled from a central control station either underground – for example, at the headgate entry – or on the surface. As a result, the operators are not subjected to difficult working conditions, they can be located a safe distance away in a dirt- and dust-free area. The outrigger steering system provides vertical horizon control. Steering is normally operated manually, but can be automated.

Systems of Choice

The production rate achieved by plows compared to shearers has continued to increase over the years, making the plow a reliable, high-productivity longwall mining system for thin and medium seams.

For seams with an average height under 1.8 m (71 in), plows are now the system of choice for longwall mining. The GH1600 plow, due to its higher installed power, can cut up to 2.3 m (91 in) when fitted with a portal stabilizing arm.



Plow horizon control



GH1600 gliding plow in hard coal

In seams from 1.8 to 2.3 m (71 to 91 in), the choice between a plow or shearer depends largely on the geological conditions. But for any given height within this range, the plow outperforms the shearer in terms of productivity.

Average seam height	< 1.8 m (< 71 in)	1.8 – 2.3 m (71 – 91 in)	> 2.3 m (> 91 in)
Preferred mining method	Plow	Plow or shearer depending on geological conditions	Shearer

Features of Cat® Plows

Horizon Control

Effective plow horizon control is necessary to cope with undulations in the coal seam. Providing the plow with the ability to follow the seam minimizes cutting of adjacent rock strata and the associated preparation costs, reduces cutting tool (bit) consumption and reduces power consumption while maximizing seam recovery. Caterpillar has developed an outrigger steering system for vertical horizon control that employs the use of hydraulic cylinders located between the gobside of the AFC and the relay bar of the shield. Extension of the cylinder promotes a downward (digging) cutting direction of the plow. Retracting the cylinder promotes an upward (climbing) direction of the plow. The steering cylinders can be controlled either manually or automatically via the Cat PMC™-R electro-hydraulic control system. A block anchorage system consisting of cylinders installed between face conveyor and shields (at the face ends) controls conveyor creep and helps maintain the proper tension in the plow chain.

Benefits

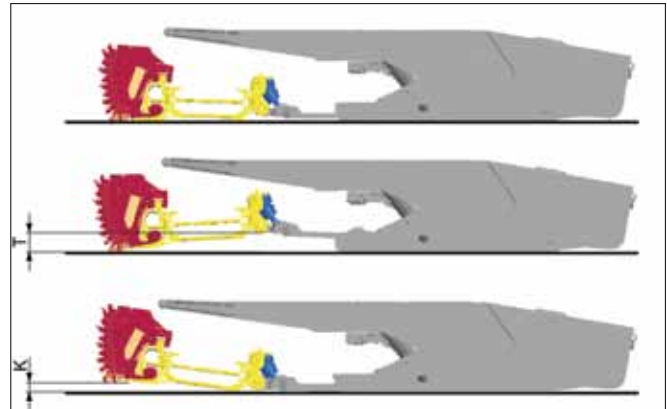
- The plow is advanced in relatively small increments (cuts) compared to a shearer. This allows the horizon control system to vertically steer the plow, keeping it in the seam even when severe seam undulations are encountered. A shearer, due to its larger cutting depths and fixed position relative to the AFC, can only make gradual changes in vertical alignment. Therefore, in severely undulating conditions, the product mined with a shearer contains a higher amount of "out-of seam" dilution.
- Easy height adjustment allows plows to work smoothly through faults or undulations, minimizing the cutting of adjacent, unwanted strata.
- Coal production is maximized while preparation costs are minimized.

Load-sharing

Variable Frequency Drive (VFD) motors allow speed to be varied between 0 and 120% of nominal while maintaining constant torque throughout a wide range of speeds. Power consumption on the motors is constantly monitored to allow load-sharing between the individual drives.

Benefits

- Full utilization of available power
- Prevention of motor overheating and resultant downtime
- Reduced motor current with optimum torque during startup
- Excellent power factor (~1)

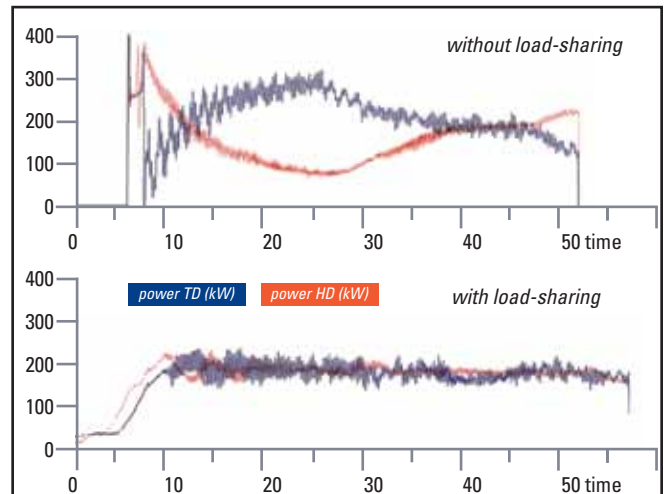


Plow horizon control with outrigger steering system



Horizon control for easy height adjustments

Load-sharing capabilities of the drive system



TD = tail drive HD = head drive

Overload Protection

Effective overload protection is essential for fast, high-power plowing. The Cat planetary UEL overload protection system has an integrated multi-disc clutch with the pressure set to allow the clutch to slip well below the torque required to reach the breaking strength of the chain. If “clutch slip” is sensed, the gearbox torque is immediately decreased, combined with a simultaneous shutdown of the plow motors to prevent damage to the chain.

Benefits

- Eliminates shock loads from all drive components
- Minimizes chain failures and maximizes component life
- Allows for a quick system restart

Shock Absorber

Caterpillar has developed an innovative shock absorber to provide added protection for the plow and chain. The elastic coupling inserted into the plow pulling sledge contains elastomers with properties that reduce the peak forces applied to the chain. This results in smoother plow operation, minimizing loads on the plow chain, the plow connectors and the drives, thereby extending their effective service life. The shock absorber is only available for the gliding (GH plow).

Benefits

- Reduces wear and tear on plow, drives and chain
- Smooth plow operation extends overall service life

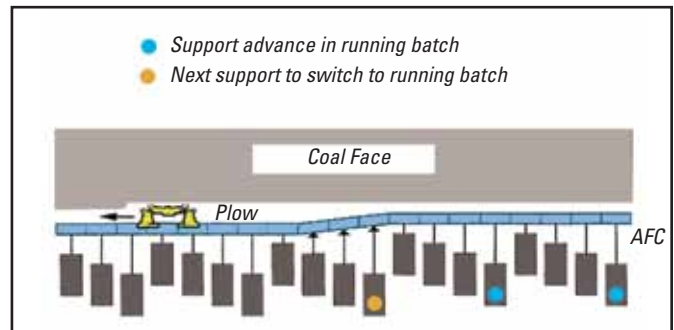
Incremental Plowing

The key requirements for high-performance plowing are remote control, adjustable cutting depth and the ability to maintain a straight face line. These requirements are all achieved by the Cat incremental cutting system and the fully-automated plow longwall system. With conventional plows, variations in coal hardness lead to variations in cutting depth that often result in overloading of the conveyor and downstream equipment or jamming of the plow. Incremental plowing prevents these problems by keeping the depth of cut constant regardless of coal hardness or presence of rock bands. The plow makes a double cut – or a cut with double web – at each drive end, keeping the face straight at all times.

Under favorable roof conditions – where the shield tip-to-face distance is not an issue – the shields are positioned in a saw tooth form: Only every 4th or 5th shield performs the “lower – advance – set” sequence during each plow pass. This minimizes the hydraulic pump capacity required



Shock Absorber for reduced wear



Principle of the incremental plowing method

for the shields and assures that plowing does not need to be halted for the purpose of advancing shields. If the roof is friable, shields can be programmed to advance more frequently, minimizing the average shield tip-to-face distance and maximizing the effective support. Also, in order to guarantee effective support of the roof, the PMC™-R electrohydraulic control system monitors pressure in the shield legs and prevents two adjacent shields from being lowered simultaneously.

Benefits

- Remote operation allows highest safety and maximum productivity in low coal.
- The AFC/plow system and shield supports can be positioned exactly where they are needed (snakes, roof condition, faults etc.).
- System is self-correcting for over- or underpush, thereby maintaining a straight face regardless of conditions.
- Optimum use of installed power for maximum cutting depth for every area of the face.
- Automated Cat plow systems allow access to extended reserves in low coal seams to achieve a higher percentage of reserve recovery.
- Significantly more coal can be mined with more efficient layouts that reduce overall costs.



Base-plate Plow System RHH800

For Extremely Thin Seams

The base-plate plow is used for extremely low seams down to 0.6 m (24 in) with a practical minimum height of approximately 0.8 m (31.5 in). The typical maximum seam height is approximately 1.6 m (63 in). This system positions the plow chain on the gobside of the AFC, which makes it easily accessible for maintenance, a critical feature in low seam heights where working space is limited. The base-plate slides over the floor and underneath the line pans during operation. The integrated cleaning edge pushes coal from underneath the AFC back into the plow travelway.

The cast plow guide is welded to the gobside of the face conveyor. Plow chains of up to 42 mm in diameter can be used, allowing the use of up to 2 x 400 kW (2 x 540 hp) installed power. Both gobside and face side pan connectors have a breaking strength of up to 2 000 kN (220 tons), depending on the line pan being used.



Gliding Plow System GH800

For Thin to Medium Seams

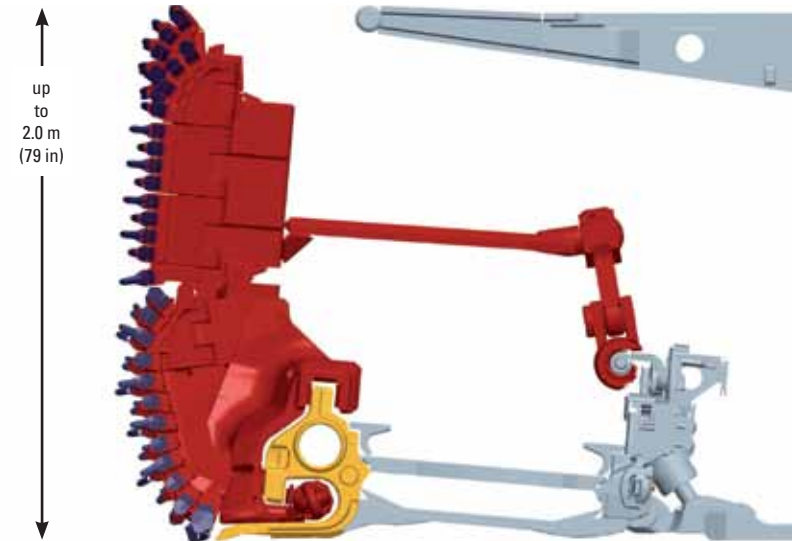
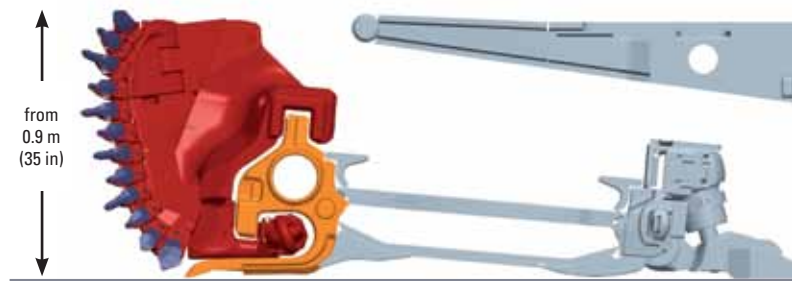
The gliding plow system GH800 is the standard plow of choice today and can be used in seams from approximately 0.9 m (35 in) up to 2.0 m (79 in), regardless of the inclination of the seam or the hardness of the coal. The gliding plow guide is welded to the face side of the AFC conveyor. Plow chains up to 38 mm can be used, allowing installations up to 2 x 400 kW (2 x 540 hp). The plow guide has a maximum height to withstand the reactionary forces produced during the cutting process, yet it does not hinder coal flow during the loading process.

The upper plow guide can be opened for quick and easy access to both the top and bottom chains for maintenance. Proven design and geometry, in conjunction with high-strength steel and optimized material properties, combine to ensure minimum wear for maximum life. Both gobside and face side pan connectors have a breaking strength of up to 3 000 kN (330 tons), depending on the line pan being used. Maximum cutting depth at high plow speeds provides high productivity. Every point of contact between plow body and plow guide is designed as a wear part, again to facilitate maintenance.

Modular Design

All parts of the plow body, especially the wear parts, can be replaced underground – a major benefit. Due to its modular design, the height of the plow body can be adjusted by simply inserting or removing bit blocks with a height of 265 mm (10 in) each. The plow body can also be adapted to smaller variations in seam height by using a bit turret that is built into the plow body. The turret carries the top bits of the plow body and can be precisely raised or lowered up to 300 mm (12 in) by means of a worm gear that is accessible from the gobside.

Typically, the single gliding plow body is used, which is attached to the bottom chain. For special applications, there is also the double-plow or triple-plow body, which separates loading and cutting coal streams for very soft coal in thin seams.



Gliding Plow System GH1600

For Extremely Hard Coal

The gliding plow system GH1600 was specifically developed for very hard coal and high productivity by doubling the installed horsepower of the GH800. It can be used in seams from approximately 1.0 m (39 in) up to 2.3 m (91 in) with a portal arm. Like the GH800, the cast gliding plow guide GH1600 is welded to the face side of the conveyor; a 42 mm plow chain is used. This allows installations of up to 2 x 800 kW (2 x 1080 hp).

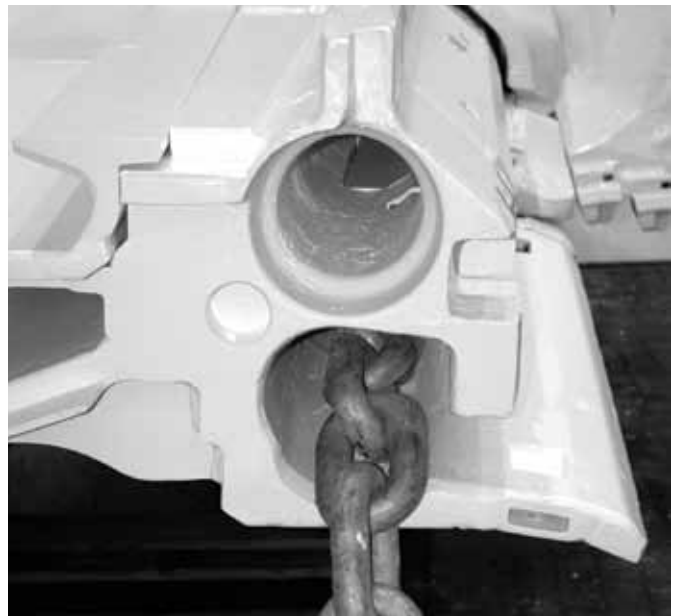
The plow guide is only slightly higher than the GH800 but it is cast to withstand the significantly higher reactionary forces. The plow guide is designed to provide minimum friction between plow guide and plow chain. Doors inside the plow guide (at every second pan) can be opened for quick and easy access to both the top and bottom chains. Both gobside and face side pan connectors have a breaking strength of 3 600 kN (400 tons) with the PF4 plow line pan specially modified for use with this plow system.

Double Power

The plow body design is similar to the GH800, but the main elements – including the plow bits – were upgraded to handle twice the installed power. This next-generation plow system has been working successfully in several longwalls since 2003. In Germany, this system achieved a productivity of more than twice the amount of coal ever mined from a 400 m (1,300 ft) face on a 1.5 m (59 in) seam of extremely hard coal. In Poland, this system has broken the European production record for thin seams.



GH 1600 gliding plow at a German Mine in an inclined seam



Plow guide



Benefits of Cat Plow Systems

- High area rates of advance allow highest productivity even in very low seams and extremely hard coal.
- The use of plow systems in medium or thin seams allows a longwall system to operate at the lowest overall cost.
- Maximum efficiency by utilizing the available power for cutting coal, not rock, during the mining process
- Maximum cutting depth at high plow speed means high productivity.
- No unnecessary rock is being mined, which decreases preparation costs.
- Any maintenance required during the mining process can be performed quickly and easily, as the plow is accessible anywhere along the face.
- Plow consists of mechanical parts only, eliminating the potential of a mid-face breakdown that could result in extended downtimes during the production shift.
- Minimum maintenance costs
- Adjustment of plow cutting height via bit blocks and turret adjustment allows very quick setting from gobside.
- Easy and quick adjustment for changes in coal seam height or for areas with faults and rock intrusions
- Highest level of operator safety due to remote operation



GH1600 plow body

Cat Plows at a Glance

Plow Systems	Base-plate Plow RHH800	Gliding Plow GH800	Gliding Plow GH1600
Plow body height	0.6 m – 1.6 m (24 – 63 in)	0.9 m – 2.0 m (35.5 – 79 in)	1.0 m – 2.3 m (39.4 – 90.5 in)
Typical cutting height	0.8 m – 1.6 m (31.5 – 63 in)	1.0 m – 2.0 m (39 – 79 in)	1.1 m – 2.3 m (43 – 90.5 in)
Coal hardness	Soft – hard coal	Soft – hard coal	Medium – extremely hard coal
Max. seam inclination	up to 60°	up to 60°	up to 60°
Max. installed power	2 x 400 kW (2 x 540 hp)	2 x 400 kW (2 x 540 hp)	2 x 800 kW (2 x 1,080 hp)
Max. plow speed	2.5 m/s (500 fpm)	3.0 m/s (600 fpm)	3.6 m/s (720 fpm)
Max. cutting depth	150 mm (6.0 in)	180 mm (7.0 in)	250 mm (10 in)



Plow Line Pans

State-of-the-art conveyor technology for underground mining

The innovative PF plow line pans from Caterpillar define the new state of the art for underground face conveyor technology. They are based on the tried-and-tested PF3 and PF4 generations that meet all requirements regarding quality, wear resistance and conveying capacity. PF line pans form the powerful backbone of the entire conveyor system. The pioneering conveyor technology and extremely rugged pan design have been subjected to extensive testing.

Separation of Wear Parts and Structural Parts

The smart and totally new concept of segregating the different functional areas separates the wear elements from the structural elements. Extremely hard and wear-resistant materials are used for parts subject to wear, while the structural parts are made of tough, high-strength steels. The pan design allows problem-free replacement of worn-out top troughs, which delivers a lower cost of ownership during its lifetime.

Benefits

- Substantially longer service life
- Considerably lower overall pan wear

Optimized Contact Surfaces

The use of the proven PF profile in the top race means maximum contact surface between the flightbar and the profile. This minimizes the surface pressure of the flightbars in snakes and undulating seams. Special shaping of the bottom race – which almost doubles the contact surface – reduces the wear of the flightbar shoulder while substantially reducing friction. Also, the curve-shaped transition at the pan ends greatly reduces the noise level during operation of the chain conveyor.

Benefits

- Minimal friction
- Low wear of flightbar shoulder in the bottom race
- Minimized power losses
- Longer service life of flightbars and profiles
- Lower noise level during operation

Available types of line pans:

PF3/822 and PF4/932:

- For smaller systems and shorter face length with less required carrying capacity

PF4/1032:

- For medium to high sized plow systems

PF4/1132:

- For high carrying capacities



Doors inside the plow guide for quick and easy access to the plow chain

Plow Roof Supports

Roof supports for plow systems working in thin seams have some special requirements and restrictions:

- Direct-acting DA ram allows the use of shorter roof supports to cope with undulating seams.
- Only high-strength steel is used for structural components to ensure minimum thickness and maximum travelway height.
- A split base allows the vertical movement of the relay bar necessary for effective horizon control and access to the DA ram for maintenance.
- Elephant step is available to prevent dirt accumulation and overcome soft floor conditions.

Electronic Roof Support Control System

The modern, reliable and easy-to-operate electrohydraulic PMC™-R shield control systems are designed, manufactured and programmed by Caterpillar. Their primary function is automation of the cutting process using incremental plowing. Two configurations are possible: A control in each shield (typically used) or one control shared by three shields in cases where fewer shield functions are required.

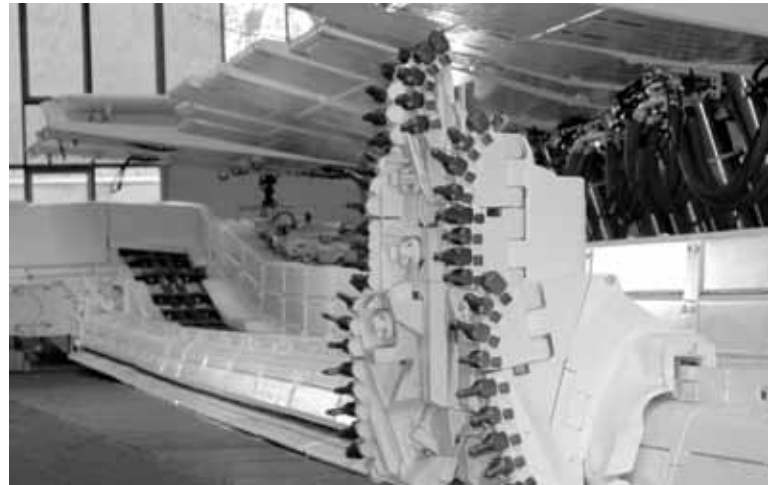
The VCU (Visualization & Control Unit) not only controls the entire longwall, but also visualizes face operations on a graphic display, including position, actual coal load on the AFC (through AFC power consumption), shield position, leg pressure, stroke and plow position. The VCU provides a face-wide network and allows remote maintenance of shield components as well as data recording and transfer of data to the surface.

Caterpillar® Global Customer Service

At Caterpillar, our relationship does not end with the sale of new equipment – it is just the beginning of a long-term partnership. We offer full life-cycle customer service with every purchase. When you invest in Cat equipment, you invest in productivity.

Our global service and support packages include field service, repairs, overhauls and superior-quality OEM parts, ensuring the best long-term return on investment. Our goal is to constantly maximize customer productivity. We achieve this by remaining on the cutting edge of mining technology, providing customers with the best equipment with the lowest life-cycle costs.

Cat Global Customer Service ensures that your mining equipment remains a highly productive asset.



The elephant step (lifting one toe during advance)



Automated Plow Systems

For more complete information on Cat products, dealer services, and industry solutions, visit us on the web at mining.cat.com and www.cat.com

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