SMART**RIG**™ Handbook

Think Smart - Drill Smart

Atlas Copco

Drill Smarter

Atlas Copco's SmartRig will help you to drill smarter holes with high shift capacity, low energy consumption, and innovative modules that improve productivity. SmartRig gives you outstanding safety and ergonomics, environmental friendliness and excellent documentation of the working progress.

This handbook introduces the benefits of using the SmartRig. If you find some unfamiliar abbreviations, please see the explanations on pages 38-39.

Contents

What is SmartRig?

A SmartRig is a computer controlled drill rig. It has a PC-based control system with semi-automation possibilities. This type of control system is intended for a wide variety of automation purposes.

Hydraulic valves are electrically control-

One control system for all product families

led, but the electrical signal comes from the PC's input/output-modules via the software in the PC and not directly from the operator's panel. The PC functions include the possibility to introduce advanced automation, proportional valve control, timers and parameterized rock drill control. The SmartRig control system may be upgraded in the field and has built-in logging and monitoring functions. SmartRig also has a built-in support system for diagnostics and trouble-

shooting. The SmartRig control system is used in every product family, both in underground equipment and for surface crawlers. This means that it is quite easy to move functions and improvements between the different products.

The hardware is designed to operate safely and reliably in all possible weather conditions. The design is made by Atlas Copco.

Advantages of SmartRig
- Semi-automation possibilities
- Functionality upgrade in the field
- Easy to maintain and adjust
- Simple hydraulic and electric system
- Low maintenance cost
- Easy to learn and operate, which means low training costs
- Safe, for example, built in functions for drill rod breakage detection
- Smoother drilling, which means savings on drilling consumables
- Documentation and logging functions that can be used in other systems for analyses and future planning

System Architecture

The figure on the left shows that the rig control system is almost independent of product family. This means that the "black boxes" are freely interchangable. For instance, if an input/output module on a Simba drill rig fails, you can exchange it with a similar one from a Boomer. The software is internally named "3-track-software." This software is very reliable, and functions and features from one product can easily be adapted to another product. The difference is in the application software, which is unique for each product family. The system architecture is now well tested and very stable. The "3-track-software" is a good platform for developing further benefits for the user.

Hardware

The input/output module consists of 14 input ports and 14 output ports, which can be configured using the software. A typical use of an input/output module is in controlling the valves on the feeder for maneuvering the rock drill. There are a maximum of five input/output modules on a SmartRig. They are connected to the main computer via a CAN-bus network.

The application module, APP, is the main application module. All process-specific software runs from the APP module. Typical tasks for the APP module are those controlling the drilling process. There is a variant of the APP called CCI. This module is identical to the APP module, but contains some extra ports that can be used for external communication, such as Ethernet and/or wireless LAN.

The display module, DISP, is the main computer in the system. All user interfaces run from this computer.

An application module

A display module

SmartRig Benefits

The unique SmartRig features comprise a set of tools enabling you to optimize operations, maintain your competitive edge, and maximize your profitability. SmartRig provides high productivity, excellent documentation of the working progress and outstanding safety and ergonomics.

Productivity
SmartRig comprises several subsystems, which improve productivity. One example is the AutoRAS functionality, which enables the operator to conduct parallel activities during drilling, such as re-grinding drill bits and probing holes for hole deviation. The AutoPOS functionality is a part of the MEDIUM automation package. Fewer stops due to drill rod breakage and shank adapter changes contribute to higher productivity. More than 30% higher service life of consumables has been recorded.

Documentation
The biggest difference between an ordinary hydraulically-controlled rig and a SmartRig is the documentation capability. The SmartRig is capable of producing several types of data logs, including:
* Quality log
* Performance log
* MWD log

Excluded from the SmartRig concept is the Probe log. The Quality log consists of data from the drilled holes. Facts such as collaring coordinates (only with HNS), hole length and angles are stored in a quality log. When the Hole Navigation System, HNS, is used, the coordinates are contained in the local site coordinate system. This can vary from place to place, but it means that we can always interact with super systems used on the specific site such as mine map systems. The quality of positioning bore holes has been dramatically improved using HNS, and the connection with the semi-automatic feed alignment system has improved the quality of the drilled holes. These data can be analyzed in ROC Manager 2.0, or in a separate tool that can handle IREDES data.

The Performance log consists of data such as average the penetration rate, total number of holes drilled, average hole length, tramming hours, and percussion hours. These data can also be displayed and analyzed inside ROC Manager for statistical purposes. The SmartRig's documentation capability is unique.

MWD-logs form part of the AD-

VANCED package, and can be ordered either from the factory or as an aftermarket product. **The MWD functionality should be used together with HNS to take full advantage of the SmartRig's capabilities.** MWD logs can be used for monitoring the rock quality before blasting. For instance, the boundaries between ore and waste could be identified to minimize unnecessary dilution.

Environment
Today, environmental matters are very important, especially in the Nordic

Region. Demands to curb pollution are continuously increasing, and a SmartRig is far better than an ordinary hydraulic rig when it comes to fluid leakage. Because of the lower number of hoses, joints and couplings, the risk of leakage has decreased by almost 30%. As far as noise and sound dampening are concerned, the SmartRig D-series can have a silencing kit mounted. This means that a SmartRig can drill almost one kilometer nearer to settlements and buildings! Learn more about the Silenced SmartRig on pages 35-36.

Automation with Atlas Copco
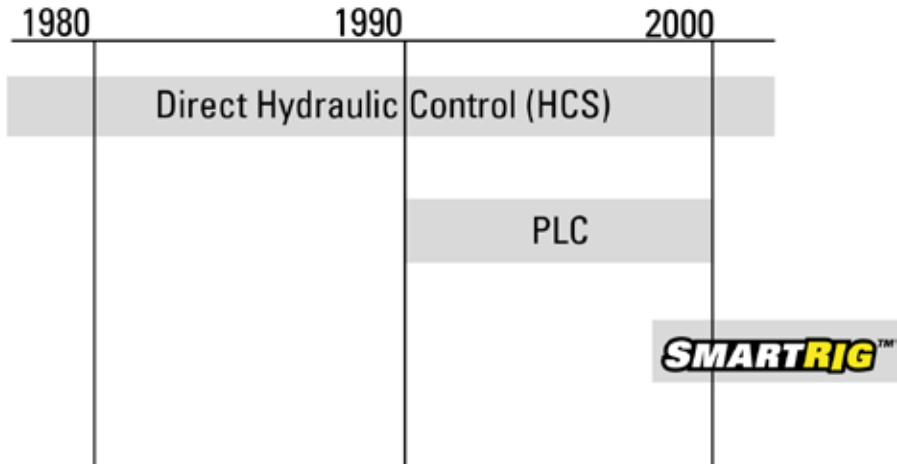
The history of Atlas Copco's automation possibilities

The first hydraulic rock drill built by Atlas Copco was the 818H, built in 1976 which was driven by the most common control system used by surface crawlers today. There were no automation features available, and all operator controls were manual.

One example of an Atlas Copco PLC-equipped drill rig is the ROC F9, which was introduced in 1998. PLC stands for "Programmable Logical Control", and is a "box" made for process control purposes. It can be programmed to perform certain tasks such as rod handling and cooling fan controls. The PLC-system is used on surface crawlers like the ROC F9.

The first computerized drill rig was introduced in 1998. It was a Rocket Boomer. The word SmartRig is unique for surface crawlers and was established in 2005. In 1998, the rigs were called "RCS rigs", where RCS is an abbreviation for Rig Control System. The first SmartRig delivered from Surface Drilling Equipment, SDE, was a ROC D7C in 2002. Today SDE has three surface crawler models of SmartRigs: ROC D7C, D9C and F9C. The newest one is the ROC D9C, which actually is a ROC D7C with a more powerful drill and a bigger compressor. Today over 100 SmartRig units have been delivered to customers in 16 countries throughout the globe.

Data Exchange - IREDES

To enable standardization of the exchange of data, the common format IREDES is used.

IREDES stands for "International Rock Excavation Data Exchange Standard". It covers all data flow required for the manual and automated operation of rock excavation equipment such as drill rigs, load-haul-and dump vehicles and explosive-handling trucks/carriers.

The intention of the IREDES project has been to create a standard data interface for rock excavation and mining equipment, facilitating efficient communication between machines and computers. This means that separate software and interface development enabling the computer to talk with the machine will no longer be necessary. Instead, equipment and computers will comunicate using the IREDES global standard language.

The IREDES standard was established

by organizations from all over the world to meet the local requirements of any machine user. This is a precondition to make equipment globally usable and to make use of unified information from local mining sites within mining companies with global operations.

IREDES is a global non-profit initiative founded by major players in the mining and construction industry for development and maintenance of a practice-related standard. It is jointly financed by the members.

The standard documents are open to the public and are accessible free of charge for any IREDES member. Non-members can purchase the documents from the IREDES office for a small contribution to the standardization work.

Read more about IREDES at
http://www.iredes.org

In the future IREDES might be with all types of drilling equipment.
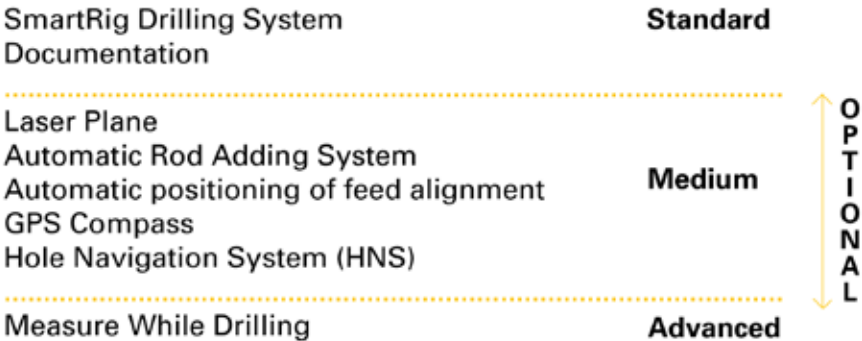
SmartRig Automation Levels

Even a **standard** SmartRig alone offers advantages over a hydraulically controlled rig. Benefits such as improved documentation and higher productivity can still be achieved, due to the advanced drilling system and the built-in documentation features.

Medium-level means that the customer has selected one or more options. They can be combined freely, but if HNS is selected, the laser plane functionality will not be necessary, since this comes standard with HNS. The combination of semi-automatic positioning, AutoPOS of feeder alignment and HNS yields very high accuracy in drilling parallel holes, very exact collaring and therefore improved fragmentation of blasted rock. **Itshould also be noted that if the silencing kit is mounted, the laser plane will not work.**

The highest level of automation, the **advanced** level, consists of only one additional feature: Measure While Drilling. (MWD). You don't need all of the medium features, but without them MWD will create less value for the customer. MWD can be used to determine the rock quality before blasting.

Automation levels for surface crawlers

SmartRig Drilling System Documentation	**Standard**	
Laser Plane Automatic Rod Adding System Automatic positioning of feed alignment GPS Compass Hole Navigation System (HNS)	**Medium**	OPTIONAL
Measure While Drilling	**Advanced**	

Standard Features

SmartRig Drilling System
The drilling is supervised by an advanced drilling control system. The fundamental components of the advanced rock drill control system are:
• RPCF
• DPCI
• The anti-jamming function

RPCF (Rotation pressure controlled feed force) is a function to adjust the feed pressure according to the measured rotation pressure. This function keeps the joints correctly tightened at all times, thereby increasing the lifetime of drill rods.

DPCI stands for Damper Pressure Controlled Impact. DPCI protects the rock drill by monitoring the damper pressure. The damper pressure indicates the quality of the contact between the rock drill and the hole bottom. This function will ensure that percussion will be activated only when the damper pressure is between the high and low limits. It will also ensure that the switching from low impact to high will be done only when the damper pressure is above the lower limit.

The anti-jamming function uses the rotation pressure or the air-flushing pressure to detect a jamming situation. When jamming occurs, the control system reverses the feed of the rock drill and initiates new collaring of the hole.

Benefits of the SmartRig Drilling System
• Yields maximum life for the shank adapter, tubes and drill bits
• Makes rod extraction easier since it monitors the tightness of joints
• Maximum penetration rate is maintained in different ground conditions, as well as in different drilling directions

Customer Testimonial
After using Atlas Copco's drill rig SmartRig ROC D7C for just over one year, Ulf Jonsson at NCC Roads can make two important observations. The drill rods last approximately 20% longer and the service life of the shank adapter has increased by 76%.

Jonsson knows what he is talking about. He has drilling experience in hard rock conditions on many road work sites in Jämtland and in various quarries in Northern Sweden; previously using a ROC D7, but since August 2002, using a SmartRig. "Thanks to all the adjustment possibilities, such as percussion pressure and rotation pressure, the drilling becomes much smoother and the holes straighter", says Ulf Jonsson.

The adjustments are crucial
"I take full advantage of the automatic functions to make all the proper adjustments to achieve maximum effect", says Jonsson "because this makes the holes straighter and the drilling smoother."

Smoother drilling saves shank adapter
The Atlas Copco drill rig SmartRig ROC D7C has many features that increase the lifespan of the shank adapter. Among other benefits is the smoother drilling, which is facilitated mainly by the ramp between the drilling parameter levels. Another advantage is that in the automatic mode you can tighten the threads with an adjustable threading pressure, which can be adapted to the rotation pressure.

Logging of Data

There are two separate logs that can be analyzed after the drilling has finished:

- Performance log (PL)
- Drill quality log (QL)

The performance log shows engine hours, tram hours, etc. The performance log can be analyzed in ROC Manager afterwards. See the example table to the left.

Example of a performance log

The drill quality log shows coordinates of the collaring point for each hole, as well as angles, hole depth, etc.

Number	Col: Roc	Diameter (mm)	Vertical Depth (m)	Length (m)	Vertical Angle (degr)	Horizontal Angle (degr)	Start Time	Stop Time
1	0:0	90.0	13.45	13.67	10.29	-0.16	2005/03/ 15 15:53	2005/03/ 15 15:53
2	8:0	90.0	9.46	9.93	17.47	2.99	2005/03/ 15 16:05	2005/03/ 15 16:14
3	16:0	90.0	14.92	15.47	15.23	-0.05	2005/03/ 15 16:32	2005/03/ 15 16:51

Example of a quality log

Benefits of Logging Data
- Maintenance can be predicted using the figures stored in the performance log
- Drilling results can be stored for analysis of the drilling (collaring errors)

Medium Automation Level

The Automatic Rod Adding System
The automatic rod adding function, AutoRAS, is a very useful function that enables the operator to drill a hole automatically to a given depth. This means that the operator will be able to do other things during drilling such as grinding drill bits. The drilling is supervised by the drill rod break detection system (read more on the following page), which means that the drill rig will not get damaged if a drill rod breaks above the surface.

> **Benefits of AutoRAS:**
> • Better rig utilization (1-2 more holes drilled/shift)

Semi Automatic Feed Positioning, AutoPOS
It is very important that the feeder is set at a very exact angle. Especially when drilling deeper holes, a very small error in the angle causes a very big deviation at the bottom of the hole. For example:
$\pm1°$ error = 1.8 cm/m => 20 m bench => 36 cm deviation,
$\pm2°$ error = 3.6 cm/m => 72 cm at hole bottom

This function avoids errors during setup of the feed. It is a "push-button operation", meaning that the operator presses a button until the feed is set to the predefined angles.

> **Benefits with AutoPOS:**
> • More parallel holes - better blasting
> • More even bench bottoms

Indication System for Drill Rod Breakage

When a drill rod breaks inside the hole it is normally not a safety problem, but if the drill rod breaks above the surface it can cause both injuries and damage on the drill rig. Therefore, a simple but well-functioning indication system for drill rod break detection is available on SmartRigs. It is only in operation when the operator is not inside the cabin. If the indication system detects a broken rod, the drilling is immediately stops.

Benefits of Drill Rod Breakage Detection System:
- Safer drilling
- Minimized damage to the rig caused by drill rod breakage above surface

Laser Plane

It is very important that the bench bottom is as flat as possible. There are a number of methods available to ensure that a bench bottom as even as possible. One method is the Laser Plane function, which is not a unique SmartRig function, but combined with the sophisticated control system in SmartRigs, the result is improved.

A rotating horizontal laser plane is generated by a laser transmitter. A reciever is mounted to the rock drill. The theoretical depth <h> (see illustration below) is entered into the system, and the drilling is automatically stops when the vertical plane has been reached. This means that every hole has its own depth, depending on the topography. The laser transmitter can be moved without changing the hole depth, you just enter an offset height from the previous position of the transmitter into the system.

Benefits of Laser Plane
- Reduced drilling costs
- Reduced explosives costs
- Less secondary blasting
- Reduced crushing costs
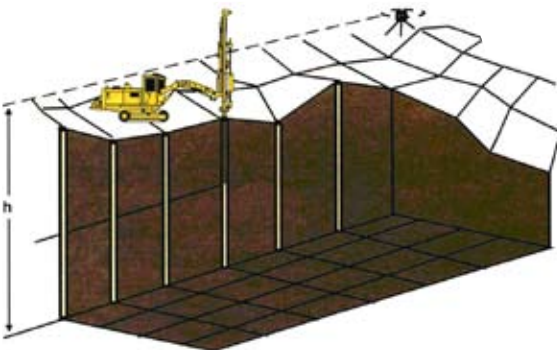
Graphical view of bench drilling with laser plane

GPS Compass

The GPS Compass is an aiming device that uses the GPS satellite system. When you use this device while working with drill patterns, it means that the blast direction can be locked for every hole in the blast. It is the same functionality as with the bigger Hole Navigation System (see page 29 for details about locking the blast direction).

> **Benefits with GPS:**
> • More precisely parallell holes
> • Better blasting and fracturing
> • Bench bottoms are more even
> • Better utilization - more drill meters

Hole Navigation System

Navigation with the aid of global positioning systems has rapidly become commonplace in everyday life. It is used in a wide range of industries and applications from shipping and road transport to public services and leisure activities.

Now there's another, more unusual application that has been added to the list -blast hole drilling. Drillers in quarries and mines are now using it to "navigate" their way to the precise spot where a blast hole has to be started, and align the

drill string to aim at a desired hole bottom, specified by a drill plan.

For surface drillers in particular, this drastically reduces the margin of error in hole positioning and translates into more productive and more efficient drilling operations.

The Hole Navigation System allows for accurate positioning of the rig in relation to drill holes according to a predetermined blast design. It eliminates the need for surveying or hole marking procedures, which saves time. It is also accurate to within 10 centimeters.

The system itself uses GPS technology, and now, the SmartRig drill rigs also can communicate with ANMASK, a common tool for road construction purposes in Scandinavia. The Hole Navigation System is also usable in quarries and mines, but the most important benefits are in large road constructions projects. To achieve high accuracy, the system uses the RTK GPS system (Real Time Kinematic GPS) with which it is possible to limit error in X-Y coordinates on the drill bit to less than 10 cm.

Sensors and brackets for added HNS equipment

How HNS works

The rig itself communicates with the satellites via two separate GPS systems. The one that has its antenna located at the top of the feed is called a "Moving Base System". The fixed one, with its antenna mounted on the back of the frame, is a kind of "slave" system. The two systems communicate with each other and also with the radio base station through a radio connection.

HNS Hardware

The HNS is divided into two parts:
1. Atlas Copco parts and software
2. External parts, such as GPS receivers and antennas

The Atlas Copco parts consist of sensors assembled at the joints on the feed. The external parts consist of the following parts:
- Two satellite receivers capable of counting RTK coordinates

- One GPS antenna located at the top of the feed.
- One radio modem that is compatible with the country and a Radio Base Station often called the Reference Station.

The items listed are installed when the rig is delivered to the customer and the GPS/GNSS agency can help you set up reference stations to get good satellite reception.

Typical RTK/GNSS receivers
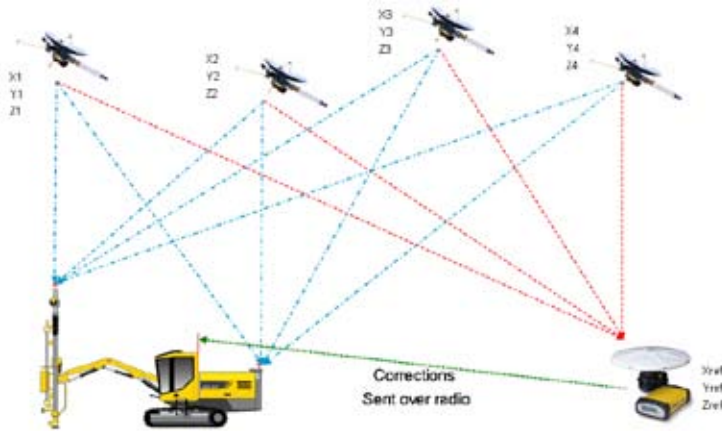
Theoretical overview of RTK GPS

The Radio Base Station, often called the reference station, is located at a fixed point, and has the task of correcting the data that the "moving" systems are collecting from the satellites. An uncorrected signal is accurate to 7-8 meters. There are two different correction methods: post processing and real-time (RTK = Real Time Kinematic). The concept is the same. A base station is surveyed to 1-3 cm accuracy. When the satellite signals reach a base station, it recognizes the difference between its accurate surveyed position and the error position sent by the satellites. The correction is either saved to a hard disk for post-processing or communicated in real-time to the GPS receiver. This can be done either by radio or by GSM communication. In our case, a radio connection is used. It sends back correct positions several times per second. With the radio base station, the magnitude of error is less than ± 10 cm in XY and less than 20 cm in Z. Most of the time the error is below 5 cm in XY and 10 cm in Z! The variation in accuracy depends on a number of different factors,

such as quality of satellite connections to satellites in contact, and reflection of signals in the atmosphere. Most of the time if we have five or more satellites to communicate with, the difference between the origin X (east) and Y (north) position and the actual position measured by the satellite receivers is below 10 cm. The Z coordinate (altitude) is more difficult to calculate since the angle above the horizon is very small. Normally, this means that we can limit altitude error to at most ±10 cm.

The drill pattern is made in our tool ROC Manager, and there are several ways to make a drill pattern inside the ROC Manager. However, you need one point in the local coordinates. This point can be established either by pointing at the ground with the drill bit, and then entering the coordinates into the ROC Manager, or by using an external GPS Tool. After this reference point is given, ROC Manager automatically calculates the rest of the coordinates for the blast.

The hole navigation system uses the planned hole bottom location as a starting point for calculating and adjusting the actual hole depth to be drilled. This calculation is carried out automatically and is based on the X, Y, and Z coordinates of the hole bottom. This helps to achieve a horizontal and smooth bench floor after blasting.

Making a Drill Pattern with ROC Manager

The drill pattern is transferred to the rig via a PC card. After it has been is loaded into the rig, you can immediately start to drill, without any markings at all on the surface! To work correctly, the system needs to have contact with at least four satellites. Otherwise, accuracy is lost and the coordinates are not dependable. In that case, monitoring of the coordinates is automatically shut off, but will be restarted as soon as the system obtains contact again with more than three satellites. During this period, drilling can be done "as usual."
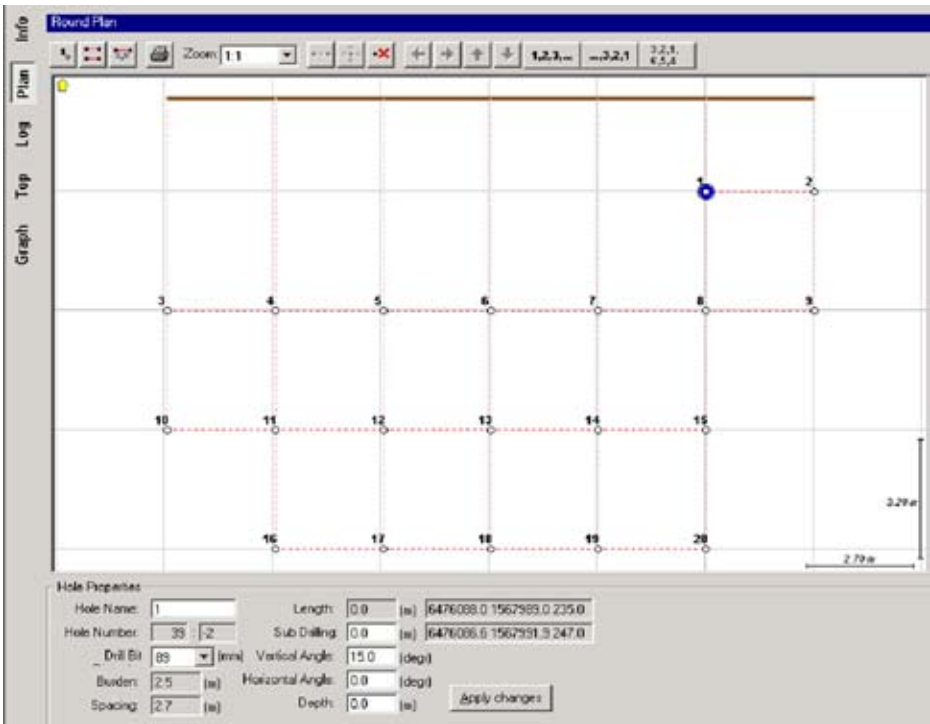

Planning a blast in ROC manager

User Interface - Crude Navigation Menu

This is the first of three possible displays when you are navigating to the hole using the Hole Navigation System. This display appears only if you are too far away from the hole.

Local north is the geographic North Pole, not the magnetic North Pole.

The blast direction is shown only if it is set. This is also indicated by the green indicator in the lower left corner.

The satellite status indicator is green if the number of connected satellites is four or more. If not, the indicator turns yellow and the tramming arrow is marked grey.
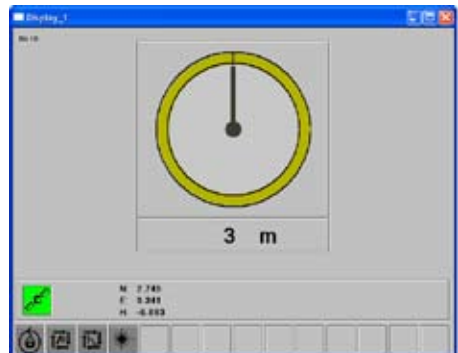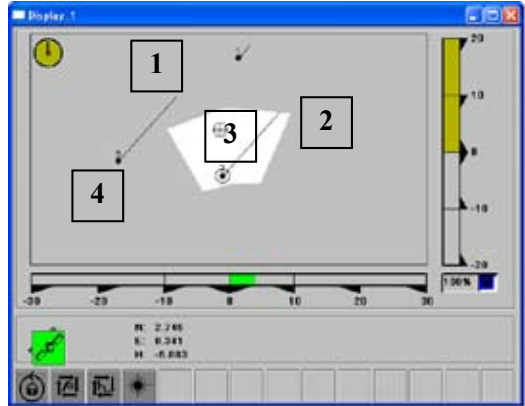

The crude navigation menu on board

User Interface - Fine Navigation Menu

This is an example of the fine navigation menu on board.

The drill pattern is actually a map, and is located exactly as it is on the ground, depending on the drill rig's location.
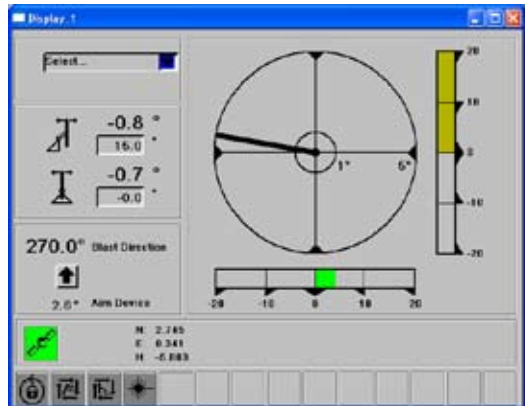

The fine navigation menu on board
1) Hole bottom
2) Coverage area
3) Drill bit
4) Calculated hole start

User Interface - Feed Alignment Menu

This is the Feed Alignment Menu. This can be accessed by pressing the F4 key. When the drill bit is closer than ±10 cm, the accuracy is deemed and the drilling can start.

The feeder inclination setting menu on board

Calculation of Hole Length

The XY position for the drill bit is shown. Depending on the Z-coordinate of the drill bit, the projection of the hole is recalculated several times per second. The calculated hole start is calculated from the predefined bottom level, up to current position of the drill bit. This means that the small lines in the fine navigation menu representing the projection of the drill string are changed if the drill bit is moved upwards or downwards.

Applications

There are basically two different applications using the Hole Navigation System:
1. Road construction with ANMASK
2. Quarries/mines

In the first case, drill plans and information concerning where to drill are provided by ANMASK. The SmartRig system then guides the operator to the correct drilling area.

In the second case, the drill plan is provided by an external tool such as ROC Manager. The drill plan is transferred to the rig via a PC card and the drill plan is read into the system "the normal way."

The operator selects a hole to drill in the drill plan. Depending on the distance to the hole, different guiding displays appear on the display, helping the operator to tram and find the correct place to start drilling.

You can also design the blasting direction for every hole in a blast to a predefined value. Without Hole Navigation System, you have to aim at something as far as possible from the rig, as shown below. The illustration is exaggerated, but shows that the holes are not exactly parallel.

Conventional positioning. The drill rig and feed are aligned with a landmark in the distance. Note that the resulting holes are not parallel.

On the other hand, using HNS, the blasting direction is set at a fixed value.
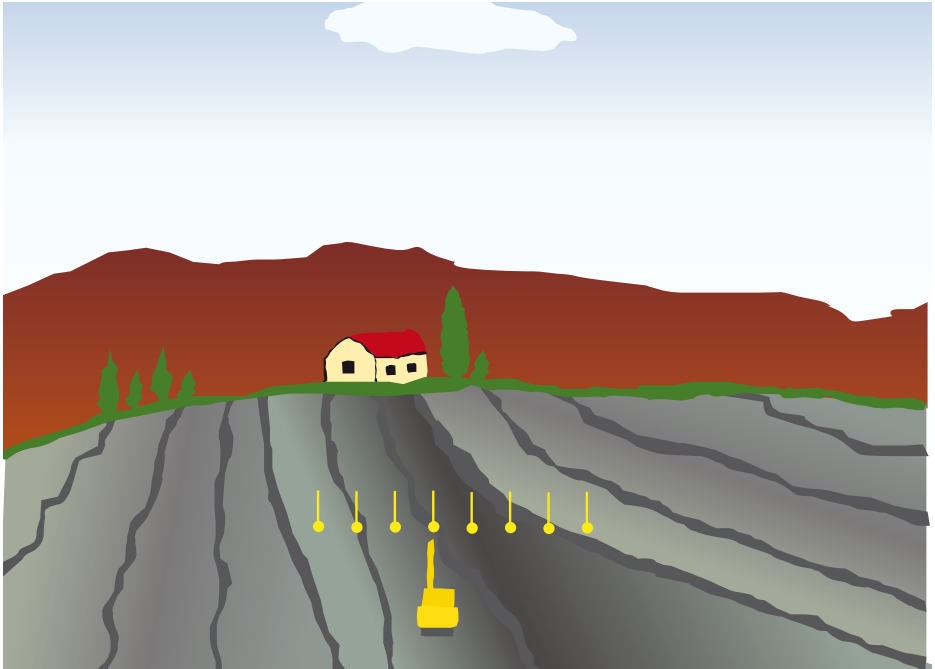
Hole Navigation System (HNS). Using HNS and GPS, the blasting direction is set at a fixed value which ensures that all holes are parallel.

Benefits of HNS
- No need to mark the hole on the surface - Saves time and money.
- Very accurate compass, meaning that all drill holes will be parallel: better blasting and fragmentation.
- No need to aim visually to set the angles - Better rig utilization.
- The coverage area of the rig is visible to the operator - Capability of reaching more than one hole without moving the rig.
- The drilled holes in the logs on the rig have local coordinates - Drill holes can be mapped into the user's own mine map system.
- Fewer boulders due to better blasting.
- Less drill meters because of the parallel holes and the even bench bottom. - Saving of drilling consumables

Customer Testimonials

As mentioned above, there are two different user areas implemented in the Hole Navigation System - Road Construction and Mining/Quarrying.

Road Constructions

For large road construction projects in Norway, a tool called ANMASK is used. ANMASK is a PC-based program, which consists of the road vector model. Today, every vehicle in such a project can communicate with ANMASK. The program itself is executed in a separate PC installed in the cabin. ANMASK provides the road model, and in the drilling application, it displays the exact hole length and inclination depending on the drill bit position. Example:

- The operator gets the road section ID which he should tram to and drill into. The operator moves the rig until ANMASK responds that the rig is within the correct road section.
- The operator moves the rig inside the drilling area.
- The operator touches the ground with the drill bit. The SmartRig system then requests the hole depth and angle for this point.
- ANMASK gives the exact hole depth and angle, and the starting point is recalculated. The operator positions the feed, either manually or automatically.
- Drilling can start.
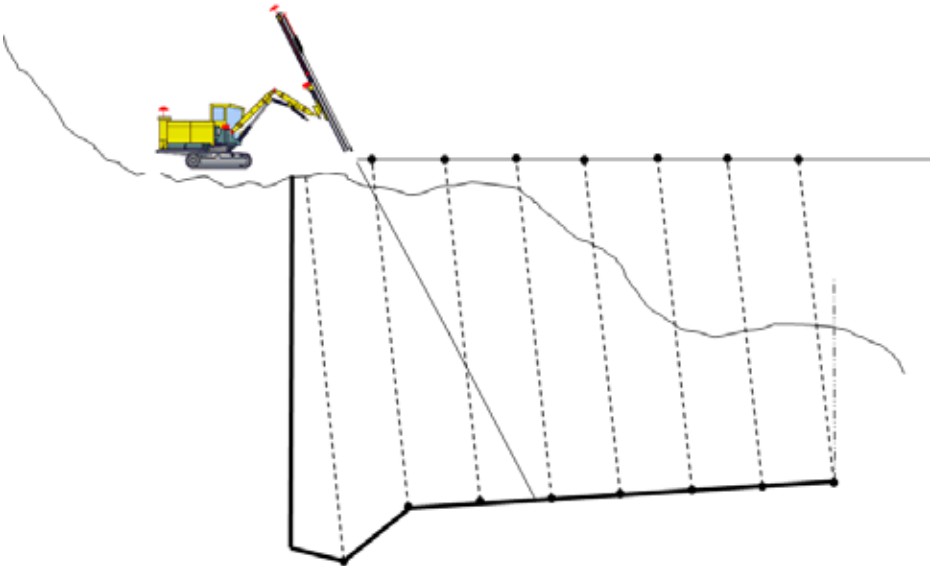
Schematic view of setting hole angles and depth in road construction

Mining/quarry

The second case is the quarry case, where a drill pattern is used. The drill pattern is made in ROC Manager, Atlas Copco's own tool, and obtains its positions from a map or from a position taken either by the drill rig itself, or by an external GPS tool for surveying.

The position is entered into ROC Manager where all the other positions are automatically calculated. This quarry application has been used by a Norwegian customer in the cement industry, Norcem, which is a part of the Heidelberg group. The higher accuracy and more parallel holes have led to savings of 30% in explosives! Also, the need for secondary breaking has been eliminated, thanks to better fragmentation.

The Future of the Hole Navigation System

There are several possible new functions that may be developed in the future. One of them is the "self-collaring-rig." Today the operator still needs to aim and make the collaring, but in the future it should be possible to do this automatically. Also, a natural step would be to make the rig "self-moving," meaning that the rig can tram by itself to start collaring the next hole. In this case, it would be a fully automatic drill rig with less or no need for an operator. Alternatively, the operator could monitor two or more drill rigs at the same time.

Benefits of HNS
- Reduced costs - better fragmentation, less explosives used and reduced secondary breaking
- Speed of operations - no need to wait for a surveyor
- More parallel holes - every hole has the same blast direction
- No hole marking - the driller is guided directly to the collaring spot
- Better rig utilization - no need to align the rig with landmarks and no downtime due to bad weather or darkness
- More even benches thanks to perfectly parallel holes and more precise drilling to the pre-planned depth
- Specialization - capable of drilling a specific profile (e.g. road construction)
- Better fragmentation
- No sub-drilling needed

Additional Benefit for Road Constructions
- Capable of drilling to the exact profile of the road.

Advanced Automation Level

At the highest level of automation, a prediction of rock qualities can be done using MWD, Measure While Drilling. Using MWD together with HNS, the Hole Navigation System, dramatically improves results in terms of profitability and of course, quality of drilling.

MWD

It is vital to know rock properties when charging and blasting to achieve a good rock fragmentation. MWD provides good input on rock properties for analysis. A number of parameters are logged at regular intervals during drilling. The interval can be changed through the menu system.

The following parameters are logged during drilling:
1. Hole depth
2. Penetration rate
3. Damper pressure
4. Feed pressure
5. Percussion pressure
6. Rotation pressure
7. A time mark for every interval

The log data is saved on an external storage medium for transfer to ROC Manager. MWD data can be recorded for every second cm up to a maximum penetration rate of three m/minute.

In ROC Manager, the MWD data can be illustrated in slices through the bench, and the different rock properties are shown with different colors. The colors and limits are set by the customer him/herself, and depends on the conditions at the site. But once they have been set, they are valid for the whole site. This function is very useful when you want a "map" of your site, in which different qualities and/or types of minerals are represented by a specific color. The example below shows a "map" for a limestone mine. The blue colors represent "good rock," and the green colors represent "bad rock." In this case, the preparation for loading and hauling can be done BEFORE blasting, resulting in savings of time and money.
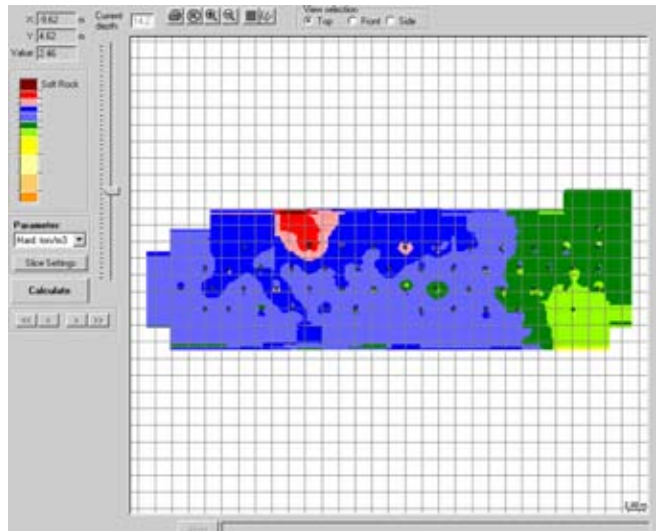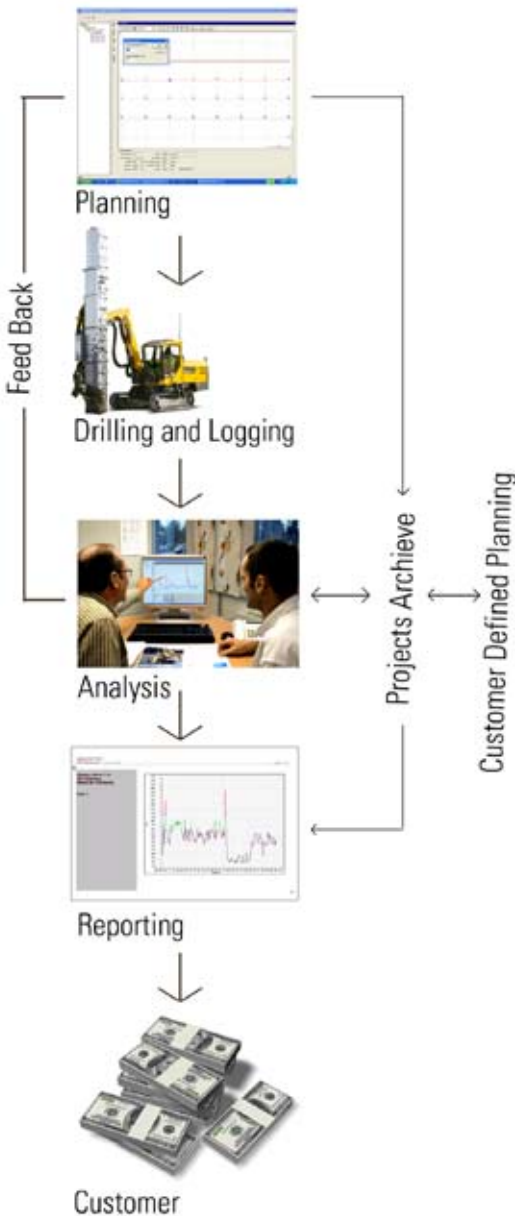

Typical rock quality map provided by the MWD functionality

Benefits of MWD
- In combination with hole deviation measurements, MWD facilitates an optimal charging and blasting process resulting in cost savings for the entire rock excavation process.
- Understandable rock mass properties
- Makes it possible to prepare loaders and haulers to load and move different qualities to different places before blasting has taken place. - Better logistics in the mine/quarry.
- Minimizes laboratory costs for sample analyses. (Fewer samples needed to ensure the quality of the rock)

Other Features

Planning

Feed Back

Drilling and Logging

Analysis

Projects Archieve

Customer Defined Planning

Reporting

Customer

Streamlining the process, from planning to evaluation of results

ROC Manager

ROC Manager is a program for supporting the planning and administration of surface rock excavation, and is specially developed to support all versions of computer-controlled drill rigs from Atlas Copco Surface Drilling Equipment.

ROC Manager consists of several integrated functions.

1. Administration of mines
2. Creating work orders and drill plans
3. Presentation and analysis of drilling logs
4. Presentation and analysis of MWD logs
5. Presentation and analysis of hole deviation measurements
6. Report generator

ROC Manager is an essential tool for mining in rock using mechanized and automated production drilling equipment.

The figure to the left describes the process for rock drilling and the stages in which ROC Manager is used.

Silenced SmartRig

Atlas Copco has the vision to be in the forefront when it comes to protecting our environment. Environmental awareness is increasing all over the world and the rock excavation industry is following the trend. In rock drilling this means reducing noise, dust, oil spillage and engine emissions created during operation.

Engine emissions are already regulated by international agreements. In some countries, stricter noise restrictions will soon be imposed for drilling in urban areas and close to inhabited areas. This is exactly the situation for which the Silenced SmartRig was developed as the first SmartRig for use especially in areas where noise levels have to be restricted. Substantial efforts have been put into redesigning components, systems and soundproofing enclosures, resulting in a considerable external noise reduction. A silenced rig is not only good for people outside the rig, but also for the operator, who can now work with a more comfortable noise level.

Two of Atlas Copco's SmartRigs can be equipped with the silencing kit. These two drill rigs are quite small and are therefore often used in or close to urban areas where a common maximum sound level is 55 dB(A). Consequently, it is almost impossible to drill there without a Silencing kit. The Silencing kit reduces the level with about 10 dB

(A), which is perceived as less than half the noise level of other rigs.

When using a drill rig, noise is generated from several different parts of the rig such as the rock drill, the drill string, the drill bit hitting the rock, the engine, the cooler fans, and the hydraulic and pneumatic system. Since the noise is generated from various sources, it also has to be silenced in several ways. Three main technical solutions are combined to

Enclosed rock drill and feed

Noise trap for dust collector

Rpm regulated cooling fans

make the Silenced SmartRig so quiet. The first is an insulated lightweight aluminum cover including a rubber cover attached to the feed to reduce noise from the drill string. This is the most visible difference between the Silenced SmartRig and other drill rigs. The entire enclosure is designed for quick removal when not needed. The second solution is a sound trap on the dust hood and a special coating to avoid noise leakage. Thirdly, the speed of the cooling fan is controlled in an optimized way that prevents it from making more noise than is necessary. The studies also led to some other noise reduction solutions. Atlas Copco holds several patents regarding these silencing solutions. These solutions make the Silenced SmartRig a perfect choice for civil engineering work sites in restricted urban areas.

In 2004, the first prototype of the Silenced SmartRig was ready for testing by some Swedish customers. After numerous tests, the Silenced SmartRig was launched at an exhibition in Finland in 2005, and the first Silenced SmartRig was sold shortly thereafter.

The Silenced SmartRig is a major step forward for the environment, presenting a flexible choice for quarries and civil engineering work sites, and was therefore one

● With Silencing Kit
● Without Silencing Kit
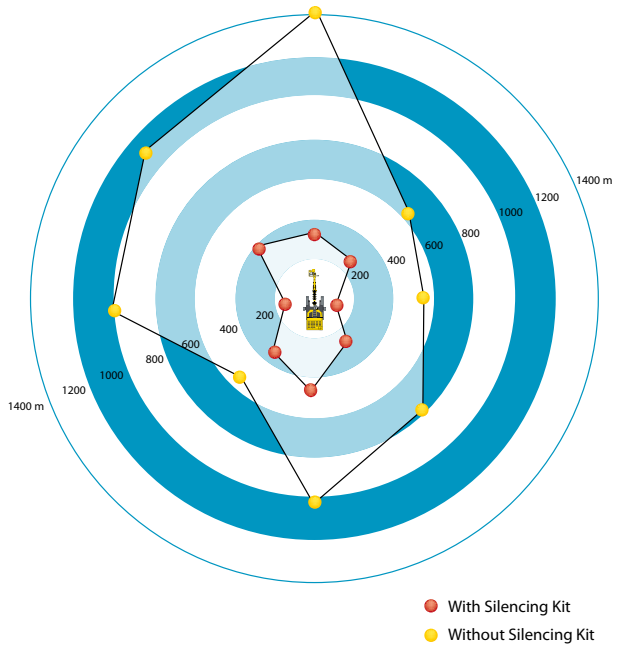
The noise mat shows the degree to which sound travels with and without the Silencer, and shows that the Silenced SmartRig can work up to 1 km nearer to settlements and buildings. The reference sound level is 55 dB(A). This is a common maximum sound level (in northern Europe) when drilling close to urban areas. The area should be used as a reference only.

of the finalists for the Siemens Business Innovation of the Year Award in 2007.

This article first appeared in Achieve 2006/2007

Summary

The benefits of using a SmartRig can be divided into three parts:

1) Productivity
Automatic drilling by
- Automatic feed alignment
- Automatic rod-adding system
- Hole Navigation System

Longer lifetime of consumables
- Shank adapter
- Drill string components, drill-rods

2) Documentation (quality assurance)
Efficient planning process with MWD, all managed from the office
Streamlining the drilling and blasting process - ROC Manager
Automatic hole documentation by using the Hole Navigation System

3) Environmental friendly
Less risk for leakage:
- 30% fewer hoses and hose meters
- 10% fewer cables
- 60 % fewer conductors and joints

Less noise:
Silenced ROC for drilling in urban areas means more job opportunities and more hours

Less fuel consumption:
- Up to 20 % lower fuel consumption (D series with silence option only)

Abbreviations

» CAN   Common Area Network is a standardized communication system developed by Bosch for the automotive industry in the early 1990s. CAN is used on drill rigs equipped with RCS.

» DPCI   DPCI stands for Damper Pressure Controlled Impact. DPCI is protecting the rock drill, by monitoring the damper pres sure. The damper pressure shows the quality of the contact between the rock drill and the ground. The function secures that the percussion is activated only when the damper pressure is between the high and low limits. It also ensures that switching from low impact to high impact occurs only if the damper pressure is above the lower limit. The limitations can be adjusted by Atlas Copco service personnel only.

» GNSS   Common description of satellite based navigation systems that consist of one or more different satellite systems, receivers or support systems.

» GPS   The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

» HCS   Hydraulic Control Systems: the most common control system used on surface crawlers today. No automation features are available. All controls are made manually by the operator.

» HNS   Hole Navigation System, Atlas Copco's navigation system used for drilling with predefined drill patterns without any markings on the surface.

» Input/Output Module   Input/Output module, receives and transmits electrical signals from/to sensors and gauges on the rig.

» IREDES   IREDES stands for International Rock Excavation Data Exchange Standard. It is a common format for exchanging data.

» MWD   Measure While Drilling. This is a technique to determine the rock quality before blasting. A number of pressures and values are sampled each 2 cm during the drilling. The MWD log are analyzed afterwards in ROC Manager or another program that can read IREDES files.

» PLC   Programmable Logical Control is a "box" specially made for process control purposes. It can be programmed to perform certain tasks such as rod handling and cooling fan controls. PLC is used on "half-automated" crawlers such as ROC F9.

» RCS   Rig Control System is the common name used for the computerized control system used on Atlas Copco drill rigs.

» RPCF   RPCF (Rotation Pressure Controlled Feed force) is a function to adjust the feed pressure according to measured rotation pressure. This function keeps the joints correctly tightened at all times increasing the lifespan of steel.

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