

APPLICATION GUIDE BOOK

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INTRODUCTION

Achieving the lowest overall costs for your operation begins with selecting the right equipment to support it. This decision is based on a number of factors, including the material to be mined, the mine plan and the mining application. Each of these factors has an impact on the performance of the fleet that you select. Choosing production equipment is a priority, but it is equally important to understand the impact that support equipment can have on your operation, from drilling and blasting to enabling a safe, efficient and productive loading and hauling fleet.

Once the right fleet has been selected and put to work, how that equipment is being operated and the conditions in which it is working will determine the overall cost per ton your site achieves. Proper selection and implementation of your machines, combined with an adherence to mining best practices, will drive your operation toward lower owning and operating costs..



CHOOSING THE RIGHT EQUIPMENT FOR YOUR APPLICATION

Loading Tools

Electric Rope Shovels. In the right conditions, with the appropriate face height and adequate infrastructure, the electric rope shovel (ERS) can deliver the lowest cost per ton. The mine life must be long enough to support the investment in a machine with a long life and the option to rebuild. In addition, the loading process must be supported by a right-sized, efficient hauling fleet.

Hydraulic Mining Shovels. In most applications, a hydraulic mining shovel (HMS) can deliver the same costs as a large wheel loader. This shovel is ideal for large faces and benches that do not require much tramming, as they lack the mobility to get from face to face throughout the day. Breakout forces are greater with the hydraulic mining shovels, so they perform better in tougher digging materials than either the rope shovel or wheel loader.

Large Wheel Loaders. The cost per ton delivered by large wheel loaders is very similar to that of hydraulic mining shovels in the correct applications. They are considered a mobile machine so if flexibility in locations is important, a wheel loader may be the best choice. In addition, wheel loaders are capable of loading ultra class trucks, keeping production going while maintenance is performed on the main production tools.

Draglines. Thanks to their size, draglines deliver the lowest cost per ton, but only in very specific conditions. They are typically operated around the clock, and are one of the most important tools in coal mining applications. They require support from dozers and in some cases wheel tractor-scrappers. In addition, a dragline installation requires a great deal of upfront mine and maintenance planning.



CHOOSING THE RIGHT EQUIPMENT FOR YOUR APPLICATION

Hauling Machines

Large Mining and Off-Highway Trucks. The hauling fleet can account for 45 percent of overall mining costs. At the same time, selection of the correct type and size of hauler to match the loading fleet can deliver some of the greatest value to your operation. Once you have determined the target payload, it's crucial that you maintain that target to achieve the lowest possible cost per ton. Supporting the fleet with properly designed and maintained haul roads is also critical. Good haul road maintenance can be achieved with motor graders or wheel dozers, and the proper application of water when required.



CHOOSING THE RIGHT EQUIPMENT FOR YOUR APPLICATION

Support Equipment

Motor Graders. Motor graders have a direct influence on mine-site productivity and costs by taking care of haul roads. When roads are kept in top condition, trucks run faster, cycle times improve and more ore is produced. Good road conditions also reduce truck maintenance, lower fuel costs and reduce tire damage.

Wheel Dozers. Wheel dozers combine the production capabilities of track-type tractors with the mobility and versatility of wheel loaders. Applications include loading area cleanup, dump area maintenance, haul road construction and maintenance, blasting area cleanup, reclamation and stock pile. A wheel dozer should be assigned to each loading tool (ERS or HMS) to keep the loading area free of spillage and to eliminate rough surfaces. They are also useful where compaction is desired, such as coal piles.

Track-Type Tractors. In mining and production dozing applications it takes both machine weight and horsepower to move large volumes of material. Large dozers have high weight-to-horsepower ratios to push large loads. They perform several valuable functions in open pit surface mines, such as truck dump maintenance, ripping, stockpile management, stripping overburden, dragline support, trapping and road building.

Hydraulic Excavators. Excavators perform many valuable functions in open pit surface mines, such as building haul roads, maintaining haul road berms, drains and drainage sumps, breaking rock, cleaning truck beds, and many other tasks.

Scrapers. Wheel tractor-scrapers are ideal for jobs that require moving large amounts of dirt with little time — like clearing greenfield coal mines, removing overburden, digging partings, spreading stone and reclaiming mine sites. They are quick to load and unload, spread evenly on the go and have an appetite for a broad range of materials. They offer the lowest cost in moving materials.

Articulated Trucks. Articulated trucks are extremely versatile — moving a wide variety of material in dozens of applications and underfoot conditions. They are simple to operate, with easy controls and automotive-style comfort. A tighter turning radius makes articulated trucks more maneuverable than rigid trucks in confined spaces, and their wider frame and lower center of gravity make them ideal for extreme conditions, such as inclines and soft, muddy, frozen or uneven ground. Options include standard dump or on-the-go ejector options for faster cycle times.



CHOOSING THE RIGHT EQUIPMENT FOR YOUR APPLICATION

Support Equipment (Continued)

Water Trucks. Dust is a concern on many mine sites. Not only is it a safety hazard because it reduces visibility, but dust also can stress machines by clogging filters, brakes and other components. A water truck is an essential piece of support equipment to counter these problems by controlling the amount of dust in the air. Caterpillar offers an off-highway truck bare chassis designed for special machines, including water trucks. In addition, the Cat Water Delivering & Control System (WDS) is an optional attachment that controls spray patterns and allows for a consistent spray width regardless of engine rpm. The WDS includes factory-installed controls in the cab, a hydraulic pump and motor, a water pump and spray heads.

Production Dozing. Track-type tractors are the most common tool for production dozing, especially when the job requires a long push distance. Maximizing the productivity of the tractor, having the blade fully burdened during every pass, is key to production dozing. This technique is critical for applications such as stripping, stockpiling and reclamation. Ensuring the tractor is properly equipped for the application it is being used in is imperative for the highest possible level of productivity. DozSim is a simulation application that allows the user to input specific information on various machine characteristics, job specifications, and other factors that might affect dozer productivity. This allows users to perform “what if” calculations to see what affect changes in job specifications, material, slope, operator skill, and other factors have on anticipated machine productivity. Caterpillar also offers a number of attachments and technologies that help operators with minimal experience be successful in these applications.

Drilling & Blasting. Rock fragmentation is provided by the complementary work of drilling and blasting. This starts the entire process for mining and quarrying yet is critically dependent on precision in planning and execution. This impacts owning and operating cost from dig ability, haulage factors to thru put at the plant. Model and drilling method selection are driven by application requirements of bench height, hole diameter and rock hardness. Drilling is conducted by the complimentary functions of high pressure compressed air, rotation torque and speed with hydraulic pull down force on the rock bit. Automation and autonomy are a growing customer requirement which integrates this to Cat® Terrain in Cat® MineStar™.



MAKING HAUL ROADS AN ASSET TO YOUR OPERATION

Haul roads are the lifeline of the production system. They have a direct impact on productivity and profitability and can be a mining operation's greatest asset — or its greatest liability. They have a major effect on operating and maintenance costs as well as machine downtime. Haul road conditions dictate speed, fuel burn, tire life, safety, machine and component life, and annual tonnage moved.

Smooth, constant grades extend the life of tires and components and reduce the chance of machine damage due to road hazards. Productivity gains can be realized as well. Shift change times are optimized when employees can reach their working areas as quickly as possible, and cycle times are improved when operators are not constantly reducing speed to avoid potholes or other road hazards. Smooth, clean road surfaces also deliver safety benefits. They suppress dust to provide a healthier

working environment and improve visibility. In addition, good haul roads ensure better access for emergency vehicles in the event of an accident.

Haul roads are the operating domain of a site's trucks, and their design and maintenance should be approached with truck performance in mind. Haul roads have the largest influence on both the immediate and long-term performance and cost of truck fleet, as well as the cost per ton they deliver. Poor haul roads have an adverse effect on cycle times, which will ultimately lead to higher operation and maintenance costs.



MAKING HAUL ROADS AN ASSET TO YOUR OPERATION

Impact of Slower Cycle Times

Just adding one minute to cycle time can have a significant impact on productivity and cost per ton in a short-haul coal mine. Let's assume a mine is operating 785-size trucks, hauling 150 tons of overburden. Reducing the cycle time from 9 minutes down to 8 can increase the number of cycles per hour by 0.8 cycles per hour. This is a difference of 120 tons per hour.

This doesn't seem like much when looking at a short period of time, however over the course of a year this slight reduction in cycle time can reflect in a difference in revenue upwards of \$2.38 million. Minor changes can have a major impact on the bottom line of an operation.

The minimal expenditure required to maintain good haul roads will pay for itself many times over when compared to the extra costs and lost productivity to be incurred when roads are in poor condition.

Haul Road Design and Maintenance Tools

Caterpillar can help mines improve their haul roads with the following tools:

- **Fleet Production and Cost (FPC)** Estimate cycle times, fuel consumption and fleet productivity.
- **Road Analysis Control (RAC)** Monitor haul road conditions by activating on several trucks.
- **Mine Equipment Investment Analysis (MineEIA)**
Compare the economics of two or more mining systems in an application
- **Value Estimating Tool (VET)** Translate Cat features and benefits into tangible value for customers.
- **Performance Handbook** Review machine performance and overall owning and operating costs.
- **Training** Define training opportunities that will improve site conditions and productivity.



TRAINING: ENSURING OPERATORS AND SUPERVISORS ARE PRODUCTIVE AND EFFICIENT

A decade ago, it would have taken a new hire at a mine several years to become proficient at operating a single machine or gaining a total understanding of how a mine site operates. This lengthy training period worked because senior operators were there to do what needed to be done. Today, a mine's foremen or supervisors may have just two years of mining experience. Most mines are so busy training new operators on individual tasks that they do not have enough time to do advanced follow-up with their quickly-promoted foremen or supervisors. These same individuals, with limited time and experience, are then responsible for helping to educate newer operators. This scenario leads to miscommunication and frustration for the management team.

Mining operations have a lot to lose when they don't go beyond the basic training new operators receive. These operators often learn on the job, developing both good and bad habits. They focus on the task at hand with little to no understanding of how what they are doing can affect the mine's cost per ton.

At the same time, today's mine sites face a lack of skilled people on site due to the retirement of many senior level employees and the lack of people interested in working in the mining sector. The result is lost knowledge that is difficult to replace.

Training courses

A key to overcoming this lack of skills and knowledge is providing comprehensive training. While this may not be a core competency of the mining organization, it is a key component of Caterpillar's beyond-the-iron offerings. Caterpillar offers:

- Instructor-led classroom sessions
- Instructor-led in-the-iron training sessions
- Online e-learning classes
- Self-learning CDs
- Simulators

Basic operator training can be provided at Caterpillar's Tinaja Hills training center near Tucson, Arizona.

Caterpillar can also assist with more advanced training that teaches workers how to look at efficiencies across the mine in the areas of loading, hauling, dumping and returning to the load area. Training can also be broken down into training on individual

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Another approach to training that can be more economical, safer, and easier on equipment, is the use of simulators. Caterpillar has a variety of its own basic simulators as well as an alliance with Immersive Technologies to provide cutting-edge, realistic training opportunities.



EVALUATING OPERATIONS TO LOOK FOR INEFFICIENCIES AND OPPORTUNITIES

The more productively, efficiently and cost-effectively a mine can operate, the more profitable it will become. Continuous improvement is a must. By evaluating operations, equipment, maintenance practices and operator performance, mines can identify inefficiencies and find opportunities for improvements that will have an impact on the overall cost per ton. Application inefficiencies add up by the minute and can adversely affect overall production significantly. Even the slightest improvements can reap great benefits

Payload Management/Scale Study

Managing payload and measuring productivity are essential to helping mines improve the efficiency of operations and get more from their equipment investment. Production and volumetric studies, which can be conducted in partnership with Caterpillar Global Mining, can focus on a number of variables and analyses, such as:

- Vehicle and fleet productivity
- Loading/hauling system analysis
- Loading tool sizing/matching analysis
- Equipment operational reviews
- Payload weighing
- Productivity analysis

Haul trucks are designed to operate at a manufacturer-designed payload. Exceeding that payload negatively affects fuel consumption, the life of tires, frames and components, overall cycle times and safety. More is not always better and has the potential not only to reduce production and availability but also to increase maintenance costs.

An important tool in the management of payload is the scale truck, which is used in a scale study to weigh payload. Scale studies are needed to monitor the fleet's adherence to Caterpillar's 10/10/20 payload management guidelines. Scale studies help mine sites:

- Ensure adherence to payload guidelines
- Improve load placement
- Establish a correct target payload
- Ensure TPMS accuracy for future payload management

The scope of any prospective study needs to be clearly understood and agreed to up front. Such studies will typically take three to five days on site, and another three to five days of office work and report writing.

Site Assessment

The application in which a machine operates will have a significant impact on its performance. It's important to evaluate site conditions and review all aspects of an operation beyond the equipment itself to identify areas of opportunity. Once these opportunities are identified a course of action can be determined and the results measured over time. Improvement opportunities can be found in a number of areas, including:

- Operator Inefficiencies
- Haul Road Design
- Haul Road Maintenance
- Payload Management
- Fleet Optimization



CONCLUSION

Mine sites measure productivity by cost per ton – the lower that number, the greater their profitability. A successful equipment management program is essential in making this happen. While there are significant benefits to simply selecting the appropriate equipment fleet for your application, it is equally important to ensure that best practices are being followed in maintaining and operating the fleet.

Small changes at a site can have a major impact on the bottom line. A noticeable reduction in cost per ton is recognized with a minimal 5% change in hourly efficiency, payload, operator efficiency and cycle times –all by increasing machine availability and utilization.

For more information on all things application related, please visit <https://dealer.cat.com/en/ps/industry/mining/c/application.html>





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