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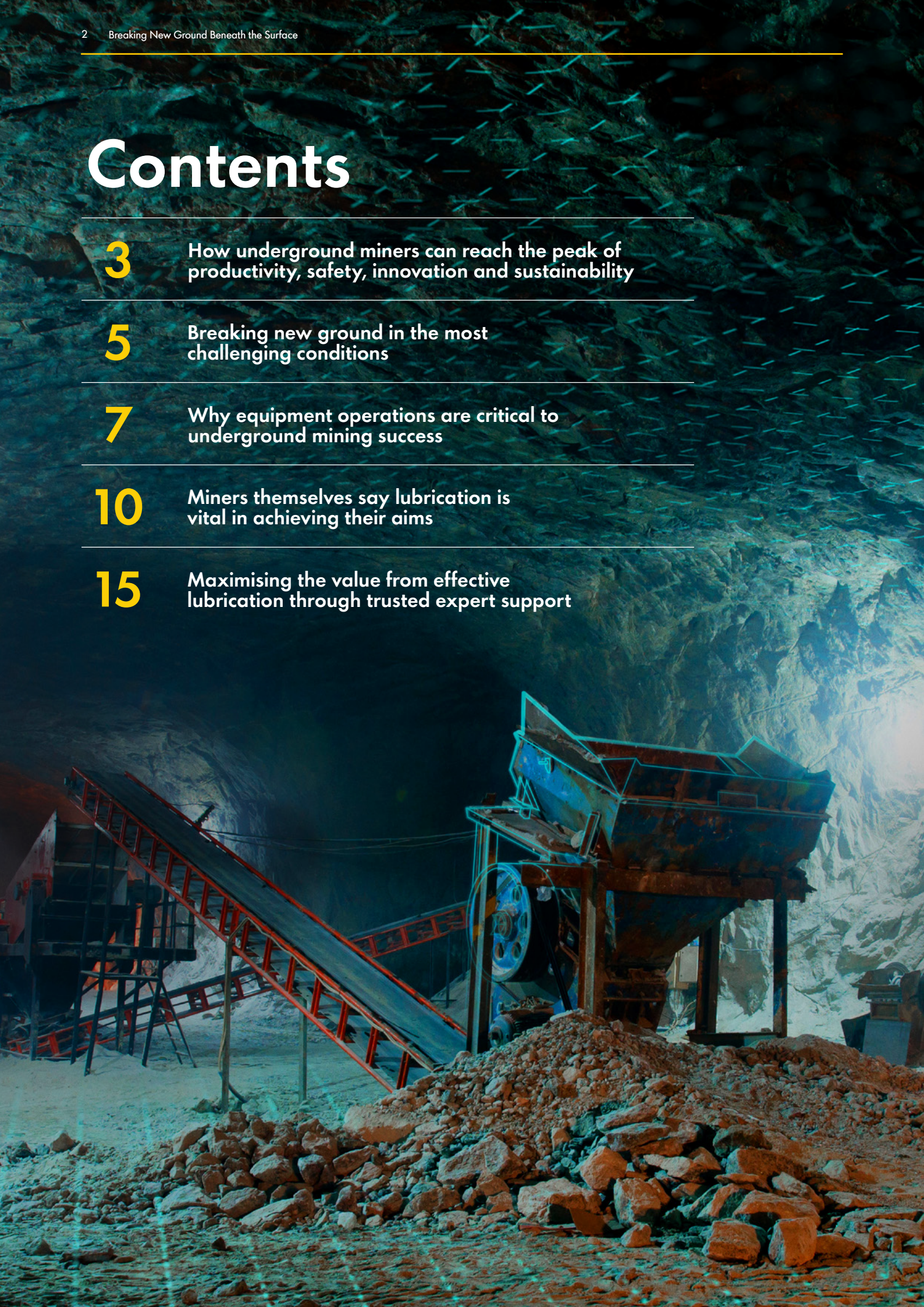
Breaking New Ground: Beneath the Surface

How underground miners can enhance the productivity, safety and sustainability of their operations, and get ready for the future, while adapting to new technologies – all by implementing a more holistic, expert-led approach to equipment lubrication.

Contents



How underground miners can reach the peak of productivity, safety, innovation and sustainability

Foreword by Vanessa Boag, VP Global Marketing for Shell Lubricant Solutions

When talking about the challenges that underground miners face, I often liken it to climbing Mount Kilimanjaro. This might sound strange, as reaching the peak of Africa's highest mountain is the opposite of digging down into the Earth. However, the two activities share some interesting similarities.

Hiking at its most basic can still be difficult depending on the terrain, weather and the equipment you have. Now imagine climbing more than 1,200 metres (4,000 feet) towards the summit at night, and in increasingly challenging conditions.

Similarly, mining in general is an incredibly tough job – to start with, miners face similar macro-economic pressures as other sectors do. The cost of consumables is rising while shareholders are pushing for greater profitability, and tightening legislation is putting miners under pressure to operate more sustainably.

At the same time, demand for some materials is increasing. From the metals that build wind turbines to the minerals powering electrification, mining is essential in providing the resources needed to advance the energy transition. So, miners must also increase production to help society break new ground in response to climate change.

Now look at those challenges again from the perspective of underground mining, which adds new layers of complexity for those operating in these environments. For example, mine shafts need to go deeper to access critical minerals needed for the energy transition – presenting significant challenges in managing the safety of workers and the efficiency of equipment.

To deliver more while balancing cost pressures with the need for sustainability, underground mines must dig deeper than ever before. They must focus on how they can lower their total cost of ownership (TCO) by improving operational efficiency while future-proofing their business and their license to operate by adopting more sustainable practices.

Vanessa Boag

As VP of Global Marketing at Shell Global Lubricants Solutions, Vanessa brings over 25 years of experience at Shell to the role. She has held diverse roles in Shell as a commercial professional spanning Retail, Lubricants, and Aviation in China, the Netherlands, Malaysia, and the UK.

With a proven track record of leading global teams, Vanessa delivers impactful marketing strategies, providing customers in key sectors, such as mining, with innovative lubricant solutions to drive transformational success.

Achieving this means investing in new technologies or enhancing existing ones that might have been overlooked – including dedicated lubricants, services and lubrication programmes. These both have a valuable role to play in improving mining TCO and reducing harmful emissions by making sure equipment can operate as efficiently as possible for as long as possible. However, effective lubrication programmes are about more than the products themselves. How you choose and use them, how you monitor them and how you optimise them are just as important.

As our new *Voice of the Underground Customer* study highlights in this whitepaper, lubricant experts are vital in helping underground miners to understand the benefits of such a holistic approach to proactive equipment maintenance. They help site operations and maintenance teams look at the bigger picture to see the value of lubrication solutions over their entire lifecycle – exploring what they can do for their equipment and the positive impact they can have on site operations.

With effective lubrication programmes, underground miners can significantly improve site efficiency. This can then help them to meet growing production targets while managing operational costs, meeting shareholder demands and adopting new technologies. It can also help them to strengthen their license to operate (and potentially win future government contracts) by putting them in a better position to adapt to dynamic emissions targets. In fact, most importantly of all, it can enhance safety on site.

I will finish with one more similarity between someone scaling Kilimanjaro and underground miners. They all have a mountain to climb ahead. But, with the right experts guiding the way, there is every chance they will achieve their goals.

Vanessa Boag
Vice President, Global Marketing Lubricants

Breaking new ground in the most challenging conditions

To reach the deepest shaft of the deepest mine in the world, you have to head to Mponeng – a gold mine roughly 90km south-west of Johannesburg in South Africa.[1] There, you take the tallest elevator in the world more than 2,000 metres (7,940 feet) down into the ground before switching to another elevator that travels to 3,597 m (11,800 ft) below the surface.[2] Even then, you still have not reached the mine's current deepest point of 3,891 m.[1]

As you descend into the mine, you will notice the temperature rising. Due to the planet's geothermal gradient, each kilometre you travel towards the centre of the Earth will – on average – add 25-30°C to the temperature of the rock around you.[3] In theory, the temperature of the rock at Mponeng's deepest point could be around 95°C hotter than at the surface.

To reduce the air temperature, miners pump a slurry made from ice and salt into the mine – blowing the resulting cool air around the shafts with giant fans (with 'cool' meaning 37°C or 98°F).[4]

The challenges around worker safety in these conditions are clear. What is often underestimated is the significant impact such conditions have on equipment reliability and – by extension – the productivity of wider operations.

In this whitepaper, we will explore the importance of equipment operations in underground mining – and why effective lubrication programmes are essential. We will also look at how miners can unlock opportunities in key areas by tapping into dedicated technical expertise and the latest innovations.

Underground mining explored: Digging into four key priorities

While not every underground mine extends more than 3km into the ground, they all face challenging conditions – including those that reach beyond their sites.

As industries around the world adapt to the ongoing energy transition, the need for critical minerals and metals is increasing rapidly. For example, the electric vehicles driving sustainability in road transport require up to five times more copper than their petrol or diesel counterparts[5], contributing to the growing demand for copper that could rise by more than 70% by 2050.[6] This means that miners are under pressure to produce more, pushing them to break new ground as they fulfil a vital role in supporting a societal shift towards more sustainable practices.

Shell's latest *Voice of the Underground Customer* research[7] (based on in-depth interviews with 63 underground mining decision makers carried out between October and December 2023) reflects on the impact this situation has on underground miners and highlights four key focus areas for site teams.

Four key focus areas:

1. **Productivity**
   Sites are pushing to meet production targets and costs (with availability of equipment a key concern) as they work to address the challenges of increased demand and an unpredictable economic climate.

2. **Safety**
   Ensuring worker safety and safety on site is critical as miners continuously explore to produce more and dig deeper in challenging conditions.

3. **Innovation**
   Underground miners are looking at how they can overcome the challenges of implementing the latest technologies – including electrified equipment – into their operations while making sure their workforces have the evolving skills and capabilities to deploy them effectively.

4. **Sustainability**
   Meeting environmental, social and governance (ESG) goals is set to become a priority for miners as they look to make CO_2 emission reductions and reduce environmental impact, whilst currently not being the main factor driving operational decisions at the site level.

How miners meet their goals in these four areas will define their ability to support the global energy transition, address shareholder and investor demand for greater profitability and maintain their license to operate.

Why equipment operations are critical to underground mining success

Underground miners have an array of targets to meet across their four focus areas, but there is a seam that connects them all: **equipment**.

Equipment operations have a key role to play in helping miners **increase productivity, improve safety, drive innovation and operate more sustainably**. The more reliable a machine is, the more efficiently it can work, and for longer.

This means its operator can produce more in a shorter period while helping to reduce CO_2 emissions.

Conversely, an unexpected breakdown can halt operations and put workers at undue risk. The problem for underground miners is that their equipment is under much greater strain than it would be above ground due to operating in some of the harshest and most extreme conditions on Earth.

Equipment is under much greater strain due to operating in some of the

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conditions on Earth

The impact of underground mining on equipment

Miners understand the conditions they face when working in this environment, but the effects on machine health and efficiency are often not fully realised. Here are three ways the challenging conditions can have a negative impact on equipment operations:

These factors make it vital for miners to extend the lifetime of their equipment as much as possible by providing protection for components that can endure the challenging conditions underground.

1

Increased risk of breakdown from heat

The deeper miners dig, the hotter their operating conditions become, putting components under ever-greater strain and increasing the risk of failure.

2

Reduced equipment life due to severe operating conditions

The lower oxygen levels in underground mines places a higher strain on engines, causing greater wear and reducing the lifetime of the equipment.

3

Decreased component protection from water use

The high levels of water used in extraction processes increase the risk of contamination and corrosion – as well as washout of the lubricants which are meant to be protecting components.

4

Increased downtime from lack of access

With mine shafts reaching more than 3,000 meters under the surface, repairs and replacements become incredibly difficult and time consuming – leading to higher amounts of unplanned downtime and lost productivity.

This situation means that the equipment lifecycle for underground mining can, in some cases, be significantly shorter than that of similar machinery used above ground. Components fail earlier, making breakdowns more likely – reducing operational efficiency while increasing maintenance costs.

Repairs can also take a lot longer than they do above ground. This can be exacerbated by the diversity of equipment in use across an underground mine, making it difficult to standardise maintenance practices. A shortage of technical maintenance skills within workforces also makes it hard to prevent equipment breakdown while adding to the time and expense required to get machines up and running again.

Underground miners are aware of these challenges. The study highlights what they see as their three most important maintenance needs:

Machine health and reliability

To reduce disruption by keeping equipment running at full capacity.

Safety

To provide safe working conditions by identifying risks and preventing accidents.

Workforce Skills

To keep pace with new equipment and technologies.

The key opportunity for underground miners

Despite the equipment challenges they face, underground miners have a crucial opportunity to improve their productivity, safety and sustainability.

Effective lubrication programmes – as part of wider maintenance practices – offer the ability to enhance machine health and reliability while extending equipment lifetime. By combining high-performance lubricant products with expert-led and digital services that help to monitor and optimise those lubricants, miners can better protect machines components, reducing the risk of breakdown to keep equipment running at optimal efficiency for longer.

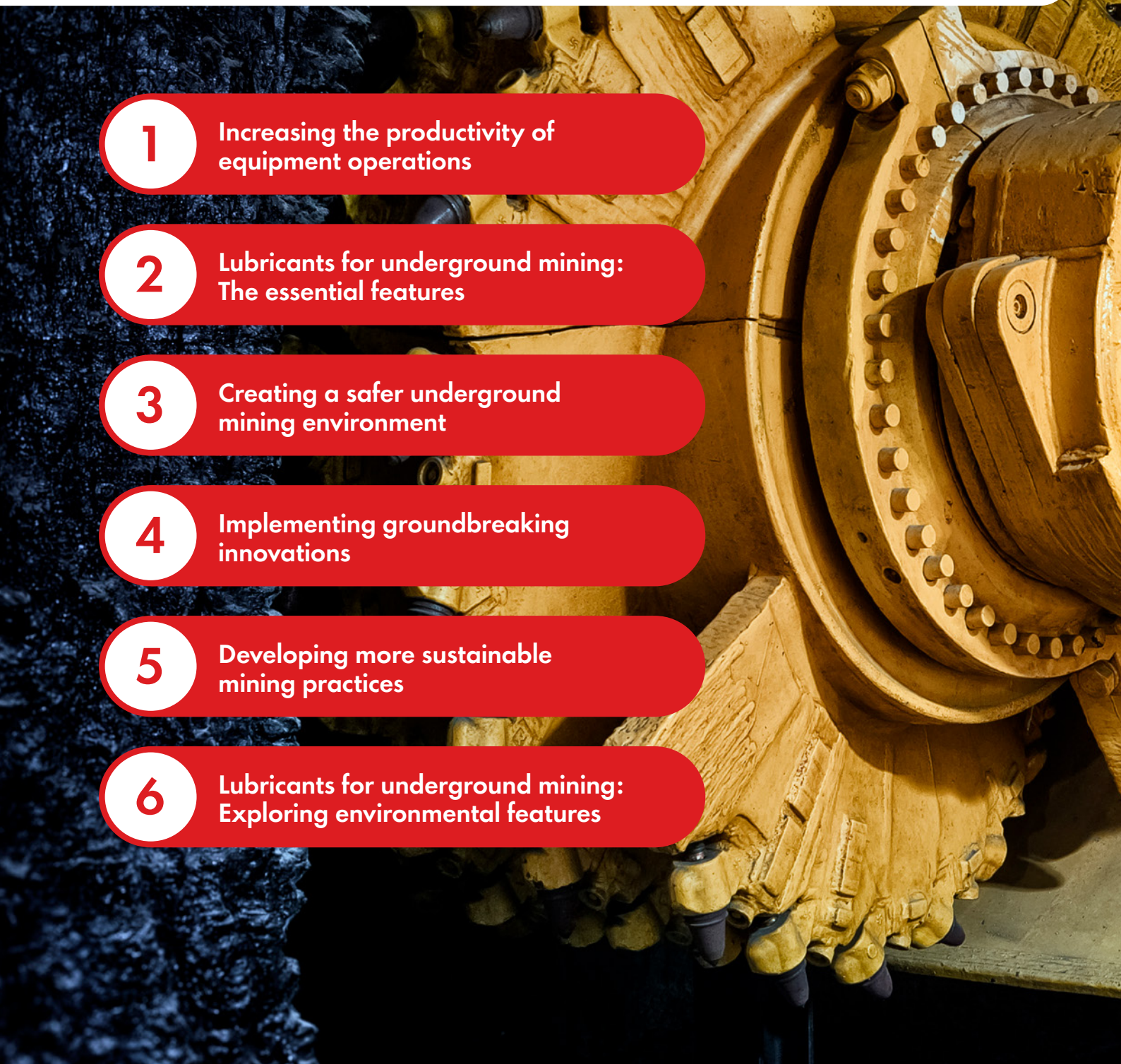
These can be seemingly small changes to a site's overall operations (lubricants are often a low priority for miners with the need to manage the rising costs of operations and societal pressure to reduce CO_2 emissions as key priorities)[8], but they have a significant positive impact on operational efficiency, worker safety, GHG emissions reduction – and on the mine's ability to implement new technologies.

The need to manage rising costs might be paramount, but sustainability is a challenge that mines cannot ignore. According to the *Voice of the Customer* study, the next priority after cost reduction is societal pressure to lower their CO_2 emissions and minimise the impact of contaminated water and soil on local communities (from reduced crop yields to increased health risks).[8] This pressure is mainly coming from legislators, but sites are also facing the demand for change from the wider value chain and adjacent industries.

Miners themselves say lubrication is vital in achieving their aims

To understand the difference that effective lubrication programmes can make to underground mining operations, the study uncovers miners' top maintenance needs across the four key areas of productivity, safety, innovation and sustainability.

Here, we explore those needs and look at how miners can work with expert providers to bring the right solutions into their site operations.



1. Increasing the productivity of equipment operations
2. Lubricants for underground mining: The essential features
3. Creating a safer underground mining environment
4. Implementing groundbreaking innovations
5. Developing more sustainable mining practices
6. Lubricants for underground mining: Exploring environmental features

1 Increasing the productivity of equipment operations

The top maintenance priority for underground miners, according to the study, is maintaining machine reliability to drive operational efficiency. The primary expectation is to have machines up and running with minimal downtime. As part of this, underground miners are looking to enhance their equipment efficiency with proactive solutions such as innovative lubrication technologies. They are also looking for suppliers who can ensure lubricant availability – with a reliable supply chain essential for keeping their operations running as effectively as possible.

In terms of the lubricants themselves, there are certain features which are considered essential to support safe and efficient mining operations. This includes lubricants which are fire resistant, have low toxicity and anti-corrosion properties, as well as those which are compatible with seals and gaskets to prevent leaks. It's also important to see the benefit of lubricants which have thermal stability properties to make sure products can maintain viscosity when working in environments with increased heat or temperature variations. While sustainability is growing in importance and requirement, biodegradable lubricants and lubricant performance remains as important as ever.

Maintenance support is highly valued among underground miners, with services such as on-site assistance, oil analysis and inventory management considered essential. These skills may not currently be present at some sites, making suppliers who provide technical expertise crucial for integrating them into mining practices. This means that underground miners should be looking to work closely with suppliers who can deliver:

High-performance lubricant products formulated to withstand harsh on-site conditions.

A reliable supply of products to prevent unnecessary downtime by ensuring they are available when needed.

Expert technical and digital services to support the monitoring, analysis and optimisation of the lubricants in use across mine sites.

2 Lubricants for underground mining: The essential features

The key features that underground miners need from their lubricants include:

Compatibility with seals and gaskets

Lubricants that are compatible with the seals and gaskets on equipment are essential in improving reliability and longevity by preventing leaks and contamination.

Enhanced protection from friction and wear

Miners can look to use lubricants that contribute to equipment longevity and efficiency by reducing friction, wear and tear.

Water-resistant properties

High volumes of water are used to extract metals and minerals in underground mines, which means sites need lubricants that prevent washout and the resulting corrosion of components.

Heat- and fire-resistant properties

Using lubricants that can manage the heat generated by extended machine operations – especially in the depths of an underground mine – is vital for maintaining equipment efficiency.

Ultimately, the right lubricant products properly managed can contribute to a site's operational resilience – leading to improved machine performance, extended equipment life and increased operational efficiency.

3 Creating a safer underground mining environment

Safety is, understandably, a critical priority for underground miners. We have already established that they operate in some of most severe working conditions on the planet. Ensuring that workers are safe, the equipment they use is safe and that their procedures adhere to safety standards is non-negotiable.

The role that machine health and reliability plays in this is vital. The less reliable equipment is, the more it fails and breaks down – and the greater the risk to those operating it and working in the shaft.

Regular inspections and maintenance are key in identifying risks, preventing accidents and creating safe working conditions. Within this, effective lubrication programmes can protect machine components, extending equipment life and keeping them running at optimal capacity for longer. This means fewer breakdowns and reduced risk to the safety of mine workers.

Remote sensors can add to this by allowing workers to collect oil analysis data without the need for as many physical inspections. And intrinsically safe automated single-point lubricators, featuring Bluetooth or LoRa (long range) connection technologies, help miners to manage their grease regime remotely via an app. Safety training programmes are another effective way to help sites adhere to standards.

For instance, implementing proper lubricant handling and storage procedures or waste management processes can help to remove additional risks from the working environment while contributing to improved operational efficiency.

Providing a safe environment for underground mining also goes beyond the lubricant products keeping machines operating safely. Digital tools like oil condition monitoring can help maintenance teams to identify potential issues before they become critical and prevent component failure – further reducing safety risks.

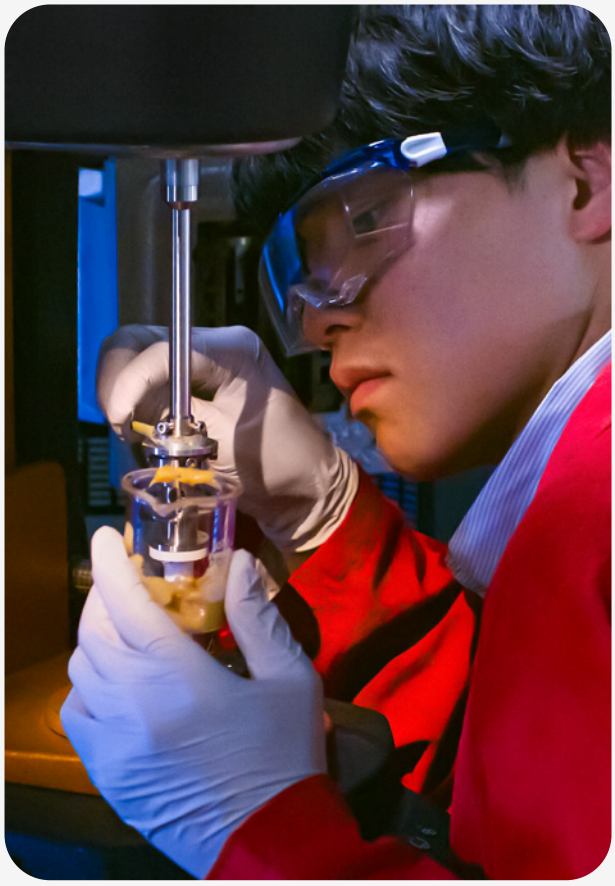
4 Implementing groundbreaking innovations

Innovation continues to be essential in enabling underground miners to operate more productively and safely than they could without advanced technology.

However, cost also continues to be a barrier to adoption – along with a shortage of new workforce skills required to make the most of the latest technologies. It is why miners are looking for suppliers to help them integrate new technologies and digital systems into their operations.

When it comes to maintenance and lubrication, underground miners anticipate a growing need to collaborate with suppliers on the adoption of advanced lubricant technologies and innovative solutions. Compared to standard lubricants and technologies, these are designed to increase operational efficiency, reduce costs and enhance the lifespan of critical equipment.

One such element is the use of data to drive decision making. For example, miners are looking to take advantage of oil analysis programmes that deliver actionable insights on the condition of their equipment.



As well as providing the ability to identify potential failures before they occur, these tools can provide miners with an overview of equipment health across a site. This can then inform strategic maintenance decisions, allowing teams to take a more predictive and proactive approach.

Alongside the desire to use data more effectively, underground miners are looking for tools that help them to improve efficiency through remote monitoring. This includes the integration of sensor technology to provide oil condition analysis in real-time and the implementation of solutions that enable the remote management of lubricant usage across a site. Miners also see great value in tools that help them to optimise their energy consumption by monitoring and analysing lubricant performance.

The research stated that miners would appreciate support from their suppliers in the form of digital tools for tracking usage, scheduling maintenance and optimising lubrication processes. But it is not all about the products and solutions. Miners are similarly keen to work with suppliers to deliver equipment maintenance training. This can help them to provide vital upskilling for site teams, enabling those teams to adapt more quickly to new technologies and deliver the efficiency gains they uncover.

Ultimately, to drive site productivity and profitability both today and in the future, underground miners need to choose suppliers who can deliver innovative integrated solutions with expert support and proven tangible benefits.

5 Developing more sustainable mining practices

While powering the global energy transition, underground miners must deliver the seemingly impossible: increase their output and reduce their environmental impact. In real terms, this means complying with tightening sustainability regulations while continuing to meet growing operational targets. However, it is not all about maintaining productivity and a license to operate in the face of external pressure from regulators. Companies have their own sustainability commitments to deliver on, with communities, society and shareholders pushing for reductions in CO_2 emissions and environmental impact alongside an increase in profitability.

Lubrication (from usage to disposal) has an important role to play in helping reduce GHG emissions and meet environmental responsibilities. For example, lubricant products that deliver environmental benefits alongside high performance properties can effectively drive both productivity and sustainability across an underground mine site. This includes products that are readily biodegradable, provide low ecotoxicity and low bioaccumulation (see: What is a 'readily biodegradable' lubricant), which can strengthen a company's license to operate by helping deliver on their commitment to sustainability and protecting elements such as any groundwater reserves in proximity to their mining operations.

There are a multitude of benefits associated with high performance lubricants which are increasingly attractive to miners. This is due to the positive impact high-performance lubricants versus standard lubricants can have on a machine's energy efficiency and its ability to work harder for longer. By protecting equipment, maintenance teams can reduce the need for early replacement of components and machines – both of which can help reduce the site's carbon footprint.

Other priorities for underground miners in this area include recycling and reuse initiatives, sustainable packaging and waste management. On the last point, sites are particularly keen to work with suppliers who can provide comprehensive support that covers training on waste collection and guidance in implementing recycling programmes.

What is a 'readily biodegradable' lubricant?

A readily biodegradable lubricant is a product where at least 60% of the lubricant biodegrades within 28 days.[9] **It must also feature low ecotoxicity, which makes sure it offers a reduced impact on organisms when exposed to the environment.**

Another element is low bioaccumulation – making sure the product does not build up in organisms over time and have a negative impact on the food chain.

6 Lubricants for underground mining: Exploring environmental features

Here are the environmental features that miners should look for in their lubricants to help them to deliver sustainability improvements:

Biodegradability

Working with suppliers who provide high-performance, readily biodegradable lubricants can help miners to minimise the environmental impact of their operations.

Low chemical content

By looking for products with lower chemical content, miners can minimise waste and reduce their environmental impact.

Carbon reduction

Miners should look to use lubricants that contribute to reduced emissions and that support their overall sustainability efforts.

Reusable and sustainable packaging

Beyond the products themselves, miners can work with suppliers to ensure that the packaging of their lubricants can be reduced, reused or recycled, helping to reduce site waste and promote circularity.

Water reduction and reusability

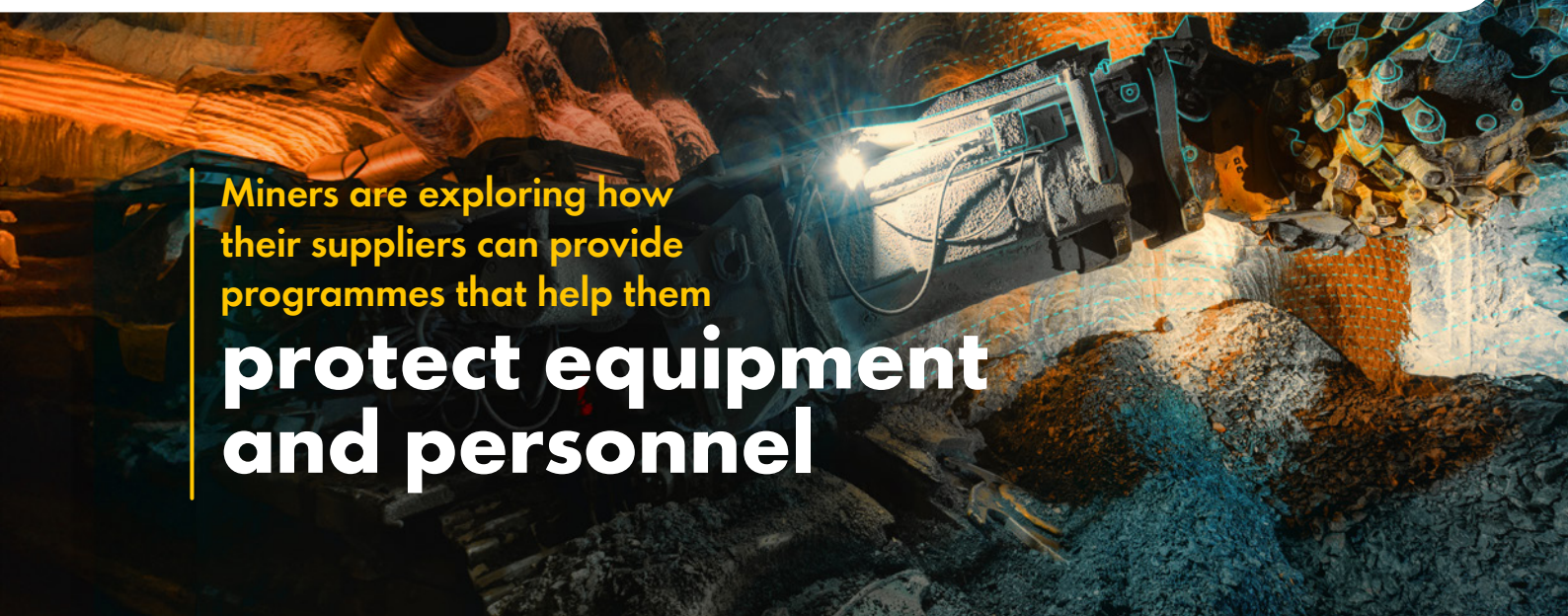
With high water use in underground mines, sites need lubricants that contribute to reduced usage and improved recyclability.

Maximising the value from effective lubrication through trusted expert support

How underground miners address their most pressing lubrication and maintenance needs will determine their ability to deliver on their aims across the four imperatives they see lying ahead of them in the short term and for the future. This is because equipment operations offer a critical opportunity for miners to drive improvements in productivity, safety, innovation and sustainability. Yet equipment is not the only common thread between the four focus areas for underground mining. Among the various maintenance needs outlined by the Voice of the Underground Customer research, there is one requirement that underpins all the others: **the need for expert support**.

It is not enough for underground miners to have suppliers who provide them with high-quality lubricants. In fact, lubricant selection is often only one step for maintenance teams to take on their route to an effective, holistic lubrication programme (see: How the experts build a comprehensive, holistic lubrication programme). Sites need highly skilled maintenance teams on hand to create the environment in which they can ensure the products themselves deliver their intended performance benefits. This means it is crucial for miners to work with suppliers who can make professional site assessments to identify lubrication gaps and opportunities and provide in-depth training to help their maintenance teams improve their lubrication programmes, keeping up with changes in equipment and lubricant technologies. Not only can this training upskill site teams in the use of new digital tools, but it can also help them to mitigate the workforce skills shortage – bridging a talent gap that shows no sign of abating soon.

Underground miners are already looking to their suppliers for this level of support. For instance, the delivery of technical expertise and consultation – covering elements such as oil analysis and monitoring – is seen as key. Safety training to help site teams comply with international standards, local government regulations and commodity-specific guidelines is also vital. Miners are exploring how their suppliers can provide programmes that help them protect equipment and personnel. Another critical area for expert support is the ongoing digitalisation of underground mining. Miners want support from suppliers who can demonstrate their own leadership in this space through the provision of digital tools and services. They also want to work with suppliers who can help them integrate new technologies – including real-time monitoring tools – into their operations. Again, predictive maintenance driven by oil condition monitoring is an effective example of how miners are keen to work with suppliers to make the most of the lubricant products they use.



Miners are exploring how their suppliers can provide programmes that help them

protect equipment and personnel

How the experts build a comprehensive, holistic lubrication programme

To maximise efficiency and extend equipment lifetime, underground miners need to work with expert suppliers to create the right environment for optimal lubrication. This includes the following steps:

1. Improve monitoring and analysis of overall lubrication practices (through total fluid management and dispensing intelligence)
2. Focus on controlling fluid contamination
3. Implement oil condition monitoring
4. Explore available options for temperature control
5. Optimise lubrication practices through training
6. Gain a complete understanding of machine specifications and lubricant applicationstraining
7. Select the right quality lubricants for each application training

Implementing this approach might require a culture shift and can support miners to overcome the cost barriers in place, depending on the site processes in place. However, the productivity, safety and sustainability benefits of implementing effective lubrication practices outweigh the cost for their implementation.

Yet it is not all about expertise. Miners also need to know they can trust their suppliers to deliver based on a track record of working with companies to improve equipment operations across underground and open-pit sites. Ultimately, underground miners must look at lubrication and maintenance holistically – and select their suppliers accordingly as total solutions providers. By collaborating with expert solutions providers who can back up the products and services with the right technical support, underground miners will be better placed to break new ground in productivity, safety, innovation and sustainability while delivering the materials that society and industries depend on today and in the future.

Find out more about how Shell can work with you to achieve your performance and sustainability goals.

Visit Shell.com/mining

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