INGERSOLL RAND WHITE PAPER | NOVEMBER 2023

Using Compressed Air to Prevent Downtime and Improve Quotas in the Mining Industry

Ingersoll Rand®

Table of Contents

Introduction

In 1986, a mining tradition dating back to 1911 that used canaries to detect carbon monoxide and other toxic gasses in mines before they could cause harm to humans ended. The archaic and inhumane tradition was replaced with digital gas detectors that ensured the mines were safe before humans went inside.

Working deep underground has always presented a range of complex challenges for miners. The hard-to-reach places where minerals and fossil fuels reside have pushed the industry to rely on the best technological advancements available to ensure worker safety, maximize production and minimize environmental impact.

Compressed air systems have played a crucial role in many modern mining operations. They are used to improve mine safety, as well as allow for more efficient resource extraction. To keep up with the demands of the mining industry, compressed air technology has developed and improved over time.

In an effort to increase output, watertight chambers were added. New filtration systems helped miners overcome the challenges posed by water, as well as improved the performance of equipment, like rock drills. Better ventilation and cooling were provided, offering the industry unparalleled opportunities for research, development and extraction. This was all thanks to the introduction of compressed air, and its value to the industry has only continued to grow since.

In This White Paper, You Will Learn:

- The growth of compressed air in the mining industry and how it is used in mining processes
- How you can use compressed air to prevent downtime and improve quotas
- The expert compressed air solutions we have available to you
- How to find service and maintenance programs that optimize the total cost of ownership

Ventilation is essential in mining, especially in the deeper tunnels where fresh air is non-exsistent.

The Growth of Compressed Air in the Mining Industry

In 1799, an English inventor by the name of George Medhurts created the first motorized air compressor system for the mining industry. More than 50 years later, Isambard K. Brunel expanded on the use of compressed air underground by creating ways to help prevent water and mud from entering waterlogged workspaces like bridge construction sites. Soon afterwards, an English engineer, Thomas Cochrane, invented a better compressed air rock drill that allowed workers to tunnel.

These early successes in compressed air-driven machinery promoted years of research and development and the subsequent improvement of mining technology; a practice which has continued more than two centuries later.

As the mining industry and the demand for consumable natural resources have continued to grow, so have the demands placed on compressed air systems used in the industry. From exploration and ore processing to smelting and refining, the entire mining process requires some form of compressed air.

Today, a wide range of different, complex compressor systems that are designed for both large and small tasks are available. These systems allow for more efficient ways to move coal and other mining materials. They also help to provide better ventilation, especially deep inside the tunnels where fresh air is non-existent.

Compressed air efficiently powers rotating drills that act like jackhammers. Dry air extends the life of pneumatic tools and equipment.

How Compressed Air is Used in Mining Processes

Compressed air is used throughout the entire mining process; this includes everything from exploration to smelting.

During exploration and extraction, a range of compressed air systems are commonly used to power things, like drills, conveying systems, and other pneumatic tools that require a steady stream of clean, dry air to operate efficiently. To achieve this quality of compressed air, the presence of downstream and air treatment equipment is critical to remove moisture and any other contaminants from your air. Not only does this ensure optimum air quality, but it also protects the longevity and performance of your conveying systems and pneumatic tools.

Mined ores and other raw materials are refined to increase the purity of the metals

High-velocity streams of compressed air are also used to trigger controlled explosives that allow miners to break through the ground and extract raw materials. Due to this demand for high-velocity air streams, you may want to request an air audit to ensure your existing equipment is up to the challenge!

Compressed air systems are vital in keeping miners safe while working deep underground in hazardous conditions. These systems vent dangerous gasses out of the mine, provide clean breathing air, remove water and moisture from the site and safely move and handle materials around the site.

Once the ore has been removed from the ground, the refining process relies on compressed air to promote oxidization. This process helps miners to maximize output and increase the quantity and purity of minerals and metals in the ore. Compressed air systems are also vital in downstream processes like smelting and floatation. These applications allow miners to efficiently and safely extract minerals and metals from the mined ore.

Mining Applications Where Compressed Air Works Best

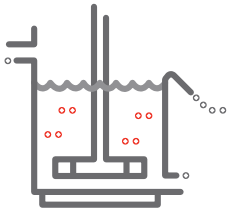
Many surface and subsurface mining operations require steady, high-volume flows of compressed air at lower pressures. There are a range of applications where low-pressure compressor technologies can help to maximize efficiency without compromising reliability.

Exploration Drilling

Just like a jackhammer is used to break apart concrete and other materials in the construction industry, miners rely on high-powered pneumatic drills to penetrate rock formations to access minerals. Pneumatic drills use compressed air to drive the drill bit in a percussive movement similar to that of a jackhammer.

The compressed air used by the drill not only drives the drill bit but also prevents it from overheating and helps to bring cuttings to the surface. It also helps to maintain the structural stability of the formation that is being drilled.

Clean, dry compressed air is essential to power these pneumatic drills, meaning an effective downstream system is vital to prevent moisture from impacting the performance and longevity of your equipment. This is essential for exploration drilling, where rust and corrosion can cause equipment safety breaches!



Froth Floatation

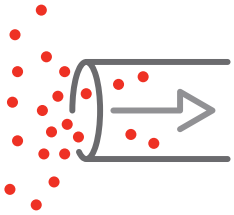
Froth floatation is one of the most important technologies in modern mining. It enables efficient recovery of precious metals from even the lowest grade ore. The process uses chemicals to exploit the natural hydrophobicity of minerals and separates them from the waste gangue. The mined ore is crushed and placed into a flotation cell, where it is mixed with chemicals to form a pulp or slurry.

Compressed air is then introduced into the flotation cells, aerating the slurry to produce bubbles that attach to the hydrophobic materials, allowing them to float to the top of the slurry, forming a froth. The tailings, or materials that do not float to the top are collected. They are then put through floatation again to further enhance recovery.

Heap Leaching

Heap leaching is a chemical process that uses a series of chemical reactions to extract dissolved minerals, like copper, uranium and gold, from mined ore. While there is some variation depending on the type of ore and the concentration of minerals within that ore, the general leaching process is the same -the mined ore is crushed and placed onto a leach pad, where a leaching solution is then added to the heap.

Compressed air is used to optimize the heap leaching process. A steady stream of low-pressure compressed air is pushed through the leaching pad, aerating and mixing the solution to ensure a more even distribution of the leaching solution, maximizing the potential for recovery throughout the leach cycle. Due to these specific pressure requirements, an air audit may be required to analyze whether your current system can meet these demands!



Material Handling

The mining process generates a range of fine materials, like coal dust. This can be hazardous to workers' health if not handled properly. Many mining operations rely on compressed air to enable processes, like fluidization and conveying, that maximize worker safety by reducing their exposure to potentially hazardous fine particulates.

The fluidization process introduces a steady flow of low-pressure compressed air into a chamber filled with fine particulate matter, causing it to liquefy and behave like a fluid or gas.

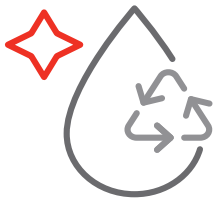
Compressed air is also used in pneumatic conveying systems that are used to safely and efficiently move various materials and ore into (backfilling) and out of (extraction) the mine. As mentioned before, any pneumatic tools or conveying systems will require a consistent stream of clean, dry, compressed air. This means an effective downstream system is essential for material handling, not only to protect your equipment but also to ensure filtered, clean air to maximize worker safety!

Ventilation Systems

The introduction of sensors, instead of canaries, to detect gasses such as carbon monoxide and methane in mines was a positive step towards improving worker safety; however, it didn't completely eliminate the risk to mine workers until the advent of ventilation systems.

Ventilation systems are driven by compressed air and have the ability to filter air from harmful gasses and contaminants. They also remove dust and other particulates that can be harmful to humans if inhaled. These systems can also be used to flush the air inside a mine prior to workers entering, ensuring a safe and comfortable working environment.

Worker safety is of optimum importance in the mining industry, meaning a downstream system should be present in your set-up to ensure that only the highest-quality air is entering your ventilation systems.



Wastewater Treatment

Mining operations require large amounts of water to perform a range of processes, from conveying and mineral extraction to cooling and waste management. Water used in many of these industrial processes is often contaminated with chemicals, bacteria, and pollutants, making it potentially hazardous to the local flora and fauna, as well as the communities in areas surrounding the mine site. Therefore, wastewater from mining operations needs to be treated before being disposed of.

Aerobic wastewater treatment is used by many sites to effectively treat water by removing harmful chemicals and pollutants and allowing it to be re-introduced into the local environment.

The process is similar to that of froth flotation, where wastewater is placed into tanks and then aerated to promote the growth of bacteria that effectively separates harmful chemicals from water. Compressed air is required to not only introduce oxygen into the mixture but also provide continuous agitation to further promote the growth of bacteria and maximize the effectiveness of the treatment process.

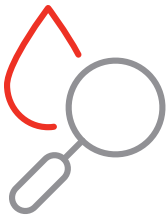
Removing the Pain Points

How to Use Compressed Air to Prevent Downtime & Improve Quotas in The Mining Industry

As mentioned, compressed air plays a vital role in your mining operations; however, maximizing the value of your compressed air system can be complex and overwhelming. As your compressed air solutions partner, Ingersoll Rand can take the burden off you, collaborating to design, deliver and install compressed air systems that are a perfect match for your operations. We can also help you to use your compressed air to prevent downtime and improve quotas! But how can we do this?

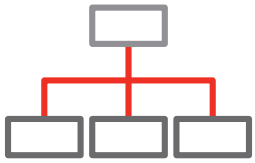
1. AIR AUDIT

The first step to maximizing the value and efficiency of your compressed air equipment is to undergo a comprehensive air audit. This will involve a thorough analysis of your existing system in order to detect any issues, leaks, inefficiencies, or potential areas of improvement. From here, we then work with you to identify the exact compressed air needs for your mining applications. We then either make enhancements to your existing system or design a compressed air system that delivers the right level of quality, quantity and power required by your processes. We can also oversee the installation process and recommend service and maintenance programs that will effectively align with your operations to optimize your total cost of ownership. This will mean that your system is entirely tailored to your exact needs, helping you to operate more efficiently whilst also preventing the risk of unexpected downtime due to equipment not being up to scratch!



2. OIL SAMPLING

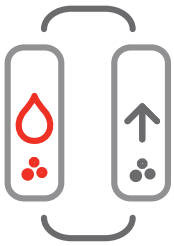
As mentioned, air quality is critical in the mining industry, particularly for ensuring worker safety and for preventing equipment damage. Therefore, by maximizing your air quality, you can prevent downtime due to health and safety breaches or equipment breakdowns, thus improving quotas. But how can you ensure the quality and usability of your compressed air? One way is with oil sampling assessments. This service will provide you with a comprehensive report about any external or internal contamination that may impact your compressed air equipment. It looks at the quality of the oil or lubricant in your system and the inner workings of your system, its components, and its ambient conditions. Identifying these issues is vital to ensure optimal air quality, as contamination in the oil or lubricant in your system can have detrimental impacts on your compressed air. This assessment means that any issues can be dealt with, and a predictive, proactive maintenance plan can be created based on the typical degradation period of your oil. Frequent changing of the lubricant in your system is essential to prevent equipment damage that could lead to safety breaches, meaning it is vital to ensure the safety of your mining processes. It's also important to ensure you are consistently producing Class 0 ISO air for your mining processes, particularly for those that involve ventilation systems, material handling, powering pneumatic tools and conveyance systems, as high-quality, safe air is non-negotiable!



3. AN EFFECTIVE DOWNSTREAM SYSTEM

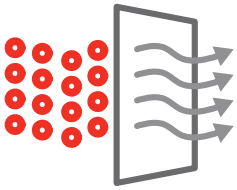
Another way to maximize your air quality is by having an effective, reliable downstream system in place to ensure you are producing clean, dry air at a steady pressure! This consists of 3 components:

Dryers:



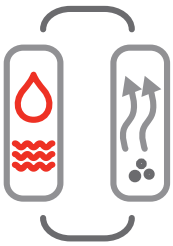
To prevent downtime and equipment degradation, an efficient compressed air dryer is essential, as it helps to remove moisture from your compressed air. There are a range of dryers on the market, including refrigerant, which are better suited for general applications, and desiccant, which offer ultra-dry, high-quality compressed air at a lower pressure dew point. If you want to utilize wasted compression heat, there are also heat of compression dryers, which are the most energy-efficient on the market! Due to the heavy pneumatic and conveyance tools used for the mining industry, we'd recommend a desiccant dryer due to its effectiveness at removing moisture and producing ultra-dry air! This is important to ensure workplace safety and prevent rust and corrosion from damaging your equipment, which could potentially lead to health and safety breaches.

Filtration System:



A filtration system is an essential part of any downstream or air treatment solution, as it helps to remove contaminants and impurities such as oil, dust and moisture. This is essential, particularly for worker safety, as the mining industry deals with a lot of harmful chemicals! It is also important to ensure the consistent production of clean, dry, high-quality air for all of your mining processes and applications.

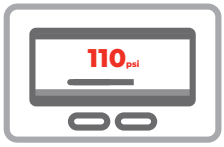
Condensate Management & Treatment:



The last element of an effective downstream system is a condensate management and air treatment unit. This is an essential part of your compressed air set-up, as condensate is a natural by-product of compressing air. Typically, the best way to deal with condensate is by implementing a condensate management unit, which often contains timer-controlled zero-loss drains. These drains will transport the condensate into an oil water separator, which will separate it out before removing it from your system. An oil water separator is a fundamental piece of kit when managing condensate, as it ensures it is correctly removed from your system in a way that adheres to strict industry regulations. The removal of condensate is also essential to ensure that the air that you use to power your pneumatic and conveyance equipment is of a high quality, helping to prevent equipment downtime!

4. EXPERT COMPRESSED AIR SOLUTIONS

The easiest way to prevent downtime and improve quotas is to have a compressed air solution that stands up to the challenges of the mining industry. With various compressed air configurations available, including fixed or variable speed drives, single or two-stage airends, as well as Total Air System packages, our team collaborates with you to design a completely integrated solution that maximizes efficiency and air flow.



5. SYSTEM MONITORING & MANAGING

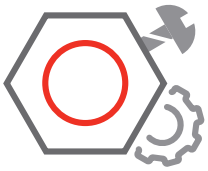
To prevent downtime and improve quotas, compressor monitoring and management is vital! This can be done with a compressor controller, which allows you to adjust flow rates and pressure to prevent inefficiency and make sure your compressed air meets your exact requirements. Due to the often challenging nature of mining processes and

applications, this is important to ensure your operations can run smoothly and safely without any unexpected equipment breakdowns or health and safety breaches that will lead to downtime.

At Ingersoll Rand, we also offer our 24/7 remote monitoring system - the Helix™ Connected Platform! This is discussed in more detail in the Services and Maintenance part of this Whitepaper, but effectively, it is an efficient compressor monitoring system driven by innovative IIoT technology. It provides you with valuable insights and full transparency into your compressed air system to ensure you are operating at your most efficient to prevent downtime and improve quotas!

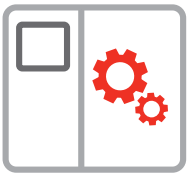
6. HEAT RECOVERY SYSTEMS

Not necessarily to reduce downtime and improve quotas but more to do with maximizing the cost and energy efficiency of your mining processes is the potential for a heat recovery system. Heat is a natural by-product of the compression process, and due to the often challenging conditions and demands of the mining industry, your operations will produce a lot of heat. But did you know that 90% of the wasted heat can actually be recovered and used? By implementing a reliable heat recovery system, you can reuse this heat within your operations, for heating process water or your facility, allowing you to save 1000s of dollars a year! Not only does this help maximize your efficiency and productivity, but you are also drastically reducing your carbon footprint, which is particularly important within the mining industry, as some processes can be considered invasive and pollutant.



7. WARRANTIES, OEM PARTS & MAINTENANCE

Understanding the additional services available to you is vital to optimize your total cost of ownership and extend the life of your compressed air equipment. However, it is also important to prevent unexpected, costly downtime and improve quotas in your mining facility. For example, at Ingersoll Rand, we offer a suite of comprehensive CARE packages to help you predict and prevent any downtime or periods of inefficiency. You can find out more about these later on in the Whitepaper, but they include everything from warranties, scheduled maintenance, remote monitoring, spare genuine OEM parts and accessories, as well as total asset management. No matter what your mining facility or compressed air system needs, Ingersoll Rand ensures you are receiving the exact service you need!



Powering Critical Tools and Equipment - Achieving The Compressed Air You Need

There are many opportunities for high-quality compressed air systems to be used across your mining operations. At Ingersoll Rand, we pride ourselves on offering a broad portfolio of tools and equipment that are needed to work in the mining industry safely and efficiently. Our reliable air compressors can be used in both surface and subsurface mining to power pneumatic tools, equipment, and ventilation systems. They are also used to power hoists and winches that help support material processing production.

Ingersoll Rand oil-flooded rotary screw air compressors offer the very best combination of time-proven designs and technologies, as well as advanced features that ensure the highest levels of reliability, efficiency and productivity. Our world-class products and services, and the peace of mind that comes from our commitment to stand behind our customers in all aspects of what we do has cemented our reputation as a reliable, industry-leading partner in compressed air.

Efficient operation: A significant portion of mining energy costs can be associated with compressed air. Our rotary screw compressors are designed to minimize energy use to lower your operating costs. They achieve this by utilizing:

- Advanced airends and motors that deliver uncompromising efficiency
- Optional two-stage airends and variable speed drives (VSD) to save even more on energy costs, even at partial loads
- Simplified, compact package designs for easier access to internal parts, quicker maintenance, minimized piping and reduced connections

Built-in reliability: You need a compressor system that is designed to operate over long periods of time in locations with extreme temperatures or dirty environments that are difficult to access. That's what you get with Ingersoll Rand rotary screw compressors. We achieve high levels of reliability through:

- Durable package designs and drive components, as well as robust hoses and pipe connections to eliminate leaks
- Intuitive control systems to ensure reliable operation by continuously monitoring operational parameters
- Air treatment products, including air dryers and filters, that remove moisture and contaminants from your compressed air system, extending equipment life
- Industry leading synthetic lubricants that are better for the environment, last longer, are less expensive and are less prone to contamination.

Service and Maintenance Programs

There are many applications in which you will require high-quality compressed air in your plant. You also now understand how to use compressed air to prevent downtime and improve quotas in the mining industry. Now it's time to look at how to service and maintain your equipment to avoid unplanned, unbudgeted downtime and production interruptions.

Lower cost of ownership, quality results, increased uptime, and efficient energy use all add up to peace of mind.

Lower cost of ownership, quality results, increased uptime, and efficient energy use all add up to peace of mind.

PackageCARE™: We Protect You

- The greatest value for asset management
- Transfer operational risk for up to 10 years
- Includes all scheduled maintenance
- Predictive and analytical tools prevent production interruptions

PlannedCARE™: We Help You

- Predictable, on-time planned maintenance
- Preventative diagnostics to catch potential problems
- Up to five-year coverage on major airend components in new rotary compressors

Performance Services

Our performance services include electronic, air leak and system assessments. Whether you need to manage costs, increase reliability, or plan for future growth, our portfolio of assessment tools provides you with detailed diagnostics that give you the proper insights to help lower the total cost of ownership.

System Automation

System assessments often identify waste caused by a lack of adequate controls. Our suite of system automation solutions lowers energy costs and stability pressure.

HELIX™

24/7 Remote Monitoring With The Helix™ Connected Platform

Developed to maximize uptime and peace of mind, the Helix™ Connected Platform from Ingersoll Rand gives you real-time monitoring that provides visibility into machine functionality and equips you to operate at maximum efficiency. Your team will have direct access anytime to Helix™ insights and diagnostic reporting that can help prevent lost productivity from unforeseen breakdowns. Maintenance scheduling is simplified thanks to proactive service reminders and automated communications that help to preserve machine health.

There's a lot riding on the quality of your air. Let Ingersoll Rand help you get it right!

Reliability for Life

- Generate air in any environment. We offer solutions that operate indoors and outdoors in compact spaces and extreme temperatures.
- Enjoy increased oversight with controls you can access remotely. Regulate your air use with compressor controls that monitor critical operating parameters and adapt the system to prevent downtime.
- Designed for easy serviceability and maintenance, our compressors minimize the total cost of ownership.
- An extensive catalogue of OEM genuine consumable and replacement parts are available to you to make service and maintenance easy and cost-effective. Genuine OEM parts guarantee a perfect fit and function to the highest quality standards.

About Ingersoll Rand Inc.

Ingersoll Rand Inc. (NYSE:IR), driven by an entrepreneurial spirit and ownership mindset, is dedicated to helping make life better for our employees, customers and communities. Customers lean on us for our technology-driven excellence in mission-critical flow creation and industrial solutions across 40+ respected brands where our products and services excel in the most complex and harsh conditions. Our employees develop customers for life through their daily commitment to expertise, productivity and efficiency. For more information, visit irco.com

ingersollrand.com

Member of Pneurop

Ingersoll Rand compressors are not designed, intended or approved for breathing air applications. Ingersoll Rand does not approve specialized equipment for breathing air applications and assumes no responsibility or liability for compressors used for breathing air service.

Nothing contained on these pages is intended to extend any warranty or representation, expressed or implied, regarding the product described herein. Any such warranties or other terms and conditions of sale of products shall be in accordance with Ingersoll Rand's standard terms and conditions of sale for such products, which are available upon request.

Product improvement is a continuing goal at Ingersoll Rand. Any designs, diagrams, pictures, photographs and specifications contained within this document are for representative purposes only and may include optional scope and/or functionality and are subject to change without notice or obligation.