

SAMPLING, PREPARATION AND ANALYSIS MINING

Good data. Sound decisions.
Strong margins.



FLS

Sampling, preparation and analysis fact sheet



SUSTAINABILITY

AUTOMATED LABORATORIES REDUCE EMPLOYEE EXPOSURE TO MANUAL HANDLING HAZARDS, NOISE EXPOSURE AND DUST INHALATION



AUTOMATION

LABORATORY AUTOMATION OFTEN REDUCES LABOUR COSTS BY HALF OR EVEN MORE



ONE MINING COMPANY

THREE LABORATORIES –
FIVE YEARS – 4.5 MILLION SAMPLES –
ZERO TRIFR



MILLIONS \$ SAVED

REPRESENTATIVE SAMPLING CAN SAVE MILLIONS OF DOLLARS IN INCORRECT ORE GRADE ANALYSIS



EFFICIENCY

AUTOMATED SAMPLE PREPARATION SIGNIFICANTLY IMPROVES DATA QUALITY AND CAN REDUCE MISCLASSIFICATION OF ORE AS WASTE PRODUCT



EVALUATION

THE SUBSTANTIAL COST OF IRRELEVANT DATA VARIABILITY IS NOT EASY TO DETECT, QUANTIFY, OR CORRECT. YOUR DECISIONS ARE ONLY AS GOOD AS YOUR SAMPLES

36 MILLION REASONS WHY CORRECT SAMPLING AND SAMPLE PREPARATION ARE IMPORTANT A GOLD RESOURCE DEFINITION SCENARIO

You have identified a resource of 1.18 million tonnes of ore, which you believe to be grade 6.3 g/t Au. That's about 240,000 oz gold. Your calculation includes a relative standard deviation of 10%. That is 24,000 oz gold or US\$36 million in gold value. That's roughly half the cost of a 450 tpd gold plant.

Size matters. Understanding the value of better sample preparation and sub-sampling is extremely valuable and goes a long way in reducing your exploration risks.

Improved profitability. Greater efficiency. Optimum quality.

It all starts with reliable data

Low grade deposits and the increasing cost of processing are dampening profitability across minerals industries. But could you be making more of your mineral deposits? Representative sampling and accurate analysis provides the data you need to optimise all aspects of your exploration and mining processes.



**Greater control over
the life of your mine**



**A sound basis for
making process decisions**

What you get



**A better-quality product –
and the proof to back it up**



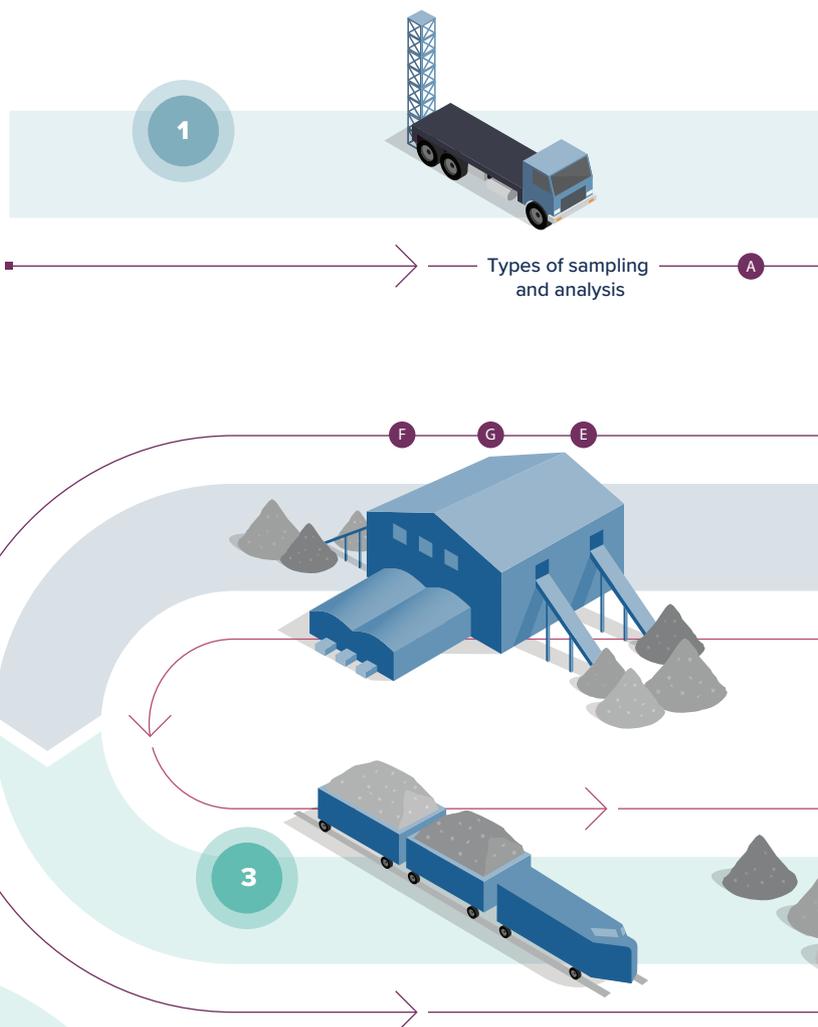
**Improved profitability
and process efficiency**

SOLUTIONS OVERVIEW

1. Prospect. Insights to where to mine.

From mineral exploration to mine development, good samples, properly prepared and precisely analysed, will help determine where and how to mine to get the most from your deposit.

- Exploration
- Ore reserve and resource estimation
- Mine development

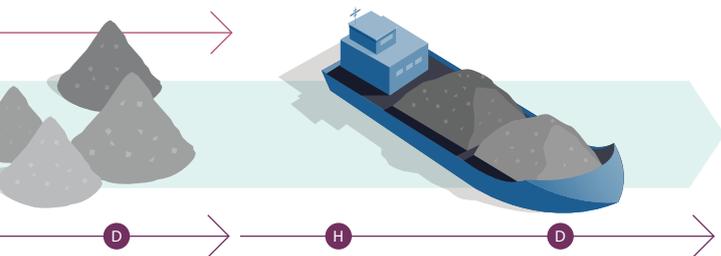
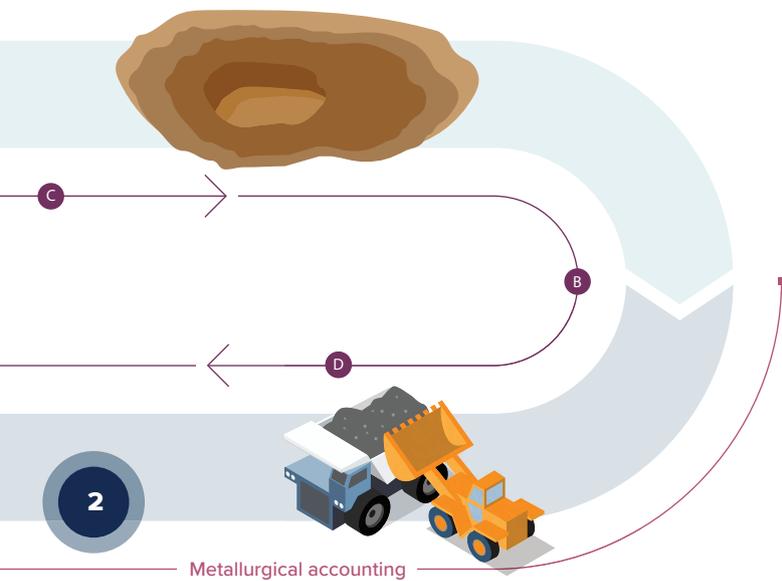


3. Product. Establish your worth.

Correct sampling and analysis of your product enables you to establish its worth, both as a seller and a buyer. Accuracy is the key to building customer trust.

- Inventory control
- Commercial transactions





"Poorly designed geochemistry protocols can result in elevated project risk by increasing variability. Critically, such variability produces both financial and intangible losses. Sample collection, preparation and assay procedures and equipment that are optimised to suit the ore type, together with QAQC systems, will reduce variability".



Prospect: Strategic decisions begin with representative samples

The number of high-grade deposits is falling, yet demand for minerals remains high. Making the right investment to ensure maximum profitability over the longest possible term depends on sound data, which starts with analysis you can trust.

Exploration demands reliable and timely data

When it comes to defining investment viability, the laboratory plays a key role. Obtaining the right samples and making sure they are properly prepared and accurately analysed – these are all critical steps in determining whether or not this multi-million-dollar investment goes ahead.

With high sample volumes and often very low elemental levels, it's easy for contamination to occur, whether by mixing with other samples or from the equipment itself. At best, these tainted samples are unusable – a waste of time and money. Worst case scenario they mislead your whole decision-making process.

With such high stakes, you need reliable sample preparation and analysis equipment from a supplier who understands the challenges in the field. Which is why you need FLSmidth. Our long association with the exploration industry ensures our products and services make a positive impact in overcoming real-world geochemistry challenges.

Laboratory equipment for exploration and mining operations

For over 30 years, we have led the way in engineering laboratory sample preparation equipment. We pioneered the development of large-capacity pulverising systems using our unique bowl and disc grinding elements. Today our drying ovens, crushers and pulverising mills are used extensively on mine sites, exploration camps and in commercial assay and research laboratories around the world.

On the analysis side, our laboratory solutions provide precise testing that gives confidence to mine exploration and development projects. Readily transportable and relocatable containerised laboratories are a specialty, available fully-equipped and stocked if required. You can also make the most of the experience of our in-house laboratory staff, who help with all aspects of laboratory design.

We offer a total package of sample preparation, metallurgical testing and laboratory equipment solutions that cater to a full spectrum of requirements. This includes total lifecycle support through the delivery of spare and wear parts and consumables.

We also offer laboratory audits to help you achieve maximum efficiency, quality and safety of your preparation and analysis systems.

The potential for quality errors can occur all the way along the sample chain from the field through to final analysis and reporting. Appropriate sampling, preparation and handling protocols, together with well-chosen equipment, can minimise uncertainty in the data.

Here is one estimate* of the amount of possible uncertainty:

Field sampling	10% to >100%
Storage and transport	<1% to >100%
Sample preparation and sub-sampling	10% to >100%
Chemical preparation	5% to 20%
Chemical preparation	1% to 10%
Reporting	<1%

* Dr. Ed Paski, CMA 2005

Safety by design

All manual handling comes with risk. You can mitigate that risk by selecting equipment that is fit for purpose, safe to operate and requires minimal maintenance. Our equipment is designed with these principles in mind: robust and reliable tools that cope with the rough demands of mineral exploration job sites, while providing the accuracy required to guide good decision-making.

Reliable data reduces exploration risk

Mineral exploration isn't a quick job. For every day the work goes on, the cost goes up. Again, the onus is on the laboratory to provide the information needed to get to work. Drill rigs have to be paid for, whether they are being used or not. The quicker the turnaround on sample analysis, the sooner decisions can be made on where to drill next.

Process: Continuous insights drive optimum productivity

Your process moves fast. Can your lab keep up? Regular sampling and laboratory analysis together with online solutions paints you the best picture of your product as it moves through the process, giving you the data you need to drive efficiencies and save money.

Ore deposits are naturally occurring – they are bound to be irregular. But with regular sampling and analysis, you can see those variations coming and make the necessary adjustments accordingly. Whether that's ore coming from the mine or from the stockpile, it's essential to know exactly what you're dealing with at all times to avoid pitfalls such as:

- Low product quality
- Too high quality – using up the high-grade ore that should be used to extend the life of your mine
- Process inefficiencies caused by unexpected material properties
- Product forecasting problems
- Ore being misclassified as waste

Analysis that works as hard as your process

Process sampling has to be reliable to be effective. We use specially designed equipment based on accepted sampling practises to extract samples throughout the process, preferably at points where there is a falling stream of product. This way, samples can be extracted quickly and easily from the full width of the product stream using our linear or rotary samplers.

Our online analyser uses x-ray technology to provide continuous, real-time elemental analysis of the slurry, ensuring you're unlikely to be caught unawares by changes in the process stream.

Over in the laboratory, sample preparation and analysis is carried out in our state-of-the-art automated laboratories. Automating these tasks ensures that the sample bias is reduced, providing a solid basis for monitoring and analysing process trends. The repetitive nature of analysis at this stage in the process is ideally suited to automated technologies, which deliver improved precision and reproducibility while providing a full audit trail. Moreover, the results are calculated quickly and precisely and reported automatically. Of course, automation also offers cost and capacity efficiencies, in addition to safety benefits, compared with manual techniques.

The importance of sampling – copper process plant example:

At one copper process plant, the tails were sold to a third party for treatment. This amounted to about 96,000 tonnes of ore per day. Based on their calculations, the plant assumed a tails grade of 0.15% copper, working out at about 144 tpd.

But after many years of making this assumption the plant installed a representative sampling station that revealed the actual tails grade to be 0.2% copper, or 192 tpd.

The plant worked out that this difference in assumed vs actual grade of copper cost them \$105,600 per day. That's \$38.5 million per year for 20 years.

The capex cost of a representative sampling system for tails stream? A comparatively meagre \$500,000.

Benefits

The benefits of representative sampling, best practice sample preparation and accurate analysis during minerals processing extend beyond improved management of the process chemistry. You also get a fuller understanding of your process, which makes it easier to diagnose and solve problems as they arise, and to understand where inefficiencies are occurring and what can be done about them.

All this process insight helps with overall communication – especially to management, who are able to add this perspective to their overview of operations and create a more informed flowsheet design.

"The starting point of an efficient metal accounting system is a precise understanding of the process operations. It should rely on an accurate sampling and measurement system".



Product: Know your worth

Miscalculations can cost more than just money. If your product doesn't meet the required quality standards, you lose customer trust. On the other hand, if you are underestimating your ore, you could be missing out on revenue. Representative sampling and accurate analysis is the best way to ensure that everyone is getting a fair deal.

Our products and services have been designed to make a difference in overcoming the challenges encountered every day at mining and mineral processing operations, including:

- Plant sampling
- Sample transport
- Sample preparation
- Analysis
- Data collection and management
- Inventory management
- Sampling audits
- Laboratory operation and maintenance

The value of accuracy

With the high tonnage going through ports and railyards, it is critical that you have a system in place that ensures the samples you are analysing are truly representative. If you don't, your buyers will.

Best practice sampling

Best practice involves firstly taking a representative primary sample from a conveyor. This is followed by degrees of subdivision, both in volume and particle size, to arrive at a manageable sample for analysis that is representative of the original primary ore.

We engineer complete sampling solutions to achieve this goal. From small operators, to high tonnage mineral processing plants and ore shipment loading, we have samplers suitable for all stages in your process. Whether for primary, secondary, or tertiary sampling, or further sample reduction, our sampling equipment is designed to ensure the final sample presented for analysis is truly representative.

Of course, the discrepancy could work in their favour – but where does that leave you? Out of pocket.

Operate with confidence

The more you know about your product, the more efficient your operation will be. With accurate analysis, based on good quality, well prepared samples, you can be confident in:

Take this scenario as an example:

A manganese supplier is selling shipments at \$7.50/1% Mn per tonne. With a shipment sold as 46% Mn with an acceptable variation of $\pm 1\%$ (i.e. 45.5 – 46.5%), that's a value of \$345/tonne. The supplier intended to supply 45.5% Mn, but due to sampling inaccuracies they delivered 46.5% Mn. This 1% difference equated to a \$300,000 loss on one 40,000 tonne shipment.

This company was sending 50 shipments/year. If they were all 1% out, that's a \$15 million loss over the year.

- The accuracy of your mine plans
- Your knowledge of your resource basis
- The marketability of life of mine (LOM) products
- The validity of your LOM project assumptions
- The reliability of supply

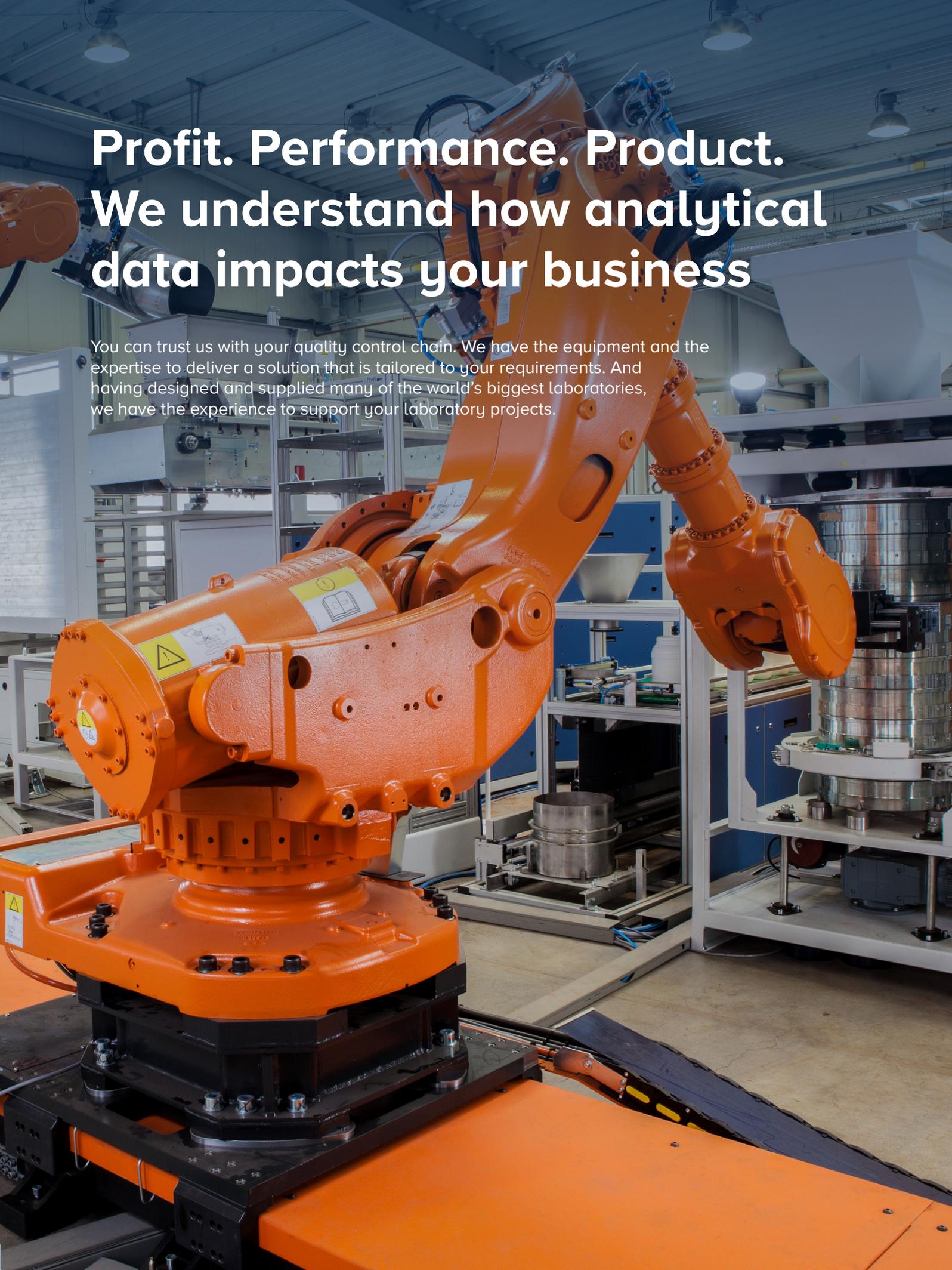
How can we help?

High tonnage sampling is our speciality. Our robust, reliable samplers are designed to withstand the rigours of fast-moving, heavy and abrasive falling product. Sample collectors ensure samples are secure and contaminant-free for transport back to the laboratory, where you have the choice of mechanical or automated size reduction and sample division technologies.

We also offer audits of your sampling systems and philosophy to assist you with standards compliance and theory of sampling.

A photograph of a worker in a white hard hat and a yellow safety vest standing on a large pile of bright orange material, likely iron ore. The worker is holding a small tool and appears to be sampling the material. In the background, there are large industrial structures and more piles of the same material under a clear sky. A blue text box is overlaid on the upper right portion of the image.

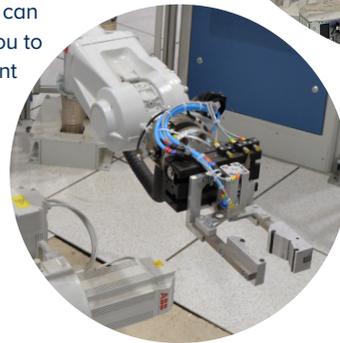
"If the sampling is poor, the entire measurement chain is corrupted at the outset – no amount of re-analysis can solve the problem".

A large, orange industrial robotic arm is the central focus of the image. It is mounted on a black base and is positioned in a laboratory or industrial setting. The background shows various pieces of equipment, including a large stainless steel container and a blue cabinet. The lighting is bright, and the overall scene is clean and professional.

Profit. Performance. Product. We understand how analytical data impacts your business

You can trust us with your quality control chain. We have the equipment and the expertise to deliver a solution that is tailored to your requirements. And having designed and supplied many of the world's biggest laboratories, we have the experience to support your laboratory projects.

- 90% world share of robotic mining laboratories
- Largest robotic sample preparation and wet chemistry laboratory in the world for Freeport
- Largest fully automated iron ore laboratory for BHP
- Largest laboratory automation project in the world, sold to Anglo American. The size of a football pitch, it includes 14 robots
- More than 825 million tonnes of iron ore, 50% of the global export market, is shipped from Australian ports every year. The vast majority of this ore will be sampled by Essa® mechanical samplers



You don't need to be planning a world-first laboratory to come to us. We support labs of all sizes and any age. If you're concerned about your existing laboratory operations, we can help. A lab audit will identify any weak spots, enabling you to tighten up practises and recalibrate equipment to get plant performance back on track.

A UNIQUE COMBINATION OF PRODUCTS, PROJECTS & SERVICES



PRODUCTS

- Our robust samplers are engineered and manufactured to conform to international sampling standards
- We're pioneers of large capacity sample preparation
- We've developed practical innovations in drying, crushing and pulverising equipment
- We've designed online and inline analysers to deliver rapid process control data
- We offer specialist analytical instruments and apparatus for the assay laboratory



PROJECTS

- Whether a greenfield or brownfield project, we have the solutions from sampling to analysis
- Engineered, representative sampling systems
- Sample transport systems to transport samples automatically, safely and quickly
- Manual laboratory installations
- Containerised laboratory projects
- Intelligent and flexible automated laboratory solutions



SERVICES

- Audits on sampling systems and sampling philosophy
- Assisting with standards compliance and theory of sampling
- Audits on laboratories to maximise the efficiency, quality and safety of your preparation and analysis
- Operation and maintenance of laboratory automation systems
- Training
- Spare and wear part supply
- Installation, repair and maintenance

Our products and solutions

Essa® Laboratory Equipment

We offer a total package of sample preparation solutions, including pulverising mills, bowl and disc grinding elements, crushers, dryers, sample dividers, XRF preparation and particle sizing equipment. We also design and supply metallurgical testing equipment and specialist equipment and consumables for the assay laboratory. When it comes to thermogravimetric analysers, we offer both automated and semi-automated options to suit your application. Our robust solutions cater to a full spectrum of requirements across the minerals industries

Essa® Dry Bulk Sampling Systems

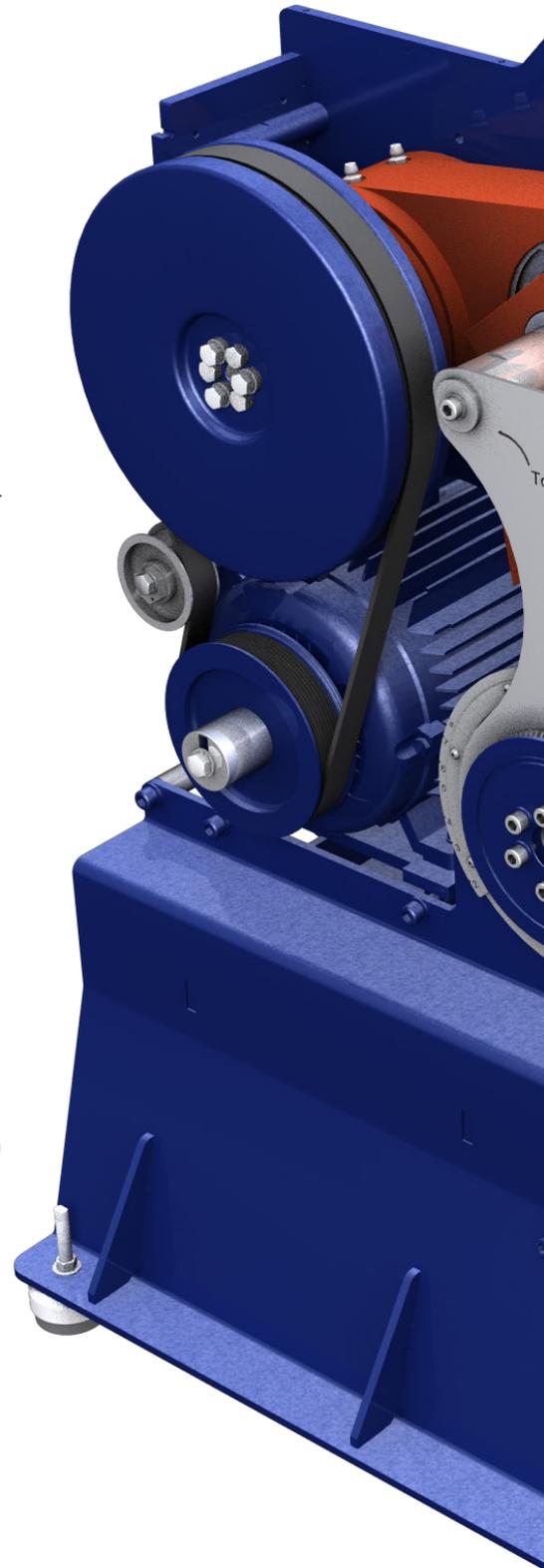
To get a truly representative sample, it's critical that your sampler's cutter shape, positioning and operation are designed so that every particle has an equal chance of being captured in the sample. We engineer several different types of falling stream samplers to suit different flow sheets and applications, including linear and rotary samplers. Suitable for exploration, mining, process plant, stockpiles and shipment loading and unloading, these samplers are designed for maximum uptime, minimal maintenance and a long life.

Essa® Slurry Sampling Systems

Our range of slurry sampling solutions is well tested and proven to perform even in the most challenging of settings. And because we have complete flowsheet expertise, we take in all the important issues like material type, pipe routing, pump requirements, slurry flow, and sampler location. With our specialist advice, you will have sampling systems positioned in exactly the right place in your process to get the accurate results you need.

PERI™ Online Slurry Analyser

Our PERI Online Slurry Analysis System is a technologically advanced, customisable solution for your plant. The system uses the latest in x-ray technology to provide elemental analysis of the slurry and can handle 4 – 6 streams with a single multiplexer and up to 12 by adding a second multiplexer.





Automated Laboratory Solutions

Our automated laboratory solutions are designed to enhance quality and reduce the health and safety risks associated with laboratory work. With the fast pace and high volume of minerals processes making it difficult for manual laboratory operations to keep up, automation improves equipment utilisation and throughput, giving laboratories a way of working at speed, at high capacity, all while maintaining the highest possible quality control standards.

Automated laboratory solutions also provide a full audit trail. Intermediate steps are monitored, allowing for rapid troubleshooting, as well as increased confidence in the accuracy of the analysis. Our remote asset management monitoring system further enhances performance and maintenance optimisation. Finally – but importantly – occupational health and safety risks are reduced, as fewer manual handling steps are involved with automated solutions.

We take full responsibility for your entire laboratory automation project, from feasibility through conceptual design, to planning, installation, commissioning, full competency based training and handover.

Automating laboratory operations is not a “one size fits all” solution. Diverse commodities, different mineralogy, unique applications and specific customer requirements all call for customised solutions.

We value the challenge to work with forward-thinking customers to engineer innovative bespoke automation projects covering almost every industry from alumina to zinc. We’ve been doing it successfully for over 30 years.

Essa® JC1250 Jaw Crusher



CUSTOMER STORY

Lab automation dramatically reduces health and safety risks

At a nickel laboratory in Australia, lab employees would spend their days and nights preparing and analysing samples. Working in shifts, they completed analysis of 250 samples per day. With the repetitive workload taking its toll on staff health, management decided to investigate automated laboratory solutions.

Defining the project

When it comes to laboratory automation, FLSmidth is a world leader. The customer had done their research and came to us to see how we could help create a better working environment in their laboratory. Together with the lab team, we embarked on a six-week pre-feasibility study that culminated in a proposed solution to design, build, install and commission five automated laboratory preparation and analysis modules. This would both eliminate the manual handling of potentially dangerous chemicals and increase the sampling capacity of the lab.

The solution

The new lab includes highly innovative equipment, such as the 3D particle sizer, which takes a photo of every nickel powder particle and uses 3D imagery to calculate sizing distribution. Liquor processing and powder preparation are taken care of without any need for operator intervention. The digestion module uses engineering controls to manage the process of using chemicals and heat blocks to dissolve the nickel in solution. A robot dispenses the acids and handles all flasks

from the point of entry until the task is complete, so there is no risk to the operator. Wash downs are also completed automatically. The module even includes an automated test tube sorter to eliminate the repetitive job of loading test tubes into position. Two analytical modules are in situ that are capable of analysing all existing plant samples and future samples at a rate of up to 1200 samples per day – far surpassing the previous testing capacity.

The results

The automated laboratory has delivered the health and safety benefits the lab team wanted – and more. With the increased sample processing capacity, the customer has the ability to increase the recovery of nickel and cobalt and reduce ammonia consumption. The plant is also well equipped to expand and diversify, given the capacity and capabilities of its new laboratory.



Digital services. Further optimising laboratory performance

- 24/7 remote equipment and lab-wide monitoring
- Global visibility anytime, anywhere on any device
- Proactive asset health monitoring – minimising unplanned interruptions to sample processing
- Maximise uptime – improved overall equipment availability
- Sample load optimisation – balancing work load and wear between equipment
- Empowering fast, informed decisions – confidently
- Early equipment fault detection – help prevent catastrophic failures
- Cost effective maintenance – profitability through reliability
- High quality diagnostic services
- Optimised spares inventory
- Scalable and fully flexible



Make the most of your sample – our experience, combined with specialised equipment, systems, software and service, provides a pathway to superior analysis.

Our extensive chemical and mineralogical knowledge, in-house laboratories and process expertise help you achieve:

- Accurate and timely results
- Improved quality and traceability
- Superior hazard management
- Standards compliance
- Seamless integration

We know what, where and how to sample successfully. When integrated with our automated laboratory solutions, we take your quality control and productivity to a new level of excellence.

Bulk Commodity Sampling (Essa®)

- Linear falling stream samplers
- Rotary falling stream samplers
- Cross belt samplers
- Sampling system dryers
- Sample collectors
- Sample feeders and size reduction equipment
- Sampling stations
- Project solutions

Slurry Sampling (Essa®)

- Metallurgical accounting samplers
- On-line analyser samplers
- Linear and rotary falling stream samplers
- Shark fin static cutters
- Pressure pipe samplers
- Project solutions

Laboratory Equipment (Essa®)

- Electric and infrared drying ovens
- Jaw crushers
- Rolls crushers
- Manual and automated pulverising mills
- Pulverising mill bowls
- XRF and XRD presses
- XRF bead fusion systems
- Sample dividers
- Automated particle size measurement
- Test sieves and sieve shakers
- Thermogravimetric analysers
- Flux weighing, dosing and mixing devices
- Fire assay flux mixing, multiload and multipour systems
- Crucibles and cupels
- Foundry crucibles
- Ball and rod mills
- Bottle rollers
- Certified pressure filters
- Flotation test machine

Online Analysis

- Sample multiplexers
- Slurry analyser
- Bulk material applications

Laboratory Automation

- Laboratory information management systems
- Automated sample transport systems
- Automated sample preparation systems
- Automated wet chemistry systems
- Automated analysis

Life Cycle Services

- Performance monitoring
- Remote service technologies
- Training courses
- Spare and wear part supply
- Installation, repair and maintenance
- Commissioning services
- Sampling system audits
- Laboratory audits
- Laboratory operation and maintenance services





1. ROTARY SAMPLE COLLECTOR
2. BALL SCREW LINEAR PRIMARY AND SECONDARY SAMPLERS
3. BELT DRIVE LINEAR PRIMARY SAMPLER
4. SYNCHRONOUS BELT DRIVE LINEAR PRIMARY SAMPLER
5. BALL SCREW LINEAR SECONDARY SAMPLERS
6. AUTOMATED SIZE FRACTION AND MOISTURE ANALYSIS LABORATORY

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