

# Mobile Analysis – Boosting Operational Efficiency, Profitability, and Safety throughout the Metals Manufacturing Process

The analysis of metals has become vital to the many industries that these materials underpin, including the automotive and aerospace sectors. The ability for on-site analysis of materials to deliver accurate results provides the means not only for product quality assurance and improvements to the efficiency of the production process, but also for ensuring the safety of the people who use those products. In response to this demand for materials analysis, Hitachi High-Tech Analytical Science Ltd. supplies analyzer equipment and solutions for a wide variety of alloys.

**Mikko Järvikivi**

## 1. Introduction

The introduction of mobile and handheld analyzers for materials analysis has revolutionized metals analysis in the 21st century. Today, analysis can be taken on the spot rather than bringing a sample into the laboratory, allowing immediate decision-making. Not only does this make the process more efficient, but accurate on-site analysis can also be a critical part of operational safety and even save lives.

Portability combined with ease of use and accurate analysis has made handheld analyzers an essential tool for professionals from mining to metals producers and fabricators. And, when a product reaches end of life, the value of the material is determined with handheld and mobile alloy analyzers.

Hitachi High-Tech Analytical Science Ltd. offers a solution for every step of the way and is the only

supplier today who can offer a complete range of alloy analyzers for virtually any analysis need (see **Figure 1**).





## 2. Principles of Surface Analysis

A number of different techniques are used for surface analysis, each of which works on different principles. This section explains these principles and the characteristics of the different methods.

X-ray fluorescence (XRF) uses X-rays to excite the atoms in the sample. Exposure to X-rays excites inner-shell electrons causing orbital vacancies to form. When an outer-shell electron falls to fill such a vacancy, it emits a photon with an energy that is characteristic of this electron transition. This process of restoring the electron orbitals to their ground state results in the emission of radiation that is characteristic of the elements contained in the sample. This emitted radiation is acquired by a detector. A feature of XRF is that it

**Figure 1 — Analyzers and Cloud Services Supplied by Hitachi High-Tech Analytical Science**

The handheld analyzers can accurately analyze objects on the spot in a short period of time. The OES instruments are used in a wide range of applications, ranging from laboratory analysis to use in the workplace or on factory piping. Use of ExTOPE Connect, meanwhile, not only provides shared management of analysis results in the cloud, it also allows remotely located experts to evaluate or assess results while leaving instrument operators to concentrate on the practical tasks of analysis.

Handheld XRF Analyzer X-MET8000 Series	Vulcan Series	OES Master Series	ExTOPE Connect
			
<p>The X-MET8000 series of handheld XRF analyzers are fast, ergonomic, and lightweight at 1.5kg for quick and completely non-destructive analysis. No mark will be left on the sample surface. In addition to metals and mining samples, the X-MET can be used to measure coatings, soil, plastic, wood, rubber, and virtually any solid sample types. The instrument is factory-calibrated and ready to use when delivered.</p>	<p>Vulcan is the latest addition to Hitachi High-Tech Analytical Science's mobile toolbox. Based on LIBS technology it is probably the fastest alloy analyzer in the world today, identifying alloys and providing full chemistry of the alloying components in just one second. Just a tiny burn mark is left on the sample surface. Like the X-MET, Vulcan is small, ergonomic, and weighs just 1.5 kg.</p>	<p>Stationary Foundry-Master and mobile PMI-Master OES instruments provide the highest level of performance. OES instruments are able to measure elements that handheld XRF and LIBS cannot do at all or with not sufficient accuracy of boron, nitrogen, carbon, phosphorous, and sulphur. PMI-Master Smart is the smallest and lightest OES analyzer in the world, which makes it field portable and suitable for various on-site analysis needs.</p>	<p>ExTOPE Connect is Hitachi High-Technologies Corporation's cloud-based data management and storage system, which is available today for Vulcan and X-MET series analyzers. With ExTOPE Connect mobile app, it's possible to share data instantly from the field using e-mail, text message or other services for real-time decision-making. The data is also transferred automatically to ExTOPE Connect cloud service, which can host several instruments and provides a safe storage for the analysis data.</p>

PMI: positive material identification XRF: X-ray fluorescence LIBS: laser-induced breakdown spectroscopy OES: optical emission spectrometry

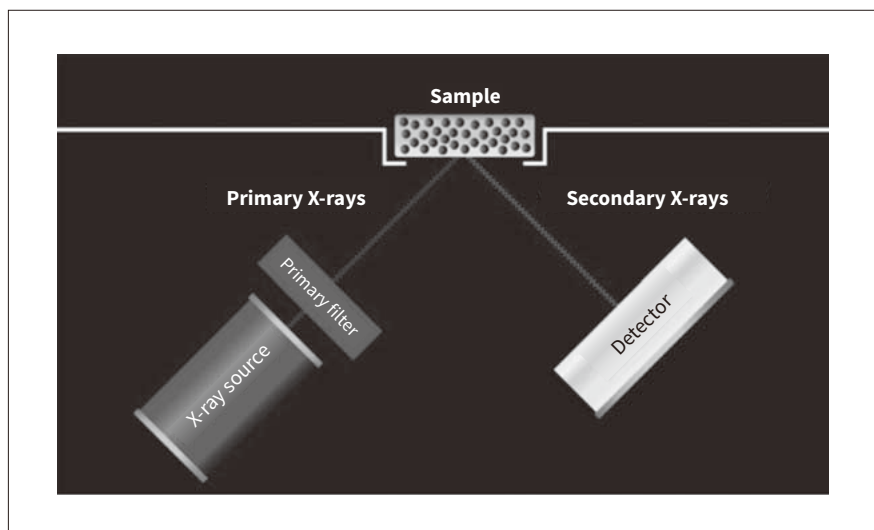
does not leave any trace on the surface being examined, meaning that it is non-destructive (see **Figure 2**).

XRF instruments can be broadly divided into those that use energy-dispersive spectrometry and those that use wavelength-dispersive spectrometry. The handheld XRF analyzers supplied by Hitachi High-Tech

Analytical Science are based on energy-dispersive spectrometry, a technique that uses a detector able to resolve the X-ray energies and that is suitable for miniaturization. The X-MET8000 is equipped with a silicon drift detector (SDD) that combines high resolution with small size.

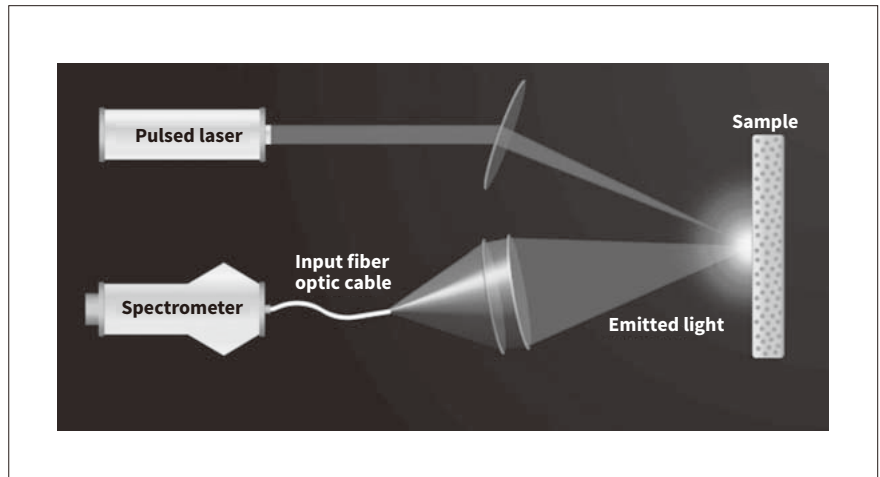
**Figure 2 — Principle of XRF Spectroscopy**

The diagram shows how X-rays are used to excite atoms in the sample.



**Figure 3 — Principles of LIBS and OES**

The diagram shows how LIBS and OES work. LIBS uses a laser to excite the sample and OES uses an arc or spark.



Laser-induced breakdown spectroscopy (LIBS) and optical emission spectrometry (OES), meanwhile, are both based on optical emission but use different excitation methods. That is, LIBS uses laser excitation and OES uses an arc or spark to excite the sample. The plasma generated by this excitation emits light with wavelengths that are characteristic of the elements present. This emitted light is split into these characteristic wavelengths by a spectroscope before entering the detector.

As the laser or arc discharge in LIBS and OES causes spattering of the surface, detaching atoms from the surface to form a plasma, a feature of these techniques is that they are more sensitive than XRF at detecting lighter elements. Although both are destructive tests, the amount of damage due to LIBS is very small because the laser beam it directs at the sample surface is so tightly focused (see **Figure 3**).

Because surface analyzers work on different principles, it is important to choose the right one based on the type of samples to be measured and the information to be acquired.

### 3. Efficient Mining Operations Help Use Scarce Resources Wisely

Raw materials are limited and finding new ore deposits is becoming increasingly challenging. At the same time, the need of various raw materials is higher than ever and constantly growing. For example the modern electronic industry and battery technology relies on elements such as lithium, cobalt and various rare earth elements that are not abundant in the earth's crust.

An efficient way to map the resources is critical for any successful mining operation, making handheld X-ray fluorescence (XRF) one of the most important tools in exploration geologist's toolbox.

Hitachi High-Tech Analytical Science's X-MET8000 series of handheld XRF analyzers provide point-and-shoot analysis which maps up to 40 elements simultaneously even in a matter of seconds with minimal sample preparation. The analysis data is available immediately for the geologist to evaluate the geochemical profile and identify interesting anomalies that indicates possible ore deposits. When the data is combined with Global Positioning System (GPS) coordinates, also collected by the instrument, a map of resources can be created (see **Figure 4**).

When the actual excavation work begins, handheld analyzers can be used for guiding the process to ensure that only minimal amount of waste rock is excavated

**Figure 4 — X-MET8000 Series Handheld XRF Analyzer Used for Soil Testing**

The handheld analyzer can perform rapid onsite analysis of soil or mineral deposits without the need to collect samples. Geographical analysis results can also be added to a map by using analysis and Global Positioning System (GPS) information.



as well as to monitor the environment to minimize the impact on nature. When it's time to close down the mine, handheld XRF analyzers are an invaluable tool to identify possible contamination in soil and tailings. Therefore, it's fair to say that handheld XRF is a true multipurpose tool that improves the efficiency of the mining operation throughout its lifetime.

#### 4. Metals Recycling – The Greener Alternative

Metals are ideal materials to be recycled as they can be melted over and over again, and used as a raw material. Metal recycling is also environmentally friendly and energy efficient. For example, when producing aluminum from scrap metal, up to 95% energy savings are achieved compared to using bauxite ore as a raw material.

Metal recycling is not only wise from environmental perspective, but it can also be very profitable business. The typical business model is to purchase a batch of mixed metal scrap that is valued according to the lowest guaranteed composition. Sorting the metal by using handheld or mobile analyzers, and selling the higher value segments forwards is pure profit. The investment made in the instrument is paid back very quickly.

One of the challenges in metals recycling is contaminations that start to accumulate when the metal is recycled repeatedly. Unwanted materials can cause severe issues in metals production and therefore screening for low level contaminants is becoming

**Figure 5 — VULCAN Handheld LIBS Analyzer in Use at Scrap Yard**  
Rapid and accurate analysis is needed to analyze and identify large quantities of scrap metal of different types. The LIBS analyzer is able, for example, to identify the grade of an aluminum alloy in just a few seconds. As the measurement data is managed in the cloud on EXTPOE Connect, users in the field can focus on taking measurements.



increasingly important. Elements such as copper, tin, sulphur, and phosphorous must be identified before adding the scrap metal to a melt.

Handheld XRF is by far the most commonly used technology in scrap yards. However, the latest development in metal recycling analyzers is based on laser technology. Laser induced breakdown spectroscopy (LIBS) instruments, such as Hitachi High-Tech Analytical Science's Vulcan, identifies a metal grade in just one second. This means that even large quantities of scrap metal can be sorted quickly and efficiently (see Figure 5).

#### 5. Metals Production, where Accuracy Matters

In metal production the highest level of accuracy is required to ensure a quality end product that meets the manufacturer's specifications. Therefore, analysis is carried out throughout the process from incoming material inspection to the quality control of end product.

Handheld XRF and LIBS can be used to screen the incoming scrap metal but for the highest accuracy optical emission spectrometers (OES) should be choice.

OES instruments provide the highest level of accuracy and lowest detection limits for all the key elements that need to be monitored in metals production. OES is also the only technology that provides the necessary accuracy to monitor one of the most important alloying elements in steels, carbon. Even the notoriously challenging low levels of boron and nitrogen can be accurately measured down to parts per million level with OES.

Hitachi High Technologies' stationary foundry-master (FM) and mobile positive material identification (PMI)-Master spectrometers are trusted tools that numerous metal producers rely on daily basis running their operations.

#### 6. In Metals Fabrication Quality Control is Essential

"Trust but verify" is the phrase commonly used in the metals fabrication industry today. It means that



**Figure 6 — VULCAN for Measuring Supplied Materials and OES FM Series Used for Quality Management**

The handheld analyzer can perform rapid-on-the-spot analyses of material inventory. Similarly, the OES FM series is installed in laboratories and used for precise quality management in industries such as iron and steel.



instead of just relying on suppliers' material certificates, alloy analyzers are used to be absolutely sure that the right materials are being used in the process. This is understandable as using wrong material can have catastrophic consequences leading to accidents and even loss of lives.

Many industries, led by aerospace, automotive and petrochemical, have adopted a 100% check policy. All raw materials are analyzed and checked that the specifications meet what is shown on the certificate. This is quite an investment for the company to make, but on the other hand when safety and reputation is at stake, it's the only way to go.

To measure hundreds or even thousands of samples per day, analyzers need to be fast, accurate and provide tools to manage the massive amount of data created in the process. The needs in manufacturing industry are various, but most commonly the analysis is done in the warehouse to check the incoming materials. Checks are also carried out at the factory floor to avoid material mix-ups, for example in cases when the material stamps or certificates are lost.

Depending on the customer's requirement, Hitachi High-Tech Analytical Science's alloy analyzer toolbox offers analysis solutions from lightning fast LIBS, non-destructive handheld XRF to high accuracy OES (see **Figure 6**). Handheld XRF is an ideal tool to check finished products as it leaves no mark on the analyzed surface.

## 7. Onsite Inspection

An incident at BP p.l.c. Texas City Refinery in 2005 highlighted the importance of onsite inspections of materials used in critical process components. Today, the components installed in petrochemical and power plants are verified before installation to ensure that the alloy being used is fit for purpose and can withstand the often very harsh operating conditions including high pressure, temperature and corrosive agents.

Mobile and handheld instruments make it possible to measure the sample on-site. The measurement can be taken from a process component such as pipe, flange, joint or a weld without stopping the process. There's no need to run down the process, which is always costly and time consuming. With handheld XRF instruments, it's even possible to measure hot surface that are up to 400°C directly and still get a highly accurate results.

In on-site inspection the analyzers must provide the highest level of accuracy as the company providing the inspection services will issue a report and take a responsibility that their measurement data is accurate and reliable. If not, the company will be held responsible for possible damage.

Most of the elements can be measured accurately with handheld XRF analyzer but when carbon is required, OES is the only technology that provides the accuracy needed. Today, even OES has been shrunk to mobile form. Hitachi High-Tech Analytical

**Figure 7 — On-site Inspection Using OES**

The portable spectrometer can be used for material checks on piping prior to welding or for precise inspection of existing piping.



Science's PMI-Master Smart is the world's smallest and lightest OES instrument making it possible to carry out high accuracy analysis even in demanding and difficult to reach locations (see **Figure 7**).

## 8. Conclusions

As of today, there's no single instrument that is able to do all applications from quick sorting to high accuracy trace element analysis. The need to understand the customer requirement is the key. What makes Hitachi High-Tech Analytical Science's product portfolio unique is our possibility to cover all the elemental analysis needs of the metals industry. Regardless of the application, Hitachi can always offer the best technology with no compromises. That is its strength today and the key to success tomorrow.

### Reference

- 1) Hitachi High-Tech Analytical Science, <https://hha.hitachi-hightech.com/en/>

### Author



**Mikko Järvikivi**

Espoo Office, Hitachi High-Tech Analytical Science Finland, Oy *Current work and research*: Handheld XRF, LIBS, and portable OES product management and business development.