Sample Management

Tips, tricks and solutions for effective sample management

e-book 1

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From Azenta Life Sciences

Contents

1 What is sample management?

Sample management is the selecting, collecting, storage, and retrieval of samples and their inherent data. It is a fundamental part of quality control in a laboratory and, if overlooked, can have costly and time-consuming repercussions.

Until the late 1970s, most laboratory samples were manually handled and managed; they were identified by handwritten labels and physically recorded in logbooks. This clearly flawed system was riddled with transcription errors and mismanagement and, subsequently, encouraged the development of streamlined laboratory information management systems (LIMSs).

With the advancement of computers in the early 1980s, laboratories began to tentatively automate their sample information systems. The success of the first-generation LIMSs continued into the 1990s, where ubiquitous personal computers allowed a network of management systems to be formed for exchanging laboratory data. With the development of the internet allowing LIMSs to be connected to the web, sample management could take place anywhere in the world and was no longer restricted to the confines of the laboratory.

> **"Sample management is the selecting, collecting, storage, and retrieval of samples and their inherent data"**

To define a modern-day LIMS is difficult because of the variety of laboratory operations that are performed. LIMSs must therefore be dynamic and adaptable, as the needs of laboratories are ever-evolving. However, any system that aims to streamline laboratory workflows by overseeing the management of its samples can be described as a LIMS. Modern sample management systems include tailored software and hardware that allow sample data to be accumulated and analysed.

These systems can also involve the automation of processes and integration of laboratory instruments, enabling the tracking of sample data from all areas of the laboratory, with the data subsequently being incorporated into electronic laboratory notebooks.

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2 Why is effective sample management important?

Sample management sets the precedent for the entire workflow of a laboratory. The validity and reliability of research is dependent on the integrity of the samples involved. Without precise and careful sample collection, recording, and storage, confidence in the data can be compromised. Handwritten labels and physically logging sample information can lead to loss of irreplaceable samples, samples becoming mixed up, or data from samples being untraceable.

The key benefit of a LIMS is that it reduces human error and lessens the chance of samples being compromised. Barcode labels and scanners reduce the time taken to input sample IDs and increase the accuracy of information entry. The data recorded within a LIMS can also be backed up in a database and the sample information accessible in several locations eliminating the possibility of losing an entire sample database.

A sample management system or LIMS can also ensure that your samples are stored in the correct environment. Integrating hardware (such as a -80°C freezer) into a LIMS and monitoring its operation means that samples can be constantly maintained at the ideal conditions; this reduces the risk of damage to samples and helps to increase the quality of the recorded data.
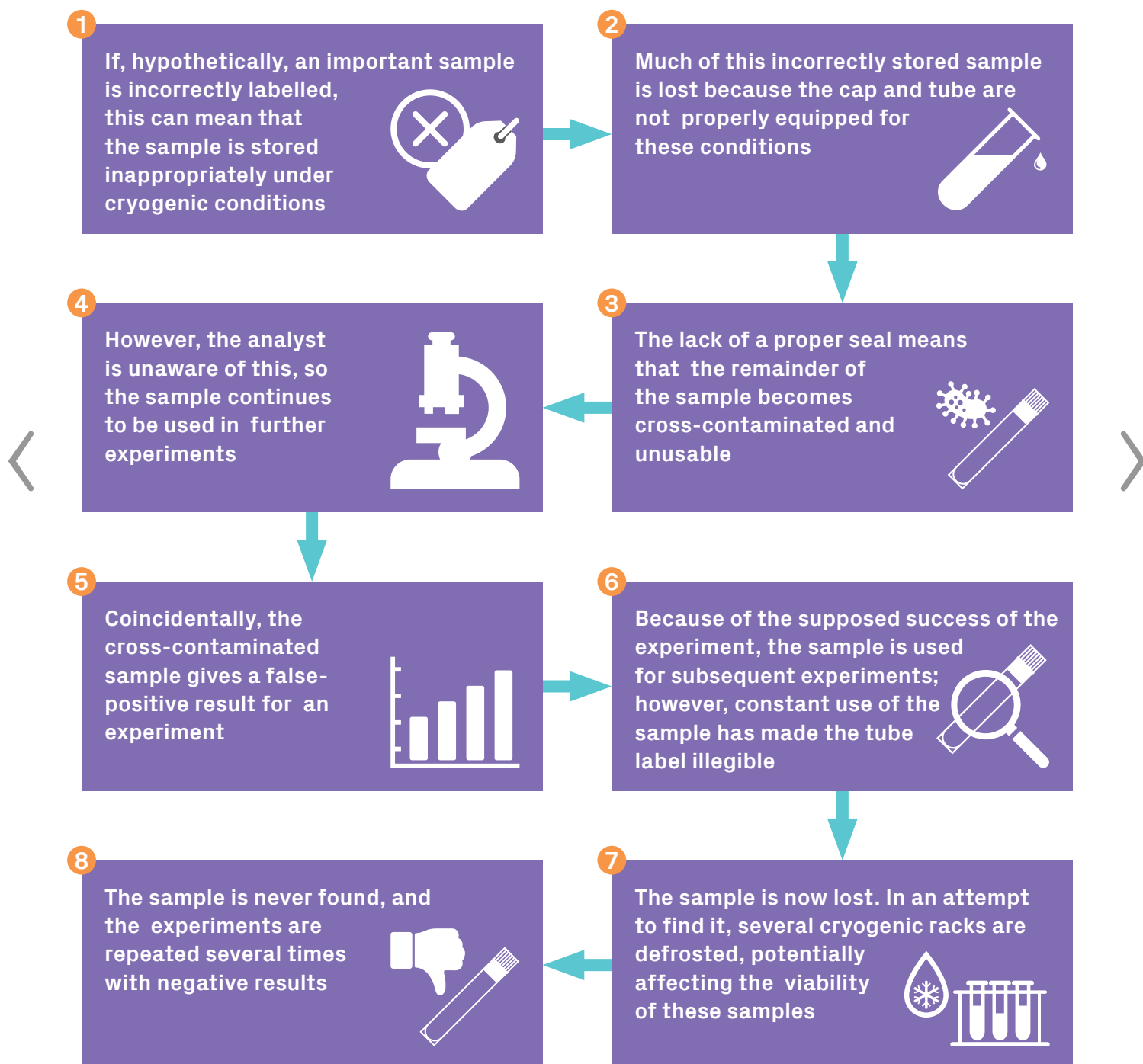
With the complexities of a modern laboratory, multiple researchers may handle samples before, during, and after analysis. This leads to several opportunities for samples to be mishandled or misplaced. Without a functioning LIMS in place, tracking the location and status of a sample is particularly difficult. By utilising a LIMS, it's possible to locate a sample and know if it has been tampered with, avoiding costly repeat experiments and improving workflow efficiency.

The tracking and tracing of samples can also be improved by integrating single tube and rack readers to record movements of samples and tubes throughout the laboratory process. This reduces the accidental loss of samples when transferred from rack to rack; a common cause of errors even in modern sample management systems.

In the next section of this eBook, we show how just a single error in the laboratory can quickly escalate without having a sample management system in place to counteract it. With some 2D-coded tubes it is worth checking that your scanner can read them!

3 Worst-case scenario

Without an effective LIMS in place, even a small laboratory can quickly find itself wasting time and resources. In fact, a worst-case scenario can occur from just a single mismanagement error:

1 If, hypothetically, an important sample is incorrectly labelled, this can mean that the sample is stored inappropriately under cryogenic conditions

2 Much of this incorrectly stored sample is lost because the cap and tube are not properly equipped for these conditions

3 The lack of a proper seal means that the remainder of the sample becomes cross-contaminated and unusable

4 However, the analyst is unaware of this, so the sample continues to be used in further experiments

5 Coincidentally, the cross-contaminated sample gives a false-positive result for an experiment

6 Because of the supposed success of the experiment, the sample is used for subsequent experiments; however, constant use of the sample has made the tube label illegible

7 The sample is now lost. In an attempt to find it, several cryogenic racks are defrosted, potentially affecting the viability of these samples

8 The sample is never found, and the experiments are repeated several times with negative results

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3 Worst-case scenario *(continued)*

The above may seem dramatic but it's easy to see how small errors can have large consequences within a laboratory. In this scenario, a simple mistake meant that several faultless samples were discarded, needless costly experiments were performed, and valuable time was wasted. These consequences are not merely hypothetical; there are several infamous instances of laboratory sample mismanagement.

One example takes place in the early 1990s at the Fort Detrick U.S. Army research laboratory. The laboratory's sample management system was proven to be inadequate when 27 sets of dangerous specimens were reported missing, including samples of anthrax spores, Ebola, hanta virus, simian AIDS virus, and two samples that were labelled "unknown". One of these samples was later found in the laboratory despite being reported missing, but the majority of the samples were never seen again.

A subsequent inquiry found evidence that someone was secretly entering the laboratory late at night to conduct unauthorised research on the anthrax samples. A numerical counter on a piece of laboratory equipment had been rolled back in an attempt to hide the work that had been performed. Also, a sample was suspiciously misspelled as "antrax" in the machine's electronic memory.

This real-world scenario of poor sample management meant that potentially lethal anthrax spores could have been exposed to the public. Poor inventory controls allowed samples to be mislabelled and go missing, and poor security measures allowed a potentially unauthorised person to conduct covert research. This high-risk situation shows the importance of a rigorous and robust sample management system, as well as the need to implement security controls to prevent unauthorised users from gaining access to sample information.

To keep your laboratory from running into potentially disastrous problems, in this eBook we have summarised our top tips for preventing common sample management issues, including advice for tube selection and labelling, sample collection, barcode scanning, sample tracking, and sample storage.

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4 Top tips for tube selection and labelling

Selecting an appropriate cap and tube is essential for the proper management of samples. If they are incompatible with each other, samples could leak or become contaminated, and if they are incompatible with other laboratory hardware, such as a decapping machine, then errors and inefficiencies can occur. Similarly, often overlooked but absolutely crucial in sample management, is an effective and consistent way to label tubes, such as with 2D codes. Incorrect selection and labelling of tubes can lead to repeated experiments, wasted time, and lost samples.

Top tips for preventing issues occurring with tube selection and labelling:

Spillage or cross-contamination of a sample can undo many hours of research and analysis. This is especially pertinent for samples that are stored in freezing or cryogenic conditions, as the low temperatures can affect the integrity of the tubes and caps. How can you minimise the chance of this occurring?

Avoid cheaper options like push caps as these can be difficult to remove and can lose their integrity at temperatures below -20°C. If a push cap loosens, then the sample is exposed and can become contaminated, or worse, could contaminate other samples. A tip for avoiding this is to opt for screw caps; they form a more robust seal on the tube and can maintain their integrity down to liquid nitrogen temperatures. Azenta offers the comprehensive Fluidx range of sample storage tubes which are made to the highest quality standards for safer sample storage.

> "Incorrect selection and labelling of tubes can lead to repeated experiments, wasted time, and lost samples"

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4 Top tips for tube selection and labelling *(continued)*

Using paper tube labels with ineffective adhesive can lead to the labels becoming illegible or simply falling off. How can this be avoided?

In freezing or cryogenic conditions, icing of the tubes can cause separation of the label from the tube. Also, during thawing, condensation can affect adhesion and label legibility. Considering the importance of correctly identifying samples, paper labels are not suitable for this purpose. Use plastic labels as they are more robust and can be comfortably stored in cryogenic conditions. They are more difficult to tear and are waterproof so are resistant to condensation when thawed. In addition, using 2D coded tubes where the DataMatrix code has been added to the tube using robust techniques, such as laser etching or integrated into the tube during the moulding process, can help to overcome issues with fixing labels to tubes. These can be stored in racks or boxes in arrays from 24 to 384 tubes; the entire rack can be imaged in seconds and the tubes positively identified. This allows the accurate tracking and tracing of thousands of tubes quickly and effectively. Azenta's Fluidx 2D coded tubes are an ideal solution and best paired with Ziath 2D code readers for seamless workflow integration

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4 Top tips for tube selection and labelling *(continued)*

Large laboratories can process hundreds of samples a day. Even small laboratories may have a large number of samples to analyse, with the tubes needing to be capped and decapped as quickly as possible. How can this be achieved?

Manually capping and decapping hundreds of tubes can be tedious and time-consuming but is sometimes the only option available. However, if your laboratory produces racks of samples that are compatible with an automated instrument, using a capper/decapper can process racks of tubes in seconds. Automation in this way can improve the workflow of laboratories of any size. Azenta offers a range of capping and decapping tools to suit most laboratory budgets.

To avoid downstream issues, choosing the correct cap and tube is vital. A screw cap is a reliable way to stop contamination and sample loss. Choosing either external or internally threaded sample tubes allows users to maximise stored volume or minimise cross contamination risk. To avoid potential leakages, samples must be stored properly in the correct environment and in an upright position. By automating the capping and decapping of tubes where possible, the throughput of your laboratory can be substantially increased.

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5 Top tips for sample collection

During sample collection, it is essential that the necessary sample data, such as unique IDs, location, sample type, expiry date etc., are entered into a database for future recall. Even in a small laboratory, it can be a laborious process to manually locate a sample; in a large laboratory, locating a lost sample could verge on impossible. Therefore, a LIMS that can be easily searched for sample parameters is vital to quickly locate samples.

Top tips for preventing issues occurring during sample collection:

Modern laboratories are complex and typically involve many different workflows, with samples being handled for a wide range of research activities. When working with many samples from multiple sources, what is an efficient way to manage the collection of samples?

If a sample is correctly labelled and entered into the database, any ambiguity surrounding the sample is eliminated. The origin of the sample can be identified, as well as the location, and any other important information that may be relevant to the sample collection, such as what container it is in. A comprehensive software solution ensures the history of the sample is fully known. Laboratory efficiency is easily compromised if samples cannot be identified, and this is a simple way of avoiding this scenario.

Modern inventory management software such as FreezerPro from Azenta can be a cost effective solution to the problem.

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5 Top tips for sample collection *(continued)*

When managing large sample sets, how can you make sure that specific samples are correctly identified?

Single or multiple search parameters applied to large sample sets can ensure the easy retrieval of information. Parameters such as location, expiry date, sample type etc., can be made mandatory for each sample record, which can then be used to narrow down your search when using a LIMS and be cross-referenced with other parameters if necessary. Quickly locating a specific sample can be crucial if working with temperature-sensitive materials that are stored together. For example, a whole box of proteins might have needed to be thawed when manually searching for a sample. With a LIMS in place, the exact location of a specific sample can be easily identified from the database, helping precious samples to be quickly located and individually removed from a storage container – the removal of these tubes can then be recorded and checked with both single tube and rack 2D code readers.

Compact 2D code readers for efficient sample processing at the benchtop

The latest camera-based 2D code reader from Ziath, the DP5 Mirage, provides a cost-effective alternative to traditional flatbed scanners. The Mirage uses innovative technology to give it a low-profile and compact design. This enables the reader to be easily used on the laboratory benchtop, as well as on the deck of liquid handling workstations, allowing you to more easily and efficiently read samples into a LIMS at the point of processing, eliminating positional and transfer errors.

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5 Top tips for sample collection *(continued)*

Sample collection needs to be as accurate and efficient as possible to reduce costs and increase laboratory throughput. Simple steps, such as ensuring all sample information is entered into a database when samples are collected, can save a lot of time further down the line. Automating this process as much as possible is the easiest and most accurate way to achieve this. Moreover, ensuring the software used for the sample database has powerful search capabilities means that samples can be located quickly. Again, FreezerPro from Azenta can certainly help with this task.

6 Top tips for 2D code reading

Reading coded tubes is an efficient way of logging a sample's unique ID in a LIMS and ensures all associated sample information is recorded under this ID. However, challenges can arise when reading coded tubes and racks.

Top tips for preventing issues occurring during 2D code reading:

Depending on the barcode type, placement, and reader features, the readability of the barcode can vary. How can you make sure that the code is always readable?

If the coded tube is not aligned correctly in the rack or the reader operates in difficult environmental conditions, then effective code reading may be hindered. By using a reader with a large depth of focus and good under-rack lighting, it is possible to alleviate most problems that may occur. Software algorithms incorporated into modern readers mean that even the very small barcodes at the bottom of 2D coded tubes can be read efficiently and reliably, even with variable heights or angles above the imaging window.

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6   Top tips for 2D code reading *(continued)*

There are a wide selection of barcode options to choose from. Which are the best and how can you optimise barcodes so that the reader achieves its top performance?

2D codes on the base of tubes allow for multiple tubes to be read in seconds; in addition, minor damage to the code is handled with error correction algorithms. The compact nature of 2D codes allows for very small DataMatrix codes to be placed and read on the tube base. For labelling racks and other large items, linear scanners will suffice and it is recommended to use Code 128 linear barcodes as Code 128 barcodes will not misread, presenting an incorrect barcode, whereas other types of linear barcodes are not as robust.

"Scanning barcoded tubes is an efficient way of logging a sample's unique ID in a LIMS"

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6 Top tips for 2D code reading *(continued)*

When reading frozen samples, a build-up of ice can cause problems with reading the barcodes. How can this issue be quickly overcome?

One of the best methods to remove ice on racks is to use an alcohol-soaked sponge. By taking the iced rack and pressing it into the saturated sponge, the ice will be swiftly removed. Next, remove the rack and gently tap it onto a dry sponge to remove any excess alcohol before placing it on the reader.

2D DataMatrix codes for more reliable sample scanning

2D DataMatrix codes are the barcode of choice for efficient sample scanning. Compared with linear barcodes, 2D codes can be much smaller and also allow for more sophisticated error correction to ensure even damaged codes can still be read - ideal if a precious sample's label has deteriorated over time. That's why at Ziath, we have specialised in developing high-quality and intuitive-to-use 2D code readers, like the truly portable Handheld 2 Single Tube Reader, which can be operated with just one hand, and the DP5 Cube which can read full Cryoboxes as well as SBS racks.

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Barcode reading is an incredibly efficient and accurate way to log all samples into a database. Following the above tips will make sure that this process is as seamless as possible. Aim for 2D DataMatrix codes and always consider the compatibility of your sample tubes, racks, and readers, and make sure that the 2D code label has good contrast for easy reading. If ice builds up on the bottom of cryogenic samples, simply remove it with an alcohol-soaked sponge.

7 Top tips for sample tracking
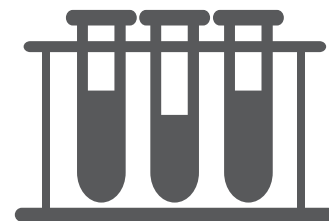
Sample tracking is one of the most important features of sample management and, if performed incorrectly, has the potential to be the most time-consuming aspect of these workflows. Inefficient and unreliable tracking methods can mean that samples are lost. It is therefore essential that a robust management system is in place, as problems with sample tracking cannot always be easily rectified.

Top tips for preventing issues with sample tracking:

When dealing with a significant number of samples, effective sample tracking becomes even more important. However, setting up and maintaining a system for a large number of samples can be a daunting task. How can you ensure that this process is as efficient as possible?

Fortunately, there is software capable of automating the importing/exporting process, which can alleviate the procedure of manually inputting a large number of samples. Furthermore, if there are any pre-existing inventories of older sample sets, it's possible to merge and update the data into a cohesive database. After the inventory is modernised, mandatory data fields can be applied to ensure that all new data will be accurately logged when entered into the system. It's also worth noting that the initial time investment associated with setting up a modern sample management system will have significant benefits in the future. Linfinity™ from Azenta is an enterprise level LIMS system that can coordinate all sample movements, processing and analysis date, while Azenta's FreezerPro is a laboratory-scale inventory management program which can easily track and trace barcoded samples throughout the workflow.

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> **"Sample tracking is one of the most important features of sample management and, if performed incorrectly, has the potential to be the most time-consuming aspect of these workflows"**

Data confidentiality is critical in some laboratories. With many users inputting sample information into the same LIMS, it is vital that the databases are protected from being compromised, either by accidental deletion or through unauthorised user access to the system. How can the security of sample data be ensured?

Tracking the movement of samples from location to location guards against samples going missing when relocated; this can be done by the use of a 2D rack reader. In addition, using integrated software helps researchers track who used which sample and when. Systems can also be password protected with additional controls for user access to data and can have automatic log-out functions to prevent security breaches.

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7 Top tips for sample tracking *(continued)*

It is important for laboratories to keep a record of all samples stored. If records of old samples need to be recalled, is this possible with a LIMS?

Using a sample management system with an archive function allows recall of key information later if needed. The process of recalling old sample data is much more efficient with a LIMS than the outdated method of looking through an Excel workbook. Also, an archiving feature can help with information maintenance and record keeping by providing an easy way to keep older data accessible but separate from current datasets.

Selecting a user-friendly software solution that meets your laboratory's sample management needs makes recording, managing, and recalling sample data convenient for all users, not just those specifically trained as system administrators. This will help to avoid errors with sample entry and will help prevent some of the most common sample tracking problems.

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Top tips for sample tracking *(continued)*

Sample Management Software can be customised to your laboratory's needs

Implementing a sample management system isn't a one-size-fits-all approach – in fact, some manufacturers will tailor sample management software to the precise needs of your laboratory. For example, some LIMSs will let you define the exact size and shape of your sample containers and will allow you to set up whatever mandatory sample fields you require depending on the types of samples you work with.

8 Top tips for sample storage

Whether you're running a large or small laboratory, it can be difficult to know where your free space is. Without an automated LIMS in place, finding available storage space for a sample can be challenging. Even with space available, it can be hard to locate exactly where in the freezer or store room it is, and removing multiple racks from storage in an attempt to find suitable space can damage precious samples. Having access to relevant sample storage information allows you to plan your storage needs accordingly.

Top tips for preventing issues occurring with sample storage:

Most samples have a defined shelf life. How can you be sure that a sample hasn't expired before using it?

By implementing a laboratory-wide sample management system, the data from all samples should be easy to accumulate and record in a database. This database can automatically monitor the samples that are stored so that users can see when samples have expired by searching for the date of purchase/ collection or expiry.

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If used in multiple experiments, the composition of a sample can alter or degrade so it is important to be aware of this. How can you find out how often a sample has been handled?

Modern laboratories have many researchers conducting various analyses, and often with the same samples. As such, a particular sample may have been frozen and thawed several times during its lifetime. This constant changing of conditions can damage the sample and make it unusable. The tracking software that is integrated with a LIMS can be used to show how many times the sample has been removed from its storage container and freeze/thawed.

When retrieving a sample from long-term cold storage, how can you be sure that no one else has used this sample since it was placed in the freezer?

There are several controls that can be put in place to reduce the possibility of sample interference; for example:

- The LIMS should be able to hide sample information from those that do not have the correct access. Alternatively, the editing of the contents of a tube can be restricted so that only authorised users alter the data record.

- Stored sample data can include parameters such as sample volume, sample type and many other identifiers. This allows the user to correctly identify the sample before accessing it; ensuring that no misidentifications occur.

- The LIMS can incorporate a check-out/check-in process for temporary sample removal, and record which users are currently accessing a sample.

Without having high-tech security (such as user-specific IDs) for access to the freezer, it is impossible to guarantee that samples have not been touched. However, the above are examples of checks that are only made with a good sample storage software package.

"Having access to relevant sample storage information allows you to plan your storage needs accordingly"

The importance of a complete sample management system cannot be overstated. For laboratories of all sizes, implementing a comprehensive sample management system is essential for ensuring workflow efficiency, experiment accuracy, and sample quality. While setting up a sample management system might seem like a daunting task, with specialists available to support you through the process and to customise a system for your laboratory's needs, installing an effective sample management system is relatively straightforward and will pay dividends in the long run.

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9 Conclusion

Effective sample management does more than merely create an efficient, streamlined laboratory – it also allows for consistent procedures and provides confidence in your results. Simple inadequacies in sample management can have dramatic effects on laboratory operations and can hinder the progress of entire projects.

We hope our sample management top tips will help your laboratory avoid some of the most common problems with tube selection and labelling, barcode reading, sample collection, tracking, and storage. By implementing successful sample management processes and systems, you can rest assured that your precious, irreplaceable samples are carefully collected and appropriately stored, and key sample information is recorded and safely logged, allowing you to focus on what you're best at: cutting-edge research.

> **"Simple inadequacies in sample management can have dramatic effects on laboratory operations and can hinder the progress of entire projects"**

10 About Ziath from Azenta Life Sciences

Azenta is a market leader in the design and manufacture of consumables and bench top instrumentation for a wide range of life science and medical applications, including research into combatting cancer and infectious diseases, drug development, molecular diagnostics, and forensics. Our leading capabilities across genomics, cryogenic storage, automation, and informatics is dedicated to sample exploration and management. We help our customers bring impactful breakthroughs and therapies to market with greater speed and precision.

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Take the stress out of managing your samples. Leave it to us

Ziath's robust and reliable products are designed to integrate into existing workflows and are primed for automation. We pride ourselves on providing high-level technical support to ensure that our customers' sample tracking processes run smoothly and efficiently. Our commitment to the development of innovative products allows us to provide a truly bespoke experience for each customer. We can provide scanners to read every available rack and box format on the market with speed and accuracy.

Detailed information and technical specifications on all of our products are contained within our product data sheets and our e-Books provide useful hints and tips relating to sample tracking and information management for life science. Please visit our website at www.ziath.com to download your copies.

DP5 CUBE
2D barcode reader for all racks and boxes

DP5 EXPRESS
Small, automation-friendly 2D barcode reader
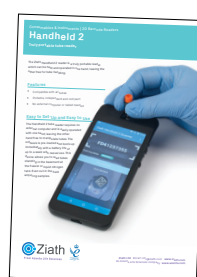
DATAPAQ™ EXPRESS NMR RACK READER
2D barcoded NMR reader

DP5 MIRAGE
Economical 2D barcode camera rack reader

RiTrack MIRAGE
Locate tubes with RFID even if covered in ice
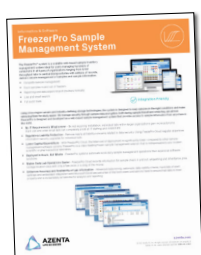
UNO AND DUO
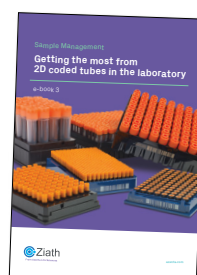Single tube readers

ZIATH HANDHELD
Handheld 2D barcode reader

ZIATH CYCLOPS
1D rack barcode scanner

MOHAWK
Semi-automated tube picker

FreezerPro®
Sample Management System

e-book 3
Getting the most from 2D barcoded tubes in the laboratory

From Azenta Life Sciences