forum
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Technical Notes and Applications for Laboratory Work

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Solutions for efficient sample management and biobanking

Modern biobanks usually contain a vast number of samples as well as a wealth of sample related information. Hence, they demand labware, periphery and information systems allowing for an efficient and secure sample management. In recent years, Greiner Bio-One has focused on the development and manufacturing of cryogenic storage tubes and racks whose features are dedicated to the requirements of modern biobanking. This application note provides an overview on the Cryo.s™ product line including cryogenic storage tubes and racks. Furthermore, the utilisation of these products in biobanking as well as their compatibility with accessory equipment such as scanners and decappers are addressed.

1. Typical Tasks of Sample Management and Biobanking

In order to reach its optimum performance each sample management system needs to be adjusted to the types of sample and sample container as well as to the applied algorithms for sample rearrangement, sample picking and sample retrieval. Despite the diversity arising from individual requirements all sample management systems have two principal tasks in common: (1) the introduction of samples and sample related information and (2) the localisation and retrieval of individual samples. Storage labware such as Cryo.s™ with Datamatrix and the accessory rack may contribute to an efficient execution of both steps.

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In particular Cryo.s™ with Datamatrix carry an individual sample identifier (ID) encrypted in their two-dimensional barcode on the tube bottom. This ID is usually read when a new sample is introduced into a storage system. At this stage all sample related information may be entered into an associated database and thus be unmistakably linked to the corresponding sample ID.

Cryo.s™ with Datamatrix may be stored in larger units – the Datamatrix Cryo Racks – each providing space for 48 samples and carrying its own ID. Windows in the bottom portion of these racks allow for the scanning and identification of an entire array of tubes (Fig.1). Thus, every rack scan can identify not only the contained samples, but also their position within the rack as well as empty positions available for future samples. When it comes to sample retrieval all required information may be extracted from the database including sample ID, rack ID and position of the sample in the rack. On this basis a specific sample of interest may be selected and recovered from the storage. A final single tube scan may be carried out to cross-check the identity of the recovered sample and to delete it from the database.

Figure 1: Datamatrix Cryo Rack with 48 positions for tube storage and bottom openings for scanning and tube identification.

2. Datamatrix Cryo Rack

Tubes, racks, freezers and liquid nitrogen tanks represent different levels in the hierarchy of storage containers used for biobanking. Each container requires an identification tag for its precise localisation in the system (table 1).

The Datamatrix Cryo Rack is available with two redundant IDs – a linear barcode on its side (Fig. 2A) and a corresponding Datamatrix code on its bottom (Fig. 2B).
Both codes hold the same ID number. Whereas the linear barcode on the side of the rack and its human readable tag can be easily identified with a linear code scanner or even the naked eye; the Datamatrix code on the rack bottom allows for rack identification within the same scan process that is carried out to read the Datamatrix codes of individual tubes. A simple adjustment of the scanner and software is needed to recognise the Datamatrix code on the rack. This requires an additional definition for the exact location of the rack's 2D code. Many manufacturers of rack scanners have already prepared their scanners and software for this additional feature (refer to 'Rack scanners' section within). The asymmetrical placement of the 2D code on the rack enables an excellent landmark for determining the orientation in which the rack is presented to the scanner.

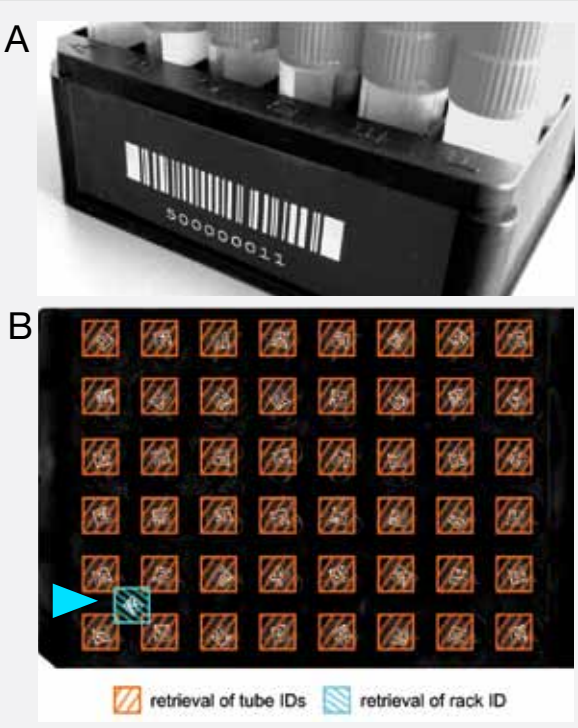


Figure 2: Datamatrix Cryo Rack
A: The Rack carries a linear barcode with human readable text.
B: Two different regions of interest may be set in order to extract individual tube IDs (visible through the scanning windows) and the rack ID during a single scan of the rack's underside.
The rack ID encoded in the linear barcode is also encoded in a corresponding Datamatrix code on the rack bottom (arrow head).

Table 1: Hierachy and identification of sample containers

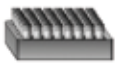
	Tube	Rack	Freezer or LN2 tank
			
Hierarchy	Lowest level	Medium level	Highest level
Contents	Sample	Tubes	Racks
Identification	Datamatrix code on tube bottom and position in the rack	Linear bar-code on side or Data-matrix on bottom	Designation and description in sample management system or LIMS

Figure 3 illustrates the classical tasks of biobanking with Cryo.s™ with Datamatrix and the Datamatrix Cryo Rack as central elements.

3. Rack Scanners

Rack scanners capture an image of the underside of the Datamatrix Cryo Rack by either moving a scan head over the entire length of the rack or by capturing a full size image presented to a CCD camera by a mirror. Whereas the advantage of scanners with movable sensors lies in their lower entry level price, full size imagers feature ultra-rapid scanning times of less than 1 second. Once captured by the scanner, the image is analysed for the presence of Datamatrix codes within a 6 x 8 array of putative tube locations (the so named region of interest, ROI). If applicable, another ROI is analysed for the presence of a single Datamatrix code to identify the rack itself (see Fig. 2B). While analysing the scanned image, scanners may discriminate between tubes with intact and damaged Datamatrix codes as well as any empty position within the rack ('no tube' detected).

Scanners feature different mechanisms to avoid condensation due to temperature gradients between their exterior scanning window (where they may be in contact with the frozen rack) and their interior components. Such anti-condensation features can be realised through different means: by evacuating the interior of the scanner, by applying a hydrophobic coating to the glass plate of the scanner, or by heating the glass plate up[1].

Table 2 provides a list of rack scanners in which Cryo.s™ with Datamatrix in the Datamatrix Cryo Rack have successfully been used and which therefore may be recommended.

4. Sample Management Software

A central and crucial element of each biobank is its sample management system for storing and managing sample related information. Such sample related information may include the sample number (ID, Datamatrix code), entry date, sample contents, and location of the sample tube within the stock as well as its status with regard to completed or upcoming steps of sample processing. Software solutions largely vary in their capabilities, complexity and market price. The choice of an appropriate software solution is important and should be based upon the expected maximum number of samples in the biobank as well as the complexity of sample management tasks to be carried out.

Small biobanks with only thousands of samples may be curated by a single store manager and supplemented with Excel or Access macros to track information and control scanners. Scanner software usually comes with helpful export features facilitating the usage of scanned data in Excel or Access. With increased sample quantities, a database should be implemented to assist in the storage and retrieval of samples. Examples of such professional database systems are EasyTrack 2D from FluidX and Samples from Ziath (Fig. 4). These programs assist in the processes of sample introduction, retrieval, re-arrangement, splitting and joining.

Fully integrated sample tracking systems may be used with medium and large scale stores and are available from suppliers such as RTS Life Science and Liconic. Finally, biobanks may be part of extensive laboratory information systems (LIMS[2]) to cover comprehensive tasks way beyond simple storage and retrieval of samples. Such systems are capable of integrating all laboratory samples as well as instruments, users, applied standards, workflows, procedures and more.

All rack scanners and their drivers offer specific functions to facilitate their implementation into LIMS (e.g. ActiveX control). Furthermore, scanner manufacturers offer support and assistance with any questions related to LIMS integration.

[1] There is no risk of unintended sample thawing with the employement of heated scanner plates, as the scanning process and the exposure of the rack to the scanner only takes a few seconds.
[2] LIMS = Laboratory Information Management System

Table 2: Recommended rack scanners

Manufacturer or supplier	Model	Type	Prepared for decoding 2D code on rack	Features
BioMicroLab www.biomicrolab.com	Sample Scan 96	Moving scan head	Yes	• Small footprint • 20 seconds total scan/decode time • Multiple export file options (e.g. LIMS) • Easy automation integration via ActiveX control • Displays damaged/missing tubes
	Sample Scan HS	Moving scan head	Yes	• Small footprint • 5 seconds total scan/decode time • Multiple export file options (e.g. LIMS) • Easy automation integration via ActiveX control • Displays damaged/missing tubes
Biosero www.bioseroinc.com	BioRead-A6	Moving scan head	Yes (release 1.26 and more recent)	• Small footprint • 6 seconds total scan/decode time • Multiple export options: Excel, text, XML, rack images • Database connectivity: SQL Server, Oracle, MySQL, Postgres, HSQL and others • Displays damaged/missing tubes • One-click scan for any tube size or brand • Integrated frost reduction
FluidX www.fluidx.co.uk	Xtr-96MKII	Moving scan head	Yes (software release 4.2.0.6. and more recent)	• Small footprint • Intuitive graphical user interface • 10 seconds total scan/decode time • Displays damaged/missing tubes • Data export to Excel possible • ODBC database integration • Winsock integration
	Xtr-96MKII Cryo	Moving scan head	Yes (software release 4.2.0.6. and more recent)	• Small footprint • Intuitive graphical user interface • 10 seconds total scan/decode time • Displays damaged/missing tubes • Data export to Excel possible • ODBC database integration • Winsock integration • Integrated frost reduction
Hamilton www.hamiltoncompany.com	Microlab® STAR, integrated deck scanner	CCD camera	Yes	• 1 second total scan time • Integrated solution for automated tube identification and tube processing
Ziath www.ziath.com	DataPaq™ AV6	Moving scan head	Yes (release 1.26 and more recent)	• Small footprint • 6 seconds total scan/decode time • Multiple export options: Excel, text, XML, rack images • Database connectivity: SQL Server, Oracle, MySQL, Postgres, HSQL and others • Displays damaged/missing tubes • One-click scan for any tube size or brand • Integrated frost reduction

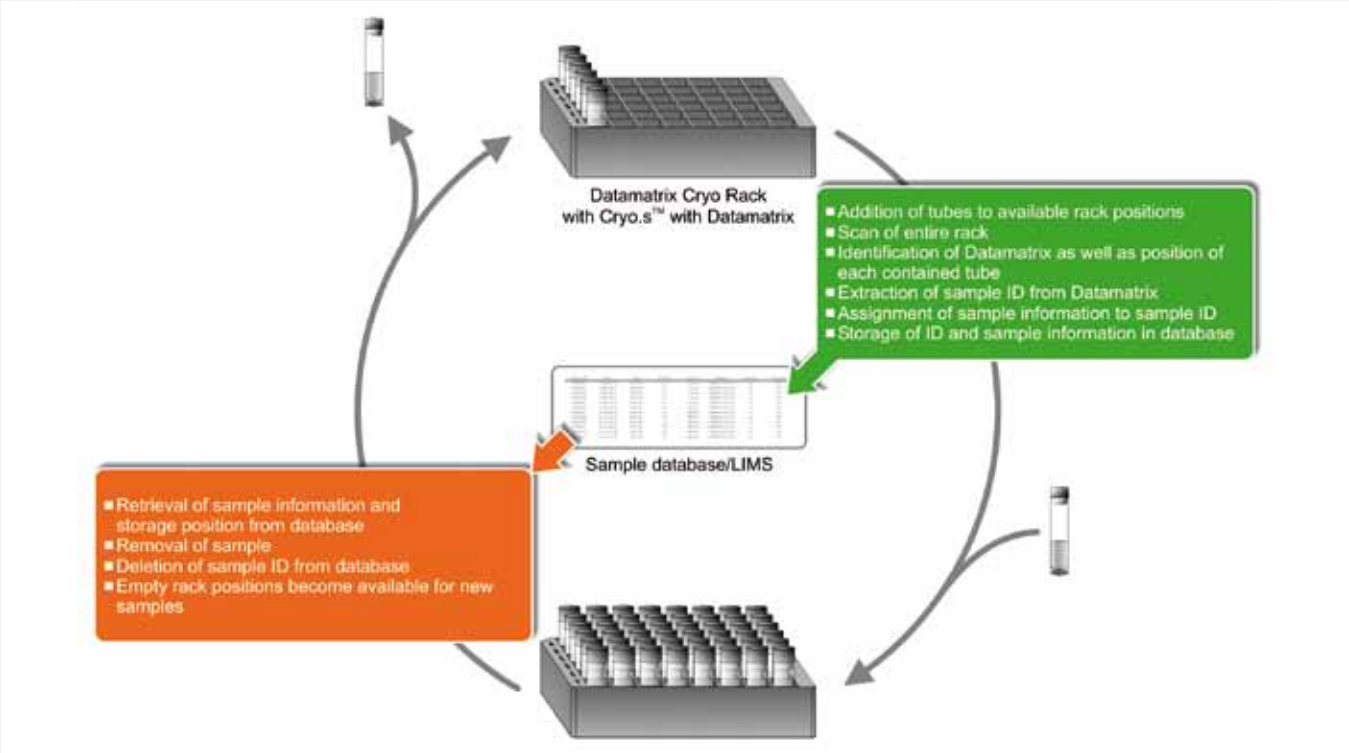


Figure 3: Introduction of samples and sample retrieval as classical tasks in biobanking.

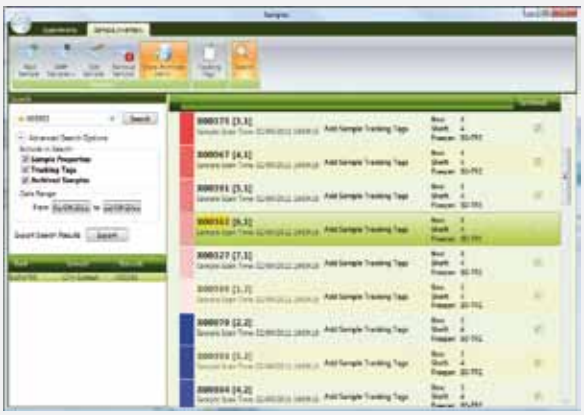


Figure 4: Screenshot of Ziath's software 'Samples'[3]. The web-based software Samples is fully integratable with Ziath DataPaq 2D barcode scanners and Greiner Bio-One's Datamatrix Rack. It assists scientists with the management and tracking of their samples as well as the planning, sharing and execution of lab protocols.

5. Rack Storage

The Datamatrix Cryo Rack and Cryo.s™ with Datamatrix can withstand storage within -80 °C and -20 °C freezers as well as the gas phase of liquid nitrogen, other than systems utilising adhesive barcode labels. The laser-written codes of the rack and tubes are particularly advantageous with regard to low temperature storage in that the polymer code labels are absolutely temperature resistant and will not fall off during repeated freeze-thaw cycles as is often observed with adhesive label systems. For convenient storage within freezers, racks need to fit into the metal shelves inside the freezer. In some cases, existing interior shelves formerly used for conventional 10 x 10 storage boxes may be used to space-efficiently store the Datamatrix Cryo Rack. For example, a metal rack holding four conventional 10 x 10 storage boxes (footprint about 133 x 133 mm²) can hold six Datamatrix Cryo Racks (footprint about 128 x 86 mm²) with the height of both containers being about the same[4].

[3] This picture has been kindly provided by Ziath Ltd./Cambridgeshire/UK.
[4] Conventional 10 x 10 boxes for 2 ml tubes have about the height as the respective Datamatrix Cryo Racks for both tube types.

In addition, many manufacturers and suppliers of freezer interior; such as National Lab, Custom Biogenic Systems and Jutta Ohst german-cryo® GmbH; offer solutions which are especially designed for the space efficient storage of racks with microplate footprint, such as the Datamatrix Cryo Rack.
Furthermore, it is common practice to have the interior of liquid nitrogen tanks manufactured on a customised basis for optimum storage of the Datamatrix Cryo Rack in the gas phase of liquid nitrogen. For this approach the exact dimensions of the Datamatrix Cryo Rack can be derived from product drawings accessible through Greiner Bio-One's website (www.gbo.com/bioscience).

6. Automated De-capping and Tube Handling Systems

A steadily increasing family of automated systems facilitates streamlining of biobanking tasks, such as de-capping, handling, re-arraying, and cherry-picking of Cryo.s™. Table 3 exemplifies some automated systems compatible with Cryo.s™ with Datamatrix, allowing the automation of individual tasks for sample handling.

Table 3: Automated De-capping and tube handling systems

Model	Manufacturer	Functions
XSD-48Pro	FluidX	De- and re-capping of *Cryo.s™ with Datamatrix* in the *Datamatrix Cryo Rack*
Capit-All	The Automation Partnership	De- and re-capping of Cryo.s™ with Datamatrix (requires adjustment for full compatibility with Greiner Bio-One's storage ware)
STAR	Hamilton	Automated liquid dispensing and tube handling systems
XL100 Vial Handler	BioMicroLab	Decoding, tube transfer, weighing, decapping, recapping and liquid handling

7. Conclusion

Greiner Bio-One's Cryo.s™ with Datamatrix and the complementary Datamatrix Cryo Rack with footprint following ANSI-standards are easy to integrate into automated workflows. Their laser-written identification tags are robust, thus assuring the sample tubes and racks remain identifiable even after long term storage at very low temperatures. For further information on the Datamatrix coding technology of Cryo.s™ with Datamatrix, to include quality testing, data capacity and recommended single tube readers, please refer to Greiner Bio-One's forum no. 10 (order no. F071 008) accessible from www.gbo.com/bioscience.

8. Ordering Information

Cryo.s™ with Datamatrix may be ordered either off the shelf with unique predefined number sequences or on demand with customised Datamatrix codes. All customised orders are processed via an order form which can be requested by telephone (+49) 7022-948-0 or downloaded directly from our website www.gbo.com/bioscience/cryos.

The option of coding the Datamatrix Cryo Rack with a laser-written linear barcode on its side and/or a Datamatrix code on the bottom is available. Please refer to order form no. F010 898.

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