forum
Technical Notes and Applications for Laboratory Work

Content

Datamatrix Coding for Sample Identification with Cryo.s™ Sample Storage Tubes

With its well-established brand, Cryo.s™, Greiner Bio-One has more than 30 years of experience in the production of cryogenic sample and storage tubes. In order to satisfy the increasing demand for secure and efficient identification of cryogenic samples, Cryo.s™ have recently become available as a Datamatrix carrying version with a two-dimensional barcode symbology on the tube bottom. Cryo.s™ with Datamatrix (**Fig. 1**) combine a long-lasting tradition in tube manufacturing with latest technology for secure sample identification.

Figure 1: Cryo.s™ tubes with Datamatrix for cryogenic sample storage and secure and efficient sample identification.

1. Datamatrix Codes in Clinical Applications and Biotechnology

A milestone to a safer health care system was reached with the 1999 publication from the Institute of Medicine[1] uncovering more than 770,000 medication errors that took place every year in U.S. hospitals in the late 20th century. It has been estimated that every year more than 44,000 fatal casualties have been caused by avoidable errors in treatment, medication, diagnostics or preventive measures. Since the 1999 report, several corrective actions have been taken such as an increasing usage of barcode symbologies for the identification of patient related medication, sampling and treatment. Today barcoding is not only applied in the clinical field, but also in sample processing and banking in pharmaceutical research and biotechnology. Barcoding allows each sample to be provided with a unique identifier (ID), which can be decoded by a reader and transferred into a laboratory information system at any time. This information flow excludes human introduced error, thus making sample identification very robust and secure.

2. The Principle of Datamatrix Coding

Today, the Datamatrix code is the state-of-the-art barcoding technology for secure and efficient item identification – not only in biotechnology, but also in many different industries. It is the standard specified by the Electronic Industries Association, Automotive Industry Action Group, the National Aeronautics and Space Administration, as well as the U.S. Department of Defence. The Datamatrix symbol is a two-dimensional barcode symbology laid out in a square or rectangular grid. Two solid, adjacent borders in an L-shape (the *finder pattern*) help to identify the symbol and determine its orientation. Two other borders consisting of alternating dark and light elements (the *timing pattern*) provide a count of the number of rows and columns in the symbol. The actual data region lies within these borders. It consists of an array of dark or light square elements encoding the information. Within the data region, each element represents one bit of information. Depending on whether it is dark or light, it represents either of the values 0 and 1. The symbol is surrounded by a neutral area (the *quiet zone*, Fig. 2). Because information is encoded in two dimensions, Datamatrix codes have a larger data capacity than linear symbologies such as Code 128, Code 39 and Code 2 of 5 Interleaved (see Tab. 1). For example, a

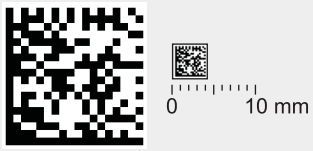

Figure 2: Datamatrix symbol: The solid black lines on the x and y axes help to locate the symbol and determine its orientation. The shown Datamatrix symbol is composed of 18×18 elements and encodes the text Greiner Bio-One. The small symbol to the right represents a possible original print size of the symbol.

Table 1: Data capacity of Datamatrix symbols. Indicated is the smallest symbol size, in the best-case scenario, for the amount of data encoded.

Size of Datamatrix	Maximum numeric capacity	Maximum alpha-numeric capacity	Maximum correctable errors/erasure
10×10	6	3	2
12×12	10	6	3
14x14	16	10	5/7
16x16	24	16	6/9
18x18	36	25	7/11
20x20	44	31	9/15
22x22	60	43	19/17
24x24	72	52	12/21
26x26	88	64	14/25
32x32	124	91	18/33

Datamatrix symbol can be 30 times smaller than a Code 39 representing the same information. One of the most striking features of the Datamatrix symbology, however, is the Reed-Solomon error correction built into the Datamatrix ECC 200. It allows for the reconstruction and

* ECC is the abbreviation for Error Checking and Correction Algorithm. ECC 200 is the newest version of Datamatrix and supports advanced error checking and correction algorithms.

successful decoding of a Datamatrix code even if more than 20 percent of the symbol is damaged. Data integrity tests revealed a statistical probability of a misread error of 1 in 10.5 million scans with a Datamatrix, compared to a misread error probability of 1 in 1.7 million with the linear Code 39[2].

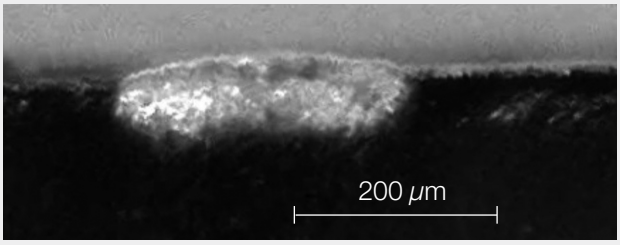

Figure 3: Cross section through a single element of a Datamatrix symbol on a sample tube of the Cryo.s™ series: In the region of the Datamatrix element, the polymer is modified, thus appearing as a white mark surrounded by the native black polymer. The polymer modification is about 350 µm wide and 80 µm deep. The complete Datamatrix symbol is an array of such single elements.

3. Datamatrix Coding on Cryo.s™ Sample Storage Tubes

The most efficient and reliable way of utilizing the Datamatrix symbology for sample identification in biotechnology and clinical applications is by means of a Datamatrix code applied on the bottom of a sample tube. Greiner Bio-One follows this principle with a coding cap that is permanently connected to the tube bottom and a Datamatrix symbol that is laser encrypted into this coding cap. The result is a stable and long-lasting identification tag. As the Datamatrix code is totally integrated into the polymer (Fig. 3), it is very resistant against abrasion and other mechanical strain that may occur during repeated freeze-thaw cycles.

The integrity of the code will remain unchanged throughout the lifespan of the tube. Due to the high quality polypropylene used for the production, Cryo.s™ with Datamatrices are very resistant against chemicals (see Tab. 2). Cryo.s™ with Datamatrix fulfil the requirements for CE marking. For this and other quality characteristics of Cryo.s™ with Datamatrix, see Box 1.

* AIM = Association for Automatic Identification and Mobility, DPM = Direct Part Marking

Table 2: Datamatrices on Cryo.s™ are resistant to the listed chemicals.

Acetonitrile	Glacial acetic acid
Acetone	Hydrochloric acid, 32%
Acetic acid, 1%	Isopropanol
Chloroform	Methanol
DMSO	Phenol
Ethanol	Sulfuric acid, 0.5 M

Box 1: Quality features of Cryo.s™ with Datamatrix and product portfolio.

- CE marked
- Non-pyrogenic, non-cytotoxic
- Free of detectable DNA, DNase and RNase
- Laser written, abrasion proof Datamatrix symbol
- ECC 200 Datamatrix with advanced algorithms for error checking and error correction
- 100% proof scanned Datamatrix code
- Datamatrix coding available for four tube types:
  1 ml tubes with internal thread
  2 ml tubes with internal or external thread
  4 ml tubes with external thread

At Greiner Bio-One, all Cryo.s™ with Datamatrix are subjected to strict quality control before leaving the factory. Part of this quality control is the proof scanning and quality verification of all Datamatrices according to the AIM DPM* Quality Guidelines.

The purpose of this verification is to ensure readability, reliability and consistency of the applied codes with eight different symbol parameters being assessed (Fig. 4). After each test scan, the performance of the Datamatrix is evaluated in respect of these symbol parameters and assigned to the categories A to F with category A representing best performance and category F standing for poor performance. Only Datamatrices that fall into categories A or B for all tested parameters pass quality control.

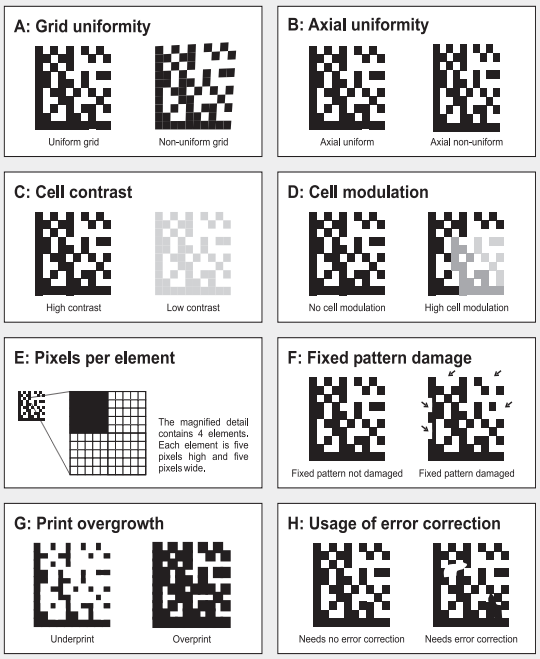

Figure 4: Datamatrix verification: Each Datamatrix is proof scanned and eight different symbol parameters are verified. This verification assures that for each Datamatrix the symbol grid and axes are uniform (A, B), the symbol contrast is sufficient and uniform (C, D), an appropriate number of pixels is used to identify each element (E), the fixed elements of the symbol are not damaged (F), elements are neither under- nor overprinted (G), and no or little use of the error correction algorithm must be made in order to decode the symbol (H).

Cryo.s™ with Datamatrix utilize the ECC 200 version of the Datamatrix symbology with advanced algorithms for error correction and the capability to recover decrypted information from symbols that have been damaged more than 20% (Fig. 5).

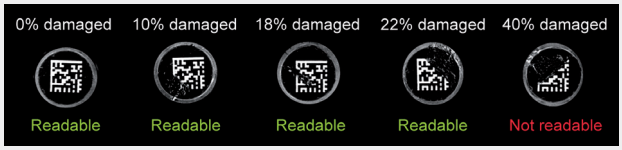

Figure 5: Datamatrix error correction: 14×14 Datamatrix codes have been applied to Cryo.s™ and partially damaged using a hot stamp. The readability of the damaged codes was assessed using an Xtr-1 Elite Datamatrix reader from FluidX. In some cases reading of the damaged codes needed several trials. However, it was possible to recover the encoded information from three of the four damaged symbols with up to 22% of the coding area being lost.

4. Datamatrix Readers

With the increasing usage of Datamatrices in many different industries, devices for Datamatrix decoding have become more complex and powerful. In contrast to linear barcodes that are read with laser scanners, Datamatrices are read with imagers, CCDs or other camera-based systems. New generation 2D readers use high resolution imager technology and help reduce the occurrence of data entry errors and misreadings[3].

Three different types of scanners have become popular for single tube identification in laboratories: (1) Handheld scanners which offer the highest flexibility, (2) fixed mount scanners that are mounted onto a stand or under a tube guiding holder, and (3) benchtop scanners with a quasi-static operational mode and the Datamatrix carrying tube being placed over the scanning window (Fig. 6)

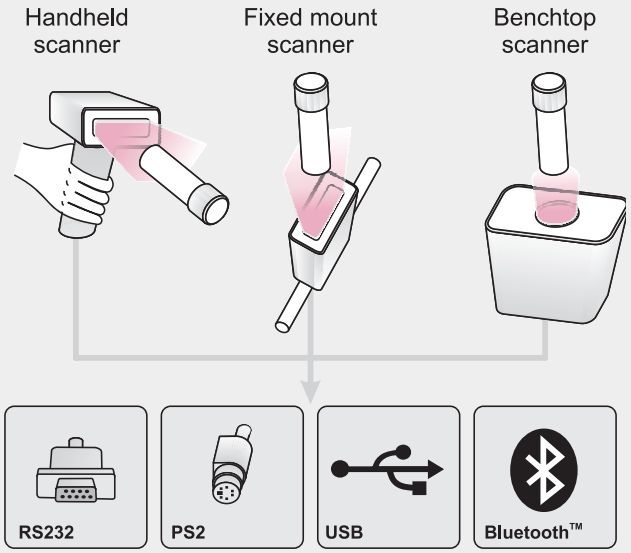

Figure 6: Common types of Datamatrix readers and computer interfaces: Handheld, fixed mount and benchtop scanners are the most commonly used types of Datamatrix readers applied for single tube identification in laboratories. For most scanner models manufacturers offer the choice between conventional RS232, PS2 or USB interfaces or wireless technology for data transfer (e.g. Bluetooth™).

2D scanners use different interfaces for data transfer into a computer based information system. In most instances USB is the interface of choice. However, many manufacturers offer their scanner models with PS2 or RS232 interfaces or wireless technology, such as Bluetooth™. Some of the wireless models can work offline in the event that they lose the connection to the cradle. They will keep collecting data in the offline mode and synchronize data with the cradle once radio contact is restored (e.g. PowerScan® M8500 from Datalogic Scanning). Many 2D readers come with additional helpful features, such as optical, acoustic or tactile "good read" functions that feedback a successful Datamatrix scan by a green light, a beep or vibration.

Algorithms for decoding the Datamatrix symbology are integrated in most standard 2D readers by default. Most readers are therefore plug and play devices that can decode Datamatrices and perform keyboard emulation. When a barcode symbol is read using keyboard emulation, the data appears at the cursor of the connected computer as if it had been typed in from the keyboard.

Table 3: Readers that have been successfully tested and may be recommended for reading 10×10, 12×12 and 14×14 Datamatrix codes on Cryo.s™ sample storage tubes

Manufacturer	Scanner model	Selected features
Datalogic Scanning www.scanning.datalogic.com	Gryphon™ 432 Plus	Handheld scanner, CMOS area sensor with 752×480 pixels, 'Green Spot' for good-read feedback
	PowerScan® PD8500	Handheld scanner, industrial line, CMOS area sensor with 1280×1024 pixels, 'Green Spot' for good-read feedback, protection class IP65
	PowerScan® M8500	Handheld scanner, wireless, narrow band, 433/910 MHz, CMOS area sensor with 1280×1024 pixels, 'Green Spot' for good-read feedback
FluidX www.fluidx.co.uk	Xtr-1 Single Tube Reader	Benchtop single tube reader, CCD sensor 1/3", large window and scan area
	Xtr-1 Eilte Single Tube Reader	Benchtop single tube reader, CCD sensor, very simple, requires no software installation
Honeywell www.honeywellaidc.com	4600gHD	Handheld scanner, imager sensor with 752×480 pixels, multiple interfaces
	4600gSFH	Handheld scanner, imager sensor with 752×480 pixels, disinfectant-ready housing
	4820gHDH	Handheld scanner, wireless, Bluetooth™, imager sensor with 752×480 pixels, disinfectant-ready housing, best results among all Honeywell scanners
Microscan www.microscan.com	MS-Q Quadrus® HD	Handheld scanner, CMOS area sensor with 1280×1024 pixels, Bluetooth™ modem available
	MINI Hawk HR	Fixed mount scanner, imager sensor with 1280×1024 pixels, may be mounted under a static tube holder
Motorola www.motorola.com	Symbol DS9808 Hybrid Presentation Imager	Hybrid scanner (handheld and hands-free scanning mode), imager sensor, omni-directional scanning (no need to align item and scanner)
	Symbol DS6700 1D/2D Imager Scanner	Scanner with handheld and hands-free mode, sensor with 1280×1024 pixels, disinfectant-ready design, omni-directional scanning (no need to align item and scanner)
Opticon Sensors www.opticon.com	OPI2201	Handheld scanner, CMOS area sensor with 1280×1024 pixels, must be adjusted to white on black Datamatrix

Leading manufacturers of 2D readers attested to Cryo.s™ with Datamatrix having best contrast values, symbol sharpness and overall performance and readability. Table 3 provides a list of 2D readers that have been successfully tested to decipher Datamatrix codes on Cryo.s™ and may be recommended for this reason.

The fact that 2D readers transfer the deciphered information directly into the keyboard buffer of a personal computer allows for highest compatibility between readers and software. Virtually any software that can handle numeric or alphanumeric sample IDs and link them to sample information may liaise with a 2D reader (e.g. OpenOffice, EXCEL, ACCESS). The low entry price of a 2D reader (starting from 300 EUR) together with the low minimal order quantity for Cryo.s™ with Datamatrix* and the availability of suitable software in most laboratories allows the set up of a Datamatrix based sample library with little investment. For higher throughput and more complex demands on sample archiving, specialised software solutions are available, such as FreezerPro from RURO Inc., SampleWare®** from Biomatrica and EasyTrack from FluidX.

5. Summary

Cryo.s™ with Datamatrix provide each sample with an individual machine readable tag, therefore allowing sample identification with a minimum margin for error. Implemented error correction algorithms as well as high robustness of the laser written symbol make Cryo.s with Datamatrix the first choice for secure, efficient and long lasting sample tagging in biotechnology, pharma and clinics.

6. Ordering Information

Cat.-No.	Description
F071 004	Order Form Datamatrix Coding Service for Cryo.s™ (English)
F071 005	Order Form Datamatrix Coding Service for Cryo.s™ (German)
127 299-2D1	Sample Pack Cryo.s™ with Datamatrix

* The minimal order quantity for Cryo.s™ with Datamatrix is one original box. This equates to 500 1 or 2 ml tubes or 300 4 ml tubes.

** SampleWare® is a registered Trademark of Biomatrica.

[1] Institute of Medicine Committee on Quality of Health Care in America, To Err Is Human: Building a Safer Health System (Washington, DC: National Academies Press, 1999).

[2] Center for Automatic Identification/University Ohio, Datamatrix and PDF417 Data Integrity (www.ent.ohiou.edu/autoid/datam417.pdf).

[3] A. Zosel and N. Wartenberg, Next-generation bar code readers to streamline analytical processes (IVD Technologie, Vol. 12, No. 1, pp. 35-41, 2006).