
**Microbeam analysis — EMSA/MAS
standard file format for spectral-data
exchange**

*Analyse par microfaisceaux — Format de fichier standard EMSA/MAS
pour échange de données spectrométriques*

STANDARDSISO.COM : Click to view the full PDF of ISO 22029:2022



STANDARDSISO.COM : Click to view the full PDF of ISO 22029:2022



COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 General considerations.....	1
5 Format description.....	2
5.1 General.....	2
5.2 Required keywords.....	3
5.3 Spectral data.....	4
5.4 Optional keywords.....	5
5.5 Ending A File.....	9
6 Examples of data files in the EMSA/MAS spectral format.....	9
Bibliography.....	12

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 202, *Microbeam analysis*.

This third edition cancels and replaces the second edition (ISO 22029:2012), which has been technically revised.

The main changes are as follows.

- The file encoding in this version has been changed from ASCII to UTF-8. This allows for the use of non-ASCII characters in specified descriptive fields but still maintains backwards compatibility with older data reading and writing software since the ASCII coding is a sub-set of the UTF-8 coding. Most of the keyword value character limits have also been removed in this version. These were originally imposed to aid readability of files output to teletype printers and are no longer deemed a necessary restriction.
- The definition of the #OFFSET keyword has been modified to specify that the value of the first spectral channel is taken from the channel's mid-point.
- A new required keyword, #TIMEZONE, has been added and the #TIME keyword is now explicitly required to be local time to ensure that the time and date the data has been recorded can be unambiguously determined.
- Eight new optional keywords have been added: #ROTATION, #WORKDIST, #CRC32C, ##MNKRESOL, ##SUPPAREA, ##SUPPTHICK, ##SUPPMAT and ##DETPOS.
- The new optional error checking keyword, #CRC32C, has been added to provide a more robust error checking option than the original #CHECKSUM value.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The original EMSA/MAS Standard File Format for Spectral Data Exchange was published in October 1991. Since then, advances in both microbeam analysis techniques and in PC technology have meant that this original standard is not fully able to meet modern requirements. The members of ISO/TC 202 propose this updated version. Every effort has been made to only make those changes that improve or update the applicability of the standard, while minimizing incompatibility with the original version. The remit of TC 202 does not include surface analysis techniques, which are addressed by TC 201, and so references to these techniques have been removed from the original standard where necessary. The original document also included examples of coding and telecommunications protocols. Since these are now largely outdated, and not integral to the formatting of the data, these have also been removed.

It is noted that one of the originating societies (EMSA) has modified its name since the original document was published. The society is now officially known as the Microscopy Society of America (MSA), the term “Electron” having been dropped to more fully indicate the work and interest of the membership of the society in all forms of microscopy.

STANDARDSISO.COM : Click to view the full PDF of ISO 22029:2022

[STANDARDSISO.COM](https://standardsiso.com) : Click to view the full PDF of ISO 22029:2022

Microbeam analysis — EMSA/MAS standard file format for spectral-data exchange

1 Scope

This document presents a simple format for the exchange of digital spectral data that has been designated as an EMSA/MAS standard. This format is readable by both humans and computers and is suitable for transmission through various electronic networks, the phone system (with modems) or on physical computer storage devices (such as removable media). The format is not tied to any one computer, programming language or computer operating system. The adoption of a standard format enables different laboratories to freely exchange spectral data, and helps to standardize data analysis software. If equipment manufacturers were to support a common format, the microscopy and microanalysis community would avoid duplicated effort in writing data analysis software.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 General considerations

The virtues of a single standard data format have been admirably related by various authors^{[1],[2],[3],[4]}. It would often be convenient, after visiting another laboratory to use a different type of microanalytical spectrometer, to be able to return to one's own laboratory to analyse the data, or for a laboratory to be able to send a spectrum to another group at another location for analysis on their computer. A common format also enables test spectra to be transported between data acquisition systems, in order to compare different data analysis routines, and would give users greater choice of analysis procedure, based on commercial or public-domain software. Most importantly, it offers a method for archiving data that does not rely on the continued availability of a given item of equipment or version of software to remain accessible.

An ideal solution is for the manufacturers to represent data in a standard format, but they are unlikely to agree on this without some direction from their customers (the microanalysis community). Therefore, it is highly desirable for EMSA and MAS to proceed with the adoption of a standard format. Such a format does not preclude any research group or manufacturer from having their own, possibly proprietary, format. Spectral data can be stored internally in any format, as long as there is an option to convert it to the external standard (and vice versa) for the purposes of exchange. A standard format should possess the following attributes.

- a) It should be capable of representing the data exactly (without altering the scientific content).
- b) The format should be simple and easy to use.

- c) It shall NOT be tied to any particular computer, programming language or operating system. It should work on a large number of computers of all sizes, although we cannot guarantee that it will work on all possible computers.
- d) The format should be both human and machine (computer) readable.
- e) It should be compatible with existing electronic communication networks. Future networks will likely retain compatibility with these.
- f) The format should support spectra of interest to the microanalysis community (such as XEDS, EELS, AES) and should be flexible enough to accommodate future data sets not yet specified.
- g) Each file should contain enough information to uniquely identify the type and origin of the spectral data and to reconstruct its significance.
- h) Where possible, the format should be compatible with various commercial data plotting or analysis programs (i.e. spreadsheets, or graphical-analysis packages).
- i) The proposed format need not be the most efficient storage mechanism. Its primary goals, stated above, will generally prevent storage efficiency. If anything, this format will err on the side of simplicity and ease of use.

The format originally employed by the Electron Microscopy and Microanalysis Public Domain Library (EMMPDL) at Argonne^[1] has the virtue of simplicity, but is too rigid for general use. A recent revision^[5] corrected some inadequacies, but a more serious re-examination is in order. The format proposed by a previous EMSA task force^{[3],[4]} addresses many of the problems, but is thought by some microscopists to be too complicated for everyday use. The VAMAS format, whose description^[6] runs to 60 pages, is also too complex for the perceived purpose. A format, named JCAMP-DX, used by the infrared-spectroscopy community^[2] is specific and detailed, but is somewhat off target for the spectroscopies of interest to the community.

The format proposed here follows JCAMP-DX in many ways but is less complicated and has features tailored to X-ray, energy-loss and Auger spectroscopies. A preliminary version of this proposal was circulated to several manufacturers of XEDS systems which have received comments and suggestions, many of which have been incorporated into this document.

5 Format description

5.1 General

The general structure of the data file format can be summarized as a simple sequential text file using the UTF-8 encoding. It begins with a series of header lines which serve to define the characteristics of the spectrum. These header lines are identified by unique keyword fields which occupy the first 15 positions of each line, followed by a data field. These are described in detail in 5.2 to 5.4. After the header lines, a keyword indicates the start of data, and the data then follow on successive lines in a manner which is defined explicitly within the header. Finally, after all the data are presented, an end-of-data keyword indicates that the data set is complete. This is diagrammatically illustrated as follows:

Header lines

:

Successive lines beginning with EMSA/MAS-defined keywords, some of which are required and some are optional

:

Start-of-data keyword

:

Experimental data

:

End-of-data keyword

In general, each line of the file either contains a keyword and its associated value or spectral data. All header lines are readily identified as they each begin with “#” in the first character field or column. This symbol demarks the start of a 13-character keyword field, providing descriptive information about the data followed by an associated value. EMSA/MAS-defined keywords (whose definition may be changed only by EMSA/MAS) begin with a single # and occupy the first 13 columns (characters) of each header line. The keyword itself consists of at most 12 characters, which directly follow the #. Shorter keywords may be employed, and any remaining spaces following the defined keyword may be filled with descriptive text such as unit designation for ease of legibility when the file is printed (see example in [Table 9](#)). If a position in the keyword field is not used, it shall be filled with a space character. The keywords are not case-sensitive, so that #Xunits is interpreted as being the same as #XUNITS.

The 14th and 15th character positions (columns) in each header line are occupied by keyword/value field separators, which consist of a colon followed by a space. The value associated with each keyword starts in column 16 and may be either textual or numeric as defined by the keyword. The previous version of this standard stipulated a line limit of 79 characters for legibility on ‘standard width CRT screens’ but this is no longer deemed necessary. The end-of-line indicator is a carriage return/linefeed combination (<CR><LF>).

The file encoding shall be UTF-8. However, the only characters allowed in the file, except where explicitly stated otherwise, are the space (UTF-8 character 32), carriage return (UTF-8 character 13) and linefeed (UTF-8 character 10) characters, plus the printable UTF-8 character set given as follows:

!"#\$%&'()*+,-./0123456789:;<=>?@ (UTF-8 characters 33 - 64)

ABCDEFGHIJKLMN O PQRSTUVWXYZ (UTF-8 characters 65 - 90)

abcdefghijklmnopqrstuvwxyz (UTF-8 characters 97 - 122)

[\]^_`{|}~ (UTF-8 characters 91 - 96, UTF-8 123 - 126)

Horizontal TAB characters are NOT permitted in this file format as a substitute for spaces or commas. Examples of keywords, separators and data can be found in [Table 1](#). The file should be named using the extension .TXT, .EMSA or .MSA.

5.2 Required keywords

The following keywords are required and shall appear at the beginning of the file, in the order specified in [Table 1](#). Although some of these may appear arbitrary, it is judged that they fulfil a long-term need. After several years of students and outside users passing through a laboratory, the result can be a vast number of data files of unknown origin. Unless some adequate form of labelling is imposed from the start, many worthwhile data files are lost, and useless data sit on a disc taking up valuable space. With

the following minimum subset of keywords, it should be possible to reconstruct the significance of most spectra.

Note that there shall be exactly one of each required keyword, except for the keyword #TITLE which shall appear at least once but may, at the user's discretion, appear more than once to provide an extended-length title.

Table 1 — Required keywords

#FORMAT	Character string identifies this format as "EMSA/MAS Spectral Data File"
#VERSION	File Format Version Number (TC202v3.0 for this implementation)
#TITLE	Gives a short description of the spectra. One or more per file.
#DATE	The calendar day-month-year in which the spectra was recorded, with the month in letters and the day and year in numbers in the form: DD-MMM-YYYY. For example, 07-JUL-2021.
#TIME	The local time of day at which the spectrum was recorded, in 24-h format: HH:MM.
#TIMEZONE	Difference of local time relative to UTC in hours. For non-integer differences this shall be expressed in decimal format. For example, India has a local time which is 5:30 ahead of UTC and have a #TIMEZONE value of 5.5
#OWNER	The name of the person who recorded the spectrum.
#NPOINTS	Total Number of Data Points in X&Y Data Arrays 1. ≤ NPOINTS. The original EMSA standard set an upper limit of 4096. This is considered to be too restrictive and unnecessary for modern computer systems.
#NCOLUMNS	Number of columns of data 1. ≤ NCOLUMNS < 5. when DATATYPE Y 1. ≤ NCOLUMNS < 3. when DATATYPE XY It is recommended that values > 1 are not used since multicolumn formats cause problems when importing data into spreadsheet packages. They were originally intended to make more efficient use of space on teletype printouts of data files.
#XUNITS	Units for x-axis data, for example: eV
#YUNITS	Units for y-axis data, for example: counts.
#DATATYPE	Method in which the data values are stored as: Y Axis only values or X,Y data pairs. The current options are the characters Y and XY.
#XPERCHAN	The number of x-axis units per channel.
#OFFSET	A real (but possibly negative) number representing the mid-point value of channel one in the same units as #XUNITS.
#SPECTRUM	Indicates the next line starts the spectral data. Note that it is permitted to add descriptive text after the colon on this line (see the example dataset in Table 9)
#ENDOFDATA	Indicates the end of the data file. Note that it is permitted to add descriptive text after the colon on this line (see the example dataset in Table 9)

5.3 Spectral data

The spectral data shall be enclosed between the following keywords:

#SPECTRUM	: Signifies the beginning of spectral data (on the next line).
#ENDOFDATA	: Signifies the end of spectral data.

Between these keywords, the spectrum is listed in one of two ways, as specified by the #DATATYPE value.

In the case of spectra with equally spaced x-values (equal increments per channel), up to #NCOLUMNS y-values may be given per line. For y-axis data type $1 < \#NCOLUMNS < 5$. Each y-value is either a real number (containing a decimal point as the decimal separator if required) or is expressed in exponential format (e.g. 3,142E+3), and is followed immediately by a comma. The corresponding x-values can be obtained from the specified values of #XPERCHAN and #OFFSET or #CHOFFSET.

If the user prefers, data may be stored as (x,y) pairs of data points, at #NCOLUMNS per line. For XY-axis data type $1 \leq \#NCOLUMNS < 3$. The x- and y-values are expressed as real numbers or in exponential format and are separated by a comma. To avoid confusion or ambiguity, a comma shall not be used as either a decimal or thousands separator in the numerical values, only as the separator between values on a line. Where there is more than one (x,y) pair per line, the (x,y) pairs themselves are separated by a comma followed by at least one blank space. Carriage return and linefeed characters act as a delimiter for the last data value on a line. Additional space or comma delimiters may be added for clarity, but any program reading the data values should treat consecutive delimiters as one. The data value zero shall therefore be represented explicitly by at least one "0" text character rather than two consecutive delimiters.

The reason for avoiding the use of integer numbers is that, in some instances, decimal values are generated, for example if energy-loss spectra have been scaled for normalization or to remove a gain change. If necessary, the decimal point and the comma can be removed with a text editor (using a global replace) to give integer values, whereas the reverse process may not be straightforward.

Numerical values between 1 and -1 can be represented either with or without a zero preceding the decimal point (e.g. -0,1 or -.1 are equivalent and allowable). In the case of negative numbers, there should be no spaces between the minus sign and the numerical value. We recommend that there be no trailing spaces after a number (preceding the comma). The (x,y) option has been included to accommodate segmented spectra, containing gaps where y-data are not specified, and to allow for the possibility that the x-axis scale is nonlinear. In addition, it makes the data compatible with most general-purpose graph-plotting software packages. In some future version of the format, this option can be extended by the addition of x and y spatial coordinates, to allow for X-ray maps or energy-selected images, but a more compact representation based on a TIFF standard might be more attractive.

5.4 Optional keywords

All optional keywords except #CHECKSUM, #CRC32C and #COMMENT shall appear before the keyword #SPECTRUM and after #OFFSET. If used, the #CHECKSUM or #CRC32C value should be the last line in the file and is the checksum value for the file, excluding the last line containing the checksum itself, and excluding any trailing spaces after the line terminator. This option is provided to test the integrity of data transmission and/or storage. Note either #CHECKSUM or #CRC32C may be used, but not both.

With one exception, the keywords listed in this subclause (see [Tables 2 to 8](#)) require the user to specify an associated value as a real number or as a permitted character string (see [5.1](#)). The exception is #CHECKSUM, which requires a signed integer value. For ease of classification, we have grouped the optional keywords in order of their function, thus keywords dealing with the spectrum, type of spectroscopy, specimen are presented together in the following listing. This grouping is not required within the file format; however, it is strongly recommended. In the keyword list in [Tables 3 to 7](#) the abbreviation [RN] means the keyword is a real number while [nCS] indicates a character string of *n* characters.

Table 2 — Keywords related to spectrum characteristics

#SIGNALTYPE	Type of Spectroscopy, allowed values are: EDS Energy Dispersive Spectroscopy WDS Wavelength Dispersive Spectroscopy ELS Energy Loss Spectroscopy CLS Cathodoluminescence Spectroscopy GAM Gamma Ray Spectroscopy
#XLABEL	X-Axis label
#YLABEL	Y-Axis label
#CHOFFSET	A real (but possibly negative) number representing the channel number whose value corresponds to zero units on the x-axis scale.
#COMMENT	Comment line. The comment keyword may be repeated as often as desired within header lines of the file and may contain any of the UTF-8 characters.

Table 3 — Keywords related to Microscope/Instrument

#BEAMKV	Accelerating Voltage of Instrument in kilovolts [RN]
#EMISSION	Gun Emission current in microampere [RN]
#PROBECUR	Probe current in nanoampere [RN]
#BEAMDIA	Diameter of incident probe in nanometers [RN]
#MAGCAM	Magnification or Camera Length [RN] Mag in x or times, Cl in mm
#CONVANGLE	Convergence semi-angle of incident beam in milliRadians [RN]
#OPERMODE	Operating Mode, allowed values are: IMAGE Imaging Mode DIFFR Diffraction Mode SCIMG Scanning Imaging Mode SCDIF Scanning Diffraction Mode

Table 4 — Keywords related to specimen

#THICKNESS	Specimen thickness in nanometers [RN]
#XTILTSTGE	Specimen stage tilt x-axis in degrees relative to the beam normal [RN]
#YTILTSTGE	Specimen stage tilt y-axis in degrees relative to the beam normal [RN]
#XPOSITION	Specimen/Beam position along the x-axis [RN]
#YPOSITION	Specimen/Beam position along the y-axis [RN]
#ZPOSITION	Specimen/Beam position along the Z axis [RN]
#ROTATION	Specimen stage rotation in degrees [RN]
#WORKDIST	Working distance. Distance in mm between the specimen surface and the bottom plane of the objective lens of the electron column [RN]

Table 5 — Keywords related to ELS

#DWELLTIME	Dwell time/channel for serial data collection in msec [RN]
#INTEGTIME	Integration time per spectrum for parallel data collection in milliseconds [RN]
#COLLANGLE	Collection semi-angle of scattered beam in mR [RN]

Table 5 (continued)

#ELSDET	Type of ELS Detector, allowed values are: SERIAL Serial ELS Detector PARALL Parallel ELS Detector
---------	---

Table 6 — Keywords related to EDS

#ELEVANGLE	Elevation angle of EDS, WDS detector in degrees [RN]
#AZIMANGLE	Azimuthal angle of EDS, WDS detector in degrees [RN]
#SOLIDANGLE	Collection solid angle of detector in sr [RN]
#LIVETIME	Signal Processor Active (Live) time in seconds [RN]
#REALTIME	Total clock time used to record the spectrum in seconds [RN]
#TBEWIND	Thickness of Be Window on detector in cm [RN]
#TAUWIND	Thickness of Au Window/Electrical Contact in cm [RN]
#TDEADLYR	Thickness of Dead Layer in cm [RN]
#TACTLYR	Thickness of Active Layer in cm [RN]
#TALWIND	Thickness of Aluminium Window in cm [RN]
#TPYWIND	Thickness of Pyrolene Window in cm [RN]
#TBNWIND	Thickness of Boron-Nitride Window in cm [RN]
#TDIWIND	Thickness of Diamond Window in cm [RN]
#THCWIND	Thickness of Hydrocarbon Window in cm [RN]
#EDSDET	Type of X-ray Detector. Allowed values are: SIBEW – Si(Li) with Be Window SIUTW – Si(Li) with Ultra-Thin Window SIWLS – Si(Li) Windowless GEBEW – Ge with Be Window GEUTW – Ge with Ultra-Thin Window GEWLS – Ge Windowless SDBEW – SDD with Be Window SDUTW – SDD with Ultra-Thin Window SDWLS – SDD Windowless OTHER – Detector type not listed above
#CHECKSUM	Sum of all the UTF-8 character values of all characters in the file, including spaces and line terminators. Trailing blanks (on each line) and the last line containing the checksum itself are excluded from this sum. Note that #CHECKSUM is unable to trap transposed character errors [32 BIT SIGNED INTEGER NUMBER]
#CRC32C	Checksum value generated using the CRC32C method. This is a more robust check than the UTF-8-based #CHECKSUM and is able to trap transposed characters. The checksum is calculated on the whole file, including line feeds and carriage returns, with the exception of the LF/CR of the line preceding the #CRC32C keyword and the whole of the line containing the #CRC32C itself. [8-character, upper case hexadecimal number (without a leading qualifier such as “0x”). For example, A6E3BAF6].

The #CHECKSUM or #CRC32C optional keywords and values are used to test for data transmission errors in the file. If the calculated checksum value agrees with that stored in the data file, the user can be reasonably sure that data set has been faithfully transmitted.

Optional user-defined keywords may be also included within the header of the data file. These keywords shall begin with the double ## sign and follow all EMSA/MAS defined keywords, except for the start of data #SPECTRUM keyword. All field restrictions as outlined above apply to user-defined keywords and their values. These user defined keywords allow for expansion of this file structure to cover items that have not yet been explicitly defined by the EMSA/MAS Task Force. To aid consistency of use the following optional user-defined keywords are specified in [Table 7](#).

Table 7 — Optional user-defined keywords

##TCONLYR	Thickness of contact layer in cm [RN]
##TMCONLYR	Contact layer metal
##FILENAME	Name of data file. Should have the extension .TXT, .EMSA, or .MSA
##INCOUNT	Input count rate of the pulse processor, in counts per second [RN]
##OUTCOUNT	Output count rate of the pulse processor, in counts per second [RN]
##DEADTIME	Dead time of the detector, in percent [RN]
##EDTCONST	Time constant/process time of the pulse processor, in μ s [RN]
##EDWINMAT	Material type of the detector window, expressed either as a common name (e.g. polymer) or using a simple formula format (e.g. Si ₃ N ₄)
##EDWINT	Thickness of the detector window in nm [RN]
##SETELEM	Declared or set element symbol, for example which are known to be present in the specimen. One element per ##SET ELEM declaration [2CS]
##SCOATEL	Specimen coating layer material. Elements shall use the 1- or 2-character abbreviation, compound coatings should be expressed in simple formula form. For example, an alumina coating would be expressed as Al ₂ O ₃ . For a multiple coatings, the materials shall be declared in sequential order, starting at the substrate surface and finishing at the top-most surface.
##SCOATTH	Thickness of coating layer in nm. There shall be a thickness declared for each ##SCOATEL declared and shall be declared in the same layer order. Where the thickness of the layer is unknown a value of 0 shall be declared [RN]
##MNKRESOL	Full width half maximum (FWHM) energy resolution of the Mn Ka line, measured in accordance with ISO 15632 [RN].
##SUPPAREA	Coverage of the detector window by support grid in percent, calculated as (detector area – grid area)/sensor area [RN]. Note that this value does not take into account the possible increase in the effective grid area at short detector to sample distances.
##SUPPTHICK	Thickness of the support grid in mm [RN].
##SUPPMAT	Material of support grid.
##DETPOS	Detector insertion/retraction position. This text field can either be a measured position with units given, e.g., '25 mm' or a relative position e.g., 'INSERTED' or 'RETRACTED'

The keywords in [Table 8](#) have been added to allow for non-ASCII text fields to be stored with data.

Table 8 — Free-text keyword fields

##TITLE	Additional TITLE field which is permitted to be in any UTF-8 characters.
##OWNER	Additional OWNER field which is permitted to be in any UTF-8 characters.
##XLABEL	Additional XLABEL field which is permitted to be in any UTF-8 characters.
##YLABEL	Additional YLABEL field which is permitted to be in any UTF-8 characters.
##COMMENT	Additional COMMENT field which is permitted to be in any UTF-8 characters.

5.5 Ending A File

The last line of every file shall be either an #ENDOFDATA, #CRC32C or #CHECKSUM line. The #ENDOFDATA keyword shall immediately follow the spectral data, if present the #CRC32C or #CHECKSUM keyword shall follow the #ENDOFDATA keyword.

6 Examples of data files in the EMSA/MAS spectral format

[Table 9](#) shows an ELS data set using the x,y pair data format. with the minimum required keyword information. [Table 10](#) shows an example EDS x,y, dataset which includes optional and user-defined keywords.

Table 9 — Example of a single column (x,y) data set with the minimum required keywords except for the use of the optional #CRC32C checksum

```
#FORMAT      : EMSA/MAS Spectral Data File
#VERSION     : TC202v3.0
#TITLE       : CRC32C example
#DATE        : 08-MAR-2021
#TIME        : 13:47
#TIMEZONE    : 0.
#OWNER       : Unknown
#NPOINTS     : 10
#NCOLUMNS   : 1
#XUNITS      : Energy Loss (eV)
#YUNITS      : Intensity
#DATATYPE    : XY
#XPERCHAN    : 3.1
#OFFSET      : 520.13
#SPECTRUM    : Spectral Data Starts Here
520.13, 4066.0
523.22, 3996.0
526.32, 3932.0
529.42, 3923.0
532.51, 5602.0
535.61, 5288.0
538.70, 7234.0
541.80, 7809.0
544.90, 4710.0
547.99, 5015.0
#ENDOFDATA   : Spectral Data Ends Here
#CRC32C      : 64D80A44
```

Table 10 — Example of a single column (x,y) EDS data set which includes optional and user-defined keywords

```
#FORMAT      : EMSA/MAS Spectral Data File
#VERSION     : TC202v3.0
#TITLE       : Test Sample X37-A
#DATE        : 18-FEB-2021
#TIME        : 19:20:53
#TIMEZONE    : -1
```

Table 10 (continued)

#OWNER	:
#NPOINTS	: 1024
#NCOLUMNS	: 1
#XUNITS	: keV
#YUNITS	: Intensity
#DATATYPE	: XY
#XPERCHAN	: 0.010000000
#OFFSET	: 0.000000000
#CHOFFSET	: 0.000000
#SIGNALTYPE	: EDS
#XLABEL	: X-Ray Energy
#YLABEL	: X-Ray Intensity
#BEAMKV	: 300.0
#EMISSION	: 0.0000
#PROBECUR	: 1.0000
#BEAMDIA	: 0.0
#MAGCAM	: 200000.0
#OPERMODE	: IMAG
#XTILTSTGE	: 0.000
#YTILTSTGE	: 0.000
#XPOSITION	: 0.729
#YPOSITION	: -11.842
#ZPOSITION	: -27.445
#ELEVANGLE	: 30.50
#AZIMANGLE	: 0.00
#SOLIDANGL	: 1.6792
#LIVETIME	: 150.000
#REALTIME	: 200.586
#TAUWIND	: 2.00E-06
#TDEADLYR	: 1.00E-06
#EDSDET	: SIUTW
#COMMENT	:
##DEADTIME	: 50.586
#SPECTRUM	:
0.0000,	0.0,
0.0100,	0.0,
0.0200,	0.0,
0.0300,	0.0,
0.0400,	0.0,
0.0500,	0.0,
0.0600,	0.0,
0.0700,	0.0,
0.0800,	0.0,
0.0900,	0.0,
0.1000,	0.0,
0.1100,	0.0,
0.1200,	0.0,
0.1300,	0.0,
0.1400,	0.0,
0.1500,	0.0,