



**International
Standard**

ISO 5820

**Microbeam analysis — Hyper-
dimensional data file specification
(HMSA)**

**First edition
2024-02**

**iTeh Standards
(<https://standards.itih.ai>)
Document Preview**

[ISO 5820:2024](#)

<https://standards.itih.ai/catalog/standards/iso/60d39974-e5e4-4554-bd3b-cae831dbba9a/iso-5820-2024>

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[ISO 5820:2024](https://standards.iteh.ai/catalog/standards/iso/60d39974-e5e4-4554-bd3b-eae831dbba9a/iso-5820-2024)

<https://standards.iteh.ai/catalog/standards/iso/60d39974-e5e4-4554-bd3b-eae831dbba9a/iso-5820-2024>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

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

Foreword.....	xi
Introduction	xii
1 Scope.....	1
2 Normative references	1
3 Terms and definitions.....	1
4 Overview.....	1
4.1 Design Considerations	1
4.2 Binary and XML file pair	2
4.2.1 General.....	2
4.2.2 HMSA general structure	2
4.2.3 XML general structure	3
4.2.4 HMSA-XML association	3
4.3 Hyper-dimensional data.....	3
Table 1 — Dimensionality of common data types	3
4.4 Unicode and internationalization.....	4
4.5 Minimalism	4
4.6 Extensibility.....	4
4.7 What HMSA does not do.....	5
5 XML File Specification	6
5.1 XML general structure	6
5.2 XML specification	7
5.2.1 General.....	7
5.2.2 XML features not supported.....	7
5.2.3 XML conformance and validation	7
5.2.4 Character encodings.....	7
5.2.5 Byte order markers	8
5.2.6 Case sensitivity	8
5.3 XML declaration.....	8
5.3.1 General.....	8
5.3.2 XML version attribute	8
5.3.3 XML character encoding attribute.....	8
5.3.4 XML standalone attribute.....	8
5.4 Document root element.....	8
5.4.1 General.....	8
5.4.2 The version attribute	9
5.4.3 The XML:lang attribute.....	9
5.4.4 The UID attribute	9
5.5 XML Parameter element formats.....	9
5.5.1 General.....	9
5.5.2 Numerical values	9
5.5.3 Arrays of values	10

Table 2 — Array type attribute values.....	10
5.5.4 Physical units	10
5.5.5 Alternative language attributes.....	11
5.5.6 Special characters.....	11
Table 3 — Non-permitted element or attribute characters.....	11
5.5.7 Ordering of elements	12
6 The <Header> list element.....	12
6.1 General.....	12
6.2 Header items are optional.....	12
6.3 The <Checksum> element.....	12
6.4 The <Title>, <Author> and <Owner> elements.....	13
6.5 The <Date>, <Time> and <Timezone> elements.....	13
6.6 The <ArbitraryData> element.....	13
6.7 Other optional header elements.....	14
7 The <Conditions> list element.....	15
7.1 General.....	15
7.2 Conditions are optional.....	15
7.3 Condition templates and classes.....	15
7.4 Condition identifiers.....	17
7.5 Typical conditions	17
8 The <Dataset> element.....	18
8.1 General.....	18
8.2 The <DataLength> and <DataOffset> elements.....	19
8.3 The <DatumType> element.....	19
Table 4 — <DatumType> element values	19
8.4 The <Dimensions> list element.....	20
8.4.1 General.....	20
8.4.2 Ordering of dimensions.....	20
8.4.3 Coordinate mapping equations.....	21
8.4.4 Identity and calibration of dimensions.....	22
8.5 The <IncludeConditions> list element.....	24
Annex A (normative) Condition templates and classes	25
A.1 General.....	25
A.2 <Instrument>.....	25
A.2.1 General.....	25
A.2.2 The <Manufacturer> and <Model> elements	25
A.2.3 The <SerialNumber> element.....	25
A.3 <Probe>.....	25
A.4 <Probe Class="EM">.....	26
A.4.1 General.....	26
A.4.2 Required elements:	26
A.4.2.1 The <ProbeEnergy> element	26
A.4.3 Optional elements:.....	26

A.4.3.1	The <GunType> element.....	26
A.4.3.2	The <EmissionCurrent> element.....	26
A.4.3.3	The <FilamentCurrent> element.....	26
A.4.3.4	The <ExtractorBias> element.....	26
A.4.3.5	The <GunPressure> element.....	27
A.4.3.6	The <ProbeDiameter> element.....	27
A.4.3.7	The <ProbeCurrent> element.....	27
A.4.3.8	The <ProbeConvergenceAngle> element.....	27
A.4.3.9	The <Aperture> element(s).....	27
A.4.3.10	The <Control> element(s).....	27
A.4.3.11	The <LensCurrent> element(s).....	27
A.5	<Probe Class="EM/SEM">.....	28
A.5.1	General.....	28
A.5.2	Optional elements:.....	28
A.5.2.1	The <WorkingDistance> element.....	28
A.6	<Probe Class="EM/TEM">.....	28
A.6.1	General.....	28
A.6.2	Optional elements:.....	28
A.6.2.1	The <ProbeMode> element.....	28
A.6.3	Example:.....	28
A.7	<Specimen>.....	29
A.7.1	General.....	29
A.7.2	The <Name> element.....	29
A.7.3	The <Description> element.....	29
A.7.4	The <Owner> element.....	29
A.7.5	The <Origin> element.....	29
A.7.6	The <Material> element.....	29
A.7.7	The <Coating> element.....	29
A.7.8	The <Thickness> element.....	30
A.7.9	Example:.....	30
A.8	<SpecimenEnvironment>.....	30
A.8.1	General.....	30
A.8.2	The <Pressure> element.....	30
A.8.3	The <Temperature> element.....	30
A.8.4	The <Medium> element.....	31

A.8.5	Example:	31
A.9	<MeasurementMode>	31
A.9.1	Optional elements:.....	31
A.9.1.1	The <Control> element(s)	31
A.10	<MeasurementMode Class="TEM">	32
A.10.1	General.....	32
A.10.2	Optional elements:.....	32
A.10.2.1	The <Aperture> element(s).....	32
A.10.2.2	The <LensCurrent> element(s)	32
A.11	<MeasurementMode Class="TEM/Imaging">	32
A.11.1	General.....	32
A.11.2	Optional elements:.....	32
A.11.2.1	The <Defocus> element	32
A.11.2.2	The <AcceptanceAngle> element	33
A.11.2.3	The <NominalMagnification> element.....	33
A.11.3	Example:	33
A.12	<Detector>.....	33
A.12.1	General.....	33
A.12.2	Optional elements:.....	33
A.12.2.1	The <Manufacturer> and <Model> elements	33
A.12.2.2	The <SerialNumber> element.....	33
A.12.2.3	The <SignalType> element.....	34
A.12.2.4	The <MeasurementUnit> element	35
A.12.2.5	The <CollectionMode> element.....	35
A.12.2.6	The <Distance> element.....	35
A.12.2.7	The <Area> element.....	35
A.12.2.8	The <SolidAngle> element.....	35
A.12.2.9	The <SemiAngle> element	35
A.12.2.10	The <Temperature> element	36
A.12.2.11	The <Elevation> element	36
A.12.2.12	The <Azimuth> element	36
A.12.2.13	The <DetectorName> element.....	36
A.12.2.14	The <Aperture> element(s).....	36
A.12.2.15	The <Control> element(s)	36
A.12.3	Example:	37

A.13	<Detector Class="Camera">.....	37
A.13.1	General.....	37
A.13.2	Base template:.....	37
A.13.3	Optional elements:.....	37
A.13.3.1	The <FocalLength> element.....	37
A.13.3.2	The <ExposureTime> element.....	37
A.13.3.3	The <FrameIntegration> element.....	37
A.13.3.4	The <Magnification> element.....	37
A.13.3.5	The <NumericalAperture> element.....	38
A.13.3.6	The <PixelSize> element.....	38
A.13.4	Example:	38
A.14	<Detector Class="CL">.....	38
A.14.1	General.....	38
A.14.2	Base templates:.....	38
A.14.3	Optional elements:.....	38
A.14.3.1	The <DispersionElement> element.....	38
A.14.3.2	The <Grating-d> element.....	39
A.14.3.3	The <EntranceSlit> element.....	39
A.14.4	Example:	39
A.15	<Detector Class="WDS">.....	39
A.15.1	General.....	39
A.15.2	Base templates:.....	39
A.15.3	Optional elements:.....	39
A.15.3.1	The <DispersionElement> element.....	40
A.15.3.2	The <Crystal-2d> element.....	40
A.15.3.3	The <RowlandCircleDiameter> element.....	40
A.15.3.4	The <PulseHeightAnalyzer> elements.....	40
A.15.3.5	The <Counter> element.....	41
A.15.3.6	The <WDSPosition> element.....	41
A.15.4	Examples:	41
A.16	<Detector Class="XEDS">.....	42
A.16.1	General.....	42
A.16.2	Base templates:.....	42
A.16.3	Optional elements:.....	42
A.16.3.1	The <Technology> element.....	42

A.16.3.2	The <NominalThroughput> element.....	42
A.16.3.3	The <TimeConstant> element.....	43
A.16.3.4	The <StrobeRate> element.....	43
A.16.3.5	The <Window> element.....	43
A.16.3.6	The <GoldLayer> element	43
A.16.3.7	The <DeadLayer> element	44
A.16.3.8	The <ActiveLayer> element	44
A.16.4	Examples:.....	44
A.17	<Acquisition>.....	45
A.17.1	General.....	45
A.17.2	The <DateTime> element.....	45
A.17.3	The <SpecimenPosition> element.....	45
A.17.4	Position elements:	45
A.17.4.1	The <X>, <Y> and <Z> elements.....	45
A.17.4.2	The <EulerRotation> element	46
A.17.4.3	The <R> element	46
A.17.4.4	The <TotalTime> element	46
A.17.4.5	The <FrameCount> element.....	46
A.17.4.6	The <FrameTime> element	46
A.17.4.7	The <DwellTime> element	47
A.17.4.8	The <DwellTime_Live> element.....	47
A.18	<Sequence>.....	47
A.18.1	General.....	47
A.18.2	The <Control> element	47
A.18.3	Example:.....	48
A.19	<Calibration>.....	48
A.19.1	General.....	48
A.19.2	The <Quantity> element.....	48
A.19.3	The <Unit> element.....	49
A.19.4	<Calibration Class="Constant">.....	49
A.19.4.1	General.....	49
A.19.4.2	The <Value> element	49
A.19.4.3	Example:.....	49
A.19.5	<Calibration Class="LinearDispersion">.....	49
A.19.5.1	General.....	49

A.19.5.2	The <Gradient> element	49
A.19.5.3	The <Intercept> element.....	50
A.19.6	<Calibration Class="PolynomialDispersion">.....	50
A.19.6.1	General.....	50
A.19.6.2	The <Coefficients> element.....	50
A.19.7	<Calibration Class="Explicit">.....	50
A.19.7.1	General.....	50
A.19.7.2	The <Values> element.....	50
A.19.8	<Calibration Class="Intensity">.....	51
A.19.8.1	General.....	51
A.19.8.2	The <Quantity> element.....	51
A.19.8.3	The <Unit> element.....	51
A.19.8.4	Example:	51
Annex B (normative)	Units and prefixes	52
B.1	General.....	52
B.2	SI units.....	52
Table 5	— SI Units.....	52
B.3	SI-derived units.....	52
Table 6	— SI derived units	52
B.4	Non-SI units.....	53
Table 7	— Non-SI units	53
B.5	SI prefixes.....	54
Table 8	— SI magnitude prefixes.....	54
Annex C (normative)	Unicode character substitutions.....	55
Annex D (informative)	Example files	56
D.1	Optical micrograph.....	56
D.2	Single XEDS spectrum	57
D.3	SEM backscattered electron image.....	58
D.4	Conventional TEM image.....	60
D.5	Conventional electron diffraction pattern	62
D.6	SEM-XEDS hyper-spectral map.....	64
D.7	EPMA+XEDS+CL+BSE map	66
Annex E (Informative)	Common dataset dimensions	70
E.1	General.....	70
E.2	<x>, <y> and <z>.....	70

ISO 5820:2024(en)

E.3	<U> and <V>.....	70
E.4	<Position>.....	71
E.5	<Channel>.....	71
E.6	<Color>.....	71
E.7	<Rotation> and <Tilt>.....	72
E.8	<Focus>.....	72
E.9	<Measurement>.....	73

iTeh Standards (<https://standards.iteh.ai>) Document Preview

[ISO 5820:2024](https://standards.iteh.ai/catalog/standards/iso/60d39974-e5e4-4554-bd3b-cae831dbba9a/iso-5820-2024)

<https://standards.iteh.ai/catalog/standards/iso/60d39974-e5e4-4554-bd3b-cae831dbba9a/iso-5820-2024>

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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*.

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

Most if not all commercial microanalysis systems acquire and store data in proprietary formats. This hinders the transfer of data between instruments and or between laboratories, such as might be required for multi-technique analyses, round robin studies or collaborations. It is possible that even software from the same manufacturer but for different generations of instruments does not store data in compatible formats. This makes the archiving of data extremely difficult beyond the lifetime of the supported system. The format in this document has been developed by an independent group of experts from the Microscopy Society of America (MSA), the US Micro-Analysis Society (MAS), and the Australian Microbeam Analysis Society (AMAS) to be fully transferrable and archivable. It is independent of instrument manufacturer, computer hardware and operating system.

An existing standard (ISO 22029) allows for platform independent transfer and archiving of simple x-ray spectral data, but the increasing capabilities of microanalysis systems to acquire multi-dimensional signals in parallel has made this standard insufficient to meet all current needs. This standard has been written to meet these expanded requirements.

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[ISO 5820:2024](#)

<https://standards.iteh.ai/catalog/standards/iso/60d39974-e5e4-4554-bd3b-cae831dbba9a/iso-5820-2024>

Microbeam analysis — Hyper-dimensional data file specification (HMSA)

1 Scope

The MSA/MAS/AMAS hyper-dimensional data file specification (HMSA, for short) is a platform-independent data format to permit the exchange of hyper-dimensional microscopy and microanalytical data between different software applications. The applications include, but are not limited to:

- Hyper-spectral maps, such as electron energy loss spectroscopy (EELS), energy dispersive x-ray spectrometry (XEDS), or cathodoluminescence spectroscopy (CL).
- ‘Hyper-image’ maps, such as pattern maps using electron backscatter diffraction (EBSD) or convergent beam electron diffraction (CBED).
- 3-dimensional maps, such as confocal microscopy, or focused ion beam (FIB) serial section maps.
- 4-dimensional maps, such as double-tilt electron tomography.
- Time-resolved microscopy and spectroscopy.

In addition to storing hyper-dimensional data, the HMSA file format is applicable for storing conventional microscopy and microanalysis data, such as spectra, line profiles, images, and quantitative analyses, as well as experimental conditions and other metadata.

<https://standards.iteh.ai/catalog/standards/iso/60d39974-e5e4-4554-bd3b-cae831dbba9a/iso-5820-2024>

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 Overview

4.1 Design Considerations

The following requirements were considered in the design of this file format:

- a) Modern experimental apparatus produce data with high dimensionality, such as spectral maps and 3D serial section maps. Therefore, this file format shall store data of high dimensionality.

- b) High dimensionality data is necessarily very large, and consequently difficult and time consuming to store or transfer over networks. The file format shall therefore be as compact as is reasonably practical.
- c) Many microanalytical techniques produce structurally similar hyperdimensional data. To simplify implementation of common tools, this file format shall use a common format to store data produced by different analytical techniques.
- d) The data format shall preserve the scientific accuracy and meaning of the data. Therefore, the file format shall store data without loss of precision and include sufficient experimental parameters to permit the correct interpretation of the data.
- e) To achieve the intended mission of being a widely supported exchange format, the file format shall achieve acceptance from instrument and software vendors, and from the microanalysis community. Consequently, the file format shall be useful, easy to understand, and easy to implement.
- f) Furthermore, as the file format is intended for exchange, it shall be readable (and implementable) in any commonly available programming languages and environments. The format shall therefore be platform independent, and not require any proprietary or special software or hardware.

4.2 Binary and XML file pair

4.2.1 General

To satisfy the above requirements, the MSA/MAS/AMAS hyper-dimensional data file format uses a pair of files; a simple binary file to efficiently store the experimental data, and a text-based XML file to store the experimental conditions. The advantages of this dual format are:

- The structure of the binary file format is simple, unambiguous, and precisely defined in a human readable format within the XML file.
- High dimensionality experimental data is binary encoded for space efficiency, whilst also being easy to read and write programmatically.
- Experimental conditions are stored in a human-readable and self-descriptive format. Conditions are stored in a hierarchical structure to logically classify related settings.
- No special libraries are required to read or write HMSA/XML files. For convenience, XML libraries may be used, and are freely available on most programming environments.

4.2.2 HMSA general structure

The HMSA file is a binary file format consisting of an 8 byte (64 bit) unique identifier (5.4.4: The `UID` attribute), followed by one or more dataset objects. The location, size and layout of the binary dataset objects are described in the dataset definitions within the XML file (8: The `<Dataset>` element), and are not described within the binary HMSA file. The values contained within the HMSA file datasets cannot therefore be read or interpreted without the corresponding dataset definition within the XML file.

Blocks of arbitrary and proprietary binary or text data also may be placed in the binary HMSA file. These arbitrary data blocks may be used to store proprietary application-specific data, or ancillary experimental data that cannot be formatted as a HMSA data set object (8: The `<Dataset>` element). The formatting of these arbitrary data blocks in the HMSA file are not defined by this specification,