

mzTab-M  
*exchange format for metabolomics results*

# Table of Contents

Preface	1
Abstract	2
1. Introduction	3
1.1. Background	3
1.2. Document Structure	3
2. Use Cases for mzTab	4
3. Notational Conventions	5
4. Relationship to Other Specifications	6
4.1. Relationship to mzTab 1.0	6
4.2. The PSI Mass Spectrometry Controlled Vocabulary (CV)	6
5. Resolved Design and scope issues	8
5.1. Use of identifiers for input spectra to a search	8
5.2. Recommendations for reporting replicates within experimental designs	10
5.3. Reporting derivatization approaches	12
5.4. Encoding missing values, zeroes, nulls, infinity and calculation errors	12
5.5. Reliability score	12
5.6. Support for positive and negative modes	12
5.7. Referencing evidence for small molecule identifications	12
5.8. Guidelines for reporting results prior to or with no alignment step across features	13
5.9. Guidelines for workflows involving pre-fractionation	13
5.10. Comments on Specific Use Cases	13
5.11. Adding optional columns	13
5.12. Referencing external resources	14
5.13. Other supporting materials	14
6. Format specification	15
6.1. Sections	16
6.2. Metadata Section	16
6.3. Small Molecule Section	37
6.4. Small Molecule Feature (SMF) Section	46
6.5. Small Molecule Evidence (SME) Section	51
7. Non-supported use cases	60
8. Conclusions	61
9. Authors	62
10. Contributors	63
References	64
11. Intellectual Property Statement	65
TradeMark Section	66
Copyright Notice	67

# Preface

## *Status of This Document*

This document presents the final specification of the mzTab data format developed by members of the Human Proteome Organisation (HUPO) Proteomics Standards Initiative (PSI) Proteomics Informatics (PI) Working Group, in collaboration with the Metabolomics Standards initiative (MSI). Distribution is unlimited.

## *Version of This Document*

The current version of this document is: version 1.1.0-draft, April 2018.

The latest draft version of this document may be found at <https://github.com/HUPO-PSI/mzTab>.

# Abstract

The Metabolomics Standards initiative (MSI) and the Human Proteome Organisation (HUPO) Proteomics Standards Initiative (PSI) define community standards for data representation in proteomics/metabolomics to facilitate data comparison, exchange and verification. In this context, the two organizations are working together on a shared standard for downstream results, following mass spectrometry (MS) analysis. This document defines a tab-delimited text file format to report metabolomics results, based on a shared core mzTab format, also used in the proteomics context.

# Chapter 1. Introduction

## 1.1. Background

This document addresses the systematic description of small molecule identification and quantification data retrieved from mass spectrometry (MS)-based experiments. A large number of software tools are available that analyze MS data and produce a variety of different output data formats.

mzTab-M is intended as a reporting standard for quantitative results from metabolomics/lipodomics approaches. This format is also intended to provide local LIMS systems as well as MS metabolomics repositories a simple way to share and combine basic information.

mzTab has been developed with a view to support the following general tasks (more specific use cases are provided in [Chapter 2](#)):

1. *Facilitate the sharing of final experimental results*, especially with researchers outside the field of metabolomics.
2. *Export of results to external software*, including programs such as Microsoft Excel® and Open Office Spreadsheet and statistical software / coding languages such as R.
3. *Act as an output format of (web-) services* that report MS-based results and thus can produce standardized result pages.
4. *Be able to link to the external experimental evidence* e.g. by referencing back to mzML files.

This document presents a specification, not a tutorial. As such, the presentation of technical details is deliberately direct. The role of the text is to describe the model and justify design decisions made. The document does not discuss how the models should be used in practice, consider tool support for data capture or storage, or provide comprehensive examples of the models in use. It is anticipated that tutorial material will be developed independently of this specification.

## 1.2. Document Structure

The remainder of this document is structured as follows.

2. [Chapter 2](#) lists use cases mzTab-M is designed to support. . [Chapter 3](#) describes the terminology used.
3. [\[relationships-to-other-specifications\]](#) describes how the specification presented in [Chapter 6](#) relates to other specifications, both those that it extends and those that it is intended to complement.
4. [Chapter 5](#) discusses the reasoning behind several design decisions taken.
5. [Chapter 6](#) contains the documentation of the file.
6. [Chapter 7](#) lists use cases that are currently not supported.
7. [Chapter 8](#) Conclusions are presented last.

## Chapter 2. Use Cases for mzTab

The following cases of usage have driven the development of the mzTab data model, and are used to define the scope of the format in version 1.1.

1. mzTab-M files should be simple enough to make metabolomics results accessible to people outside the respective fields. This should facilitate the sharing of data beyond the borders of the fields and make it accessible to non-experts.
2. mzTab-M files should contain sufficient information to provide an electronic summary of all findings in a metabolomics study to permit its use as a standard documentation format for ‘supplementary material’ sections of publications in metabolomics. It should thus be able to replace PDF tables as a way of reporting small molecules make published identification and quantification information more accessible.
3. mzTab-M files should enable reporting at different levels of detail: ranging from a simple summary of the final results to a detailed reporting including the experimental design.
4. It should be possible to open mzTab-M files with “standard” software such as Microsoft Excel<sup>®</sup> or Open Office Spreadsheet. This should furthermore improve the usability of the format to people outside the fields of metabolomics.
5. mzTab files should make MS derived results easily accessible to scripting languages allowing bioinformaticians to develop software without the overhead of developing sophisticated parsing code. Since mzTab files will be comparatively small, the data from multiple experiments can be processed at once without requiring special resource management techniques.
6. It should be possible to contain the complete final results of an MS-based metabolomics experiment in a single file. This should furthermore reduce the complexity of sharing and processing an experiment’s final results. mzTab-M files should be able to store quantitative values for small molecule identifications.
7. It should be useful as an output format by web-services that can then be readily accessed by tools supporting mzTab-M.
8. It should be possible to directly link a small molecule record to its source spectrum in an external MS data file.

# Chapter 3. Notational Conventions

The key words “MUST,” “MUST NOT,” “REQUIRED,” “SHALL,” “SHALL NOT,” “SHOULD,” “SHOULD NOT,” “RECOMMENDED,” “MAY,” and “OPTIONAL” are to be interpreted as described in RFC-2119 ([Bradner 1997](#)).

# Chapter 4. Relationship to Other Specifications

The specification described in this document has not been developed in isolation; indeed, it is designed to be complementary to, and thus used in conjunction with, several existing and emerging models. Related specifications include the following:

1. *mzML* (<http://www.psdev.info/mzml>). *mzML* is the PSI standard for capturing mass spectra / peak lists resulting from mass spectrometry in proteomics (Martens *et al.* 2011). *mzTab* files MAY be used in conjunction with *mzML*, although it will be possible to use *mzTab* with other formats of mass spectra. This document does not assume familiarity with *mzML*.
2. *ISA-TAB* (<http://isa-tools.org/>). The ISA framework allows for reporting experimental metadata and study designs in considerable detail, and is already used for describing metabolomics experiments. It is expected that *mzTab* files may be linked to ISA-TAB formatted files, for cases where a rich experimental design is to be captured. The linkage between *mzTab-M* and ISA-TAB is further exemplified in section [Section 5.12](#).

## 4.1. Relationship to *mzTab* 1.0

The first stable version of *mzTab* (version 1.0) was developed primarily by the PSI as a format for the final results (identification or quantification) of a proteomics experiment, using MS. In *mzTab* version 1.0 limited support was included for metabolomics, through a small molecule table, in which end results could be encoded at the level of quantified metabolites. The intention of *mzTab-M* is to extend these concepts, so that more detail can be captured about the evidence trail for quantification, including MS features (different charge states or adducts) and the evidence trail for identifications - both of which could not be easily supported in *mzTab* v 1.0. *mzTab-M* is not formally backwards compatible, but follows a similar design pattern. Design decisions made in *mzTab-M* may in the future be adopted for a version of *mzTab* specifically intended for proteomics only, but at the time of writing *mzTab* version 1.0 remains in active use for proteomics, but is deprecated for use in metabolomics.

## 4.2. The PSI Mass Spectrometry Controlled Vocabulary (CV)

The PSI-MS controlled vocabulary is intended to provide terms for annotation of mass spectrometry-related file formats. The CV has been generated with a collection of terms from software vendors and academic groups working in the area of mass spectrometry and MS informatics. Some terms describe attributes that must be coupled with a numerical value attribute in the *CvParam* element (e.g. MS:1001191 “p-value”) and optionally a unit for that value (e.g. MS:1001117, “theoretical mass”, units = “dalton”). The terms that require a value are denoted by having a “datatype” key-value pair in the CV itself: MS:1000511 “ms level” value-type:xsd:int. Terms that need to be qualified with units are denoted with a “has\_units” key in the CV itself (relationship: has\_units: UO:0000221 ! dalton).

As recommended by the PSI CV guidelines, psi-ms.obo should be dynamically maintained via the



[psidev-ms-vocab@lists.sourceforge.net](mailto:psidev-ms-vocab@lists.sourceforge.net) mailing list that allows any user to request new terms in agreement with the community involved. Once a consensus is reached among the community the new terms are added within a few business days. If there is no obvious consensus, the CV coordinators committee should vote and make a decision. A new psi-ms.obo should then be released by updating the file on the GitHub server without changing the name of the file.

The following ontologies or controlled vocabularies specified below may also be suitable or required in certain instances:

- Unit Ontology (<http://www.obofoundry.org/ontology/uo.html>)
- ChEBI (<ftp://ftp.ebi.ac.uk/pub/databases/chebi/ontology/chebi.obo>)
- OBI Ontology of Biological Investigations (<http://obi-ontology.org/>)
- NEWT UniProt Taxonomy Database (<http://www.ebi.ac.uk/ontology-lookup/browse.do?ontName=NEWT>)
- BRENDA tissue/ enzyme source ([http://www.brenda-enzymes.info/ontology/tissue/tree/update/update\\_files/BrendaTissueOBO](http://www.brenda-enzymes.info/ontology/tissue/tree/update/update_files/BrendaTissueOBO)).
- Cell Type ontology (<https://raw.githubusercontent.com/obophenotype/cell-ontology/master/cl-basic.obo>).

# Chapter 5. Resolved Design and scope issues

There were several issues regarding the design of the format that were not clear cut, and a design choice was made that was not completely agreeable to everyone. So that these issues are not continuously revisited, we document the issues here and why the decision that is implemented was made.

## 5.1. Use of identifiers for input spectra to a search

Small molecules MUST be linked to an identifier of the source spectrum (in an external file) from which the identifications are made by way of a reference in the `spectra_ref` attribute and via the `ms_run` element which stores the URL of the file in the `location` attribute.

It is advantageous if there is a consistent system for identifying spectra in different file formats. The following table is implemented in the PSI-MS CV for providing consistent identifiers for different spectrum file formats.

### NOTE

This table shows examples from the CV but will be extended. The CV holds the definite specification for legal encodings of spectrum identifier values.

Table 1. Controlled vocabulary terms and rules implemented in the PSI-MS CV for formulating the “nativeID” to identify spectra in different file formats.

ID	Term	Data type	Comment
MS:1000768	Thermo nativeID format	controllerType=xsd:nonNegativeInteger controllerNumber=xsd:positiveInteger scan=xsd:positiveInteger	controller=0 is usually the mass spectrometer
MS:1000769	Waters nativeID format	function=xsd:positiveInteger process=xsd:nonNegativeInteger scan=xsd:nonNegativeInteger	
MS:1000770	WIFF nativeID format	sample=xsd:nonNegativeInteger period=xsd:nonNegativeInteger cycle=xsd:nonNegativeInteger experiment=xsd:nonNegativeInteger	
MS:1000771	Bruker/Agilent YEP nativeID format	scan=xsd:nonNegativeInteger	
MS:1000772	Bruker BAF nativeID format	scan=xsd:nonNegativeInteger	

ID	Term	Data type	Comment
MS:1000773	Bruker FID nativeID format	file=xsd:IDREF	The nativeID must be the same as the source file ID
MS:1000774	multiple peak list nativeID format	index=xsd:nonNegativeInteger	Used for referencing peak list files with multiple spectra, i.e. MGF, PKL, merged DTA files. Index is the spectrum number in the file, starting from 0.
MS:1000775	single peak list nativeID format	file=xsd:IDREF	The nativeID must be the same as the source file ID. Used for referencing peak list files with one spectrum per file, typically in a folder of PKL or DTAs, where each sourceFileRef is different
MS:1000776	scan number only nativeID format	scan=xsd:nonNegativeInteger	Used for conversion from mzXML, or a DTA folder where native scan numbers can be derived.
MS:1000777	spectrum identifier nativeID format	spectrum=xsd:nonNegativeInteger	Used for conversion from mzData. The spectrum id attribute is referenced.
MS:1001530	mzML unique identifier	xsd:string	Used for referencing mzML. The value of the spectrum id attribute is referenced directly.

In mzTab, the spectra\_ref attribute should be constructed following the data type specification in [CV Terms and Rules](#). As an example, to reference the third spectrum (index = 2) in an MGF (Mascot Generic Format) file:

```

MTD ms_run[1]-format [MS, MS:1001062, Mascot MGF file, ]

MTD ms_run[1]-id_format [MS, MS:1000774, multiple peak list nativeID format, ]

...

SEH ... spectra_ref ...

SME ... ms_run[1]:index=2 ...

```

Example: Reference the spectrum with identifier “scan=11665” in an mzML file.

```
MTD ms_run[1]-format [MS, MS:1000584, mzML file, ]

MTD ms_run[1]-id_format [MS, MS:1001530, mzML unique identifier, ]

...

SEH ... spectra_ref ...

SME ... ms_run[1]:scan=11665 ...
```

## 5.2. Recommendations for reporting replicates within experimental designs

Modeling the correct reporting of technical/biological replicates within experimental designs is supported in mzTab as shown in Figure 1. The following components have various cross-references and MUST be used in different types of mzTab files as follows:

- *study\_variable* – The variables about which the final results of a study are reported, which may have been derived following averaging across a group of replicate measurements (assays). The same concept has been defined by others as “experimental factor”.
- *ms\_run* – An MS run is effectively one run on an MS instrument, and is referenced from assay in different contexts. In the case of pre-fractionation into  $n$  fractions, an assay SHOULD reference  $n$  *ms\_runs*.
- *assay* – The application of a measurement about the sample (in this case through MS) – producing values about small molecules or lipids. One assay is typically mapped to one MS run in the case of label-free MS analysis (with no pre-fractionation). At the present time, multiplexing within an *ms\_run* is not supported in mzTab-M, thus there would typically be a one:one relationship between assay and *ms\_run*.
- *sample* – a biological material that has been analyzed, to which descriptors of species, cell/tissue type etc. can be attached. In all of types of mzTab file, these MAY be reported in the metadata section as *sample[1-n]-description*. Samples are NOT MANDATORY in mzTab, since many software packages cannot determine what type of sample was analyzed (e.g. whether biological or technical replication was performed). If the file producer wishes to describe whether biological or technical replication has been performed, then sample elements SHOULD be provided.

Clear definitions of biological and technical replicates are difficult to provide as these are somewhat dependent upon the biological domain. However, we use the following general definitions in mzTab.

- Biological replicates are where different samples have been analyzed by MS.
- Technical replicates are where same samples are analyzed multiple times by MS.

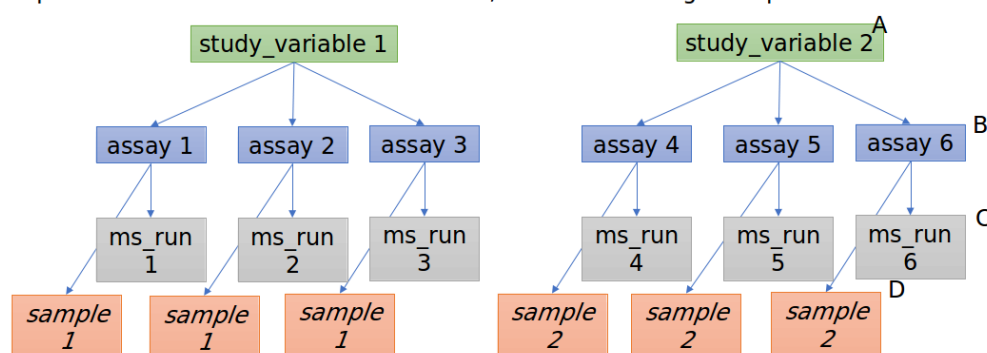
**NOTE** There is deliberately no attempt to define the boundary of the term “sample”.

If sample level information is provided optimally, it is expected that: \*  $n$  biological replicates can be mapped to sample[1- $n$ ] \*  $m$  technical replicate measurements of sample 1 SHOULD be mapped to assay[1- $m$ ] referencing sample[1] (for example).

However, an open challenge remains since some analysis software is often not aware of whether replicates (multiple MS runs) are originally biological or technical in nature. As such, the default behavior for mzTab exporters from quantitative software is to exclude sample level information and report quantitative data for assay[1- $n$ ] and study\_variable[1- $n$ ].

Additional annotation software would typically be required to add the sample-level information, as provided (often manually) by the user.

Pairwise comparison of two treatments or conditions, with three biological replicates and no technical replicates.



Pairwise comparison of two treatments or conditions, with no biological replicates, three technical replicates.

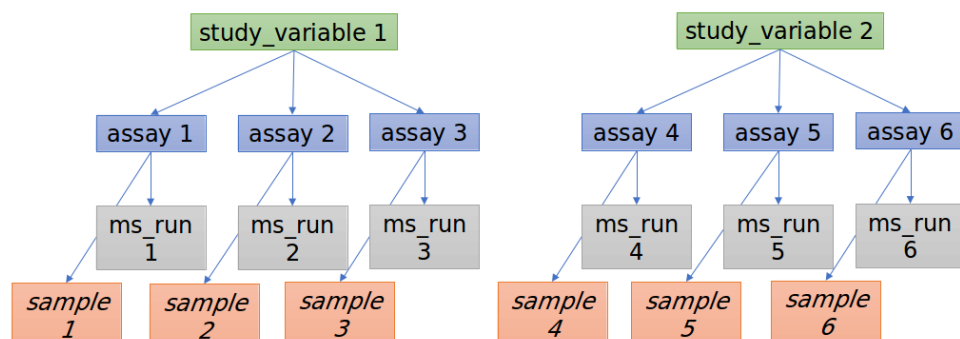


Figure 1. Simple experimental designs in mzTab can be represented using a combination of study\_variable (SV), assay, ms\_run and sample. Quantitative values can be reported in files for SVs and assays. A) SV is intended to capture different groups of replicates, which might have resulted from different sample types e.g. control versus treated (as 2 SVs),  $n$  time points over a treatment course (as  $n$  SVs). Nested designs can be captured by annotation of additional CV terms onto SVs. B) assay captures a measurement made about a molecule (small molecule/lipid) where multiple assays within the same group are taken to be replicates of some kind (biological or technical). Additional details about the sample processing to generate an assay should not be captured in mzTab, but could be captured via a reference to an external suitable format such as ISA-TAB. C) ms\_run captures a single run on an MS instrument. If pre-fractionation has been performed then an assay can reference to multiple ms\_runs. In this case, ms\_run can have a nested structure enabling assay to reference to a group of MS files. D) samples are optional in mzTab since the quantitative software may often be unaware of the biological samples that have been analysed.

## 5.3. Reporting derivatization approaches

### IMPORTANT

TODO Some text needed in here about how to encode derivatization results - Nils is working on this

## 5.4. Encoding missing values, zeroes, nulls, infinity and calculation errors

In the table-based sections there MUST NOT be any empty cells. In case a given property is not available “null” MUST be used, but this is only allowed for parameters with “is nullable=True”.

For numerical values, they MUST be encoded following the specifications of [xs:decimal](#). This does not natively support NaN, INF, scientific notation or null. As such, it is allowed in mzTab to include “NaN” for incalculable numbers and “null” for no data. In some cases, there is ambiguity with respect to the use of “0” versus “null”: e.g. if there are alignment issues and it is unclear whether a molecule has been quantified with zero abundance or the feature was potentially present in the data but was not found. Export software would be expected to make a decision on this cases, based on best understanding of the case in hand.

Scientific notation and infinity is explicitly not supported.

## 5.5. Reliability score

All small molecule identifications reported in an mzTab file MAY be assigned a reliability score (column “reliability” in all tables). This reliability only applies to the identification reliability.

## 5.6. Support for positive and negative modes

It is common in metabolomics workflows to use both positive and negative ionisation modes to increase coverage of molecules quantified. In general, an mzTab-M file is intended to capture a data set generated from assays have been aligned (e.g. in the retention time dimension) to produce a coherent data matrix with few missing values. To our knowledge, it is not common to compare directly the results from positive and negative modes in the same data matrix. As such, we anticipate that such results (i.e. positive mode and negative mode) should be encoded in two different mzTab-M files.

## 5.7. Referencing evidence for small molecule identifications

Evidence for small molecule identification is captured by reference from the SML table via features (SMFs) down to the final table - Small Molecule Evidence elements. It is possible to have a legal mzTab-M file that does not contain any features (SML summary level only). In this case, detailed information about small molecule evidence cannot be provided. It is generally RECOMMENDED to include data at the SML, SMF and SME levels.

SMF elements should reference down to all evidence elements (SME rows) that support the identification of that particular feature.

[image] | *img/media/figure2.png*

Figure 2. A) The summary level (SML) reports the final assumed identification, allowing for ambiguity by “|” separated results in the relevant columns; B) The feature level (SMF) does not explicitly report identifications but references down to the SME level. Ambiguity is propagated via referencing multiple SME elements (rows) with different identification results; C) One SME element (one row) represents a single possible identification from some input evidence. Multiple identifications from the same input data share the same value for `evidence_input_id`. Ambiguity is captured by different rows for the same input data.

## 5.8. Guidelines for reporting results prior to or with no alignment step across features

The most common intended use for mzTab-M is to encode MS results that have been aligned across multiple analyses (assays), for example by retention time alignment in LC-MS or GC-MS approaches. However, it is possible to use mzTab-M as part of internal pipelines to represent small molecules quantified by MS (features) before alignment. The RECOMMENDED encoding for doing this would be to represent the features from  $n$  MS analyses in  $n$  mzTab files, rather than attempting to create an SMF table including a sparse matrix filled with nulls for in all but one of the assay columns.

## 5.9. Guidelines for workflows involving pre-fractionation

It is possible that a single analysis of a sample is split offline via some fractionation technology prior to LC/GC-MS into  $n$  MS analyses to limit the complexity of the molecules arriving at the detector. Such workflows, while relatively rare in metabolomics, can be encoded in mzTab-M via an assay referencing to  $n$  `ms_runs`. It may be desirable to maintain the link from a feature (SMF row) to the `ms_run` from which it was obtained. This SHOULD be achieved through the use of an optional column called `opt_global_ms_run_refs`, in which the identifiers of `ms_runs` are placed where the feature has been quantified from.

## 5.10. Comments on Specific Use Cases

Many special use cases for mzTab were considered during its development. Each of these use cases has a corresponding example file that exercises the relevant part of the format and provides a reference implementation example (see supporting documentation). Authors of software that create mzTab are encouraged to examine the examples that accompany this format release before implementing the writer.

## 5.11. Adding optional columns

Additional columns MAY be added to the end of rows in all the table-based sections.

These column headers MUST start with the prefix “opt\_” followed by the identifier of the object they reference: assay, study variable, MS run or “global” (if the value relates to all replicates). Column names MUST only contain the following characters: ‘A’-‘Z’, ‘a’-‘z’, ‘0’-‘9’, ‘,’ ‘-’, ‘[’, ‘]’, and ‘.’. *CV parameter accessions MAY be used for optional columns following the format: opt{OBJECT\_ID}\_cv\_{accession}\_{parameter name}*. Spaces within the parameter’s name MUST be replaced by ‘\_’.

The information stored within an optional column is completely up to the resource that generates the file. It MUST not be assumed that optional columns having the same name in different mzTab files contain the same type of information. CV parameter accessions MAY be used as optional column names according to the following convention: opt\_{OBJECT\_ID}\_cv\_{accession}\_{parameter name}. Spaces within the parameter’s name MUST be replaced by ‘\_’.

```
COM Example showing how emPAI values are reported in an additional column from MS run
1 using
```

```
COM MS CV parameter “emPAI value” (MS:1001905)
```

```
...
```

```
PRH accession ... opt_ms_run[1]_cv_MS:1001905_emPAI_value
```

```
PRT P12345 ... 0.658
```

## 5.12. Referencing external resources

The current specifications of mzTab-M only support relatively simple details about sample preparation and experimental design. Users may wish to use ISA-TAB to record more details about these aspects. The ISA-TAB file can be referenced by the external\_study\_uri attribute.

## 5.13. Other supporting materials

Example files are located at [GitHub](#)



# Chapter 6. Format specification

This section describes the structure of an mzTab file.

- **Field separator**

The column delimiter is the Unicode Horizontal Tab character (Unicode codepoint 0009).

- **File encoding**

The UTF-8 encoding of the Unicode character set is the preferred encoding for mzTab files. However, parsers should be able to recognize commonly used encodings.

- **Case sensitivity**

All column labels and field names are case-sensitive.

- **Line prefix**

Every line in an mzTab file MUST start with a three letter code identifying the type of line delimited by a Tab character. The three letter codes are as follows:

- **MTD** for metadata
- **SMH** for small molecule table header line (the column labels)
- **SML** for rows of the small molecule table
- **SFH** for small molecule feature header line
- **SMF** for rows of the small molecule feature table
- **SHE** for small molecule evidence header line
- **SME** for rows of the small molecule evidence table
- **COM** for comment lines

- **Header lines**

Each table based section (protein, peptide, PSM and small molecule) MUST start with the corresponding header line. These header lines MUST only occur once in the document since each section also MUST only occur once.

- **Dates**

Dates and times MUST be supplied in the ISO 8601 format (“YYYY-MM-DD”, “YYYY-MM-DDTHH:MMZ” respectively).

- **Decimal separator**

In mzTab files the dot (“.”) MUST be used as decimal separator. Thousand separators MUST NOT be used in mzTab files.

- **Comment lines and empty lines**

Comment lines can be placed anywhere in an mzTab file. These lines must start with the three-letter code COM and are ignored by most parsers. Empty lines can also occur anywhere in an mzTab file and are ignored.

- **Params**

mzTab makes use of CV parameters. As mzTab is expected to be used in several experimental environments where parameters might not yet be available for the generated scores etc. all parameters can either report CV parameters or user parameters that only contain a name and a value.

Parameters are always reported as [CV label, accession, name, value]. Any field that is not available MUST be left empty.

```
[MS, MS:1001477, SpectraST,]  
[, , A user parameter, The value]
```

In case, the name of the param contains commas, quotes MUST be added to avoid problems with the parsing: [label, accession, "first part of the param name, second part of the name", value].

```
[MOD, MOD:00648, "N,O-diacetylated L-serine",]
```

- **Sample IDs**

To be able to supply metadata specific to each sample, ids in the format `sample[1-n]` are used.

```
MTD sample[1]-species[1] [NEWT, 9606, Homo sapiens (Human), ]
```

- **Assay IDs**

To be able to supply metadata specific to each assay, ids in the format `assay[1-n]` are used.

```
MTD assay[1] first assay description
```

- **Study variable IDs**

To be able to supply metadata specific to each study variable (grouping of assays), ids in the format `study_variable[1-n]` are used.

```
MTD study_variable[1] Group B (spike-in 0.74 fmol/uL)
```

## 6.1. Sections

mzTab-M files MUST have one Metadata (MTD) section and one Small Molecule (SML) Section. In practice, we expect that most files SHOULD also include one Small Molecule Feature (SMF) section, and one Small Molecule Evidence (SME) Section. Files lacking SMF and SME sections can only present summary data about quantified molecules, without any evidence trail for how those values were derived. It will be left to reading software to determine whether additional validation will be requested such that SMF and SME tables MUST be present.

## 6.2. Metadata Section

The metadata section provides additional information about the dataset(s) reported in the mzTab file. All fields in the metadata section are optional apart from those noted as mandatory. The fields

in the metadata section MUST be reported in order of the various fields listed here. The field's name and value MUST be separated by a tab character:

```
MTD publication [MS, MS:1000879, PubMed identifier, 12345]
```

In the following list of fields any term encapsulated by `\{\}` is meant as a variable which MUST be replaced accordingly.

## Core Metadata

### 6.2.1. mzTab-version

<b>Description:</b>	The version of the mzTab file.
<b>Type:</b>	Regex{"1\.\d\.\d-M"}
<b>Mandatory</b>	True
<b>Example:</b>	MTD mzTab-version 1.1.0-M

### 6.2.2. mzTab-ID

<b>Description:</b>	The ID of the mzTab file, this could be supplied by the repository from which it is downloaded or a local identifier from the lab producing the file. It is not intended to be a globally unique ID but carry some locally useful meaning.
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	MTD mzTab-ID MTBL1234

### 6.2.3. title

<b>Description:</b>	The file's human readable title.
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	MTD title My first test experiment

### 6.2.4. description

<b>Description:</b>	The file's human readable description.
<b>Type:</b>	String
<b>Mandatory</b>	False

<b>Example:</b>	MTD description An experiment investigating the effects of IL-6.
-----------------	--

### 6.2.5. sample\_processing[1-n]

<b>Description:</b>	A list of parameters describing a sample processing step. The order of the data_processing items should reflect the order these processing steps were performed in. If multiple parameters are given for a step these MUST be separated by a “ ”.
<b>Type:</b>	Parameter List
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD sample_processing[1] [SEP, sep:00210, liquid chromatography,]</div>

### 6.2.6. instrument[1-n]-id

<b>Description:</b>	Within file unique identifier for a given instrument.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD instrument[1]-id 1</div>

### 6.2.7. instrument[1-n]-name

<b>Description:</b>	The name of the instrument used in the experiment. Multiple instruments are numbered 1..n.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD instrument[1]-name [MS, MS:1000449, LTQ Orbitrap,]</div>

### 6.2.8. instrument[1-n]-source

<b>Description:</b>	The instrument’s source used in the experiment. Multiple instruments are numbered 1..n.
---------------------	---

<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<pre> MTD instrument[1]-source [MS, MS:1000073, ESI,] ... MTD instrument[2]-source [MS, MS:1000598, ETD,]</pre>

### 6.2.9. instrument[1-n]-analyzer[1-n]

<b>Description:</b>	The instrument's analyzer type used in the experiment. Multiple instruments are enumerated 1..n.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<pre> MTD instrument[1]-analyzer[1] [MS, MS:1000291, linear ion trap,] ... MTD instrument[2]-analyzer[1] [MS, MS:1000484, orbitrap,]</pre>

### 6.2.10. instrument[1-n]-detector

<b>Description:</b>	The instrument's detector type used in the experiment. Multiple instruments are numbered 1..n.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<pre> MTD instrument[1]-detector [MS, MS:1000253, electron multiplier,] ... MTD instrument[2]-detector [MS, MS:1000348, focal plane collector,]</pre>

### 6.2.11. software[1-n]

<b>Description:</b>	Software used to analyze the data and obtain the reported results. The parameter's value SHOULD contain the software's version. The order (numbering) should reflect the order in which the tools were used.
<b>Type:</b>	Parameter
<b>Mandatory</b>	True
<b>Example:</b>	<pre>MTD software[1] [MS, MS:100XXXX, Progenesis QI, 3.0]</pre>

### 6.2.12. software[1-n]-setting[1-n]

<b>Description:</b>	A software setting used. This field MAY occur multiple times for a single software. The value of this field is deliberately set as a String, since there currently do not exist cvParams for every possible setting.
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD software[1]-setting Fragment tolerance = 0.1 Da ... MTD software[2]-setting Parent tolerance = 0.5 Da</pre>

### 6.2.13. publication[1-n]

<b>Description:</b>	A publication associated with this file. Several publications can be given by indicating the number in the square brackets after "publication". PubMed ids must be prefixed by "pubmed:", DOIs by "doi:". Multiple identifiers MUST be separated by " ".
<b>Type:</b>	String
<b>Mandatory</b>	False

<b>Example:</b>	<pre> MTD publication[1] pubmed:21063943 doi:10.1007/978-1-60761- 987-1_6 MTD publication[2] pubmed:20615486 doi:10.1016/j.jprot.2010 .06.008 </pre>
-----------------	--

#### 6.2.14. contact[1-n]-name

<b>Description:</b>	The contact's name. Several contacts can be given by indicating the number in the square brackets after "contact". A contact has to be supplied in the format [first name] [initials] [last name] (see example).
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<pre> MTD contact[1]-name James D. Watson ... MTD contact[2]-name Francis Crick </pre>

#### 6.2.15. contact[1-n]-affiliation

<b>Description:</b>	The contact's affiliation.
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<pre> MTD contact[1]-affiliation Cambridge University, UK MTD contact[2]-affiliation Cambridge University, UK </pre>

#### 6.2.16. contact[1-n]-email

<b>Description:</b>	The contact's e-mail address.
<b>Type:</b>	String
<b>Mandatory</b>	False

<b>Example:</b>	<pre>MTD contact[1]-email watson@cam.ac.uk ... MTD contact[2]-email crick@cam.ac.uk</pre>
-----------------	---

### 6.2.17. uri[1-n]

<b>Description:</b>	A URI pointing to the file's source data (e.g., a MetaboLights records).
<b>Type:</b>	URI
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD uri[1] https://www.ebi.ac.uk/metabolights/MTBLS 517</pre>

### 6.2.18. external\_study\_uri[1-n]

<b>Description:</b>	A URI pointing to an external file with more details about the study design (e.g., an ISA-TAB file).
<b>Type:</b>	URI
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD uri[1] https://www.ebi.ac.uk/metabolights/MTBLS 517/files/i_Investigation.txt</pre>

### 6.2.19. quantification\_method

<b>Description:</b>	The quantification method used in the experiment reported in the file.
<b>Type:</b>	Parameter
<b>Mandatory</b>	True
<b>Example:</b>	<pre>MTD quantification_method [MS, MS:1001837, iTRAQ quantitation analysis, ] MTD quantification_method [MS, MS:1001838, SRM quantitation analysis, ]</pre>



## 6.2.20. sample[1-n]

<b>Description:</b>	A name for each sample to serve as a list of the samples that MUST be reported in the following tables. Samples MUST be reported if a statistical design is being captured (i.e. bio or tech replicates). If the type of replicates are not known, samples SHOULD NOT be reported.
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD sample[1] individual number 1 MTD sample[2] individual number 2</div>

## 6.2.21. sample[1-n]-species[1-n]

<b>Description:</b>	The respective species of the samples analysed. For more complex cases, such as metagenomics, optional columns and userParams should be used.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>COM Experiment where all samples consisted of the same two species MTD sample[1]-species[1] [NEWT, 9606, Homo sapiens (Human), ] MTD sample[2]-species[1] [NEWT, 12059, Rhinovirus, ]  COM Experiment where different two samples from different species (combinations) COM were analysed as biological replicates.  MTD sample[1]-species[1] [NEWT, 9606, Homo sapiens (Human), ] MTD sample[1]-species[2] [NEWT, 573824, Human rhinovirus 1, ] MTD sample[2]-species[1] [NEWT, 9606, Homo sapiens (Human), ] MTD sample[2]-species[2] [NEWT, 12130, Human rhinovirus 2, ]</div>

### 6.2.22. sample[1-n]-tissue[1-n]

<b>Description:</b>	The respective tissue(s) of the sample.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD sample[1]-tissue[1] [BT0, BT0:0000759, liver, ]</div>

### 6.2.23. sample[1-n]-cell\_type[1-n]

<b>Description:</b>	The respective cell type(s) of the sample.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD sample[1]-cell_type[1] [CL, CL:0000182, hepatocyte, ]</div>

### 6.2.24. sample[1-n]-disease[1-n]

<b>Description:</b>	The respective disease(s) of the sample.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD sample[1]-disease[1] [DOID, DOID:684, hepatocellular carcinoma, ] MTD sample[1]-disease[2] [DOID, DOID:9451, alcoholic fatty liver, ]</div>

### 6.2.25. sample[1-n]-description

<b>Description:</b>	A human readable description of the sample.
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD sample[1]-description Hepatocellular carcinoma samples. MTD sample[2]-description Healthy control samples.</div>

### 6.2.26. sample[1-n]-custom[1-n]

<b>Description:</b>	Parameters describing the sample's additional properties.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD sample[1]-custom[1] [,,Extraction date, 2011-12-21] MTD sample[1]-custom[2] [,,Extraction reason, liver biopsy]</div>

### 6.2.27. ms\_run[1-n]-location

<b>Description:</b>	Location of the external data file e.g. raw files on which analysis has been performed. If the actual location of the MS run is unknown, a “null” MUST be used as a place holder value, since the [1-n] cardinality is referenced elsewhere. If pre-fractionation has been performed, then [1-n] ms_runs SHOULD be created per assay.
<b>Type:</b>	URL
<b>Mandatory</b>	True
<b>Example:</b>	<div>MTD ms_run[1]-location file://C:\path\to\my\file ... MTD ms_run[1]-location ftp://ftp.ebi.ac.uk/path/to/file</div>

### 6.2.28. ms\_run[1-n]-instrument\_ref

<b>Description:</b>	If different instruments are used in different runs, this attribute can be used to link a specific instrument to a specific run.
<b>Type:</b>	instrument_id
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD ms_run[1]-instrument_ref 1 ...</div>

### 6.2.29. ms\_run[1-n]-format

<b>Description:</b>	A parameter specifying the data format of the external MS data file. If ms_run[1-n]-format is present, ms_run[1-n]-id_format SHOULD also be present, following the parameters specified in Table 1.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD ms_run[1]-format [MS, MS:1000584, mzML file, ] MTD ms_run[1]-id_format [MS, MS:1000530, mzML unique identifier, ] ... MTD ms_run[2]-format [MS, MS:1001062, Mascot MGF file, ] MTD ms_run[2]-id_format [MS, MS:1000774, multiple peak list nativeID format, ]</pre>

### 6.2.30. ms\_run[1-n]-id\_format

<b>Description:</b>	Parameter specifying the id format used in the external data file. If ms_run[1-n]-id_format is present, ms_run[1-n]-format SHOULD also be present.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD ms_run[1]-format [MS, MS:1000584, mzML file, ] MTD ms_run[1]-id_format [MS, MS:1000530, mzML unique identifier, ] ... MTD ms_run[2]-format [MS, MS:1001062, Mascot MGF file, ] MTD ms_run[2]-id_format [MS, MS:1000774, multiple peak list nativeID format, ]</pre>

### 6.2.31. ms\_run[1-n]-fragmentation\_method[1-n]

<b>Description:</b>	The type(s) of fragmentation used in a given ms run.
<b>Type:</b>	Parameter

<b>Mandatory</b>	False
<b>Example:</b>	<pre> MTD ms_run[1]-fragmentation_method[1] [MS, MS:1000133, CID, ] ... MTD ms_run[1]-fragmentation_method[2] [MS, MS:1000422, HCD ..., ] </pre>

### 6.2.32. ms\_run[1-n]-scan\_polarity[1-n]

<b>Description:</b>	The polarity mode of a given run. Usually only one value SHOULD be given here except for the case of mixed polarity runs.
<b>Type:</b>	Parameter
<b>Mandatory</b>	True
<b>Example:</b>	<pre> MTD ms_run[1]-scan_polarity[1] [MS, MS:1000130, positive scan, ] OR MTD ms_run[1]-scan_polarity[1] [MS, MS:1000129, negative scan, ] OR (For mixed polarity in one run) MTD ms_run[1]-scan_polarity[1] [MS, MS:1000130, positive scan, ] MTD ms_run[1]-scan_polarity[12] [MS, MS:1000129, negative scan, ] </pre>

### 6.2.33. ms\_run[1-n]-hash

<b>Description:</b>	Hash value of the corresponding external MS data file defined in ms_run[1-n]-location. If ms_run[1-n]-hash is present, ms_run[1-n]-hash_method SHOULD also be present.
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<pre> MTD ms_run[1]-hash_method [MS, MS: MS:1000569, SHA-1, ] MTD ms_run[1]-hash de9f2c7fd25e1b3afad3e85a0bd17d9b100db4b3 </pre>

### 6.2.34. ms\_run[1-n]-hash\_method

<b>Description:</b>	A parameter specifying the hash methods used to generate the String in ms_run[1-n]-hash. Specifics of the hash method used MAY follow the definitions of the mzML format. If ms_run[1-n]-hash is present, ms_run[1-n]-hash_method SHOULD also be present.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD ms_run[1]-hash_method [MS, MS: MS:1000569, SHA-1, ] MTD ms_run[1]-hash de9f2c7fd25e1b3afad3e85a0bd17d9b100db4b3</pre>

### 6.2.35. assay[1-n]

<b>Description:</b>	A name for each assay, to serve as a list of the assays that MUST be reported in the following tables.
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<pre>MTD assay[1] first assay MTD assay[2] second assay</pre>

### 6.2.36. assay[1-n]-custom[1-n]

<b>Description:</b>	Additional parameters or values for a given assay.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD assay[1]-custom[1] [MS, MS:100XXXX, TO_COMPLETE, ]</pre>

### 6.2.37. assay[1-n]-external\_uri

#### IMPORTANT

TODO insert example URI, Need an example to show this working. Andy Jones

<b>Description:</b>	A reference to further information about the assay, for example via a reference to an object within an ISA-TAB file.
<b>Type:</b>	URI
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD assay[1]-external_uri Example URI to insert</div>

### 6.2.38. study\_variable[1-n]

<b>Description:</b>	A name for each study variable (experimental condition or factor), to serve as a list of the study variables that MUST be reported in the following tables. For software that does not capture study variables, a single study variable MUST be reported, linking to all assays.
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<div> MTD study_variable[1] "control"   MTD study_variable[2] "1 minute" </div>

### 6.2.39. assay[1-n]-sample\_ref

<b>Description:</b>	An association from a given assay to the sample analysed.
<b>Type:</b>	{SAMPLE_ID}
<b>Mandatory</b>	False
<b>Example:</b>	<div> MTD assay[1]-sample_ref sample[1]  MTD assay[2]-sample_ref sample[2] </div>

### 6.2.40. assay[1-n]-ms\_run\_ref

<b>Description:</b>	<p>An association from a given assay to the source MS run. All assays <b>MUST</b> reference exactly one ms_run unless a workflow with pre-fractionation is being encoded, in which case each assay <b>MUST</b> reference <i>n</i> ms_runs where <i>n</i> fractions have been collected.</p> <p>Multiple assays <b>SHOULD</b> reference the same ms_run to capture multiplexed experimental designs.</p>
<b>Type:</b>	{MS_RUN_ID}
<b>Mandatory</b>	True
<b>Example:</b>	<div>MTD assay[1]-ms_run_ref ms_run[1]</div>

#### 6.2.41. study\_variable[1-n]-assay\_refs

##### IMPORTANT

TODO We are using different separator types across the document, these should be made consistent. Andy Jones

<b>Description:</b>	Bar-separated references to the IDs of assays grouped in the study variable.
<b>Type:</b>	{ASSAY_ID}, ...
<b>Mandatory</b>	True
<b>Example:</b>	<div>MTD study_variable[1]-assay_refs assay[1]</div>
assay[2]	assay[3] ....

#### 6.2.42. study\_variable[1-n]\_average\_function

<b>Description:</b>	The function used to calculate the study variable quantification value if it is reported and the operation used is not arithmetic mean (default) e.g. “geometric mean”, “median”. The 1-n refers to different study variables.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD study_variable_average_function [MS, MS:0000XXX, Median, ]</div>



### 6.2.43. study\_variable[1-n]\_variation\_function

<b>Description:</b>	The function used to calculate the study variable quantification variation value if it is reported and the operation used is not coefficient of variation (default) e.g. “standard error”.
<b>Type:</b>	Parameter
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD study_variable_variation_function [MS, MS:0000XXX, Standard error, ]</div>

### 6.2.44. study\_variable[1-n]-description

<b>Description:</b>	A textual description of the study variable.
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<div>MTD study_variable[1]-description Group B (spike-in 0.74 fmol/uL)</div>

### 6.2.45. study\_variable[1-n]-factors

**IMPORTANT**

TODO We need examples. Andy Jones

<b>Description:</b>	Additional parameters or factors, separated by bars, that are known about study variables allowing the capture of more complex, such as nested designs.
<b>Type:</b>	Param List
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD study_variable[1]-factors EXAMPLE HERE e.g. param1 = geneK0; param2 = drug treatment</div>

### 6.2.46. custom[1-n]

<b>Description:</b>	Any additional parameters describing the analysis reported.
<b>Type:</b>	Parameter

<b>Mandatory</b>	false
<b>Example:</b>	<div>MTD custom[1] [,,MS operator, Florian]</div>

#### 6.2.47. cv[1-n]-label

<b>Description:</b>	A string describing the labels of the controlled vocabularies/ontologies used in the mzTab file as a short-hand e.g. "MS" for PSI-MS.
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<div>MTD cv[1]-label MS ...</div>

#### 6.2.48. cv[1-n]-full\_name

<b>Description:</b>	A string describing the full names of the controlled vocabularies/ontologies used in the mzTab file
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<div>MTD cv[1]-full_name PSI-MS controlled vocabulary ...</div>

#### 6.2.49. cv[1-n]-version

<b>Description:</b>	A string describing the version of the controlled vocabularies/ontologies used in the mzTab file
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<div>MTD cv[1]-version 3.54.0 ...</div>

#### 6.2.50. cv[1-n]-url

<b>Description:</b>	A string containing the URLs of the controlled vocabularies/ontologies used in the mzTab file
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<pre> MTD cv[1]-url http://psidev.cvs.sourceforge.net/viewvc /psidev/psi/psi- ms/mzML/controlledVocabulary/psi- ms.obo[_http://psidev.cvs.sourceforge.ne t/viewvc/psidev/psi/psi- ms/mzML/controlledVocabulary/psi- ms.obo_] ... </pre>

### 6.2.51. database[1-n]

<b>Description:</b>	<p>The description of databases used. For cases, where a known database has not been used for identification, a userParam SHOULD be inserted to describe any identification performed e.g. de novo.</p> <p>If no identification has been performed at all then "no database" should be inserted followed by null.</p>
<b>Type:</b>	Param
<b>Mandatory</b>	True
<b>Example:</b>	<pre> MTD database[1] [MIRIAM,MIR:00100079 , "HMDB", ] MTD database[3] [,de novo , "dn", ] MTD database[3] [MIRIAM,MIR:00000002 , "CHEBI", ] MTD database[4] [, ,"mydatabase", "mydb" ] OR MTD database[1] [, , "no database", &gt;null"] </pre>

### 6.2.52. database[1-n]-prefix

#### IMPORTANT

TODO Make sure to explain that the colon must followed these prefixes in the SMF section below. Andy Jones

<b>Description:</b>	The prefix used in the “identifier” column of data tables. For the “no database” case "null" must be used.
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<div> MTD database[1]-prefix hmdb  MTD database[1]-prefix dn    or  MTD database[1]-prefix null </div>

### 6.2.53. database[1-n]-version

<b>Description:</b>	The database version is mandatory where identification has been performed. This may be a formal version number e.g. “1.4.1”, a date of access “27/10/2016” or “Unknown” if there is no suitable version that can be annotated.
<b>Type:</b>	String
<b>Mandatory</b>	True
<b>Example:</b>	<div> MTD database[1]-version 3.6 </div>

### 6.2.54. database[1-n]-url

<b>Description:</b>	The URL to the database.
<b>Type:</b>	URL
<b>Mandatory</b>	True
<b>Example:</b>	<div> database[1]-url http://www.hmdb.ca/ </div>

## Metabolomics Metadata

The metadata fields in this section MAY be reported in a metabolomics type file, but MUST NOT be reported in a proteomics file.

### 6.2.55. derivatization\_agent[1-n]

<b>Description:</b>	A description of derivatization agents applied to small molecules, using userParams or cvParams where possible.
---------------------	---

<b>Type:</b>	Param
<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD derivatization_agent[1] [ , PUBCHEM:00XXX, idomethylation, ]</pre>

### 6.2.56. small\_molecule-quantification\_unit

#### IMPORTANT

TODO Examples to be added from a range of software packages. Andy Jones

<b>Description:</b>	Defines what type of units is reported in the small molecule quantification fields.
<b>Type:</b>	Parameter
<b>Mandatory</b>	True
<b>Example:</b>	<pre>MTD small_molecule-quantification_unit [PSI-MS, MS:000XXXX, Progenesis QI Normalised Abundance, ]</pre>

### 6.2.57. small\_molecule\_feature-quantification\_unit

#### IMPORTANT

TODO Examples to be added from a range of software packages. Andy Jones

<b>Description:</b>	Defines what type of units is reported in the small molecule feature quantification fields.
<b>Type:</b>	Parameter
<b>Mandatory</b>	True
<b>Example:</b>	<pre>MTD small_molecule_feature- quantification_unit [PSI-MS, MS:000XXXX, Progenesis QI Normalised Abundance, ]</pre>

### 6.2.58. small\_molecule-identification\_reliability

#### IMPORTANT

TODO To revisit. Andy Jones

<b>Description:</b>	The system used for giving reliability codes to small molecule identifications MUST be specified if not using the default codes.
<b>Type:</b>	Param

<b>Mandatory</b>	False
<b>Example:</b>	<pre>MTD small_molecule- identification_reliability [, , Numerical system defined in publication, PMID:XXX]</pre>

### 6.2.59. id\_confidence\_measure[1-n]

<b>Description:</b>	The type of small molecule confidence measures or scores MUST be reported as a CV parameter [1-n]. The CV parameter definition should formally state whether the ordering is high to low or vice versa. The order of the scores SHOULD reflect their importance for the identification and be used to determine the identification's rank.
<b>Type:</b>	Parameter
<b>Mandatory</b>	True
<b>Example:</b>	<pre>id_confidence_measure[1] [MS,MS:1000XXX,Progenesis MetaScope Score,] id_confidence_measure[2] [MS,MS:1000XXX,Fragmentation Score,] id_confidence_measure[3] [MS,MS:1000XXX,Isotopic fit Score,]</pre>

### 6.2.60. colunit-small\_molecule

<b>Description:</b>	<p>Defines the used unit for a column in the small molecule section. The format of the value has to be \{column name\}=\{Parameter defining the unit\}</p> <p>This field MUST NOT be used to define a unit for quantification columns. The unit used for small molecule quantification values MUST be set in small_molecule-quantification_unit.</p>
<b>Type:</b>	String
<b>Mandatory</b>	False

<b>Example:</b>	<div>MTD colunit-small_molecule GIVE EXAMPLE NOT RT</div>
-----------------	---

### 6.2.61. colunit-small\_molecule\_feature

<b>Description:</b>	<p>Defines the used unit for a column in the small molecule feature section. The format of the value has to be \{column name}=\{Parameter defining the unit}</p> <p>This field MUST NOT be used to define a unit for quantification columns. The unit used for small molecule quantification values MUST be set in small_molecule-quantification_unit.</p>
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<div>MTD colunit-small_molecule GIVE EXAMPLE NOT RT</div>

### 6.2.62. colunit-small\_molecule\_evidence

<b>Description:</b>	<p>Defines the used unit for a column in the small molecule evidence section. The format of the value has to be \{column name}=\{Parameter defining the unit}.</p>
<b>Type:</b>	String
<b>Mandatory</b>	False
<b>Example:</b>	<div>Example needed</div>

## 6.3. Small Molecule Section

The small molecule section is table-based. The small molecule section MUST always come after the metadata section in a metabolomics type file. All table columns MUST be Tab separated. There MUST NOT be any empty cells; missing values MUST be reported using “null” for columns where Is Nullable = “True”. The order of columns MUS

Each row of the small molecule section is intended to report one final result to be communicated in terms of a molecule that has been quantified. In many cases, this may be the molecule of biological interest, although in some cases, the final result could be a derivatized form as appropriate – although it is desirable for the database identifier(s) to reference to the biological (non-derivatized)

form. In general, different adduct forms would generally be reported in the Small Molecule Feature section.

The order of columns MUST follow the order specified below.

All columns are MANDATORY except for “opt\_” columns.

### 6.3.1. SML\_ID

<b>Description:</b>	A within file unique identifier for the small molecule.
<b>Type:</b>	Integer
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<div>SMH SML_ID ... SML 1 ... SML 2 ...</div>

### 6.3.2. SMF\_ID\_REFS

<b>Description:</b>	References to all the features on which quantitation has been based (SMF elements) via referencing SMF_ID values. Multiple values SHOULD be provided as a “ ” separated list. This MAY be null only if this is a Summary file.
<b>Type:</b>	{SMF_ID} list
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<div>SMH SML_ID SMF_ID_REFS SML 1 2 3 11...</div>

### 6.3.3. database\_identifier



<b>Description:</b>	<p>A list of “ ” separated possible identifiers for the small molecule; multiple values MUST only be provided to indicate ambiguity in the identification of the molecule and not to demonstrate different identifier types for the same molecule. Alternative identifiers for the same molecule MAY be provided as optional columns.</p> <p>The database identifier must be preceded by the resource description (prefix) followed by a colon, as specified in the Metadata section.</p> <p>A null value MAY be provided if the identification is sufficiently ambiguous as to be meaningless for reporting or the small molecule has not been identified.</p>
<b>Type:</b>	String List
<b>Is Nullable:</b>	TRUE
<b>Example:</b>	<pre>SMH SML_ID database_identifier ... SML 1 CID:00027395 ... SML 2 HMDB:HMDB12345 SML 3 null</pre>

#### 6.3.4. chemical\_formula

<b>Description:</b>	<p>A list of “ ” separated potential chemical formulae of the reported compound. The number of values provided MUST match the number of entities reported under “database_identifier”, even if this leads to redundant reporting of information (i.e. if ambiguity can be resolved in the chemical formula), and the validation software will throw an error if the number of “ ” symbols does not match. “null” values between bars are allowed.</p> <p>This should be specified in Hill notation (<a href="#">EA Hill 1900</a>), i.e. elements in the order C, H and then alphabetically all other elements. Counts of one may be omitted. Elements should be capitalized properly to avoid confusion (e.g., “CO” vs. “Co”). The chemical formula reported should refer to the neutral form.</p> <p><b>Example:</b> N-acetylglucosamine would be encoded by the string “C8H15NO6”</p>
---------------------	---

<b>Type:</b>	String List
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<div> SMH SML_ID ... chemical_formula ...  SML 1 ... C17H20N4O2 ... </div>

### 6.3.5. smiles

<b>Description:</b>	<p>A list of “ ” separated potential molecule structures in the simplified molecular-input line-entry system (SMILES) for the small molecule. The number of values provided MUST match the number of entities reported under “database_identifier”, and the validation software will throw an error if the number of “ ” symbols does not match. “null” values between bars are allowed.</p>
<b>Type:</b>	String List
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<div> SMH SML_ID ... chemical_formula smiles ...  SML 1 ... C17H20N4O2  C1=CC=C(C=C1)CCNC(=O)CCNNC(=O)C2=CC=NC=C2 ... </div>

### 6.3.6. inchi

<b>Description:</b>	<p>A list of “ ” separated potential standard IUPAC International Chemical Identifier (InChI) of the given substance.</p> <p>The number of values provided MUST match the number of entities reported under “database_identifier”, even if this leads to redundant information being reported (i.e. if ambiguity can be resolved in the InChi), and the validation software will throw an error if the number of “ ” symbols does not match. “null” values between bars are allowed.</p>
<b>Type:</b>	String List
<b>Is Nullable:</b>	<b>TRUE</b>

<b>Example:</b>	<pre>SMH SML_ID ... chemical_formula ... inchi ... SML 1 ... C17H20N4O2 ... InChI=1S/C17H20N4O2/c22-16(19-12-6-14-4- 2-1-3-5-14)9-13-20-21-17(23)15-7-10-18- 11-8-15/h1-5,7-8,10-11,20H,6,9,12- 13H2,(H,19,22)(H,21,23) ...</pre>
-----------------	---

### 6.3.7. chemical\_name

<b>Description:</b>	A list of “ ” separated possible chemical/common names for the small molecule, or general description if a chemical name is unavailable. Multiple names are only to demonstrate ambiguity in the identification. The number of values provided MUST match the number of entities reported under “database_identifier”, and the validation software will throw an error if the number of “ ” symbols does not match. “null” values between bars are allowed.
<b>Type:</b>	String List
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SMH SML_ID ... description ... SML 1 ... N-(2-phenylethyl)-3-[2- (pyridine-4- carbonyl)hydrazinyl]propanamide...</pre>

### 6.3.8. uri

<b>Description:</b>	A URI pointing to the small molecule’s entry in a reference database (e.g., the small molecule’s HMDB or KEGG entry). The number of values provided MUST match the number of entities reported under “database_identifier”, and the validation software will throw an error if the number of “ ” symbols does not match. “null” values between bars are allowed.
<b>Type:</b>	URI List
<b>Is Nullable:</b>	<b>TRUE</b>

<b>Example:</b>	<div> SMH SML_ID ... uri ...  SML 1 ... example_URL ... </div>
-----------------	--

### 6.3.9. theoretical\_neutral\_mass

<b>Description:</b>	<p>The small molecule's precursor's theoretical neutral mass.</p> <p>The number of values provided MUST match the number of entities reported under "database_identifier", and the validation software will throw an error if the number of " " symbols does not match. "null" values (in general and between bars) are allowed for molecules that have not been identified only, or for molecules where the neutral mass cannot be calculated. In these cases, the SML entry SHOULD reference features in which exp_mass_to_charge values are captured.</p>
<b>Type:</b>	Double List
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<div> SMH SML_ID ... theoretical_neutral_mass ...  SML 1 ... 1234.5 ... </div>

### 6.3.10. adduct\_ions

<b>Description:</b>	<p>A " " separated list of adducts for this molecule, following the general style in the 2013 IUPAC recommendations on <a href="#">terms relating to MS</a> e.g. , [M+Na], [M+NH4]<sup>+</sup>, [M-H]<sup>-</sup>, [M+Cl]<sup>-</sup>. If the adduct classification is ambiguous with regards to identification evidence it MAY be null.</p>
<b>Type:</b>	String List
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<div> SMH SML_ID ... adduct_ions ...  SML 1 ... [M+H]<sup>1+</sup>   [M+Na]<sup>1+</sup> ... </div>

### 6.3.11. reliability

<b>Description:</b>	<p>The reliability of the given small molecule identification. By default, the following system is used.</p> <p>This must be supplied by the resource and <b>MUST</b> be reported as an integer between 1-4:</p> <ol style="list-style-type: none"> <li>1. identified metabolite</li> <li>2. putatively annotated compound</li> <li>3. putatively characterized compound class</li> <li>4. unknown compound</li> </ol> <p>These <b>MAY</b> be replaced using a suitable CV term in the Metadata section e.g. to use MSI recommendation levels.</p> <p>A String data type is set to allow for different systems to be specified in the metadata section.</p>
<b>Type:</b>	String
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	SMH identifier ... reliability ... SML 1 ... 3 ...

### 6.3.12. best\_id\_confidence\_measure

<b>Description:</b>	The approach or database search that identified this small molecule with highest confidence.
<b>Type:</b>	Parameter
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<div> SMH SML_ID ... best_  id_confidence_measure ...  SML 1 ... [MS, MS:1001477, SpectraST,] ... </div>

### 6.3.13. best\_id\_confidence\_value

<b>Description:</b>	<p>The best confidence measure in identification (for this type of score) for the given small molecule across all assays. The type of score <b>MUST</b> be defined in the metadata section. If the small molecule was not identified by the specified search engine, “null” <b>MUST</b> be reported.</p>
<b>Type:</b>	Double

<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre> ... SMH SML_ID ... best_id_confidence_value ... SML 1 ... 0.7 ... </pre>

#### 6.3.14. abundance\_assay[1-n]

<b>Description:</b>	The small molecule's abundance in every assay described in the metadata section <b>MUST</b> be reported. Null or zero values may be reported as appropriate.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre> SMH SML_ID ... abundance_assay[1] ... SML 1 ... 0.3 ... </pre>

#### 6.3.15. abundance\_study\_variable[1-n]

<b>Description:</b>	The small molecule's abundance in all the study variables described in the Metadata section (study_variable[1-n]_average_function), calculated using the method as described in the Metadata section (default = arithmetic mean across assays). Null or zero values may be reported as appropriate.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre> SMH SML_ID ... abundance_study_variable[1] ... SML 1 ... 0.3 ... </pre>

#### 6.3.16. abundance\_variation\_study\_variable [1-n]

<b>Description:</b>	A measure of the variability of the study variable abundance measurement, calculated using the method as described in the Metadata section (study_variable[1-n]_average_function), with a default = arithmetic co-efficient of variation of the small molecule's abundance in the given study variable.
<b>Type:</b>	Double
<b>Is Nullable:</b>	TRUE
<b>Example:</b>	<pre>SMH SML_ID ... abundance_study_variable[1] abundance_variation_study_variable[1]... SML 1 ... 0.3 0.04 ...</pre>

### 6.3.17. opt\_{identifier}\_\*

<b>Description:</b>	Additional columns can be added to the end of the small molecule table. These column headers MUST start with the prefix “opt_” followed by the {identifier} of the object they reference: assay, study variable, MS run or “global” (if the value relates to all replicates). Column names MUST only contain the following characters: ‘A’-‘Z’, ‘a’-‘z’, ‘0’-‘9’, ‘,’ ‘-’, ‘[’, ‘]’, and ‘:’. <i>CV parameter accessions MAY be used for optional columns following the format: opt{identifier}_cv_{accession}_{parameter name}</i> . Spaces within the parameter's name MUST be replaced by ‘_’.
<b>Type:</b>	Column
<b>Is Nullable:</b>	TRUE
<b>Example:</b>	<pre>SMH SML_ID ... opt_assay[1]_my_value opt_global_another_value SML 1 ... My value some other value</pre>

#### Example optional columns:

- Species
- Taxid
- Retention time index values normalised to a given scale
- Identification scores specific to each assay
- Raw quantification values, assuming normalised values are provided in the standard assay

quantification columns.

## 6.4. Small Molecule Feature (SMF) Section

The small molecule feature section is table-based, representing individual MS regions (generally considered to be the elution profile for all isotopomers formed from a single charge state of a molecule), that have been measured/quantified. However, for approaches that quantify individual isotopomers e.g. stable isotope labelling/flux studies, then each SMF row SHOULD represent a single isotopomers.

Different adducts or derivatives and different charge states of individual molecules should be reported as separate SMF rows.

The small molecule feature section MUST always come after the Small Molecule Table. All table columns MUST be Tab separated. There MUST NOT be any empty cells. Missing values MUST be reported using “null”.

The order of columns MUST follow the order specified below.

All columns are MANDATORY except for “opt\_” columns.

### 6.4.1. SMF\_ID

<b>Description:</b>	A within file unique identifier for the small molecule feature.
<b>Type:</b>	Integer
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<div>SFH SMF_ID ... SMF 1 ... SMF 2 ...</div>

### 6.4.2. SME\_ID\_REFS

<b>Description:</b>	References to the identification evidence (SME elements) via referencing SME_ID values. Multiple values MAY be provided as a “ ” separated list to indicate ambiguity in the identification. For the case of a consensus approach where multiple adduct forms are used to infer the SML ID, different features should just reference the same SME_ID value(s).
<b>Type:</b>	{SME_ID} list
<b>Is Nullable:</b>	<b>TRUE</b>



<b>Example:</b>	<pre>SFH SMF_ID SME_ID_REFS SMF 1 5 6 12...</pre>
-----------------	---

### 6.4.3. SME\_ID\_REF\_ambiguity\_code

<b>Description:</b>	If multiple values are given under SME_ID_REFS, one of the following codes MUST be provided. 1=Ambiguous identification; 2=Only different evidence streams for the same molecule with no ambiguity; 3=Both ambiguous identification and multiple evidence streams. If there are no or one value under SME_ID_REFS, this MUST be reported as null.
<b>Type:</b>	Integer
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SFH SMF_ID SME_ID_REFS SME_ID_REF_ambiguity_code SMF 1 5 6 12... 1</pre>

### 6.4.4. adduct\_ion

**IMPORTANT**

TODO Add URL to these recommendations? Andy Jones

<b>Description:</b>	The assumed adduct classification of this molecule, following the general style in the 2013 IUPAC recommendations on terms relating to MS e.g. , [M+Na], [M+NH4] <sup>+</sup> , [M-H] <sup>-</sup> , [M+Cl] <sup>-</sup> .
<b>Type:</b>	Regex{"[\\d*M([-]\\w*)\\d*[+-]}"}
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SFH SMF_ID ... adduct_ion ... SMF 1 ... [M+H]1+ ...</pre>

### 6.4.5. isotopomer

<b>Description:</b>	If de-isotoping has not been performed, then the isotopomer quantified MUST be reported here e.g. "+1", "+2", "13C peak" using cvParams, otherwise (i.e. for approaches where SMF rows are de-isotoped features) this MUST be null.
<b>Type:</b>	String

<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SFH SMF_ID ... isotopomer ... SMF 1 ... [MS,MS:1000XX,"13C peak", ]...</pre>

#### 6.4.6. exp\_mass\_to\_charge

<b>Description:</b>	The <i>experimental</i> mass/charge value for the feature, by default assumed to be the mean across assays or a representative value. For approaches that report isotopomers as SMF rows, then the m/z of the isotopomer <b>MUST</b> be reported here.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<pre>SFH SMF_ID ... exp_mass_to_charge ... SML 1 ... 1234.5 ...</pre>

#### 6.4.7. charge

<b>Description:</b>	The feature's charge value using "-1" or "1" for negative or positive mode.
<b>Type:</b>	Integer
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<pre>SFH SMF_ID ... charge ... SMF 1 ... 1 ... SMF 1 ... -1 ...</pre>

#### 6.4.8. retention\_time\_in\_seconds

<b>Description:</b>	The apex of the feature on the retention time axis, in a Master or aggregate MS run. Retention time <b>MUST</b> be reported in seconds. Retention time values for individual MS runs (i.e. before alignment) <b>MAY</b> be reported as optional columns. Retention time <b>SHOULD</b> only be null in the case of direct infusion MS or other techniques where a retention time value is absent or unknown. Relative retention time or retention time index values <b>MAY</b> be reported as optional columns, and could be considered for inclusion in future versions of mzTab as appropriate.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SFH SMF_ID ... retention_time_in_seconds ... SMF 1 ... 1345.7 ...</pre>

#### 6.4.9. retention\_time\_in\_seconds\_start

<b>Description:</b>	The start time of the feature on the retention time axis, in a Master or aggregate MS run. Retention time <b>MUST</b> be reported in seconds. Retention time start and end <b>SHOULD</b> only be null in the case of direct infusion MS or other techniques where a retention time value is absent or unknown and <b>MAY</b> be reported in optional columns.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SFH SMF_ID ... retention_time_in_seconds_start ... SMF 1 ... 1327.0 ...</pre>

#### 6.4.10. retention\_time\_in\_seconds\_end

<b>Description:</b>	The end time of the feature on the retention time axis, in a Master or aggregate MS run. Retention time <b>MUST</b> be reported in seconds. Retention time start and end <b>SHOULD</b> only be null in the case of direct infusion MS or other techniques where a retention time value is absent or unknown and <b>MAY</b> be reported in optional columns..
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SFH SMF_ID ... retention_time_in_seconds_end ... SMF 1 ... 1327.8 ...</pre>

#### 6.4.11. abundance\_assay[1-n]

<b>Description:</b>	The feature's abundance in every assay described in the metadata section <b>MUST</b> be reported. Null or zero values may be reported as appropriate.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre>SMH SML_ID ... abundance_assay[1] ... SMF 1 ... 38648 ...</pre>

#### 6.4.12. opt\_{identifier}\_\*

<b>Description:</b>	Additional columns can be added to the end of the small molecule feature table. These column headers <b>MUST</b> start with the prefix “opt_” followed by the {identifier} of the object they reference: assay, study variable, MS run or “global” (if the value relates to all replicates). Column names <b>MUST</b> only contain the following characters: ‘A’-‘Z’, ‘a’-‘z’, ‘0’-‘9’, ‘_’, ‘-’, ‘[’, ‘]’, and ‘.’. <i>CV parameter accessions MAY be used for optional columns following the format: opt{identifier}_cv_{accession}_{parameter name}</i> . Spaces within the parameter's name <b>MUST</b> be replaced by ‘_’.
<b>Type:</b>	Column
<b>Is Nullable:</b>	<b>TRUE</b>

**Example:**

```
SFH SMF_ID ... opt_assay[1]_my_value
opt_global_another_value
SMF 1 ... My value some other value
```

**Example optional columns:**

- (Apex) retention time values for each MS run pre-alignment
- Retention time index values normalised to a given scale
- Raw quantification values, assuming normalised values are provided in the standard assay quantification columns.
- Predicted retention time
- CCS values
- Two-dimensional retention times e.g. `opt_retention_time_in_seconds1`  
`opt_retention_time_in_seconds2`

## 6.5. Small Molecule Evidence (SME) Section

The small molecule evidence section is table-based, representing evidence for identifications of small molecules/features, from database search or any other process used to give putative identifications to molecules. In a typical case, each row represents one result from a single search or interpretation of a piece of evidence e.g. a database search with a fragmentation spectrum. Multiple results from a given input data item (e.g. one fragment spectrum) SHOULD share the same value under `evidence_input_id`.

The small molecule evidence section MUST always come after the Small Molecule Feature Table. All table columns MUST be Tab separated. There MUST NOT be any empty cells. Missing values MUST be reported using “null”.

The order of columns MUST follow the order specified below.

All columns are MANDATORY except for “opt\_” columns.

### 6.5.1. SME\_ID

<b>Description:</b>	A within file unique identifier for the small molecule evidence result.
<b>Type:</b>	Integer
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<pre>SEH SME_ID ... SME 1 ...</pre>

### 6.5.2. evidence\_input\_id

<b>Description:</b>	A within file unique identifier for the input data used to support this identification e.g. fragment spectrum, RT and m/z pair, isotope profile that was used for the identification process, to serve as a grouping mechanism, whereby multiple rows of results from the same input data share the same ID. The identifiers may be human readable but should not be assumed to be interpretable. For example, if fragmentation spectra have been searched then the ID may be the spectrum reference, or for accurate mass search, the ms_run[2]:458.75.
<b>Type:</b>	String
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<div>SEH SME_ID evidence_input_id ... SME 1 ms_run[1]:index=274 SME 2 ms_run[2]:index=287 SME 3 ms_run[3]:index=365</div> <p>(in this example three identifications were made from the same accurate mass search)</p>

### 6.5.3. database\_identifier

<b>Description:</b>	<p>The putative identification for the small molecule sourced from an external database, using the same prefix specified in database[1-n]-prefix.</p> <p>This could include additionally a chemical class or an identifier to a spectral library entity, even if its actual identity is unknown.</p>
<b>Type:</b>	String
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<div>SEH SME_ID identifier ... SME 1 CID:00027395 ... SML 2 HMDB:HMDB12345 ...</div>

### 6.5.4. chemical\_formula

<b>Description:</b>	<p>The chemical formula of the identified compound e.g. in a database, assumed to match the theoretical mass to charge (in some cases this will be the derivatized form, including adducts and protons).</p> <p>This should be specified in Hill notation (<a href="#">EA Hill 1900</a>), i.e. elements in the order C, H and then alphabetically all other elements. Counts of one may be omitted. Elements should be capitalized properly to avoid confusion (e.g., “CO” vs. “Co”). The chemical formula reported should refer to the neutral form. Charge state is reported by the charge field.</p> <p><b>Example:</b> N-acetylglucosamine would be encoded by the string “C8H15NO6”</p>
<b>Type:</b>	String
<b>Is Nullable:</b>	TRUE
<b>Example:</b>	<pre>SEH SME_ID ... chemical_formula ... SME 1 ... C17H20N4O2 ...</pre>

### 6.5.5. smiles

<b>Description:</b>	The potential molecule's structure in the simplified molecular-input line-entry system (SMILES) for the small molecule.
<b>Type:</b>	String
<b>Is Nullable:</b>	TRUE
<b>Example:</b>	<pre>SEH SME_ID ... chemical_formula smiles ... SML 1 ... C17H20N4O2 C1=CC=C(C=C1)CCNC(=O)CCNNC(=O)C2=CC=NC=C 2 ...</pre>

### 6.5.6. inchi

<b>Description:</b>	A standard IUPAC International Chemical Identifier (InChI) for the given substance.
<b>Type:</b>	String
<b>Is Nullable:</b>	TRUE

<b>Example:</b>	<pre> SEH SME_ID ... chemical_formula ... inchi ... SML 1 ... C17H20N4O2 ... InChI=1S/C17H20N4O2/c22-16(19-12-6-14-4- 2-1-3-5-14)9-13-20-21-17(23)15-7-10-18- 11-8-15/h1-5,7-8,10-11,20H,6,9,12- 13H2,(H,19,22)(H,21,23) ... </pre>
-----------------	---

### 6.5.7. chemical\_name

<b>Description:</b>	The small molecule's chemical/common name, or general description if a chemical name is unavailable.
<b>Type:</b>	String
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre> SEH SME_ID ... chemical_name ... SML 1 ... N-(2-phenylethyl)-3-[2- (pyridine-4- carbonyl)hydrazinyl]propanamide... </pre>

### 6.5.8. uri

<b>Description:</b>	A URI pointing to the small molecule's entry in a database (e.g., the small molecule's HMDB, ChEBI or KEGG entry).
<b>Type:</b>	URI
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre> SEH SME_ID ... uri ... SME 1 ... http://www.hmdb.ca/metabolites/HMDB00054 </pre>

### 6.5.9. derivatized\_form

<b>Description:</b>	If a derivatized form has been analysed by MS, then the functional group attached to the molecule should be reported here using suitable userParam or cvParams as appropriate.
<b>Type:</b>	String
<b>Is Nullable:</b>	<b>TRUE</b>



<b>Example:</b>	SMH database_identifier ... derivatized_form ... SML CID:00027395 ... [,, "TMS",] ...
-----------------	---

## 6.5.10. adduct\_ion

**IMPORTANT**

TODO Regex in here. Andy Jones

<b>Description:</b>	The assumed adduct classification of this molecule, following the general style in the 2013 IUPAC recommendations on terms relating to MS e.g. , [M+Na], [M+NH <sub>4</sub> ] <sup>+</sup> , [M-H] <sup>-</sup> , [M+Cl] <sup>-</sup> . If the adduct classification is ambiguous with regards to identification evidence it MAY be null.
<b>Type:</b>	Regex{"[\\d*M([-][\\w]*)\\d*[+-]"}
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	SEH SME_ID ... adduct_ion ... SME 1 ... [M+H] <sup>+</sup> ... OR (for negative mode): SME 1 ... [M-H] <sup>-</sup> ...

## 6.5.11. exp\_mass\_to\_charge

<b>Description:</b>	The <i>experimental</i> mass/charge value for the precursor ion. If multiple adduct forms have been combined into a single identification event/search, then a single value e.g. for the protonated form SHOULD be reported here.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	SEH SME_ID ... exp_mass_to_charge ... SME 1 ... 1234.5 ...

## 6.5.12. charge

<b>Description:</b>	The feature's charge value.
<b>Type:</b>	Integer
<b>Is Nullable:</b>	<b>FALSE</b>

<b>Example:</b>	<pre>SEH SME_ID ... charge ... SME 1 ... 1 ...</pre>
-----------------	--

### 6.5.13. theoretical\_mass\_to\_charge

<b>Description:</b>	The theoretical mass/charge value for the small molecule or the database mass/charge value (for a spectral library match).
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<pre>SEH SME_ID ... theoretical_mass_to_charge ... SME 1 ... 1234.71 ...</pre>

### 6.5.14. spectra\_ref

<b>Description:</b>	<p>Reference to a spectrum in a spectrum file, for example a fragmentation spectrum has been used to support the identification. If a separate spectrum file has been used for fragmentation spectrum, this MUST be reported in the meta-data section as additional ms_runs. The reference must be in the format ms_run[1-n]:{SPECTRA_REF} where SPECTRA_REF MUST follow the format defined in 5.2 (including references to chromatograms where these are used to inform identification). Multiple spectra MUST be referenced using a “ ” delimited list for the (rare) cases in which search engines have combined or aggregated multiple spectra in advance of the search to make identifications.</p> <p>If a fragmentation spectrum has not been used, the value should indicate the ms_run to which is identification is mapped e.g. “ms_run[1]”.</p>
<b>Type:</b>	String List
<b>Is Nullable:</b>	<b>FALSE</b> IMPORTANT: TODO To add to documentation how to do this for manual curation etc. Andy Jones
<b>Example:</b>	<pre>SEH SME_ID ... spectra_ref ... SME 1 ... ms_run[1]:index=5 ...</pre>

### 6.5.15. identification\_method

<b>Description:</b>	The database search, search engine or process that was used to identify this small molecule e.g. the name of software, database or manual curation etc.
<b>Type:</b>	Parameter
<b>Is Nullable:</b>	<b>FALSE</b> IMPORTANT: TODO To add to documentation how to do this for manual curation etc. Andy Jones
<b>Example:</b>	<pre>SEH SME_ID ... identification_method... SME 1 ... [MS, MS:1001477, SpectraST,] ...</pre>

### 6.5.16. ms\_level

<b>Description:</b>	The highest MS level used to inform identification e.g. MS1 (accurate mass only) = “ms level=1” or from an MS2 fragmentation spectrum = “ms level=2”. For direct fragmentation or data independent approaches where fragmentation data is used, appropriate CV terms SHOULD be used .
<b>Type:</b>	Parameter
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<pre>SEH SME_ID ... ms_level ... SME 1 ... [MS,MS:1000511,"ms level",2] ...</pre>

### 6.5.17. id\_confidence\_measure[1-n]

<b>Description:</b>	Any statistical value or score for the identification. The metadata section reports the type of score used, as id_confidence_measure[1-n] of type Param.
<b>Type:</b>	Double
<b>Is Nullable:</b>	<b>TRUE</b>

<b>Example:</b>	<pre> MTD id_confidence_measure[1] [MS, MS:1001419, SpectraST:discriminant score F,] ... SEH SME_ID ... id_confidence_measure[1] ... SME 1 ... 0.7 ... </pre>
-----------------	---

### 6.5.18. rank

<b>Description:</b>	The rank of this identification from this approach as increasing integers from 1 (best ranked identification). Ties (equal score) are represented by using the same rank – defaults to 1 if there is no ranking system used.
<b>Type:</b>	Integer
<b>Is Nullable:</b>	<b>FALSE</b>
<b>Example:</b>	<pre> SEH SME_ID ... rank ... SME 1 ... 1 ... </pre>

### 6.5.19. opt\_{identifier}\_\*

<b>Description:</b>	<p>Additional columns can be added to the end of the small molecule evidence table. These column headers <b>MUST</b> start with the prefix “opt_” followed by the {identifier} of the object they reference: assay, study variable, MS run or “global” (if the value relates to all replicates). Column names <b>MUST</b> only contain the following characters: ‘A’-‘Z’, ‘a’-‘z’, ‘0’-‘9’, ‘_’, ‘-’, ‘[’, ‘]’, and ‘:’. <i>CV parameter accessions MAY be used for optional columns following the format: opt_{identifier}_cv_{accession}_{parameter name}</i>. Spaces within the parameter’s name <b>MUST</b> be replaced by ‘_’.</p>
<b>Type:</b>	Column
<b>Is Nullable:</b>	<b>TRUE</b>
<b>Example:</b>	<pre> SEH SME_ID ... opt_assay[1]_my_value opt_global_another_value SML 1 ... My value some other value </pre>

**Example optional columns:**

- Additional statistical measures or annotations about evidence, such as decoy identifications.

## Chapter 7. Non-supported use cases

There are a number of use cases that were discussed during the development process and it was decided that they are not explicitly supported in mzTab version 1.1-M. They may be implemented in future versions of the standard.

Examples include:

- Multiplexing technologies
- Merging results from negative and positive polarities (for quantitation purposes) into a single aligned files
- Including the results from different technologies in one mzTab file e.g. DIMS and LC/MS

# Chapter 8. Conclusions

## IMPORTANT

TODO This document contains the specifications for using the mzTab format to represent results from small molecule pipelines, in the context of a metabolomics or lipidomics investigation. This specification constitutes a proposal for a standard from the Proteomics Standards Initiative and Metabolomics Standards Initiative. These artefacts are currently undergoing the PSI document process, which will result in a standard officially sanctioned by PSI.

# Chapter 9. Authors

## IMPORTANT

Please add affiliations#

- Nils Hoffmann
- Joel Rein
- Kenneth Haug
- Saravanan Dayalan
- Philippe Rocca-Serra
- Da Qi
- Timo Sachsenburg
- Juan Antonio Vizcaíno
- Reza M Salek
- Steffen Neumann
- Andrew R Jones

Apologies if I missed anyone!



# Chapter 10. Contributors

In addition to the authors, the following people contributed to the model development, gave feedback or tested mzTab:

- COSMOS
- Nuno Bandeira, Center for Computational Mass Spectrometry, University of California, San Diego, CA, USA.
- Robert J. Chalkley, Department of Pharmaceutical Chemistry, University of California San Francisco, CA, USA.
- Jürgen Cox, Max Planck Institute of Biochemistry, Martinsried, Germany.
- Martin Eisenacher, Medizinisches Proteom-Center, Ruhr-Universität Bochum, Germany.
- Jun Fan, Queen Mary University of London, United Kingdom.
- Fawaz Ghali, University of Liverpool, United Kingdom.
- Laurent Gatto, University of Cambridge, Cambridge, United Kingdom.
- Jürgen Hartler, Graz University of Technology, Graz, Austria.
- Gerhard Mayer, Medizinisches Proteom-Center, Ruhr-Universität Bochum, Germany.
- Nadin Neuhauser, Max Planck Institute of Biochemistry, Martinsried, Germany.
- Yasset Pérez-Riverol, European Bioinformatics Institute, Cambridge, United Kingdom.
- Steffen Neumann, Leibniz Institute of Plant Biochemistry, Halle, Germany.
- Florian Reisinger, European Bioinformatics Institute, Cambridge, United Kingdom.
- Reza M. Salek, European Bioinformatics Institute, Cambridge, United Kingdom.
- Christoph Steinbeck, European Bioinformatics Institute, Cambridge, United Kingdom.
- Noemi del Toro, European Bioinformatics Institute, Cambridge, United Kingdom.
- Gerhard Thallinger, Graz University of Technology, Graz, Austria.
- Ioannis Xenarios, Swiss Institute of Bioinformatics, Geneva, Switzerland.
- Qing-Wei Xu, European Bioinformatics Institute, United Kingdom.

# References

- [bradner-1997] Bradner, S. (1997). Key words for use in RFCs to Indicate Requirement Levels, Internet Engineering Task Force. RFC 2119.
- [martens-2011] Martens, L., et al. (2011). "mzML—a community standard for mass spectrometry data." *Mol Cell Proteomics* 10(1): R110 000133.
- [jones-2012] Jones, A. R., et al. (2012). "The mzIdentML data standard for mass spectrometry-based proteomics results." *Mol Cell Proteomics* doi:10.1074/mcp.M111.014381.
- [hill-1900] EA Hill (1900). "ON A SYSTEM OF INDEXING CHEMICAL LITERATURE; ADOPTED BY THE CLASSIFICATION DIVISION OF THE U. S. PATENT OFFICE." *J. Am. Chem. Soc.* 22 (8): 478–494. doi:10.1021/ja02046a005.
- [walzer-2013] Walzer et al. (2013) "The mzQuantML data standard for mass spectrometry-based quantitative studies in proteomics" *Mol Cell Proteomics* doi: 10.1074/mcp.O113.028506.
- [griss-2014] Griss et al. (2014) "The mzTab data exchange format: communicating mass-spectrometry-based proteomics and metabolomics experimental results to a wider audience." *Mol Cell Proteomics* doi: 10.1074/mcp.O113.036681.

# Chapter 11. Intellectual Property Statement

The PSI/MSI takes no position regarding the validity or scope of any intellectual property or other rights that might be claimed to pertain to the implementation or use of the technology described in this document or the extent to which any license under such rights might or might not be available; neither does it represent that it has made any effort to identify any such rights. Copies of claims of rights made available for publication and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementers or users of this specification can be obtained from the PSI Chair.

The PSI/MSI invites any interested party to bring to its attention any copyrights, patents or patent applications, or other proprietary rights that may cover technology that may be required to practice this recommendation. Please address the information to the PSI Chair (see contacts information at PSI website).

# TradeMark Section

Microsoft Excel®

# Copyright Notice

Copyright © Proteomics Standards Initiative (2018). All Rights Reserved.

This document and translations of it may be copied and furnished to others, and derivative works that comment on or otherwise explain it or assist in its implementation may be prepared, copied, published and distributed, in whole or in part, without restriction of any kind, provided that the above copyright notice and this paragraph are included on all such copies and derivative works. However, this document itself may not be modified in any way, such as by removing the copyright notice or references to the PSI or other organizations, except as needed for the purpose of developing Proteomics Recommendations in which case the procedures for copyrights defined in the PSI Document process must be followed, or as required to translate it into languages other than English.

The limited permissions granted above are perpetual and will not be revoked by the PSI or its successors or assigns.

This document and the information contained herein is provided on an "AS IS" basis and THE PROTEOMICS STANDARDS INITIATIVE DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE."