Designation: F3560 – 22

Standard Specification for Additive Manufacturing – Data – Common Exchange Format for Particle Size Analysis by Light Scattering[1]

This standard is issued under the fixed designation F3560; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification has been developed to facilitate exchanging and analyzing particle size distribution (PSD) by light scattering data from databases, data management systems, point of origin, or other data sources that may use different data dictionaries, schemas, or formats.

1.2 This specification prescribes the use of a common exchange format in such a way that PSD data defined through proprietary means can be easily exchanged for process understanding and qualification.

1.3 This specification facilitates the interoperability of PSD data by identifying the data elements defined in standardized terminology, as well as defining those salient terms with indisputable meanings. In doing so, this specification extends the common AM data dictionary defined in Practice F3490 to encapsulate PSD process-specific data elements. Generic data elements and relationships present in that standard are inherited and applied in this practice where relevant.

1.4 This specification specifies names that serve to uniquely identify the PSD data elements. The data type, value domain, and term definition for each data element are also specified in this practice. References are provided for those data elements with established definitions or reporting guidelines in existing standards.

1.5 This specification prescribes a file format and structure for the exchange of PSD data. This format defines a method for sharing data via the defined PSD data elements herein and provides a basis for validation of data exchanged using this format.

1.6 This specification recommends levels of data sharing that vary from minimal to robust. It prescribes best practices for checking conformance based on the common data exchange format.

1.7 This specification does not specify:

1.7.1 An exhaustive set of data items that could be exchanged related to PSD by light scattering.

1.7.2 A definition of a minimum viable data set for PSD by light scattering.

1.7.3 Data items or an exchange format for PSD methods other than light scattering, for example, imaging or sieving.

1.7.4 Data elements for data modules related to PSD (for example, for personnel, material, or equipment).

1.7.5 The implementation details of how data should be imported to proprietary data management systems from the common data exchange format.

1.7.6 The implementation details of how data should be exported from proprietary data management systems to the common data exchange format.

1.7.7 Guidelines for creating unique identifiers for data module records

1.8 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B821 Guide for Liquid Dispersion of Metal Powders and Related Compounds for Particle Size Analysis

B822 Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering

E1617 Practice for Reporting Particle Size Characterization Data

E3340 Guide for Development of Laser Diffraction Particle Size Analysis Methods for Powder Materials

[1] This specification is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.08 on Data.

Current edition approved Aug. 1, 2022. Published October 2022. DOI: 10.1520/F3560-22.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

F3490 Practice for Additive Manufacturing — General Principles — Overview of Data Pedigree

2.2 *ISO Standards:*[3]

ISO 8601 Date and time format

ISO 13320 Particle size analysis — Laser diffraction methods

3. Terminology

3.1 *Abbreviations:*

3.1.1 *AM*—Additive Manufacturing

3.1.2 *CDD*—Common Data Dictionary

3.1.3 *CDEF*—Common Data Exchange Format

3.1.4 *ID*—Identifier

3.1.5 *JSON*—Java Script Object Notation

3.1.6 *PSD*—Particle Size Distribution

3.1.7 *SI*—International System of Units

3.1.8 *TIC*—Test / Inspection / Characterization

3.2 *Definitions:*

3.2.1 For the purposes of this document, the terms and definitions given in Practice F3490 shall apply.

4. PSD by Light Scattering CDEF Requirements

4.1 Data shared according to this standard shall conform to the data element definitions in Section 6. Any additional data elements included in the data package and not defined in this standard shall have definitions agreed upon by the parties involved in the data exchange.

4.2 If the JSON format is used, data shared according to this standard shall conform to the JSON schema defined in Annex A1 up to the definition of required terms, which should be established by the parties involved in the exchange of data. Those parties may refer to the recommended reporting levels in Section 6 to establish required data elements. Note that the schema in Annex A1 sets required data elements per Recommended Reporting Level 1 with a dry dispersion method, the "required" tags in the schema should be updated to reflect the agreed-upon data reporting level. See the JSON schema documentation for more information about specifying required elements: https://json-schema.org/understanding-json-schema/reference/object.html#required-properties.[4] Parties involved in the exchange of data may agree upon a different format (for example, XML-based) while utilizing the structure developed in Annex A1.

NOTE 1—Descriptive information for the JSON schema defined in Annex A1 is provided in Appendix X1.

4.3 Data elements not included in this specification may be added to the format when agreed upon by the parties exchanging data. Data elements added thusly should have names prepended with an underscore ("_") when included in the JSON CDEF or corresponding JSON schema as defined in Annex A1.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[4] See Referenced Link after Table 3 for an active link to this web page.

5. Reporting Levels

5.1 Data reporting levels are suggested and based on reporting guidelines in Practice E1617 and ISO 13320. Recommended reporting levels are suggested for each data element in Table 1, Table 2, and Table 3. Two parties exchanging data may agree to follow different, mutually agreed-upon reporting requirements. Non-required data elements may be omitted when exchanging data in these cases.

5.2 A data package satisfying Recommended Reporting Level 1 shall include basic identifiers and descriptors of the test. It includes minimal test preparation details and sample information as well as the most essential results to analyze the data. Two parties exchanging data may agree to follow different, mutually agreed-upon reporting requirements. Non-required data elements may be omitted when exchanging data in these cases.

5.3 A data package satisfying Recommended Reporting Level 2 includes additional information on ambient environment conditions and test preparation details. Test results are added that can be derived from the results included in Level 1.

5.4 A data package satisfying Recommended Reporting Level 3 includes full equipment calibration information and test performance details. Additionally, linkages to complete information module records as defined in Practice F3490 are maintained. For example, the TIC Operator data element has Recommended Reporting Level 1 for the operator's name as a minimum requirement. At Level 3, the operator's unique identifying ID or, equivalently, their complete record of Personnel Information Module data elements as defined in Table 24 of Practice F3490, shall be reported.

5.5 Data elements with a Reporting Level marked as O in Table 1, Table 2, and Table 3 are considered optional at all levels.

5.6 Procedures using a wet dispersion method shall include data elements marked with a W in the Reporting Level column in Table 1. Those using a dry dispersion method shall include data elements marked with a D.

6. PSD by Light Scattering Data Element Definitions

6.1 *Data Type and Common Value Set Definition:*

6.1.1 Data types (for example, string, integer) used by the data element definitions in this standard are as defined in Practice F3490 Table 1.

6.2 *Data Element Definitions:*

6.2.1 The data elements for PSD by light scattering are listed and described in this section.

6.2.2 Some data elements are inherited from the Test / Inspection / Characterization information module defined in Practice F3490, most notably, those beginning with TIC. PSD is a specific type of Test / Inspection / Characterization and these terms are maintained as-is for consistency.

6.2.3 A dataset shall specify the version of this specification it is conforming to in order to reduce miscommunications.

NOTE 2—As this standard continues to evolve, the data elements, relationships, or file format will be updated. It is possible that this will

TABLE 1 Metadata Elements for Particle Size Distribution by Light Scattering

Data Element Name	Data Type	Value Range, Value Set, or Primary Units	Definition / Standard	Reporting Level
TIC ID	string	free text	A unique identifier of the test, inspection, or characterization type.	1
TIC Name	string	free text	A short description of the test / inspection / characterization.	1
TIC Type	string	free text	Type of test / inspection / characterization, such as tensile test, fatigue test, etc.	1
TIC Standard	string	free text	An identifier for the corresponding standard used.	1
TIC Procedure	string	free text	The procedure used if it is not from an existing standard.	3
TIC Start Time and Date	date / time	N/A	Start time and date of the test. ISO 8601.	1
TIC End Time and Date	date / time	N/A	End time and date of the test. ISO 8601.	1
TIC Location	globalAddressFormat	N/A	The physical location where the test was conducted.	3
TIC Notes/Comments/ Description	string	free text	Itemized descriptions of observations relating to the individual test, inspection, or characterization of an individual specimen.	0
TIC Operator	string	Personnel ID	Identifier of the operator who facilitated the test, inspection, or characterization linking to Personnel ID.	1 – Name 3 – ID
TIC Point of Contact	string	Personnel ID	The name of the point of contact for the task being performed, if not the person performing the task.	1 – Name 3 – ID
TIC Vendor / Supplier / Contractor	string	Organization ID	Identifier of Vendor / Supplier / Contractor who physically performed the test, inspection, or characterization linking to Organization ID.	1 – Name 2 – Qualification / Certification 3 – ID
TIC Equipment	string	Other Equipment ID	Identifier of Non-AM Equipment used during the test, inspection, or characterization.	1 – Name 3 – ID
Range Selected	reals (min-max)	micrometre	Selected measurement range of particle size diameters. Test Method B822, Practice E1617.	1
Optical Arrangement	string	free text	Description of optics. ISO 13320.	3
Date of Last Calibration	datetime	N/A	The date on which the equipment was last calibrated. ISO 13320.	1
Date and Time of Last Alignment	date / time	N/A	The date on which the optical arrangement was last aligned. ISO 13320.	3
Equipment Temperature	real	°C	The temperature inside the analysis unit.	2
TIC Software	string	Software ID	Identifier of any Software that was used during the test, inspection, or characterization.	2 – Name 2 - Version 3 – ID
TIC Destructive versus Non-Destructive	string	destructive	Indication of whether the test, inspection, or characterization irreversibly changed the nature of the specimen.	1
TIC Temperature	real	°C	The ambient atmospheric temperature during the test, inspection, or characterization.	2
TIC Temperature control method	string	free text	The method for controlling the ambient temperature during the test, inspection, or characterization.	2
TIC Location of Temperature Measurement	string	free text	Where the ambient temperature was measured during the test, inspection, or characterization.	2
TIC Humidity	real	%	The ambient humidity measurement during the test, inspection, or characterization.	2
Instrument analysis run time	real	minutes	The amount of time elapsed during instrument analysis. Test Method B822.	1
Number of Measurement	integer	N/A	The number of measurements averaged on a replicate to give the final particle size distribution.	1

TABLE 1 *Continued*

Data Element Name	Data Type	Value Range, Value Set, or Primary Units	Definition / Standard	Reporting Level
Replicate Number	integer	N/A	The number of replicate analysis on a sample to be averaged.	1
Particle Size Distribution Principle of Measurement	string	laser light scattering	The particle size analysis technique (for example, sieving, sedimentation, light blockage, laser light scattering). Practice E1617.	1
Particle Size Distribution Parameter Basis	string	volume	The bases for the reported parameter (for example, distribution, scattering area distribution, or mass distribution). Practice E1617.	1
Optical obscuration	real	%	The fraction of incident light that is attenuated due to extinction (scattering or absorption, or both) by particles. ISO 13320.	1
Type of light scattering model applied	string	″Mie″ or ″Fraunhofer″	The theoretical model used for computing the model matrix for optically homogeneous and isotropic spheres with, if necessary, a specified complex refractive index. Test Method B822, ISO 13320.	1
Threshold for acquisition of valid data (if applied)	real	micrometre	Threshold value used to filter out background signal. ISO 13320.	2

cause datasets to become non-conforming with the latest data exchange standard practice.

6.2.4 For convenience, the data elements have been divided into three categories: test metadata (Table 1), specimen information (Table 2), and test results (Table 3).

7. Keywords

7.1 additive manufacturing; data exchange; data format; data pedigree; particle size distribution

TABLE 2 Specimen Data Elements for PSD by Light Scattering

Data Element Name	Data Type	Value Range, Value Set, or Primary Units	Definition / Standard	Reporting Level
Specimen ID	string	free text	The identifier of the individual specimen.	1
Specimen Origin ID	string	Material ID	The identifier of the part or material batch that the specimen was extracted from. Links to Built Part or Material foreign key.	Name – 1 ID – 3
Specimen Type	string	powder sample	The type of specimen, which may refer to the geometry or configuration of the specimen.	1
Specimen Mass	real	grams (g)	The measured weight of the individual specimen.	2
Specimen Description	string	free text	A description of the specimen.	O
Specimen Sampling/ Extraction/Fabrication Method	string	free text	The method in which the sample or specimen was extracted from the powder batch.	2
Specimen Deviations from recommended specimen configuration or preparation	string	free text	Description of any differences from recommendations made in the standards for specimen configuration and preparation.	2
Real refractive index of the sample material (where applicable)	real	N/A	The positive real part of the refractive index of the sample material. Test Method B822, ISO 13320.	1
Imaginary refractive index of the sample material (where applicable)	real	N/A	The positive imaginary (absorption) part of the refractive index of the sample material. Test Method B822, ISO 13320.	1
Dispersion gas ID	string	Material ID	The identifier of the gas in which the powder is dispersed. Guide E3340.	1D – Name 2D – Chemistry Characterization 3D – ID
Dry dosing/feeding device	string	Non-AM Equipment ID	Equipment used to disperse the powder in a dry medium. Guide E3340, ISO 13320.	1D – Name 3D – ID
Dry dispersion dosing rate (where applicable)	real	g/min	The feed rate of the dry dispersed sample generated by the dosing unit. Guide E3340, ISO 13320.	2D
Dry dispersion pressure	real	MPa	Pressure of the dry dispersed sample. Guide E3340, ISO 13320.	1D
Dispersion liquid ID	string	Material ID	The identifier of the liquid in which the powder is dispersed. Guide B821, Guide E3340, ISO 13320	1W – Name 2W – Chemistry Characterization 3W – ID
Dispersion liquid volume	real	mL	The volume of the liquid in which the powder is dispersed. Guide B821, Guide E3340, ISO 13320.	1W
The real refractive index of the dispersing liquid	real	N/A	The positive real part of the refractive index of the dispersion liquid. Guide B821, Test Method B822, Guide E3340, ISO 13320.	1W
Dispersion liquid temperature	Real	°C	The measured temperature of the dispersion liquid. Guide B821, Guide E3340, ISO 13320.	1W
Dispersion liquid pump speed	Real	cm^3/min	Pumping speed for transport of liquid dispersions. Guide B821, Guide E3340, ISO 13320.	1W
Dispersion liquid stirring speed	real	r/min	Stirring speed for transport of liquid dispersions. Guide B821, Guide E3340, ISO 13320.	1W

TABLE 2 *Continued*

Data Element Name	Data Type	Value Range, Value Set, or Primary Units	Definition / Standard	Reporting Level
Liquid dispersant ID(s)	string	Material IDs	Dispersant(s) applied for de-agglomeration of particles and for stabilization of the dispersion. Guide B821, Guide E3340, ISO 13320.	2W
Liquid dispersant(s) concentrations	real	%	Concentration of the dispersant in the dispersed sample. Guide B821, Guide E3340, ISO 13320.	2W
Sonication equipment	string	Non-AM Equipment ID	Equipment used to de-agglomerate and stabilize the dispersion via sonication. Guide B821, Guide E3340, ISO 13320.	2W – Name 3W - ID
Wet dispersion sonication frequency (energy)	real	kHz	Frequency at which sonication is conducted. Guide B821, Guide E3340, ISO 13320.	2W
Wet dispersion sonication duration	real	seconds (s)	Duration of application of sonication. Guide E3340, Guide E3340, ISO 13320.	2W
Wet dispersion sonication pause before starting measurement	real	seconds (s)	Length of time between sonication and the particle size measurement. Guide B821, Guide E3340, ISO 13320.	2W
Wet dispersion optical path length (where applicable)	real	mm	Length of the optical path of the laser. Guide B821, Guide E3340, ISO 13320.	2W

TABLE 3 Test Result Data Elements for PSD by Light Scattering

Data Element Name	Data Type	Value Range, Value Set, or Primary Units	Definition / Standard	Reporting Level
Particle size distribution density function	tabular	% versus micrometre	The measured frequency distribution of particle sizes. Test Method B822.	1
Particle size cumulative distribution	tabular	% versus micrometre	The measured cumulative distribution of particle sizes. Test Method B822.	1
Particle Size Distribution Percentiles	tabular	micrometre versus %	Particle size measurement at specified percentiles.	2
Particle Size Distribution Mean Diameter	real	micrometre	Mean of particle size distribution data. Test Method B822.	1
Particle Size Distribution Mode Diameter	real	micrometre	Mode of particle size distribution data.	2
Particle Size Distribution Standard Deviation	real	micrometre	Standard deviation of particle size distribution data. Practice E1617.	1
Particle Size Distribution Range	reals ([min, max])	micrometre	The range of particle size distribution data.	2
TIC Pass/Fail	string	“pass” or “fail”	Indication of whether the results of the test/inspection/characterization met the requirement(s) specified.	1

Referenced Link

https://json-schema.org/understanding-json-schema/reference/object.html#required-properties.

ANNEX

(Mandatory Information)

A1. PSD BY LIGHT SCATTERING CDEF JSON SCHEMA


```
{
    "$schema": "http://json-schema.org/draft-06/schema#",
    "title": "Particle Size Distribution by Light Scattering Common Data Exchange Format",
    "description": "Schema for PSD CDEF JSON format per ASTM F3560",
    "type": "object",
    "properties": {
      "particleSizeDistribution": {
        "type": "object",
        "properties": {
            "ticMetadata": {
                "description": "Metadata and setup information related to the test, inspection, or characterization",
                "type": "object",
                "properties": {
                    "ticID": {
                        "description": "An identifier of the test, inspection or characterization type.",
                        "type": "string"
                    },
                    "ticName": {
                        "description": "A short description of the test/inspection/characterization.",
                        "type": "string"
                    },
                    "ticType": {
                        "description": "Type of test/inspection/characterization, such as tensile test, fatigue test, etc.",
                        "const": "Particle Size Analysis"
                    },
                    "ticStandard": {
                        "description": "An identifier for the corresponding standard used.",
                        "type": "string"
                    },
                    "ticProcedure": {
                        "description": "The procedure used if it is not from an existing standard.",
                        "type": "string"
                    },
                    "ticStartTimeAndDate": {
                        "description": "Start time and date of the test. ISO 8601.",
                        "format": "date-time",
                        "type": "string"
                    },
                    "ticEndTimeAndDate": {
                        "description": "End time and date of the test. ISO 8601.",
                        "type": "string",
                        "format": "date-time"
                    },
                    "ticLocation": {
                        "description": "The physical location where the test was conducted. ISO 19160.",
                        "$ref": "#/definitions/address"
                    },
                    "ticNotes": {
                        "description": "Itemized descriptions of observations relating to the individual test, inspection, or characterization of
                                an individual specimen.",
                        "type": "string"
                    },
                    "ticOperator": {
                        "description": "Identifier of the operator who facilitated the test, inspection, or characterization linking to Personnel
                                ID.",
                        "type": "object",
                        "properties": {
                            "personnelName": {"type": "string"},
                            "personnelID": {"type": "string"}
                        }
                    },
                    "ticPOC": {
                        "description": "The name of the point of contact for the task being performed, if not the person performing the task.",
                        "type": "object",
                        "properties": {
                            "personnelName": {"type": "string"},
                            "personnelID": {"type": "string"}
                        },
                        "required": ["personnelName"]
                    },
```