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Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems —

Part 5: Two-dimensional data coding of components and data exchange format for PE piping systems

Tubes et raccords en matières plastiques — Appareillage pour l'assemblage par soudage des systèmes en polyéthylène —

Partie 5: Codage bidimensionnel des données des composants et format d'échange de données pour les systèmes de canalisations en PE

Reference number
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Contents

Page

Foreword

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

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

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

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

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

This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 4, *Plastics pipes and fittings for the supply of gaseous fuels*.

A list of all parts in the ISO 12176 series can be found on the ISO website.

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

Introduction

The use of two-dimensional code is becoming increasingly popular because of the quantity of information that it is possible to group in a small space, and this can provide increased opportunities for manufacturers and customers. There are many benefits for the market, but the scope of this document is not to show all of them. The most important technical advantage of using a two-dimensional code is the possibility to apply a built-in correction level to the coding, so that, even with some scratches or missing parts, the operator can still use all information coded safely. Another important fact, for those that want to use the power of the whole traceability, is that any important information regarding the piping component can be stored in an electronic device, by reading only one code instead of two (ISO 12176-4 and ISO 13950) and thus avoiding overlapping information. This document provides a means for coding all aspects not covered by ISO 12176-4 or ISO 13950, e.g. large diameters, big saddles or other imperial sizes. This document also aims to standardize the transfer of data stored in the memories of electronic units to another electronic equipment (e.g. computer/data base) and to encourage, at any level, the use of the traceability for a further development of the polyethylene piping systems.

Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems —

Part 5:
Two-dimensional data coding of components and data exchange format for PE piping systems

1 Scope

This document specifies an encoding system for data of components, assembly methods and jointing operations for polyethylene (PE) piping systems for gas, water and other industrial applications. These data can be used in a traceability system and/or used to perform the fusion of components by using equipment as specified in ISO 12176-1 and in ISO 12176-2.

This encoding system is explained in ISO/IEC 16022, ISO/IEC 18004 and ISO/IEC 24778 which refer to established code types, e.g. QR code.

Data to be encoded are: fusion cycle(s), traceability of manufactured products, other manufacturer's information that can also be given on websites such as voluntary certificates of quality and approvals.

This document specifies the export of data (type, format and sequence) from a data retrieval system.

Provisions of this document are applicable to polyethylene components conforming to ISO 4427-2, ISO 4427-3, ISO 4437-2, ISO 4437-3, ISO 4437-4 and ISO 15494, and can also be applicable to any other components used in PE systems.

ISO 13950 and ISO 12176-4, which partly cover the fields of application of this document, can be used in parallel.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 10646, *Information technology — Universal coded character set (UCS)*

ISO 12176-1, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 1: Butt fusion*

ISO 12176-2, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 2: Electrofusion*

ISO 12176-3, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 3: Operator's badge*

ISO/IEC 16022, *Information technology — Automatic identification and data capture techniques — Data Matrix bar code symbology specification*

ISO/IEC 18004, *Information technology — Automatic identification and data capture techniques — QR Code bar code symbology specification*

ISO/IEC 21778, *Information technology — The JSON data interchange syntax*

ISO/IEC 24778, *Information technology — Automatic identification and data capture techniques — Aztec Code bar code symbology specification*

ASTM F 2897-15a, *Standard Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms and definitions

3.1.1
delimiter
character used to define a specific set of data

3.1.2
"]"
hexadecimal character code 5d
delimiter (3.1.1) of fields used in region data

3.1.3
"~"
hexadecimal character code 7e
delimiter (3.1.1) of sub-fields

3.1.4
fusion equipment
equipment that conforms to either ISO 12176-1 (butt fusion machine) or to ISO 12176-2 (control unit)

3.1.5
jointing process
act of jointing separate parts of a plastic piping system

Note 1 to entry: For the purpose of this document a fusion process can be either electro-fusion or butt fusion.

Note 2 to entry: For the purpose of this document jointing can also be performed using a mechanical fitting as defined in ISO 17885.

3.1.6
JSON
Java Script Object Notification
lightweight data-interchange format

Note 1 to entry: JSON is based on a subset of the JavaScript Programming Language Standard, ECMA-262 3rd Edition – December 1999.

Note 2 to entry: JSON is defined by ISO/IEC 21778.

3.1.7
JSON schema
JSON-based format for describing JSON data

Note 1 to entry: Published on https://json-schema.org.

Note 2 to entry: The version of JSON-Schema used in this document is the “Draft 2019-09”.

3.1.8
multilevel fusion
sequence of more than one fusion phase on the same electro-fusion fitting, i.e. pre-heating, heat soak and fusion

3.1.9
multiplicity
defines how often an element can be present in the respective context

Note 1 to entry: Multiplicity’s symbols have the following meanings: 1 = exactly once; 1...* = at least once; 0...1 = optionally none or once; 0...* = optionally none or several times.

3.1.10
nominal target heating energy
heating energy to be reached at 20 °C before correction in conjunction with the ambient temperature

3.1.11
nominal target heating time
heating time to be reached at 20 °C before correction in conjunction with the ambient temperature

3.1.12
protocol
JSON object that contains one or more fusion records of a fusion device

Note 1 to entry: A fusion record is made by an electronic device, which is coupled with fusion equipment as described in ISO 12176-1 or ISO 12176-2.

3.1.13
UTF-8
8-bit Unicode Transformation Format
variable-width character encoding

Note 1 to entry: This is capable of encoding all 1, 112, 064 valid character code points in Unicode using one to four one-byte (8-bit) code units.

3.2 Abbreviated terms

Classification of pipes not in the International System of Units (SI):

CTS	copper tube size (dimensions in inches)
DIPS	ductile iron pipe size (dimensions in inches)
IPS	iron pipe size (dimensions in inches)

4 Barcode type, structure and contents

4.1 General

This data encoding system shall use alternatively a code type according to ISO/IEC 16022 (Data Matrix code), ISO/IEC 18004 (QR code), and ISO/IEC 24778 (Aztec code). A maximum of 1 024 bytes can be included in the two-dimensional code.

When the two-dimensional code conforms to ISO/IEC 18004 (QR code), the two-dimensional code shall be of the following characteristics:

a) minimum module width: 0,253 mm (valid for all versions);

b) minimum resolution: 300 dpi (valid for all versions);

c) correction level M (for codes smaller or equal to type 14, level L correction level may be used).

Examples of two-dimensional codes are given in Annex E.

In the case that the resulting code size is too large (e.g. to be stuck on small fittings or components), the code symbols may be appended in a structured format.

For multi-byte encoding characters, examples of checksum calculation are given in Annex F.

Attention is drawn to control units that can have limited character sets and can not be able to represent multi-byte characters correctly on their display or in their pdf file output. Nevertheless, control units shall guarantee that the characters are correct in data retrieval for exchange formats, like csv or JSON.

4.2 Contents

Data are coded in fields as defined hereafter. Fields are identified and delimited by the use of the symbol "]" at the end of any field. All data are grouped in homogeneous regions. There are five regions:

Region 0:	revision of data coding definition	(subclause 4.2.1)
Region 1:	identification components type	(subclause 4.2.2)
Region 2:	jointing process information	(subclause 4.2.3)
Region 3:	Traceability	(subclause 4.2.4)
Region 4:	additional factory information	(subclause 4.2.5)

Each field consists of a defined number of characters (see 4.2.1, 4.2.2, 4.2.3, 4.2.4 and 4.2.5) and only characters defined in the following are acceptable. The characters: "]" and "~" shall be used exclusively as delimiters. Each character is an alphanumerical digit or one special character. Each character is represented as 1 to 4 bytes and shall be encoded in UTF-8.

After the five regions there is the checksum (subclause 4.2.6).

4.2.1 Revision of data coding definition (region 0)

The region 0 is without field(s) and it starts and ends with character '~' (see 3.1.2.2). The revision number is shown as a double-digit counter, starting with "00" with the first publication of this document and increases by +1 for every revision of the data format.

Region 0, for the first publication of this document, is identified by the characters ~00~. For clarity, at the next revision of the data format the region 0 will be: ~01~ (this document can be revised in the future without changes of the data format).

In region 0, a minimum and a maximum of four characters are used comprising two delimiters "~".

The following is an example of data in region 0, total characters used 4 out of 4 available in this region:

Region 0				
Data	~	0	0	~

4.2.2 Identification components type (characters of region 1)

Field n°1: type component, identified as per Table 1.

Table 1 — Characters for Field n°1 and meaning

Character	Meaning
0	Other component
1	Pipe
2	Electrofusion fitting
3	Spigot fitting
4	Mechanical fitting[7]

A total of two characters is used comprising the delimiter "]".

Field n°2: dimensional unit systems used to manufacture the component, identified as per Table 2.

Table 2 — Characters for Field n°2 and meaning

Character	Meaning
0	Metric system (mm)
1	IPS
2	DIPS
3	CTS

A combination between characters in Table 2 is allowed with a maximum of two characters. The order of the characters shall represent the actual joint figure and is important for a good interpretation of diameters as indicated in Field n°6.

EXAMPLE 1 Metric by IPS→ 01, IPS by metric→ 10.

In case of components with equal dimensions, the coding is reduced to only one character.

EXAMPLE 2 Metric by metric→ 0.

In Field n°2, a minimum of two and a maximum of three characters are used comprising the delimiter "]".

Field n°3: manufacturer shall be coded in the form of a name or trade mark. A minimum of three and a maximum of 21 characters are used comprising the delimiter "]". Only spaces are not allowed.

NOTE 1 For a better comprehension of the coding of the manufacturer, see Reference [9].

Field n° 4: component type, identified as per Table 3.

Table 3 — Components and character identification for Field n° 4

Component	Character
Other components	00
Pipe, straight	01
Pipe, coiled	02
Socket	03
Tapping saddle	04
Branching saddle	05
Elbow, 90°	06
Elbow, 45°	07
Elbow, undefined	08
Tee	09
End cap	10

Table 3 *(continued)*

Component	Character
Reducer	11
Swept bend	12
Flange adapter	13
Mechanical fitting	14
PE-body valve, quarter-turn (QT)	15
PE-body valve, multi-turn (MT)	16
Non-PE-body valve, QT	17
Non-PE-body valve, MT	18
Repair fitting	19
Transition fitting (e.g.: with welding end, etc.)	20
Wall channel, rigid	21
Wall channel, flexible	22
Pressure tapping valve	23
Ventilation end cap	24
Stop-off saddle	25
Cap for tapping saddle	26
PE/steel transition fitting threaded	27
PE/brass transition fitting threaded	28
Excess-flow valve	29
Cross	30
Manhole	31
Filter	32
Wall plate	33
Gas excess flow valve integrated in a socket	34
Anchoring bracket	35

NOTE 2 Components and characters are coded with reference to Reference [9].

A total of three characters is used, comprising the delimiter "]".

Field n° 5: component's particularity. If the component is a pipe, then Table 4 applies.

Table 4 — Characters for Field n° 5 and meaning

Character	Meaning
0 (zero)	Other
1	co-extruded layers
2	Solid wall
3	PE pipes with a peelable layer
4	Barrier pipe

If the component is other than a pipe, then Table 5 applies.

Table 5 — Characters for Field n° 5 and meaning

Character	Meaning
0 (zero)	Other
A	Monofilar

Table 5 *(continued)*

Character	Meaning
B	Bifilar
C	Single socket
D	Multi socket

A combination of two characters is acceptable.

A minimum of two and a maximum of three characters, as capital letters or numbers, are used comprising the delimiter "]".

Field n° 6: component diameter.

Number characters "0,1...9", the character "x", as separator for two diameters are allowed only.

In addition, and for a correct identification of imperial sizes (inches), the character "/" and a space can be used.

For examples of component diameter and units and characters to be used, see Table 6.

Table 6 — Examples of component diameter and units and characters to be used

Component diameter and units (mm) or (inches)	Characters	
	Field n° 2	Field n° 6
1 200 mm	0	1200
250 mm × 110 mm	0	250×110
12" IPS × 10"IPS	1	12×10
12" IPS × 110 mm	10	12×110
400 mm × 10"IPS	01	400×10
1"1/4 CTS × 4"IPS	31	1[a] 1/4×4

[a] A space is left when imperial sizes are used; this space is used to identify fractions of inches.

Content of this field is expressed in a syntax diagram (given for programming purposes), see Figure 1 and Figure 2.

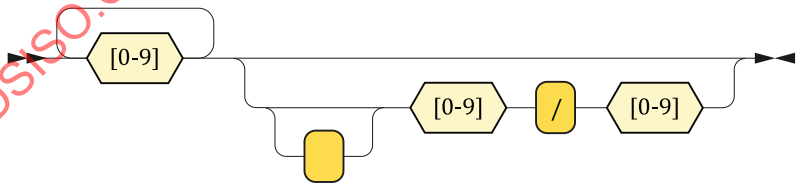

Figure 1 — DimPart

DimPart ::= [0-9]+ (' '? [0-9] '/' [0-9])?

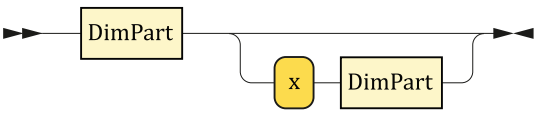

Figure 2 — Dimension

Dimension ::= DimPart ('x' DimPart)?

A minimum of two and a maximum of thirteen characters are used comprising the delimiter "]".

Field n° 7: component design SDR.

Number characters '0,1...,9' and the decimal dot '.' are allowed only.

A minimum of two and a maximum of five characters are used comprising the delimiter "]".

EXAMPLE SDR13,6 → 13.6].

Field n° 8: materials used for manufacturing components are identified by using characters as per Table 7.

Table 7 — List of relevant materials and characters

Material	Characters
Other material	00
PE 80	11
PE 100	12
PE 100 RC	13
PE 100 RT Type 1	14
PE 100 RT Type 2	15
PE 3710	31
PE 4608	32
PE 4708	33
PE 4710	34
Copper	51
Copper alloys	52
Spheroidal graphite cast iron	61
Malleable cast iron	62
Steel	63
Stainless steel	64

A combination of four characters for two materials, is acceptable.

A minimum of three and a maximum of five characters are used comprising the delimiter "]".

The following provides and example of data in region 1, total characters used 42 out of 55 available in this region:

Field	1		2		3														
Data	**2**	**]**	**0**	**]**	**a**	**n**	**y**		**t**	**r**	**a**	**d**	**e**		**m**	**a**	**r**	**k**	**]**

Field	4			5		6									7					8		
Data	**0**	**3**	**]**	**B**	**]**	**1**	**2**	**0**	**0**	**X**	**1**	**0**	**0**	**0**	**]**	**1**	**3**	**.**	**6**	**]**	**1**	**2**	**]**

4.2.3 Jointing process information (characters of region 2)

In region 2 the jointing process information, e.g. for controlling an electro-fusion process, is encoded.

Region 2 consists of only one field with a flexible number of characters including the delimiter. Specification given in Annex A shall be used to code region 2.

Data field 1 of region 1 determines the contents of region 2 as given in Table 8.

Table 8 — Cross-reference between field 1 of region 1 and fusion data

Value of field 1 of region 1	Type of jointing process information	Number of characters	Reference
0	No information given	1	
1	No information given	1	
2	Electro-fusion process information	min. 22 to max. 121	Annex A
3	No information given	1	
4	No information given	1	

If no jointing process information is defined for a value of Field n° 1 of region 1, region 2 contains the delimiter only "]".

EXAMPLE If character in Field n° 1 of region 1 is "2", region 2 will be filled with fusion process information for electro-fusion process, e.g. 1~0.85C0~140.0012054~30].

4.2.4 Traceability (characters of region 3)

Field n° 1: batch n° (or production date) = xxxxxxxxxx. A minimum of one character up to a maximum of eleven characters are used comprising the delimiter "]".

EXAMPLE 1 If batch number is not given, the character is the delimiter "]" only.

Field n° 2: name of compound = xxxxxxxxxx. A minimum of one character up to a maximum of eleven characters are used comprising the delimiter "]".

EXAMPLE 2 If the name of compound is not given, the character is the delimiter "]" only.

Compound name can be in plain text or coded. For a better comprehension of the coding of the compound, more information can be found at Reference [9].

Field n° 3: identification of MFR value. The MFR value of the compound used is identified as per Table 9.

Table 9 — Characters for Field n° 3 to identify MFR value

MFR (g/10 min)	Character
MFR value not specified[a]	0
MFR ≤ 5	1
5 < MFR ≤ 7	2
7 < MFR ≤ 10	3
10 < MFR ≤ 15	4
15 < MFR ≤ 20	5
20 < MFR ≤ 25	6
25 < MFR ≤ 32	7
32 < MFR ≤ 40	8
MFR > 40	9

[a] e.g.: for electrofusion fusion.

Two characters are used comprising the delimiter "]".

Field n° 4: type of material (virgin or reprocessable). The quality of the material is identified as per Table 10.

Table 10 — Characters for field n° 4, type of material identification

Type of material	Character
Virgin material	0
100 % reprocessable material	1
Virgin + reprocessable material	2

Two characters are used comprising the delimiter “]”.

Field n° 5: production site = xxxxxxxxxxxxxxx. A minimum of one character up to a maximum of sixteen characters are used, comprising the delimiter “]”.

EXAMPLE 3 If a production site is not given, the character is the delimiter “]” only.

Field n° 6: length of the component in meters. This field is filled only if character in field 1 of region 1 is 1; otherwise only ”]” is used.

Integers and floating point numbers with one decimal are allowed.

A minimum of one character up to a maximum of seven characters (e.g. xxxxxx) are used comprising the delimiter “]”.

Field n° 7: serial n° of the component in the batch. If information is not provided, just place the delimiter “]”.

A maximum of 25 characters (e.g. xxxxxxxxxxxxxxxxxxxxxxxx) is used comprising the delimiter “]”.

The following provides and example of data in region 3, total characters used 63 out of 74 available in this region:

Field	1										2									3		4	
Data	a	n	y		b	a	t	c	h	]	c	o	m	p	o	u	n	d	]	1	]	0	]

Field	5																6	7															
Data	p	r	o	d	u	c	t	i	o	n		s	i	t	e	]	]	s	e	r	i	a	l		#		o	f		t	h	e	

Field	7						
Data	c	o	m	p	t	.	]

4.2.5 Additional factory information (characters of region 4)

In region 4, the first three fields and the last one are assigned. Depending on the choice made by the manufacturer regarding the dimension of the two-dimensional code, remaining characters may be used for specific purposes. The manufacturer may define a number of additional fields or subfields, other than the first three, each individuated by the use of the delimiter “]” or “~”.

This region shall be finished by the delimiter “]”.

Field n° 1: item code.

A maximum of twenty-five characters is used comprising the delimiter “]”.

If the item code is not used, the field shall contain only the delimiter “]”.

Field n° 2: traceability data as per ASTM F 2897.

A maximum of seventeen characters is used comprising the delimiter “]”.

If the ASTM F 2897 data are not used, the field shall contain only the delimiter “]”.

Field n° 3: web site.

This field may contain a web data reference. No maximum characters are defined and the field is limited by the delimiter "]".

If the field is not used, the field shall contain only the delimiter "]".

Field 3+n.

This field (or fields) may contain additional factory information selected by the manufacturer. Any additional set of fields or subfields are individuated by the use of the delimiter "]" or "~".

Examples of information that may be provided are:

— standard(s) and or approval(s);

— conformity certificate(s);

— instructions of use.

If region 4 is not used, only four delimiters "]" are placed after region 3, e.g. "]]]]"

Example of data in region 4:

Field	1														2												
Data	**a**	**n**	**y**		**i**	**t**	**e**	**m**		**C**	**o**	**d**	**e**	**]**	**a**	**s**	**t**	**m**		**f**	**2**	**8**	**9**	**7**		**c**	**o**	**d**	**e**	**]**

Field	3																				3+n				
Data	**h**	**t**	**t**	**p**	**:**	**/**	**/**	**a**	**n**	**y**	**c**	**o**	**m**	**p**	**a**	**n**	**y**	**.**	**c**	**o**	**m**	**]**	**.**	**.**	**.**	**.**	**]**

4.2.6 Checksum

The checksum is calculated over the significant part of the code (Region 0 to Region 4). The checksum is an unsigned 16 bit number represented as a hexadecimal numbers of four characters using the digits {0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F}. Leading zeros must be written in the Checksum. Checksum is written in the sequence high order byte, low order byte.

After the checksum there is no delimiter "]".

EXAMPLE 1 For 0x1F3D the last four characters are 1F3D (characters in the code are ...)

EXAMPLE 2 For 0xF0 the last four characters are 00F0

The checksum is determined according to the algorithm described in pseudo code below.

NOTE 1 The algorithm is known as "Fletcher's Checksum" (Fletcher16)

Input: Array "codedData" of 8-bit-integers

Output: 16-bit-checksum of "codedData"

sum1 := 0

sum2 := 0

```
for i := 0 to length (codedData) do
   sum1 := (sum1 + codedData [i]) modulo 255
   sum2 := (sum2 + sum1) modulo 255
endfor
checksum := sum1 *256 + sum2

return checksum
```

NOTE 2 Examples of checksum calculation are given in Annex F.

5 Data retrieval system

5.1 General

This clause describes what data a fusion equipment (with integrated retrieval system) or data recorders, shall log. Subclause 5.2 defines the data model that the log data should follow and also specifies which data are mandatory and which are optional for the protocol (see multiplicity). The mapping rules of the data model to different file formats are defined in the subsequent subsections.

Data to be retrieved are collected from:

— fusion and/or mechanical jointing operations, and

— data stored in the two-dimensional code, and

— manual operation made by fusion operator

— automatic operations (e.g.: GPS data, etc.).

Automatic operations are not compulsory and are executed by an electronic equipment connected to the fusion equipment.

The data retrieval system described hereunder is based on the jointing method of piping components. Data from other coding systems (e.g. ISO 13950 or ISO 12176-4) are also useful for the data retrieval system.

The data retrieval system shall use the message codes given in Annex B for log purposes.

5.2 Data model

5.2.1 Data types

The data types used for the data retrieval system are defined according to Table 11. The data type is related to the system of data representation (e.g.: pdf format, XML format, etc.).

Table 11 — Data types for the retrieval system

Abbreviation	Definition
Decimal <n,m>	A positive or negative point number with maximum *n* valid digits before and maximum *m* valid digits behind the decimal point. The range of values can be limited by specifying a closed interval [x..y] in square brackets, where x and y are pointed numbers. It is recommended to represent decimal numbers with Decimal<10,2> when nothing else is required by this document. EXAMPLES Decimal<1,2>[-1.00..1.00] Allowed values are from -1.00 to 1.00 Decimal<3,1>[0.0..100.0] Allowed values are from 0.0 to 100.0
Integer <n>	A positive or negative integer with *n* digits, when <n> is omitted, any integer number is allowed.
String <n>	An UTF8-String length of <n>. The encoding of special characters is given by the mapping. It is recommended to limit string length to a total of <255> bytes when nothing else is required by this document.
String	An UTF8-String with undefined length. Manufacturers of equipment are allowed to limit the length written by their devices to a reasonable length. It is recommended to limit string length to a total of <255> bytes when nothing else is required by this document.
Enum	An enumeration can only take one of the allowed values. It is possible to define a special encoding for Enums (Integers or Strings) so that the encoding may be stored and displayed instead of the full text value.
TimeAndDate	Date and time in local time of the equipment represented as "YYYY-MM-DDThh:mm:ssTZD" (www.w3.org). Difference to universal time coordinated (UTC) may be omitted (TZD).
Date	Date in local time of the equipment represented as "YYYY-MM-DD" (www.w3.org)
GeoPosition	Geographical Position referring to WGS 84[a] (Longitude, Latitude as Decimal value of degree and Altitude in meters as Decimal)
[a] World Geodetic System 1984 is a mathematical model based on the dimension of the terrestrial ellipsoid. It is a datum featuring coordinates that change with time.	

5.2.2 Protocol object

A protocol object contains fusion equipment information and one or more log records from such a fusion equipment. The structure of a protocol object is given in Table 12.

Table 12 — Structure of protocol object

Key	Multiplicity	Type	Description
Version	1	String	Version of the data object (and mapping rule) in this document. For the current document, this field shall have the value "1.0"
FEquipmentData	1	FEquipmentData Object	See 5.2.3
JointingData	0...*	JointingData Object	See JointingData Object
MFProtocolData	0...1	Any	Manufacturer-defined object for additional protocol information.

5.2.3 Fusion equipment data object

The Fusion equipment data object (FEquipmentData) contains device-specific information of the fusion equipment. The fusion equipment data object structure is given in Table 13.

Table 13 — Fusion equipment data object

Key	Multiplicity	Type	Description
SerialNumber	1	String<20>	Manufacturer serial number of the fusion equipment.
DeviceType	1	String<20>	The device type is a sequence of maximum 20 characters provided by the equipment manufacturer to identify the type and version of the equipment
TemperatureUnit	1	Enum	Unit used for the representation of temperatures. Defined Values: "C", "F".
MFFEquipmentData	0...1	Any	Manufacturer defined object for additional manufacturer specific device information

5.2.4 Jointing data object

The Jointing data object (Jointingdata) contains information specific to a one or more joints as performed by the fusion equipment and collected by the data retrieval system. The jointing data object structure is given in Table 14.

Table 14 — Jointing data object

Key	Multiplicity	Type	Description
JointingTime	1	TimeAndDate	Time at which jointing started
DevJointNumber	0...1	Integer	Sequential number of joint process on the fusion equipment
OperatorId	0...1	String	As per ISO 12176-3 (Barcode) or other operator identification
Contractor	0...1	String	Name of contractor or piping company
JobNumber	0...1	String	Identifier of the Job
JointNumber	1	String	Unique alphanumeric number of the joint[a]
Localization	0...1	GeoPosition	Geographic position of the jointing
InstallationHeight	0...1	Decimal	Installation depth/height in m. Negative numbers for below ground
AmbientTemperature	0...1	Decimal	Ambient temperature (Unit as per fusion equipment "TemperatureUnit")

[a] A unique joint number is essential for identifying a specific data record. A unique joint number shall be generated automatically by the fusion equipment, e.g. by a time stamp in combination with the fusion operator badge and/or the device serial number.

[b] For reasons of correct interpretation, enumeration values shall be exactly as shown in this table (capital letter at the start).

[c] Electro-fusion process.

[d] Butt fusion process.

[e] Infrared fusion process.

[f] Other jointing method.

Table 14 *(continued)*

Key	Multiplicity	Type	Description
WeatherCondition	0...*	Enum	Enum with the values[b]: Sunny Dry Rain_snowfall Wind
EnvironmentControl	0...*	Enum	Enum with the values[b]: None Screen Tent Heating
Component	0...*	ComponentData Object	First component corresponds to the component being fused
JointingStandard	0...1	String	The jointing procedures references used shall be provided as a plain text comprising (whenever and if applicable): the number part and clause of the standard or technical specification; year of publication. E.g. for electro-fusion: ISO 13950 or ISO 12176-5 (this document). E.g. for butt fusion: ISO 21307:2017, 5.2.
JointingStatus	1	Enum	Status of the jointing: NoError Fail
JointingMethod	0...1	Enum	EF[c] BF[d] IR[e] OT[f]
EFFusionData or BFFusionData or IRFusionData	0...1	EFFusionData or BFFusionData or IRFusionData	Only 1 out of the 3 keys shall be provided
MFJointingData	0...1	Any	Manufacturer-defined object for additional jointing information

[a] A unique joint number is essential for identifying a specific data record. A unique joint number shall be generated automatically by the fusion equipment, e.g. by a time stamp in combination with the fusion operator badge and/or the device serial number.

[b] For reasons of correct interpretation, enumeration values shall be exactly as shown in this table (capital letter at the start).

[c] Electro-fusion process.

[d] Butt fusion process.

[e] Infrared fusion process.

[f] Other jointing method.

5.2.5 Component data object

There is a component data object (ComponentData) for each component (fitting/pipe) processed with the fusion equipment (see 5.2.4). The component data object structure is given in Table 15.

Table 15 — Component data object

Key	Multiplicity	Type	Description
Trademark	0..1	String	See Region 1, Field n° 3
BatchNo	0..1	String	See Region 3, Field n° 1
ProductionSite	0..1	String	See Region 3, Field n° 4
SerialNo	0..1	String<25>	See Region 3, Field n° 7
Category	0..1	Enum	Category of the fitting, see Region 1, Field n° 1
ComponentType[a]	0..1	Enum	Component Type of the fitting, see Region 1, Field n° 4
Particularity[a]	0..2	Enum	Particularity of the component, see Region 1, Field n° 5.
Diameter	0..1	String	Component's diameter and units (see Region 1, Field n° 6) as shown in first column of Table 6.
Length	0..1	Decimal	Length of component (m)
SDR	0..1	Decimal<2,3>	Component's design SDR, see Region 1, Field n° 7.
Materials	0..2	Enum	Materials used for manufacture components, see Region 1, Field n°8. Encoding as in Table 7.
MFR	0..1	Enum	Encoded MFR value, see Region 3, Field n° 3. Encoding for the Enum as in Table 9.
MaterialType	0..1	Enum	Encoded type of material value (see Region 3, Field n° 4). Encoding as in Table 10.
EncodedData[b]	0..1	String	Original encoded data from the 1D- or 2D-barcode.
MFCmpData	0..1		Manufacturer-defined object for additional component data.

[a] If barcodes conforming to ISO 13950 and/or ISO 12176-4 have been used for data recording and/or welding, it is up to the manufacturer to find the best representation of the contained information from the given tables and definitions to match data with this document.

[b] This key may contain one barcode of type ISO 13950 and one barcode of type ISO 12176-4 separated by a space character (0x32).

5.2.6 Electro-fusion data object

The electro-fusion data object (EFFusionData) contains the actual protocol information of the jointing process for an electro-fusion fitting (see 5.2.4). The electro-fusion data object structure is given in Table 16.

Table 16 — Electro-fusion data object

Key	Multiplicity	Type	Description
OperatingMode	1	Enum	Enum with the values[a]: Barcode 2D-Code Manual Automatic Preset Other
NomResistance	0...1	Decimal	Component's nominal resistance in Ohm
FusionPhases	1...*	FusionPhase object	FusionPhase Object

[a] For reasons of correct interpretation, enumeration values shall be exactly as shown in this table (capital letter at the start).

5.2.7 Fusion phase object

The fusion phase object (FusionPhase) contains single fusion phase information (see 5.2.6). The fusion phase object structure is given in Table 17.

Table 17 — Fusion phase object

Key	Multiplicity	Type	Description
RegulationType	1	Enum	Type of regulation, encoded according to A.2.1, Table A.4
Resistance	1	Decimal	Measured resistance
NomRegLevel	0...1	Decimal	Nominal level of regulation
MeasRegLevel	1	Decimal	Measured level of regulation
GvnTmOrEnergy	1	Decimal	Target heating time or energy
MeasTmOrEnergy	1	Decimal	Reached heating time or energy
MsgCode	1	Enum	Message code, for encoding see Table B.1
MFFusionPhase	0...1		Manufacturer defined object for additional fusion phase data

Depending on the type of regulation, the measurements in the object represent different physical dimensions. The units to be used are given in Table 18.

Table 18 — Units to be used in the fusion phase object

Dimension	Unit
Voltage	V (Volt)
Time	s (Second)
Current	A (Ampere)
Power	W (Watt)
Energy	kJ (Kilojoule)
Resistance	Ω (Ohm)

5.2.8 Butt fusion data object

The butt fusion data object (BFFusionData) contains the actual protocol information of the butt fusion jointing process (see 5.2.4).

NOTE 1 See ISO 21307 for further information on terms used in relation to the butt fusion data object.

NOTE 2 Most of the national specifications for butt fusion follow prescriptions in ISO 21307.

The values shall not carry any unit. The values refer to the unit given in Table 19.

Table 19 — Units for butt fusion

Information	Unit
Pressure	bar (bar)
Force	newton (N)
Piston area	square millimeter (mm^2)
Pipe face area	square millimeter (mm^2)
Bead-up size	millimeter (mm)
Heat soak time	second (s)
Heater plate removal time	second (s)
Time to achieve fusion jointing pressure	second (s)
Fusion jointing time	second (s)
Cooling time	minute (min)
Heater plate temperature	Unit as per fusion equipment "TemperatureUnit"

The structure of the butt fusion object (BFFusionData) is given in Table 20.

Table 20 — Butt fusion data object

Key	Multiplicity	Type	Description
BFStandard	1	String	Butt fusion standard applied (e.g. ISO 21307)
ControlType	1	Enum	Enum with the values: N – force control (electric, etc.) or P – pressure control (hydraulic ram)
PistonArea	0…1	Integer	Piston area in mm^2
FusionFaceArea	0…1	Integer	Fusion face area in mm^2
DragPressure	1	Decimal	Drag pressure (force)
NomHeatPlateTmp	1	Decimal	Nominal heater plate temperature
MaxHeatPlateTmp	1	Decimal	Real maximum heater plate temperature (during the bead-up and heat soak time)
MinHeatPlateTmp	1	Decimal	Real minimum heater plate temperature (during the bead-up and heat soak time)
NomBeadUpP	1	Decimal	Nominal bead-up/fusion pressure incl. drag pressure (force)
MaxBeadUpP	1	Decimal	Real maximum bead-up pressure (force)
MinBeadUpP	1	Decimal	Real minimum bead-up pressure (force)
MaxHeatSoakP	1	Decimal	Real maximum heat soak pressure (force)
MinHeatSoakP	1	Decimal	Real minimum heat soak pressure (force)

Table 20 *(continued)*

Key	Multiplicity	Type	Description
MinTrgtBeadUpSize	0...1	Decimal	Minimum target bead-up size for single (or dual) low pressure fusion jointing or Minimum target bead-up size after heating for single high-pressure fusion jointing
MinHeatSoakTime	1	Integer	Minimum heat soak time
HeatSoakTime	1	Integer	Real heat soak time
MaxHPRemovalTime	1	Integer	Maximum heater plate removal time
HPRemovalTime	1	Integer	Real heater plate removal time
MaxFusJntPTime	1	Integer	Maximum time to achieve fusion jointing pressure (force)
FusJntPTime	1	Integer	Real time to achieve fusion jointing pressure (force)
NomFusJntP	1	Decimal	Nominal fusion jointing pressure (force)
MinFusJntP	1	Decimal	Real min. fusion jointing pressure (force)
MaxFusJntP	1	Decimal	Real max. fusion jointing pressure (force)
NomFusJntTmDualLP	0...1	Integer	Fusion jointing time for dual low-pressure procedure
FusJntTmDualLP	0...1	Integer	Real fusion jointing time for dual low-pressure procedure
NomCoolingTm1	1	Integer	Nominal cooling time 1 [e.g. cooling cycle with reduced pressure (force) for dual low-pressure procedure]
CoolingTm1	1	Integer	Real cooling time 1 [e.g. cooling cycle with reduced pressure (force) for dual low-pressure procedure]
NomFusJntP2	0...1	Decimal	Nominal fusion jointing pressure (force) 2
MinFusJntP2	0...1	Decimal	Real minimum fusion jointing pressure (force) 2
MaxFusJntP2	0...1	Decimal	Real maximum fusion jointing pressure (force) 2
NomCoolingTm2	0...1	Integer	Nominal cooling time 2 [e.g.: minimum cooling time in the machine under pressure (force)]
CoolingTm2	0...1	Integer	Real cooling time 2 [e.g.: minimum cooling time in the machine under pressure (force)]
MsgCode	1	String	Message code, see B.2

5.2.9 Infrared butt fusion data object

The infrared butt fusion data object (IRFusionData) contains the actual protocol information of the infrared butt fusion jointing process (see 5.2.4).

The values do not carry any unit. The values are referring to the unit given in Table 21.

Table 21 — Units for infrared butt fusion process

Information	Unit
Element face area	square millimeter (mm^2)
Facing measure	millimeter (mm)

Table 21 *(continued)*

Information	Unit
Facing position	millimeter (mm)
Component temperature	Unit as per fusion equipment "TemperatureUnit"
Heater plate temperature	Unit as per fusion equipment "TemperatureUnit"
Heating time	second (s)
Heater plate removal time	second (s)
Overlap distance	millimeter (mm)
Fusion force	newton (N)
Cooling time	minute (min)

The structure of the infrared butt fusion object (IRFFusionData) is given in Table 22.

Table 22 — Infrared butt fusion object

Key	Multiplicity	Type	Description
IRStandard	1	String	Infrared fusion standard applied
PipeFaceArea	0...1	Integer	Pipe face area in mm^2
CompTmp	1	Decimal	Real component temperature
RefacingNo	1	Integer	Number of re-facings
FacingLeft	0...1	Decimal	Real facing on left side
FacingRight	0...1	Decimal	Real facing on right side
NomFacingPos	1	Decimal	Nominal facing position
FacingPos	1	Decimal	Real facing position
NomHeaterTmp	1	Decimal	Nominal heater element temperature
HeaterTmp	1	Decimal	Real heater element temperature
NomHeatingTm	1	Integer	Nominal heating time
HeatingTm	1	Integer	Real heating time
MaxHeatPlateRemTm	1	Integer	Maximum heater plate removal time
HeatPlateRemTm	1	Integer	Real heater plate removal time
NomOverleapDist[a]	0...1	Decimal	Nominal overlap distance
OverLeapDist[a]	0...1	Decimal	Real overlap distance
NomFusionForce[a]	0...1	Decimal	Nominal fusion force
FusionForce[a]	0...1	Decimal	Real fusion force
NomCoolingTm	1	Integer	Nominal cooling time
CoolingTm	1	Integer	Real cooling time
MsgCode	1	String	Message code (see B.3)

[a] Either overlapping distance fields or force fields shall be included in the object.

5.3 Mapping data retrieving model to JSON

Any fusion equipment implementing this document shall provide protocol files matching the mapping to JSON described in this subclause.

All objects from the data model are directly mapped to JSON objects with the same name. The data types are mapped using standard JSON data types. Table 23 provides data type for mapping to JSON.

Table 23 — Data type for mapping to JSON

Type	JSON Type
Decimal<n,m>	Number
Integer<n>	Number
String<n>	String with max length
String	String
Enum	Number or string with restriction to enum
TimeAndDate	String with format date
Date	String with format date
GeoPosition	Object with longitude, latitude and altitude as numbers

For the complete definition of the JSON Mapping, see Annex C.

5.4 Mapping data retrieval model to CSV

5.4.1 General

The fusion equipment may implement data export in CSV (comma separated value) format. For each type of fusion method (EF, BF or IR) a separate file shall be exported.

The CSV-file shall meet the definitions in subclause 5.4.

5.4.2 CSV-file format and data type representation

The format of the CSV file shall comply to the following rules:

— Each character in the CSV file shall be encoded in UTF-8 as per ISO/IEC 10646.

— Each record is located in a separate line, delimited by the line break CRLF (hexadecimal character codes: 0d and 0a).

— The last record in the file may or may not have an ending line break.

— The first line of CSV file shall hold a header with the column keys (see 5.4.3). The header file shall have the same number of fields as each record in the rest of the file.

— Within the header and each record, there may be one or more field, separated by commas (hexadecimal character codes: 2C). Each line should contain the same number of fields throughout the file. The last field in the record must not be followed by a comma.

— The value of each field shall be enclosed by double quotation marks (hexadecimal character code: 22), for example “12345”. An empty field is represented by two double quotation marks: “”.

The CSV file shall use the same representation of the different data types as described for JSON in Table 23 and ISO/IEC 21778, but UTF-16 character encoding shall be transferred to UTF-8 character encoding.

For data from the following fields, the selected enumerations shall be listed in a string separated by a slash character (hexadecimal character code: 2F):

— WeatherCondition;

— EnviromentControl.

5.4.3 Header names, keys and order of fields

As header names for the CSV, the keys from the data model are used. Annex D provides examples of named headers. The fields in the header and in each record shall be lined up in the order of the objects as given in Tables 24, 25, 26, 27 and according to their position in the referenced table.

The key names of the objects shall be omitted since CSV is a serialized record set.

Header keys shall be unique. For multiple objects and fields (e.g. in Component Data) the keys shall be expanded by an underline character (hexadecimal character code: 5F) followed by a number, as given in Tables 24, 25, 26 and 27.

EXAMPLE 1 SerlialNo_0: Serial number of component 0

In case of electro-fusion, the header and each record shall include all fields of the welding procedure with the largest number of fusion phase.

EXAMPLE 2 All procedures have only one phase: Use fusion phase object 0 for all records

EXAMPLE 3 One procedure has 3 phases: Use fusion phase object 0,1,2 for all records

Component data objects shall not be omitted if empty. In case of electro-fusion, component data object 0 shall contain the fitting data.

For the complete header definition of the CSV Mapping, see Annex D.

Table 24 — Order of object for other jointing methods

Object	Number	Reference	Keys to omit
Protocol object		Table 12	FEquipmentData, JointingData
Fusion equipment data object		Table 13	
Component data object	0	Table 15	
Component data object	1	Table 15	
Component data object	2	Table 15	
Component data object	3	Table 15	
Jointing data object		Table 14	FittingComponent, PipeComponent, EFFusion-Data, BFFusionData, IRFusionData

Table 25 — Order of object for electro-fusion

Object	Number	Reference	Keys to omit
Protocol object		Table 12	FEquipmentData, JointingData
Fusion equipment data object		Table 13	
Component data object	0	Table 15	
Component data object	1	Table 15	
Component data object	2	Table 15	
Component data object	3	Table 15	
Jointing data object		Table 14	FittingComponent, PipeComponent, EFFusion-Data, BFFusionData, IRFusionData
Electro-fusion data object		Table 16	FusionPhases
Fusion phase object	0	Table 17	
Fusion phase object	1	Table 17	
Fusion phase object	2	Table 17	
Fusion phase object	3	Table 17	
Fusion phase object	4	Table 17	

Table 25 *(continued)*

Object	Number	Reference	Keys to omit
Fusion phase object	5	Table 17	
Fusion phase object	6	Table 17	
Fusion phase object	7	Table 17	
Fusion phase object	8	Table 17	

Table 26 — Order of object for butt fusion

Object	Number	Reference	Keys to omit
Protocol object		Table 12	FEquipmentData, JointingData
Fusion equipment data object		Table 13	
Component data object	0	Table 15	
Component data object	1	Table 15	
Component data object	2	Table 15	
Component data object	3	Table 15	
Jointing data object		Table 14	FittingComponent, PipeComponent, EFFusion-Data, BFFusionData, IRFusionData
Butt fusion data object		Table 20	

Table 27 — Order of object for infrared butt fusion

Object	Number	Reference	Keys to omit
Protocol object		Table 12	FEquipmentData, JointingData
Fusion equipment data object		Table 13	
Component data object	0	Table 15	
Component data object	1	Table 15	
Component data object	2	Table 15	
Component data object	3	Table 15	
Jointing data object		Table 14	FittingComponent, PipeComponent, EFFusion-Data, BFFusionData, IRFusionData
Butt fusion data object		Table 20	
Infrared butt fusion object		Table 22	
Electro-fusion data object		Table 16	

5.5 Mapping data retrieval model to other formats

Since the mapping to JSON is a modern compatible format for data exchange, this document doesn't provide any specification for other formats like XML, etc. The fusion equipment manufacturer may supply equipment provided with any data export format.

Annex A
(normative)

Electro-fusion process information

A.1 Structure of the coding

A.1.1 Introduction

The structure of coding of the electro-fusion process information supports multilevel fusion (see 3.1.8).

Region 2 (see 4.2.3) is composed in a field. This in turn is structured into several sub-fields separated by "~". The number of sub-fields depends on the number of fusion phases (hereafter referred as "n") defined in sub-field 1. An overview of the structure is given in Table A.1:

Table A.1 — Structure of the coding region 2 (see 4.2.3)

Sub-field 1	Sub-field 2	Sub-field 3	...	Sub-field n+2	Sub-field n+3
Number of fusion phases	Resistance information	Fusion phase information 1	...	Fusion phase information n	Cooling time information
n~	xxxxxx~	xxxxxxxxxxx~	...	zzzzzzzzzzz~	yyy]

A.1.2 Sub-field 1

This sub-field defines the number of fusion phases. Only characters representing integer numbers from 1 to 9 are allowed.

Two characters including the separator "~" are used.

A.1.3 Sub-field 2

A.1.3.1 General

This sub-field defines the nominal resistance of the heating elements including the tolerances. Subclauses A.1.3.2 to A.1.3.4 shall be used to complete sub-field 2.

Seven characters including the separator "~" are used.

A.1.3.2 Characters 1, 2,3 and 4: Value of nominal resistance

Characters 1, 2, 3 and 4 express the value of the nominal resistance of the heating element including exactly one decimal dot "." at any position.

EXAMPLE 1 For a value of 1,20 Ohm, the data in the code is 1.20

EXAMPLE 2 For a value of 0,12 Ohm the data in the code is 0.12

EXAMPLE 3 For a value of 0,123 Ohm the data in the code is .123

EXAMPLE 4 For a value of 12,0 Ohm the data in the code is 12.0

EXAMPLE 5 For a value of 120 Ohm the data in the code is 120.

Code 0000 or any zero-value coding indicate that the value of the resistance of the heating element is not determined.

EXAMPLE 6 000.

EXAMPLE 7 0.00

EXAMPLE 8 00.0

A.1.3.3 Character 5: Tolerance on value of nominal resistance

Character 5 expresses the tolerance of the value of the nominal resistance; the code shall be in accordance with Table A.2.

Table A.2 — Character code related to tolerance on nominal resistance

Tolerance (±, %)	Character code
2,5	0
5	1
6	2
7	3
7,5	4
8	5
10	6
12	7
15	8
19	9
20	A
24	B
30	C

A.1.3.4 Character 6: Variation of nominal resistance

Character 6 expresses the temperature coefficient α of the resistance of the heating element at 20 °C (see A.1.2.1) in units of 10^{-3} Ω / °C. The code shall be in accordance with Table A.3.

Table A.3 — Code for the variation α of the nominal resistance

α	Code
0	0
$0 < \alpha \leq 0,5$	1
$0,5 < \alpha \leq 1$	2
$1 < \alpha \leq 1,4$	3
$1,4 < \alpha \leq 1,8$	4
$1,8 < \alpha \leq 2,4$	5
$2,4 < \alpha \leq 3,2$	6
$3,2 < \alpha \leq 4$	7
$4 < \alpha \leq 5$	8
$5 < \alpha \leq 6$	9
$0 < \alpha \leq 1$	A
$1 < \alpha \leq 4$	B

Table A.3 *(continued)*

α	Code
$4 < \alpha \leq 6$	C

NOTE It is possible that the use of the electrical parameters will be the subject of the next revision of ISO 12176-2.

A.1.4 Sub-field from 3 to n+2

The quantity of these sub-fields depends on the value expressed in sub-field 1. For each fusion phase defined in sub-field 1, a sub-field containing the fusion phase information shall be provided.

For each fusion phase information sub-field, a set of 12 characters including the separator "~" is used.

Each character is assigned to a specific element of information as given in A.2.

A.1.5 Sub-field no. n+3

This sub-field shall contain data for the cooling time expressed in minutes. A minimum of one and a maximum of four characters including the field delimiter "]" shall be used. In case no cooling time is defined only the field delimiter "]" is used.

EXAMPLE 1

One fusion phase and no cooling time given (ref. A.3.2): 1~1.2080~140.0020033~]

EXAMPLE 2

One fusion phase and cooling time given (ref. A.3.2): 1~0.85C0~140.0012054~30]

EXAMPLE 3

Multilevel fusion phases (3) and cooling time given (ref. A.3.2): 3~1.2016~120.0036054~10000060054~140.00 60054~120]

A.2 Fusion phase information

A.2.1 General

The fusion phase information (see Table A.1, sub field 3 and n+2) consists of 12 characters including the delimiter "~". Each character is assigned to a specific information.

A.2.2 Character 1: Type of regulation

Character 1 selects the type of regulation. The coding character shall be in accordance with Table A.4.

Table A.4 — Type of regulation and character code

Type of regulation	Code
Mode U-t: voltage regulation with heating time	1
Mode I-t: current intensity regulation with heating time	2
Mode U-E: voltage regulation with heating energy	3
Mode I-E: current intensity regulation with heating energy	4
Mode P-t: power regulation with heating time.	5
Mode P-E: power regulation with heating energy.	6

EXAMPLE Mode U-t means that the voltage is regulated on a constant level as given in characters 2, 3, 4 and 5 (level of regulation) until the heating time given in characters 6 to 9 (heating time/energy) is reached.

Attention is drawn to electrofusion fittings manufacturers to use code 1, and to the fact that in the future “Mode I-t” and “Mode I-E” might be removed from the product standards.

A.2.3 Characters 2, 3, 4 and 5: Level of regulation

A.2.3.1 Principle

Characters 2, 3, 4 and 5 express the set-point of the regulation selected by character 1.

A.2.3.2 Mode U-t and U-E

The characters express directly the value of the nominal fusion voltage in volts including exactly one decimal dot “.” at any position.

EXAMPLE 1 For a value of 40,0 V the data in the code is 40.0

EXAMPLE 2 For a value of 24,6 V the data in the code is 24.6

EXAMPLE 3 For a value of 120,0 V the data in the code is 120.

EXAMPLE 4 For a value of 8,0 V the data in the code is 08.0

Any zero-value coding is a code indicating a heat soak phase, in which, for a certain time, no power is supplied to the heating element. This mode shall be used only in regulations types with heating time indication (character 1 of code: 1, 2 or 5).

EXAMPLE 5 0000

EXAMPLE 6 0.00

EXAMPLE 7 00.0

EXAMPLE 8 000.

A.2.3.3 Mode I-t and I-E

Code 0001 to 0900 express directly the value of the intensity in ampere selected and kept constant during the heating cycle.

EXAMPLE For a value of 12 Ampere the data in the code is 0012

A.2.3.4 Mode P-t and P-E

The characters express directly the value of the nominal fusion power in Kilowatts exactly including one decimal dot “.” at any position.

EXAMPLE 1 For a value of 150 W the data in the code is 0.15

EXAMPLE 2 For a value of 1,55 kW the data in the code is 1.55

EXAMPLE 3 For a value of 12,1 kW the data in the code is 12.1

EXAMPLE 4 For a value of 1,0 kW the data in the code is 01.0

Any zero-value coding is a code indicating a heat soak phase, in which, for a certain time, no power is supplied to the heating element. This mode shall be used only in regulations types with heating time indication (character 1 of code: 1,2 or 5).

EXAMPLE 5 0000

EXAMPLE 6 0.00

EXAMPLE 7 00.0

EXAMPLE 8 000.

A.2.4 Characters 6, 7, 8 and 9: Nominal target heating time or nominal target energy

A.2.4.1 General

According to A.2.2, character 1 (type of regulation), the digits 6 to 9 express the nominal target heating time or the nominal target heating energy.

A.2.4.2 Nominal target heating time

If the target value is defined as heating time (character 1 of code: 1, 2 or 5), digits 6 to 9 directly express the heating time in the range of 0001 to 9999 seconds.

The nominal target heating time shall be corrected to the actual target heating time according to the ambient temperature at the time of installation as indicated by the characters 10 and 11.

A.2.4.3 Nominal target heating energy

If the target value is defined as heating energy (character 1 of code: 3, 4 or 6), characters 6 to 9 express the heating energy in the format (character 6, character 7, character 8) × 10 ^ [character 9] Joules.

The nominal target heating energy shall be corrected to the actual target heating energy according to the ambient temperature at the time of installation as indicated by the characters 10 and 11.

A.2.5 Characters 10 and 11: Heating time or heating energy correction

Characters 10 and 11 are used to calculate the actual target heating time or actual target heating energy in conjunction with the ambient temperature.

Actual target heating time or actual target heating energy, is calculated as follows:

— below and equal to 20 °C the following formula applies:

  — actual target value = Nominal Target value x [1+(0.001 x character_10 x (20 °C – ambient temperature))]

— above 20 °C the following formula applies:

  — actual target value = Nominal Target value x [1+(0.001 x character_11 x (20 °C – ambient temperature))]

NOTE It is possible that the clarification of these parameters will be the subject of a future revision of ISO 12176-2.

A.3 Coding examples

A.3.1 Introduction

The following coding examples clarify how to encode only fusion process data referring to subclauses A.1 and A.2. To obtain a complete two-dimensional code, regions 0, 1, 3 and 4 are required to be added.

A.3.2 Process information encoding of examples from ISO 13950:2007, A.10

The code example from ISO 13950:2007, Table A.17 is: 3102030411034012052003334. The fusion process information here encoded can be given as per Table A.5.

The following data are considered:

— one phase electro-fusion process

— coil resistance of 1,2 Ω

— possible variation of 15 % (standard correction)

— fusion voltage 40 V

— fusion time 200 s

— energy correction coefficients above and below 20 °C of 0,3 % per degree Celsius of difference

The resulting string of data is: 1~1.2080~140.0020033~].

Table A.5 — Reference to ISO 13950:2007, Table A.17

Sub-field n°	Information	Character code	Meaning	Digit
1	Number of fusion phases	1	One fusion phase	1
	Separator	~	Sub-field separator	2
2	Value of nominal resistance	1	1,20 Ω (alternative coding: 1.20 or 01.2)	1
		.		2
		2		3
		0		4
	Tolerance on value of nominal resistance	8	±15 %	5
	Variation of nominal resistance	0	Not specified in code example	6
	Separator	~	Sub-field separator	7
3	Type of regulation	1	Mode U-t: Voltage regulation with heating time	1
	Level of regulation (U or I)	4	40 V (alternative coding: 40.0 or 040.)	2
		0		3
		.		4
		0		5
	Heating time / energy	0	200 s	6
		2		7
		0		8
		0		9
	Heating time / heating energy correction	3	+0,3 %/ °C below 20 °C	10
	Heating time / heating energy correction	3	−0,3 %/ °C above 20 °C	11
	Separator	~	Sub-field separator	12
4	Cooling time		No cooling time	
	Delimiter	]	Field end marker	1

The code example from ISO 13950:2007, Table A.18 is: 9301023425334008581205 46. The fusion process information here encoded can be given as per Table A.6.

The following data are considered:

— one phase electro-fusion process

— coil resistance of 0.85 Ω

— possible variation of 30 % (standard correction)

— fusion voltage 40 V

— fusion time 120 s

— energy correction coefficients of 0,5 % per degree Celsius of difference below 20 °C and 0,4 % per degree Celsius of difference above 20 °C

— cooling time of 30 min

The resulting string of data is: 1~0.85C0~140.0012054~30].

Table A.6 — Reference to ISO 13950:2007, Table A.18

Sub-field n°	Information	Character code	Meaning	Digit
1	Number of fusion phases	1	One fusion phase	1
	Separator	~	Sub-field separator	2
2	Value of nominal resistance	0	0,85 Ω (alternative coding: 0.85 or .850)	1
		.		2
		8		3
		5		4
	Tolerance on value of nominal resistance	C	±30 %	5
	Variation of nominal resistance	0	Not specified in code example	6
	Separator	~	Sub-field separator	7
3	Type of regulation	1	Mode U-t: Voltage regulation with heating time	1
	Level of regulation (U or I)	4	40 V (alternative coding: 40.0 or 040.	2
		0		3
		.		4
		0		5
	Heating time / energy	0	120 s	6
		1		7
		2		8
		0		9
	Heating time / heating energy correction	5	+0,5 %/°C below 20 °C	10
	Heating time / heating energy correction	4	−0,4 %/ °C above 20 °C	11
	Separator	~	Sub-field separator	12
4	Cooling time	3	30 min	1
		0		2
	Delimiter	]	Field end marker	3

A.3.3 Example for multilevel fusion

In Table A.7 an example is given showing the encoding of a multilevel fusion with pre-heating, heat-soak and fusion phases: 3~1.2016~120.0036054~10000060054~140.0060054~120].

Table A.7 — Example of encoding multilevel fusion

Sub-field n°	Information	Character code	Meaning	Digit
1	Number of fusion phases	3	3 fusion phases	1
	Separator	~	Sub-field separator	2
2	Value of nominal resistance	1	1,20 Ω (alternative coding: 1.20 or 01.2)	1
		.		2
		2		3
		0		4
	Tolerance on value of nominal resistance	1	±5 %	5
	Variation of nominal resistance	6	Between $2,4 \times 10^{-3}$ Ω / °C and $3,2 \times 10^{-3}$ Ω / °C	6
	Separator	~	Sub-field separator	7
Pre-heating phase				
3	Type of regulation	1	Mode U-t: Voltage regulation with heating time	1
	Level of regulation (U or I)	2	20 V (alternative coding: 20.0 or 020.)	2
		0		3
		.		4
		0		5
	Heating time / energy	0	360 s	6
		3		7
		6		8
		0		9
	Heating time / heating energy correction	5	+0,5 %/ °C below 20 °C	10
	Heating time / heating energy correction	4	−0,4 %/ °C above 20 °C	11
	Separator	~	Sub-field separator	12
Heat-soak phase				
4	Type of regulation	1	Mode U-t: Voltage regulation with heating time	1
	Level of regulation (U or I)	0	No power distribution (alternative coding: 0000, .000, 0.00, 00.0 or 000.)	2
		0		3
		0		4
		0		5
	Heating time / Energy	0	600 s	6
		6		7
		0		8
		0		9
	Heating time / heating energy correction	5	+0,5 %/ °C below 20 °C	10
	Heating time / heating energy correction	4	−0,4 %/ °C above 20 °C	11
	Separator	~	Sub-field separator	12
Fusion phase				

Table A.7 *(continued)*

Sub-field n°	Information	Character code	Meaning	Digit
5	Type of regulation	1	Mode U-t: Voltage regulation with heating time	1
	Level of regulation (U or I)	4	40 V (alternative coding: 40.0 or 040.	2
		0		3
		.		4
		0		5
	Heating time / energy	0	600 s	6
		6		7
		0		8
		0		9
	Heating time / heating energy correction	5	+0,5 %/ °C below 20 °C	10
	Heating time / heating energy correction	4	−0,4 %/ °C above 20 °C	11
	Separator	~	Sub-field separator	12
Cooling phase				
6	Cooling time	1	120 min	1
		2		2
		0		3
	Delimiter	]	Field end marker	4

Annex B
(normative)

Message codes for data retrieval

B.1 Message codes for electro-fusion

The message codes for electro-fusion are given in Table B.1.

Table B.1 — Message codes for electro-fusion

Message code	Description	Details
M00	Success	Fusion phase completed without electrical error
M01	Not started	Not started due to error in previous phase
M02	Resistance error	Resistance out of tolerances
M03	Input voltage too low	
M04	Input voltage too high	
M05	Input voltage error	Input voltage out of tolerance
M06	Input power interrupted	
M07	Heating coil short circuit	
M08	Output short circuit	
M09	Output circuit interrupted	
M10	Output voltage error	Instable output voltage
M11	Output power required too high	
M12	Output power too low	
M13	Emergency stop	Stopped by operator
M14	Controller overheated	
M15	Heating coil interrupted	
M16	Frequency out of range	
M17	System error	
M18[a]	Generator not suitable	
M99	Controller specific message	Message description not listed in this table
[a] Between M19 and M98 the control unit manufacturer may communicate messages not listed in this table.		

B.2 Message codes for butt fusion

The message codes are according to Table B.2 in combination with the fusion phases identified as per Table B.3. The two codes will be separated by the "*" character, e.g. M23*PH1.

For M00 (success) no fusion phase will be combined.

Table B.2 — Message code

Message code	Description	Details
M00	Success	Fusion phase completed without error
[a] Between M33 and M98 the control unit manufacturer may communicate messages not listed in this table.		

Table B.2 *(continued)*

Message code	Description	Details
M03	Input voltage too low	
M04	Input voltage too high	
M05	Input voltage error	Input voltage out of tolerance
M06	Input power interrupted	
M13	Emergency stop	Stopped by operator
M20	Heater plate temperature too low	
M21	Heater plate temperature too high	
M22	Heater plate temperature error	
M23	Pressure/force too low	
M24	Pressure/force too high	
M25	Pressure/force error	
M26	Machine does not open carriages	
M27	Machine does not close carriages	
M28	Displacement error	From displacement sensor
M29	Time overflow	
M30	Heater plate not removed	
M31	Pipe slipping in clamps	
M32[a]	Fusion interrupted by operator	
M99	Device specific message	Message description not listed in this table

[a] Between M33 and M98 the control unit manufacturer may communicate messages not listed in this table.

Table B.3 — Fusion phases

Phase Code	Phase
PH1	Bead-up phase
PH2	Heat soak phase
PH3	Heater plate removal phase
PH4	Fusion pressure build-up phase
PH5	Fusion jointing phase
PH6	Cooling phase 1 in machine under pressure
PH7	Cooling phase 2 in machine under pressure

B.3 Message codes for infrared butt fusion

The message codes are according to Table B.4 in combination with the fusion phases identified as per Table B.5. The two codes will be separated by the "*" character, e.g.: M23*PH2.

For M00 (success), no fusion phase will be combined.

Table B.4 — Message code

Message code	Description	Details
M00	Success	Fusion phase completed without error
M03	Input voltage too low	
M04	Input voltage too high	

[a] Between M42 and M98 the control unit manufacturer may communicate messages not listed in this table.

Table B.4 *(continued)*

Message code	Description	Details
M05	Input voltage error	Input voltage out of tolerance
M06	Input power interrupted	
M13	Emergency stop	Stopped by operator
M20	Heater plate temperature too low	
M21	Heater plate temperature too high	
M22	Heater plate temperature error	
M23	Force too low	
M24	Force too high	
M25	Force error	
M26	Machine does not open carriages	
M27	Machine does not close carriages	
M28	Displacement Error	From displacement sensor
M29	Time overflow	
M30	Heater plate not removed	
M31	Pipe slipping in clamps	
M32	Component removed	
M33	Incorrect facing	
M34	Fusion process confirmed	
M35	Ambient temperature too high	
M36	Ambient temperature too low	
M37	Component temperature too high	
M38	Component temperature too low	
M39	Fusion process interrupted	
M40	Overlap distance too high	
M41[a]	Overlap distance too low	
M99	Device specific message	Message description not listed in this table

[a] Between M42 and M98 the control unit manufacturer may communicate messages not listed in this table.

Table B.5 — Fusion phases

Phase Code	Phase
PH2	Heating phase
PH3	Heater plate removal phase
PH4	Fusion force build-up phase
PH5	Fusion jointing phase
PH6	Cooling phase in machine under pressure

Annex C
(informative)

JSON mapping of Data Retrieval System

C.1 JSON schema for mapping of fusion equipment data model

The following JSON-Schema maps the data models (electro-fusion, butt and IR fusion) of the data retrieval model to JSON.

NOTE 1 The schema is based on "JSON Schema Draft 2019-09" as released on https://json-schema.org/draft/2019-09/json-schema-core.html

For JSON-Files produced by fusion equipment, implementing the data retrieval system according Clause 5, it is recommended to validate successfully against the following schema.

NOTE 2 The https://www.jsonschemavalidator.net/ offers an online, interactive JSON Schema validator.

Schema

```
{
    "$schema": "https://json-schema.org/draft/2019-09/schema",
    "description": "A Schema validating JSON data retrieval according ISO12176-5",
    "type": "object",
    "properties": {
      "Protocol": {
        "$ref": "#/$defs/Protocol"
      },
      "additionalProperties": false
    },
    "$defs": {
      "Protocol": {
        "type": "object",
        "properties": {
          "Version": {
            "type": "string",
            "enum": [
              "1.0"
            ]
          },
          "FEquipment": {
            "$ref": "#/$defs/FEquipmentData"
          },
          "Jointings": {
            "type": "array",
            "items": {
              "$ref": "#/$defs/JointingData"
            }
          },
          "MFProtocol": {
            "type": "object"
          }
        },
        "additionalProperties": false,
        "required": [
          "Version",
          "FEquipment",
          "Jointings"
        ]
      },
      "FEquipmentData": {
       "type": "object",
```

```
    "properties": {
     "SerialNumber": {
      "type": "string",
      "maxLength": 20
     },
     "DeviceType": {
      "type": "string",
      "maxLength": 20
     },
     "TemperatureUnit": {
      "type": "string",
      "enum": [
       "C",
       "F"
      ]
     },
     "MFEquipment": {
      "type": "object",
      "additionalProperties": true
     }
    },
    "additionalProperties":false,
    "required": [
     "SerialNumber",
     "DeviceType",
     "TemperatureUnit"
    ]
  },
  "JointingData": {
   "type": "object",
   "properties": {
    "JointingTime": {
     "type": "string",
     "format": "date-time"
    },
    "DevJointNumber": {
     "type": "integer",
     "minimum": 0
    },
    "OperatorId": {
     "type": "string",
     "maxLength": 30
    },
    "Contractor": {
     "type": "string",
     "maxLength": 255
    },
    "JobNumber": {
     "type": "string"
    },
    "JointNumber": {
     "type": "string"
    },
    "Localization": {
     "$ref": "#/$defs/GeoPosition"
    },
    "InstallationHeight": {
     "type": "number"
    },
    "AmbientTemperature": {
     "type": "number"
    },
    "WeatherCondition": {
     "type": "array",
     "items": {
      "$ref": "#/$defs/WeatherCondition"
     }
    },
    "EnvironmentControl": {
     "type": "array",
     "items": {
```

```
      "$ref": "#/$defs/EnvironmentControl"
     }
    },
    "Component": {
     "type": "array",
     "items": {
      "$ref": "#/$defs/ComponentData"
     },
     "minOccurences": 1
    },
    "JointingStandard": {
     "type": "string"
    },
    "JointingStatus": {
     "type": "string",
     "enum": [
      "NoError",
      "Fail"
     ]
    },
    "JointingMethod": {
     "type": "string",
     "enum": [
      "EF",
      "BF",
      "IR",
      "OT"
     ]
    },
    "FusionData": {
     "$ref": "#/$defs/FusionData"
    },
    "MFJointingData": {
     "type": "object",
     "additionalProperties": true
    }
   },
   "additionalProperties": false,
   "required": [
    "JointingTime",
    "JointNumber",
    "JointingStatus"
   ]
  },
  "ComponentData": {
   "type": "object",
   "properties": {
    "Trademark": {
     "type": "string"
    },
    "BatchNo": {
     "type": "string"
    },
    "ProductionSite": {
     "type": "string"
    },
    "SerialNo": {
     "type": "string",
     "maxLength": 25
    },
    "Category": {
     "type": "string",
     "enum": [
      "0",
      "1",
      "2",
      "3"
     ]
    },
    "ComponentType": {
     "type": "string",
```

```
 "enum": [
  "00",
  "01",
  "02",
  "03",
  "04",
  "05",
  "06",
  "07",
  "08",
  "09",
  "10",
  "11",
  "12",
  "13",
  "14",
  "15",
  "16",
  "17",
  "18",
  "19",
  "20",
  "21",
  "22",
  "23",
  "24",
  "25",
  "26",
  "27",
  "28",
  "29",
  "30",
  "31",
  "32",
  "33",
  "34",
  "35"
 ]
},

"Particularity":{
 "type": "array",
 "items": {
  "type": "string",
  "enum": [
   "0",
   "1",
   "2",
   "3",
   "4",
   "A",
   "B",
   "C",
   "D"
  ]
 }
},
"Diameter": {
 "type": "string"
},
"Length": {
 "type": "number"
},
"SDR": {
 "type": "number"
},
"Materials": {
 "type": "array",
 "items":{
  "type": "string",
  "enum": [
```

```
        "00",
        "11",
        "12",
        "13",
        "14",
        "15",
        "31",
        "32",
        "33",
        "34",
        "51",
        "52",
        "61",
        "62",
        "63",
        "64"
       ]
      }
     },
     "MFR": {
      "type": "string",
      "enum": [
       "0",
       "1",
       "2",
       "3",
       "4",
       "5",
       "6",
       "7",
       "8",
       "9"
      ]
     },
     "MaterialType": {
      "type": "string",
      "enum": [
       "0",
       "1",
       "2",
       "3",
       "4",
       "5",
       "6",
       "7",
       "8",
       "9"
      ]
     },
     "EncodedData": {
      "type": "string"
     },
      "MFCmpData": {
       "type": "object",
       "additionalProperties": true
      }
     },
     "additionalProperties": false
    },
    "GeoPosition": {
     "type": "object",
     "properties": {
      "Longitude": {
       "type": "number",
       "min": -180,
       "max": 180
      },
      "Latitude": {
        "type": "number",
        "min": -90,
        "max": 90
```

```
    },
    "Altitude": {
     "type": "number"
    }
   },
   "required": [
    "Longitude",
    "Latitude"
   ],
   "additionalProperties": false
  },
  "WeatherCondition": {
   "type": "string",
   "enum": [
    "Sunny",
    "Dry",
    "Rain_snowfall",
    "Wind"
   ]
  },
  "EnvironmentControl": {
   "type": "string",
   "enum": [
    "None",
    "Screen",
    "Tent",
    "Heating"
   ]
  },
  "FusionData": {
   "oneOf": [
    {
     "$ref": "#/$defs/EFFusionData"
    },
    {
     "$ref": "#/$defs/BFFusionData"
    },
    {
     "$ref": "#/$defs/IRFusionData"
    }
   ]
  },
  "EFFusionData": {
   "type": "object",
   "properties": {
    "OperatingMode": {
     "type": "string",
     "enum": [
      "barcode",
      "2Dbcode",
      "manual",
      "automatic",
      "preset",
      "other"
     ]
    },
    "NomResistance":{
     "type":"number"
    },
    "FusionPhases": {
     "type": "array",
     "items": {
      "$ref": "#/$defs/EFFusionPhases"
     },
     "minItems": 1
    }
   },
   "required": [
    "OperatingMode",
    "FusionPhases"
   ],
```

```
 "additionalProperties": false
},
"EFFusionPhases": {
 "type": "object",
 "properties": {
  "RegulationType": {
   "type": "string",
   "enum": [
    "0",
    "1",
    "2",
    "3",
    "4",
    "5",
    "6"
   ]
  },
  "Resistance": {
   "type": "number"
  },
  "NomRegLevel": {
   "type": "number"
  },
  "MeasRegLevel": {
   "type": "number"
  },
  "GvnTmOrEnergy": {
   "type": "number"
  },
  "MeasTmOrEnergy": {
   "type": "number"
  },
  "MsgCode": {
   "type": "integer",
   "minimum": 0,
   "maximum": 99
  },
  "MFFusionPhase": {
   "type": "object",
   "additionalProperties": true
  }
 },
 "required": [
  "RegulationType",
  "Resistance",
  "MeasRegLevel",
  "GvnTmOrEnergy",
  "MeasTmOrEnergy",
  "MsgCode"
 ],
 "additionalProperties": false
},
"BFFusionData": {
 "type": "object",
 "properties": {
  "BFStandard": {
   "type": "string"
  },
  "ControlType": {
   "type": "string",
   "enum": [
    "N",
    "P"
   ]
  },
  "PistonArea": {
   "type": "integer"
  },
  "FusionFaceArea": {
   "type": "integer"
  },
```

```
"DragPressure": {
 "type": "number"
},
"NomHeatPlateTmp": {
 "type": "number"
},
"MaxHeatPlateTmp": {
 "type": "number"
},
"MinHeatPlateTmp": {
 "type": "number"
},
"NomBeadUpP": {
 "type": "number"
},
"MaxBeadUpP": {
 "type": "number"
},
"MinBeadUpP": {
 "type": "number"
},
"MaxHeatSoakP": {
 "type": "number"
},
"MinHeatSoakP": {
 "type": "number"
},
"MinTrgtBeadUpSize": {
 "type": "number"
},
"HeatSoakTime": {
 "type": "integer"
},
"MaxHPRemovalTime": {
 "type": "integer"
},
"HPRemovalTime": {
 "type": "integer"
},
"MaxFusJntPTime": {
 "type": "integer"
},
"FusJntPTime": {
 "type": "integer"
},
"NomFusJntP": {
 "type": "number"
},
"MinFusJntP": {
 "type": "number"
},
"MaxFusJntP": {
 "type": "number"
},
"NomFusJntTmDualLP": {
 "type": "integer"
},
"FusJntTmDualLP": {
 "type": "integer"
},
"NomCoolingTm1": {
 "type": "integer"
},
"CoolingTm1": {
 "type": "integer"
},
"NomFusJntP2": {
 "type": "integer"
},
"MinFusJntP2": {
 "type": "number"
```

```
    },
    "MaxFusJntP2": {
     "type": "number"
    },
    "NomCoolingTm2": {
     "type": "integer"
    },
    "CoolingTm2": {
     "type": "integer"
    },
    "MsgCode": {
     "type": "integer",
     "minimum": 0,
     "maximum": 99
    }
   },
   "required": [
    "BFStandard",
    "ControlType",
    "DragPressure",
    "NomHeatPlateTmp",
    "MaxHeatPlateTmp",
    "MinHeatPlateTmp",
    "NomBeadUpP",
    "MaxBeadUpP",
    "MinBeadUpP",
    "MinHeatSoakP",
    "MinHeatSoakTime",
    "HeatSoakTime",
    "MaxHPRemovalTime",
    "HPRemovalTime",
    "MaxFusJntPTime",
    "FusJntPTime",
    "NomFusJntP",
    "MinFusJntP",
    "MaxFusJntP",
    "NomCoolingTm1",
    "CoolingTm1",
    "MsgCode"
   ],
   "additionalProperties": false
  },
  "IRFusionData": {
   "type": "object",
   "properties": {
    "IRStandard": {
     "type": "string"
    },
    "PipeFaceArea": {
     "type": "integer"
    },
    "CompTmp": {
     "type": "number"
    },
    "ReFacingNo": {
     "type": "integer"
    },
    "FacingLeft": {
     "type": "number"
    },
    "FacingRight": {
     "type": "number"
    },
    "NomFacingPos": {
     "type": "number"
    },
    "FacingPos": {
     "type": "number"
    },
    "NomHeaterTmp": {
     "type": "number"
```

```
        },
        "HeaterTmp": {
         "type": "number"
        },
        "NomHeatingTm": {
         "type": "integer"
        },
        "HeatingTm": {
         "type": "integer"
        },
        "MaxHeatPlateRemTm": {
         "type": "integer"
        },
        "HeatPlateRemTm": {
         "type": "integer"
        },
        "NomOverleapDist": {
         "type": "number"
        },
        "OverLeapDist": {
         "type": "number"
        },
        "NomFusionForce": {
         "type": "number"
        },
        "FusionForce": {
         "type": "number"
        },
        "NomCoolingTm": {
         "type": "integer"
        },
        "CoolingTm": {
         "type": "integer"
        },
        "IRMsgCode": {
         "type": "string"
        }
       },
       "required": [
        "IRStandard",
        "CompTmp",
        "RefacingNo",
        "NomFacingPos",
        "FacingPos",
        "NomHeaterTmp",
        "HeaterTmp",
        "NomHeatingTm",
        "HeatingTm",
        "MaxHeatPlateRemTm",
        "NomCoolingTm",
        "CoolingTm",
        "IRMsgCode"
       ],
       "additionalProperties": false
      }
     }
    }
```

C.2 Example

```
{
  "Protocol": {
   "Version":"1.0",
   "FEquipment": {
    "SerialNumber": "123456789",
    "DeviceType": "ANY CONTROL UNIT",
    "TemperatureUnit": "C"
   },
   "Jointings": [
    {
     "JointingTime": "2020-08-30T08:21:12+01:00",
```

```
      "JointNumber": "123456789-4711",
      "Components": [
       {
        "Diameter": "63"
       }
      ],
      "WeatherCondition": [
      "Sunny",
      "Wind"
     ],
     "JointingStatus": "NoError",
     "JointingMethod": "EF",
     "FusionData": {
      "operatingMode": "barcode",
     "FusionPhases": [
      {
       "RegulationType": "1",
       "Resistance": 1.2,
       "NomRegLevel": 22.5,
       "MeasRegLevel": 22.5,
       "GvnTmOrEnergy": 220,
       "MeasTmOrEnergy": 223,
       "MsgCode": 0
      },
      {
       "RegulationType": "1",
       "Resistance": 1.2,
       "NomRegLevel": 22.5,
       "MeasRegLevel": 22.5,
       "GvnTmOrEnergy": 220,
       "MeasTmOrEnergy": 223,
       "MsgCode": 0
      }
     ]
    }
   },
   {
    "JointingTime": "2020-09-01T08:21:12+01:00",
    "JointNumber": "123456789-4712",
    "JointingStatus": "NoError"
   },
   {
    "JointingTime": "2020-09-01T08:22:01+01:00",
    "JointNumber": "123456789-4713",
    "JointingStatus": "NoError",
    "Localization": {
     "Longitude": 8.3915827,
     "Latitude": 49.0788756
    },
"JointingMethod": "BFW",
"FusionData": {
"BFStandard": "",
"ControlType": "",
"PistonArea": 500,
"FusionFaceArea": 6600,
"DragPressure": 9.0,
"NomHeatPlateTmp": 220.0,
"MaxHeatPlateTmp": 222.8,
"MinHeatPlateTmp": 216.0,
"NomBeadUpP": 20.5,
"MaxBeadUpP": 21.0,
"MinBeadUpP": 20.0,
"MaxHeatSoakP": 10.3,
"MinHeatSoakP": 0.3,
"HeatSoakTime": 145,
"MaxHPRemovalTime": 8,
"HPRemovalTime": 3,
"MaxFusJntPTime": 5,
"FusJntPTime": 5,
"NomFusJntP": 20.5,
"MinFusJntP": 21.0,
```