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| **INTERNATIONAL ORGANIZATION FOR STANDARDIZATION ORGANISATION INTERNATIONALE DE NORMALISATION ISO/IEC JTC 1/SC 29/WG 5 MPEG JOINT VIDEO EXPERTS TEAM WITH ITU-T SG 16** |
| **ISO/IEC JTC 1 / SC 29 / WG 5 N 261** |
| **Online – 17–26 January 2024** |
| |  |  | | --- | --- | | **Source:** | **Convenor (Jens-Rainer Ohm)** | | **Title:** | **Preliminary working draft 7 of SEI processing order and processing order nesting SEI messages in VVC** | | **Type:** | **Project** | | **Subtype:** | **Other** | | **Status:** | **Approved** | | **Date:** | **2024-03-15** | | **Expected Action:** | **Info** | | **Action due date:** | **N/A** | | **Pages:** | **10** (not including this cover page) | | **Email of convenor:** | **ohm @ ient . rwth-aachen . de** | | **Committee URL:** | **https://sd.iso.org/documents/ui/#!/browse/iso/iso-iec-jtc-1/iso-iec-jtc-1-sc-29/iso-iec-jtc-1-sc-29-wg-5** | |

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| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29**  33rd Meeting, by teleconference, 17–26 January 2024 | Document: JVET-AG2027-v1 |

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| *Title:* | **SEI processing order and processing order nesting SEI messages in VVC (draft 7)** | | |
| *Status:* | Output document approved by JVET | | |
| *Purpose:* | Draft text | | |
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| *Source:* | Editors | | |

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# Abstract

This document contains the draft text for changes to the Versatile Video Coding (VVC) standard (Rec. ITU-T H.266 | ISO/IEC 23090-3), to specify the SEI processing order (SPO) and processing order nesting (PON) SEI messages.

**Changes that have been integrated:**

1. Item 2 option 1 from JVET-AG0052v4.
2. Delete “However, if po\_sei\_wrapping\_flag[ i ] is equal to 0 and no SEI message is present …” (and NOTE 2). (Documented under JVET-AG0053.) (NOTE 2 seemed unrelated to the deletion, providing a clarification of po\_sei\_wrapping\_flag[ i ] and hence was kept.)
3. Agreed: An SEI message being present within a PON should be equivalent, from a decoder perspective, to being present outside of a PON. (Documented under JVET-AG0053.)
4. Delete “The persistence of all the SEI messages included in the same processing order nesting SEI message shall be the same.” (Documented under JVET-AG0053.)
5. Add a clarification of the persistence issue (activation/deactivation/persistence). (Documented under JVET-AG0053.)
6. Add a clarifying note in the semantics to describe the flexibility supported when multiple PON SEI messages are sent. (Documented under JVET-AG0165.)
7. Add (editors to develop text): If NNPFC is in a PON, the corresponding NNPFA and any NNPFC updating for that NNPF shall be in a PON (not necessarily the same PON). (Documented under JVET-AG0169.)
8. Add (editors to develop text): For all SEI messages (not just NNPFC), there should be a constraint that there should not be “activation” outside of a PON and then later a deactivation or some update inside of a PON. (Documented under JVET-AG0169.)
9. Use of the film grain characteristics SEI message as a part of a processing order indicated by an SEI processing order SEI message (JVET-AG0180).

**Changes to the specification text:**

*Replace subclause D.2.1 with the following:*

**D.2.1 General SEI payload syntax**

|  |  |
| --- | --- |
| sei\_payload( payloadType, payloadSize ) { | **Descriptor** |
| SeiExtensionBitsPresentFlag = 0 |  |
| if( nal\_unit\_type = = PREFIX\_SEI\_NUT ) |  |
| if( payloadType = = 0 ) |  |
| buffering\_period( payloadSize ) |  |
| else if( payloadType = = 1 ) |  |
| pic\_timing( payloadSize ) |  |
| else if( payloadType = = 3 ) |  |
| filler\_payload( payloadSize ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| else if( payloadType = = 4 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| user\_data\_registered\_itu\_t\_t35( payloadSize ) |  |
| else if( payloadType = = 5 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| user\_data\_unregistered( payloadSize ) |  |
| else if( payloadType = = 19 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| film\_grain\_characteristics( payloadSize ) |  |
| else if( payloadType = = 45 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| frame\_packing\_arrangement( payloadSize ) |  |
| else if( payloadType = = 47 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| display\_orientation( payloadSize ) |  |
| else if( payloadType = = 56 ) /\* Specified in ISO/IEC 23001-11 \*/ |  |
| green\_metadata( payloadsize ) |  |
| else if( payloadType = = 129 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| parameter\_sets\_inclusion\_indication( payloadSize ) |  |
| else if( payloadType = = 130 ) |  |
| decoding\_unit\_info( payloadSize ) |  |
| else if( payloadType = = 133 ) |  |
| scalable\_nesting( payloadSize ) |  |
| else if( payloadType = = 137 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| mastering\_display\_colour\_volume( payloadSize ) |  |
| else if( payloadType = = 142 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| colour\_transform\_info( payloadSize ) |  |
| else if( payloadType = = 144 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| content\_light\_level\_info( payloadSize ) |  |
| else if( payloadType = = 145 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| dependent\_rap\_indication( payloadSize ) |  |
| else if( payloadType = = 147 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| alternative\_transfer\_characteristics( payloadSize ) |  |
| else if( payloadType = = 148 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| ambient\_viewing\_environment( payloadSize ) |  |
| else if( payloadType = = 149 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| content\_colour\_volume( payloadSize ) |  |
| else if( payloadType = = 150 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| equirectangular\_projection( payloadSize ) |  |
| else if( payloadType = = 153 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| generalized\_cubemap\_projection( payloadSize ) |  |
| else if( payloadType = = 154 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| sphere\_rotation( payloadSize ) |  |
| else if( payloadType = = 155 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| regionwise\_packing( payloadSize ) |  |
| else if( payloadType = = 156 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| omni\_viewport( payloadSize ) |  |
| else if( payloadType = = 165 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| alpha\_channel\_info( payloadSize ) |  |
| else if( payloadType = = 168 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| frame\_field\_info( payloadSize ) |  |
| else if( payloadType = = 177 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| depth\_representation\_info( payloadSize ) |  |
| else if( payloadType = = 179 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| multiview\_acquisition\_info( payloadSize ) |  |
| else if( payloadType = = 180 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| multiview\_view\_position( payloadSize ) |  |
| else if( payloadType = = 200 ) |  |
| sei\_manifest( payloadSize ) |  |
| else if( payloadType = = 201 ) |  |
| sei\_prefix\_indication( payloadSize ) |  |
| else if( payloadType = = 202 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| annotated\_regions( payloadSize ) |  |
| else if( payloadType = = 203 ) |  |
| subpic\_level\_info( payloadSize ) |  |
| else if( payloadType = = 204 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| sample\_aspect\_ratio\_info( payloadSize ) |  |
| else if( payloadType = = 205 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| shutter\_interval\_info( payloadSize ) |  |
| else if( payloadType = = 206 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| extended\_drap\_indication( payloadSize ) |  |
| else if( payloadType = = 207 ) |  |
| constrained\_rasl\_encoding\_indication( payloadSize ) |  |
| else if( payloadType = = 208 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| scalability\_dimension\_info( payloadSize ) |  |
| else if( payloadType = = 209 ) /\* Specified in ISO/IEC 23090-13 \*/ |  |
| vdi\_sei\_envelope( payloadsize ) |  |
| else if( payloadType = = 210 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| nn\_post\_filter\_characteristics( payloadSize ) |  |
| else if( payloadType = = 211 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| nn\_post\_filter\_activation( payloadSize ) |  |
| else if( payloadType = = 212 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| phase\_indication( payloadSize ) |  |
| else if( payloadType = = 213 ) |  |
| sei\_processing\_order( payloadSize ) |  |
| else if( payloadType = = 214 ) |  |
| processing\_order\_nesting( payloadSize ) |  |
| else /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| reserved\_message( payloadSize ) |  |
| else /\* nal\_unit\_type = = SUFFIX\_SEI\_NUT \*/ |  |
| if( payloadType = = 3 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| filler\_payload( payloadSize ) |  |
| else if( payloadType = = 132 ) /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| decoded\_picture\_hash( payloadSize ) |  |
| else if( payloadType = = 133 ) |  |
| scalable\_nesting( payloadSize ) |  |
| else if( payloadType = = 214 ) |  |
| processing\_order\_nesting( payloadSize ) |  |
| else /\* Specified in Rec. ITU-T H.274 | ISO/IEC 23002-7 \*/ |  |
| reserved\_message( payloadSize ) |  |
| if( SeiExtensionBitsPresentFlag | | more\_data\_in\_payload( ) ) { |  |
| if( payload\_extension\_present( ) ) |  |
| **sei\_reserved\_payload\_extension\_data** | u(v) |
| **sei\_payload\_bit\_equal\_to\_one** /\* equal to 1 \*/ | f(1) |
| while( !byte\_aligned( ) ) |  |
| **sei\_payload\_bit\_equal\_to\_zero** /\* equal to 0 \*/ | f(1) |
| } |  |
| } |  |

*In subclause D.2.2, make the following changes:*

...

**Table D.1 – Persistence scope of SEI messages (informative)**

|  |  |
| --- | --- |
| **SEI message** | **Persistence scope** |
| Buffering period | The remainder of the bitstream |
| Picture timing | The AU containing the SEI message |
| DU information | The AU containing the SEI message |
| Scalable nesting | Depending on the scalable-nested SEI messages. Each scalable-nested SEI message has the same persistence scope as if the SEI message was not scalable-nested |
| SEI manifest | The CVS containing the SEI message |
| SEI prefix indication | The CVS containing the SEI message |
| Subpicture level information | The CVS containing the SLI SEI message and up to but not including the next CVS, in decoding order, that contains an SLI SEI message with different content |
| Constrained RASL encoding indication | The CVS containing the SEI message |
| SEI processing order | For each value of po\_id, the number of SEI messages and the payloadType codes of the SEI messages indicated within the SEI processing order SEI message persist for the CVS containing the SEI processing order SEI message. |
| Processing order nesting | Depending on the processing-order-nested SEI messages. Each processing-order-nested SEI message has the same persistence scope as if the SEI message was not nested. |

...

The list VclAssociatedSeiList is set to consist of the payloadType values 3, 19, 45, 47, 129, 132, 137, 142, 144, 145, 147 to 150, inclusive, 153 to 156, inclusive, 165, 168, 177, 179, 180, 200 to 202, inclusive, and 204 to 214, inclusive.

...

*Replace subclause D.11.2 with the following (where highlighted text indicates the changes):*

**D.11.2 Use of the film grain characteristics SEI message**

For purposes of interpretation of the film grain characteristics SEI message, the following variables are specified:

If the film grain characteristics SEI message is not applied as part of a processing chain indicated by an SEI processing order SEI message or is applied as the first processing step of the processing chain indicated by an SEI processing order SEI message, the following applies:

– PicWidthInLumaSamples and PicHeightInLumaSamples are set equal to pps\_pic\_width\_in\_luma\_samples and pps\_pic\_height\_in\_luma\_samples, respectively.

– ChromaFormatIdc is set equal to sps\_chroma\_format\_idc.

– BitDepthY and BitDepthC are both set equal to BitDepth.

Otherwise (the film grain characteristics SEI message is applied as the second or a later processing step of the processing chain indicated by an SEI processing order SEI message), prevPic is a picture resulting from the previous processing step of the processing chain indicated by the SEI processing order SEI message, and the following applies:

– PicWidthInLumaSamples and PicHeightInLumaSamples are set equal to the picture width and picture height of prevPic, respectively.

– ChromaFormatIdc is set equal to the picture chroma format indicator of prevPic.

– BitDepthY and BitDepthC are set equal to the luma bit depth and chroma bit depth of prevPic, respectively.

*Add subclause D.11 with subordinate subclauses as follows:*

**D.11 SEI processing order and processing order nesting SEI message**

**D.11.1 SEI processing order SEI message**

D.11.1.1 SEI processing order SEI message syntax

|  |  |
| --- | --- |
| sei\_processing\_order( payloadSize ) { | **Descriptor** |
| **po\_id** | u(8) |
| **po\_num\_sei\_messages\_minus2** | u(8) |
| for( i = 0, i < po\_num\_sei\_messages\_minus2 + 2; i++ ) { |  |
| **po\_sei\_wrapping\_flag**[ i ] | u(1) |
| **po\_sei\_importance\_flag**[ i ] | u(1) |
| **po\_sei\_payload\_type**[ i ] | u(13) |
| **po\_sei\_prefix\_flag**[ i ] | u(1) |
| **po\_sei\_processing\_order**[ i ] | u(8) |
| } |  |
| for( i = 0; i < po\_num\_sei\_messages\_minus2 + 2; i++ ) |  |
| if( po\_sei\_prefix\_flag[ i ] ) { |  |
| **po\_num\_bits\_in\_prefix\_indication\_minus1**[ i ] | u(8) |
| for( j = 0; j <= po\_num\_bits\_in\_prefix\_indication\_minus1[ i ]; j++ ) |  |
| **po\_sei\_prefix\_data\_bit**[ i ][ j ] | u(1) |
| while( !byte\_aligned( ) ) |  |
| **po\_byte\_alignment\_bit\_equal\_to\_one** /\* equal to 1 \*/ | f(1) |
| } |  |
| } |  |

**D.11.1.2 SEI processing order SEI message semantics**

The SEI processing order (SPO) SEI message carries information indicating the preferred processing order, as determined by the encoder (i.e., the content producer), for a group of types of SEI messages that may be present in a CVS.

The semantics of the SPO SEI message uses the concept of types of SEI messages. SEI messages that have different payloadType values are considered different types of SEI messages. Additionally, different SEI messages that have the same payloadType value but are differentiated by values of syntax elements in the SEI payload are considered different types of SEI messages. Such differentiation by values of syntax elements in the SEI payload is to be performed by comparing values sent using po\_sei\_prefix\_data\_bit[ i ][ j ] syntax elements (when present) or values sent as SEI messages within a processing order nesting SEI message (when present). For example, neural-network post-filter characteristics (NNPFC) SEI messages can be differentiated by having different nnpfc\_id values.

When the i-th SEI message seiA in any SPO SEI message has po\_sei\_wrapping\_flag[ i ] and po\_sei\_prefix\_flag[ i ] both equal to 0, there shall be no other SEI message seiB included in the same SPO SEI message or in a different SPO SEI message in the current CVS for which all of the following are true:

– The value of po\_sei\_payload\_type[ i ] of seiB is the same as that for seiA.

– The value of po\_sei\_wrapping\_flag[ i ] of seiB is equal to 0.

– The value of po\_sei\_prefix\_flag[ i ] of seiB is equal to 1.

When an SPO SEI message with a particular value of po\_id is present in any access unit of a CVS, an SPO SEI message with that particular value of po\_id shall be present in the first access unit of the CVS in decoding order. The number of SEI messages and the payloadType codes of the SEI messages indicated within each SPO SEI message with the same value of po\_id persist in decoding order from the current access unit until the end of the CVS in output order.

The SPO SEI message can carry one or more SEI prefix indications of a particular payloadType. When present, each SEI prefix indication is a bit string that follows the SEI payload syntax of that value of payloadType and contains a number of complete syntax elements starting from the first syntax element in the SEI payload. These SEI prefix indications should provide sufficient information to determine the specific processing order for types of SEI messages having the same value of payloadType but a different preferred processing order.

**po\_id** contains an identifying number to identify the SPO SEI message.

A processing chain consists of a list of types of SEI messages identified by an SPO SEI message in the preferred processing order indicated in the SPO SEI message.

Each type of SEI message in the processing chain indicated by an SPO SEI message is identified by the syntax elements po\_sei\_payload\_type[ i ], po\_sei\_wrapping\_flag[ i ], po\_sei\_processing\_order[ i ] and, when present, po\_num\_bits\_in\_prefix\_indication\_minus1[ i ] and po\_prefix\_data\_bit[ i ][ j ].

An SEI message type is not required to belong to any processing chain and may belong to any number of processing chains identified by SPO SEI messages with different po\_id values.

Each SEI message of an SEI message type identified within the SPO SEI message has the same persistence scope as if the SEI message was carried outside of the SPO SEI message and not identified within an SPO SEI message.

NOTE 1 – Processing chains can be alternatives to each other, i.e., such that at most processing chain is chosen to be applied, or they can be complementary, i.e., such that more than one processing chain is chosen and applied separately, with each processing chain generating one output.

**po\_num\_sei\_messages\_minus2** plus 2 indicates the number of types of SEI messages for which the preferred order of processing is indicated in the SPO SEI message.

**po\_sei\_wrapping\_flag**[ i ] equal to 1 specifies that one or more processing order nesting SEI messages with both of the following constraints should be present:

– pon\_target\_po\_id[ j ] with any value of j is equal to po\_id.

– There is a k-th loop entry in the processing order nesting SEI message such that the payloadType of the k-th nested SEI message is equal to po\_sei\_payload\_type[ i ] and pon\_processing\_order[ k ] is equal to po\_sei\_processing\_order[ i ].

When po\_sei\_wrapping\_flag[ i ] is equal to 0, an SEI message with payloadType equal to po\_sei\_payload\_type[ i ] (and, when po\_sei\_prefix\_flag[ i ] equal to 1, prefix data that matches the values of po\_sei\_prefix\_data\_bit[ i ][ j ]) should be present outside of the processing order nesting SEI message.

NOTE 2 – po\_sei\_wrapping\_flag[ i ] equal to 1 enables SEI messages to be carried within the processing order nesting SEI message to prevent such SEI messages from being incorrectly interpreted by decoders that do not process the SPO SEI message. Thus, po\_sei\_wrapping\_flag[ i ] equal to 1 is intended to be used when po\_sei\_wrapping\_flag[ i ] equal to 0 can lead to unintended results being produced by such decoders.

**po\_sei\_importance\_flag**[ i ] indicates the degree of importance determined by the encoder for the type of SEI message with index i.

If the decoding system cannot interpret or does not support the functionality indicated by any indicated SEI message that has po\_sei\_importance\_flag[ i ] equal to 1, it should ignore the entire SPO SEI message.

**po\_sei\_payload\_type**[ i ] specifies the payloadType value of the i-th type of SEI message.

**po\_sei\_prefix\_flag**[ i ] equal to 1 specifies that po\_num\_bits\_in\_prefix\_indication\_minus1[ i ] and some po\_sei\_prefix\_data\_bit[ i ][ j ] syntax elements are present. po\_sei\_prefix\_flag[ i ] equal to 0 specifies that these syntax elements are not present.

SeiProcessingOrderSeiList is set to consist of the payloadType values 3, 4, 5, 19, 137, 142, 144, 147, 148, 149, 165, 177, 210, and 211. The value of po\_sei\_payload\_type[ i ] for each i in the range of 0 to po\_num\_sei\_messages\_minus2 + 1, inclusive, shall be equal to a value in SeiProcessingOrderSeiList.

**po\_sei\_processing\_order**[ i ] indicates the preferred order of processing of the i-th type of SEI message for which preferred processing order information is provided in the SPO SEI message. For any two different integer values of m and n, po\_sei\_processing\_order[ m ] less than po\_sei\_processing\_order[ n ] indicates that the type of SEI message associated with index m should be processed before the type of SEI message associated with index n, and po\_sei\_processing\_order[ m ] equal to po\_sei\_processing\_order[ n ] indicates that there is no preferred order of processing between the types of SEI messages associated with indexes m and n (e.g., they can indicate different properties that are both applicable at that stage, or alternative processes that can be applied, or one can indicate a property and the other can indicate a process).

For i greater than 0, po\_sei\_processing\_order[ i ] shall be greater than or equal to po\_sei\_processing\_order[ i − 1 ].

**po\_num\_bits\_in\_prefix\_indication\_minus1**[ i ] and **po\_sei\_prefix\_data\_bit**[ i ][ j ], when present, have the same semantics as the num\_bits\_in\_prefix\_indication\_minus1[ i ] and sei\_prefix\_data\_bit[ i ][ j ] syntax elements of the SEI prefix indication SEI message, with prefix\_sei\_payload\_type replaced by po\_sei\_payload\_type[ i ].

When more than one SPO SEI message with a particular value of po\_id is present in a CVS, the values of po\_num\_sei\_messages\_minus2 and, for each value of i, the values of po\_sei\_wrapping\_flag[ i ], po\_sei\_prefix\_flag[ i ], po\_sei\_importance\_flag[ i ], po\_sei\_payload\_type[ i ], po\_sei\_processing\_order[ i ] shall be the same as in the other SPO SEI messages in the CVS with the same value of po\_id.

**po\_byte\_alignment\_bit\_equal\_to\_one** shall be equal to 1.

**D.11.2 Processing order nesting SEI message**

**D.12.2.1 Processing order nesting SEI message syntax**

|  |  |
| --- | --- |
| processing\_order\_nesting( payloadSize ) { | **Descriptor** |
| **pon\_num\_po\_ids\_minus1** | u(8) |
| for( i = 0; i <= pon\_num\_po\_ids\_minus1; i++ ) |  |
| **pon\_target\_po\_id**[ i ] | u(8) |
| **pon\_num\_seis\_minus1** | u(8) |
| for( i = 0; i <= pon\_num\_seis\_minus1; i++ ) { |  |
| **pon\_processing\_order**[ i ] | u(8) |
| sei\_message( ) |  |
| } |  |
| } |  |

**D.12.2.2 Processing order nesting SEI message semantics**

The processing order nesting (PON) SEI message includes one or more SEI messages that should be applied only as parts of the processing chain identified by an associated SEI processing order SEI message and should not be applied in a manner that would contradict with the processing chain identified by the associated SEI processing order SEI message.

The SEI messages contained in a PON SEI message are referred to as PON-nested SEI messages.

NOTE – An encoder can include multiple PON SEI messages in the same access unit. For example, a first PON SEI message in an access unit can contain a PON-nested SEI message that applies to multiple processing chains and one or more other PON SEI messages in the same access unit that apply to a single processing chain only.

It is a requirement of bitstream conformance that the semantics and effect of an SEI message that is not a PON-nested SEI message shall not depend on any PON-nested SEI message. Consequences of this constraint include the following specific constraints, in which an associated SEI message is considered to be an SEI message that affects the semantics or effect of a particular SEI message:

– When a neural-network post-filter characteristics SEI message is present with a particular value of nnpfc\_id that is a PON-nested SEI message, any associated neural-network post-filter activation SEI messages with nnpfa\_target\_id equal to that particular value of nnpfc\_id shall also be PON-nested SEI messages.

– When a neural-network post-filter activation (NNPFA) SEI message is present with nnpfa\_persistence\_flag equal to 1 and a particular value of nnpfa\_target\_id that is not a PON-nested SEI message, the next picture in output order in the same CLVS that has an NNPFA SEI message with the same value of nnpfa\_target\_id (if any) shall not have an associated NNPFA SEI message that is a PON-nested SEI message.

– When a film grain characteristics SEI message is present with fg\_characteristics\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated film grain characteristics SEI message in the same CLVS that is a PON-nested SEI message.

– When a frame packing arrangement SEI message is present with fp\_arrangement\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated frame packing arrangement SEI message in the same CLVS with fp\_arrangement\_cancel\_flag equal to 1 or the same value of fp\_arrangement\_id that is a PON-nested SEI message.

– When a content colour volume SEI message is present with ccv\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated frame packing arrangement SEI message in the same CLVS that is a PON-nested SEI message.

– When an equirectangular projection SEI message is present with erp\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated equirectangular projection SEI message in the same CLVS that is a PON-nested SEI message.

– When a generalized cubemap project SEI message is present with gcmp\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated generalized cubemap project SEI message in the same CLVS that is a PON-nested SEI message.

– When a sphere rotation SEI message is present with sphere\_rotation\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated sphere rotation SEI message in the same CLVS that is a PON-nested SEI message.

– When a region-wise packing SEI message is present with rwp\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated region-wise packing SEI message in the same CLVS that is a PON-nested SEI message.

– When an omnidirectional viewport SEI message is present with omni\_viewport\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated omnidirectional viewport SEI message in the same CLVS that is a PON-nested SEI message.

– When a sample aspect ratio SEI message is present with sari\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated sample aspect ratio SEI message in the same CLVS that is a PON-nested SEI message.

– When an annotated regions SEI message is present that is not a PON-nested SEI message, there shall not be an associated annotated regions SEI message in the same CLVS that is a PON-nested SEI message.

– When an alpha channel information SEI message is present that is not a PON-nested SEI message, there shall not be an associated alpha channel information SEI message in the same CLVS that is a PON-nested SEI message.

– When a display orientation SEI message is present that is not a PON-nested SEI message, there shall not be an associated display orientation SEI message in the same CLVS that is a PON-nested SEI message.

– When a colour transform indication SEI message is present with colour\_transform\_persistence\_flag equal to 1 that is not a PON-nested SEI message, there shall not be an associated colour transform indication SEI message in the same CLVS with colour\_transform\_cancel\_flag equal to 1 or the same value of colour\_transform\_id that is a PON-nested SEI message.

**pon\_num\_po\_ids\_minus1** plus 1 specifies the number of the SEI processing order SEI messages SEI associated with this PON SEI message.

**pon\_target\_po\_id**[ i ] indicates the po\_id of the i-th associated SEI processing order SEI message.

**pon\_num\_seis\_minus1** plus 1 specifies the number of the PON-nested SEI messages that are included in this PON SEI message.

**pon\_processing\_order**[ i ] specifies the position of the i-th processing-order-nested SEI message within the processing order defined by the associated SEI processing order SEI message. When i is greater than 0, pon\_processing\_order[ i ] shall be greater than or equal to pon\_processing\_order[ i − 1 ].

For each associated SEI processing order SEI message there shall be at least one value of i in the range of 0 to pon\_num\_seis\_minus1, inclusive, in the PON SEI message for which the associated SEI processing order SEI message has some entry k for which all of the following are true:

– po\_sei\_processing\_order[ k ] is equal to pon\_processing\_order[ i ]

– po\_sei\_payload\_type[ k ] is equal to the payloadType value of the i-th PON-nested SEI message.

– When po\_sei\_prefix\_flag[ k ] is equal to 1, po\_sei\_prefix\_data\_bit[ k ][ j ] for j in the range of 0 to po\_num\_bits\_in\_prefix\_indication\_minus1[ k ], inclusive, contain the same content as the po\_num\_bits\_in\_prefix\_indication\_minus1[ k ] plus 1 initial bits of the SEI message payload of the i-th PON-nested SEI message.

The i-th PON-nested SEI message should be applied as the k-th loop entry of the associated SEI processing order SEI message.