SMPTE ST 381-5:2023
Revision of SMPTE ST 381-5:2020

SMPTE STANDARD

Material Exchange Format — Mapping HEVC Streams into the MXF Generic Container

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Approved February 28, 2023

Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual. This SMPTE Engineering Document was prepared by Technology Committee 31FS.

The following changes were made during the revision process:

- A restriction of the Picture Item length field for frame wrapping that limited the length of a coded stream to less than less 0x1000000 bytes per frame was overcome by updating the length field of the KLV coded container to be either 4 bytes or 5 bytes BER long-form encoded.
- Updating of a normative reference.
- Editorial adjustments.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

1 Scope

This standard specifies the mapping of all HEVC coding data as defined in ISO/IEC 23008-2 | Rec. ITU-T H.265 into the Material Exchange Format Generic Container (MXF-GC) based on the MXF MPEG mapping standard (SMPTE ST 381-2).

This standard does not apply to Annexes G (MHEVC), H (SHEVC) or I (3DHEVC) of the HEVC standard. This standard also does not support the HEIF file format (ISO/IEC 23008-12).

This document specifies the carriage of parameter sets in an HEVC essence stream “in-band”.

The MXF specification is written in several parts. This is an MXF mapping specification that defines header metadata sets and values, essence container elements and index table applications.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any clause explicitly labeled as "Informative" or individual paragraphs that start with "Note:”

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this engineering document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this engineering document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 377-1:2019, Material Exchange Format (MXF) - File Format Specification

SMPTE ST 379-1:2009, Material Exchange Format (MXF) - MXF Generic Container

SMPTE ST 379-2:2010, Material Exchange Format (MXF) - MXF Constrained Generic Container

SMPTE ST 381-2:2018, Material Exchange Format (MXF) - Mapping MPEG Streams into the MXF Constrained Generic Container

ISO/IEC 23008-2 | Rec. ITU-T H.265, Information technology - High efficiency coding and media delivery in heterogeneous environments - Part 2: High efficiency video coding or ITU-T Recommendation H.265 - High efficiency video coding

4 Terms and Definitions

The general glossary of acronyms, terms and data types used in the MXF specification is given in SMPTE ST 377-1 and is supplemented in SMPTE ST 379-1 and SMPTE ST 379-2. These glossaries are not repeated here to avoid any divergence of meaning.

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

4.1
HEVC

High Efficiency Video Coding as documented in ISO/IEC 23008-2 I Rec. ITU-T H.265

4.2
NAL

Network Abstraction Layer

4.3
I Picture

picture consisting only of I-Slices

4.4
IDR Picture

instantaneous decoding refresh picture as defined in ISO/IEC 23008-2 I Rec. ITU-T H.265

4.5
CRA Picture

clean random access picture as defined in ISO/IEC 23008-2 I Rec. ITU-T H.265

4.6
BLA Picture

broken link access picture as defined in ISO/IEC 23008-2 I Rec. ITU-T H.265

4.7
P Picture

picture consisting of P-Slices, or P-Slices and I-Slices

4.8
B Picture

picture consisting of B-Slices, or B-Slices and P-Slices, or B-Slices, P-Slices and I-Slices

4.9
Br Picture

B Picture that is available as a reference for another Picture

4.10
GOP

Group of Pictures starting with IDR Picture, CRA Picture or BLA Picture, including all subsequent pictures but not including any subsequent IDR Picture, CRA Picture or BLA Picture in coded order

Note 1 to entry: This term is not defined in the HEVC specification, but is widely used in the industry, and is defined for the purpose of this standard.

4.11
Key Picture

earliest preceding I Picture required for decoding the indexed Picture

4.12
parameter sets

video parameter sets, sequence parameter sets and picture parameter sets

4.13
in-band

carried within an HEVC essence stream

5 Technical Introduction (Informative)

5.1 HEVC Coding Summary

The HEVC (High Efficiency Video Coding) standard defined in the ISO/IEC 23008-2 | Rec. ITU-T H.265 has been developed as an advanced high-performance compression technology. In the HEVC coding streams, the bitstream can be in one of two formats: the NAL unit stream or the byte stream.

The NAL unit stream format consists of a sequence of NAL unit syntax structures.

The byte stream format can be constructed from the NAL unit stream by prefixing each NAL unit with a start code prefix and zero or more zero-valued bytes to form a stream of bytes.

5.2 Requirements of Mapping HEVC Streams into MXF

This standard was developed to meet the following requirements:

- The mapping needs to support the NAL unit stream format and the byte stream format.
- HEVC streams need to be wrapped using the MPEG Picture Element Key as defined in SMPTE ST 381-2.
- The Picture Element needs to be able to contain all variants of HEVC streams using frame wrapping, clip wrapping, or custom wrapping.
- The mapping needs to support carriage of in-band video parameter sets, in-band sequence parameter sets and in-band picture parameter sets.
- Full details of the precise HEVC stream need to be specified in the Essence Descriptor, and HEVC coding variants need to be specified in the Picture Essence Coding Label.
- A Sub-Descriptor needs to be specified to give information on HEVC streams.

6 Mapping the HEVC Streams to the MXF Generic Container

HEVC streams shall be mapped using the MXF Generic Container using frame wrapping, clip wrapping or custom wrapping as defined in SMPTE ST 379-1 and SMPTE ST 379-2.

7 Key-Length-Value Coding

7.1 Picture Element Key

HEVC streams shall be wrapped using the MPEG Picture Element Key as defined in SMPTE ST 381-2. The values of the first 12 bytes of the Essence Element Key are defined in SMPTE ST 379-1 and SMPTE ST 379-2. The values of the last four bytes of the Picture Element Key are given in Table 1.

Table 1 — Key Value for the MPEG Picture Element (Informative)

Byte No.	Description	Value (hex)	Meaning
1 to 12	Specified by the MXF Generic Container Specification, SMPTE ST 379-1 and SMPTE ST 379-2		
13	Item Type Identifier	15h	Generic Container Picture Item (as defined in SMPTE ST 379-1 and SMPTE ST 379-2)
14	Essence Element Count	kkh	Count of Picture Elements in this Picture Item
15	Essence Element Type	05h 06h 07h	Frame-Wrapped Picture Element Clip-Wrapped Picture Element Custom-Wrapped Picture Element
16	Essence Element Number	nnh	The Number (used as an Index) of this Picture Element in this Picture Item

7.2 Picture Element Length

For frame wrapping, the length field of the KLV coded Element shall be constant for all Edit Units of the essence container and shall be either 4 bytes BER long-form encoded (i.e., 83h.xx.yy.zz) or 5 bytes BER long-form encoded (i.e., 84h.ww.xx.yy.zz).

For clip wrapping, the length field of the KLV coded Element shall be 8 bytes BER long-form encoded (i.e., 87h.aa.bb.cc.dd.ee.ff.gg).

For custom wrapping, the length field shall be constant for all Edit Units of the essence container and shall be either 4 bytes or 8 bytes as appropriate.

NOTE In SMPTE ST 381-5:2020, the length field of the KLV coded Element had been restricted to 4 bytes BER long-form encoded for frame wrapping.

7.3 Picture Element Value

The Picture Element Values shall be the HEVC NAL unit stream or the HEVC byte stream. The bitstreams carried in the Value field shall contain complete NAL units including their relevant parameter sets, other Supplemental Enhancement Information (SEI) and padding zeroes.

NOTE Stream format is defined in the Byte 14 of the Essence Container Label described in Clause 8.1.

If a field-encoded stream is frame-wrapped, the Value field shall contain two fields, with a frame comprising a pair of fields, and byte 15 of the Picture Element Key shall be 05h (frame-wrapped). The Edit Rate of the Track that links such an Essence Container Element shall equal the frame rate.

If a field-encoded stream is field-wrapped, the Value field shall contain a single field, and byte 15 of the Picture Element Key shall be 05h (frame-wrapped). The Edit Rate of the Track that links such an Essence Container Element shall equal the field rate.

The frame wrapping or the field-wrapping shall be signaled by the Essence Container Label (see Table 2).

8 SMPTE Label Values

8.1 Essence Container Label

This Essence Container Label is the UL value carried in the Essence Container Properties of the Partition Packs, Preface Set and File Descriptor.

The values of the Essence Container Label for the HEVC coding with the value of “60h” (the default value) for the Byte 15 shall be as shown in Table 2.

Table 2 — Essence Container Label Values for HEVC

Item Name	Symbol	Kind	Item UL
MXF-GC HEVC NAL Unit Stream	MXFGCHEVCNALUnitStream	NODE	urn:smpte:ul:060e2b34.0401010d.0d010301.021f0000
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID	MXFGCHEVCNALUnitStreamWithVideoStream0SID	NODE	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6000
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID Frame-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDFrameWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6001
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID Clip-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDClipWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6002
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID CustomStripe-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDCustomStripeWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6003
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID CustomSplice-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDCustomSpliceWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6006
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID CustomClosedGOP-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDCustomClosedGOPWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6007
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID CustomSlave-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDCustomSlaveWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6008
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID Field-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDFieldWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f6009
MXF-GC HEVC NAL Unit Stream With VideoStream-0 SID CustomUnconstrained-wrapped	MXFGCHEVCNALUnitStreamWithVideoStream0SIDCustomUnconstrainedWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.021f607f
MXF-GC HEVC Byte Stream	MXFGCHEVCByteStream	NODE	urn:smpte:ul:060e2b34.0401010d.0d010301.02200000
MXF-GC HEVC Byte Stream With VideoStream-0 SID	MXFGCHEVCByteStreamWithVideoStream0SID	NODE	urn:smpte:ul:060e2b34.0401010d.0d010301.02206000
MXF-GC HEVC Byte Stream With VideoStream-0 SID Frame-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDFrameWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02206001
MXF-GC HEVC Byte Stream With VideoStream-0 SID Clip-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDClipWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02206002
MXF-GC HEVC Byte Stream With VideoStream-0 SID CustomStripe-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDCustomStripeWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02206003
MXF-GC HEVC Byte Stream With VideoStream-0 SID CustomSplice-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDCustomSpliceWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02206006
MXF-GC HEVC Byte Stream With VideoStream-0 SID CustomClosedGOP-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDCustomClosedGOPWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02206007

Item Name	Symbol	Kind	Item UL
MXF-GC HEVC Byte Stream With VideoStream-0 SID CustomSlave-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDCustomSlaveWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02206008
MXF-GC HEVC Byte Stream With VideoStream-0 SID Field-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDFieldWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.02206009
MXF-GC HEVC Byte Stream With VideoStream-0 SID CustomUnconstrained-wrapped	MXFGCHEVCByteStreamWithVideoStream0SIDCustomUnconstrainedWrapped	LEAF	urn:smpte:ul:060e2b34.0401010d.0d010301.0220607f

NOTE Although Table 2 shows Labels used with VideoStream-0 SID, Labels used with VideoStream-1 SID to VideoStream-15 SID are also listed in SMPTE Labels Register.

The basis of the derivation of the HEVC Essence Container Label values is described in Annex B.

8.2 Picture Essence Coding Label

The Picture Essence Coding Label is used in the Generic Picture Essence Descriptor. The values for the Picture Essence Coding Label for the HEVC are given in Table 3. These Label values are listed in the SMPTE Labels Register.

Table 3 — Picture Essence Coding Label Values for HEVC

Item Name	Symbol	Kind	Item UL
H.265/HEVC Video	H265HEVCVideo	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01400000
H.265/HEVC Main Profiles	H265HEVCMainProfiles	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01410000
H.265/HEVC Main Profile	H265HEVCMainProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01411000
H.265/HEVC Main Profile Unconstrained Coding	H265HEVCMainProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01411001
H.265/HEVC Main 10 Profile	H265HEVCMain10Profile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01412000
H.265/HEVC Main 10 Profile Unconstrained Coding	H265HEVCMain10ProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01412001
H.265/HEVC Main 12 Profile	H265HEVCMain12Profile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01413000
H.265/HEVC Main 12 Profile Unconstrained Coding	H265HEVCMain12ProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01413001
H.265/HEVC Main 4:2:2 Profiles	H265HEVCMain422Profiles	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01420000
H.265/HEVC Main 4:2:2 10 Profile	H265HEVCMain42210Profile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01422000
H.265/HEVC Main 4:2:2 10 Profile Unconstrained Coding	H265HEVCMain42210ProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01422001
H.265/HEVC Main 4:2:2 12 Profile	H265HEVCMain42212Profile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01423000
H.265/HEVC Main 4:2:2 12 Profile Unconstrained Coding	H265HEVCMain42212ProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01423001
H.265/HEVC Main 4:4:4 Profiles	H265HEVCMain444Profiles	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01430000
H.265/HEVC Main 4:4:4 Profile	H265HEVCMain444Profile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01431000
H.265/HEVC Main 4:4:4 Profile Unconstrained Coding	H265HEVCMain444ProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01431001
H.265/HEVC Main 4:4:4 10 Profile	H265HEVCMain44410Profile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01432000
H.265/HEVC Main 4:4:4 10 Profile Unconstrained Coding	H265HEVCMain44410ProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01432001
H.265/HEVC Main 4:4:4 12 Profile	H265HEVCMain44412Profile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01433000
H.265/HEVC Main 4:4:4 12 Profile Unconstrained Coding	H265HEVCMain44412ProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01433001
H.265/HEVC Main Intra Profiles	H265HEVCMainIntraProfiles	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01440000

Item Name	Symbol	Kind	Item UL
H.265/HEVC Main Intra Profile	H265HEVCMainIntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01441000
H.265/HEVC Main Intra Profile Unconstrained Coding	H265HEVCMainIntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01441001
H.265/HEVC Main 10 Intra Profile	H265HEVCMain10IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01442000
H.265/HEVC Main 10 Intra Profile Unconstrained Coding	H265HEVCMain10IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01442001
H.265/HEVC Main 12 Intra Profile	H265HEVCMain12IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01443000
H.265/HEVC Main 12 Intra Profile Unconstrained Coding	H265HEVCMain12IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01443001
H.265/HEVC Main 4:2:2 Intra Profiles	H265HEVCMain422IntraProfiles	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01450000
H.265/HEVC Main 4:2:2 10 Intra Profile	H265HEVCMain42210IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01452000
H.265/HEVC Main 4:2:2 10 Intra Profile Unconstrained Coding	H265HEVCMain42210IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01452001
H.265/HEVC Main 4:2:2 12 Intra Profile	H265HEVCMain42212IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01453000
H.265/HEVC Main 4:2:2 12 Intra Profile Unconstrained Coding	H265HEVCMain42212IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01453001
H.265/HEVC Main 4:4:4 Intra Profiles	H265HEVCMain444IntraProfiles	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01460000
H.265/HEVC Main 4:4:4 Intra Profile	H265HEVCMain444IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01461000
H.265/HEVC Main 4:4:4 Intra Profile Unconstrained Coding	H265HEVCMain444IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01461001
H.265/HEVC Main 4:4:4 10 Intra Profile	H265HEVCMain44410IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01462000
H.265/HEVC Main 4:4:4 10 Intra Profile Unconstrained Coding	H265HEVCMain44410IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01462001
H.265/HEVC Main 4:4:4 12 Intra Profile	H265HEVCMain44412IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01463000
H.265/HEVC Main 4:4:4 12 Intra Profile Unconstrained Coding	H265HEVCMain44412IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01463001
H.265/HEVC Main 4:4:4 16 Intra Profile	H265HEVCMain44416IntraProfile	NODE	urn:smpte:ul:060e2b34.0401010d.04010202.01465000
H.265/HEVC Main 4:4:4 16 Intra Profile Unconstrained Coding	H265HEVCMain44416IntraProfileUnconstrainedCoding	LEAF	urn:smpte:ul:060e2b34.0401010d.04010202.01465001

NOTE 1 The node entries do not constitute valid essence coding UL values that can be used in the descriptor.

NOTE 2 In Table 3 and the corresponding entries in the SMPTE Labels Register, the term “Unconstrained Coding” is taken to mean “Profile-compliant coding with no additional constraints.”

All Labels are Leaves of urn:smpte:ul:060e2b34.0401010d.04010202.01xxyyzz MPEG Compression. Table 4 shows the meaning of Bytes 14, 15 and 16 of the HEVC Essence Coding Label.

Table 4 — Meaning of HEVC Essence Coding Label

Byte No.	Description	Value (hex)	Meaning
14	HEVC Profile Category	xxh	Identifies the HEVC Profile Category defined in Table 5. 41h: Main Profiles 42h: Main 4:2:2 Profiles 43h: Main 4:4:4 Profiles 44h: Main Intra Profiles 45h: Main 4:2:2 Intra Profiles 46h: Main 4:4:4 Intra Profiles
15	HEVC Profile Constraints	yyh	Identifies the HEVC Profile and its constraints of the HEVC picture coding. Bits [7..4] shall indicate the maximum bit width of the HEVC Profile. 01h: 8-bit 02h: 10-bit 03h: 12-bit 04h: 14-bit 05h: 16-bit Bits [3..0] shall indicate the constraints of the HEVC picture coding. 00h: Generic application that has no coding constraints Others: Reserved for specifications defining additional coding constraints registered in SMPTE Labels Register
16	HEVC Coding variants	zzh	Identifies the HEVC coding variants. When bits [3..0] of byte 15 indicates a generic application, the value of byte 16 shall be 01h.

The relation of the HEVC Profile Categories defined in this specification and the HEVC Profiles defined in the ISO/IEC 23008-2 I Rec. ITU-T H.265 is given in Table 5.

Table 5 — HEVC Profile Category

HEVC Profile Categories	HEVC Profiles
H.265/HEVC Main Profiles	H.265/HEVC Main Profile H.265/HEVC Main 10 Profile H.265/HEVC Main 12 Profile
H.265/HEVC Main 4:2:2 Profiles	H.265/HEVC Main 4:2:2 10 Profile H.265/HEVC Main 4:2:2 12 Profile
H.265/HEVC Main 4:4:4 Profiles	H.265/HEVC Main 4:4:4 Profile H.265/HEVC Main 4:4:4 10 Profile H.265/HEVC Main 4:4:4 12 Profile
H.265/HEVC Main Intra Profiles	H.265/HEVC Main Intra Profile H.265/HEVC Main 10 Intra Profile H.265/HEVC Main 12 Intra Profile
H.265/HEVC Main 4:2:2 Intra Profiles	H.265/HEVC Main 4:2:2 10 Intra Profile H.265/HEVC Main 4:2:2 12 Intra Profile
H.265/HEVC Main 4:4:4 Intra Profiles	H.265/HEVC Main 4:4:4 Intra Profile H.265/HEVC Main 4:4:4 10 Intra Profile H.265/HEVC Main 4:4:4 12 Intra Profile H.265/HEVC Main 4:4:4 16 Intra Profile

NOTE 3 There are some minor HEVC Profiles defined in the ISO/IEC 23008-2 I Rec. ITU-T H.265 that are not included in Table 3 and Table 5.

9 Essence Descriptor for HEVC Mapping

9.1 HEVC Sub Descriptor

For the HEVC wrapping, the HEVC Sub Descriptor, which is strongly referenced from the CDCI Descriptor or the RGBA Descriptor, should be used. The HEVC Sub Descriptor consists of the HEVC-specific properties as shown in Table 6 and Table 7. If the properties in Table 7 are present, their values shall apply to the entire Essence described. Therefore, these properties allow fixed picture patterns to be identified.

Annex A defines an additional optional HEVC Sub Descriptor item.

Table 6 — HEVC Sub Descriptor ULs

Item Name	Symbol	Kind	Item UL
HEVC Sub Descriptor	HEVCSubDescriptor	LEAF	urn:smpte:ul:060e2b34.02530101.0d010101.01018101
HEVC Constant B Picture Flag	HEVCConstantBPictureFlag	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02030000
HEVC Coded Content Kind	HEVCCodedContentKind	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02040000
HEVC Closed GOP Indicator	HEVCClosedGOPIndicator	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02060000
HEVC Identical GOP Indicator	HEVCIdenticalGOPIndicator	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02070000
HEVC Maximum GOP Size	HEVCMaximumGOPSize	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02080000
HEVC Maximum B Picture Count	HEVCMaximumBPictureCount	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02090000
HEVC Profile	HEVCProfile	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.020a0000
HEVC Maximum Bitrate	HEVCMaximumBitrate	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.020b0000
HEVC Profile Constraint	HEVCProfileConstraint	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.020c0000
HEVC Level	HEVCLevel	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.020d0000
HEVC Decoding Delay	HEVCDecodingDelay	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.020e0000
HEVC Maximum Ref Frames	HEVCMaximumRefFrames	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.020f0000

Item Name	Symbol	Kind	Item UL
HEVC Sequence Parameter Set Flag	HEVCSequenceParameterSetFlag	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02100000
HEVC Picture Parameter Set Flag	HEVCPictureParameterSetFlag	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02110000
HEVC Tier	HEVCTier	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02120000
HEVC Video Parameter Set Flag	HEVCVideoParameterSetFlag	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02130000
HEVC Average Bitrate	HEVCAverageBitrate	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02140000
HEVC CTU Size	HEVCCTUSize	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02150000
HEVC Tile Uniform Spacing Flag	HEVCTileUniformSpacingFlag	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02160000
HEVC Tile Columns Minus 1	HEVCTileColumnsMinus1	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02170000
HEVC Tile Rows Minus 1	HEVCTileRowsMinus1	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02180000
HEVC Tile Width Minus 1	HEVCTileWidthMinus1	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.02190000
HEVC Tile Height Minus 1	HEVCTileHeightMinus1	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.021a0000

Table 7 — Element of HEVC Sub Descriptor Set

Symbol	Type	Len	Req ?	Meaning	Default
HEVCSubDescriptor	Set UL	16	Req	Defines the HEVC Sub Descriptor Set	
Length	BER Length	4	Req	Set length	
All items from the abstract Sub Descriptor as specified in SMPTE ST 377-1:2019 Annex B.3					
HEVCDecodingDelay	UInt8	1	Req	Specifies the delay required for decoded pictures in number of access units. The value is given by the presentation time of the first presented picture in a GOP minus the decoding time of the first decoded picture in the GOP. The value shall be zero if there are no B Pictures in the essence stream. The value shall be FFh if the delay is unknown.	
HEVCConstantBPictureFlag	Boolean	1	Opt	TRUE if the number of the consecutive B Pictures is always constant. FALSE if the number of the consecutive B Pictures is not constant or is unknown.	FALSE
HEVCCodedContentKind	HEVCCoded ContentType	1	Opt	‘0’ = “Unknown” ‘1’ = “Progressive Frame Picture” ‘2’ = “Interlaced Field Picture” Enumerated value specifying Picture type and Coding type. See Table 8 for details.	0
HEVCClosedGOPIndicator	Boolean	1	Opt	TRUE if all GOPs are started with an IDR Picture. FALSE if not all GOPs are started with an IDR Picture or if it is unknown whether all GOPs start with an IDR Picture	FALSE
HEVCIdenticalGOPIndicator	Boolean	1	Opt	TRUE if every GOP in the sequence has the same number of pictures and the same types of pictures in the same order. FALSE if not all GOPs are known, or if there is at least one GOP in the sequence which has any of the following: 1. a different number of pictures 2. the same type of pictures but in a different order 3. different types of pictures.	FALSE
HEVCMaximumGOPSize	UInt16	2	Opt	Specifies the maximum occurring spacing between I Pictures. A value of 0 or the absence of this property indicates either there is no limit to the maximum GOP or the maximum GOP is unknown.	
HEVCMaximumBPictureCount	UInt16	2	Opt	Specifies the maximum number of B Pictures between P or I Pictures.	

Symbol	Type	Len	Req ?	Meaning	Default
HEVCMaximumBitrate	UInt32	4	Opt	Maximum bit rate of the HEVC stream in bit/s is given by bit_rate_scale and bit_rate_value_minus1 in the HRD parameters in the sequence parameter set. The equivalent value is assigned for this property of the stream even if the stream does not include the HRD parameters.	
HEVCAverageBitrate	UInt32	4	Opt	Average bitrate of the HEVC stream in bit/s over the entire HEVC bitstream.	
HEVCProfile	UInt8	1	Opt	Specifies the HEVC video profile. The value is taken from general_profile_idc in the sequence parameter set.	
HEVCProfileConstraint	UInt16	2	Opt	Specifies the HEVC video profile constraint flags. The value of bit [15..4] is taken from general_non_packed_constraint_flag, general_frame_only_constraint_flag, general_max_12bit_constraint_flag, general_max_10bit_constraint_flag, general_max_8bit_constraint_flag, general_max_422chroma_constraint_flag, general_max_420chroma_constraint_flag, general_max_monochrome_constraint_flag, general_intra_constraint_flag, general_one_picture_only_constraint_flag, general_lower_bit_rate_constraint_flag, and general_max_14bit_constraint_flag in the sequence parameter set. The value of bit [3..0] shall be zero.	
HEVCLevel	UInt8	1	Opt	Specifies the HEVC level. The value is taken from general_level_idc in the sequence parameter set.	
HEVCTier	UInt8	1	Opt	Specifies the HEVC tier. The value is taken from general_tier_flag in the sequence parameter set.	
HEVCMaximumRefFrames	UInt8	1	Opt	Specifies the maximum number of reference frames.	
HEVCVideoParameterSetFlag	UInt8	1	Opt	Specifies the location and the constancy of video parameter sets. See Table 9 for details.	0
HEVCSequenceParameterSetFlag	UInt8	1	Opt	Specifies the location and the constancy of sequence parameter sets. See Table 10 for details.	0
HEVCPictureParameterSetFlag	UInt8	1	Opt	Specifies the location and the constancy of picture parameter sets. See Table 11 for details.	0
HEVCCTUSize	UInt8	1	Opt	Specifies the size of CTU. The value is log2(horizontal and vertical size of the CTU) – 3 as follows. 1 for 16x16 2 for 32x32 3 for 64x64 Other values are prohibited.	
HEVCTileUniformSpacingFlag	Boolean	1	Opt	TRUE if tile column boundaries and tile row boundaries are distributed uniformly. FALSE if tile column boundaries and tile row boundaries are not distributed uniformly. The value is taken from uniform_spacing_flag in the picture parameter set. If there is no tile division, this property shall not be present	
HEVCTileColumnsMinus1	UInt8	1	Opt	Specifies the number of tile columns minus 1. The value is taken from num_tile_columns_minus1 in the picture parameter set. If there is no tile division, this property shall not be present.	

Symbol	Type	Len	Req ?	Meaning	Default
HEVCTileRowsMinus1	UInt8	1	Opt	Specifies the number of tile rows minus 1. The value is taken from num_tile_rows_minus1 in the picture parameter set. If there is no tile division, this property shall not be present.	
HEVCTileWidthMinus1	Array of UInt16	8+2n	Opt	Specifies the width minus 1 of tiles in units of CTBs. The value is taken from column_width_minus1 in the picture parameter set. If there is no tile division or the value of HEVC Tile Uniform Spacing Flag is TRUE, this property shall not be present.	
HEVCTileHeightMinus1	Array of UInt16	8+2n	Opt	Specifies the height minus 1 of tiles in units of CTBs. The value is taken from row_height_minus1 in the picture parameter set. If there is no tile division or the value of HEVC Tile Uniform Spacing Flag is TRUE, this property shall not be present.	

The HEVCCodedContentType type shall be an enumerated UInt8 specifying picture type and coding type for HEVC coded content.

Table 8 — Meaning of HEVC Coded Content Kind

Value	Source image	Picture type	Coding type
0	Unknown		
1	Progressive	Frame	Frame Coding
2	Interlaced	Field	Field Coding
3 to Fh			Reserved

NOTE 1 In the case of Value 1 of the HEVC Coded Content Kind, if byte 15 of the Picture Element Key is 05h (Frame Wrapped), then byte 16 of the HEVC Essence Container Label is 01h (Frame Wrapping).

NOTE 2 In the case of Value 2 of the HEVC Coded Content Kind, if byte 15 of the Picture Element Key is 05h (Frame Wrapped), then byte 16 of the HEVC Essence Container Label is either 01h (Frame Wrapping) or 09h (Field Wrapping) as defined in Clause 7.3.

Table 9 — Meaning of HEVC Video Parameter Set Flag

Bit number	Name	Values and Descriptions	Default
7	Constancy flag	Specifies whether all video parameter sets are constant 0: unknown (video parameter sets may vary in the stream) 1: constant (all video parameter sets are identical throughout the stream)	0
6 to 4	In-band location	Specifies the location of video parameter sets in the stream 0: Unknown or no specific location 1: Only the first access unit in the stream 2: Every access unit in the stream 3: Periodically placed at the first access unit in each GOP others: reserved	0
3 to 0	reserved	Reserved for future use and shall be zero	0

Table 10 — Meaning of HEVC Sequence Parameter Set Flag

Bit number	Name	Values and Descriptions	Default
7	Constancy flag	Specifies whether all sequence parameter sets are constant 0: unknown (sequence parameter sets may vary in the stream) 1: constant (all sequence parameter sets are identical throughout the stream)	0
6 to 4	In-band location	Specifies the location of sequence parameter sets in the stream 0: Unknown or no specific location 1: Only the first access unit in the stream 2: Every access unit in the stream 3: Periodically placed at the first access unit in each GOP others: reserved	0
3 to 0	reserved	Reserved for future use and shall be zero	0

Table 11 — Meaning of HEVC Picture Parameter Set Flag

Bit number	Name	Values and Descriptions	Default
7	Constancy flag	Specifies whether all picture parameter sets are constant 0: unknown (picture parameter sets may vary in the stream) 1: constant (all picture parameter sets are identical throughout the stream)	0
6 to 4	In-band location	Specifies the location of picture parameter sets in the stream 0: Unknown or no specific location 1: Only the first access unit in the stream 2: Every access unit in the stream 3: Periodically placed at the first access unit in each GOP others: reserved	0
3 to 0	reserved	Reserved for future use and shall be zero	0

9.2 Key for the HEVC Sub Descriptor

The key (UL) for this Local Set shall be as defined in Table 12.

Table 12 — Key for HEVC Sub Descriptor

Byte No.	Description	Value (hex)	Meaning
1 to 13	Defined in the Structural Header Metadata Implementation clause of SMPTE ST 377-1		
14	Set Kind (1)	01h	HEVC Sub Descriptor
15	Set Kind (2)	81h	
16		01h	

NOTE The version byte of the HEVC Sub Descriptor Key is 01h.

10 Index Table for HEVC Mapping

This clause clarifies how the Index Entry Properties are set for indexing an HEVC stream.

There are several properties in the Index Table Entry that have specific meanings for an HEVC Long GOP MPEG Index Table. The Flags Property, shown in Table 13, shall be correctly set for HEVC according to the text following Table 13 that describes the conditions for setting the Flags.

NOTE Flags bits 3 to 0 are reserved for use in SMPTE Essence mapping specifications in SMPTE ST 377-1 and the definitions for HEVC Essence mapping are given in this document.

Table 13 — Index Table Entry Properties for HEVC

Parameter	Type	Meaning	Use
Temporal Offset	Int8	Offset in Edit Units from Display Order to Coded Order (see SMPTE ST 377-1 for usage)	Used to find the Index Entry for a stored Picture given its Display Temporal position.
Key Frame Offset	Int8	Offset in Edit Units to previous Key Picture. The value is zero if this is a Key Picture.	The offset to the Key Picture
Flags	UInt8	Flags for this Edit Unit Bit 7: Random Access Bit 6: Sequence Parameter Set Bits 5,4: Forward/backwards prediction flag Bit 3: Offsets out of range Bits 2,1,0: HEVC picture type	Used to fetch a sufficient number of frames to ensure that all Key Pictures required to decode any Picture within the MPEG GOP sequence are available

Temporal Offset: This is an offset used to allow lookups in the Index Table. It corresponds to the difference between the display order and coded order for the indexed picture measured in Edit Units, not in frames. This is explained in the text of SMPTE ST 377-1.

If the numerical range of this Property is exceeded, then bit 3 of the Flags shall be set, and this Property shall be clipped to the maximum value which can be represented. The actual temporal offset may be determined by inspecting Index Entries for neighboring pictures until a valid temporal offset is found. The value of temporal offset may be determined by the number of Index Entries inspected, their picture types and the valid temporal offset value found.

Key Frame Offset: This is the offset measured in Edit Units (not frames) to the Key Picture (I Picture) required for decoding the indexed picture.

If the stream consists of I Pictures only, then this parameter shall be zero since there would be no Key Pictures required to decode an indexed picture.

If the numerical range of this Property is exceeded, then bit 3 of the Flags shall be set, and this Property shall be clipped to the maximum value which can be represented. The actual Key Frame Offset may be determined by inspecting Index Entries for neighboring pictures until a valid Key Frame Offset is found. The value of Key Frame Offset may be determined by the number of Index Entries inspected, their picture types and the valid Key Frame Offset value found.

Key Frame Offset is always negative for HEVC streams. The offset is measured in Edit Units and is the coded order offset of the Key Picture Index Entry. This keeps the meaning of the sign of Key Frame Offset consistent with the sign of temporal offset. It also means that the only display order process is to use the temporal offset to find the appropriate index entry. Index entries are always stored in coded order.

Flag Bit 7: This is the random access bit when a random access point in the HEVC Long GOP stream is encountered. A random access point is one where decoding can commence at that point in the stream with valid parameter sets.

All random access points will be the first access unit in a GOP.

All Pictures needed for display after the recovery point will have no decoding dependency on any data preceding the random access point. They are also present in the decoding sequence after this random access point.

Flag Bit 6: This bit shall mark a sequence parameter set in the HEVC stream.

Flag Bits 5 and 4: These bits shall indicate the temporal dependence of the Indexed Picture. The settings of these bits by an encoder shall be as follows:

- 00 No prediction. This is always the case for I Pictures.
- 10 Forward prediction from previous Picture.
- 01 Backward prediction to future Picture.
- 11 Forward and backward prediction.

Flag Bit 3: This bit shall indicate that the numerical range of the Temporal Offset or Key Frame Offset fields has been exceeded. In this case, the offset and/or Key Picture may be determined by inspecting other Index Entries to determine the precise values.

Flag Bits 2, 1 and 0: These bits indicate HEVC picture type. The setting of these bits shall be as follows:

- 000 Non-IDR I Picture (CRA Picture or BLA Picture)
- 100 IDR Picture
- 010 P Picture. This Picture may be referenced.
- 110 referenced P Picture
- 011 non-referenced B Picture
- 111 referenced B Picture (Br Picture)

Annex A HEVC Sub Descriptor Item for closed environments (normative)

The HEVC Sub Descriptor item shown in Table A.1 and Table A.2 may be used in closed environments to distinguish it from the generic optional items listed in Table 7. The item is not needed for generic decoder designs, but useful for decoders of embedded systems with limited memory capacity.

Table A.1 — HEVC Sub Descriptor UL for closed applications

Item Name	Symbol	Kind	Item UL
HEVC Number of PPSs	HEVCNumberOfPPSs	LEAF	urn:smpte:ul:060e2b34.0101010e.04010606.021b0000

Table A.2 — Element of HEVC Sub Descriptor Set for closed applications

Symbol	Type	Len	Req ?	Meaning	Default
HEVCNumberOfPPSs	UInt8	1	Opt	Maximum number of picture parameter sets that have different pps_pic_parameter_set_id in each GOP.	64

Annex B HEVC Essence Container Label structure (informative)

Table B.1 shows the basis of the derivation of the HEVC Essence Container Label values.

Table B.1 — Structure of the HEVC Essence Container Label

Byte No.	Description	Value (hex)	Meaning
1 to 12	Specified by the MXF Generic Container Specification, SMPTE ST 379-1 and SMPTE ST 379-2		
13	Essence Container Kind	02h	MXF Generic Container (as defined in SMPTE ST 379-1 and SMPTE ST 379-2)
14	Mapping Kind	1Fh 20h	HEVC NAL unit stream HEVC byte stream
15	Locally defined	6zh	ISO/IEC 13818-1 stream_id bits 6..0 The default value is 60h.
16	Locally defined	yyh	00h: Not used 01h: Frame Wrapping 02h: Clip Wrapping 03h: Custom: Stripe Wrapping 04h: Reserved 05h: Reserved 06h: Custom: Splice 07h: Custom: Closed GOP 08h: Custom: Slave 09h: Frame (Field) Wrapping 0Ah to 7Eh: Reserved 7Fh: Custom: No specific wrapping constraints

Byte 14 identifies the container as the MPEG mapping into the Generic Container.

Byte 15 enumerates the content of the element within the essence container. According to ISO/IEC 13818-1, stream_id ‘1110 xxxx’ is assigned to HEVC video stream number ‘xxxx’, where binary notation is indicated by enclosing the string of bit values by single quote marks and each x means ‘0’ or ‘1’. The stream_id value is mapped to byte 15 with setting bit 7 to 0, therefore, byte 15 value ‘0110 xxxx’ (6zh) is assigned to HEVC video stream number ‘xxxx’ (zh).

The custom wrappings (byte 16 values of 03h, 06h, 07h and 08h) are as defined in SMPTE ST 381-2 which inherits the definition from SMPTE ST 381-1.

The version byte of the Essence Container Label is 0Dh.

Bibliography (informative)

SMPTE ST 381-1:2005, Material Exchange Format (MXF) – Mapping MPEG Streams into the MXF Generic Container

SMPTE ST 381-3:2017, Material Exchange Format (MXF) – Mapping AVC Streams into the MXF Generic Container

ISO/IEC 13818-1:2019, Information technology – Generic coding of moving pictures and associated audio information: Systems