SMPTE ST 2065-5:2023
Revision of SMPTE ST 2065-5:2016

SMPTE STANDARD

Material Exchange Format — Mapping ACES Image Sequences into the MXF Generic Container

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Foreword

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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.

The following changes were made during the revision process:

- The constraints for the following items of the Generic Picture Essence Descriptor were updated: Signal Standard, Active Format Descriptor, Video Line Map, Coding Equations
- Editorial changes, including rearrangement of subclauses

Introduction

This clause is entirely informative and does not form an integral part of this Engineering Document.

This standard specifies the mapping of a sequence of ACES coded still images into the MXF Constrained Generic Container, which is specified in SMPTE ST 379-2.

ACES is an image-by-image coding scheme where each image is coded in an entirely independent bitstream and can be processed as an independent entity.

This essence mapping does not constrain the use of any particular operational pattern.

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1 Scope

This standard specifies frame- and clip-based mappings of a sequence of monoscopic ACES images, as specified in SMPTE ST 2065-4, into the MXF Constrained Generic Container, as defined in SMPTE ST 379-2.

This standard specifies the key, the length, and the value fields of the ACES coded picture element. This standard also defines the essence container and label values and the essence descriptor.

2 Normative References

The following standards contain provisions that, through reference in this text, constitute provisions of this standard. Dated references require that the specific edition cited shall be used as the reference. Undated citations refer to the edition of the referenced document (including any amendments) current at the date of publication of this document. All standards are subject to revision, and users of this engineering document are encouraged to investigate the possibility of applying the most recent edition of any undated reference.

SMPTE ST 298:2009, Universal Labels for Unique Identification of Digital Data

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

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

SMPTE ST 2065-4:2023, ACES Image Container File Layout

3 Terms and Definitions

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

3.1
UL

SMPTE Administered Universal Label as defined in SMPTE ST 298

3.2
ACES image

ACES image container file as defined in SMPTE ST 2065-4

4 Essence Container Constraints

4.1 General

The essence container shall conform to SMPTE ST 379-2.

The ACES images shall be monoscopic.

4.2 Homogeneous Essence

The byte count of all ACES images in the sequence shall be identical.

NOTE The end-of-file filler and/or the optional image header attribute “free” (see SMPTE ST 2065-4) can be used to achieve a constant image size.

The ACES image header attributes listed in Table 1, and defined in SMPTE ST 2065-4, shall be identical for all ACES images.

Table 1 — ACES image header attributes constrained by this standard

channels
dataWindow
displayWindow
pixelAspectRatio

5 Key and Value Coding

5.1 Picture Element Key

The picture element key shall be the UL defined in Table 2 or the UL defined in Table 3. Values for bytes 14 and 16 (denoted cc and nn respectively) are defined in SMPTE ST 379-2. Table 2 and Table 3 define Essence registry entries for the ACES picture element keys.

Table 2 — ACES frame-wrapped picture element key

Name	Frame-wrapped ACES Picture Element
Item UL	urn:smpte:ul:060e2b34.01020101.0d010301.15cc12nn
Definition	Identifies a frame-wrapped ACES Picture Element

Table 3 — ACES clip-wrapped picture element key

Name	Clip-wrapped ACES Picture Element
Item UL	urn:smpte:ul:060e2b34.01020101.0d010301.15cc13nn
Definition	Identifies a clip-wrapped ACES Picture Element

5.2 Picture Element Value

5.2.1 Frame-wrapped

The value field shall comprise a single ACES image.

5.2.2 Clip-wrapped

The value field shall comprise a sequence of one or more concatenated ACES images.

Each individual ACES image within a sequence of ACES images shall contain all components of the ACES file layout as defined in SMPTE ST 2065-4. The components of the file layout are the magic number, a version field, the header, the line offset table, the scan line storage and the end-of-file filler.

6 SMPTE Label Values

6.1 Essence Container Label

This Essence Container Label is the UL value carried in the Essence Containers Properties of the Partition Packs, Preface Set and File Descriptor. Partition Packs, Preface Set and File Descriptor are as defined in SMPTE ST 377-1.

The value for the Essence Container Label shall be the UL defined in Table 5 or the UL defined in Table 6. Table 4, Table 5 and Table 6 define Label registry entries for the ACES Essence Container labels.

The essence container UL is used within a batch of ULs in partition packs and the preface set and on its own in the essence descriptor.

Table 4 — Essence container label node for ACES images

Name	MXF-GC ACES Pictures
Symbol	MXFGCACESPictures
Namespace	http://www.smpte-ra.org/reg/400/2012/13/1/aaf
Item UL	urn:smpte:ul:060e2b34.0401010d.0d010301.02190000
Definition	Identifiers for MXF-GC mappings of ACES SMPTE ST 2065-4 Pictures

Table 5 — Essence container label for Frame-wrapped ACES images

Name	MXF-GC Frame-wrapped ACES Pictures
Symbol	MXFGCFrameWrappedACESPictures
Namespace	http://www.smpte-ra.org/reg/400/2012/13/1/aaf
Item UL	urn:smpte:ul:060e2b34.0401010d.0d010301.02190100
Definition	Identifier for MXF-GC, Frame-wrapped ACES SMPTE ST 2065-4 images

Table 6 — Essence container label for Clip-wrapped ACES images

Name	MXF-GC Clip-wrapped ACES Pictures
Symbol	MXFGCClipWrappedACESPictures
Namespace	http://www.smpte-ra.org/reg/400/2012/13/1/aaf
Item UL	urn:smpte:ul:060e2b34.0401010d.0d010301.02190200
Definition	Identifier for MXF-GC, Clip-wrapped ACES SMPTE ST 2065-4 images

6.2 Picture Essence Coding Label

The picture essence coding label is a UL used in the generic picture essence descriptor.

The value for the picture essence coding label shall be the UL defined in Table 8 or the UL defined in Table 9. Table 7, Table 8 and Table 9 define Label registry entries for the ACES Picture Essence Coding labels.

Table 7 — Picture essence coding label node for ACES SMPTE ST 2065-4 picture coding

Name	ACES Picture Coding Schemes
Symbol	ACESPictureCodingSchemes
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04010202.03040000
Definition	Identifies ACES SMPTE ST 2065-4 Picture Coding Schemes

Table 8 — Picture essence coding label for ACES SMPTE ST 2065-4 monoscopic uncompressed picture coding without alpha channel

Name	ACES Uncompressed Monoscopic Without Alpha
Symbol	ACESUncompressedMonoscopicWithoutAlpha
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04010202.03040100
Definition	Identifier for ACES SMPTE ST 2065-4 monoscopic uncompressed picture coding without alpha channel

Table 9 — Picture essence coding label for ACES SMPTE ST 2065-4 monoscopic uncompressed picture coding with alpha channel

Name	ACES Uncompressed Monoscopic With Alpha
Symbol	ACESUncompressedMonoscopicWithAlpha
Namespace	http://www.smpte-ra.org/reg/400/2012
Item UL	urn:smpte:ul:060e2b34.0401010d.04010202.03040200
Definition	Identifier for ACES SMPTE ST 2065-4 monoscopic uncompressed picture coding with alpha channel

7 Application Issues

7.1 Index Table Usage (Informative)

The length of an ACES image is not indicated in the ACES header component. If there is no index table as defined in SMPTE ST 377-1 and clip-wrapping is used, an arbitrary ACES image within the essence can be reached by:

- first seeking to the beginning of the end of file filler of the first ACES image in the essence container,
- then, from that position, searching for the magic number of the second ACES image in the essence container,
- then seeking to the beginning of the end of file filler of the second ACES image in the essence container,
- and so forth until the desired ACES image is reached.

An index table can provide the means to directly seek to an image.

7.2 Essence Container Partitions

Each ACES image shall be entirely within one partition.

NOTE SMPTE ST 377-1:2019, Clause 6.2.2 (Partition Rules Summary) summarizes the use of partitions in MXF files.

8 Essence Descriptors

8.1 General

SMPTE ST 2065-4 defines only RGB images (with or without alpha channel). Therefore, the Top-Level File Package of Image Track File shall reference an RGBA Picture Essence Descriptor as defined in SMPTE ST 377-1.

8.2 Generic Picture Essence Descriptor

8.2.1 Constraints

The Generic Picture Essence Descriptor items, as defined in SMPTE ST 377-1, shall be constrained as specified in Table 10.

Table 10 — Generic Picture Essence Descriptor Items

Generic Picture Essence Descriptor Item Name	Constraints
Sample Rate	See Clause 8.2.2.
Signal Standard	Shall be ignored.
Frame Layout	Shall be 00h (= full_frame)
Stored Width	See Clause 8.2.3.
Stored Height	See Clause 8.2.3.
StoredF2Offset	Shall not be present.
Sampled Width	Shall not be present or shall be equal to Stored Width.
Sampled Height	Shall not be present or shall be equal to Stored Height.
SampledXOffset	Shall not be present or shall be 0.
SampledYOffset	Shall not be present or shall be 0.
DisplayHeight	See Clause 8.2.4.
DisplayWidth	
DisplayXOffset	
DisplayYOffset	
DisplayF2Offset	Shall not be present.
AspectRatio	See Clause 8.2.5.
Active Format Descriptor	Shall be ignored.
Video Line Map	Shall be ignored.
Alpha Transparency	Shall not be present.
Transfer Characteristic	Shall be present. See Clause 8.2.6.
Image Alignment Offset	Shall not be present.

Generic Picture Essence Descriptor Item Name	Constraints
Image Start Offset	Shall not be present.
Image End Offset	Shall not be present.
FieldDominance	Shall not be present.
Picture Essence Coding	Shall be present. See Clause 6.2.
Coding Equations	Shall be ignored.
Color Primaries	Shall be present. See Clause 8.2.7.

NOTE All item names are as listed in SMPTE ST 377-1. Some item names might be inconsistent between SMPTE ST 377-1 and the SMPTE register.

8.2.2 Sample Rate

The value of the Sample Rate shall be set according to the Edit Rate of the material.

8.2.3 Stored Width and Stored Height

The values of the Stored Width and Stored Height items shall be set according to the ACES `dataWindow` attribute, as specified in Table 11. The ACES attributes are defined in SMPTE ST 2065-4.

Table 11 — Stored Width and Stored Height values

MXF Item Name	*Values from required ACES Attributes*
Stored Width	dataWindow.xMax – dataWindow.xMin + 1
Stored Height	dataWindow.yMax – dataWindow.yMin + 1

8.2.4 DisplayWidth, DisplayHeight, DisplayXOffset, DisplayYOffset

The values of the DisplayWidth, DisplayHeight, DisplayXOffset and DisplayYOffset items shall be set according to the ACES `displayWindow` and `dataWindow` attributes, as specified in Table 12. The ACES attributes are defined in SMPTE ST 2065-4.

Table 12 — Display values

MXF Item Name	*Values from required ACES Attributes*
DisplayWidth	displayWindow.xMax – displayWindow.xMin + 1
DisplayHeight	displayWindow.yMax – displayWindow.yMin + 1
DisplayXOffset	displayWindow.xMin – dataWindow.xMin
DisplayYOffset	displayWindow.yMin – dataWindow.yMin

8.2.5 Aspect Ratio

The value of the Aspect Ratio item shall be calculated from the ACES `displayWindow` and `pixelAspectRatio` attributes as specified in Table 13. The ACES attributes are defined in SMPTE ST 2065-4.

Table 13 — Aspect Ratio value

MXF Item Name	*Values from required ACES Attributes*
Aspect Ratio (numerator)	roundToIntegralTiesToAway(DisplayWidth * pixelAspectRatio)
Aspect Ratio (denominator)	DisplayHeight

roundToIntegralTiesToAway(x) rounds x to the nearest integral value, with halfway cases rounding away from zero.

NOTE 1 For the calculation of DisplayWidth and DisplayHeight see Clause 8.2.4.

NOTE 2 In case of non-square pixels (i.e., `pixelAspectRatio` is not equal to 1.0), the calculation rule for the numerator value of the Aspect Ratio item as given in Table 13 can introduce a rounding error.

8.2.6 Transfer Characteristic

The value of the Transfer Characteristic item shall be the UL defined in Table 14. Table 14 shows the Label registry entry for the Linear Transfer Characteristic label.

Table 14 — Registry Entry for the Linear Transfer Characteristic Label

Name	`Linear Transfer Characteristic`
Symbol	`TransferCharacteristic_linear`
Namespace	`http://www.smpte-ra.org/reg/400/2012`
Item UL	`urn:smpte:ul:060e2b34.04010106.04010101.01060000`
Definition	`Identifies a linear transfer characteristic`

8.2.7 Color Primaries

The value of the Color Primaries item shall be the UL defined in Table 15. Table 15 defines the Label registry entry for the ACES Color Primaries label.

Table 15 — Registry Entry for the ACES Color Primaries Label

Name	`ACES Color Primaries`
Symbol	`ColorPrimaries_ACES`
Namespace	`http://www.smpte-ra.org/reg/400/2012`
Item UL	`urn:smpte:ul:060e2b34.0401010d.04010101.03070000`
Definition	`Identifies ACES SMPTE ST 2065-1 color primaries and white point`

8.3 RGBA Picture Essence Descriptor

8.3.1 Constraints

The RGBA Picture Essence Descriptor items shall be constrained as specified in Table 16.

Table 16 — RGBA Picture Essence Descriptor items

RGBA Picture Essence Descriptor Item Name	Constraints
Component Max Ref	Shall not be present.
Component Min Ref	Shall not be present.
Alpha Max Ref	Shall not be present.
Alpha Min Ref	Shall not be present.
ScanningDirection	Shall be present and shall be equal to 00h.
PixelLayout	See 8.3.2
Palette	Shall not be present.
PaletteLayout	Shall not be present.

NOTE All item names are as listed in SMPTE ST 377-1. Some item names might be inconsistent between SMPTE ST 377-1 and the SMPTE register.

8.3.2 PixelLayout

The channel structure of ACES images is defined in SMPTE ST 2065-4.

For ACES images with channels “B”, “G” and “R”, the value of the PixelLayout item shall be equal to:

```
{‘B’, 253, ‘G’, 253, ‘R’, 253, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}
```

For ACES images with channels “A”, “B”, “G” and “R”, the value of the PixelLayout item shall be equal to:

```
{‘A’, 253, ‘B’, 253, ‘G’, 253, ‘R’, 253, 0, 0, 0, 0, 0, 0, 0, 0}
```

Bibliography

SMPTE ST 2065-1:2021, Academy Color Encoding Specification (ACES)