

# SMPTE STANDARD



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

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## 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.

SMPTE ST 2065-5 was prepared by Technology Committee 31FS.

## 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.

## Introduction

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

This standard specifies the mapping of a sequence of ACES (SMPTE ST 2065-4) coded still images into the MXF generic container, as 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.

## 1 Scope

This standard specifies frame- and clip-based mappings of a sequence of monoscopic ACES coded still pictures, as specified in SMPTE ST 2065-4, into the MXF 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 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 section 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 298:2009, Universal Labels for Unique Identification of Digital Data

SMPTE ST 377-1:2011, Material Exchange Format (MXF) — File Format Specification

Amendment 1:2012 to SMPTE ST 377-1:2011

Amendment 2:2012 to SMPTE ST 377-1:2011

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

SMPTE ST 2065-1:2012, Academy Color Encoding Specification (ACES)

SMPTE ST 2065-4:2013, ACES Image Container File Layout

## 4 Terms and Definitions

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

### 4.1 UL

SMPTE Administered Universal Label as defined in SMPTE ST 298.

### 4.2 ACES image

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

## 5 Essence Container Constraints

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

## 6 Homogeneous Essence

For both frame-wrapping and clip-wrapping as specified in SMPTE ST 379-2, the ACES image header attributes listed in Table 1, and defined in SMPTE ST 2065-4, shall be identical for all ACES images in the essence container.

**Table 1 – ACES image header attributes (SMPTE ST 2065-4) to be identical**

ACES image header attribute
channels
dataWindow
displayWindow
pixelAspectRatio

The size in bytes of all ACES images in the essence container 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

## 7 Key and Value Coding

### 7.1 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:smppte: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:smppte:ul:060e2b34.01020101.0d010301.15cc13nn
Definition	Identifies a clip-wrapped ACES Picture Element

### 7.2 Picture Element Value

#### 7.2.1 Frame-wrapped

The value field shall comprise a single ACES image as defined in SMPTE ST 2065-4.

#### 7.2.2 Clip-wrapped

The value field shall comprise a sequence of one or more concatenated ACES images, where each ACES image is as defined in SMPTE ST 2065-4.

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.

## 8 SMPTE Label Values

### 8.1 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.

**Table 4 – Essence container label node for ACES SMPTE ST 2065-4 images**

Name	MXF-GC ACES Pictures
Symbol	MXFGCACESPictures
Namespace	<a href="http://www.smpte-ra.org/reg/400/2012/13/1/aaf">http://www.smpte-ra.org/reg/400/2012/13/1/aaf</a>
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 SMPTE ST 2065-4 images**

Name	MXF-GC Frame-wrapped ACES Pictures
Symbol	MXFGCFrameWrappedACESPictures
Namespace	<a href="http://www.smpte-ra.org/reg/400/2012/13/1/aaf">http://www.smpte-ra.org/reg/400/2012/13/1/aaf</a>
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 SMPTE ST 2065-4 images**

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

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.

## 8.2 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	<a href="http://www.smpte-ra.org/reg/400/2012">http://www.smpte-ra.org/reg/400/2012</a>
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	<a href="http://www.smpite-ra.org/reg/400/2012">http://www.smpite-ra.org/reg/400/2012</a>
Item UL	urn:smpite: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	<a href="http://www.smpite-ra.org/reg/400/2012">http://www.smpite-ra.org/reg/400/2012</a>
Item UL	urn:smpite:ul:060e2b34.0401010d.04010202.03040200
Definition	Identifier for ACES SMPTE ST 2065-4 monoscopic uncompressed picture coding with alpha channel

## 9 Application Issues

### 9.1 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.

### 9.2 Essence Container Partitions

Each ACES image shall be entirely within one partition.

Note: SMPTE ST 377-1-2011, Section 6.2.2 (Partition Rules Summary) summarizes the use of partitions in MXF files.

## 10 Essence Descriptors

### 10.1 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.

### 10.2 Generic Picture Essence Descriptor

The Generic Picture Essence Descriptor items shall be constrained as specified in Table 10.

**Table 10 – Generic Picture Essence Descriptor Items**

Generic Picture Essence Descriptor Item	Constraints
Sample Rate	See Section 10.2.1.
Signal Standard	Shall not be present.
Frame Layout	Shall be 00h (= full_frame )
Stored Width	See Section 10.2.2.
Stored Height	See Section 10.2.2.
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	
DisplayWidth	See Section 10.2.3.
DisplayXOffset	
DisplayYOffset	
DisplayF2Offset	Shall not be present.
AspectRatio	See Section 10.2.4.
Active Format Descriptor	Shall not be present.
Video Line Map	Shall be present and equal to {00h,00h} Note: Video Line Map is set to its Distinguished Value because no video interface is defined for ACES.
Alpha Transparency	Shall not be present.
Transfer Characteristic	Shall be present. See Section 10.2.5.
Image Alignment Offset	Shall not be present.

Generic Picture Essence Descriptor Item	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 Section 8.2.
Coding Equations	Shall not be present.
Color Primaries	Shall be present. See Section 10.2.6.

### 10.2.1 Sample Rate

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

### 10.2.2 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**

<i>MXF Item</i>	<i>Values from required ACES Attributes</i>
Stored Width	<code>dataWindow.xMax – dataWindow.xMin + 1</code>
Stored Height	<code>dataWindow.yMax – dataWindow.yMin + 1</code>

### 10.2.3 Display Width, Display Height, Display X Offset, Display Y Offset

The values of the Display Width, Display Height, Display X Offset and Display Y Offset 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**

<i>MXF Item</i>	<i>Values from required ACES Attributes</i>
DisplayWidth	<code>displayWindow.xMax – displayWindow.xMin + 1</code>
DisplayHeight	<code>displayWindow.yMax – displayWindow.yMin + 1</code>
Display X Offset	<code>displayWindow.xMin – dataWindow.xMin</code>
Display Y Offset	<code>displayWindow.yMin – dataWindow.yMin</code>

### 10.2.4 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**

<i>MXF Item</i>	<i>Values from required ACES Attributes</i>
Aspect Ratio (numerator)	<code>roundToIntegralTiesToAway(DisplayWidth*pixelAspectRatio)</code>
Aspect Ratio (denominator)	<code>DisplayHeight</code>

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

The value of Aspect Ratio is provided for information only if the `pixelAspectRatio` is a non-integral value.

Note 1: For the calculation of `DisplayWidth` and `DisplayHeight` see Section 10.2.3

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

### 10.2.5 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	<code>Linear Transfer Characteristic</code>
Symbol	<code>TransferCharacteristic_linear</code>
Namespace	<code>http://www.smp-te-ra.org/reg/400/2012</code>
Item UL	<code>urn:smp-te:ul:060e2b34.04010106.04010101.01060000</code>
Definition	<code>Identifies a linear transfer characteristic</code>

### 10.2.6 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	<code>ACES Color Primaries</code>
Symbol	<code>ColorPrimaries_ACES</code>
Namespace	<code>http://www.smp-te-ra.org/reg/400/2012</code>
Item UL	<code>urn:smp-te:ul:060e2b34.0401010d.04010101.03070000</code>
Definition	<code>Identifies ACES SMPTE ST 2065-1 color primaries and white point</code>

### 10.3 RGBA Picture Essence Descriptor

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	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 10.3.1
Palette	Shall not be present.
PaletteLayout	Shall not be present.

#### 10.3.1 PixelLayout

The channel structure of ACES images is defined in SMPTE ST 2065-4. This standard supports wrapping of monoscopic images only.

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 }
```

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 }
```