

CONFIDENTIAL COMMITTEE DRAFT

SMPTE STANDARD

**D-Cinema Distribution Master —
Packed Image**Approved - 2024-03-14

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Foreword

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Introduction

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

Digital Cinema Distribution Master (DCDM) image essence is regularly exchanged between post-production facilities, typically using the constrained TIFF files specified at [SMPTE RP 428-5](#). Such exchange is time-consuming and costly because of the size of these files – on the order of 10 TB for a motion picture. This document specifies a means of mapping DCDM images into packed images such that file size is reduced, while:

- preserving all image information;
- preserving image processing throughput;
- preserving file-based workflow practices based on [SMPTE RP 428-5](#); and
- minimizing implementation risk.

This is achieved by:

- using JPEG 2000 reversible coding, which results in a typical file size reduction of 50% while allowing mathematically exact reconstruction of the baseband image code values;
- allowing the use of the block coder specified in [Rec. ITU-T T.814 | ISO/IEC 15444-15](#), which greatly speeds-up encoding and decoding;
- efficiently packing the 12-bit code values of the image essence, removing the need to use a 16-bit container and thereby reducing file size by 25%;
- storing packed images into file sequences using the conventions specified in [SMPTE RP 428-5](#); and
- reusing existing JPEG 2000 operating points.

The resulting files that contained packed images, i.e. lossless JPEG 2000 codestreams, are unrelated to, and not intended to replace the final lossy JPEG 2000 codestreams that will ultimately reside in the D-Cinema Package (DCP) that is distributed to

theaters.

1 Scope

This document specifies a mapping of DCDM images, as specified in [SMPTE ST 428-1](#), into mathematically lossless JPEG 2000 codestreams, each called a packed image.

2 Conformance

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

SMPTE ST 428-1, D-Cinema Distribution Master — Image Characteristics.

SMPTE ST 2067-40, Interoperable Master Format — Application #4 Cinema Mezzanine.

IETF RFC 5234, Augmented BNF for Syntax Specifications: ABNF.

4 **Terms and definitions**

No terms and definitions are listed in this document.

5 **Packed image**

A packed image is a single JPEG 2000 codestream that:

- conforms to the encoding constraints specified at [SMPTE ST 2067-40](#);
- contains an image whose characteristics conform to [SMPTE ST 428-1](#); and
- includes, in its main header, zero or one COM marker that conforms to [Table 1](#).

Table 1 – Contents of the COM marker that signals that the image data conforms to [SMPTE ST 428-1](#).

Parameter	Value
Rcom	1
Ccom ⁱ	53.4D.50.54.45.20.44.43.44.4D.20.58.27.59.27.5A 27.20.69.6D.61.67.65.20.61.73.20.64.65.66.69.6E 65.64.20.69.6E.20.53.4D.50.54.45.20.53.54.20.34 32.38.2D.31

NOTE 1 — The contents of the Ccomⁱ bytes corresponds to the string SMPTE DCDM X'Y'Z' image as defined in SMPTE ST 428-1.

One COM marker that conforms to [Table 1](#) should be present in the main header of the packed image.

RPCL progression order and Pcap¹⁵ = 1 should be used.

[Annex A](#) provides sample packed images.

NOTE 2 — Pcap¹⁵ = 1 specifies that the High-Throughput (HT) block coder defined in [Rec. ITU-T T.814](#) | [ISO/IEC 15444-15](#) is used. The HT block coder significantly improves encoding and decoding speeds.

NOTE 3 — The RPCL progression order allows decoding of images in throughput-limited and -varying environments with a single contiguous read operation of a partial codestream.

NOTE 4 — The constraints of [SMPTE ST 428-1](#) narrow the constraints of [SMPTE ST 2067-40](#). For example, XRsizⁱ = YRsizⁱ = 1 for all components.

6 **File sequence and naming convention**

A sequence of packed images can be stored as a sequence of files as follows.

Each file shall contain exactly one packed image.

All packed images in the sequence shall have identical image characteristics, as specified in [SMPTE ST 428-1](#), but their encoding constraints, as specified in [SMPTE ST 2067-40](#), may vary.

All files from one sequence shall be stored in one directory that contains files from no other sequence.

The file name of each file of the sequence shall conform to the following file-name syntax, expressed using the ABNF rules specified in [IETF RFC 5234](#).

```
file-name = [sequence-name "."] frame-number suffix
sequence-name = *(ALPHA / DIGIT / "_" / "-" / ".")
frame-number = 1*d49-57
suffix = ".pdc.j2c"
```

EXAMPLE —

```
Your_Movie_R1_SCOPE.000192.pdc.j2c
Your_Movie_R1_SCOPE.000193.pdc.j2c
...
Your_Movie_R1_SCOPE.028223.pdc.j2c
```

The length of `file-name` in characters shall not be greater than 128. The collection of `frame-number` values shall be an integer sequence {*n*, *n* + 1, *n* + 2, ..., *n* + *N* – 1} where *N* is the number of images in the sequence and *n* can be any non-negative integer.

The length of `frame-number` in characters shall be identical for all files in the sequence. Leading zeros can be used to satisfy this requirement.

The `sequence-name` shall be identical for all files in the sequence.

The `sequence-name` can contain post-production reel names and abbreviations. When sorted in increasing order of `frame-number`, the files shall be in the intended temporal display order.

- NOTE 1 — `frame-number` can be used to represent an offset in frames from the timecode 01:00:00:00. For example, a `frame-number` value of 086400 can correspond to 01:00:00:00 at 24 frames per second, i.e., the “picture start” frame in the head leader for reel 1.
- NOTE 2 — This file naming convention is similar to that specified in [SMPTE RP 428-5](#)
- NOTE 3 — The `pdc` token in the file name `suffix` is intended to differentiate files containing packed images from those containing lossy-coded frames intended to be wrapped into a D-Cinema composition for distribution to theaters.

7 Digital leader

Each image sequence that comprises a post-production reel shall begin with a digital head leader that has a duration of eight seconds.

The digital leader specified in [SMPTE RP 428-6](#) should be used.

[Table 2](#) list examples of digital leader durations.

Table 2 – Digital Leader duration as a function of frame rate.

Frame rate (frames per second)	Digital leader duration (number of frames)
24	192
25	200
30	240
48	384
50	400

60	480
----	-----

8 Conversion to and from TIFF files (informative)

When converting a TIFF file that conforms to [SMPTE RP 428-5](#) to a packed image, only the most significant 12 bits of each 16-bit TIFF sample are used.

Conversely, when converting packed images to TIFF files that conform to [SMPTE RP 428-5](#), each 12-bit packed image sample is padded into a 16-bit TIFF sample as specified in [SMPTE RP 428-5](#).

Except for their respective suffixes, the filenames of the TIFF and packed image files can be identical.

Annex A

Sample packed images (informative)

[Table A.1](#) lists sample files containing packed images generated by encoding [Element a](#) (a TIFF file) using commonly-available tools.

Table A.1 – Sample files containing packed images.

Element b	Tool	https://kakadusoftware.com/documentation-downloads/
	Method of generation	<pre>kdu_compress -i \$SRC_FILE -o \$KDU_J2C Creversible=yes Corder=RPCL \ Cblk="{32,128}" Cmodes=HT ORGtparts=R Clevels=5 ORGgen_tlm=6 -fprec 12M \ Cprecincts="{256,256},{256,256},{256,256},{256,256},{256,256},{128,128}" \ -com "SMPTE DCDM X'Y'Z' image as defined in SMPTE ST 428-1"</pre>
Element c	Tool	https://github.com/aous72/OpenJPH
	Method of generation	<pre>ojph_compress -i \$SRC_FILE -o \$OJPH_J2C -reversible true -prog_order RPCL \ -block_size "{128,32}" -num_decomps 5 -tlm_marker true \ -precincts "{128,128},{256,256}" -tileparts R -bit_depth 12 \ -com "SMPTE DCDM X'Y'Z' image as defined in SMPTE ST 428-1"</pre>

Additional elements

This annex lists non-prose elements of this document.

- Sample 2K DCDM image whose pixel array includes every code value between 0 and 4095 (normative). file: <sample.00000001.tiff.zip>.
- Sample packed image generated using Kakadu SDK (normative). file: <sample_kdu.00000001.pdc.j2c>.
- Sample packed image generated using OpenJPH (normative). file: <sample_ojph.00000001.pdc.j2c>.

Bibliography

SMPTE RP 428-5, D-Cinema Distribution Master — Mapping of Images into Constrained Tag Image File.

SMPTE RP 428-6, D-Cinema Distribution Master — Digital Leader.

Rec. ITU-T T.814 | ISO/IEC 15444-15, Information technology — JPEG 2000 image coding system — Part 15: High-Throughput JPEG 2000.