INTERNATIONAL STANDARD

ISO 12234-2

First edition
2001-10-15

Electronic still-picture imaging — Removable memory —

Part 2: TIFF/EP image data format

Imagerie de prises de vue électroniques — Mémoire mobile —

Partie 2: Format de données image TIFF/EP

Reference number
ISO 12234-2:2001(E)

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Printed in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 12234 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12234-2 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO 12234 consists of the following parts, under the general title *Electronic still-picture imaging — Removable memory*:

— *Part 1: Basic removable-memory module*

— *Part 2: TIFF/EP image data format*

— *Part 3: Design rule for camera file system (DCF)*

Annex A of this part of ISO 12234 is for information only.

Introduction

The term TIFF/EP refers to Tag Image File Format/Electronic Photography, defined in this part of ISO 12234. The term “TIFF 6.0” refers to the TIFF Revision 6.0 specification. TIFF/EP is defined to be as compatible as possible with existing desktop software packages, to enable them to operate with images from electronic still-picture cameras. TIFF Revision 6.0 is used as the basis for achieving this interoperability with the large installed base of imaging software. Wherever possible, TIFF/EP uses tags already defined in TIFF 6.0 and provides guidelines for the use of these tags as well as the allowed field values. New tags are defined to encode image data features that are not included in TIFF 6.0. These new tags conform to the practices specified in TIFF 6.0. This document also describes how related images, such as both “parent” high resolution and “thumbnail” low resolution images of the same subject, or temporal sequence “bursts” of the same scene, can be stored in a single TIFF/EP file.

With the permission of Adobe Systems Incorporated, sections of this TIFF/EP specification have been copied verbatim from the TIFF 6.0 specification dated June 3, 1992 specification © 1986-1988, 1992 Adobe Systems Incorporated. All Rights Reserved.

In this part of ISO 12234, references to tags and tag values defined in TIFF 6.0 are shown in bold typeface. Tags and tag values that are not defined in TIFF 6.0 are identified in italic type face. These new tags have been chosen to be as compatible as possible with the Exif tags defined in “Digital Still Camera Image File Format Standard (Exchangeable image file format for Digital Still Cameras: Exif)”, Version 2.1, June 1998 by the Japan Electronic Industry Development Association (JEIDA). The new TIFF/EP tag-fields containing enumerated values follow the TIFF 6.0 convention, where the lower half of the values (0 to 127 for byte values, 0 to 32,767 for short values, and 0 to 2,147,483,647 for long values) are reserved by TIFF/EP and the upper half of the values (128 to 255 for byte values, 32,768 to 65,535 for short values, and 2,147,483,648 to 4,294,967,296 for long values) are private values that may be registered by I3A.

I3A may be contacted at the Photographic and Imaging Manufacturers Association, 550 Mamaroneck Avenue, Suite 307, Harrison, NY 10528-1612 USA, or by e-mail at pima@pima.net.

TIFF/EP complies with the TIFF 6.0 specification and uses the same header specified in TIFF 6.0. The reason for this is to maintain the highest degree of compatibility with existing TIFF readers and to make the adoption of TIFF/EP, including the new TIFF/EP tags, as easy as possible. In the future, if TIFF is revised, a revised version of TIFF/EP may be developed using the revised TIFF specification. TIFF/EP editors of a given TIFF/EP version number shall not update TIFF/EP files having a higher version number without warning the user that, in doing so, unknown tags will be deleted. This is explained in the section describing the ***TIFF/EPStandardID*** tag.

TIFF/EP tag definitions do not allow default values. All values shall be explicitly stated in order to improve interoperability with future versions of TIFF/EP. Images may be stored in uncompressed form or using JPEG baseline (DCT based) compression. In the latter case, an uncompressed baseline-TIFF-readable reduced resolution “thumbnail” image should also be stored in the 0th IFD to allow the images to be identified using a baseline TIFF 6.0 reader.

TIFF/EP uses the TIFF/JPEG specification given in “DRAFT TIFF Technical Note No. 2”. This method differs from the JPEG method described in the TIFF 6.0 specification. In the method used within TIFF/EP, each image segment (tile or strip) contains a complete JPEG data stream that is valid according to the ISO JPEG standard (ISO/IEC 10918-1). TIFF/EP requires that readers only support the DCT based lossy JPEG process.

TIFF/EP currently does not define how to embed audio information within a TIFF/EP image file. Audio can be stored in a separate file on the same removable media, if desired, or stored within a TIFF/EP file using a private TIFF tag obtained from Adobe Corp. This does not preclude a future release of TIFF/EP from implementing embedded audio as part of the TIFF/EP file.

TIFF/EP image files should be stored in a READ-ONLY fashion using the appropriate file system mechanism. This will prevent accidental loss of important TIFF/EP tag-value information if the image is edited by a non-TIFF/EP compliant application. TIFF editors generally remove unknown tags when saving or updating an image file to

maintain the integrity of the TIFF file, since the unknown tags might not apply to the edited image. By creating TIFF/EP image files READ-ONLY, accidental loss of important information is prevented. TIFF/EP editors, on the other hand, shall warn the user, whenever editing a newer version TIFF/EP file with an older version TIFF/EP editor, that proceeding may result in the loss of information. The mandatory ***TIFF/EPStandardID*** tag-field specifies the TIFF/EP version used in creating a TIFF/EP image file.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this International Standard may involve the use of patents from the following companies:

— Canon Incorporated

— Eastman Kodak Company

— Fuji Photo Film Company Ltd.

— Nikon Corporation

— Olympus Optical Company Ltd.

The holders of these patent rights have assured ISO that they are willing to negotiate licenses under reasonable and non-discriminatory terms and conditions throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from the companies listed. Other companies have also determined that, upon approval of this International Standard, they too will grant patent licenses in accordance with ISO Directives, Part 2. Information regarding these companies may also be obtained from the ISO Central Secretariat

ISO takes no position concerning the evidence, validity and scope of any of the patent rights listed.

Electronic still-picture imaging — Removable memory —

Part 2:
TIFF/EP image data format

1 Scope

This part of ISO 12234 specifies the TIFF/EP data format described in ISO 12234-1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12234. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12234 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 12232:1998, *Photography — Electronic still-picture cameras — Determination of ISO speed*

ISO 12233:2000, *Photography — Electronic still-picture cameras — Resolution measurements*

ISO 12234-1:2001, *Electronic still-picture imaging — Removable memory — Part 1: Basic removable-memory module*

ISO 14524:1999, *Photography — Electronic still-picture cameras — Methods for measuring opto-electronic conversion functions (OECFs)*

ISO/IEC 10918-1:1994, *Information technology — Digital compression and coding of continuous-tone still images: Requirements and guidelines*

ITU-R BT.709-4 (03/00), *Parameter values for the HDTV standards for production and international programme exchange*

3 Terms and definitions

For the purposes of this part of ISO 12234, the following terms and definitions apply.

3.1
file system
software structure which specifies how the data is logically organized on a given storage medium

3.2
image data format
structure and content which specifies how the data is logically organized on a given storage medium

4 Image data features

This clause describes all the features of the TIFF/EP standard and lists the tags used to implement each feature.

4.1 TIFF/EP file encoding structure

A TIFF/EP file is a valid TIFF file that contains the TIFF/EP format identifier and conforms to the restrictions described in this part of ISO 12234. The TIFF/EP header is exactly the same as the TIFF header. The use of the TIFF/EP format and revision number is identified in the ***TIFF/EPStandardID*** tag-field.

TIFF is an image file format. In this part of ISO 12234, a *file* is a sequence of 8-bit bytes, where the bytes are numbered from 0 to N. The largest possible TIFF file is 2**32 bytes in length. A TIFF file begins with an 8-byte *image file header* that points to an *image file directory (IFD).* An image file directory contains information about the image, as well as pointers to the actual image data.

A TIFF file structure is shown in Figure 1.

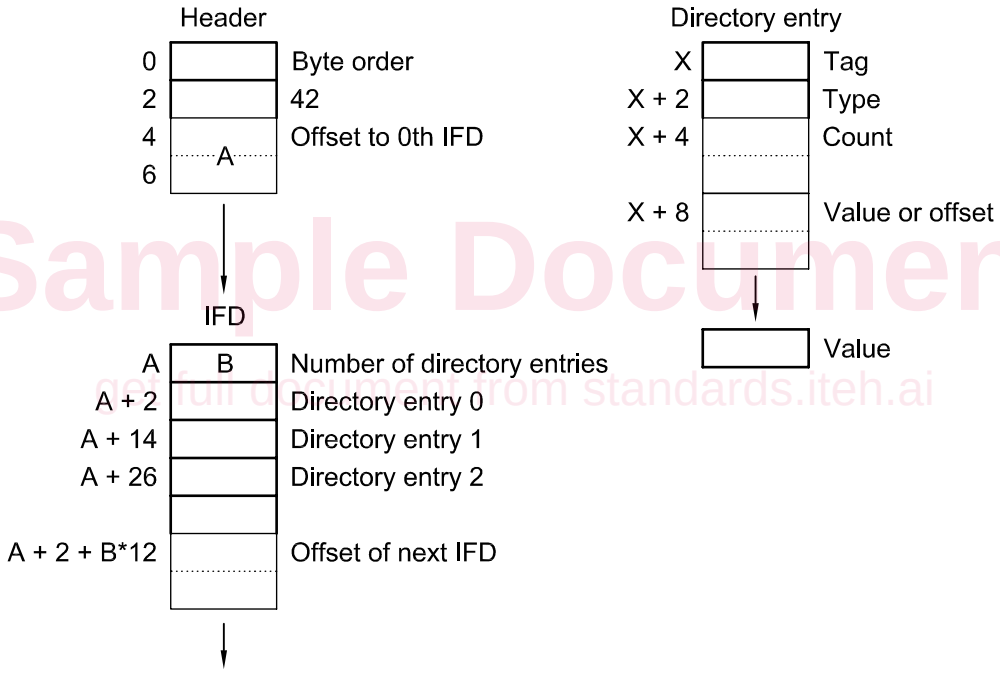

Figure 1 — TIFF file structure

4.1.1 Image file header

A TIFF file begins with an 8-byte image file header, containing the following information:

Bytes 0-1: The byte order used within the file. Legal values are:

II (4949.H)

MM (4D4D.H)

In the II format, byte order is always from the least significant byte to the most significant byte, for both 16-bit and 32-bit integers. This is called *little-endian* byte order. In the MM format, byte order is always from the most significant byte to the least significant byte, for both 16-bit and 32-bit integers. This is called *big-endian* byte order.

Bytes 2-3: An arbitrary but carefully chosen number (42) that further identifies the file as a TIFF file.

The byte order depends on the value of Bytes 0-1.

Note that, in order to allow backward compatibility with future versions of TIFF/EP based on future versions of TIFF, all TIFF/EP readers should test the TIFF header version value to determine if VERSION >= 42, not to test if VERSION == 42. This will allow higher version numbers to be used in the future and to be detected as TIFF/EP files.

Bytes 4-7: The offset (in bytes) of the first IFD. The directory may be at any location in the file after the header but shall begin on a word boundary. In particular, an image file directory may follow the image data it describes. Readers shall follow the pointers wherever they may lead.

The term *byte offset* is always used in this part of ISO 12234 to refer to a location with respect to the beginning of the TIFF file. The first byte of the file has an offset of 0.

4.1.2 Image file directory (IFD)

An IFD consists of a 2-byte count of the number of directory entries (i.e. the number of fields), followed by a sequence of 12-byte field entries, followed by a 4-byte offset of the next IFD (or 0 if none). Do not forget to write 4 bytes of 0 after the last IFD.

There shall be at least 1 IFD in a TIFF file and each IFD shall have at least one entry.

4.1.2.1 IFD entry

Each 12-byte IFD entry has the following format:

Bytes 0-1: The tag that identifies the field.

Bytes 2-3: The field type.

Bytes 4-7: The number of values, *Count* of the indicated type.

Bytes 8-11: The value offset, i.e. the file offset (in bytes) to the value(s) for the field. This value offset is expected to begin on a word boundary; the corresponding value offset will thus be an even number. This file offset may point anywhere in the file, even after the image data. (See below for more information.)

4.1.2.2 IFD terminology

A *TIFF field* is a logical entity consisting of a TIFF tag and its value. This logical concept is implemented as an *IFD entry*, plus the actual value if it doesn't fit into the value/offset part, the last 4 bytes of the *IFD entry*. The terms *TIFF field* and *IFD entry* are interchangeable in most contexts.

4.1.2.3 Sort order

The entries in an IFD shall be sorted in ascending order by tag. The values to which directory entries point need not be in any particular order in the file.

4.1.2.4 Value/Offset

To save time and space, the value offset contains the value instead of pointing to the value only if the value fits into 4 bytes. If the value is shorter than 4 bytes, it is left-justified within the 4-byte value offset, i.e. stored in the lower-numbered bytes. Whether the value fits within 4 bytes is determined by the type and count of the field.

Note that the 4 byte value offset should not be thought of as a LONG data type since, if the value is shorter than 4 bytes, it is always left-justified regardless of whether the II or MM byte order is used. For example, to store the SHORT hex value "AB CD" in MM byte order, the 4 bytes are "AB CD xx xx" (where x indicates "don't care"). The same hex value in II byte order is given by "CD AB xx xx".

4.1.2.5 Count

Count, called *Length* in previous versions of the TIFF specification, is the number of values. Note that count is not the total number of bytes. For example, a single 16-bit word (SHORT) has a count of 1 not 2.

4.1.2.6 Types

The field types and their sizes are:

1=BYTE	8-bit unsigned integer.
2=ASCII	8-bit byte that contains a 7-bit ASCII code; the last byte shall be NUL (binary zero).
3=SHORT	16-bit (2-byte) unsigned integer.
4=LONG	32-bit (4-byte) unsigned integer.
5=RATIONAL	Two LONGs: the first represents the numerator of a fraction, the second represents the denominator.
6=SBYTE	An 8-bit signed (twos-complement) integer.
7=UNDEFINED	An 8-bit byte that may contain anything, depending on the definition of the field.
8=SSHORT	A 16-bit (2-byte) signed (twos-complement) integer.
9=SLONG	A 32-bit (4-byte) signed (twos-complement) integer.
10=SRATIONAL	Two SLONGs: the first represents the numerator of the fraction, the second represents the denominator.
11=FLOAT	Single precision (4-byte) IEEE format.
12=DOUBLE	Double precision (8-byte) IEEE format.

WARNING — It is possible that other TIFF field types will be added in the future. Readers should ignore fields containing an unexpected field type.

The value of the count part of an ASCII field entry includes the NUL. If padding is necessary, the count does not include the pad byte. Note that there is no initial count byte as in Pascal-style strings. Any ASCII field can contain multiple strings, each terminated with a NUL. A single string is preferred whenever possible. The count for multistring fields is the number of bytes in all strings in that field plus their terminating NUL bytes. Only one NUL is allowed between strings, so that the strings following the first string will often begin on an odd byte.

The reader shall check the type to verify that it contains an expected value. TIFF currently allows more than 1 valid type for some fields. For example, ImageWidth and ImageLength are usually specified as having type SHORT. But images with more than 64K rows or columns shall use the LONG field type. TIFF readers should accept BYTE, SHORT or LONG values for any unsigned integer field. This allows a single procedure to retrieve any integer value, makes reading more robust and saves disk space in some situations.

Each TIFF field has an associated count. This means that all fields are actually one-dimensional arrays, even though most fields contain only a single value. For example, to store a complicated data structure in a single private field, use the UNDEFINED field type and set the count to the number of bytes required to hold the data structure.

4.1.3 Vendor unique information

Each camera manufacturer may choose to store additional information in the form of private tags or private tag-values. This can be done by obtaining private tags and/or tag-values for TIFF 6.0 tags from the Adobe Developers Desk and vendor unique tag-values from PIMA/IT10 for the new TIFF/EP defined tags. When storing additional vendor unique information within TIFF/EP files, care shall be taken not to violate the TIFF/EP guidelines described in this part of ISO 12234.

4.2 Image data

The image width, i.e. horizontal or X dimension, is recorded as a binary value in the **ImageWidth** tag-field. The image width may be the shorter or longer dimension of the image, depending upon the orientation of the camera during image capture. The image orientation is defined by the **Orientation** tag-field. The image length, i.e. vertical or Y dimension, is recorded as a binary value in the **ImageLength** tag-field. The camera's desired image output rendering resolution in the X-dimension, i.e. the horizontal dimension when the camera is normally oriented, is recorded using the **XResolution** tag-field, while the output resolution in the Y-dimension is recorded in the **YResolution** tag-field. The **ResolutionUnits** tag-value gives the units for the **XResolution** and **YResolution** values. These mandatory TIFF 6.0 tag-fields are typically used to determine the default size of the image on the screen. They do not indicate the sample spacing of the image sensor in an electronic still-picture camera. The latter is given in the **FocalPlaneXResolution**, **FocalPlaneYResolution** and **FocalPlaneResolutionUnits** tag-values. The pixel aspect ratio (ratio of the pixel width to pixel height) is determined by the ratio of the **XResolution** and **YResolution** values. The recommended TIFF/EP pixel aspect ratio is 1:1 (square), so that **XResolution** equals **YResolution**.

The number of colour components or samples per pixel in the image is recorded using the **SamplesPerPixel** tag-field as a binary value. For example, an image captured using a monochrome sensor has only one colour component or sample per pixel, while a 3-sensor colour RGB camera has three colour components or samples per pixel. The number of bits needed to store each of the colour components (samples) is recorded using the **BitsPerSample** tag-field as a set of binary values. In the case of a monochrome image, the **BitsPerSample** tag-field contains only one value, equal to the actual number of bits per pixel. In the case of an RGB image having three colour samples per pixel, the **BitsPerSample** tag-field contains three values equal to the actual number of bits of storage used to store each component or sample. In the latter case, the number of bits for each colour-component could be different and hence is explicitly stated.

The type of image data components are provided by the **PhotometricInterpretation** tag-value. All TIFF/EP readers shall handle greyscale, RGB and YCbCr data. If YCbCr data values are stored, the number of Cb and Cr values may either be equal to the number of Y values or smaller owing to subsampling. The chrominance subsampling factors of a YCbCr image are encoded in the **YCbCrSubSampling** tag-field. This tag-field contains both the horizontal and vertical subsampling factors, which are labelled YCbCrSubSamplingHoriz and YCbCrSubSamplingVert respectively. The subsampling factors are given relative to the appropriate dimension of the corresponding luminance image. The positions of the subsampled chrominance components relative to the luminance samples are encoded in the **YCbCrPositioning** tag-field. The headroom/footroom image data values (codes) for each each pixel component associated with a YCbCr image is specified within the **ReferenceBlackWhite** tag-field. The pair of headroom/footroom values (codes) associated with the luminance component (Y) refer to this component's ReferenceWhite and ReferenceBlack. The pair of headroom/footroom values (codes) associated with the chrominance components, Cb and Cr, refer to these components' ReferenceBlack and ReferenceWhite, where here the ReferenceWhite value is used to code reference blue and reference red respectively.

The image data may optionally be stored using a single image component having a colour filter array (CFA) area pattern of the image data derived from a single-chip colour CCD image sensor. TIFF/EP readers are not required to handle this type of image data. The colour filter array area pattern is the repetitive spatial colour sampling pattern of photosites on the CCD image sensor. There are many different CFA-type CCDs which capture only one colour component per photosite on the CCD. The tags used to describe a CCD's CFA pattern are: **SamplesPerPixel**, **PlanarConfiguration**, ***CFARepeatPatternDim***, ***CFAPattern*** and ***SensingMethod***.

The image data is stored using either strips or tiles, which are collectively termed segments. If strips are used, the following tag-fields define the number of strips and the number of rows of image data stored in each strip: **StripOffsets**, **RowsPerStrip** and **StripByteCounts**. The image shall be divided into an integral number of strips, from one strip to the maximum number of strips, which equals the image's length. If necessary, the final strip can be "padded" with zeros. TIFF/EP recommends that the image data, prior to compression, does not exceed 64 Kbytes per strip. This value is chosen to maximize compatibility with various operating systems. The **StripOffsets** tag-field stores the offsets from the start of the image file to the start of each image data strip. In this way, the reader can easily access various parts of the image. The number of rows per strip is stored in the **RowsPerStrip** tag-field. The number of image data bytes stored within each strip is recorded in the **StripByteCounts** tag-field. The "strip" mechanism is very useful in accessing images, because it uses less buffer memory than would otherwise be needed to read in the entire image all at one time. The order of the image strips is from the top to the bottom of the image.

EXAMPLE ImageWidth = 768

ImageLength = 512

PhotometricInterpretation = 2 (RGB)

SamplesPerPixel = 3

BitsPerSample = 8,8,8

PlanarConfiguration = 1 (Chunky), i.e. RGBRGBRGB...

The size in bytes of each row in this image is 768 PixelsPerRow * (3 SamplesPerPixel * 8 BitsPerSample)/8 BitsPerByte ==> 2304 BytesPerRow. Assuming 8 rows of image data in each strip, the number of bytes per strip is 8 RowsPerStrip * 2304 BytesPerRow ==> 18,432 BytesPerStrip. The number of strips equals 512 Rows/8 RowsPerStrip ==> 64 strips.

If tiles are used, the following tag-fields define the number of tiles and the size of each tile: **TileWidth**, **TileLength**, **TileOffsets** and **TileByteCounts**. The image shall be divided into an integral number of tiles. The purpose of tiles is to provide the reader with the ability to perform image "panning", i.e. to view portions of the image on a display which is smaller than the overall image size. The **TileWidth** tag-field stores the width of the tile in pixels. The **TileLength** tag-field stores the length of the tile in rows. The **TileOffsets** tag-field stores the offsets from the start of the image file to the start of each image data tile. The number of image data bytes in each tile is recorded in the **TileByteCounts** tag-field. TIFF/EP recommends that the image data, prior to compression, does not exceed 64 Kbytes per tile.

Using the above example, the image could be broken up into 64 tiles each having a width of 96 pixels and a length of 64 pixels. Each tile would have a size in bytes of 96 PixelsPerTileWidth * 64 RowsPerTileLength * (3 SamplesPerPixel * 8 BitsPerSample)/8 BitsPerByte ==> 18,432 BytesPerTile, i.e. 18K BytesPerTile.

NOTE If the image data is compressed using JPEG, i.e. **Compression** tag-field contains the value of 7, each segment (strip or tile) shall contain a valid JPEG datastream according to the ISO JPEG standard's rules for interchange-format or abbreviated-image-format data.

4.3 Thumbnail images

There may be more than one IFD in a TIFF 6.0 file. Each IFD defines a *subfile*. One potential use of subfiles in TIFF 6.0 is to describe related images, such as the pages of a facsimile transmission. A baseline TIFF 6.0 reader is not required to read any IFDs beyond the first one.

In TIFF/EP files, the 0th IFD should be an image that can be read by a baseline TIFF 6.0 reader. Note that JPEG compression is not required for baseline TIFF 6.0 readers. Therefore, if the full-resolution image is stored using compression, the TIFF/EP file should include a thumbnail (reduced-resolution) image stored in the 0th IFD that is readable by a baseline TIFF 6.0 reader. This thumbnail should not be compressed, and should be stored in strips, rather than in tiles, in order to be fully compatible with TIFF 6.0. A ***SubIFDs*** tag in the 0th IFD is used to point to the compressed full-resolution image. If the full-resolution image is stored uncompressed as a baseline-readable TIFF image, the full-resolution image could be stored in the 0th IFD. However, TIFF/EP recommends that a thumbnail image be stored in the 0th IFD, regardless of whether the full-resolution image is baseline TIFF readable or not. This provides a version of the image that is small (relative to the full-resolution image) and that may be quickly accessed by reader software. The use of the ***SubIFDs*** tag is the TIFF recommended method of performing this "treeing" mechanism. The idea of IFD treeing via the use of the ***SubIFDs*** tag is described below. TIFF/EP uses the IFD "chaining" mechanism to store a "burst" motion sequence of temporally related images in the same TIFF/EP file. Figure 2 shows graphically an example of IFD treeing to store both the thumbnail image and the full resolution "main" image. This is done using the ***SubIFDs*** tag. The ***SubIFDs*** tag is used within a given IFD to initiate a "tree" or "branch" to another IFD describing another rendition of the same image within a TIFF/EP file. This tag is described in detail in the tag-definition section of this document. The ***SubIFDs*** tag is not described in the TIFF 6.0 specification, but is described in "TIFF Technical Note 1: TIFF Trees" available from Adobe Corporation. This technical note describes the mechanism to use if treeing is needed. The TIFF/EP ***SubIFDs*** tag value provides the offset from the start of the TIFF/EP file to the beginning of the IFD for the full resolution image. The **NewSubFileType** tag identifies the image as a full resolution image. This IFD treeing technique, using the

SubIFDs and **NewSubFileType** tags, is a clear and unambiguous method associating the thumbnail images and main images. IFD treeing is used instead of IFD chaining because TIFF/EP recommends that chaining be used to store a burst of temporally related images in the same file, as described in 4.4.

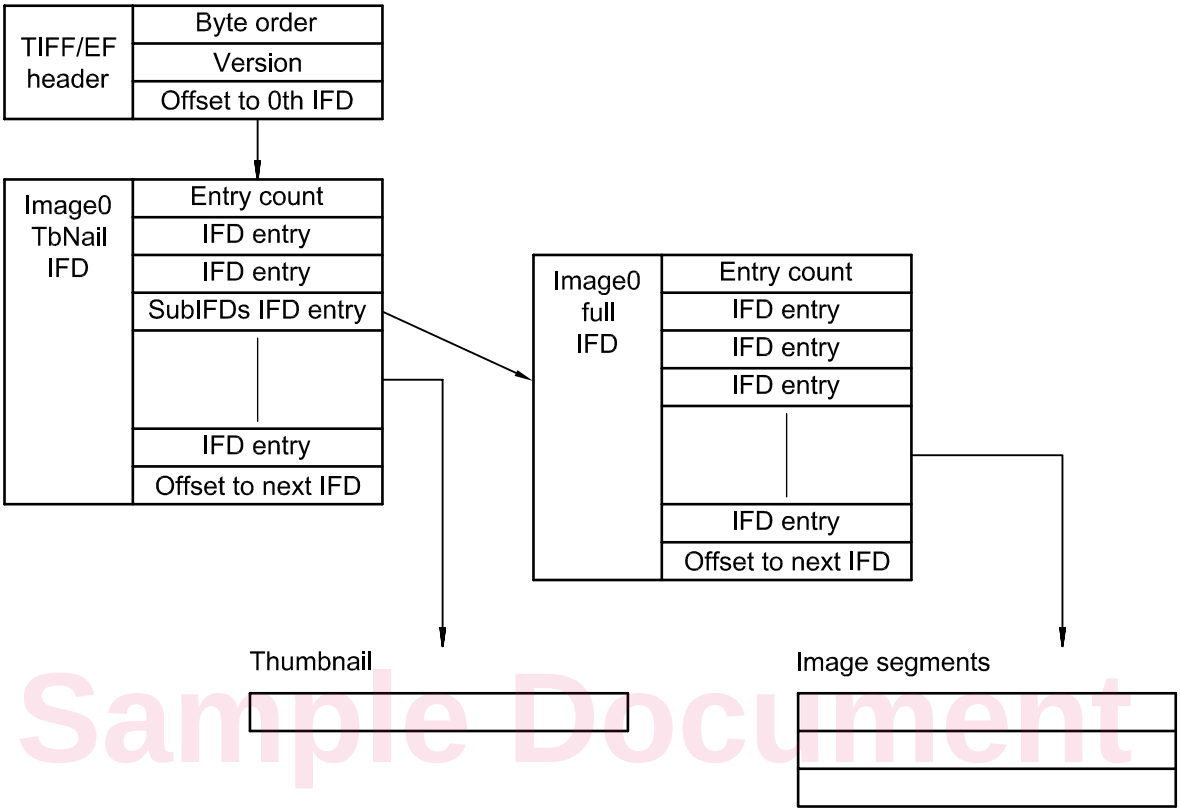

Figure 2 — TIFF/EP encoding structure with treeing

TIFF/EP requires that the thumbnail image be stored in strips, so that the thumbnails may be read by any baseline TIFF 6.0 reader. The dimensions of the thumbnail image are restricted by TIFF/EP to 256 pixels maximum horizontally and 256 pixels maximum vertically. The following tag-fields are necessary to define the number of strips and the number of rows of thumbnail image data stored in each strip: **StripOffsets**, **RowsPerStrip** and **StripByteCounts**.

In the example below, the thumbnail image has one eighth the number of lines and one eighth the number of pixels per line as its parent image. The thumbnail image is a single strip which holds the thumbnail image data. The **StripOffsets** tag-field stores the offset from the start of the image file to the start of the thumbnail image data strip. The number of rows per strip, i.e. 64 rows, is stored in the **RowsPerStrip** tag-field. The number of thumbnail image data bytes stored in the strip is recorded in the **StripByteCounts** tag-field.

EXAMPLE Parent ImageWidth = 768

Parent ImageLength = 512

Parent PhotometricInterpretation = 2 (RGB)

Parent SamplesPerPixel = 3

Parent BitsPerSample = 8,8,8

Parent PlanarConfiguration = 1 (Chunky), i.e. RGBRGBRGB...

Thumbnail ImageWidth = 96

Thumbnail ImageLength = 64

Thumbnail PhotometricInterpretation = 2 (RGB)

Thumbnail SamplesPerPixel = 3

Thumbnail BitsPerSample = 8,8,8

Thumbnail PlanarConfiguration = 1 (Chunky), i.e. RGBRGBRGB...

The size in bytes of the single thumbnail image strip is 96 PixelsPerRow * (3 SamplesPerPixel * 8 BitsPerSample)/8 BitsPerByte ==> 288 BytesPerRow. We are storing 64 rows of thumbnail image data in the strip, hence the number of bytes per strip is 64 RowsPerStrip * 288 BytesPerRow ==>18,432 BytesPerStrip. The number of strips is equal to 64 Rows/64 RowsPerStrip ==> 1 strip.

4.4 Burst sequences using chaining

Figure 3 shows how TIFF/EP allows image chaining to be used to store a burst motion sequence of temporally related images. The Image0 IFD stores the first image in the sequence, the Image1 IFD stores the second image in the sequence and so on. Therefore, the IFD numbers indicate the temporal sequence of the burst of images. By storing the entire sequence in a single TIFF/EP file via chaining, the sequence is encapsulated in a way that allows it to be copied without losing images or altering the image sequence. As noted earlier, the **SubIFDs** tag provides the mechanism to store both thumbnail and main images for each temporal sample of the “chain” all in the same TIFF/EP file.

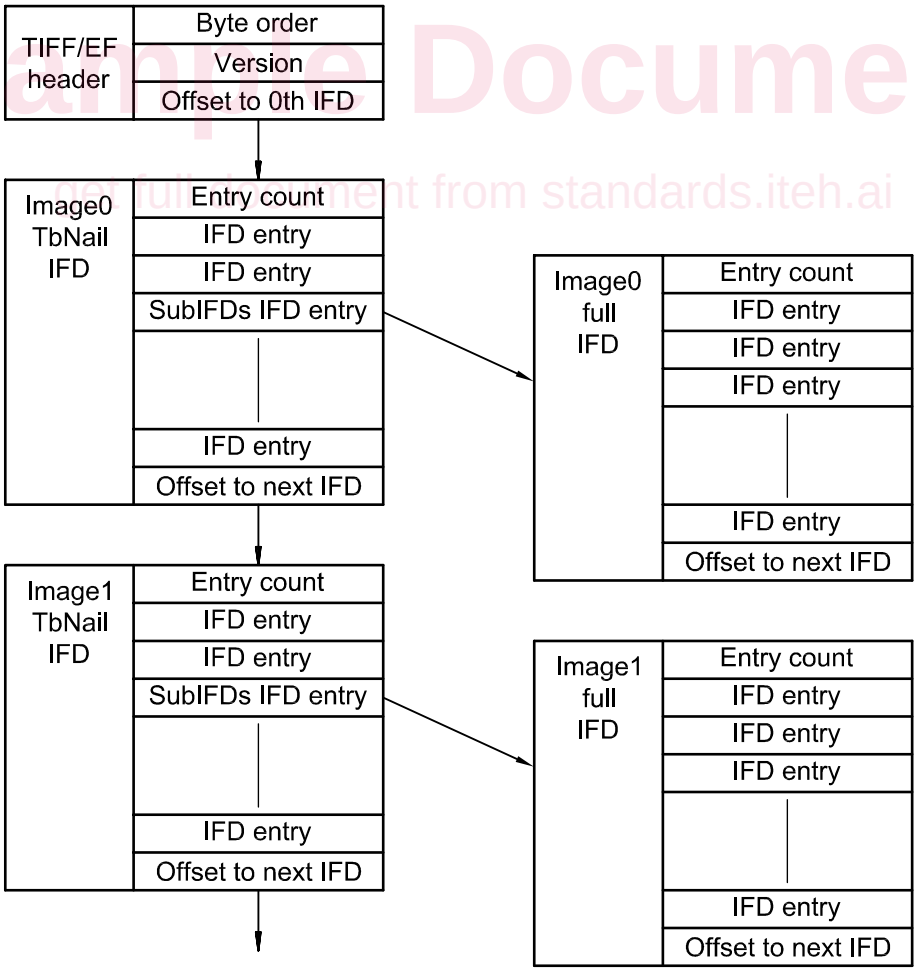

Figure 3 — TIFF/EP encoding structure with image chaining

TIFF/EP recommends that chaining be used to store a motion sequence burst of images. Note that if chaining is used for both thumbnails and motion sequences, readers could be confused by the relationships between IFDs in the file. Neither TIFF/EP nor TIFF 6.0 requires baseline readers to read past the first image in the chain. Note that if image categorization or databasing is required, the filing system should provide this mechanism. Image chaining should not be used for this purpose. The definition of a filing system for image databasing is outside the scope of the TIFF/EP specification.

4.5 Camera colour space information

The ICC (InterColour) profile, contained in the ***InterColourProfile*** tag-field, may be used to provide the information required to interpret the digital code values of a colour image. Note that the ICC profile format may be revised in the future and the most recent version of the ICC specification should be used. To prevent duplication and confusion, the TIFF 6.0 PrimaryChromaticities, WhitePoint and TransferFunction tags are not allowed in TIFF/EP, since this same information is specified within the ***InterColourProfile*** tag value. In some applications, the use of an ICC profile may be inadequate to achieve the desired level of camera colour charactization. In these applications, the camera spectral sensitivities and OECF (opto-electronic conversion function) may be provided, using the ***SpectralSensitivity*** and ***OECF*** tag values, in order to provide the desired camera colour characterization information.

The target colour space describes the number and type of colour components and is recorded in the **PhotometricInterpretation** tag-field. The allowed target colour spaces are greyscale, RGB, YCbCr and CFA (colour filter array).

The chromaticities of the primaries of the image are encoded using the redColourantTag, greenColourantTag and blueColourantTag values within the ***InterColourProfile*** tag value. The chromaticity of the white point of the image is encoded using the mediaWhitePointTag values within the ***InterColourProfile*** tag value.

The transfer function which indicates the meaning of each image data code is encoded using the redTRCTag, greenTRCTag and blueTRCTag values within the ***InterColourProfile*** tag value. The recommended TIFF/EP reference colour primaries and opto-electronic conversion function (gamma correction) are equal to the values given in ITU-R BT.709: 1993, “Basic parameter values for the HDTV standard for the studio and for international programme exchange”.

The coefficients used in the transformation from RGB to YCbCr image data are encoded in the **YCbCrCoefficients** tag-field as 3 RATIONAL numbers, i.e. LumaRed, LumaGreen and LumaBlue. These three coefficients are the proportions of red, green and blue respectively in the luminance (Y) channel. This tag is only necessary if the image data is stored in YCbCr form.

4.6 Image data compression

This data feature indicates the type of image data compression. The compression method is stored in the **Compression** tag-field as a binary value. If no compression is used, a value of 1 is recorded in this tag-field. Other values indicate some form of image compression. For compressed images, the average number of bits per pixel may be recorded using the ***CompressedBitsPerPixel*** tag-field.

4.6.1 Baseline JPEG compression

All TIFF/EP readers shall support the DCT (lossy) baseline version of the TIFF/JPEG compression method defined by the Independent JPEG Group and described in TIFF technical note number 2. This compression method is in accordance with ISO/IEC 10918-1:1994. To indicate JPEG compression, a value of 7 is stored in the **Compression** tag-field as a binary value. JPEG compression works in either strip-based or tile-based TIFF/EP files. The term “segment” refers to either a strip or a tile. When the **Compression** tag-field has the value 7, each image segment contains a complete JPEG datastream which is valid according to the ISO JPEG standard (ISO/IEC 10918-1). TIFF/EP requires that readers only support baseline (lossy DCT) based compression.

Each image segment in a JPEG-compressed TIFF/EP file shall contain a valid JPEG datastream according to the ISO JPEG standard’s rules for interchange-format (including JPEG quantization and Huffman tables) or