

Standard of Japan Electronics and Information Technology Industries Association

JEITA CP-3461

**Design rule for Camera File system
DCF Version 2.0**

Established in ***, 2003 DRAFT**

**Prepared by
Technical Standardization Committee on AV & IT Storage Systems and Equipment**

**Published by
Japan Electronics and Information Technology Industries Association**

11, Kanda-Surugadai 3-chome, Chiyoda-ku, Tokyo 101-0062, Japan

Printed in Japan

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Standard of Japan Electronics and Information Technology Industries Association

Design rule for Camera File system: DCF Version 2.0

1. Scope

DCF is applicable to products for writing image files on an interchangeable medium (removable memory) formatted with the DOS FAT file system, and to products for reading (or printing) the images recorded on removable memory by these reader products.

2. Normative reference

The standards listed below compose a part of this standard. If the publish date is added, only that version composes a part of this standard. If the publish data is not added, the latest version is adopted.

a) **JEITA**

CP-3451 Exchangeable image file format for digital still cameras(Exif)

b) **IEC**

IEC 61966-2-1 Amd.1 Ed.1 to Multimedia systems and equipment - Color measurement and management - Part 2-1: Colour Management - Default RGB colour space - sRGB (2003).

c) **ISO**

ISO/IEC 10918-1 / ITU-T Recommendation T81 information technology Digital compression and coding of continuous-tone still images -Requirements and guide-lines

3. Definition

3.1 Definition of Terms

DCF	The standard specified in this document.
Exif Standard	Digital Still Camera Image File Format Standard (Exif) of the Japan Electronics and Information Technology Industries Association (JEITA)
Exif Ver. 2	Exif versions 2.x, from 2.1 and later
JPEG Standard	ISO/IEC 10918-1 ITU-T Recommendation T81 information technology - Digital compression and coding of continuous-tone still images - Requirements and guidelines
DSC	Digital still camera
PC	Personal computer
DCF-compatible	Compliant with the DCF
DCF media	Removable memory recorded in compliance with the DCF
Play	To display an image or output it as a hard copy
Application	Image application software for use on a PC
File name	An 8-character file name of the DOS/FAT file system,

	excluding the dot and file extension.
File extension	Three identifying characters used in the DOS/FAT file system following the file name and dot.
Horizontal pixels	The number of pixels of image data in the main scanning direction.
Vertical pixels	The number of pixels of image data in the sub-scanning direction.
Main image	The primary data of the image
Thumbnail	A small version of the main image, used for indexing.

The following are specified in detail in the subsequent chapters, but are summarized here for convenience.

DCF image root directory	The directory directly under the root directory, created in accord with the DCF directory rules.
DCF directory	A directory under the DCF image root directory created in accord with the DCF directory rules, for storing images.
DCF directory name	A directory name assigned in accord with the DCF directory naming conventions.
DCF object	A group of files recorded in accord with DCF.
DCF file name	A file name assigned in accord with the DCF file naming conventions.
Directory number	A three-digit number making up part of the DCF directory name.
File number	A four-digit number making up part of the DCF file name.
Free characters	The five characters following the directory number in a DCF directory name, or the four characters at the head of a DCF file name.
DCF basic file	An image file stored directly under a DCF directory, having a DCF file name and the extension "JPG," and having the data structure specified in this standard.
DCF basic main image	An Exif primary image included in a DCF basic file.
DCF basic thumbnail	An Exif thumbnail image included in a DCF basic file.
DCF optional file	An image file stored directly under a DCF directory, having a DCF file name and the extension "JPG," and recorded in the DCF optional color space specified in this standard.
DCF optional main image	The primary image in a DCF optional file.
DCF extended image file	An image file stored directly under a DCF directory, having a DCF file name but an extension other than "JPG" or "THM" and its own data structure.

DCF thumbnail file	A compressed file for storing the thumbnail image of a DCF extended image file.
Protection	Setting the Read Only attribute for a DCF object or directory.
Level 1	A playback compatibility level capable of detecting the existence of a DCF basic file and recognizing thumbnail images.
Level 2	A playback compatibility level capable of displaying and using DCF basic file main images.
Writer	A recording function compliant with the DCF Writer specification
Reader 1	Playback function in conformity with the DCF Reader 1 specification
Reader 2	Playback function in conformity with the DCF Reader 2 specification
DCF basic color space	The color space used in a DCF basic file, the widely used sRGB. Its characteristics are indicated in IEC 61966-2-1: 2003.
DCF optional color space	The color space used in a DCF optional file. Its characteristics are indicated in Chapter 5 of this standard.
Color space transformation	Processing for converting image data to the proper colors for playback when the color space assumed in recording differs from that used in the playback environment.

3.2 Definition of characters used in directory and file names

When a directory or file is created, only the characters shown in Table 1 are used. Two-byte characters or other special codes shall not be used. If an existing directory or file name uses lower-case letters, they shall be treated as all upper-case letters.

Table 1 Allowed characters

				b7	0	0	0	0	0	0	0	0	0
				b6	0	0	0	0	1	1	1	1	
				b5	0	0	1	1	0	0	1	1	
				b4	0	1	0	1	0	1	0	1	
b3	b2	b1	b0		0	1	2	3	4	5	6	7	
0	0	0	0	0				0		P			
0	0	0	1	1				1	A	Q			
0	0	1	0	2				2	B	R			
0	0	1	1	3				3	C	S			
0	1	0	0	4				4	D	T			
0	1	0	1	5				5	E	U			
0	1	1	0	6				6	F	V			
0	1	1	1	7				7	G	W			
1	0	0	0	8				8	H	X			
1	0	0	1	9				9	I	Y			
1	0	1	0	A					J	Z			
1	0	1	1	B					K				
1	1	0	0	C					L				
1	1	0	1	D					M				
1	1	1	0	E					N				
1	1	1	1	F					O	_			

30.H to 39.H,41.H to 5A.H,and 5F.H are used.

If lower-case letters from 61.H through 7A.H are used, they shall be treated as upper-case letters from 41.H to 5A.H

4. Overview

4.1 DCF and recording media

DCF is intended to enable use of files interchangeably among different equipment using the same kinds of DCF media. It must be noted carefully that equipment using different kinds of media will not be able to exchange files even if they adopt DCF.

4.2 Configuration of DCF specification

DCF consists of the three specifications shown in Figure 1.

- DCF media specification (Chapter 5) The status of data that should be on DCF media, and the status of data for enabling files to be exchanged among DCF-compatible products are specified.
- Writer specification (Chapter 6) Based on the media specification in Chapter 5, the Writer specification stipulates the directory and file structure for recording data, and the file operations.
- Reader specifications (Chapter 7) The directory and file scope, playback methods and deletion methods are specified for reading data from DCF media recorded in accord with the DCF media specification in Chapter 5.

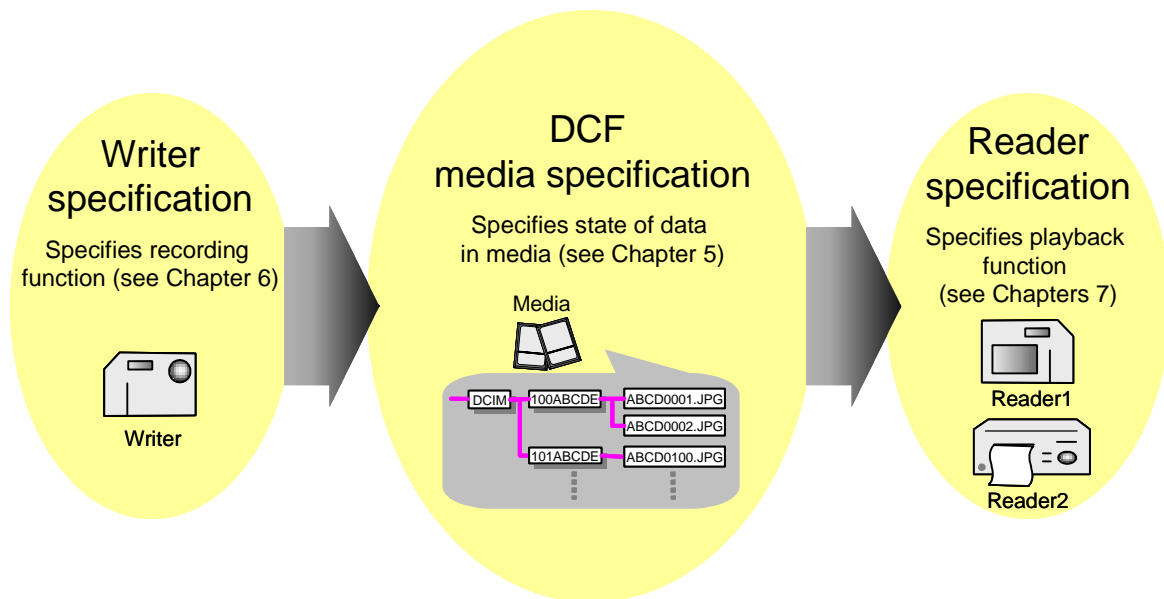


Figure 1 DCF standards

4.3 Approach to playback compatibility

In considering playback compatibility, a division is made into two levels as follows.

- Level 1 Even when a device is incapable of reproducing the DCF basic main image in a DCF basic file recorded on DCF media, it shall be able to read and display the corresponding DCF basic thumbnail.
- Level 2 Level 2 compatibility means the ability to read and display DCF basic main images in DCF basic files, within the supported pixel count specification. Layout is left up to individual product specifications.

DCF, in stipulating as mandatory items the rules for directory and file naming and the form of thumbnail image recording, establishes as a minimum condition that a DSC, for example, shall implement level 1 playback compatibility. Printers or other playback products, whose primary function is to reproduce main images, are expected to implement level 2 compatibility, for which a supported pixel count specification is defined.

4.4 Classification of functions

The functions of DCF-compatible equipment are classified into Writer, Reader 1, and Reader 2 functions as shown in Table 2. This classification is based on the recording and playback functions with which the products are equipped, and is not a classification of equipment specifications. (On the applicable equipment, see 4.5.)

Table 2 Classification of DCF functions

Classification		Functionality	Remarks
Writer		Functionality for recording in conformity with the DCF Writer specification.	Includes move, copy and delete functions.
Reader	Reader 1	Playback function in conformity with the DCF specifications for Reader 1.	Equipped with Level 1 playback compatibility. Only equipment whose primary function is that of a Writer may be equipped with the Reader 1 functionality. Includes move, copy and delete functions.
	Reader 2	Playback function in conformity with the DCF specifications for Reader 2.	Equipped with Level 2 playback compatibility. Assumed here are printers and other equipment whose main function is main image playback. Playback here means display and printing. Includes move, copy and delete functions.

4.5 Categories of DCF-compatible equipment

The categories of DCF-compatible equipment are the four types shown in Table 3. The products given are only examples and are not intended to specify the equipment.

Table 3 Categories of DCF-compatible equipment

	Recording				Playback						Typical Products
	A	B	C	D	A		B		C	D	
					Main image	Thumb	Main image	Thumb			
Category 1 (Writer only)	M	O	O	O	N		N		N	O ^(a)	Record-only DSC, scanner, etc
Category 2 (Writer + Reader 1)	M	O	O	O	T		T ^(c)		O	O	DSC with simple playback function, etc
Category 3 (Writer + Reader 2)	M	O	O	O	M	O	O ^(d)	O	O	O	DSC with playback function; printer/player with recording function; application software, etc.
Category 4 (Reader 2)	N	N	N	O ^(b)	M	O	O ^(d)	O	O	O	Printer, player, print service, etc

A: DCF basic files

B: DCF optional files

C: DCF objects other than DCF basic files and DCF optional files

D: Other files

M: Mandatory function

O: Optional function

N: Not to be implemented. Does not apply to move, delete and copy functions.

T: Thumbnail substitute playback function present if main image cannot be displayed

^(a) Having a function for image playback but having neither Reader 1 nor Reader 2 functionality is prohibited.

^(b) Being a Reader with an image recording function but not having a Writer function is prohibited.

^(c) Preferably playback should be made using color space transformation processing. In the absence of a color space transformation capability, playback shall be made in the sRGB color space.

^(d) Preferably playback should be made using color space transformation.

5. DCF Media Standard

5.1 Directory definition

The following are defined here.

- Directory structure
- Directory name

5.1.1 DCF image root directory

The directory with the name "DCIM" directly under the root directory is called the DCF image root directory. DCIM stands for "Digital Camera Images".

5.1.2 DCF directories

The directories that store DCF objects are called DCF directories. They are created directly under the DCF image root directory. The directory names conforming to the following rules are called DCF directory names.

- The directory name is 8 characters in length.
- The first three characters are a number between "100" and "999"; numbers "000" through "099" shall not be used. This number is referred to as the directory number.
- The rest of the name after the directory number shall be five characters. These are referred to here as the DCF directory name Free characters.
- These five characters consist only of the upper-case alphanumeric characters shown in Table 1. They shall not contain two-byte characters or special codes.

The conventions of DCF directory names are illustrated in Table 4.

Table 4 DCF directory naming example (excluding extension)

Specification	Directory number			Free characters (5 alphanumerics)				
Example	1	0	0	A	B	C	D	E

The Read Only attribute of the DOS FAT file system may be assigned to each directory to prevent accidental deletion. This is called directory protection. No other directory attributes are specified. Directory operations are handled as per the Writer and Reader specifications.

5.1.3 Other directories

The following is prohibited. No specification is made regarding other directories.

- DCF file names are used as directory names under the DCF image root directory.

5.1.4 Directory example

A typical DCF directory is shown in Figure 2.

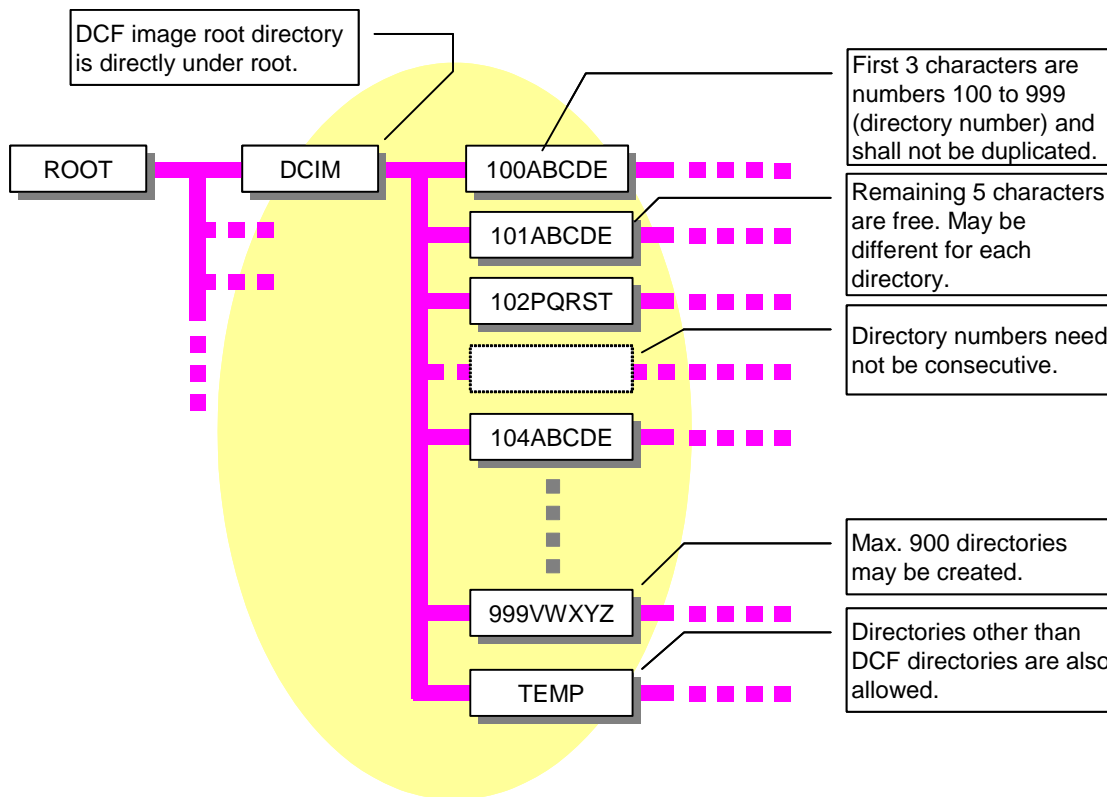


Figure 2 Typical DCF directory

5.2 File definition

5.2.1 DCF file names

File names conforming to the following rules are called DCF file names.

- The file name is 8 characters (not including the file extension).
- The first four characters consist only of the upper-case alphanumeric characters shown in Table 1. These are referred to as the DCF file name Free characters. They shall not contain two-byte characters or special codes.
- The four characters that follow are a number between "0001" and "9999". "0000" shall not be used. These four digits are referred to as File number.
- Files with the same file number stored in the same DCF directory are considered to be object component files as defined in 5.2.2.

The DCF file naming conventions are illustrated in Table 5

Table 5 DCF file naming example (excluding extension)

Specification	Free (4 alphanumerics)				File number			
Example	A	B	C	D	0	0	0	1

5.2.2 DCF objects

DCF objects are file groups defined as follows.

5.2.2.1 Purpose of DCF objects

Of the files stored on DCF media, objects may be created for the files related with each other, such as the main image file and the related audio file, to be handled together for the convenience of users.

5.2.2.2 Object definition

All files stored in a DCF directory with DCF file names are DCF object components. The free characters of the file name and the extensions may be different for files belong to the same object. A standalone file for which no other file with the same file number exists is still a DCF object. Two or more files in a DCF directory that share the same file number belong to the same DCF object. Files in directories that are not located under a DCF directory are not DCF object components, regardless of their file name.

5.2.2.3 Files included in objects

DCF defines files included in DCF objects. Files with other extensions and data structures not specified in DCF may also be included in a DCF object.

a) DCF basic file

- An image file conforming to the Exif standard.
- The extension is "JPG".
- The data structure and other details are given below.

b) DCF optional file

- An image file conforming to the Exif standard.

- The extension is "JPG".
 - The data structure and other details are given below.
- c) **DCF extended image file**
- A file with a DCF file name but having an extension and data structure other than "JPG" or "THM".
 - The data structure is not specified.
- d) **DCF thumbnail file**
- A file containing only a thumbnail image. It will be possible to achieve level 1 equivalent playback compatibility of a DCF extended image file.
 - It shall always coexist with the corresponding DCF extended image file.
 - The extension is "THM".
 - The data structure and other details are given below.
- e) **The rules for DCF object structure and elements prohibit the following.**
- More than one DCF basic file in the same object.
 - More than one DCF optional file in the same object.
 - More than one DCF thumbnail file in the same object.
 - A DCF basic file and DCF thumbnail file in the same object.
 - A DCF optional file and DCF thumbnail file in the same object.
 - A DCF basic file and DCF optional file in the same object.
 - A standalone DCF thumbnail file with no corresponding DCF extended image file in the same object.
 - Files with the extension "JPG" other than DCF basic files and DCF optional files.
 - A file with the extension "THM" having a data format other than that of a DCF thumbnail file.

5.2.2.4 Object file attributes

The Read Only attribute of the DOS FAT file system may be set for each file as Protection of individual objects, to prevent accidental deletion. A DCF object is protected when all the files in the object are set with the Read Only attribute. No specification is made regarding other file attributes.

5.2.2.5 Object operation

Object handling is as stipulated in the Writer and Reader specifications.

5.3 DCF basic files

5.3.1 Purpose

Image files conforming to Exif Ver. 2 and recorded as stipulated in this chapter are called DCF basic files. The purpose of DCF basic files is to achieve interchangeability of image files among DCF-compatible devices and applications. For level 2 playback compatibility to be realized among DCF-compatible devices and applications, the image files shall be DCF basic files.

5.3.2 Directory, file names and extensions

A DCF basic file is a component of a DCF object, is stored directly under a DCF directory, has a DCF file name, and has the extension "JPG". The character "_" shall not be used as the first character of a file name.

5.3.3 Images in a DCF basic file

An Exif primary image in a DCF basic file is called a DCF basic main image. An Exif thumbnail image in a DCF basic file is called a DCF basic thumbnail.

5.3.4 Data structure of a DCF basic main image

5.3.4.1 Data structure

The only supported data format for DCF basic main image data is Exif compressed format (JPEG format). The pixel composition and sampling may be either YCbCr4:2:2 or YCbCr4:2:0.

5.3.4.2 Data compression

The compression ratio of DCF main basic images is not specified. The JPEG data structure is as stipulated in the Exif standard. Insertion of a restart marker is optional. As Huffman Table, the Typical Huffman Table specified in the JPEG standard shall be used.

5.3.4.3 Pixel count

the number of pixels is not specified.

5.3.4.4 Image aspect ratio

The image aspect ratio is not specified.

5.3.5 Attribute information

Attribute information is recorded as follows, based on the Exif standard.

5.3.5.1 Exif tag structure

The byte order used in the TIFF structure may be either Big Endian or Little Endian, as in the Exif specification.

5.3.5.2 Information about shooting conditions and camera

Image-related information shall be recorded, as per the Exif standard. In addition to the Exif mandatory tags, inclusion of the following tags is mandatory in DCF.

Make (0th IFD, mandatory)

In the Exif standard this is optional, but its inclusion is mandatory here so the Writer manufacturer name can be determined.

Tag	=	271 (10F.H)
Type	=	ASCII
Count	=	Any
Default	=	none

Model (0th IFD, mandatory)

In the Exif standard this is optional, but its inclusion is mandatory here so the Writer model name can be determined.

Tag	=	272 (110.H)
Type	=	ASCII
Count	=	Any
Default	=	none

DateTimeOriginal (Exif IFD, mandatory)

In the Exif standard this is optional, but its inclusion is mandatory here so the original image creation date and time can be determined. If the date and time the original image was shot are unknown, this field may be filled with spaces as stipulated in the Exif standard.

Tag	=	36867 (9003.H)
Type	=	ASCII
Count	=	20
Default	=	none

DateTimeDigitized (Exif IF, mandatory)

In the Exif standard this is optional, but its inclusion is mandatory here so the digital data creation date and time can be determined. If the date and time of digital data creation are unknown, this field may be filled with spaces as stipulated in the Exif standard.

Tag	=	36868 (9004.H)
Type	=	ASCII
Count	=	20
Default	=	none

5.3.5.3 DCF basic file identifying information

Information is specified in the Interoperability IFD for identifying a file as a DCF basic file. See the Exif standard for details of the Interoperability IFD. Tags in the Interoperability IFD are specified as follows in DCF.

InteroperabilityIndex (Interoperability IFD, mandatory)

Since the file content is equivalent to ExifR98 Version 1.0, the value is "R98". The tag including end code is 4 bytes. Note that this differs from the value (THM) defined for DCF thumbnail files in section 3.4.4.

Tag	=	1 (1.H)
Type	=	ASCII
Count	=	4
Default	=	"R98"

InteroperabilityVersion (Interoperability IFD, mandatory)

This tag records the Interoperability version. Since the file content is equivalent to ExifR98, the value is the 4-byte ASCII "0100" meaning Version 1.00. This is not terminated by NULL since the Type is UNDEFINED.

Tag	=	2 (2.H)
Type	=	UNDEFINED
Count	=	4

Default = 0100

RelatedImageFileFormat (Interoperability IFD, optional)

This is normally used in a DCF thumbnail file, but it may also be included in a DCF basic file, in which case it indicates that file's own format (Exif JPEG Ver. 2.1, etc.). It is recorded as an ASCII character string.

Tag = 4096 (1000.H)
 Type = ASCII
 Count = Any
 Default = none

RelatedImageWidth (Interoperability IFD, optional)

This is normally used in a DCF thumbnail file, but it may also be included in a DCF basic file, in which case it indicates the number of horizontal pixels of that image itself.

Tag = 4097 (1001.H)
 Type = SHORT or LONG
 Count = 1
 Default = none

RelatedImageLength (Interoperability IFD, optional)

This is normally used in a DCF thumbnail file, but it may also be included in a DCF basic file, in which case it indicates the number of vertical pixels of that image itself.

Tag = 4098 (1002.H)
 Type = SHORT or LONG
 Count = 1
 Default = none

5.3.5.4 Color space

The ColorSpace tag declares sRGB in the Exif IFD specified in the Exif standard, as follows.

ColorSpace (Exif IFD, mandatory)

This tag declares sRGB.

Tag = 40961 (A001.H)
 Type = SHORT
 Value = 1 (sRGB)
 Count = 1

5.3.6 DCF basic thumbnail data structure

5.3.6.1 Image data format

The thumbnail data structure is in accord with the Exif compressed thumbnail specification. The pixel composition and sampling is YCbCr4:2:2. The reason for limiting to one choice here is to ensure Level 1 playback compatibility. The color space used for a thumbnail image shall be sRGB as with main images.

5.3.6.2 Compressed data

The JPEG data structure is as specified in Exif. As in the Exif specification, no restart marker is inserted. As Huffman Table, the Typical Huffman Table specified in the JPEG standard shall be used. The compression ratio of DCF basic thumbnails is not specified.

5.3.6.3 Number of pixels

The number of pixels for thumbnail recording is 160 horizontal pixels by 120 vertical pixels, chosen as a size large enough to enable the image to be recognized. Any other pixel size is prohibited.

5.3.6.4 Layout

If the DCF basic main image has an aspect ratio different from that of the DCF basic thumbnail, the difference shall be adjusted by padding. The recommended method for recording thumbnail images is as follows.

- Padding data: black (RGB all 0)
- Image position: centered
- Relation to main image: should conform to the field angle of the main image to the extent possible, without cutting out part of the image.

5.3.7 image data format in DCF basic files

The DCF basic main image format is summarized in Table 6. The DCF basic thumbnail data format is summarized in Table 7.

Table 6 DCF Basic Main Image Data Format

Compression	Number of pixels	Aspect ratio	Chrominance sampling	Compression ratio	Huffman Table	Color space
Compressed (JPEG)	Not specified	Not specified	4:2:2 or 4:2:0	Not specified	Typical	sRGB

Table 7 DCF Basic Thumbnail Data Format

Compression	Number of pixels	Aspect ratio	Chrominance sampling	Compression ratio	Huffman Table	Color space
Compressed (JPEG)	160 x 120 (fixed)	4:3 (fixed)	4:2:2 (fixed)	Not specified	Typical	sRGB

5.4 DCF optional files

5.4.1 Purpose

A DCF optional file is used when an image is to undergo extensive processing, notably in professional uses such as commercial printing. The image data uses the DCF optional color space.

5.4.2 Directory, file names and extensions

A DCF optional file is a component of a DCF object, is stored directly under a DCF directory, has a DCF file name, and has the extension "JPG". The character "_" shall always be used as the first character of the file name.

Typical file name: "_ABC0001.JPG"

5.4.3 Data structure of a DCF optional file main image

5.4.3.1 Data structure

The only supported data format for DCF optional main image data is Exif compressed format (JPEG format). The pixel composition and sampling may be either YCbCr4:2:2 or YCbCr4:2:0.

5.4.3.2 Data compression

The compression ratio of image data is not specified. The JPEG data structure is as stipulated in the Exif standard. Insertion of a restart marker is optional. As Huffman Table, the Typical Huffman Table specified in the JPEG standard shall be used.

5.4.3.3 Pixel count

The number of pixels is not specified.

5.4.3.4 Image aspect ratio

The image aspect ratio is not specified.

5.4.4 Attribute information

Attribute information is recorded as follows, based on the Exif standard.

5.4.4.1 Exif tag structure

The byte order used in the TIFF structure may be either Big Endian or Little Endian, as in the Exif specification.

5.4.4.2 Image-related information

Image-related information shall be recorded, as per the Exif standard. In addition to the Exif mandatory tags, inclusion of the following tags is mandatory in DCF.

Make (0th IFD, mandatory)

Tag data is the same as for DCF basic files (see 5.3.5.).

Model (0th IFD, mandatory)

Tag data is the same as for DCF basic files (see 5.3.5.).

DateTimeOriginal (Exif IFD, mandatory)

Tag data is the same as for DCF basic files (see 5.3.5.).

DateTimeDigitized (Exif IF, mandatory)

Tag data is the same as for DCF basic files (see 5.3.5.).

5.4.4.3 DCF optional file identifying information

Information is specified in the Interoperability IFD for identifying a file as a DCF optional file. See the Exif standard for details of the Interoperability IFD. Tags in the Interoperability IFD are specified as follows for DCF optional files.

InteroperabilityIndex (Interoperability IFD, mandatory)

The value is "R03". The tag including end code is 4 bytes.

Tag	=	1 (1.H)
Type	=	ASCII
Count	=	4
Default	=	"R03"

InteroperabilityVersion (Interoperability IFD, mandatory)

This tag records the version of the InteroperabilityIndex value. The value is the 4-byte ASCII "0100" meaning Version 1.00. This is not terminated by NULL since the Type is UNDEFINED.

Tag	=	2 (2.H)
Type	=	UNDEFINED
Count	=	4
Default	=	0100

RelatedImageFileFormat (Interoperability IFD, optional)

This is normally used in a DCF thumbnail file, but it may also be included in a DCF optional file, in which case it indicates that file's own format (Exif JPEG Ver. 2, etc.). It is recorded as an ASCII character string.

Tag	=	4096 (1000.H)
Type	=	ASCII
Count	=	Any
Default	=	none

RelatedImageWidth (Interoperability IFD, optional)

This is normally used in a DCF thumbnail file, but it may also be included in a DCF optional file, in which case it indicates the number of horizontal pixels of that image itself.

Tag	=	4097 (1001.H)
Type	=	SHORT or LONG
Count	=	1
Default	=	none

RelatedImageLength (Interoperability IFD, optional)

This is normally used in a DCF thumbnail file, but it may also be included in a DCF optional file, in which case it indicates the number of vertical pixels of that image itself.

Tag = 4098 (1002.H)
 Type = SHORT or LONG
 Count = 1
 Default = none

5.4.4.4 Color space

The DCF optional color space is used in a DCF optional file, and its characteristics are defined using the WhitePoint tag, PrimaryChromaticities tag, YCbCrCoefficients tag, and Gamma tag.

ColorSpace (Exif IFD, mandatory)

This tag records Uncalibrated, indicating non-use of the sRGB color space.

Tag = 40961 (A001.H)
 Type = SHORT
 Value = FFFF.H (Uncalibrated)
 Count = 1

WhitePoint (0th IFD, mandatory)

This tag indicates the chromaticities of reference whitepoint. Information shall be recorded as follows in a DCF optional file.

Tag = 318 (13E.H)
 Type = RATIONAL
 Count = 2
 Value = 139.H / 3E8.H 149.H / 3E8.H

The above values are for chromaticities of (X, Y) = (0.313, 0.329).

PrimaryChromaticities (0th IFD, mandatory)

This tag indicates the chromaticities of the three primary colors. Information shall be recorded as follows in a DCF optional file.

Tag = 319 (13F.H)
 Type = RATIONAL
 Count = 6
 Value = 40.H / 64.H 21.H / 64.H 15.H / 64.H 47.H / 64.H F.H / 64.H
 6.H / 64.H

The above values are for the following chromaticities.

R chromaticities: (X, Y) = (0.64, 0.33)
 G chromaticities: (X, Y) = (0.21, 0.71)
 B chromaticities: (X, Y) = (0.15, 0.06)

YCbCrCoefficients (0th IFD, mandatory)

This tag indicates the color transform matrix coefficients for going from RGB to YCbCr image data. Information shall be recorded as follows in a DCF optional file.

Tag = 529 (211.H)
 Type = RATIONAL
 Count = 3
 Value = 12B.H / 3E8.H 24B.H / 3E8.H 72.H / 3E8.H

The above values correspond to the following coefficients.

0.299, 0.587, 0.114

Gamma (Exif IFD, mandatory)

This tag indicates a gamma compensation coefficient used by the transformation function in playback. Information shall be recorded as follows in a DCF optional file.

Tag = 42240 (A500.H)
 Type = RATIONAL
 Count = 1
 Value = 16.H / 0A.H

The above value is for a gamma compensation coefficient of 2.2.

5.4.5 DCF optional file thumbnail data structure**5.4.5.1 Image data format**

The thumbnail data structure is in accord with the Exif compressed thumbnail specification. The pixel composition and sampling is YCbCr4:2:2. The color space used for a thumbnail image shall be the same DCF optional color space used with main images.

5.4.5.2 Compressed data

The JPEG data structure is as specified in Exif. As in the Exif specification, no restart marker is inserted. As Huffman Table, the Typical Huffman Table specified in the JPEG standard shall be used. The compression ratio of thumbnails is not specified.

5.4.5.3 Number of pixels

The number of pixels for thumbnail recording is 160 horizontal pixels by 120 vertical pixels, chosen as a size large enough to enable the image to be recognized. Any other pixel size is prohibited.

5.4.5.4 Layout

If the main image has an aspect ratio different from that of the thumbnail image, the difference shall be adjusted by padding. The recommended method for recording thumbnail images is as follows.

- Padding data: black (RGB all 0)
- Image position: centered
- Relation to main image: should conform to the field angle of the main image to the extent possible, without cutting out part of the image.

5.4.6 Image data format in DCF optional files

The DCF optional file main image format is summarized in Table 8. The DCF optional file thumbnail data format is summarized in Table 9.

Table 8 DCF Optional File Main Image Data Format

Compression	Number of pixels	Aspect ratio	Chrominance sampling	Compression ratio	Huffman Table	Color space
Compressed (JPEG)	Not specified	Not specified	4:2:2 or 4:2:0	Not specified	Typical	DCF optional color space

Table 9 DCF Optional File Thumbnail Data Format

Compression	Number of pixels	Aspect ratio	Chrominance sampling	Compression ratio	Huffman Table	Color space
Compressed (JPEG)	160 x 120 (fixed)	4:3 (fixed)	4:2:2 (fixed)	Not specified	Typical	DCF optional color space

5.5 DCF thumbnail files

5.5.1 Purpose

DCF extended image files recorded with proprietary functions often cannot be displayed on other Reader systems. In order to allow the images and their attributes to be checked on other systems and achieve playback equivalent to DCF basic file level 1 compatibility, small indexing files are defined, which are recorded separate from the DCF extended image files. These are called DCF thumbnail files.

The inclusion of DCF thumbnail files with DCF extended image files is not mandatory. For this reason, level 1-equivalent compatibility is not necessarily achieved for DCF extended image files. Likewise, it should be noted carefully that even if DCF thumbnail files are used, this does not guarantee playback equivalent to DCF basic file level 2 compatibility.

5.5.2 Directory, file name and extension

DCF thumbnail files shall be located in the same directory as their corresponding DCF extended image file. They have a DCF file name and "THM" as the file extension. The file number is the same as that of the corresponding DCF extended image file, and together they belong to one DCF object.

5.5.3 Image data structure

5.5.3.1 Data format

The data structure of a DCF thumbnail file is that specified in the Exif standard for compressed thumbnails. If the file has attribute information, however, the structure may be the same as the Exif file using APP1 and APP2 as specified in the Exif standard for compressed files. It shall not have APPn markers other than APP1 and APP2, or COM markers. APP1 shall not contain a thumbnail of the thumbnail. The DCF thumbnail file data structure is outlined in Figure 3.

The pixel composition and sampling is YCbCr4:2:2 only, as with DCF basic thumbnails specified at 5.3.4.

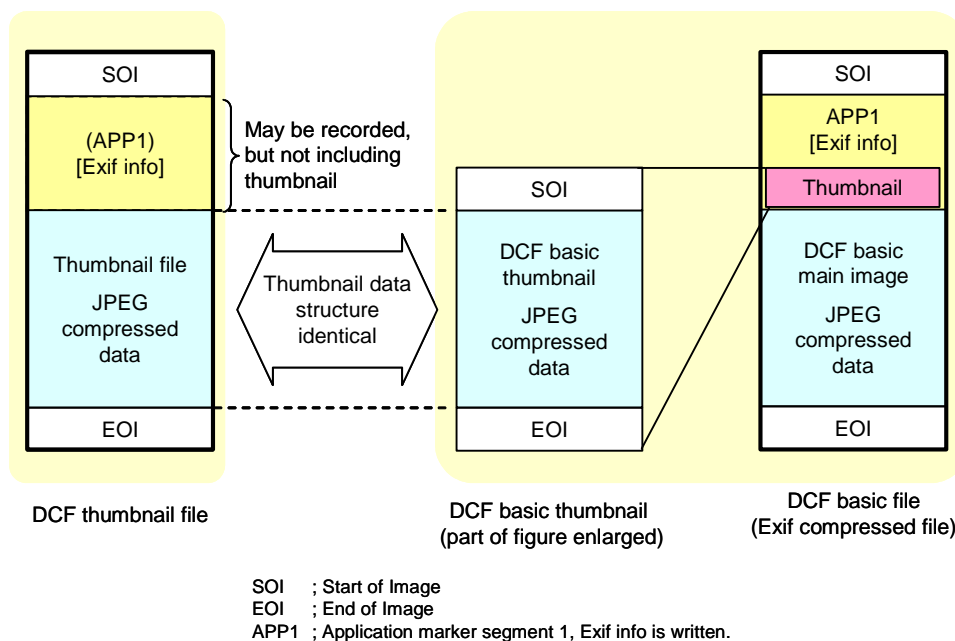


Figure 3 DCF thumbnail file structure

5.5.3.2 Compressed data specification

This is the same as that for DCF basic thumbnails specified at 5.3.4.

5.5.3.3 Pixel count

This is the same as that for DCF basic thumbnails specified at 5.3.4.

5.5.3.4 Image aspect ratio

This is the same as that for DCF basic thumbnails specified at 5.3.4.

5.5.4 Attribute information

When attribute information is included, it is recorded as follows.

5.5.4.1 Exif tag structure

The byte order used in the TIFF structure may be either Big Endian or Little Endian, as in the Exif specification.

5.5.4.2 Image-related information

When attribute information is included, it is recorded as in the Exif standard. In addition to Exif mandatory tags, the following tags are mandatory for DCF thumbnail files.

Make (0th IFD, mandatory when attribute information is recorded)

The contents are the same as for DCF basic files (see 5.3.5.).

Model (0th IFD, mandatory when attribute information is recorded)

The contents are the same as for DCF basic files (see 5.3.5.).

DateTimeOriginal (Exif IFD, mandatory when attribute information is recorded)

The contents are the same as for DCF basic files (see 5.3.5.).

DateTimeDigitized (Exif IFD, mandatory when attribute information is recorded)

The contents are the same as for DCF basic files (see 5.3.5.).

5.5.4.3 DCF thumbnail identification information

DCF identifying information is specified in the Interoperability IFD. For details of the Interoperability IFD, see the separate Exif standard. In DCF, the following tags are specified in the Interoperability IFD.

InteroperabilityIndex

(Interoperability IFD, mandatory when attribute information is recorded)

The value is "THM". The tag including end code is 4 bytes. Note that this differs from the value ("R98") specified as attribute information with DCF basic files.

Tag	=	1 (1.H)
Type	=	ASCII
Count	=	4
Default	=	"THM"

InteroperabilityVersion**(Interoperability IFD, mandatory when attribute information is recorded)**

Records the Interoperability version. The value here is ASCII "0100" meaning Version 1.00.

This not terminated by NULL since the Type is UNDEFINED.

Tag	=	2 (2.H)
Type	=	UNDEFINED
Count	=	4
Default	=	0100

RelatedImageFileFormat (Interoperability IFD, optional)

This tag is used to record in a DCF thumbnail file the file format of the corresponding DCF extended image file. It consists of an ASCII character string.

Tag	=	4096 (1000.H)
Type	=	ASCII
Count	=	Any
Default	=	none

RelatedImageWidth (Interoperability IFD, optional)

This tag is used to record in a DCF thumbnail file the horizontal pixel count of the corresponding DCF extended image file.

Tag	=	4097 (1001.H)
Type	=	SHORT or LONG
Count	=	1
Default	=	none

RelatedImageLength (Interoperability IFD, optional)

This tag is used to record in a DCF thumbnail file the vertical pixel count of the corresponding DCF extended image file.

Tag	=	4098 (1002.H)
Type	=	SHORT or LONG
Count	=	1
Default	=	none

5.5.4.4 Color space

The ColorSpace tag in the Exif IFD specified in the Exif standard declares sRGB as follows.

ColorSpace (Exif IFD, mandatory when attribute information is recorded)

The contents are the same as for DCF basic files (see 5.3.5.).

5.5.5 DCF thumbnail file data structure

The thumbnail data specifications for DCF thumbnail files are summarized in Table 10.

Table 10 DCF thumbnail file format

Compression	Number of pixels	Aspect ratio	Chrominance sampling	Compression ratio	Huffman Table	Color space
Compressed (JPEG)	160 x 120 (fixed)	4:3 (fixed)	4:2:2 (fixed)	Not specified	Typical	sRGB

5.6 Tag requirement levels

Some of the optional tags specified in the Exif standard are mandatory in DCF. This level difference is shown for the 0th IFD, Exif IFD and Interoperability IFD in Table 11, Table 12 and Table 13, respectively.

Table 11 0th IFD requirement level

Field Name	Tag No.		Requirement Level			Remarks
	Dec	Hex	DCF basic	DCF optional	Thumbnail	
Make	271	10F	M	M	C	R
Model	272	110	M	M	C	R
WhitePoint	318	13E	N	M	N	O
PrimaryChromaticities	319	13F	N	M	N	O
YCbCrCoefficients	529	211	N	M	N	O

Table 12 Exif IFD requirement level

Field Name	Tag No.		Requirement Level			Remarks
	Dec	Hex	DCF basic	DCF optional	Thumbnail	
DateTimeOriginal	36867	9003	M	M	C	O
DateTimeDigitized	36868	9004	M	M	C	O
Interoperability IFD Pointer	40965	A005	M	M	C	O
Gamma	42240	A500	N	M	N	O

Table 13 Interoperability IFD requirement level

Field Name	Tag No.		Requirement Level			Remarks
	Dec	Hex	DCF basic	DCF optional	Thumbnail	
InteroperabilityIndex	1	1	M	M	C	O
InteroperabilityVersion	2	2	M	M	C	--
RelatedImageFileFormat	4096	1000	O	O	O	--
RelatedImageWidth	4097	1001	O	O	O	--
RelatedImageLength	4098	1002	O	O	O	--

Notation

M : Mandatory (shall be recorded)

C : Conditionally mandatory (shall be recorded when attribute information is included)

R : Strongly recommended (shall be recorded if possible)

O : Optional (recorded if required by particular equipment)

N : Prohibited

-- : Not specified

5.7 File structure example

An example of the file structure in a DCF directory is shown in Figure 4.

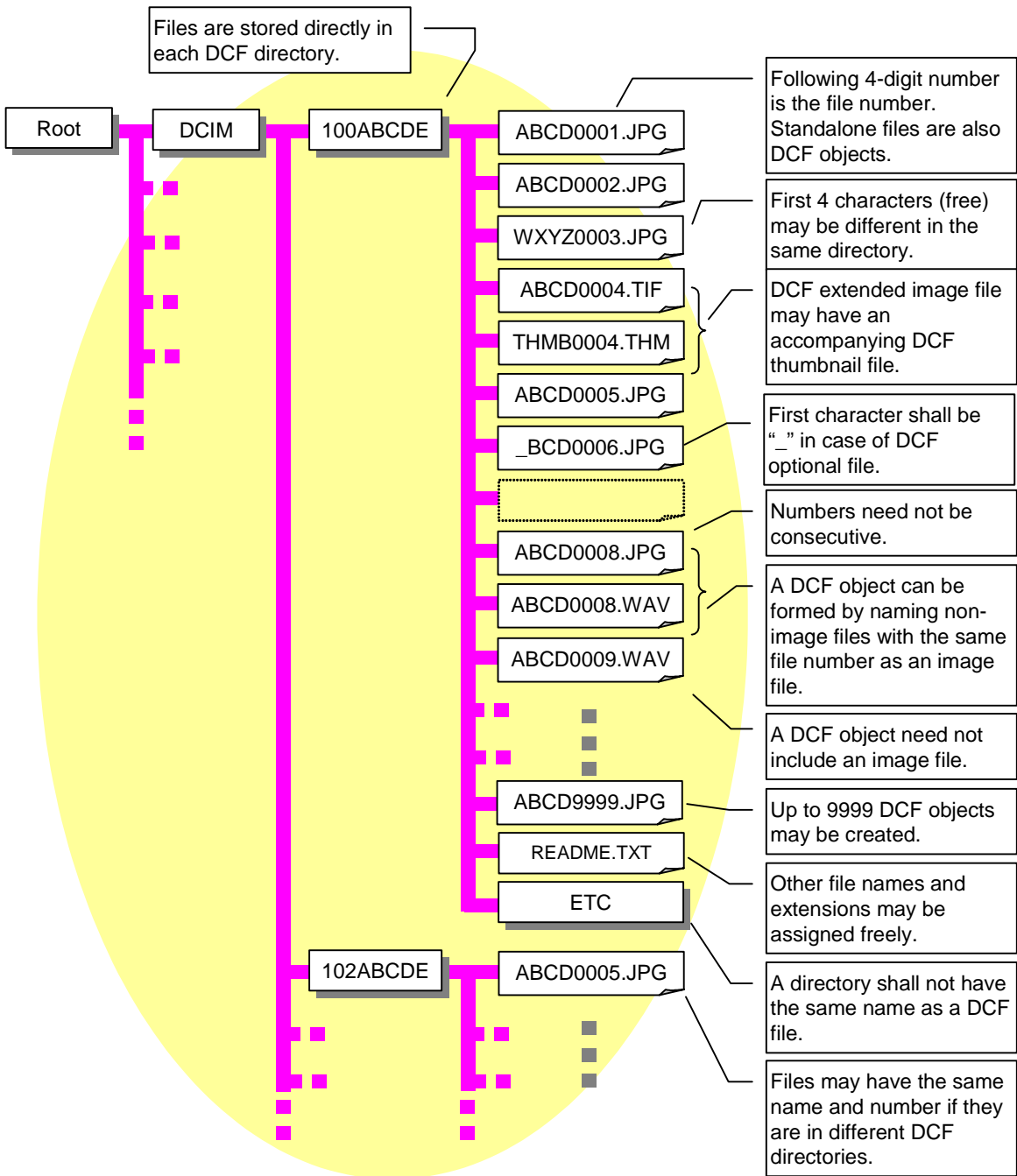


Figure 4 Typical file structure in a DCF directory

6. Writer Specification

6.1 Directories

6.1.1 Creating directories

6.1.1.1 DCF image root directory

A Writer shall have a function for creating a DCF image root directory on the DCF recording medium if no such directory exists.

6.1.1.2 DCF directories

A maximum of 900 DCF directories may be created under the DCF image root directory. The directory numbering rules are as follows.

- If a new DCF directory is being created when no other DCF directory exists directly under the DCF image root directory on the DCF recording medium, any directory number may be assigned.
- When an additional DCF directory is added, it is recommended that it be given a directory number of 1 greater than the largest existing directory number.
- Directory numbers shall not be duplicated on the same recording medium.

6.1.1.3 Other directories

It is permissible to locate directories besides the DCF image root directory directly below the root directory.

It is likewise permissible to locate directories besides DCF directories, based on individual equipment specifications, under the DCF image root directory.

Directories based on individual equipment specifications may be created inside a DCF directory, but a DCF file name shall not be used for the directory name in this case.

6.1.2 Deleting directories

It is permissible for deletion of a specific DCF directory to result in a directory number discontinuity. A user attempting to delete a protected directory shall be presented with a warning to this effect. When an entire removable medium is initialized (formatted), the handling of directory protection is left up to the specifications for individual equipment.

6.2 Files

6.2.1 Creating files

6.2.1.1 Image files

Image files are recorded in a DCF directory in accord with the specifications below.

To assure interoperability across Writer and Reader using DCF basic files, all Writer products shall have a function for recording DCF basic files. DCF optional files or DCF extended image files may be recorded as well, for the sake of proprietary functions. Note, however, that no image file without a DCF file name shall be recorded in a DCF directory.

6.2.1.2 DCF thumbnail files

A thumbnail file may be recorded along with a DCF extended image file to form a DCF object.

6.2.1.3 Other files making up a DCF object

Other files besides DCF basic files, DCF optional files, DCF extended image files, and DCF thumbnail files may be given DCF file names and recorded.

Another file having a DCF file name may be included in a DCF object, by giving it the same file number as another file. A file shall not, however, be recorded with a file number without the express intention of the Writer user.

6.2.1.4 Files without a DCF file name

When a file other than an image file is recorded in a DCF directory, it may be given any desired file name, but shall not have the "JPG" or "THM" file extension.

6.2.2 File number

The rules for recording file numbers are as follows.

- If there is no DCF file name among the files in the DCF directory where a file is to be stored, any initial file number may be used.
- If a DCF file name already exists in the DCF directory where a file is to be stored, it is recommended that the file number be assigned as the largest existing number + 1.
- Within the same DCF directory, the file numbers of DCF basic files and DCF optional files shall not be duplicated. DCF basic files and DCF optional files in different DCF directories may have the same file number.
- File numbers may be duplicated in the same directory for the purpose of forming a DCF object. Note, however, that when a DCF basic file and DCF extended image file are made part of the same object, a Reader will normally give playback priority to the DCF basic file (see Chapter 6), which may result in a different file being displayed than the one intended by the Writer user. For this reason, it is best to avoid recording a DCF basic file and DCF extended image file in the same object; or if they are in the same object, to notify the Writer user of this possibility either in the manual or by displaying a notice on the Writer display.
- The upper limit on the number of DCF objects that may be stored in one DCF directory is 9999, the same as the number of file numbers.

6.2.3 Deleting files

6.2.3.1 DCF objects

All DCF objects, that is, all DCF basic files, DCF optional files, DCF extended image files, DCF thumbnail files and other files with DCF file names, are deleted, moved and copied in object units (see 8.4.). Copying is treated in the same way as recording a new file. Moving is treated as a combination of copying and deletion. It is possible, with the Writer user's express intention, to delete, move, or copy one or some of the files in an object. A protected object shall not be deleted without presenting the user with a warning to that effect.

If a DCF object contains a file with the Hidden attribute, that file is also treated as part of the object. The Hidden flag may be ignored.

When removable memory is initialized (formatted), the handling of protection is left up to the specifications for individual equipment.

6.2.3.2 Files that are not DCF objects

No specification is made.

7. Reader Specification

7.1 Directories (common to Reader 1 and 2)

7.1.1 Playback

7.1.1.1 Playback scope

A reader shall detect the directories on a DCF medium, and shall display the files in them according to the specifications in 7.2. No specification is made regarding the playback of other directories, except that if they exist, they shall not hinder the displaying of images located in DCF directories.

7.1.1.2 Playback method

The order of playback is not specified.

7.1.2 Deletion

A user attempting to delete a protected directory shall be presented with a warning to this effect. When removable memory is initialized (formatted), the handling of directory protection is left up to the specifications for individual equipment.

7.2 Files

7.2.1 Playback

7.2.1.1 Reader 1 playback scope

Reader 1 shall display the DCF basic files and DCF optional files in a DCF directory detected as in 7.1.1.1.

Playback of the main image in a DCF basic file is preferable; but if the main image cannot be displayed because the pixel count exceeds the playback capability, etc., the corresponding thumbnail shall be displayable (thumbnail substitute playback).

It is preferable that Reader 1 be able to perform the necessary color space transformation processing for playback of the main image in a DCF optional file; but if Reader 1 lacks that capability, it shall at least be capable of thumbnail substitute playback without color space transformation. Reader 1 may also display main images without color space transformation processing.

7.2.1.2 Reader 2 playback scope

Reader 2 shall be able to detect the DCF basic files in a DCF directory as in 7.1.1.1. and shall be able to display the DCF basic main images within the range of the supported pixel count specification explained in 7.2.1.4 below. If a DCF basic main image is outside the supported pixel count and cannot be displayed, the corresponding DCF basic thumbnail may be displayed instead. It is preferable that Reader 2 be able to detect a DCF optional file in a DCF directory and to display a DCF optional main image within the range of the supported pixel count specification. If Reader 2 lacks the capability for color space transformation processing, displaying of main images without that processing is allowable.

7.2.1.3 DCF extended image files (common to Reader 1 and 2)

No specification is made regarding DCF extended image file playback. If the same object contains both a DCF basic file and DCF extended file, as a rule priority shall be given to playback of the DCF basic file. The priority of other file playback is not specified.

7.2.1.4 Supported pixel count specification

The supported pixel count specification indicates the maximum and minimum DCF basic main image size that shall be displayable on a Reader 2 device. Reader 2 shall be able to display DCF basic main images within the range shown in Table 14.

Table 14 Displayable pixel count range

	Pixel count ranges			
	Minimum		X	Maximum
Horizontal pixel range	160	<=	X	<= 1800
	and			
Vertical pixel range	120	<=	Y	<= 1200

(Pixels)

7.2.2 Playback method (common to Reader 1 and 2)

No specification is made as to the playback display layout or order of display.

7.2.3 DCF optional files and color space transformation

The relation of DCF optional file playback and the Reader 1 and 2 color space transformation capability is shown in Table 15.

Table 15 DCF optional files and color space transformation capability

Image data	Color space transformation	Reader1	Reader2
Main image	No	Optional	Optional
	Yes	Optional	Optional
Thumbnail (substitute playback)	No	Mandatory (if color space transformation not possible)	Optional
	Yes	Optional	Optional

7.2.4 Handling of color-related tags (common to Reader 1 and 2)

If a color-related tag other than the ColorSpace tag is found in a DCF basic file, it is ignored. The tags shown in Table 16 are meant by color-related tags.

Table 16 Ignored color-related tags

Field Name	IFD	Tag no
TransferFunction	0th IFD	301
WhitePoint	0th IFD	318
PrimaryChromaticities	0th IFD	319
YCbCrCoefficients	0th IFD	529
ReferenceBlackWhite	0th IFD	532
Gamma	Exif IFD	42240

In the case of DCF optional files, the tags listed in Table 17 may be referenced to find out the recorded color space characteristics. See 8.5. on the method of identifying DCF optional files.

Table 17 Referenced color-related tags

Field Name	IFD	Tag no
WhitePoint	0th IFD	318
PrimaryChromaticities	0th IFD	319
YCbCrCoefficients	0th IFD	529
Gamma	Exif IFD	42240

7.2.5 Deletion (common to Reader 1 and 2)

7.2.5.1 DCF objects

All DCF objects, that is, all DCF basic files, DCF optional files, DCF extended image files, DCF thumbnail files and other files with DCF file names, are deleted, moved and copied in object units (see 8.4). Copying is treated in the same way as recording a new file. Moving is treated as a combination of copying and deletion. It is possible, with the Reader user's express intention, to delete, move, or copy one or some of the files in an object. A protected object shall not be deleted without presenting the user with a warning to that effect.

If a DCF object contains a file with the Hidden attribute, that file is also treated as part of the object. The Hidden flag may be ignored.

When removable memory is initialized (formatted), the handling of protection is left up to the specifications for individual equipment.

7.2.5.2 Files that are not DCF objects

No specification is made.

7.3 Directory number and file number display (common to Reader 1 and 2)

A Reader with number display function shall also have a function for displaying the directory numbers and file numbers of DCF basic files and DCF optional files, and for enabling the user to designate any images with the numbers. The purpose is to allow users to designate DCF basic files and DCF optional files on DCF media without using the full path name.

The display rules are as follows.

- Show the directory number on the left and the file number on the right, separating them with a hyphen.
- Details such as zero suppression or padding are not specified.
- Directory numbers and file numbers may be displayed at all times or only when called up by an operation of some kind.
- Other methods of displaying image numbers may be used alongside this method.

The directory numbers and file numbers of DCF extended image files may also be displayed if desired.

An example of directory number and file number display is given in Table 18.

Table 18 Typical directory number and file number display

	Directory number	File number
--	------------------	-------------

Example 1	1	0	2	-	0	0	1	5
Example 2	1	0	2	-			1	5
Example 3	1	0	2	-	1	5		

8. Other Points to Note

8.1 Naming directories under the DCF image root directory

The method by which a Writer adds a new directory to media containing directories that do not follow the DCF specifications, on a PC or the like as in Figure 5, is specified here along with the Reader playback method in such cases.

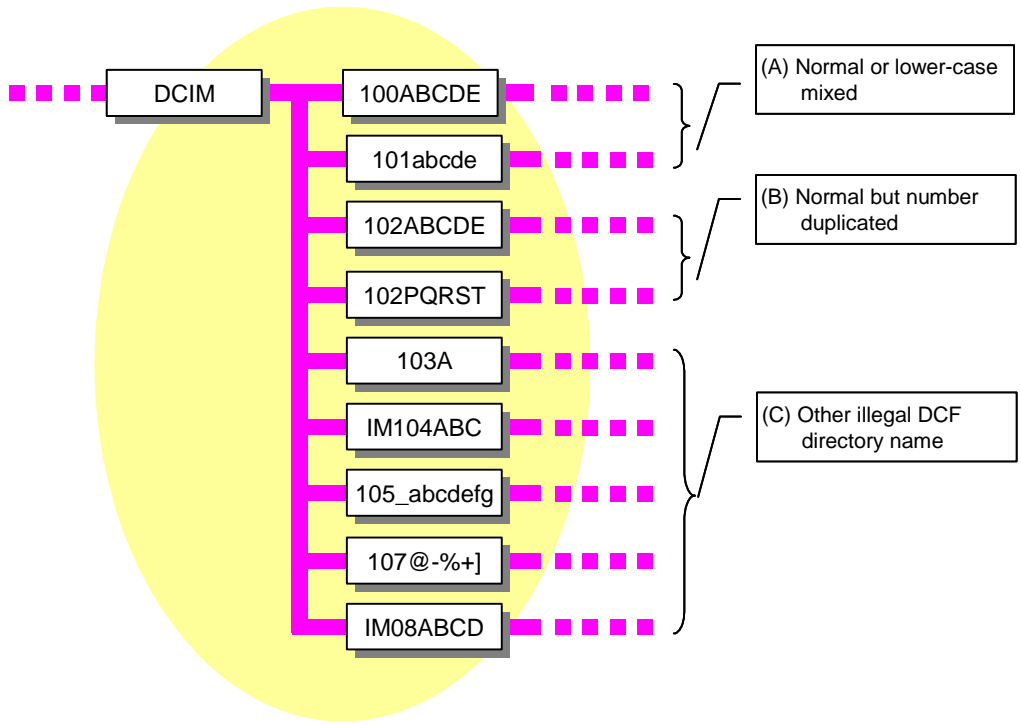


Figure 5 Directory naming precautions

8.1.1 When lower-case letters are used in a directory name

If lower-case letters are used in the free characters of a directory name but the name is otherwise compliant with DCF directory naming conventions, it shall be treated as a DCF directory without distinguishing case. A Writer may add files to such a directory, and may create new directories so long as the directory number is not duplicated. A Reader shall treat the directory as a DCF directory without distinguishing case.

8.1.2 When directory numbers are duplicated across DCF directories

Directories with duplicate directory numbers are all treated as non-DCF directories. New DCF objects shall not be recorded in such a directory. A Reader may display the files in such a directory, but the directory numbers and file numbers shall not be displayed. It shall also be made apparent to the user that files in such directories are not DCF basic files. When a Writer creates a new directory, it shall not be allowed to duplicate directory numbers.

8.1.3 Handling of directories that are not DCF directories

A Reader or Writer may completely ignore a directory that is not a normal DCF directory and that does not fall under cases 8.1.1 or 8.1.2 above. A Reader may display the files in such a directory, but

the directory numbers and file numbers shall not be displayed. It shall also be made apparent to the user that files in such directories are not DCF basic files.

8.2 Naming of files in a DCF directory

The method by which a Writer adds a new object to a directory containing files with names that do not follow the DCF specifications, on a PC or the like as in Figure 6, is specified here along with the method by which a Reader displays DCF objects in such cases.

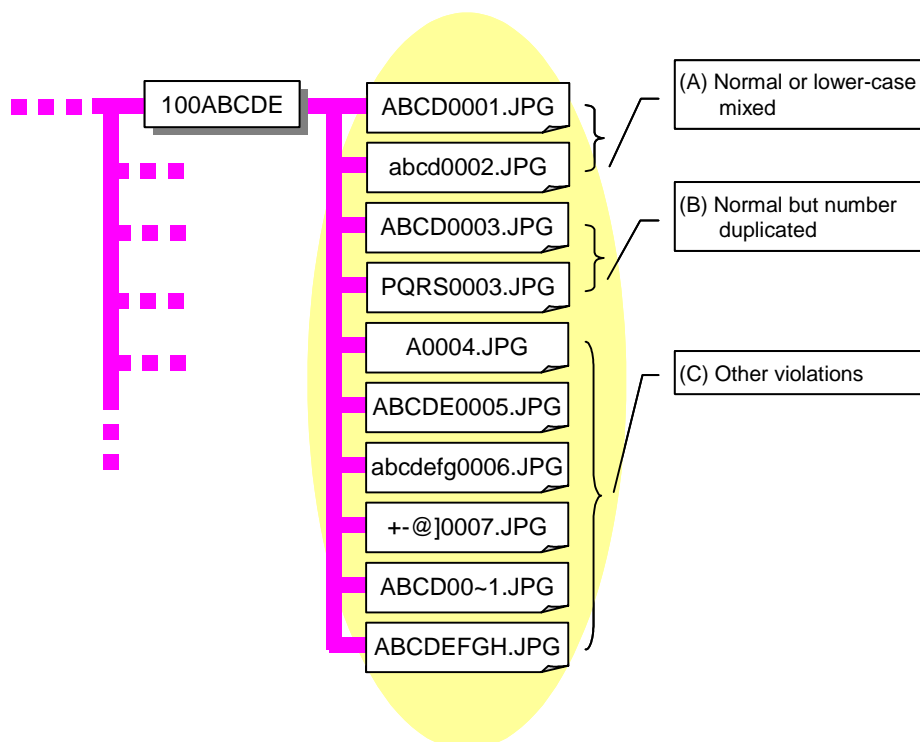


Figure 6 File naming precautions

8.2.1 When lower-case letters are used in the file name

If lower-case letters are used in the four free characters of a file name or in the extension, but otherwise the file is named in accord with DCF file naming conventions, it is treated as a DCF object without distinguishing case.

8.2.2 When file numbers are duplicated across DCF basic files or DCF optional files

If file numbers are duplicated across DCF basic files or DCF optional files, a Reader may display the files, but the directory numbers and file numbers shall not be displayed. It shall also be made apparent to the user that the files are not DCF basic files or DCF optional files. When a Writer creates a new DCF object, it shall not be allowed to duplicate the file numbers.

8.2.3 Handling of files without DCF file names

A file without a normal DCF file name that does not fall under cases 8.2.1 or 8.2.2 above may be completely ignored. A Reader may display such files, but the directory numbers and file numbers

shall not be displayed. It shall also be made apparent to the user that the files are not DCF basic files.

8.3 Updating of tag data when saving

8.3.1 Handling of date and time tags

The Exif standard specifies the following three date and time tags.

- `DateTimeOriginal`
- `DateTimeDigitized`
- `DateTime`

`DateTime` records the date and time of file updating, like a file time stamp. `DateTimeOriginal` records the date and time when an image was shot, and `DateTimeDigitized` has the date and time when digital data was created. On a DSC, in many cases these three are identical.

If a DCF basic file or DCF optional file is saved again at a time after the image was originally captured, it is recommended that only the `DateTime` tag be updated and not the `DateTimeOriginal` or `DateTimeDigitized` tags. If, however, the image is processed in a way that invalidates the date and time of original image capture, it is allowable to update the `DateTimeOriginal` and `DateTimeDigitized` tags as well.

When a DCF basic file or DCF optional file is created not on a DSC but on a PC or the like, and the capture date and time cannot be determined, the `DateTimeOriginal` tag may have the date and time left blank (filled with space characters), as indicated in the Exif standard.

8.3.2 Handling of Make, Model, and Software tags

The Exif standard specifies the following three tags for recording information about equipment and applications.

- `Make`
- `Model`
- `Software`

The `Make` tag records the equipment or application vendor name, and `Model` gives the model name. `Software` may be used to record the name of software used in equipment (embedded software) or for the application software name.

If any of these tags is updated when a DCF basic file or DCF optional file is saved, it is recommended that only the `Software` tag be changed and the `Make` and `Model` tags be left as is. If, however, the image is processed in such a way as to invalidate the equipment information of the original image, the `Make` and `Model` tags may also be updated.

When a DCF basic file or DCF optional file is created not on a DSC but on a PC or the like, `Make` and `Model` may be used to record the software name.

8.4 DCF object bulk operations

Write-protecting a DCF object requires that the Read Only attribute be assigned to all the files in the DCF object. If file attributes are changed on a PC or the like, it is conceivable that only some of the files in a DCF object will be protected.

A Writer or Reader, respecting the DCF object configuration, is designed to operate so that if even one file in a DCF object has the Read Only attribute, all files in that object are considered protected. If an object consists of a very large number of files such that bulk operations (copying, moving, deleting) are not practical, a Writer or Reader shall not perform operations involving only some of the files at one time, regardless of the Writer or Reader user's intention.

8.5 Identification of DCF optional files

A DCF optional file is identified based on the InterOperabilityIndex tag value and the color space-related tags specified in Chapter 5. A Reader uses these tags to determine whether a file is a DCF optional file. In the case of a noncompliant file such as one missing a mandatory color space-related tag or having a recorded value that differs from the specifications, the InterOperabilityIndex value may be used. If both the Gamma and TransferFunction tags are present, precedence shall be given to the Gamma tag.

Annex A Data Verification

1. Validation method

Validation testing is performed by the makers of DCF-compatible equipment and applications themselves

Annex B Relation to JPEG and Exif Standards

The Exif standard specifies requirement levels as mandatory, recommended, and optional for each item relating to image and audio file recording methods. For example, thumbnail recording is optional, and leeway is permitted in thumbnail format.

The DCF standard specifies administrative rules, which add further stipulations to the Exif standard for the sake of playback compatibility. The file format in DCF is based on the Exif standard. The relationship among JPEG, Exif and DCF standards is summarized in Figure 7. See chapter 5 and following for details.

Standard name Specification	JPEG	Exif Ver.2	DCF Ver2.0
Compressed image file format	JPEG Baseline specification JPEG extended specification	Marker segment limits Pixel sampling limits	Exif Ver. 2 conformant Typical Huffman Table used
Thumbnail image format		JPEG 4:2:2 JPEG 4:2:0 TIFF	Size 160x120 fixed Typical Huffman Table used
Image attribute information		Camera information Color space information Other information	Some mandatory items sRGB and DCF optional color space Exif Ver. 2 conformant
FlashPix Ready function		Specified	Exif Ver. 2 conformant
Directory and file naming		Not specified	Specified
Writer and reader specifications			Writer and reader conditions specified
Uncompressed image file format		TIFF Rev. 6.0 conformant (some restrictions specified)	
Audio file format		WAV format (some restrictions specified)	
Object specification			Related files specified as objects

Figure 7 Relation of DCF to Exif and JPEG standards

Annex C Notes on Image File Playback

When displaying an image file, a Reader should make the user aware of whether the file being displayed is a DCF basic file or some other kind of image, so that the user can determine whether the image is displayable on another Reader as well.

The recommended method of making the user aware is either by indicating that the displayed image is a DCF basis file when a DCF basic file is being displayed, or by indicating that the displayed image is not a DCF basic file when an image file other than a DCF basic file is being displayed. (Figure 8)

The method of distinguishing main image playback from thumbnail substitute playback is not specified but is optional. (Figure 8)

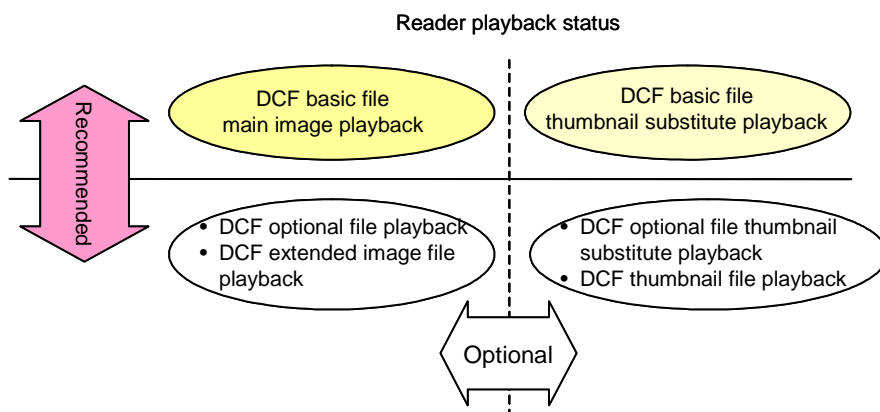


Figure 8 Playback status identification

Annex D Limits on DCF Object Operations

When there are limitations placed on the number of DCF objects that can be handled or other device specifications that may limit the ability to perform operations on some DCF objects, the user shall be warned of these limitations, such as by indicating them in product manuals or by product display.

Annex E Notes on DCF Optional Color Space Use

1. Writer

A Writer capable of recording DCF optional files shall inform users, in manuals or by other means, of the significance of the optional color space, its functions and use.

The following are examples of such indication.

- It is applicable mainly for use in commercial printing, when images undergo extensive processing.
- It is intended for professional-use software.
- DCF basic files are geared to use in kiosks, print services, and home printers.

2. Reader

If a Reader displays DCF optional files without color space transformation processing, it is recommended that the user be warned of the possibility of incorrect color rendition.

Explication of the DCF 2.0 Revision

This document provides explanatory information on the latest revision to the DCF Standard, Version 2.0. This document includes explanations referring to the definitions in the DCF Standard, reference material in relation to the standard, and information in relation to the development of the standard. This document is entirely informative and shall not be considered as an integral part of the DCF Standard.

This section gives a supplementary explanation of matters indicated or referred to in this specification and its annexes, and of related matters. It is not part of the specification itself.

1. Purpose

The present revision to the Design Rule for Camera File System (DCF) standard was undertaken mainly for the purpose of adding an optional color space (described below), as a color space specification suitable for commercial applications. In this way the DCF specification is made readily usable for such applications in addition to ordinary consumer applications as up to now.

2. History of Revision

The DCF standard, first drawn up in 1999 as a companion to the Exif format (Exchangeable image file format for digital still camera), has contributed importantly to the popularity of digital still cameras (DSC) by enabling image files to be exchanged among a variety of media and devices.

In the DCF standard, only Exif compressed format (JPEG format) files are defined as mandatory files (DCF basic files) that must be supported by image writer and reader hardware or application software. This ensures direct exchangeability of image data recorded on removable memory.

As DSC performance levels have risen, these products have come to be widely used in professional applications as well as by ordinary consumers. The professional uses include the commercial printing field, where it has become evident that the image data recorded in JPEG files (DCF basic files) can meet the requirements quite adequately.

The existing DCF Version 1.0 (DCF 1.0) specification, however, is affected by the following issues when the attempt is made to use DCF-recorded image files in such commercial applications. DCF 1.0 specifies that image data in DCF basic files be recorded assuming playback using the sRGB color space. In applications like commercial printing, however, image data is recorded for a color space different from sRGB, which means that data conversion (color space transformation) must be performed when using image data recorded by a DSC conforming to DCF 1.0. For this reason there have been calls to extend the DCF standard so as to enable direct use of the image data in professional fields like the above.

DCF Version 2.0 (DCF 2.0) was drawn up in response to these needs. In addition to the sRGB color space assumed in DCF 1.0, it enables image data for an optional color space in standard use in the commercial printing field to be recorded as Exif compressed format (JPEG format) files. This revision is therefore made only to support a specific existing color space (optional color space), and is not intended to allow for other color space extensions. The Writer and Reader specifications have

been revised to accommodate the additional recording of image files matched to the optional color space. Other revisions have been made correcting erroneous or unclear wording in the DCF 1.0 standard, in order to make the specifications easier to understand.

3. Main Issues Arising in the Deliberations

As noted above, the purpose of this revision is to enable use of an optional color space different from the sRGB color space used as standard in DCF 1.0. The main point of argument in the discussions was how to record files using the optional color space (DCF optional files) without causing problems for users of Reader products conformant to DCF 1.0. The data structure of the optional files is Exif compressed format as noted above, and tags are used to distinguish DCF optional files from DCF basic files. However, since the InteroperabilityIndex tag for identifying a DCF optional file is ignored by a Reader based on the DCF 1.0 specification, or by an ordinary JPEG reader not conforming to Exif, the images will be displayed by these readers. In this case the image data recorded for the optional color space will be displayed as sRGB color space data, causing concern that the color rendering will not be accurate. One possibility considered was to use a file extension other than ".JPG" so that DCF optional files would not be displayed by conventional Reader products. The concern in this case, however, was that users would be confused by the inability to play these files due to their different file extension. It was therefore decided to keep the same extension as that used with basic files, but to specify the prefixing of "_" at the beginning of all optional file names, as this is a character unlikely to be used ordinarily as the first character of a file name. This prefix makes it possible to identify a DCF optional file even if the identification tag in the file cannot be recognized.

4. Main Revisions

4.1 Definition of DCF optional files

DCF optional files have the following characteristics.

- Image data is recorded using the DCF optional color space. The file name shall begin with "_".
- A newly defined InteroperabilityIndex value is recorded to identify a DCF optional file.
- The Color Space tag is assigned a certain value different from sRGB.
- Tags indicating the characteristics of the optional color space (WhitePoint, PrimaryChromaticities, YCbCrCoefficient, and Gamma) are recorded in a DCF optional file.

4.2 Writer specifications

In addition to the existing specifications applying to DCF directories, these directories are now able to contain DCF optional files.

4.3 Reader specifications

In addition to the existing specifications applying to Reader 1 products, they are now able to display DCF optional file thumbnails. In displaying these files, color space transformation is preferable but is not mandatory if Reader limitations prevent it.

Display of DCF optional files by a Reader 2 product is optional (implementation dependent).

5. Industrial Properties Rights

The companies listed below have declared that they hold the patent right(s) shown below, which include issued patents and pending patent applications, and have announced that they will grant a license to these patents under reasonable and non-discriminately terms and conditions for products which conform to the JEITA standard “Exchangeable image file format for digital still cameras: Exif Version 2.21”. Such licenses should be negotiated with each patent holder.

-KONICA PHOTO IMAGING CORPORATION

-Sony Corporation

-Hewlett-Packard Japan, Ltd.

-FUJI PHOTO FILM CO., LTD.

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights other than those identified above. JEITA shall not be held responsible for any or all such patent rights.

6. DCF Optional Color Space

6.1 Overview

As a result of recent improvements in digital still camera image quality and advances in image processing techniques, the commercial printing industry has begun to change the way images are input when printing photographs. Direct input of digital images shot with digital still cameras is replacing the conventional procedure of capturing pictures on film and then putting them through a film scanner. Magazine ads and catalogs can be created more efficiently and in shorter time than before. Image data using the sRGB color space standardized in the existing Exif 2.2 specification is being used in some commercial publishing tasks.

At the same time, in the printing part of the workflow, the industry is moving in the direction of standardizing on an adequate color space, capable of rendering RGB data in ink with brighter, more saturated colors. If the RGB data input in the editing, design and layout stages use a different color space, conversion must be made between color spaces. Given the large amount of image data handled in the industry, the need for color space transformation processing puts a heavy strain on work efficiency and maintenance of quality.

With this revision of the DCF standard, an adequate color space is specified, having special advantages in the commercial printing industry workflow. The optional color space specified here is defined with the same color gamut as the Adobe RGB*1 color space in wide use by professional photographers, prepress industry including DTP, and designers. And its character is shown in chapter 6.2.

While viewing conditions are left to the discretion of respective manufacturers, it is desired that the conditions should be standardized in the future.

6.2 Color space characteristics

The characteristics of DCF optional color space are as follows.

Gamma compensation: $\gamma=2.2$

White Point: $x=0.313, y=0.329$ (D65)

Chromaticity coordinates	x	y
R	0.64	0.33
G	0.21	0.71
B	0.15	0.06

*1: This color space is called Adobe RGB

7. Committee Organization for Preparing the Draft Standard

This standard was deliberated by Exif/DCF Sub Committee of CIPA ,Camera & Imaging Products Association . The draft standard was then presented to JEITA Technical Standardization Committee on AV & IT Storage-Systems and Equipment, and approved by that Committee in () 2003.

The committees involved in drafting the standard are as follows:

JEITA

Technical Standardization Committee on AV & IT Storage Systems and Equipment

Chairman: Tadashi Ezaki Sony Corporation

Technical Standardization Committee on Color Management

Chairman: Nobuaki Usui Fujitsu Corporation

Digital Camera Standardization Group

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Sub Leader: Takao Tsuchiya Sony Corporation

Sub Leader: Hiroaki Sugiura Mitsubishi Electric Corporation

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 Hideaki Kawamura Canon Inc.

 Shuji Hayashi KONICA PHOTO IMAGING CORPORATION

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Mitsuhiko Maeda	SANYO Electric Co., Ltd.
Yukio Okano	SHARP CORPORATION
Yoshiyuki Ozawa	SEIKO EPSON CORPORATION
Hiroko Hayashi	SEIKO EPSON CORPORATION
Tadashi Ezaki	Sony Corporation
Naoya Kato	Sony Corporation
Sadao Maeyama	Sony Corporation
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Kazuya Yoshida	Dai Nippon Printing Co., Ltd.
Tatsuro Abe	TOSHIBA CORPORATION
Norihiro Aso	Victor Company of Japan, Limited
Kazuyuki Sato	Hitachi, Ltd.
Makoto Tsugita	FUJI PHOTO FILM CO., LTD.
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CIPA Standardization Committee

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	Keita Kimizuka	KONICA PHOTO IMAGING CORPORATION
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	Masao Tamashima	SANYO Electric Co., Ltd.
	Masayasu Kakami	SHARP CORPORATION
	Shohji Takada	SHARP CORPORATION

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Masako Tago	Sony Corporation
Toyoko Fujii	Sony Corporation
Toshikuni Tateno	Tamron Co., Ltd.
Urato Ariga	CHINON INDUSTRIES INC.
Tatsuro Abe	TOSHIBA CORPORATION
Kiyoshige Shibazaki	NIKON CORPORATION
Kazuto Yoneyama	Hitachi Ltd.
Kazuhiko Takemura	FUJI PHOTO FILM CO., LTD.
Hisayoshi Tsubaki	FUJI PHOTO FILM CO., LTD.
Yoshiharu Hibi	Fuji Xerox Co., Ltd.
Fumio Nakaya	Fuji Xerox Co., Ltd.
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