

1	Status	Letter Ballot
2	Date of Last Update	2017/04/04
3	Person Assigned	David Clunie
4		mailto:dclunie@dclunie.com
5	Submitter Name	Dave Harvey
6		mailto:dave@medicalconnections.co.uk
7	Submission Date	2016/06/09

8	Correction Number CP-1653	
9	Log Summary: Clarify Photometric Interpretations Permitted for Decompressed and Compressed Transfer Syntaxes	
10	Name of Standard	
11	PS3.3, PS3.5, PS3.11	
12	Rationale for Correction:	
13	Some photometric interpretations are defined primarily for use with compressed data, YBR_FULL_422 for use with (lossy) JPEG,	
14	YBR_RCT & YBR_ICT for use with JPEG 2000, and YBR_PARTIAL_420 for use with MPEG.	
15	YBR_FULL_422 has also been encountered with RLE compressed and uncompressed data (particularly in Ultrasound applications).	
16	Though there are issues with using YBR_FULL_422 (e.g., the chrominance downsampling and upsampling methods are not formally	
17	defined even though the cositing mechanism is, and different choices by sender and recipient can cause aliasing artifacts), it cannot	
18	be forbidden because it is encountered in the field. It is also included in the Ultrasound Media Application profiles. Accordingly, some	
19	clarifications and limitations are proposed.	
20	YBR_PARTIAL_422, though permitted by the Ultrasound Media Application profiles, has apparently never been used.	
21	YBR_RCT, YBR_ICT and YBR_PARTIAL_420 have problems and ambiguities if used for uncompressed data, very few, if any,	
22	recipients support such use, so it is proposed to disallow their use for uncompressed data.	
23	Some existing color IODs explicitly constrain the permitted Photometric Interpretation values to those appropriate for the Transfer	
24	Syntax, either in the IOD or in IOD-family-specific Modules. It is proposed to apply similar constraints to VL, WSI, Ophthalmology	
25	IODs by adding restrictions to the corresponding Modules. The PS3.5 descriptions of the Transfer Syntaxes are augmented with	
26	tables describing matching constraints. Those tables are constrained to plausible and encountered combinations and specifically	
27	exclude certain undesirable ones, such as the use of lossy compression for palette color data (the limitations of which are currently	
28	described in informative text in PS3.3).	
29	It is also proposed to expand the IOD-specific lists of supported Transfer Syntaxes to recognize the use of YBR_FULL for RLE when	
30	permitted (and note if not).	
31	This CP accepts the current constraint in the US IOD that the Planar Configuration be 1 for YBR_FULL data (which is intended for	
32	use with RLE). A separate proposal (CP 1678) raises the question of whether the US IOD should be modified to allow a Planar	
33	Configuration of 0 and hence allow the JPEG family of Transfer Syntaxes to be used for YBR_FULL Ultrasound images. That CP	
34	could probably be merged with this one.	

The issues with the Photometric Interpretations that are to be restricted from use for uncompressed formats are as follows:

YBR_RCT:

The defined conversion takes 3xN bit data, and produces 3 components that are N, N+1 & N+1 bits respectively. This is because the B & R components need to be signed, and can exceed the range of an N-bit signed number. For instance, pure red, in 8 bit form (R=255, G=0, B=0) transforms to (Y=63, CB= -63, CR = 192) , and there is no unambiguous way to represent both -63 and 192 in single bytes, unless we explicitly define the reconstructing algorithm to use an unsigned addition with explicitly defined/accepted wraparound. This is not a problem when encoded in JPEG 2000, which unlike the rules for DICOM uncompressed data, specifically allows differing bit depths for different components.

As there is no means in DICOM to specify different numbers of bits for different samples, this situation could not be handled without expanding the number of bits for all samples, which would make no sense, and which would break the specificities for many of the SOP classes which use such color data.

YBR_ICT:

In most respects this photometric interpretation is the same as YBR_FULL, but the CB & CR components do not have the +128 offset to bring them from the signed byte range to the unsigned range. It is therefore possible to encode and decode this data within the ranges allowed by 3x8 bit data, but only by making an assumption (unstated in the standard) that the 2nd and 3rd components should be interpreted as signed data.

YBR_PARTIAL_420:

The definition in PS3.3 C.7.6.3.1.2 does not provide sufficient information to indicate how the 4 Y values, and the CB & CR should be interleaved - e.g., as YYYYBRYYYYBR or as alternating lines of YBRYYYBR and YYYY. Neither solution is really satisfactory (especially if row or column numbers were odd) , and as there is no significant use case for this format in uncompressed form, it is proposed that the format should be disallowed rather than generating a lot of work to define the form of "cositing".

Correction Wording:

Amend DICOM PS 3.3:

2 Normative References

2.6 Other References

[Poynton 2008] Poynton, Charles. 2008/01/24. Chroma subsampling notation. http://www.poynton.com/PDFs/Chroma_subsampling_notation.pdf.

A.8.5.4 Multi-frame True Color SC Image IOD Content Constraints

In the Image Pixel Module, the following constraints apply:

- Samples per Pixel (0028,0002) shall be 3
- Photometric Interpretation (0028,0004) shall be RGB for uncompressed or lossless compressed Transfer Syntaxes that do not ~~involve~~have defined color space transformations, YBR_ICT for irreversible JPEG 2000 Transfer Syntaxes, YBR_RCT for reversible JPEG 2000 Transfer Syntaxes, YBR_PARTIAL_420 for MPEG2, MPEG-4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes, ~~and~~ YBR_FULL_422 for ~~other~~JPEG lossy compressed Transfer Syntaxes and YBR_FULL or RGB for RLE Transfer Syntaxes.

Note

Future lossless and lossy Transfer Syntaxes may lead to the need for new definitions and choices for Photometric Interpretation.

- Bits Allocated (0028,0100) shall be 8
- Bits Stored (0028,0101) shall be 8
- High Bit (0028,0102) shall be 7
- Pixel Representation (0028,0103) shall be 0
- Planar Configuration (0028,0006) shall be 0 (color-by-pixel) if Photometric Interpretation (0028,0004) is RGB

A.36.4.3.1 Enhanced MR Color Image IOD Content Constraints

Photometric Interpretation (0028,0004) shall be RGB for uncompressed or lossless compressed Transfer Syntaxes that do not ~~involve~~have defined color space transformations, YBR_ICT for irreversible JPEG 2000 Transfer Syntaxes, YBR_RCT for reversible JPEG 2000 Transfer Syntaxes, YBR_PARTIAL_420 for MPEG2, MPEG-4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes, ~~and~~ YBR_FULL_422 for ~~other~~JPEG lossy compressed Transfer Syntaxes and YBR_FULL or RGB for RLE Transfer Syntaxes.

Note

Future lossless and lossy Transfer Syntaxes may lead to the need for new definitions and choices for Photometric Interpretation.

A.76.4 Wide Field Ophthalmic Photography Stereographic Projection Image IOD Content Constraints

The following constraints on Series and Image attributes take precedence over the descriptions given in the Module Attribute Tables.

A.76.4.1 Bits Allocated, Bits Stored, and High Bit

These Attributes shall be determined based upon the Photometric Interpretation (0028,0004):

Photometric Interpretation (0028,0004)	Bits Allocated (0028,0100)	Bits Stored (0028,0101)	High Bit (0028,0102)
MONOCHROME2	8	8	7

Photometric Interpretation (0028,0004)	Bits Allocated (0028,0100)	Bits Stored (0028,0101)	High Bit (0028,0102)
	16	16	15
RGB	8	8	7
YBR_FULL_422			
YBR_PARTIAL_420			
YBR_ICT			
YBR_RCT			

A.77.4 Wide Field Ophthalmic Photography 3D Coordinates Image IOD Content Constraints

The following constraints on Series and Image attributes take precedence over the descriptions given in the Module Attribute Tables.

A.77.4.1 Bits Allocated, Bits Stored, and High Bit

These Attributes shall be determined based upon the Photometric Interpretation (0028,0004) :

Photometric Interpretation (0028,0004)	Bits Allocated (0028,0100)	Bits Stored (0028,0101)	High Bit (0028,0102)
MONOCHROME2	8	8	7
	16	16	15
RGB	8	8	7
YBR_FULL_422			
YBR_PARTIAL_420			
YBR_ICT			
YBR_RCT			

C.7.6.3 Image Pixel Module

Table C.7-11c. Image Pixel Description Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. See Section C.7.6.3.1.1 for further explanation.
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. See Section C.7.6.3.1.2 for further explanation.
Rows	(0028,0010)	1	Number of rows in the image. <u>Shall be an exact multiple of the horizontal downsampling factor if any of the samples (planes) are encoded downsampled in the horizontal direction for pixel data encoded in a Native (uncompressed) format.</u>
Columns	(0028,0011)	1	Number of columns in the image. <u>Shall be an exact multiple of the horizontal downsampling factor if any of the samples (planes) are encoded downsampled in the horizontal direction for pixel data encoded in a Native (uncompressed) format. E.g., required to be an even value for a Photometric Interpretation (0028,0004) of YBR_FULL_422.</u>

Attribute Name	Tag	Type	Attribute Description
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. Bits Allocated (0028,0100) shall be either 1, or a multiple of 8. See PS3.5 for further explanation.
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored. See PS3.5 for further explanation.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Each sample shall have the same high bit. High Bit (0028,0102) shall be one less than Bits Stored (0028,0101). See PS3.5 for further explanation.
Pixel Representation	(0028,0103)	1	Data representation of the pixel samples. Each sample shall have the same pixel representation. Enumerated Values: 0000H unsigned integer. 0001H 2's complement
Planar Configuration	(0028,0006)	1C	Indicates whether the pixel data are sent color-by-plane or color-by-pixel. Required if Samples per Pixel (0028,0002) has a value greater than 1. See Section C.7.6.3.1.3 for further explanation.
...

C.7.6.3.1 Image Pixel Attribute Descriptions

C.7.6.3.1.1 Samples Per Pixel

Samples per Pixel (0028,0002) is the number of separate planes in this image. One and three image planes are defined. Other numbers of image planes are allowed, but their meaning is not defined by this Standard.

For monochrome (gray scale) and palette color images, the number of planes is 1. For RGB and other three vector color models, the value of this attribute is 3.

Note

The use of a value of 4 was previously described, but the Photometric Interpretations that used it have been retired.

All image planes shall have the same number of Rows (0028,0010), Columns (0028,0011), Bits Allocated (0028,0100), Bits Stored (0028,0101), High Bit (0028,0102), Pixel Representation (0028,0103), and Pixel Aspect Ratio (0028,0034).

Note

Downsampled chrominance planes of a color Photometric Interpretation are a special case, e.g., for a Photometric Interpretation (0028,0004) of YBR_FULL_422. In such cases, Samples per Pixel (0028,0002) describes the nominal number of channels (i.e., 3), and does not reflect that two chrominance samples are shared between four luminance samples. For YBR_FULL_422, Rows (0028,0010) and Columns (0028,0011) describe the size of the luminance plane, not the downsampled chrominance planes.

The data in each pixel may be represented as a "Composite Pixel Code". If Samples Per Pixel is one, the Composite Pixel Code is just the "n" bit pixel sample, where "n" = Bits Allocated. If Samples Per Pixel is greater than one, Composite Pixel Code is a "k" bit concatenation of samples, where "k" = Bits Allocated multiplied by Samples Per Pixel, and with the sample representing the vector color designated first in the Photometric Interpretation name comprising the most significant bits of the Composite Pixel Code, followed in order by the samples representing the next vector colors, with the sample representing the vector color designated last in the Photometric Interpretation name comprising the least significant bits of the Composite Pixel Code. For example, for Photometric Interpretation = "RGB", the most significant "Bits Allocated" bits contain the Red sample, the next "Bits Allocated" bits contain the Green sample, and the least significant "Bits Allocated" bits contain the Blue sample.

C.7.6.3.1.2 Photometric Interpretation

The value of Photometric Interpretation (0028,0004) specifies the intended interpretation of the image pixel data.

See PS3.5 for **additional** restrictions imposed by compressed Transfer Syntaxes.

The following values are defined. Other values are permitted **if supported by the Transfer Syntax** but the meaning is not defined by this Standard.

Defined Terms:

MONOCHROME1 Pixel data represent a single monochrome image plane. The minimum sample value is intended to be displayed as white after any VOI gray scale transformations have been performed. See PS3.4. This value may be used only when Samples per Pixel (0028,0002) has a value of 1. **May be used for pixel data in a Native (uncompressed) or Encapsulated (Compressed) format; see PS3.5 Section 8.2 “Native or Encapsulated Format Encoding”.**

MONOCHROME2 Pixel data represent a single monochrome image plane. The minimum sample value is intended to be displayed as black after any VOI gray scale transformations have been performed. See PS3.4. This value may be used only when Samples per Pixel (0028,0002) has a value of 1. **May be used for pixel data in a Native (uncompressed) or Encapsulated (Compressed) format; see PS3.5 Section 8.2 “Native or Encapsulated Format Encoding”.**

PALETTE COLOR Pixel data describe a color image with a single sample per pixel (single image plane). The pixel value is used as an index into each of the Red, Blue, and Green Palette Color Lookup Tables (0028,1101-1103&1201-1203). This value may be used only when Samples per Pixel (0028,0002) has a value of 1. **May be used for pixel data in a Native (uncompressed) or Encapsulated (Compressed) format; see PS3.5 Section 8.2 “Native or Encapsulated Format Encoding”.** When the Photometric Interpretation is Palette Color; Red, Blue, and Green Palette Color Lookup Tables shall be present.

RGB Pixel data represent a color image described by red, green, and blue image planes. The minimum sample value for each color plane represents minimum intensity of the color. This value may be used only when Samples per Pixel (0028,0002) has a value of 3. **Planar Configuration (0028,0006) may be 0 or 1. May be used for pixel data in a Native (uncompressed) or Encapsulated (Compressed) format; see PS3.5 Section 8.2 “Native or Encapsulated Format Encoding”.**

HSV *Retired.*

ARGB *Retired.*

CMYK *Retired.*

YBR_FULL Pixel data represent a color image described by one luminance (Y) and two chrominance planes (CB and CR). This photometric interpretation may be used only when Samples per Pixel (0028,0002) has a value of 3. **May be used for pixel data in a Native (uncompressed) or Encapsulated (Compressed) format; see PS3.5 Section 8.2 “Native or Encapsulated Format Encoding”.** **Planar Configuration (0028,0006) may be 0 or 1.**

This Photometric Interpretation is primarily used with RLE compressed bit streams, for which the Planar Configuration (0028,0006) is required to be 1; see PS3.5 Section 8.2.2 “Run Length Encoding Compression”. **When used in the US Image Module, the Planar Configuration (0028,0006) is required to be 1; see Section C.8.5.6.1.16 “Planar Configuration”.**

Black is represented by Y equal to zero. The absence of color is represented by both CB and CR values equal to half full scale.

Note

In the case where Bits Allocated (0028,0100) has value of 8 half full scale is 128.

In the case where Bits Allocated (0028,0100) has a value of 8 then the following equations convert between RGB and YCBCR Photometric Interpretation.

$$Y = +.2990R + .5870G + .1140B$$

$$CB = -.1687R - .3313G + .5000B + 128$$

$$CR = +.5000R - .4187G - .0813B + 128$$

Note

The above is based on CCIR Recommendation 601-2 dated 1990.

YBR_FULL_422

The same as YBR_FULL except that the CB and CR values are sampled horizontally at half the Y rate and as a result there are half as many CB and CR values as Y values.

This Photometric Interpretation is only allowed with Planar Configuration (0028,0006) equal to shall be 0. May be used for pixel data in a Native (uncompressed) or Encapsulated (Compressed) format; see PS3.5 Section 8.2 "Native or Encapsulated Format Encoding".

Note

- This Photometric Interpretation is primarily used with JPEG compressed bit streams, but is also occasionally used for pixel data in a Native (uncompressed) format.**
- Though the chrominance channels are downsampled, there are still nominally three channels, hence Samples per Pixel (0028,0002) has a value of 3, not 2. I.e., for pixel data in a Native (uncompressed) format, the Value Length of Pixel Data (7FE0,0010) is not:**

$$\text{Rows (0028,0010)} * \text{Columns (0028,0011)} * \text{Number of Frames (0028,0008)} * \text{Samples per Pixel (0028,0002)} * ((\text{Bits Allocated (0028,0100)} - 1) / 8 + 1)$$

added to an even length, as it would otherwise be, but rather is:

$$\text{Rows (0028,0010)} * \text{Columns (0028,0011)} * \text{Number of Frames (0028,0008)} * 2 * ((\text{Bits Allocated (0028,0100)} - 1) / 8 + 1)$$

added to an even length.
- When used to describe JPEG compressed bit streams, the chrominance sub-sampling in the JPEG bit stream may differ from this description. E.g., though many JPEG codecs produce only horizontally sub-sampled chrominance components (4:2:2), some sub-sample vertically as well (4:2:0). Though inaccurate, the use of YBR_FULL_422 to describe both has proven harmless. For a discussion of the sub-sampling notation, see [Poynton 2008].**

Two Y values shall be stored followed by one CB and one CR value. The CB and CR values shall be sampled at the location of the first of the two Y values. For each Row of Pixels, the first CB and CR samples shall be at the location of the first Y sample. The next CB and CR samples shall be at the location of the third Y sample etc.

Note

This subsampling **sited on the even luminance pixels** is often referred to as cosited sampling. **The cositing applies when describing pixel data in a Native (uncompressed) form. When used to describe compressed bit streams, the siting depends on the compression scheme. E.g., for JPEG according to JFIF [ISO/IEC 10918-5], the siting is midway between luminance samples, whereas for MPEG2 [ISO/IEC 13818-2], the sampling is cosited with the even luminance pixels. See also [Poynton 2008].**

YBR_PARTIAL_422 ~~The same as YBR_FULL_422 except that:~~ *Retired.*

- black corresponds to Y = 16;**

2. **Y is restricted to 220 levels (i.e., the maximum value is 235);**
3. **GB and GR each has a minimum value of 16;**
4. **CB and CR are restricted to 225 levels (i.e., the maximum value is 240);**
5. **lack of color is represented by GB and GR equal to 128.**

In the case where Bits Allocated (0028,0100) has value of 8 then the following equations convert between RGB and YBR_PARTIAL_422 Photometric Interpretation

$$Y = +.2568R + .5041G + .0979B + 16$$

$$CB = -.1482R - .2910G + .4392B + 128$$

$$CR = +.4392R - .3678G - .0714B + 128$$

Note

The above is based on CCIR Recommendation 601-2 dated 1990.

YBR_PARTIAL_420 Pixel data represent a color image described by one luminance (Y) and two chrominance planes (CB and CR).

This photometric interpretation may be used only when Samples per Pixel (0028,0002) has a value of 3. The same as YBR_PARTIAL_422 except that the CB and CR values are sampled horizontally and vertically at half the Y rate and as a result there are four times less CB and CR values than Y values, versus twice less for YBR_PARTIAL_422.

This Photometric Interpretation is only allowed with Planar Configuration (0028,0006) equal to shall be 0. Shall only be used for pixel data in an Encapsulated (Compressed) format; see PS3.5 Section 8.2 "Native or Encapsulated Format Encoding".

Note

This Photometric Interpretation is primarily used with MPEG compressed bit streams. For a discussion of the sub-sampling notation and siting, see [Poynton 2008].

Luminance and chrominance values are represented as follows:

1. **black corresponds to Y = 16;**
2. **Y is restricted to 220 levels (i.e., the maximum value is 235);**
3. **CB and CR each has a minimum value of 16;**
4. **CB and CR are restricted to 225 levels (i.e., the maximum value is 240);**
5. **lack of color is represented by CB and CR equal to 128.**

In the case where Bits Allocated (0028,0100) has value of 8 then the following equations convert between RGB and YBR_PARTIAL_420 Photometric Interpretation

$$Y = +.2568R + .5041G + .0979B + 16$$

$$CB = -.1482R - .2910G + .4392B + 128$$

$$CR = +.4392R - .3678G - .0714B + 128$$

Note

The above is based on CCIR Recommendation 601-2 dated 1990.

The CB and CR values shall be sampled at the location of the first of the two Y values. For the first Row of Pixels (etc.), the first CB and CR samples shall be at the location of the first Y sample. The next CB and CR samples shall be at the location of the third Y sample etc. The next Rows of Pixels containing CB and CR samples (at the same locations than for the first Row) will be the third etc.

YBR_ICT

Irreversible Color Transformation:

Pixel data represent a color image described by one luminance (Y) and two chrominance planes (CB and CR).

This photometric interpretation may be used only when Samples per Pixel (0028,0002) has a value of 3. **Planar Configuration (0028,0006) shall be 0. Shall only be used for pixel data in an Encapsulated (Compressed) format; see PS3.5 Section 8.2 "Native or Encapsulated Format Encoding".**

Note

This Photometric Interpretation is primarily used with JPEG 2000 compressed bit streams.

Black is represented by Y equal to zero. The absence of color is represented by both CB and CR values equal to zero.

Regardless of the value of Bits Allocated (0028,0100), the following equations convert between RGB and YCBCR Photometric Interpretation.

$$Y = +.29900R + .58700G + .11400B$$

$$CB = -.16875R - .33126G + .50000B$$

$$CR = +.50000R - .41869G - .08131B$$

Note

1. The above is based on [ISO/IEC 15444-1] (JPEG 2000).
2. In a JPEG 2000 bit stream, DC level shifting (used if the untransformed components are unsigned) is applied before forward color transformation, and the transformed components may be signed (unlike in JPEG ISO/IEC 10918-1).
3. In JPEG 2000, spatial down-sampling of the chrominance components, if performed, is signaled in the JPEG 2000 bit stream.

YBR_RCT

Reversible Color Transformation:

Pixel data represent a color image described by one luminance (Y) and two chrominance planes (CB and CR).

This photometric interpretation may be used only when Samples per Pixel (0028,0002) has a value of 3. **Planar Configuration (0028,0006) shall be 0. Shall only be used for pixel data in an Encapsulated (Compressed) format; see PS3.5 Section 8.2 "Native or Encapsulated Format Encoding".**

Note

This Photometric Interpretation is primarily used with JPEG 2000 compressed bit streams.

Black is represented by Y equal to zero. The absence of color is represented by both CB and CR values equal to zero.

Regardless of the value of Bits Allocated (0028,0100), the following equations convert between RGB and YBR_RCT Photometric Interpretation.

$$Y = \lfloor (R + 2G + B) / 4 \rfloor \text{ (Note: } \lfloor \dots \rfloor \text{ mean floor)}$$

$$CB = B - G$$

$$CR = R - G$$

The following equations convert between YBR_RCT and RGB Photometric Interpretation.

$$G = Y - \lfloor (CR + CB) / 4 \rfloor$$

$$R = CR + G$$

$$B = CB + G$$

Note

1. The above is based on [ISO/IEC 15444-1] (JPEG 2000).
2. In a JPEG 2000 bit stream, DC level shifting (used if the untransformed components are unsigned) is applied before forward color transformation, and the transformed components may be signed (unlike in JPEG ISO/IEC 10918-1).
3. This photometric interpretation is a reversible approximation to the YUV transformation used in PAL and SECAM.

C.7.6.3.1.3 Planar Configuration

Planar Configuration (0028,0006) indicates whether the color pixel data are sent color-by-plane or color-by-pixel. This Attribute shall be present if Samples per Pixel (0028,0002) has a value greater than 1. It shall not be present otherwise.

Enumerated Values:

- 0 The sample values for the first pixel are followed by the sample values for the second pixel, etc. For RGB images, this means the order of the pixel values sent shall be R1, G1, B1, R2, G2, B2, ..., etc.
- 1 Each color plane shall be sent contiguously. For RGB images, this means the order of the pixel values sent is R1, R2, R3, ..., G1, G2, G3, ..., B1, B2, B3, etc.

Note

Planar Configuration (0028,0006) is not meaningful when a compression Transfer Syntax is used that involves reorganization of sample components in the compressed bit stream. In such cases, since the Attribute is required to be sent, then an appropriate value to use may be specified in the description of the Transfer Syntax in PS3.5, though in all likelihood the value of the Attribute will be ignored by the receiving implementation.

C.7.6.23.6 Lossy Compression and Palette Color Lookup Tables (Informative)

Image objects containing non-monotonic Palette Color LUTs that are lossy compressed may potentially experience a change in the index values that results in the displayed image having a significantly different appearance than the original image.

C.8.5.6 US Image Module

Table C.8-18. US Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Samples Per Pixel	(0028,0002)	1	Number of samples (planes) in this image. See Section C.8.5.6.1.12 for specialization
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. See Section C.8.5.6.1.2 for specialization.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. See Section C.8.5.6.1.13 for specialization.

Attribute Name	Tag	Type	Attribute Description
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. See Section C.8.5.6.1.14 for specialization.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. See Section C.8.5.6.1.15 for specialization.
Planar Configuration	(0028,0006)	1C	Indicates whether the pixel data are sent color-by-plane or color-by-pixel. Required if Samples per Pixel (0028,0002) has a value greater than 1. See Section C.8.5.6.1.16 for specialization.
Pixel Representation	(0028,0103)	1	Data representation of pixel samples. See Section C.8.5.6.1.3 for specialization.
...

C.8.5.6.1 US Image Attribute Descriptions

C.8.5.6.1.2 Photometric Interpretation

Defined Terms:

MONOCHROME2
 PALETTE COLOR
 RGB
 ARGB (retired)
 YBR_FULL
 YBR_FULL_422
 YBR_PARTIAL_422
 YBR_RCT
 YBR ICT
 YBR_PARTIAL_420

Note

~~It is recommended that future implementations should not use~~ The ARGB and YBR_PARTIAL_422 photometric interpretations were previously defined but are retired.

When Samples per Pixel (0028,0002) is greater than 1, Photometric Interpretation (0028,0004) shall be RGB for uncompressed or lossless compressed Transfer Syntaxes that do not have defined color space transformations, YBR ICT for irreversible JPEG 2000 Transfer Syntaxes, YBR_RCT for reversible JPEG 2000 Transfer Syntaxes, YBR_PARTIAL_420 for MPEG2, MPEG-4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes, YBR_FULL_422 for JPEG lossy compressed Transfer Syntaxes and YBR_FULL or RGB for RLE Transfer Syntaxes.

See PS3.5 for additional restrictions imposed by compressed Transfer Syntaxes.

C.8.5.6.1.3 Pixel Representation

For US Images, Pixel Representation (0028,0103) is specified to use the following.

Enumerated Values:

0000H unsigned integer

C.8.5.6.1.12 Samples Per Pixel

For US Images, Samples Per Pixel (0028,0002) is specified to use the following values for specific Photometric Interpretations:

Table C.8-19. US Samples Per Pixel

Photometric Interpretation	Samples Per Pixel Value
MONOCHROME2	1
RGB	3
YBR_FULL	3
YBR_FULL_422	3
YBR_PARTIAL_422	3
YBR_RCT	3
YBR_ICT	3
YBR_PARTIAL_420	3
PALETTE COLOR	1

C.8.5.6.1.13 Bits Allocated

For US Images, Bits Allocated (0028,0100) is specified to use the following values for specific Photometric Interpretations:

Table C.8-20. US Bits Allocated

Photometric Interpretation	Bits Allocated Value
MONOCHROME2	8
RGB	8
YBR_FULL	8
YBR_FULL_422	8
YBR_PARTIAL_422	8
YBR_RCT	8
YBR_ICT	8
YBR_PARTIAL_420	8
PALETTE COLOR	8 - 8 bit palette, or 16 - 16 bit palette

C.8.5.6.1.14 Bits Stored

For US Images, Bits Stored (0028,0101) shall be equal to Bits Allocated (0028,0100).

C.8.5.6.1.15 High Bit

For US Images, High Bit (0028,0102) shall be one less than Bits Stored (0028,0101).

C.8.5.6.1.16 Planar Configuration

For US Images, Planar Configuration (0028,0006) is specified to use the following values for specific Photometric Interpretations:

Table C.8-23. US Planar Configuration

Photometric Interpretation	Planar Configuration Value
RGB	0 - color-by-pixel, or 1 - color-by-plane
YBR_FULL	1
YBR_FULL_422	0
YBR_PARTIAL_422	0
YBR_RCT	0
YBR_ICT	0
YBR_PARTIAL_420	0

C.8.12.1.1 VL Image Module Attribute Descriptions

C.8.12.1.1.1 Photometric Interpretation

Enumerated Values:

- MONOCHROME2
- RGB
- YBR_FULL_422
- YBR_PARTIAL_420
- YBR_RCT
- YBR_ICT

Photometric Interpretation (0028,0004) shall be RGB for uncompressed or lossless compressed Transfer Syntaxes that do not have defined color space transformations, YBR_ICT for irreversible JPEG 2000 Transfer Syntaxes, YBR_RCT for reversible JPEG 2000 Transfer Syntaxes, YBR_PARTIAL_420 for MPEG2, MPEG-4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes and YBR_FULL_422 for JPEG lossy compressed Transfer Syntaxes.

Note

1. The YBR_FULL Photometric Interpretation (0028,0004), such as might be used with the RLE Transfer Syntax, is not permitted.
2. There is no formal color space defined, hence "false" color applications that encode near-visible light images may be encoded, for example, as RGB.

C.8.12.1.1.2 Bits Allocated, Bits Stored, and High Bit

Enumerated Values of Bits Allocated (0028,0100):

8

Enumerated Values of Bits Stored (0028,0101):

8

Enumerated Values of High Bit (0028,0102):

7

C.8.12.1.1.3 Pixel Representation

Enumerated Values:

0

C.8.12.1.1.4 Samples Per Pixel

Enumerated Values when Photometric Interpretation (0028,0004) is MONOCHROME2:

1

Enumerated Values when Photometric Interpretation (0028,0004) is RGB or YBR_FULL_422 or YBR_PARTIAL_420 or YBR_RCT or YBR_ICT:

3

C.8.12.1.1.5 Planar Configuration

This value shall be present if Samples per Pixel (0028,0002) has a value greater than 1.

Enumerated Values:

0

Note

The prohibition of a value of 1 for Planar Configuration (0028,0006) prevents the use of the RLE Transfer Syntax.

C.8.12.4.1.5 Photometric Interpretation and Samples Per Pixel

See Section C.7.6.3.1.2.

Enumerated Values for Photometric Interpretation (0028,0004):

MONOCHROME2

RGB

YBR_FULL_422

YBR_ICT

YBR_RCT

The value shall be appropriate to the compression Transfer Syntax used, if any, and shall be MONOCHROME2 or RGB for uncompressed or lossless compressed Transfer Syntaxes that do not ~~involve~~**have defined** color space transformations, YBR_ICT for irreversible JPEG 2000 Transfer Syntaxes, YBR_RCT for reversible JPEG 2000 Transfer Syntaxes, and YBR_FULL_422 for ~~other~~**JPEG** lossy compressed Transfer Syntaxes.

Note

1. Future lossless and lossy Transfer Syntaxes may lead to the need for new definitions and choices for Photometric Interpretation. The Enumerated Values may therefore be extended with additional Photometric Interpretation values directly associated with new Transfer Syntaxes that are negotiated, and hence do not render existing implementations non-conformant.
2. Motion compression Transfer Syntaxes are not expected to be used for Whole Slide Imaging, so the use of YBR_PARTIAL_420 for MPEG2, MPEG-4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes is not permitted.
3. The prohibition of a value of 1 for Planar Configuration (0028,0006) prevents the use of the RLE Transfer Syntax.

Multi-spectral images may be encoded as a single wavelength band (color) in each frame using MONOCHROME2, or with up to three bands in each frame using one of the color Photometric Interpretations.

Enumerated Values for Samples per Pixel (0028,0002) when Photometric Interpretation (0028,0004) is MONOCHROME2:

1

Enumerated Values for Samples per Pixel (0028,0002) when Photometric Interpretation (0028,0004) is not MONOCHROME2:

3

C.8.13.1.1 Enhanced MR Image Module Attribute Description

C.8.13.1.1.2 Photometric Interpretation, Pixel Representation, Samples Per Pixel, Planar Configuration, Bits Allocated and Bits Stored

Table C.8-82 specifies the Enumerated Values and allowed combinations of Samples per Pixel (0028,0002), Planar Configuration (0028,0006), Pixel Representation (0028,0103), Bits Allocated (0028,0100) and Bits Stored (0028,0101) for each allowable Photometric Interpretation allowed by the IOD that invokes this Module.

Table C.8-82. Allowed Combinations of Attribute Values for Photometric Interpretation, Samples Per Pixel, Planar Configuration, Pixel Representation, Bits Allocated and Bits Stored

Photometric Interpretation	Samples per Pixel	Planar Configuration	Pixel Representation	Bits Allocated	Bits Stored
MONOCHROME2	1	-	0 or 1	8	8
MONOCHROME2	1	-	0 or 1	16	12, 16
RGB	3	0	0	8	8
YBR_ICT	3	0	0	8	8
YBR_RCT	3	0	0	8	8
YBR_PARTIAL_420	3	0	0	8	8
YBR_FULL_422	3	0	0	8	8
<u>YBR_FULL</u>	<u>3</u>	<u>1</u>	<u>0</u>	<u>8</u>	<u>8</u>

C.8.17.2.1 Ophthalmic Photography Image Module Attribute Descriptions

C.8.17.2.1.2 Samples Per Pixel and Samples Per Pixel Used

Samples per Pixel (0028,0002) shall be 1 or 3.

Cameras producing 2-color images are required to use a value of 3 for Samples per Pixel (0028,0002) and a value of 2 for Samples per Pixel Used (0028,0003). For 2-color images with a RGB Photometric Interpretation, the R and G channel shall be used and the B channel shall have all values set to zero.

Note

In the case of Photometric Interpretations typically used for compression such as YBR_FULL_422, the encoding will be as if the RGB values were transformed to YCbCr.

C.8.17.2.1.3 Photometric Interpretation

Specifies the intended interpretation of the pixel data.

Enumerated Values:

MONOCHROME2

1 **RGB**
2 **YBR_FULL_422**
3 **YBR_PARTIAL_420**
4 **YBR_ICT**
5 **YBR_RCT**

6 **When Samples per Pixel (0028.0002) is greater than 1, Photometric Interpretation (0028.0004) shall be RGB for uncompressed**
7 **or lossless compressed Transfer Syntaxes that do not have defined color space transformations, YBR_ICT for irreversible**
8 **JPEG 2000 Transfer Syntaxes, YBR_RCT for reversible JPEG 2000 Transfer Syntaxes, YBR_PARTIAL_420 for MPEG2, MPEG-**
9 **4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes and YBR_FULL_422 for JPEG lossy compressed Transfer Syntaxes.**

10 **Note**

11 **The prohibition of a value of 1 for Planar Configuration (0028.0006) prevents the use of the RLE Transfer Syntax.**

12

Amend DICOM PS 3.5:

13 **2 Normative References**

14 The following standards contain provisions that, through references in this text, constitute provisions of this standard. At the time of
15 publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard
16 are encouraged to investigate the possibilities of applying the most recent editions of the standards indicated below.

17 [ECMA TR-098] European Computer Manufacturers Association. 2009. *JPEG File Interchange Format (JFIF)*. [http://](http://www.ecma-international.org/publications/techreports/E-TR-098.htm)
18 www.ecma-international.org/publications/techreports/E-TR-098.htm .

19 [ETSI TS 102 366] ETSI. Feb. 2005. *Audio Compression (AC-3, Enhanced AC-3) Standard*.

20 [ISO/IEC 10918-1] ISO/IEC. 1994. *JPEG Standard for digital compression and encoding of continuous-tone still images. Part 1 -*
21 *Requirements and implementation guidelines*.

22 [ISO/IEC 10918-2] ISO/IEC. 1995. *JPEG Standard for digital compression and encoding of continuous-tone still images. Part 2 -*
23 *Testing*.

24 [ISO/IEC 10918-5] ISO/IEC. 2013. *JPEG Standard for digital compression and encoding of continuous-tone still images. Part 5 -*
25 *JPEG File Interchange Format (JFIF)*.

26 [ISO/IEC 11172-3] ISO/IEC. 1993. *Information technology -- Coding of moving pictures and associated audio for digital storage media*
27 *at up to about 1,5 Mbit/s -- Part 3: Audio*.

28 [ISO/IEC 13818-1] ISO/IEC. 2000. *Information technology -- Generic coding of moving pictures and associated audio information -*
29 *Part 1: Systems*.

30 [ISO/IEC 13818-2] ISO/IEC. 2000. *Information technology -- Generic coding of moving pictures and associated audio information -*
31 *Part 2: Video*.

32 [ISO/IEC 13818-3] ISO/IEC. 1998. *Information technology -- Generic coding of moving pictures and associated audio information -*
33 *Part 3: Audio*.

34 [ISO/IEC 13818-4] ISO/IEC. 1998. *Information technology -- Generic coding of moving pictures and associated audio information -*
35 *Part 4: Conformance testing*.

36 [ISO/IEC 13818-7] ISO/IEC. 1997. *Information technology -- Generic coding of moving pictures and associated audio information -*
37 *Part 7: Advanced Audio Coding (AAC)*.

38 [ISO/IEC 14495-1] ISO/IEC. 1997. *Lossless and near-lossless coding of continuous tone still images (JPEG-LS)*.

39 [ISO/IEC 14496-3] ISO/IEC. 2009. *Information technology - Coding of audio-visual objects - Part 3: Audio*.

40 [ISO/IEC 14496-10] ISO/IEC. 2009. *Information technology - Coding of audio-visual objects - Part 10: Advanced Video Coding*.

41 [ISO/IEC 14496-12] ISO/IEC. 2003. *Information technology - Coding of audio-visual objects - Part 12: ISO base media file format*.

[ISO/IEC 14496-14] ISO/IEC. 2003. *Information technology - Coding of audio-visual objects - Part 14: MP4 file format.*

[ISO/IEC 15444-1] ISO/IEC. 2004. *JPEG 2000 Image Coding System.*

[ISO/IEC 15444-2] ISO/IEC. 2004. *JPEG 2000 Image Coding System: Extensions.*

[ISO/IEC 15444-9] ISO/IEC. 2005. *Information technology - JPEG 2000 image coding system: Interactivity tools, APIs and protocols.*

[ISO/IEC 23008-2] ISO/IEC. *Information technology - High efficiency coding and media delivery in heterogeneous environments - Part 2: High efficiency video coding.* http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=67660

8.2 Native or Encapsulated Format Encoding

Pixel data conveyed in the Pixel Data (7FE0,0010) may be sent either in a Native (uncompressed) Format or in an Encapsulated Format (e.g., compressed) defined outside the DICOM standard.

If Pixel Data (7FE0,0010) is sent in a Native Format, then the Photometric Interpretation (0028,0004) shall be other than:

- **YBR_RCT**
- **YBR ICT**
- **YBR PARTIAL 420**

Note

These values are not permitted because they are not encodable in an uncompressed form.

Pixel Data conveyed in the Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) shall be in a Native (uncompressed) Format if encoded in a Standard Transfer Syntax.

Note

1. In future, if Standard Transfer Syntaxes are defined for compression of Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009), this constraint may be relaxed and Encapsulated Format permitted.
2. This constraint does not apply to Private Transfer Syntaxes.

If Pixel Data (7FE0,0010) is sent in a Native Format, the Value Representation OW is most often required. The Value Representation OB may also be used for Pixel Data (7FE0,0010) in cases where Bits Allocated has a value less than or equal to 8, but only with Transfer Syntaxes where the Value Representation is explicitly conveyed (see Annex A.).

Note

The DICOM default Transfer Syntax (Implicit VR Little Endian) does not explicitly convey Value Representation and therefore the VR of OB may not be used for Pixel Data (7FE0,0010) when using the default Transfer Syntax.

Float Pixel Data (7FE0,0008) is sent in Native Format; the Value Representation shall be OF, Bits Allocated (0028,0100) shall be 32, Bits Stored (0028,0101), High Bit (0028,0102) and Pixel Representation (0028,0103) shall not be present.

Double Float Pixel Data (7FE0,0009) is sent in Native Format; the Value Representation shall be OD, Bits Allocated (0028,0100) shall be 64, Bits Stored (0028,0101) and High Bit (0028,0102) and Pixel Representation (0028,0103) shall not be present.

It is not permitted to have more than one of Pixel Data Provider URL (0028,7FE0), Pixel Data (7FE0,0010), Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) in the top level Data Set.

Note

Pixel Data encoded in Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) can be considered as consisting of Pixel Cells that entirely occupy the allocated bits, and therefore do not cross word boundaries.

Native format Pixel Cells are encoded as the direct concatenation of the bits of each Pixel Cell, the least significant bit of each Pixel Cell is encoded in the least significant bit of the encoded word or byte, immediately followed by the next most significant bit of each Pixel Cell in the next most significant bit of the encoded word or byte, successively until all bits of the Pixel Cell have been encoded, then immediately followed by the least significant bit of the next Pixel Cell in the next most significant bit of the encoded word or byte. The number of bits of each Pixel Cell is defined by the Bits Allocated (0028,0100) Data Element Value. When a Pixel Cell crosses a word boundary in the OW case, or a byte boundary in the OB case, it shall continue to be encoded, least significant bit to most significant bit, in the next word, or byte, respectively (see Annex D). For Pixel Data (7FE0,0010) encoded with the Value Representation OW, the byte ordering of the resulting 2-byte words is defined by the Little Endian Transfer Syntaxes negotiated at the Association Establishment (see Annex A.).

Note

1. For Pixel Data (7FE0,0010) encoded with the Value Representation OB, the Pixel Data (7FE0,0010) encoding is unaffected by byte ordering.
2. If encoding Pixel Data (7FE0,0010) with a Value for Bits Allocated (0028,0100) not equal to 16 be sure to read and understand Annex D.

If sent in an Encapsulated Format (i.e., other than the Native Format) the Value Representation OB is used. The Pixel Cells are encoded according to the encoding process defined by one of the negotiated Transfer Syntaxes (see Annex A.). The encapsulated pixel stream of encoded pixel data is segmented into one or more Fragments, each of which conveys its own explicit length. The sequence of Fragments of the encapsulated pixel stream is terminated by a delimiter, thus allowing the support of encoding processes where the resulting length of the entire pixel stream is not known until it is entirely encoded. This Encapsulated Format supports both Single-Frame and Multi-Frame images (as defined in PS3.3).

Note

Depending on the Transfer Syntax, a frame may be entirely contained within a single fragment, or may span multiple fragments to support buffering during compression or to avoid exceeding the maximum size of a fixed length fragment. A recipient can detect fragmentation of frames by comparing the number of fragments (the number of Items minus one for the Basic Offset Table) with the number of frames. Some performance optimizations may be available to a recipient in the absence of fragmentation of frames, but an implementation that fails to support such fragmentation does not conform to the Standard.

8.2.1 JPEG Image Compression

DICOM provides a mechanism for supporting the use of JPEG Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a number of Transfer Syntaxes that reference the JPEG Standard and provide a number of lossless (bit preserving) and lossy compression schemes.

Note

The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g., compression ratio) for JPEG lossy compression is also beyond the scope of this standard.

In order to facilitate interoperability of implementations conforming to the DICOM Standard that elect to use one or more of the Transfer Syntaxes for JPEG Image Compression, the following policy is specified:

- Any implementation that conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for lossless JPEG Image Compression, shall support the following lossless compression: The subset (first-order horizontal prediction [Selection Value 1] of JPEG Process 14 (DPCM, non-hierarchical with Huffman coding) (see Annex F).
- Any implementation that conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for 8-bit lossy JPEG Image Compression, shall support the JPEG Baseline Compression (coding Process 1).
- Any implementation that conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for 12-bit lossy JPEG Image Compression, shall support the JPEG Compression Process 4.

Note

The DICOM conformance statement shall differentiate whether or not the implementation is capable of simply receiving or receiving and processing JPEG encoded images (see PS3.2).

The use of the DICOM Encapsulated Format to support JPEG Compressed Pixel Data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream.

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS.3. C.7.6.3.1.2) are specified in Table 8.2.1-1 and Table 8.2.1-2. No other Standard Photometric Interpretation values shall be used.

Table 8.2.1-1. Valid Values of Pixel Data Related Attributes for JPEG Lossy Transfer Syntaxes using Standard Photometric Interpretations

Photometric Interpretation	Transfer Syntax	Transfer Syntax UID	Samples per Pixel	Planar Configuration	Pixel Representation	Bits Allocated	Bits Stored	High Bit
<u>MONOCHROME1</u>	<u>JPEG Baseline</u>	<u>1.2.840.10008.1.2.4.50</u>	<u>1</u>	<u>absent</u>	<u>0</u>	<u>8</u>	<u>8</u>	<u>7</u>
<u>MONOCHROME2</u>								
<u>MONOCHROME1</u>	<u>JPEG Extended</u>	<u>1.2.840.10008.1.2.4.51</u>	<u>1</u>	<u>absent</u>	<u>0</u>	<u>8</u>	<u>8</u>	<u>7</u>
<u>MONOCHROME2</u>								
<u>MONOCHROME1</u>	<u>JPEG Extended</u>	<u>1.2.840.10008.1.2.4.51</u>	<u>1</u>	<u>absent</u>	<u>0</u>	<u>16</u>	<u>12</u>	<u>11</u>
<u>MONOCHROME2</u>								
<u>YBR_FULL_422</u>	<u>JPEG Baseline</u>	<u>1.2.840.10008.1.2.4.50</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8</u>	<u>8</u>	<u>7</u>

Table 8.2.1-2. Valid Values of Pixel Data Related Attributes for JPEG Lossless Transfer Syntaxes using Standard Photometric Interpretations

Photometric Interpretation	Transfer Syntax	Transfer Syntax UID	Samples per Pixel	Planar Configuration	Pixel Representation	Bits Allocated	Bits Stored	High Bit
<u>MONOCHROME1</u>	<u>JPEG Lossless, Non-Hierarchical</u>	<u>1.2.840.10008.1.2.4.57</u>	<u>1</u>	<u>absent</u>	<u>0 or 1</u>	<u>8 or 16</u>	<u>1-16</u>	<u>0-15</u>
<u>MONOCHROME2</u>		<u>1.2.840.10008.1.2.4.70</u>						
	<u>JPEG Lossless, Non-Hierarchical, SV1</u>							
<u>PALETTE COLOR</u>	<u>JPEG Lossless, Non-Hierarchical</u>	<u>1.2.840.10008.1.2.4.57</u>	<u>1</u>	<u>absent</u>	<u>0</u>	<u>8 or 16</u>	<u>1-16</u>	<u>0-15</u>
		<u>1.2.840.10008.1.2.4.70</u>						
	<u>JPEG Lossless, Non-Hierarchical, SV1</u>							
<u>YBR_FULL</u>	<u>JPEG Lossless, Non-Hierarchical</u>	<u>1.2.840.10008.1.2.4.57</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8 or 16</u>	<u>1-16</u>	<u>0-15</u>
<u>RGB</u>		<u>1.2.840.10008.1.2.4.70</u>						
	<u>JPEG Lossless, Non-Hierarchical, SV1</u>							

The Pixel Data characteristics included in the JPEG Interchange Format shall be used to decode the compressed data stream.

Note

1. These requirements were formerly specified in terms of the "uncompressed pixel data from which the compressed data stream was derived". However, since the form of the "original" uncompressed data stream could vary between different implementations, this requirement is now specified in terms of consistency with what is encapsulated.

When decompressing, should the characteristics explicitly specified in the compressed data stream (e.g., spatial sub-sampling or number of components or planar configuration) be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

2. Those characteristics not explicitly specified in the compressed data stream (e.g., the color space of the compressed components, which is not specified in the JPEG Interchange Format), or implied by the definition of the compression scheme (e.g., always unsigned in JPEG), can therefore be determined from the DICOM Data Element in the enclosing Data Set. For example a Photometric Interpretation of "YBR_FULL_422" would describe the color space that is commonly used to lossy compress images using JPEG. It is unusual to use an RGB color space for lossy compression, since no advantage is taken of correlation between the red, green and blue components (e.g., of luminance), and poor compression is achieved.
3. The JPEG Interchange Format is distinct from the JPEG File Interchange Format (JFIF). The JPEG Interchange Format is defined in [ISO/IEC 10918-1] section 4.9.1, and refers to the inclusion of decoding tables, as distinct from the "abbreviated format" in which these tables are not sent (and the decoder is assumed to already have them). The JPEG Interchange Format does NOT specify the color space. The JPEG File Interchange Format, not part of the original JPEG standard, but defined in [ECMA TR-098] and [ISO/IEC 10918-5], is often used to store JPEG bit streams in consumer format files, and does include the ability to specify the color space of the components. The JFIF APP0 marker segment is NOT required to be present in DICOM encapsulated JPEG bit streams, and should not be relied upon to recognize the color space. Its presence is not forbidden (unlike the JP2 information for JPEG 2000 Transfer Syntaxes), but it is recommended that it be absent.
4. Should the compression process be incapable of encoding a particular form of pixel data representation (e.g., JPEG cannot encode signed integers, only unsigned integers), then ideally only the appropriate form should be "fed" into the compression process. However, for certain characteristics described in DICOM Data Elements but not explicitly described in the compressed data stream (such as Pixel Representation), then the DICOM Data Element should be considered to describe what has been compressed (e.g., the pixel data really is to be interpreted as signed if Pixel Representation so specifies).
5. DICOM Data Elements should not describe characteristics that are beyond the capability of the compression scheme used. For example, JPEG lossy processes are limited to 12 bits, hence the value of Bits Stored should be 12 or less. Bits Allocated is irrelevant, and is likely to be constrained by the Information Object Definition in PS3.3 to values of 8 or 16. Also, JPEG compressed data streams are always color-by-pixel and should be specified as such (a decoder can essentially ignore this element however as the value for JPEG compressed data is already known).
6. If JPEG Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_FULL_422 to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.

8.2.2 Run Length Encoding Compression

DICOM provides a mechanism for supporting the use of Run Length Encoding (RLE) Compression, which is a byte oriented lossless compression scheme through the encapsulated Format (see PS3.3 of this Standard). Annex G defines RLE Compression and its Transfer Syntax.

Note

The RLE Compression algorithm described in Annex G is the compression used in the TIFF 6.0 specification known as the "PackBits" scheme.

The use of the DICOM Encapsulated Format to support RLE Compressed Pixel Data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the compressed data.

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS.3. C.7.6.3.1.2) are specified in Table 8.2.2-1. No other Standard Photometric Interpretation values shall be used.

Table 8.2.2-1. Valid Values of Pixel Data Related Attributes for RLE Compression using Standard Photometric Interpretations

<u>Photometric Interpretation</u>	<u>Samples per Pixel</u>	<u>Planar Configuration</u>	<u>Pixel Representation</u>	<u>Bits Allocated</u>	<u>Bits Stored</u>	<u>High Bit</u>
<u>MONOCHROME1</u>	<u>1</u>	<u>absent</u>	<u>0 or 1</u>	<u>8 or 16</u>	<u>1-16</u>	<u>0-15</u>
<u>MONOCHROME2</u>						
<u>PALETTE COLOR</u>	<u>1</u>	<u>absent</u>	<u>0</u>	<u>8 or 16</u>	<u>1-16</u>	<u>0-15</u>
<u>YBR_FULL</u>	<u>3</u>	<u>1</u>	<u>0</u>	<u>8</u>	<u>1-8</u>	<u>0-7</u>
<u>RGB</u>	<u>3</u>	<u>1</u>	<u>0</u>	<u>8 or 16</u>	<u>1-16</u>	<u>0-15</u>

Note

1. These requirements were formerly specified in terms of the "uncompressed pixel data from which the compressed data was derived". However, since the form of the "original" uncompressed data stream could vary between different implementations, this requirement is now specified in terms of consistency with what is encapsulated.
2. Those characteristics not implied by the definition of the compression scheme (e.g., always color-by-plane in RLE), can therefore be determined from the DICOM Data Element in the enclosing Data Set. For example a Photometric Interpretation of "YBR_FULL" would describe the color space that is commonly used to losslessly compress images using RLE. It is unusual to use an RGB color space for RLE compression, since no advantage is taken of correlation between the red, green and blue components (e.g., of luminance), and poor compression is achieved (note however that the conversion from RGB to YBR_FULL is itself lossy. A new photometric interpretation may be proposed in the future that allows lossless conversion from RGB and also results in better RLE compression ratios).
3. DICOM Data Elements should not describe characteristics that are beyond the capability of the compression scheme used. For example, RLE compressed data streams (using the algorithm mandated in the DICOM Standard) are always color-by-plane.
4. If RLE Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_FULL to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding. It is permitted, however, to leave the YBR_FULL color components unconverted but decompressed in the Native format, in which case the Photometric Interpretation in the Data Set with the Native encoding would be YBR_FULL.

8.2.3 JPEG-LS Image Compression

DICOM provides a mechanism for supporting the use of JPEG-LS Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a number of Transfer Syntaxes that reference the JPEG-LS Standard and provide a number of lossless (bit preserving) and lossy (near-lossless) compression schemes.

Note

The context where the usage of lossy (near-lossless) compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g., compression ratio) for JPEG-LS lossy (near-lossless) compression is also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support JPEG-LS Compressed Pixel Data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG-LS Interchange Format shall be used to decode the compressed data stream.

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS.3. C.7.6.3.1.2) are specified in Table 8.2.3-1. No other Standard Photometric Interpretation values shall be used.

Table 8.2.3-1. Valid Values of Pixel Data Related Attributes for JPEG-LS Compression using Standard Photometric Interpretations

<u>Photometric Interpretation</u>	<u>Transfer Syntax</u>	<u>Transfer Syntax UID</u>	<u>Samples per Pixel</u>	<u>Planar Configuration</u>	<u>Pixel Representation</u>	<u>Bits Allocated</u>	<u>Bits Stored</u>	<u>High Bit</u>
MONOCHROME1	JPEG-LS Lossless	1.2.840.10008.1.2.4.80	1	absent	0 or 1	8 or 16	2-16	1-15
MONOCHROME2	JPEG-LS Lossy (Near-Lossless)	1.2.840.10008.1.2.4.81						
PALETTE COLOR	JPEG-LS Lossless	1.2.840.10008.1.2.4.80	1	absent	0	8 or 16	2-16	1-15
YBR_FULL	JPEG-LS Lossless	1.2.840.10008.1.2.4.80	3	1	0	8	2-8	1-7
	JPEG-LS Lossy (Near-Lossless)	1.2.840.10008.1.2.4.81						
RGB	JPEG-LS Lossless	1.2.840.10008.1.2.4.80	3	1	0	8 or 16	2-16	1-15
	JPEG-LS Lossy (Near-Lossless)	1.2.840.10008.1.2.4.81						

Note

- See also the notes in Section 8.2.1.
- No **color transformation** Photometric Interpretation specific for JPEG-LS is currently defined in DICOM. Annex F of ISO 14495-2 describes a "Sample transformation for inverse colour transform" and a marker segment to encode its parameters, but this is not known to have been implemented. Common practice is to compress the RGB components unconverted, which sacrifices compression performance, and send the Photometric Interpretation as RGB. Though the YBR_RCT Photometric Interpretation and component conversion could theoretically be used, in the absence of DC shifting it results in signed values to be encoded, which are not supported by JPEG-LS.
- If JPEG-LS Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from any other Photometric Interpretation to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.
- The lower limit of 2 on Bits Stored (0028.0101) reflects the minimum JPEG-LS sample precision of 2.**

8.2.4 JPEG 2000 Image Compression

DICOM provides a mechanism for supporting the use of JPEG 2000 Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a number of Transfer Syntaxes that reference the JPEG 2000 Standard and provide lossless (bit preserving) and lossy compression schemes.

Note

The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g., compression ratio) for JPEG 2000 lossy compression are also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support JPEG 2000 Compressed Pixel Data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG 2000 bit stream shall be used to decode the compressed data stream.

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS.3. C.7.6.3.1.2) are specified in Table 8.2.4-1. No other Standard Photometric Interpretation values shall be used.

Table 8.2.4-1. Valid Values of Pixel Data Related Attributes for JPEG 2000 Transfer Syntaxes using Standard Photometric Interpretations

<u>Photometric Interpretation</u>	<u>Transfer Syntax</u>	<u>Transfer Syntax UID</u>	<u>Samples per Pixel</u>	<u>Planar Configuration</u>	<u>Pixel Representation</u>	<u>Bits Allocated</u>	<u>Bits Stored</u>	<u>High Bit</u>
<u>MONOCHROME1</u>	<u>JPEG 2000 (Lossless Only)</u>	<u>1.2.840.10008.1.2.4.90</u>	<u>1</u>	<u>absent</u>	<u>0 or 1</u>	<u>8, 16, 24, 32 or 40</u>	<u>1-38</u>	<u>0-37</u>
	<u>JPEG 2000</u>	<u>1.2.840.10008.1.2.4.91</u>						
<u>PALETTE COLOR</u>	<u>JPEG 2000 (Lossless Only)</u>	<u>1.2.840.10008.1.2.4.90</u>	<u>1</u>	<u>absent</u>	<u>0</u>	<u>8 or 16</u>	<u>1-16</u>	<u>0-15</u>
<u>YBR_RCT</u>	<u>JPEG 2000 (Lossless Only)</u>	<u>1.2.840.10008.1.2.4.90</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8, 16, 24, 32 or 40</u>	<u>1-38</u>	<u>0-37</u>
	<u>JPEG 2000</u>	<u>1.2.840.10008.1.2.4.91</u>						
<u>YBR_ICT</u>	<u>JPEG 2000</u>	<u>1.2.840.10008.1.2.4.91</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8, 16, 24, 32 or 40</u>	<u>1-38</u>	<u>0-37</u>
<u>RGB</u>	<u>JPEG 2000 (Lossless Only)</u>	<u>1.2.840.10008.1.2.4.90</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8, 16, 24, 32 or 40</u>	<u>1-38</u>	<u>0-37</u>
	<u>JPEG 2000</u>	<u>1.2.840.10008.1.2.4.91</u>						
<u>YBR_FULL</u>	<u>JPEG 2000 (Lossless Only)</u>	<u>1.2.840.10008.1.2.4.90</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8, 16, 24, 32 or 40</u>	<u>1-38</u>	<u>0-37</u>
	<u>JPEG 2000</u>	<u>1.2.840.10008.1.2.4.91</u>						

Note

These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

The JPEG 2000 bit stream specifies whether or not a reversible or irreversible multi-component (color) transformation [ISO 15444-1 Annex G], if any, has been applied. If no multi-component transformation has been applied, then the components shall correspond to those specified by the DICOM Attribute Photometric Interpretation (0028,0004). If the JPEG 2000 Part 1 reversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR_RCT. If the JPEG 2000 Part 1 irreversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR_ICT.

Note

- For example, single component may be present, and the Photometric Interpretation (0028,0004) may be MONOCHROME2.
- The application of a JPEG 2000 Part 1 reversible multi-component transformation is signaled in the JPEG 2000 bitstream by a value of 1 rather than 0 in the SGcod Multiple component transformation type of the COD marker segment [ISO

15444-1 Table A.17]. No other value of Photometric Interpretation than YBR_RCT or YBR_ICT is permitted when SGcod Multiple component transformation type is 1.

3. Though it would be unusual, would not take advantage of correlation between the red, green and blue components, and would not achieve effective compression, a Photometric Interpretation of RGB could be specified as long as no multi-component transformation [ISO 15444-1 Annex G] was specified by the JPEG 2000 bit stream. Alternative methods of decorrelation of the color components than those specified in [ISO 15444-1 Annex G] are permitted as defined in PS3.3, such as a Photometric Interpretation of YBR_FULL; this may be useful when converting existing YBR_FULL Pixel Data (e.g., in a different Transfer Syntax) without further loss.

In either case (Photometric Interpretation of RGB or YBR_FULL), the value of SGcod Multiple component transformation type would be 0.

PS3.3 may constrain the values of Photometric Interpretation for specific IODs.

4. Despite the application of a multi-component color transformation and its reflection in the Photometric Interpretation attribute, the "color space" remains undefined. There is currently no means of conveying "standard color spaces" either by fixed values (such as sRGB) or by ICC profiles. Note in particular that the JP2 file header is not sent in the JPEG 2000 bitstream that is encapsulated in DICOM.
5. If JPEG 2000 Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_ICT or YBR_RCT to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.
6. **The upper limit of 40 on Bits Allocated (0028,0100) and 38 on Bits Stored (0028,0101) reflects the maximum JPEG 2000 sample precision of 38 and the DICOM requirement to describe Bits Allocated (0028,0100) as multiples of bytes (octets).**

The JPEG 2000 bitstream is capable of encoding both signed and unsigned pixel values, hence the value of Pixel Representation (0028,0103) may be either 0 or 1 **for monochrome Photometric Interpretations** depending on what has been encoded (as specified in the SIZ marker segment in the precision and sign of component parameter).

The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the JPEG 2000 standard, hence it shall be set to 0.

8.2.5 MPEG2 Main Profile / Main Level Image Compression

DICOM provides a mechanism for supporting the use of MPEG2 Main Profile / Main Level Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a Transfer Syntax that references the MPEG2 Main Profile / Main Level Standard.

Note

MPEG2 compression is inherently lossy. The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g., compression ratio) for MPEG2 Main Profile / Main Level are also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support MPEG2 Main Profile / Main Level compressed pixel data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream, with some specific exceptions noted here. The Pixel Data characteristics included in the MPEG2 Main Profile / Main Level bit stream shall be used to decode the compressed data stream.

Note

These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might

be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

The MPEG2 Main Profile / Main Level bit stream specifies whether or not a reversible or irreversible multi-component (color) transformation, if any, has been applied. If no multi-component transformation has been applied, then the components shall correspond to those specified by the DICOM Attribute Photometric Interpretation (0028,0004). MPEG2 Main Profile / Main Level applies an irreversible multi-component transformation, so DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420 in the case of multi-component data, and MONOCHROME2 in the case of single component data (even though the MPEG2 bit stream itself is always encoded as three components, one luminance and two chrominance).

Note

1. If MPEG2 Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_PARTIAL_420 to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.
2. MPEG2 proposes some video formats. Each of the standards specified is used in a different market, including: ITU-R BT.470-2 System M for SD NTSC and ITU-R BT.470-2 System B/G for SD PAL/SECAM. A PAL based system should therefore be based on ITU-BT.470 System B for each of Color Primaries, Transfer Characteristic (gamma) and matrix coefficients and should take a value of 5 as defined in [ISO/IEC 13818-2].

The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the MPEG2 Main Profile / Main Level standard, hence it shall be set to 0.

In summary:

- Samples per Pixel (0028,0002) shall be 3
- Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420
- Bits Allocated (0028,0100) shall be 8
- Bits Stored (0028,0101) shall be 8
- High Bit (0028,0102) shall be 7
- Pixel Representation (0028,0103) shall be 0
- Planar Configuration (0028,0006) shall be 0
- Rows (0028,0010), Columns (0028,0011), Cine Rate (0018,0040) and Frame Time (0018,1063) or Frame Time Vector (0018,1065) shall be consistent with the limitations of Main Profile / Main Level, as ...

8.2.6 MPEG2 Main Profile / High Level Image Compression

MPEG2 Main Profile / High Level corresponds to what is commonly known as HDTV ('High Definition Television'). DICOM provides a mechanism for supporting the use of MPEG2 Main Profile / High Level Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a Transfer Syntax that references the MPEG2 Main Profile / High Level Standard.

Note

MPEG2 compression is inherently lossy. The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g., compression ratio) for MPEG2 Main Profile / High Level are also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support MPEG2 Main Profile / High Level compressed pixel data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream, with some specific exceptions noted here. The Pixel Data characteristics included in the MPEG2 Main Profile / High Level bit stream shall be used to decode the compressed data stream.

Note

These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

Note

If MPEG2 Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_PARTIAL_420 to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.

The requirements are:

- Planar Configuration (0028,0006) shall be 0

Note

The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the MPEG2 standard, hence it is set to 0.

- Samples per Pixel (0028,0002) shall be 3
- Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420 or MONOCHROME2
- Bits Allocated (0028,0100) shall be 8
- Bits Stored (0028,0101) shall be 8
- High Bit (0028,0102) shall be 7
- Pixel Representation (0028,0103) shall be 0
- Rows (0028,0010) shall be either 720 or 1080
- Columns (0028,0011) shall be 1280 if Rows is 720, or shall be 1920 if Rows is 1080.
- The value of MPEG2 aspect_ratio_information shall be 0011 in the encapsulated MPEG2 data stream corresponding to a 'Display Aspect Ratio' (DAR) of 16:9.
- The DICOM attribute Pixel Aspect Ratio (0028,0034) shall be absent. This corresponds to a 'Sampling Aspect Ratio' (SAR) of 1:1.
- Cine Rate (0018,0040) and Frame Time (0018,1063) or Frame Time Vector (0018,1065) shall be consistent with the limitations of Main Profile / High Level, as ...

8.2.7 MPEG-4 AVC/H.264 High Profile / Level 4.1 Video Compression

MPEG-4 AVC/H.264 High Profile / Level 4.1 corresponds to what is commonly known as HDTV ('High Definition Television'). DICOM provides a mechanism for supporting the use of MPEG-4 AVC/H.264 Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a Transfer Syntax that references the MPEG-4 AVC/H.264 Standard.

Note

MPEG-4 AVC/H.264 compression / High Profile compression is inherently lossy. The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g., compression ratio) for MPEG-4 AVC/H.264 High Profile / Level 4.1 are also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support MPEG-4 AVC/H.264 compressed pixel data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream, with some specific exceptions noted here. The Pixel Data characteristics included in the MPEG-4 AVC/H.264 bit stream shall be used to decode the compressed data stream.

Note

These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

Note

If MPEG-4 Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_PARTIAL_420 to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.

The requirements are:

- Planar Configuration (0028,0006) shall be 0
- Samples per Pixel (0028,0002) shall be 3
- Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420
- Bits Allocated (0028,0100) shall be 8
- Bits Stored (0028,0101) shall be 8
- High Bit (0028,0102) shall be 7
- Pixel Representation (0028,0103) shall be 0
- The value of MPEG-4 AVC/H.264 sample aspect_ratio_idc shall be 1 in the encapsulated MPEG-4 AVC/H.264 bit stream if aspect_ratio_info_present_flag is 1.
- Pixel Aspect Ratio (0028,0034) shall be absent. This corresponds to a 'Sampling Aspect Ratio' (SAR) of 1:1.
- The possible values for Rows (0028,0010), Columns (0028,0011), Cine Rate (0018,0040), and Frame Time (0018,1063) or Frame Time Vector (0018,1065) depend on the used Transfer Syntax.
-

...

Note

1. The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the MPEG-4 AVC/H.264 standard, hence it is set to 0.
2. ...

8.2.8 MPEG-4 AVC/H.264 High Profile / Level 4.2 Video Compression

DICOM provides a mechanism for supporting the use of MPEG-4 AVC/H.264 Image Compression through the Encapsulated Format (see PS3.3). Annex A defines Transfer Syntaxes that reference the MPEG-4 AVC/H.264 Standard.

Note

MPEG-4 AVC/H.264 compression / High Profile compression is inherently lossy. The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g., compression ratio) for MPEG-4 AVC/H.264 High Profile / Level 4.2 are also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support MPEG-4 AVC/H.264 compressed pixel data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream, with some specific exceptions noted here. The Pixel Data characteristics included in the MPEG-4 AVC/H.264 bit stream shall be used to decode the compressed data stream.

Note

These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed data set might be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

Note

If MPEG-4 Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR_PARTIAL_420 to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.

The requirements are:

- Planar Configuration (0028,0006) shall be 0
- Samples per Pixel (0028,0002) shall be 3
- Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420
- Bits Allocated (0028,0100) shall be 8
- Bits Stored (0028,0101) shall be 8
- High Bit (0028,0102) shall be 7
- Pixel Representation (0028,0103) shall be 0
- The value of MPEG-4 AVC/H.264 sample aspect_ratio_idc shall be 1 in the encapsulated MPEG-4 AVC/H.264 bit stream if aspect_ratio_info_present_flag is 1.
- Pixel Aspect Ratio (0028,0034) shall be absent. This corresponds to a 'Sampling Aspect Ratio' (SAR) of 1:1.
- The values for Rows (0028,0010), Columns (0028,0011), Cine Rate (0018,0040), and Frame Time (0018,1063) or Frame Time Vector (0018,1065) shall be compliant with the High Profile / Level 4.2 of the MPEG-4 AVC/H.264 standard ([ISO/IEC 14496-10]) and restricted to a square pixel aspect ratio.

Note

1. The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the MPEG-4 AVC/H.264 standard, hence it is set to 0.
2. ...

8.2.10 HEVC/H.265 Main Profile / Level 5.1 Video Compression

HEVC/H.265 Main Profile / Level 5.1 Main tier is designed for the compression of 4:2:0 video formats up to 4k at 60 frames per second with a bit depth of 8 bits. DICOM provides a mechanism for supporting the use of HEVC/H.265 Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a Transfer Syntax that references the HEVC/H.265 Standard.

The use of the DICOM Encapsulated Format to support HEVC/H.265 compressed pixel data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream, with some specific exceptions noted here. The Pixel Data characteristics included in the HEVC/H.265 bit stream shall be used to decode the compressed data stream.

Note

1. These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.
2. When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

The requirements are:

- Planar Configuration (0028,0006) shall be 0
- Samples per Pixel (0028,0002) shall be 3
- Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420
- Bits Allocated (0028,0100) shall be 8
- Bits Stored (0028,0101) shall be 8
- High Bit (0028,0102) shall be 7
- Pixel Representation (0028,0103) shall be 0
- The value of HEVC/H.265 sample aspect_ratio_idc shall be 1 in the encapsulated HEVC/H.265 bit stream if aspect_ratio_info_present_flag is 1.
- Pixel Aspect Ratio (0028,0034) shall be absent. This corresponds to a 'Sampling Aspect Ratio' (SAR) of 1:1.
- The values for Rows (0028,0010), Columns (0028,0011), Cine Rate (0018,0040) and Frame Time (0018,1063) or Frame Time Vector (0018,1065) shall be compliant with the Main Profile / Level 5.1 of the HEVC/H.265 standard [ISO/IEC 23008-2] and restricted to a square pixel aspect ratio.

Note

1. The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the HEVC/H.265 standard, hence it is set to 0.
2. ...

8.2.11 HEVC/H.265 Main 10 Profile / Level 5.1 Video Compression

HEVC/H.265 Main 10 Profile / Level 5.1 Main tier is designed for the compression of 4:2:0 video formats up to 4k at 60 frames per second with a bit depth of 10 bits. DICOM provides a mechanism for supporting the use of HEVC/H.265 Image Compression through the Encapsulated Format (see PS3.3). Annex A defines a Transfer Syntax that references the HEVC/H.265 Standard.

The use of the DICOM Encapsulated Format to support HEVC/H.265 compressed pixel data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream, with some specific exceptions noted here. The Pixel Data characteristics included in the HEVC/H.265 bit stream shall be used to decode the compressed data stream.

Note

1. These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.
2. When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, **subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.**

The requirements are:

- Planar Configuration (0028,0006) shall be 0
- Samples per Pixel (0028,0002) shall be 3
- Photometric Interpretation (0028,0004) shall be YBR_PARTIAL_420
- Bits Allocated (0028,0100) shall be 16
- Bits Stored (0028,0101) shall be 10
- High Bit (0028,0102) shall be 9
- Pixel Representation (0028,0103) shall be 0
- The value of HEVC/H.265 sample aspect_ratio_idc shall be 1 in the encapsulated HEVC/H.265 bit stream if aspect_ratio_info_present_flag is 1.
- Pixel Aspect Ratio (0028,0034) shall be absent. This corresponds to a 'Sampling Aspect Ratio' (SAR) of 1:1.
- The values for Rows (0028,0010) , Columns (0028,0011) , Cine Rate (0018,0040) , and Frame Time (0018,1063) or Frame Time Vector (0018,1065) shall be compliant with the Main 10 Profile / Level 5.1 of the HEVC/H.265 standard [ISO/IEC 23008-2] and restricted to a square pixel aspect ratio.

Note

1. The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the HEVC/H.265 standard, hence it is set to 0.
2. ...

A Transfer Syntax Specifications (Normative)

A.4 Transfer Syntaxes For Encapsulation of Encoded Pixel Data

...

A.4.1 JPEG Image Compression

The International Standards Organization ISO/IEC JTC1 has developed an International Standard, ISO 10918-1 (JPEG Part 1) and an International Standard, ISO 10918-2 (JPEG Part 2), known as the JPEG Standard, for digital compression and coding of continuous-tone still images (see Annex F for further details).

A DICOM Transfer Syntax for JPEG Image Compression shall be identified by a UID value, appropriate to its JPEG coding process, chosen from Table A.4-3.

Table A.4-3. DICOM Transfer Syntax UIDs for JPEG

DICOM Transfer Syntax UID	JPEG coding process	JPEG description
1.2.840.10008.1.2.4.50	1	baseline
1.2.840.10008.1.2.4.51	2(8-bit),4(12-bit)	extended
1.2.840.10008.1.2.4.57	14	lossless, non-hierarchical
1.2.840.10008.1.2.4.70	14 (Selection Value 1)	lossless, non-hierarchical, first-order prediction

Note

- DICOM identifies, to increase the likelihood of successful association, three Transfer Syntaxes for Default JPEG Compression Image processes (see Section 8.2.1 and Section 10).
- Different JPEG processes may use different SOF marker segments. E.g., the baseline JPEG process 1 used with the 1.2.840.10008.1.2.4.50 Transfer Syntax uses the SOF0 marker, whereas the extended process 2 used with the 1.2.840.10008.1.2.4.51 Transfer Syntax uses the SOF1 marker. Accordingly, even though both bit streams encode 8 bit images using DCT and Huffman coding, the bit streams are not identical. Further, the extended process 2 may (but is not required to) use more AC and DC tables (up to 4 of each, rather than 2, per ISO 10918-1 Section F.1.3).

It is not compliant to send bit streams with the SOF0 marker using the 1.2.840.10008.1.2.4.51 Transfer Syntax, but it is recommended that receivers of the 1.2.840.10008.1.2.4.51 Transfer Syntax be able to decode bit streams with the SOF0 marker (this asymmetry is consistent with ISO 10918-2 requirements; see A.4.1).
- It is recommended that lossy compressed 8 bit images be encoded with the 1.2.840.10008.1.2.4.50 Transfer Syntax rather than the 1.2.840.10008.1.2.4.51 Transfer Syntax, unless the additional features of the extended process are required. Support of the 1.2.840.10008.1.2.4.50 Transfer Syntax is required for 8 bit images anyway (as described in 8.2.1) and to avoid confusion with the use of 12 bit images encoded with Process 4 in the 1.2.840.10008.1.2.4.51 Transfer Syntax (defined as a DICOM Default Transfer Syntax for 12 bit images in 10.3).

If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each fragment shall contain encoded data from a single-frame image.

Note

Though a fragment may not contain encoded data from more than one frame, the encoded data from one frame may span multiple fragments. See note in Section 8.2.

For all images, including all frames of a multi-frame image, the JPEG Interchange Format shall be used (the table specification shall be included).

Note

This refers to the [ISO/IEC 10918-1] "interchange format", not the [ISO/IEC 10918-5] JPEG File Interchange Format (JFIF).

If images with Photometric Interpretation (0028,0004) YBR_FULL_422 or YBR_PARTIAL_422, are encoded with JPEG coding Process 1 (non hierarchical with Huffman coding), identified by DICOM Transfer Syntax UID "1.2.840.10008.1.2.4.50" the minimum compressible unit is YYCBCR, where Y, CB, and CR are 8 by 8 blocks of pixel values. The data stream encodes two Y blocks followed by the corresponding CB and CR blocks.

A.4.2 RLE Compression

Annex G defines a RLE Compression Transfer Syntax. This transfer Syntax is identified by the UID value "1.2.840.10008.1.2.5". If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each frame shall be encoded in one and only one Fragment (see Section 8.2).

A.4.3 JPEG-LS Image Compression

The International Standards Organization ISO/IEC JTC1 has developed an International Standard, [ISO/IEC 14495-1] (JPEG-LS Part 1), for digital compression and coding of continuous-tone still images (see Annex F for further details).

A DICOM Transfer Syntax for JPEG-LS Image Compression shall be identified by a UID value, appropriate to its JPEG-LS coding process.

Two Transfer Syntaxes are specified for JPEG-LS:

1. A Transfer Syntax with a UID of "1.2.840.10008.1.2.4.80 ", which specifies the use of the lossless mode of JPEG-LS. In this mode the absolute error between the source and reconstructed images will be zero.
2. A Transfer Syntax with a UID of "1.2.840.10008.1.2.4.81 ", which specifies the use of the near-lossless mode of JPEG-LS. In this mode, the absolute error between the source and reconstructed images will be constrained to a finite value that is conveyed in the compressed bit stream. Note that this process can, at the discretion of the encoder, be used to compress images with an error constrained to a value of zero, resulting in no loss of information.

If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each fragment shall contain encoded data from a single-frame image.

Note

Though a fragment may not contain encoded data from more than one frame, the encoded data from one frame may span multiple fragments. See note in Section 8.2.

For all images, including all frames of a multi-frame image, the JPEG-LS Interchange Format shall be used (all parameter specifications shall be included).

A.4.4 JPEG 2000 Image Compression

The International Standards Organization ISO/IEC JTC1 has developed an International Standard, [ISO/IEC 15444-1] (JPEG 2000 Part 1), for digital compression and coding of continuous-tone still images (see Annex F for further details).

A DICOM Transfer Syntax for JPEG 2000 Image Compression shall be identified by a UID value, appropriate to the choice of JPEG 2000 coding process.

Two Transfer Syntaxes are specified for JPEG 2000 Part 1:

1. A Transfer Syntax with a UID of "1.2.840.10008.1.2.4.90 ", which specifies the use of the lossless (reversible) mode of JPEG 2000 Part 1 ([ISO/IEC 15444-1]) (i.e., the use of a reversible wavelet transformation and a reversible color component transformation, if applicable, and no quantization).
2. A Transfer Syntax with a UID of "1.2.840.10008.1.2.4.91", which specifies the use of either:
 - a. the lossless (reversible) mode of JPEG 2000 Part 1 ([ISO/IEC 15444-1]) (i.e., the use of a reversible wavelet transformation and a reversible color component transformation, if applicable, and no quantization or code stream truncation), or
 - b. the lossy (irreversible) mode of JPEG 2000 Part 1 ([ISO/IEC 15444-1]) (i.e., the use of an irreversible wavelet transformation and an irreversible color component transformation, if applicable, and optionally quantization, or the use of a reversible wavelet transformation and a reversible color component transformation, if applicable, followed by code stream truncation).

The choice reversible versus irreversible is at the discretion of the sender (SCU or FSC/FSU).

Note

When using the irreversible wavelet transformation and an irreversible color component transformation, if applicable, even if no quantization is performed, some loss will always occur due to the finite precision of the calculation of the wavelet and multi-component transformations.

Only the features defined in JPEG 2000 Part 1 ([ISO/IEC 15444-1]) are permitted for these two Transfer Syntaxes. Additional features and extensions that may be defined in other parts of JPEG 2000 shall not be included in the compressed bitstream unless they can be decoded or ignored without loss of fidelity by all Part 1 compliant implementations.

If the object allows multi-frame images in the pixel data field, then for these JPEG 2000 Part 1 Transfer Syntaxes, each frame shall be encoded separately. Each fragment shall contain encoded data from a single frame.

Note

1. That is, the processes defined in [ISO/IEC 15444-1] shall be applied on a per-frame basis. The proposal for encapsulation of multiple frames in a non-DICOM manner in so-called "Motion-JPEG" or "M-JPEG" defined in 15444-3 is not used.
2. Though a fragment may not contain encoded data from more than one frame, the encoded data from one frame may span multiple fragments. See note in Section 8.2.

For all images, including all frames of a multi-frame image, the JPEG 2000 bitstream specified in [ISO/IEC 15444-1] shall be used. The optional JP2 file format header shall NOT be included.

Note

The role of the JP2 file format header is fulfilled by the non-pixel data attributes in the DICOM Data Set.

The International Standards Organization ISO/IEC JTC1 has also developed JPEG 2000 Part 2 ([ISO/IEC 15444-2]), which includes Extensions to the compression techniques described in Part 1 of the JPEG 2000 Standard. Annex J of JPEG 2000 Part 2 describes extensions to the ICT and RCT multiple component transformations allowed in Part 1. Two types of multiple component transformations are defined in Annex J of Part 2 of JPEG 2000:

1. Array based multiple component transforms that form linear combinations of components to reduce the correlation between components. Array based transforms include prediction based transformations such as DPCM as well as more complicated transformations such as the KLT. These array based transformations can be implemented reversibly or irreversibly.
2. Wavelet based multiple component transformations using the same two wavelet filters as used in Part 1 of JPEG 2000 (5-3 reversible wavelet and 9-7 irreversible wavelet).

Annex J of JPEG 2000 Part 2 also describes a flexible mechanism to allow these techniques to be applied in sequence. Furthermore, it provides mechanisms that allow components to be re-ordered and grouped into component collections. Different multiple component transformation can then be applied to each component collection.

Two additional Transfer Syntaxes are specified for Part 2 JPEG 2000:

1. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.92, which specifies the use of the lossless (reversible) mode of JPEG 2000 Part 2 ([ISO/IEC 15444-2]) multiple component transformation extensions, as defined in Annex J of JPEG 2000 Part 2 (i.e., the use of a reversible wavelet transformation and a reversible multiple component transformation, and no quantization or code stream truncation).
2. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.93, which specifies the use of either:
 - a. the lossless (reversible) mode of JPEG 2000 Part 2 ([ISO/IEC 15444-2]) multiple component transformation extensions, as defined in Annex J of JPEG 2000 Part 2 (i.e., the use of a reversible wavelet transformation and a reversible multiple component transformation, and no quantization), or
 - b. the lossy (irreversible) mode of JPEG 2000 Part 2 ([ISO/IEC 15444-2]) multiple component transformation extensions, as defined in Annex J of JPEG 2000 Part 2 (i.e., the use of an irreversible wavelet transformation and an irreversible multiple component transformation, and optionally quantization, or the use of a reversible wavelet transformation and a reversible multiple component transformation, followed by code stream truncation).

Only the multiple component transformation extensions defined in Annex J of JPEG 2000 Part 2 ([ISO/IEC 15444-2]) are permitted for these two Transfer Syntaxes. Additional features and extensions that may be defined in other Annexes of JPEG 2000 Part 2 shall not be included in the compressed bitstream.

Note

the arbitrary wavelet transformations, as defined in Annex H of JPEG 2000 Part 2 ([ISO/IEC 15444-2]) are not allowed for these two Transfer Syntaxes. The only wavelet transformations that are allowed to be used as multiple component transformations are the reversible 5-3 wavelet transformation and the irreversible 9-7 wavelet transformation, as defined in Annex F of JPEG 2000 Part 1 ([ISO/IEC 15444-1]).

If the object allows multi-frame images in the pixel data field, then, for these JPEG 2000 Part 2 Transfer Syntaxes, the frames in the object are first processed using the multi-component transformation. After the multiple component transformation has been applied, the transformed frames are encoded using the process described in JPEG 2000 Part 1.

Optionally, the frames can be grouped into one or more component collections. The multiple component transformations are then applied to each component collection independently. The use of component collections can be used to reduce computational complexity and to improve access to specific frames on the decoder. If component collections are used, each fragment shall contain encoded data from a single component collection.

Note

1. The 3rd dimension transformations that are described in this Supplement are treated in Part 2 of JPEG 2000 as direct extensions to the color component transformations (RGB to YUV) that are described in Part 1 of JPEG 2000. For this reason, each image or frame in the sequence is called a "component". Although the term component is used as a generic term to identify an element of the 3rd dimension, no restriction is made or implied that the transformations in this Supplement apply only to multi-component (or multiple color channel) data. To compress a volumetric data set using this Transfer Syntax, each frame of the DICOM image is treated as a component of a multi-component image.
2. The progressive nature of the JPEG 2000 code stream allows for the decompression of the image before the complete image has been transferred. If a Storage SCP truncates the code stream by aborting the association, the instance has not been completely transferred and hence should not persist unless different UIDs are assigned (even though it may have been transiently used for display purposes).
3. It has been shown that the use of component collections does not significantly affect the compression efficiency (for details, see http://medical.nema.org/Dicom/minutes/WG-04/2004/2004-02-18/3D_compression_RSNA_2003_ver2.pdf).
4. Though a fragment may not contain encoded data from more than one component collection, the encoded data from one component collection may span multiple fragments.

A.4.5 MPEG2 Image Compression

The International Standards Organization ISO/IEC MPEG2 has developed an International Standard, [ISO/IEC 13818-2] 'Information Technology - Generic coding of moving pictures and associated audio information: video -- part 2', referred to as "MPEG-2".

A DICOM Transfer Syntax for MPEG2 Image Compression shall be identified by a UID value of either:

- 1.2.840.10008.1.2.4.100 corresponding to MPEG2 Main Profile / Main Level option of the ISO/IEC MPEG2 Video standard
- 1.2.840.10008.1.2.4.101 corresponding to the MPEG2 Main Profile / High Level option of the ISO/IEC MPEG2 Video standard.

A.4.6 MPEG-4 AVC/H.264 High Profile / Level 4.1 Video Compression

The International Standards Organization ISO/IEC MPEG4 has developed an International Standard, [ISO/IEC 14496-10] (MPEG-4 Part 10), for the video compression of generic coding of moving pictures and associated audio information. This standard is jointly maintained and has identical technical content as the ITU-T H.264 standard.

A DICOM Transfer Syntax for MPEG-4 AVC/H.264 Image Compression shall be identified by a UID value of either:

- 1.2.840.10008.1.2.4.102 corresponding to the MPEG-4 AVC/H.264 High Profile / Level 4.1 of the ITU-T H.264 Video standard
- 1.2.840.10008.1.2.4.103 corresponding to the MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1 of the ITU-T H.264 Video standard with the temporal and spatial resolution restrictions defined in Table 8-4 .

A.4.7 MPEG-4 AVC/H.264 High Profile / Level 4.2 Video Compression

The International Standards Organization ISO/IEC MPEG4 has developed an International Standard, [ISO/IEC 14496-10] (MPEG-4 Part 10), for the video compression of generic coding of moving pictures and associated audio information. This standard is jointly maintained and has identical technical content as the ITU-T H.264 standard.

A DICOM Transfer Syntax MPEG-4 AVC/H.264 High Profile / Level 4.2 for 2D Image Compression shall be identified by a UID value of:

- 1.2.840.10008.1.2.4.104 corresponding to the MPEG-4 AVC/H.264 High Profile / Level 4.2 of the ITU-T H.264 Video standard with the restriction that frame packing for stereoscopic 3D content shall not be used as defined in Table 8-8.

A DICOM Transfer Syntax MPEG-4 AVC/H.264 High Profile / Level 4.2 for 3D Image Compression shall be identified by a UID value of:

- 1.2.840.10008.1.2.4.105 corresponding to the MPEG-4 AVC/H.264 High Profile / Level 4.2 of the ITU-T H.264 Video standard. It should be used for transmitting stereoscopic 3D content with frame packing formats as defined in Table 8-8.

A.4.8 MPEG-4 AVC/H.264 Stereo High Profile / Level 4.2 Video Compression

The International Standards Organization ISO/IEC MPEG4 has developed an International Standard, [ISO/IEC 14496-10] (MPEG-4 Part 10), for the video compression of generic coding of moving pictures and associated audio information. This standard is jointly maintained and has identical technical content as the ITU-T H.264 standard.

A DICOM Transfer Syntax for MPEG-4 AVC/H.264 Stereo High Profile / Level 4.2 Image Compression shall be identified by a UID value of:

- 1.2.840.10008.1.2.4.106 corresponding to the MPEG-4 AVC/H.264 Stereo High Profile / Level 4.2 of the ITU-T H.264 Video standard.

A.4.9 HEVC/H.265 Main Profile / Level 5.1 Video Compression

The International Standards Organization ISO/IEC MPEG has developed an International Standard, [ISO/IEC 23008-2] (HEVC), for the video compression of generic coding of moving pictures and associated audio information. This standard is jointly maintained and has identical technical content as the [ISO/IEC 23008-2] HEVC standard.

A DICOM Transfer Syntax for HEVC/H.265 Main Profile / Level 5.1 Image Compression shall be identified by a UID value of:

- 1.2.840.10008.1.2.4.107 corresponding to the HEVC/H.265 Main Profile / Level 5.1 of the [ISO/IEC 23008-2] HEVC Video standard.

A.4.10 HEVC/H.265 Main 10 Profile / Level 5.1 Video Compression

The International Standards Organization ISO/IEC MPEG has developed an International Standard, [ISO/IEC 23008-2] (HEVC), for the video compression of generic coding of moving pictures and associated audio information. This standard is jointly maintained and has identical technical content as the [ISO/IEC 23008-2] HEVC standard.

A DICOM Transfer Syntax for HEVC/H.265 Main 10 Profile / Level 5.1 Image Compression shall be identified by a UID value of:

- 1.2.840.10008.1.2.4.108 corresponding to the HEVC/H.265 Main 10 Profile / Level 5.1 of the [ISO/IEC 23008-2] HEVC Video standard.

G Encapsulated RLE Compressed Images (Normative)

...

G.2 Byte Segments

A Byte Segment is a series of bytes generated by decomposing the Composite Pixel Code (see PS3.3).

If the Composite Pixel Code is not an integral number of bytes in size, sufficient Most Significant zero bits are added to make it an integral byte size. This is known as the Padded Composite Pixel Code.

The first Segment is generated by stripping off the most significant byte of each Padded Composite Pixel Code and ordering these bytes sequentially. The second Segment is generated by repeating this process on the stripped Padded Composite Pixel Code continuing until the last Pixel Segment is generated by ordering the least significant byte of each Padded Component Pixel Code sequentially.

Note

1. If Photometric Interpretation (0028, 0004) equals RGB and Bits Stored equals 8, then three Segments are generated. The first one holds all the Red values, the second all the Green values, and the third all the Blue values.
2. **The use of separate segments implies that the Planar Configuration (0028.0006) will always be 1 for RLE compressed images.**

Amend DICOM PS 3.11:

C Ultrasound Application Profile (Normative)

C.3 General Class Profile

C.3.1 Abstract and Transfer Syntaxes

C.3.1.1 Ultrasound Single and Multi-frame Pixel Formats Supported

The STD-US application profile requires that all ultrasound image objects only be stored using the values described in PS3.3 US Image Module and the specializations used for the Ultrasound Single and Multi-Frame IODs.

In the role of FS-Updater or FS-Creator the application can choose any of the supported Photometric Interpretations described in PS3.3 US Image Module to create an IOD. In the role of FS-Reader, an application shall support all Photometric Interpretations described in PS3.3 US Image Module.

Table C.3-2 describes restrictions on the use of various Transfer Syntaxes with the supported Photometric Interpretations for both single and multi-frame images.

Table C.3-2. Defined Photometric Interpretation and Transfer Syntax Pairs

Photometric Interpretation Value	Transfer Syntax	Transfer Syntax UID
MONOCHROME2	Uncompressed	1.2.840.10008.1.2.1
	RLE Lossless Image Compression	1.2.840.10008.1.2.5
RGB	Uncompressed	1.2.840.10008.1.2.1
	RLE Lossless Image Compression	1.2.840.10008.1.2.5
PALETTE COLOR	Uncompressed	1.2.840.10008.1.2.1
	RLE Lossless Image Compression	1.2.840.10008.1.2.5
YBR_FULL	RLE Lossless Image Compression	1.2.840.10008.1.2.5
YBR_FULL_422	Uncompressed	1.2.840.10008.1.2.1
	JPEG Lossy	1.2.840.10008.1.2.4.50
YBR_PARTIAL_422	Uncompressed	1.2.840.10008.1.2.1
	JPEG Lossy	1.2.840.10008.1.2.4.50