

DICOM Correction Proposal Form

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Correction Proposal Number	CP-143
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Correction Number	CP-143
Log Summary: Palette Color Lookup Table clarifications	
Type of Modification	Name of Standard
Clarification	PS 3.3,3.5,3.6-1999
<p>Rationale for Correction</p> <p>Several problems have been identified with Palette Color Lookup Table encoding.</p> <p>The VR of the Red/Green/Blue Palette Color Lookup Table Descriptors (0028,1101), (0028,1102), (0028,1103) are defined in PS 3.6 Section 6 to be US/US or US/SS, yet have a Value Multiplicity of 3 (not two). In PS 3.3 C.7.6.3.1.5 the first value is defined to be the number of entries, the second the first stored pixel value mapped, and the third the number of bits in the LUT entries.</p> <p>When encoding in Explicit VR, only one VR, US or SS can be specified, not different VRs for different values.</p> <p>There is no description of how or when to chose SS or US VR. Many people have assumed that the VR of the second value (first stored pixel value mapped) is determined by Pixel Representation (0028,0103).</p> <p>However, a signed pixel representation makes no sense in the case of indexed color images.</p> <p>Furthermore, if the number of entries (first value of the descriptor) was encoded as SS then the table size would be limited to less than $2^{15}-1$, except for the special case of zero that is defined to be 2^{16} in PS 3.3 C.7.6.3.1.5.</p> <p>The changes proposed here limit the pixel representation for palette color images to always unsigned, and specify the VR to be always US, thus avoiding the problem.</p> <p>The wording of PS 3.3 C.7.6.3.1.5 incorrectly refers to the first or last entry rather than value mapped in some cases and does not include the case where the value is equal to the first value mapped plus the number of entries.</p> <p>PS 3.3 C.7.6.3.1 is not explicit when it defines how 16 bit palette color tables should be used to</p>	

store 8 bit data. This leads to confusion on the part of implementers who create and parse such images. The statement in C.7.6.3.1.5 implies that padding should not be used but the text of C.7.6.3.1.6 specifies what value to use when padding the data, a direct contradiction.

Finally, Supplement 5 which revised the ultrasound objects and the definition of Palette Color LUTS in the Image Pixel Module changed the definition of encoding of Palette Color LUT Data in PS 3.5-1993 Annex A to specify always OW for all Transfer Syntaxes and added a VR or OW to the existing US/SS specified in PS 3.6-1993. Note that a 64k LUT cannot be encoded in an explicit VR of US or SS since the VL field is restricted to 16 bits.

This means that PS 3.5 and PS 3.6 are in conflict, since the Palette Color LUT Data elements cannot be encoded as other than OW. Here the US and SS VRs in PS 3.6-1998 are removed.

Also, for cases where the Palette Color LUT Data elements are used without the Palette Color Module (eg. in Secondary Capture objects), the possibility of packing 8 bit table values into bytes needs to be made consistent with the definition of other LUTs (Modality LUT, VOI LUT) though the VR remains OW and not OB (otherwise the byte order would be different for explicit VR big-endian transfer syntax).

Note that this change does not affect an implementation creating or reading LUT Data in the default Implicit VR Transfer Syntax since the byte order of OW or OB or US or SS is always little endian.

Sections of documents affected

PS 3.3-1999 C.7.6.3.1

PS 3.5-1999 Annex A

PS 3.6-1999 Section 6

Correction Wording:

Amend PS 3.3-1998 Section C.7.6.3.1 to revise definition of Palette Color LUT Descriptors

C.7.6.3.1.2 Photometric Interpretation

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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 **and Pixel Representation (0028,0103) specifies unsigned (ie, has a value of 0)**. When the Photometric Interpretation is Palette Color; Red, Blue, and Green Palette Color Lookup Tables shall be present.

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C.7.6.3.1.5 Palette Color Lookup Table Descriptor

The three values of Palette Color Lookup Table Descriptor (0028,1101-1103) describe the format of the Lookup Table Data in the corresponding Data Element (0028,1201-1203) or (0028,1221-1223).

The first value is the number of entries in the lookup table. When the number of table entries is equal to 2^{16} then this value shall be 0.

The second value is the first stored pixel value mapped. This pixel value is mapped to the first entry in the Lookup Table Data. All image pixel values less than the first **entry value mapped** are also mapped to the first entry in the Lookup Table Data. An image pixel value one greater than the first **entry value mapped** is mapped to the second entry in the Lookup Table Data. Subsequent image pixel values are mapped to the subsequent entries in the Lookup Table Data up to an image pixel value equal to number of entries + first **entry value mapped** - 1 which is mapped to the last entry in the Lookup Table Data. Image pixel values greater than **or equal to** number of entries + first **entry value mapped** are also mapped to the last entry in the Lookup Table Data.

The third value specifies the number of bits for each entry in the Lookup Table Data. **It shall take the value of 8 or 16. The LUT Data shall be stored in a format equivalent to 8 or 16 bits allocated where the high bit is equal to bits allocated-1.**

When the Palette Color Lookup Table Descriptor (0028,1101-1103) are used as part of the Palette Color Lookup Table Module, the third value shall be equal to 16.

Note: A value of 16 indicates the Lookup Table Data will range from (0,0,0) minimum intensity to (65535,65535,65535) maximum intensity.

C.7.6.3.1.6 Palette Color Lookup Table Data

Palette Color Lookup Table Data (0028,1201-1203) contain the lookup table data corresponding to the Lookup Table Descriptor (0028,1101-1103). ~~If padding is required to complete a full word, the padding value shall be 0.~~

Palette color values must always be scaled across the full range of available intensities. This is indicated by the fact that there are no bits stored and high bit values for palette color data.

Note: For example, if there are 16 bits per entry specified and only 8 bits of value are truly used then the 8 bit intensities from 0 to 255 must be scaled to the corresponding 16 bit intensities from 0 to 65535. To do this for 8 bit values, simply replicate the value in both the most and least significant bytes.

These lookup tables shall be used only when there is a single sample per pixel (single image plane) in the image **and Pixel Representation (0028,0103) specifies unsigned (ie, has a value of 0).**

The data values are always unsigned.

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Amend PS 3.5-1998 Section A to include notes to clarify Palette Color LUT Data VRs.

A.1 DICOM IMPLICIT VR LITTLE ENDIAN TRANSFER SYNTAX

Data Elements (0028,1201), (0028,1202),(0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.

Note: Previous versions of the Standard either did not specify the encoding of these Data Elements in this Part, but specified a VR of US or SS in PS 3.6 (1993), or specified OW in this Part but a VR of US, SS or OW in PS 3.6 (1996). The actual encoding of the values and their byte order would be identical in each case.

A.2 DICOM LITTLE ENDIAN TRANSFER SYNTAX (EXPLICIT VR)

Data Elements (0028,1201), (0028,1202),(0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.

Note: Previous versions of the Standard either did not specify the encoding of these Data Elements in this Part, but specified a VR of US or SS in PS 3.6 (1993), or specified OW in this Part but a VR of US, SS or OW in PS 3.6 (1996). The actual encoding of the values and their byte order would be identical in each case, though the explicitly encoded VR field would be different. However, an explicit VR of US or SS cannot be used to encode a table of 2^{16} elements, since the Value Length is restricted to 16 bits.

A.3 DICOM BIG ENDIAN TRANSFER SYNTAX (EXPLICIT VR)

Data Elements (0028,1201), (0028,1202),(0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Big Endian.

Note: Previous versions of the Standard either did not specify the encoding of these Data Elements in this Part, but specified a VR of US or SS in PS 3.6 (1993), or specified OW in this Part but a VR of US, SS or OW in PS 3.6 (1996). The actual encoding of the values and their byte order would be identical in each case, though the explicitly encoded VR field would be different. However, an explicit VR of US or SS cannot be used to encode a table of 2^{16} elements, since the Value Length is restricted to 16 bits.

A.4 TRANSFER SYNTAXES FOR ENCAPSULATION OF ENCODED PIXEL DATA

Data Elements (0028,1201), (0028,1202),(0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.

Note: Previous versions of the Standard either did not specify the encoding of these Data Elements in this Part, but specified a VR of US or SS in PS 3.6 (1993), or specified OW in this Part but a VR of US, SS or OW in PS 3.6 (1996). The actual encoding of the values and their byte order would be identical in each case, though the explicitly encoded VR field would be different. However, an explicit VR of US or SS cannot be used to encode a table of 2^{16} elements, since the Value Length is restricted to 16 bits.

Amend PS 3.6-1998 Section 6 to revise (50xx,3000) VR.

6 REGISTRY OF DICOM DATA ELEMENTS

(0028,1101)	Red Palette Color Lookup Table Descriptor	US US or SS US	3
		<u>US</u>	
(0028,1102)	Green Palette Color Lookup Table Descriptor	US US or SS US	3
		<u>US</u>	
(0028,1103)	Blue Palette Color Lookup Table Descriptor	US US or SS US	3
		<u>US</u>	
(0028,1201)	Red Palette Color Lookup Table Data	US or SS or OW	4-n 1
(0028,1202)	Green Palette Color Lookup Table Data	US or SS or OW	4-n 1
(0028,1203)	Blue Palette Color Lookup Table Data	US or SS or OW	4-n 1