

DICOM Correction Item

Correction Number		CP 692
Log Summary: Add Pixel Padding Value Range Limit attribute		
Type of Modification	Name of Standard	
Addition	PS 3.3, 3.4, 3.6 2007	
Rationale for Correction:		
<p>For the display of Full Field Digital Mammography (FFDM) images, it is desirable to suppress areas outside the organ of interest (the breast) such as the background air in the rectangular image matrix, when inverting or adjusting the grayscale contrast (windowing and leveling) the image. An existing mechanism in DICOM is for the acquisition system to specify a Pixel Padding Value, assuming that all pixels in the background have this value.</p> <p>However, a single Pixel Padding Value may not be adequate to identify the background since noise from various sources may prevent a single value from being sufficient, and it may be desirable not to replace noise pixels with a single value during processing since processing may fail.</p> <p>This requirement is not modality-specific, and hence a mechanism that applies to the generic grayscale pipeline is needed.</p> <p>Accordingly, it is proposed to add an additional attribute to identify a range rather than a single pixel value that represents the limit of values within which the background pixels occur, in backwards compatible manner that augments rather than replaces the existing Pixel Padding Value, such that a receiver unaware of the extension can still suppress only the single value with good effect, since statistically that value will represent the "majority" of the background pixels.</p> <p>Though the Pixel Padding Value is defined at the Equipment Information Entity (IE) level, the new Pixel Padding Value Range attribute is defined at the Image IE level, since the range may vary on a per-image basis.</p> <p>This proposal represents a consensus opinion of the digital, CR and scanned film acquisition and display vendors participating in the IHE Mammo profile development on the preferred mechanism for this application.</p>		
Sections of documents affected		
PS 3.3 C.7.5.1, PS 3.4 N.2.1.1, PS 3.6 section 6		
Correction Wording:		

Item #1: Update C.7.5.1 General Equipment Module in PS 3.3:

C.7.5.1 General Equipment Module

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**Table C.7-8
 GENERAL EQUIPMENT MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
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Pixel Padding Value	(0028,0120)	3	Value of pixels not present in the native image added to Single pixel value or one limit (inclusive) of a range of pixel values used in an image to pad to rectangular format or to signal background that may be suppressed. See C.7.5.1.1.2 for further explanation. Note: The Value Representation of this Attribute is determined by the value of Pixel Representation (0028,0103).
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C.7.5.1.1.2 Pixel Padding Value and Pixel Padding Range Limit

Pixel Padding Value (0028,0120) is used to pad **grayscale** images (**those with a Photometric Interpretation of MONOCHROME1 or MONOCHROME2**) to rectangular format. The native format of some images is not rectangular. It is common for devices with this format to pad the images to the rectangular format required by the DICOM Standard with a specific pixel value that is not contained in the native image. Further, when resampling, such as after spatial registration, padding may need to be used to fill previously non-existent pixels.

Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) are also used to identify pixels to be excluded from the normal grayscale rendering pipeline for other reasons, such as suppression of background air. Pixel Padding Range Limit (0028,0121) is defined in the Image Pixel Module.

- Notes:
1. The “native image” is that which is being padded to the required rectangular format, e.g., the area within the circular reconstruction perimeter of a CT image, **or the subset of the rectangular area that contains useful image information.**
 2. The pixel padding value is explicitly described in order to prevent display applications from taking it into account when determining the dynamic range of an image, since the Pixel Padding Value will be outside the range between the minimum and maximum values of the pixels in the native image.
 3. No pixels in the native image will have a value equal to Pixel Padding Value.

Pixel Padding Value (0028,0120) This attribute specifies either a single the value of this padding value, or when combined with Pixel Padding Range Limit (0028,0121), a range of values (inclusive) that are padding.

The values of **Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121)** shall be a valid values within the constraints defined by Bits Allocated (0028,0100), Bits Stored (0028,0101), and High Bit (0028,0102).

Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) This Attribute shall not be present when padding is performed but the pixel value used for padding does occur in the native image.

If Photometric Interpretation (0028,0004) is MONOCHROME2, Pixel Padding Value (0028,0120) shall be less than (closer to or equal to the minimum possible pixel value) or equal to Pixel Padding Range Limit (0028,0121). If Photometric Interpretation (0028,0004) is MONOCHROME1, Pixel Padding Value (0028,0120) shall be greater than (closer to or equal to the maximum possible pixel value) or equal to Pixel Padding Range Limit (0028,0121).

Notes: 1. When the relationship between pixel value and X-Ray Intensity is unknown, it is recommended that the following values be used to pad with black when the image is unsigned:

0 if Photometric Interpretation (0028,0004) is MONOCHROME2.

$2^{\text{BitsStored}} - 1$ if Photometric Interpretation (0028,0004) is MONOCHROME1.

and when the image is signed:

$-2^{\text{BitsStored}-1}$ if Photometric Interpretation (0028,0004) is MONOCHROME2.

$2^{\text{BitsStored}-1} - 1$ if Photometric Interpretation (0028,0004) is MONOCHROME1.

2. For projection radiography, when the relationship between pixel value and X-Ray Intensity is known (for example as defined by Pixel Intensity Relationship (0028,1040) and Pixel Intensity relationship Sign (0028,1041)), it is recommended that a pixel value equivalent to, or rendered similarly to, air (least X-Ray absorbance) be used for padding. However, if such a value may occur in the native image, the Pixel Padding Value (0028,0120) Attribute itself should not be sent.

E.g., for an XRF image obtained with an image intensifier, if air is black then a padded perimeter, if any, should also appear black. Typically though, if unpadded, this area would be collimated with a circular collimator, in which case the pixels would appear natively as white (greatest X-Ray absorbance) and a circular shutter would be necessary to neutralize them as black. Whether collimated areas are detected and treated as padded, or neutralized with shutters is at the discretion of the application. See also the Display Shutter Module C.7.6.11.

3. The conditional requirement for the Pixel Padding Value Range Limit (0028,0121) in the Image Pixel Module means that it shall not be present unless Pixel Padding Value (0028,0120) is also present.

4. The range of values to be suppressed between Pixel Padding Value (0028,0120) and Pixel Padding Value Range Limit (0028,0121) is specified as being inclusive, that is the values themselves as well as all values between are suppressed.

5. When Pixel Padding Value Range Limit (0028,0121) is present, but not supported by a rendering application, the constraint that Pixel Padding Value (0028,0120) is closest to the "blackest" value, which is typically the most frequently occurring background pixel, will most often result in an acceptable display, permitting "backward compatibility" in the majority of cases.

When modifying equipment changes the pixel padding value in the image, it shall change the values of Pixel Padding Value (0028,0120) **and Pixel Padding Range Limit (0028,0121), if present.** If modifying equipment changes the pixel padding values in the image to a-values present in the native image, the attributes Pixel Padding Value (0028,0120) **and Pixel Padding Range Limit (0028,0121)** shall be removed.

Notes: 1. For example, if a CT image containing signed values from -1024 to 3191 and a Pixel Padding Value of -2000 and a Rescale Intercept of 0 is converted to an unsigned image with a Rescale Intercept of -1024 by adding 1024 to all pixels and clipping all more negative pixels to 0, then the padding pixels will be indistinguishable from some of the modified native image pixels, and hence Pixel Padding Value (0028,0120) needs to be removed.

2. If the modification involves lossy compression, which may result in changes to the pixel values, then the application of Pixel Padding Value and Pixel Padding Range Limit may result in a different appearance, and hence these attributes may need different values also.

Item #1: Update C.7.6.3 Image Pixel Module in PS 3.3:

C.7.6.3 Image Pixel Module

Table C.7-11a describes the Image Pixel Module.

**Table C.7-11a
 IMAGE PIXEL MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
<i>Include 'Image Pixel Macro' Table C.7-11b</i>			
Pixel Data Provider URL	(0028,7FE0)	1C	A URL of a provider service that supplies the pixel data of the Image. Required if the image is to be transferred in one of the following presentation contexts identified by Transfer Syntax UID: 1.2.840.10008.1.2.4.94 (DICOM JPIP Referenced Transfer Syntax) 1.2.840.10008.1.2.4.95 (DICOM JPIP Referenced Deflate Transfer Syntax)
<u>Pixel Padding Range Limit</u>	<u>(0028,0121)</u>	<u>1C</u>	<u>Pixel value that represents one limit (inclusive) of a range of padding values used together with Pixel Padding Value (0028,0120) as defined in the General Equipment Module. See C.7.5.1.1.2 for further explanation.</u> <u>Required if pixel padding is to be defined as a range rather than a single value.</u> <u>Shall not be present if Pixel Padding Value (0028,0120) is not present.</u> <u>Note: The Value Representation of this Attribute is determined by the value of Pixel Representation (0028,0103).</u>

Item #2: Update the following in PS 3.4:

N.2.1 Grayscale Transformations

N.2.1.1 Modality LUT

The Modality LUT operation applies only to grayscale values.

The Modality LUT transformation transforms the manufacturer dependent pixel values into pixel values which are meaningful for the modality and which are manufacturer independent (e.g., Hounsfield number for CT modalities, Optical Density for film digitizers). These may represent physical units or be dimensionless. The Modality LUT in the Presentation State is modality dependent and is analogous to the same module in an Image.

- Notes: 1. In some cases, such as the CT Image Storage SOP Class, the same conceptual step as the Modality LUT is specified in another form, for example as Rescale Slope and Rescale Intercept Attributes in the CT Image Module, though the Modality LUT Module is not part of the CT Image IOD.

2. Image pixel values with a value of Pixel Padding Value (0028,0120), **or within the range specified by Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121)** (if present in the image) shall be accounted for prior to entry to the Modality LUT stage. See the definition of Pixel Padding Value in PS 3.3.

Item #3: Add the following to PS 3.6 section 6:

Tag	Name	VR	VM
(0028,0121)	Pixel Padding Range Limit	US or SS	1