### Log Summary:
Define use of Pixel Padding Value for PALETTE COLOR images

### Name of Standard
PS3.3 2022a

### Rationale for Correction:
The meaning of Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) is currently only defined for monochrome images, i.e. those with a Photometric Interpretation (0028,0004) of MONOCHROME1 or MONOCHROME2, even though the presence of these Attributes is not limited to monochrome images.

It is proposed to add explicit text on the use of pixel padding for palette color images. A typical use case would be the superimposition of a Corneal Topography Map on the corresponding source image, where certain parts of the map are rendered “transparently” so that the underlying image becomes visible. See revised version of CP-2169 where this use case is covered.

The Blending Softcopy Presentation State (as suggested in PS3.17 Section NNN.3) does not support translucency of a single pixel value. The Advanced Blending Presentation State might be an option but is probably too complex to be implemented for a simple use case like the rendering of a Corneal Topography Map on a source image in Ophthalmology.

*Editorial changes:* The spelling of “Pixel Padding Value” vs. "pixel padding value" vs. "padding value" is rather inconsistent. Also the Attribute Tag is sometimes missing when the text refers to an Attribute. It is proposed to consistently use the upper-case version “Pixel Padding Value” and add the Attribute Tag when referring to the Attribute (and not to the general concept). These changes should be made in all parts of the DICOM standard, at least for “Pixel Padding Value”.

### Correction Wording:

*Change PS3 -* Editor to change to use upper-case version “Pixel Padding Value” throughout

*Change PS3 -* Editor to change to use the Attribute Tag when referring to the Attribute (and not to the general concept) throughout.

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**C.7.5.1 General Equipment Module**

Table C.7-8 specifies the Attributes that identify and describe the piece of equipment that produced Composite Instances.

**Table C.7-8. General Equipment Module Attributes**
<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Tag</th>
<th>Type</th>
<th>Attribute Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel Padding Value</td>
<td>(0028,0120)</td>
<td>1C</td>
<td>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 or that may be rendered “transparently” when superimposing images. See Section C.7.5.1.1.2 for further explanation. Required if Pixel Padding Range Limit (0028,0121) is present and either Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present. May be present otherwise only if Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present.</td>
</tr>
<tr>
<td>Note</td>
<td></td>
<td></td>
<td>1. The Value Representation of this Attribute is determined by the value of Pixel Representation (0028,0103).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. This Attribute is not used in Presentation State Instances; there is no means in a Presentation State to &quot;override&quot; any Pixel Padding Value specified in the referenced images.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. This Attribute does apply to RT Dose and Segmentation Instances, since they include Pixel Data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. This Attribute does not apply when Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) are used instead of Pixel Data (7FE0,0010); Float Pixel Padding Value (0028,0122) or Double Float Pixel Padding Value (0028,0123), respectively, are used instead, and defined at the Image, not the Equipment, level.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5. Only a single Value is allowed for this Attribute, so it only applies to images with Samples per Pixel (0028,0002) of 1, i.e., images with a Photometric Interpretation (0028,0004) of MONOCHROME1, MONOCHROME2 or PALETTE COLOR. See Section C.7.5.1.1.2 for details.</td>
</tr>
</tbody>
</table>

_C.7.5.1.1 General Equipment Attribute Descriptions_

Change PS3.3 Section C.7.5.1.1.2

C.7.5.1.1.2 Pixel Padding Value and Pixel Padding Range Limit

Pixel Padding Value (0028,0120) is typically used to pad grayscale images (those with a Photometric Interpretation (0028,0004) of MONOCHROME1 or MONOCHROME2), or color images with a Photometric Interpretation (0028,0004) of PALETTE COLOR, 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.

Note

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, i.e., which is not to be suppressed, or e.g., is that part of a pseudo-colored image that might be superimposed on top of another image. For other mechanisms, see N.2.6 "Advanced Blending Presentation State" in PS3.4.

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 (0028,0120).

Pixel Padding Value (0028,0120) specifies either a single 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 valid values within the constraints defined by Bits Allocated (0028,0100), Bits Stored (0028,0101), and High Bit (0028,0102).

The pixel padding value shall correspond to a value in the original stored pixel data, before the Modality LUT Transformation or any other transformations are applied.

Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) 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 or PALETTE COLOR, 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).

Note

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

   and when the image is signed:
   - $-2^{\text{Bits Stored}} - 1$ if Photometric Interpretation (0028,0004) is MONOCHROME2.
   - $2^{\text{Bits Stored}} - 1$ 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 present.

   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 Section 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 values present in the native image, the Attribute Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) shall be removed.

Note

1. For example, if a CT image containing signed values from -1024 to 3191 and a Pixel Padding Value (0028,0120) of -2000 and a Rescale Intercept (0028,1052) 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 (0028,0120) and Pixel Padding Range Limit (0028,0121) may result in a different appearance, and hence these Attributes may need different values also.