DICOM Correction Proposal

STATUS	Assigned
Date of Last Update	2022/05/25
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Correction Number	CP-2189			
Log Summary: Allow MIXED image type for CT Multi Energy				
Name of Standard				
PS3.3 Section 8, PS3.17 Section JJJJ	2021e			

Rationale for Correction:

Supplement 188 introduced Image Type (0008,0008) Value 4 encoding that is consistent with requirements for the classic IOD, but inconsistent with requirements for the enhanced IOD.

Multi-energy images may be calculated based on x-ray spectra and not derived from original pixel data. Based on current Part 3 specifications, multiple multi-energy types cannot be encoded in the same enhanced object.

It is not allowed to include the multi-energy type in Value 4 of the enhanced IOD as in the classic IOD for the following reasons:

1. Table C.8-114. Enhanced CT Image Module Attributes, Image Type (0008,0008) incorporates CT image types in <u>Section C.8.16.1</u> and <u>Section C.8.15.2.1.1</u>. Neither one of these sections incorporates the multi-energy types in <u>Section C.8.2.1.1.1</u> into <u>Defined Terms for Value 4</u>

Multi-energy CT Characteristics Sequence (0018,9364), Monoenergetic Energy Equivalent (0018,937C) and <u>Table C.11.1.1.2.1-1</u>. Recommended Rescale Type Assignments for Multi-energy CT Image include conditions that dependent upon Value 4 multi-energy types in <u>C.8.2.1.1.1</u>.

2. Per <u>C.8.16.1.4</u> Derived Pixel Contrast, "Value 4 shall be used to indicate derived pixel contrast - generally, contrast created by combining or processing images with the same geometry. Value 4 shall have a value of NONE when Value 1 is ORIGINAL."

Because Value 4 shall have a value of "NONE", different multi-energy types are not allowed to be "MIXED" in the same enhanced IOD

Per note in Section <u>C.8.2.1.1.1</u>, "Multi-energy CT images are not necessarily DERIVED and may be ORIGINAL\PRIMARY."

ORIGINAL multi-energy types may include:

- Objective Image Family: VMI, ELECTRON_DENSITY, EFF_ATOMIC_NUM
- Material Quantification Family: MAT_SPECIFIC, MAT_REMOVED
- Material Visualization Family: MAT_MODIFIED

DERIVED multi-energy types may include:

- Material Quantification Family: MAT_SPECIFIC, MAT_REMOVED
- Material Visualization Family: Other IODs, MAT_MODIFIED

Grouping of ORIGINAL multi-energy types in the same enhanced object may include:

- VMI/MAT_REMOVED/MAT_SPECIFIC
- VMI/ELECTRON_DENSITY/EFF_ATOMIC_NUM

Grouping of DERIVED multi-energy types in the same enhanced object may include:

• VMI/Material Visualization Family

Correction Wording:

Define Value 5 to allow enhanced multi-frame CT images with mixed multi-energy frame types.

Note: For context see PS3.3 <u>C.8.16.1</u> for Value 1, 2, 3 and 4 definitions. <u>Value 5</u> is currently defined for contrast enhanced digital X-Ray imaging of the breast.

Add the following section to PS3.3 after Section C.8.15.2.1.1.4 Derived Pixel Contrast

C.8.15.2.1.1.x Multi-energy CT Images

Table C.8-xxx specifies the Defined Terms for CT additional to those defined in Section C.8.16.1.x for Value 5 for Image Type (0008,0008) and Frame Type (0008,9007). Image Type (0008,0008) Value 5 shall be present if Multi-energy CT Acquisition (0018,9361) has a value of YES.

Defined Term Name	Defined Term Description				
Include Defined Terms for Value 4 for Multi-energy CT Images					
MIXED	Used only as a value in Image Type (0008,0008) Value 5 in the Enhanced CT Image Module Attribute Description if frames within the image SOP Instance contain different values for the Frame Type (0008,9007) in the CT Frame Type Functional Group.				

Update PS3.3 Table C.8.15.3.12-1. Multi-energy CT Characteristics Macro Attributes, as follows

Attribute Name	Tag	Туре	Attribute Description
Multi-energy CT Characteristics	(0018,9364)	1C	Multi-energy characteristics of the generated image.
Sequence			Required if CT Image Image Type (0008.0008) Value 4.
			Enhanced CT Image Type (0008,0008) Value 5 or Frame
			Type (0008,9007) Value 5 is VMI. May be present otherwise.
			Only a single Item shall be included in this Sequence.
>Monoenergetic Energy Equivalent	(0018,937C)	1C	Single energy equivalent in keV.
			Required if Image Type (0008,0008) Value 4 is EQUAL to VMI. May be present otherwise.
			Note
			If the <u>CT Image</u> Image Type (0008,0008) Value 4 <u>, Enhanced</u> <u>CT Image Type (0008,0008) Value 5 or Frame Type</u> (0008,9007) Value 5 is (MAT_REMOVED, MAT_MODIFIED) and a VMI image was used as the source then this value
Desire Care Alexadda a	(0000 4040)		reflects the key value of the VIVII Image.
Sequence	(0022,1612)	3	Software algorithm that performed the derivation.
			One or more Items are permitted in this Sequence.
>>Include <u>Table 10-19</u>) "Algorithm	-	
Identification Macro At	<u>tributes"</u>	<u> </u>	
>Performed Processing	(0074,1212)	3	Parameters used to perform the derivation algorithm.
Parameters Sequence			Note
			Implementers are encouraged to put the Algorithm Parameters here instead of in Algorithm Parameters (0066,0032) in the Algorithm Identification Macro
			One or more items are permitted in this Sequence.
>>Include <u>Table</u> 10.2.	1-1 "Content	ltem	
with Modifiers Macro A	Attributes"		

Table C.8.15.3.12-1. Multi-energy CT Characteristics Macro Attributes

Update PS3.3 Table C.11.1.1.2.1-1. Recommended Rescale Type Assignments for Multi-energy CT Image, as follows:

Table C.11.1.1.2.1-1. Recommended Rescale Type Assignments for Multi-energy CT Image

Multi- energy Image Family	Recmd. Rescale Type (0028, 1054)	Image Type (0008,0008) <u>Value 4</u> See Note 3	Rescal e Interce pt (0028, 1052)	Rescal e Slope (0028, 1053)	Real World Value First Value Mappe d (0040, 9216)	Real World Value Last Value Mappe d (0040, 9211)	Real World Value Interce pt (0040, 9224)	Real Worl d Valu e Slop e (004 0, 9225)	LUT Label (0040,9210) in Real World Value Macro	Measureme nt Units Code Sequence (0040,08EA) in Real World Value Macro
Objectiv	e Image	Family								
Virtual Mono energeti c Image	HU	VMI	-1024	1	0	4095	-1024	1	VMI	hnsf'U
Effective AN (Z) Image (see Note <u>1</u>)	10^-2 Z_EFF	EFF_ ATOMIC_ NUM	0	1	0	4000	0	0.01	EFF_ ATOMIC_ NUM	129320
Electron Density	10^-2ED	ELECTRON _DENSITY	0	1	0	4000	0	0.01	ELECTRON _DENSITY	10*23/ml
Image	10^- 3EDW	ELECTRON _DENSITY	0	1	0	4000	0	0.001	ELECTRON _DENSITY	ratio
Material	Quantifi	cation Family	y						•	•
Material- Specific	10^- 2MGML	MAT_ SPECIFIC	(0) - (- 10)	1	0	4000	-3	0.01	MAT_ SPECIFIC	mg/cm3
Image	HU	MAT_ SPECIFIC	-1024	1	0	4095	-1024	1	MAT_ SPECIFIC	hnsf'U
Material- Remove	HU	MAT_ REMOVED	-1024	1	0	4095	-1024	1	MAT_ REMOVED	hnsf'U
d Image (see Note <u>2</u>)	HU_MO D	MAT_ REMOVED	-1024	1	0	4095	-1024	1	MAT_ REMOVED	129321
Fraction al Map Image	10^-1 PCT	MAT_ FRACTION AL	0	1	0	1000	0	0.1	MAT_ FRACTION AL	%
Value- based Map Image	US	MAT_ VALUE_ BASED	0	1	0	100	0	1	MAT_ VALUE_ BASED	US
Material	Visualiza	ation Family		I	I	I	ſ	1	1	
Material- Modified Image	HU_MO D	MAT_ MODIFIED	-1024	1	0	4095	-1024	1	MAT_ MODIFIED	129321

Note

- 1. This example assumes a scaling of 0.01 for the Effective Atomic Number which would be reasonable for images for which the effective atomic number was not greater than 40 for any pixels.
- 2. The real-world value mapped pixels in the image may have been adjusted to represent the attenuation as if the pixel was filled with the remaining materials to preserve the relationship

between the HU value of the pixel and the materials contained (shown as HU in the first row), or they may have not been adjusted (shown as HU_MOD).

3. In the Classic IOD, multi-energy types are encoded in the <u>CT Image Module Image Type</u> (0008,0008) Value 4. In the Enhanced IOD, multi-energy types are encoded in the <u>Enhanced</u> <u>CT Image Module Image Type</u> (0008,0008) Value 5 or the Frame Type (0008,9007) Value 5 Defined Terms for Value 4 for Multi-energy CT Images.

Modify PS3.6 Table 6-1 as follows:

Table 6-1. Registry of DICOM Data Elements

Tag	Name	Keyword	VR	VM	
(0008,9007)	Frame Type	FrameType	CS	4 <u>5</u>	

Update PS3.17. Update JJJJ.5.1.1 Example Multiple Physical Sources and Multiple Physical Detectors, as follows

JJJJ.5.1.1 Example Multiple Physical Sources and Multiple Physical Detectors

This example shows an Effective Atomic Number image acquired on an acquisition device with multiple physical sources and multiple physical detectors, **encoded as a classic CT IOD**.

Add a new section to PS3.17, After Section JJJJ.5.2 as follows

JJJJ.5.x Examples For Enhanced Multi-Frame, Multi-Energy:

JJJJ.5.x.1 Example For Mixed Multi-Energy Image Types:

This example shows a mixed multi-energy image types: virtual monoenergetic, material specific and material removed image types encoded within the same enhanced multi-frame object.

Table	JJJJ.	5.x.1-2.	Dimension	Module
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ltem	Attribute	Value	Comment
1	Dimension Index Pointer	(0008,9007)	Multi-energy CT Image Type
	Dimension Description Label	Multi-energy image type	1 mono
			2 material specific
			3 material removed
2	Dimension Index Pointer	(0018,937C)	Monoenergetic Energy Equivalent
	Functional Group Pointer	(0018,9364)	Multi-energy CT Characteristics Sequence
	Dimension Description Label	keV	1 60
			2 70
			3 none
3	Dimension Index Pointer	(0040,9220)	Quantity Definition Sequence

ltem	Attribute	Value	Comment
	Functional Group Pointer	(0040,0441)	Content Item Modifier Sequence
	Dimension Description Label	Material specific	1 water 2 iodine 3 none

Table JJJJ.5.x.1-1. Per-Frame Attributes

Example	Multi-Energy Family	Multi-energy CT Frame Type Value 5	Quantity Definition Sequence	Dimension Index Values
60 keV	Objective Image	VMI		1\1\3
Water	Material Quantification	MAT_SPECIFIC	11713004, SCT, "Water"	2\3\1
lodine	Material Quantification	MAT_SPECIFIC	44588005, SCT, "Iodine"	2\3\2
lodine removed	Material Quantification	MAT_REMOVED		3\3\2