ACR-NEMA

DIGITAL IMAGING AND COMMUNICATIONS

IN MEDICINE (DICOM)

SUPPLEMENT 12

POSITRON EMISSION TOMOGRAPHY
IMAGE OBJECTS

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FORWARD

NEMA (the National Electrical Manufacturers Association) and the ACR (the American College of Radiology) formed a joint ad-hoc Committee to further expand the Standard for Digital Imaging and Communications in Medicine initially adopted by ACR and NEMA. The corresponding Supplements to the DICOM Standard were developed according to NEMA Procedures.

This Supplement to the Standard is developed in liaison with other Standards Organizations including CEN TC251 in Europe and JIRA in Japan, with review also by other member organizations of the ANSI HISPP in the USA which include IEEE, HL7 and X12.

The DICOM standard is structured as a multi-part document using the guidelines established in the following document:

   - ISO/IEC Directives, 1989 Part 3 - Drafting and Presentation of International Standards.

This document is a Supplement to the DICOM Standard. It is an extension to Part 3, 4 and 6 of the published DICOM Standard which consists of the following parts:

   PS 3.1   -   Introduction and Overview
   PS 3.2   -   Conformance
   PS 3.3   -   Information Object Definitions
   PS 3.4   -   Service Class Specifications
   PS 3.5   -   Data Structures and Encoding
   PS 3.6   -   Data Dictionary
   PS 3.7   -   Message Exchange
   PS 3.8   -   Network Communication Support for Message Exchange
   PS 3.9   -   Point-to-Point Communication Support for Message Exchange
   PS 3.10   -   Media Storage and File Formats for Data Interchange
   PS 3.11   -   Media Storage Application Profiles
   PS 3.12   -   Storage Functions and Media Formats for Data Interchange
   PS 3.13   -   Print Management - Point-to-point Communication Support

These parts are independent but related documents.

SCOPE AND FIELD OF APPLICATION

This Supplement to the DICOM Standard specifies a DICOM Image Information Object for Positron Emission Tomography (PET) and a DICOM PET Curve Information Object. It specifies the semantic content of PET Images and PET Curves. It is commonly abbreviated the PET IOD. It also includes the corresponding Storage SOP Classes so that this IOD can be used in Network and Media Storage exchanges.

Since this document proposes changes to existing Parts of DICOM, the reader should have a working understanding of the Standard.

This proposed Supplement includes a number of Addenda to existing Parts of DICOM:

1. Part 3   Addenda (Extension to Annex A and C)
2. Part 4   Addenda (Extension to Annex B)
3. Part 6   Addenda (Extension to Section 6 and Annex A)

ACR-NEMA

DIGITAL IMAGING AND COMMUNICATIONS

IN MEDICINE (DICOM)

PART 3 ADDENDUM

POSITRON EMISSION TOMOGRAPHY
INFORMATION OBJECT DEFINITION

CHANGES FOR PART 3, SECTION A.1.4 - OVERVIEW OF THE COMPOSITE IOD MODULE CONTENT

Item #1
Change Table A.1-1 - All modifications to the existing table are shown in BOLD font.

Table A.1-1 - Composite Information Object Modules Overview

Modules	PET	PET Curve
Patient	M	M
Patient Summary		
General Study	M	M
Patient Study	U	U
Study Content		
General Series	M	M
CR Series		
NM Series **NM/PET Patient Orientation**	M	
PET Series	M	M
PET Isotope	M	M
PET Multi-gated Acquisition	C	C
Frame of Reference	M	
US Frame of Ref.		
General Equipment	M	M
NM Equipment		
SC Equipment		
General Image	M	
Image Plane	M	
Image Pixel	M	
NM Image Pixel		
Contrast/Bolus		
Cine		
Multi-frame		
NM Multi-frame		
CR Image		
CT Image		
MR Image		
NM Image		
NM SPECT		
NM Multi-Gated		
NM Isotope		
NM Detector		
NM TOMO Acquisition		
NM Multi-Gated Acquisition		
NM Phase		
NM Reconstruction		
US Region Calibration		
US Image		
SC Image		
PET Image	M	
Overlay Identification		
Overlay Plane	U	
Multi-frame Overlay		
Curve Identification		M
Curve		M
PET Curve		M
Audio		
Modality LUT		
VOI LUT	U	
LUT Identification		
SOP Common	M	M

CHANGES FOR PART 3, ANNEX A - NUCLEAR MEDICINE IMAGE INFORMATION OBJECT DEFINITION

> **Item #2**
> **In Table A.5-1, revise the name of the "NM Series" module to be the "NM/PET Patient Orientation" module.**

> **Item #3**
> **In Section C.8.4.6 (Supplement 7 "Nuclear Medicine Image Object"), revise the name of the "NM Series" module to be the "NM/PET Patient Orientation" module.**

CHANGES FOR PART 3, ANNEX A - PET IMAGE INFORMATION OBJECT DEFINITION

Item #4   Add Section A.X

A.X   Positron Emission Tomography Image Information Object Definition

A.X.1   PET Image IOD Description

The Positron Emission Tomography (PET) Image Information Object Definition specifies an image which has been created by a Positron Tomograph imaging device, including dedicated PET cameras and Nuclear Medicine imaging devices operating in coincidence mode. This includes data created by external detection devices which create images of the distribution of administered radioactive materials, specifically positron emitters, in the body. Depending on the specific radiopharmaceuticals administered and the particular imaging procedure performed, problems involving changes in metabolism, function, or physiology can be investigated and various region pathologies can be studied. For these problems, quantitation of image data in absolute activity and physiological units is important. In addition, the PET Image IOD specifies attenuation (transmission) images used for correction and anatomical reference of emission images.

A.X.2   PET Image IOD Entity-Relationship Model

The E-R model in Section A.1.2 of this part depicts those components of the DICOM Information Model which directly reference the PET Image IOD. The overlay IE, modality LUT IE, VOI LUT IE, and curve IE are not components of the PET Image IOD.

A.X.3   PET Image IOD Module Table

Table A.X.3 -- PET Image IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
Series	General Series	C.7.3.1	M
	PET Series	C.8.X.1	M
	PET Isotope	C.8.X.2	M
	PET Multi-gated Acquisition	C.8.X.3	C - Required if Series Type (0054,1000) Value 1 is GATED.
	NM/PET Patient Orientation	C.8.4.6	M
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
Image	General Image	C.7.6.1	M
	Image Plane	C.7.6.2	M
	Image Pixel	C.7.6.3	M
	PET Image	C.8.X.4	M
	Overlay Plane	C.9.2	U
	VOI LUT	C.11.2	U
	SOP Common	C.12.1	M

CHANGES FOR PART 3, ANNEX A - STANDALONE PET CURVE INFORMATION OBJECT DEFINITION

Item #5
Add Section A.Y

A.Y   Standalone PET Curve Information Object Definition

A.Y.1   Standalone PET Curve IOD Description

A standalone PET curve IOD is the specification of a PET curve which may be related to an image, but also may have its own existence within a PET Series.

A.Y.2   Standalone PET Curve IOD Entity-Relationship Model

The E-R model in Section A.1.2 of this part depicts those components of the DICOM Information Model which directly reference the standalone PET curve IOD. The frame of reference IE, overlay IE, modality LUT IE, VOI LUT IE and Image IE are not components of the standalone PET curve IOD.

A.Y.3   Standalone PET Curve IOD Module Table

Table A.Y.3 -- Standalone PET Curve IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
Series	General Series	C.7.3.1	M
	PET Series	C.8.X.1	M
	PET Isotope	C.8.X.2	M
	PET Multi-gated Acquisition	C.8.X.3	C - Required if Series Type (0054,1000) Value 1 is GATED.
Equipment	General Equipment	C.7.5.1	M
Curve	Curve Identification	C.10.1	M
	Curve	C.10.2	M
	PET Curve	C.8.X.5	M
	SOP Common	C.12.1	M

CHANGES FOR PART 3, ANNEX C.8 - PET INFORMATION MODULE DEFINITIONS

Item #6
Add Section C.8.X

C.8.X   PET Information Module Definitions

This section describes Positron Emission Tomography series and image Modules. These Modules contain Attributes that are specific to Positron Emission Tomography images.

C.8.X.1 PET Series Module

Table C.8.X.1 contains IOD Attributes that describe a PET Series.

Table C.8.X.1 -- PET Series

Attribute Name	Tag	Type	Attribute Description
Series Date	(0008,0021)	1	Date the Series started. See C.8.X.1.1.2 for specialization.
Series Time	(0008,0031)	1	Time the Series started. See C.8.X.1.1.2 for specialization.
Units	(0054,1001)	1	Pixel value units. See C.8.X.1.1.3 for explanation. Defined terms: CNTS, NONE, CM2, PCNT, CPS, BQML, MGMINML, UMOLMINML, MLMING, MLG, 1CM, UMOLML, PROPCNTS, PROPCPS, MLMINML, MLML, GML, STDDEV
Counts Source	(0054,1002)	1	The primary source of counts. The primary source leads to the underlying image Units (0054,1001), as opposed to secondary sources which are used during reconstruction correction. Enumerated Values: EMISSION TRANSMISSION
Series Type	(0054,1000)	1	A multi-valued indicator of the type of Series. See C.8.X.1.1.4 for explanation. Value 1 Enumerated Values: STATIC DYNAMIC GATED WHOLE BODY Value 2 Enumerated Values: IMAGE REPROJECTION
Reprojection Method	(0054,1004)	2C	Method for projecting volumetric data onto planar projection. Required if Series Type (0054,1000), Value 2 is REPROJECTION. Defined terms: SUM MAX PIXEL

Number of R-R Intervals	(0054,0061)	1C	The maximum number of R-R Intervals that may exist in this Series. Required if Series Type (0054,1000), Value 1 is GATED.
Number of Time Slots	(0054,0071)	1C	The maximum number of Time Slots that may exist in this Series. Required if Series Type (0054,1000), Value 1 is GATED.
Number of Time Slices	(0054,0101)	1C	The maximum number of Time Slices that may exist in this Series. Required if Series Type (0054,1000), Value 1 is DYNAMIC.
Number of Slices	(0054,0081)	1	The maximum number of Slices that may exist in this Series.
Corrected Image	(0028,0051)	2	A value that indicates which, if any, corrections have been applied to the images in this series. Defined terms: DECY=decay corrected ATTN=attenuation corrected SCAT=scatter corrected DTIM=dead time corrected MOTN=gantry motion corrected (e.g. wobble, clamshell) PMOT=patient motion corrected CLN=count loss normalization (correction for count loss in gated Time Slots). RAN=randoms corrected RADL=non-uniform radial sampling corrected DCAL=sensitivity calibrated using dose calibrator NORM=detector normalization
Randoms Correction Method	(0054,1100)	3	Type of randoms correction processing. Defined terms: NONE = no randoms correction DLYD = delayed event subtraction SING = singles estimation
Attenuation Correction Method	(0054,1101)	3	A textual description of the attenuation correction processing. e.g. measured vs. calculated, transmission source type (ring, line, point), assumed patient geometry (polygon, ellipse, segmented, attenuation coefficient, skull thickness), post-injection transmission, smoothing.
Scatter Correction Method	(0054,1105)	3	A textual description of the scatter correction processing. e.g. convolution-subtraction, dual energy window, model-based, use of attenuation data.
Decay Correction	(0054,1102)	1	The real-world event to which images in this Series were decay corrected. See C.8.X.1.1.5 for explanation. Defined terms: NONE = no decay correction START= acquisition start time ADMIN = radiopharmaceutical administration time

Reconstruction Diameter	(0018,1100)	3	Diameter, in mm, of the region within which the data was used in creating the reconstruction of the image. Data may exist outside this region and portions of the patient may exist outside this region.
Convolution Kernel	(0018,1210)	3	Textual description of the convolution kernel(s) used to reconstruct the data (e.g. name, cutoff, radial/axial/angular, mathematical form, DC handling)
Reconstruction Method	(0054,1103)	3	Textual description of reconstruction processing, e.g. 2D filtered backprojection, 2D iterative, 3D PROMIS, 3D FAVOR, 3D iterative.
Detector Lines of Response Used	(0054,1104)	3	Textual description of which detector lines of response were used, mashed, or otherwise processed during tomographic reconstruction.
Acquisition Start Condition	(0018,0073)	3	Description of how the data collection was started. Defined terms: DENS = density (counts/sec) RDD = relative density difference (change in counts/sec) MANU = manual TIME = time AUTO = automatic, when ready TRIG = physiological trigger See C.8.X.1.1.6 for explanation.
Acquisition Start Condition Data	(0018,0074)	3	Count density, change in count density, or physiological triggers causing data collection to start.
Acquisition Termination Condition	(0018,0071)	3	Description of how the data collection for the series was stopped. Defined terms: CNTS = counts DENS = density (counts/sec) RDD = relative density difference (change in counts/sec) MANU = manual OVFL = data overflow TIME = time TRIG = physiological trigger See C.8.4.9.1.3 for explanation.
Acquisition Termination Condition Data	(0018,0075)	3	Number of counts, count density, change in count density, or physiological triggers causing the termination.
Field of View Shape	(0018,1147)	3	Shape of the field of view of the PET camera. Defined Terms: CYLINDRICAL RING HEXAGONAL MULTIPLE PLANAR
Field of View Dimensions	(0018,1149)	3	Dimensions of the field of view, in mm. Transverse detector diameter followed by axial width.

Gantry/Detector Tilt	(0018,1120)	3	Angle of tilt in degrees of the gantry. See C.8.X.1.1.7 for explanation.
Gantry/Detector Slew	(0018,1121)	3	Angle of slew in degrees of the gantry. Positive slew is moving the gantry on the patient's left toward the patient's superior, when the patient is supine.
Type of Detector Motion	(0054,0202)	3	Describes the detector motion during acquisition. Defined Terms: NONE = stationary gantry STEP AND SHOOT = Interrupted motion, acquire only while stationary CONTINUOUS = Gantry motion and acquisition are simultaneous and continuous WOBBLE = wobble motion CLAMSHELL = clamshell motion
Collimator Type	(0018,1181)	2	Collimator Type. Defined Terms: NONE = no collimator RING = transverse septa
Collimator/Grid Name	(0018,1180)	3	Label describing the collimator used.
Axial Acceptance	(0054,1200)	3	Maximum axial angle accepted, in degrees.
Axial Mash	(0054,1201)	3	Number of adjacent axial lines of response mashed together. See C.8.X.1.1.8 for explanation.
Transverse Mash	(0054,1202)	3	Number of adjacent transverse lines of response mashed together. See C.8.X.1.1.9 for explanation.
Detector Element Size	(0054,1203)	3	Size of an individual detector element, in mm. Transverse dimension followed by axial dimension. For a discrete crystal, this is the crystal size. For a continuous detector, this is the pixel bin size.
Coincidence Window Width	(0054,1210)	3	The width of the coincidence timing window, in nsec. The maximum time difference accepted between two single events.
Energy Window Range Sequence	(0054,0013)	3	Sequence of Repeating Items that describes the energy windows used for this Series. This sequence may contain zero or more items. See C.8.X.1.1.10 for explanation.
> Energy Window Lower Limit	(0054,0014)	3	The lower limit of the energy window, in KeV.
> Energy Window Upper Limit	(0054,0015)	3	The upper limit of the energy window, in KeV.
Secondary Counts Type	(0054,1220)	3	Array defining the type of additional counts accumulated during acquisition. Defined terms: DLYD=delayed events SCAT=scattered events in secondary window SING=singles DTIM=events lost due to deadtime

C.8.X.1.1 PET Series Attribute Descriptions

  Note: The meaning of a General Series in DICOM is determined by the attributes in the General Series

Module and by the Source Entities (Patient, Study, Frame of Reference, Equipment) that originate the Series. The Source Entities are the single-valued entities of the 1->n relationship, where the Series is the multi-valued entity. Therefore, a Series is a group of images that: are from the same patient and study; are from the same Equipment; and, are from the same spatial Frame of Reference.

The PET Image IOD further refines a PET Series IE by the attributes in the PET Series Module, the PET Isotope Module, and the PET Multi-gated Acquisition Module. These are the attributes that shall not change from Image to Image. Therefore, in addition to the criteria above for a General Series (same patient, study, frame of reference, equipment), the attributes in the PET Series IE define a PET series as a group of images that: are from the same temporal frame of reference; have the same fundamental meaning (e.g. same units: either activity density, metabolism, or attenuation); are derived from the same activity source (emission or transmission); are from the same isotope and radiopharmaceutical; were derived from the same reconstruction processing; and, originated from the same acquisition setup and parameters.

C.8.X.1.1.1 Specialization of Image Plane Module and Image Pixel Module Attributes

For PET Series, the following Image Pixel Module attributes shall not vary from Image to Image :
Photometric Interpretation (0028,0004)
Rows (0028,0010)
Columns (0028,0011)
Bits Allocated (0028,0100)
Bits Stored (0028,0101)
Pixel Representation (0028,0103)

For PET Series, the following Image Plane Module attributes shall not vary from Image to Image :
Pixel Spacing (0028,0030)

For PET Series where Series Type (0054,1000), Value 2 is IMAGE, the following Image Plane Module attributes shall not vary from Image to Image :
Image Orientation (0020,0037)

Note: This means that for a Series Type (0054,1000) Value 2 of IMAGE, all images in the PET Series lie on parallel planes. The images, however, may have non-uniform spacing along the normals to the planes.

For PET Series where Series Type (0054,1000), Value 2 is REPROJECTION, the Image Orientation (0020,0037) attribute shall vary such that the images rotate about a single axis. Geometrically, the normal to each image plane is defined by the cross product of its row and column vectors. Each reprojection image has one Center Normal that passes through the center of the image. Reprojection images within a PET Series shall have their Center Normals be co-planar and pass through a single point.

C.8.X.1.1.2 Series Date, Series Time

For PET Series, Series Date (0008,0021) and Series Time (0008,0031) are specified to be Type 1. The Series Date (0008,0021) and Series Time (0008,0031) are used as the reference time for all PET Image attributes that are temporally related, including activity measurements. The Series Date (0008,0021) and Series Time (0008,0031) are not tied to any real-world event (e.g. acquisition start, radiopharmaceutical administration) and their real-world meaning are implementation dependent.

C.8.X.1.1.3 Units

The pixel value units of the Pixel Data (7FE0,0010). Defined Terms:
CNTS = counts
NONE = unitless
CM2 = centimeter**2
PCNT = percent

CPS = counts/second
BQML = Becquerels/milliliter
MGMINML = milligram/minute/milliliter
UMOLMINML = micromole/minute/milliliter
MLMING = milliliter/minute/gram
MLG = milliliter/gram
1CM = 1/centimeter
UMOLML = micromole/milliliter
PROPCNTS = proportional to counts
PROPCPS = proportional to counts/sec
MLMINML = milliliter/minute/milliliter
MLML = milliliter/milliliter
GML = grams/milliliter
STDDEV = standard deviations

C.8.X.1.1.4 Series Type

  The Series Type (0054,1000), Value 1 is used to identify the spatial location and temporal nature of the images within a PET Series. The Enumerated Values and their definitions are:
    STATIC = a group of images at varying spatial locations at the same time
    DYNAMIC = a group of images at a set of spatial locations (e.g. slices) at varying time slices, with all spatial locations acquired at all time slices
    GATED = a group of images at the same spatial location, same starting and ending time, but acquired in different time slots of (possibly) different R-R intervals
    WHOLE BODY = same as STATIC, except covering multiple axial fields of view (and therefore acquired at a different time).

  Note: Using this definition and the comments in C.8.X.1.1.1, here are some examples of PET series and the encoding of Series Type (0054,1000) Value 1.

            Static acquisition: a group of n transverse images at varying superior<->inferior locations, all acquired between the same starting and ending time. Series Type = STATIC.

            Dynamic acquisition: a group of n*m transverse images at n superior<->inferior locations, acquired with m different starting and ending times. Series Type = DYNAMIC.

            Gated acquisition: a group of n*m*p transverse images at n superior<->inferior locations, all acquired between the same starting and ending time, acquired in m different R-R Intervals (as determined by Low R-R Value (0018,1081) and High R-R Value (0018,1082)), and acquired in p time slots of a given R-R Interval (as determined by Trigger Time (0054,1000)). Series Type = GATED.

            Whole body acquisition: a group of n transverse images at varying superior<->inferior locations covering a significant fraction of the entire body. Series Type = WHOLE BODY.

            Multiple axial fields of view: a group of n transverse images at varying superior<->inferior locations. Series Type = WHOLE BODY.

            Interleaved: group of 2*n transverse images acquired at overlapped AFOVs to increase axial sampling. Series Type = WHOLE BODY.

            Sagittal (Coronal, Oblique): sagittal (coronal, oblique) re-sliced images derived by reformatting transverse images. The Series Type is STATIC, DYNAMIC, GATED, or WHOLE BODY depending on source Series Type.

            Arithmetic: images derived by an arithmetic operation on operand images. The Series Type is STATIC, DYNAMIC, GATED, or WHOLE BODY depending on source Series Type.

            Metabolic: images derived by a metabolic model. The Series Type is STATIC, DYNAMIC, GATED, or WHOLE BODY depending on source Series Type.

Note: Using this definition, here are some images that are <u>not</u> stored in the same PET Series:

Two images from the same scan that were reconstructed differently.

Emission and transmission images for the same Patient and Study, even if acquired simultaneously (because emission and transmission images have different reconstruction processing).

Two images of same patient, one after NH3 injection and one after FDG injection.

Two images: an original image created from reconstructed scan data and its derived image based on a metabolic model.

The Series Type (0054,1000), Value 2 is used to identify the volumetric meaning of the images within a PET Series. The Enumerated Values and their definitions are:
    IMAGE = a tomographic image slice
    REPROJECTION = a projection image derived from forward projection through slices of tomographic images, using the algorithm defined in Reprojection Method (0054,1004).

C.8.X.1.1.5 Decay Correction

The Decay Correction (0054,1102) is the real-world event to which images in this Series were decay corrected. If decay correction is applied, all images in the Series shall be decay corrected to the same time. The Defined Terms and definitions are:
    NONE = no decay correction
    START= acquisition start time, Acquisition Time (0008,0032)
    ADMIN = radiopharmaceutical administration time, Radiopharmaceutical Start Time (0018,1072)

The time to which images have been decay corrected can be derived from Decay Factor (0054,1321), Frame Reference Time (0054,1300), Radionuclide Half Life (0018,1075), Series Date (0008,0021), and Series Time (0008,0031).

C.8.X.1.1.6 Acquisition Start Condition

Acquisition Start Condition (0018,0073) is the method of starting acquisition data collection. The Defined Terms and definitions are:
    DENS = preset count density (counts/sec) was reached
    RDD = preset relative count density difference (change in counts/sec) was reached
    MANU = acquisition was started manually
    TIME = preset time limit was reached
    AUTO = start automatically, when ready
    TRIG = preset number of physiological triggers was reached

C.8.X.1.1.7 Gantry/Detector Tilt

Gantry/Detector Tilt (0018,1120) for PET Image data is the angle in degrees of the gantry relative to the patient's major (Head to Feet) axis (or the table supporting the patient). Positive tilt is moving the top of the gantry towards the patient's feet.

C.8.X.1.1.8 Axial Mash

Axial Mash (0054,1201) is multi-valued and is defined as the number of unique axial Lines of Response (LOR) that were mashed together (center of the axial field of view only). Value 1 is the number of LORs mashed for an odd slice. Value 2 is the number of LORs mashed for an even slice. For discrete crystal scanners, each unique LOR corresponds to a pair of crystals. For continuous detectors whose bin size is variable, the number of LORs mashed is determined by the actual bin size divided by the Detector

Element Size (0054,1203), Value 2. The value of Axial Mash (0054,1201) is the same regardless of whether the mashing was done during acquisition or reconstruction.

Note: As an example on a discrete crystal scanner, if a ring difference of -2,0,+2 are binned as an odd slice and a ring difference of -1,+1 are binned as an even slice, then the Axial Mash (0054,1201) is equal to 3\2 .
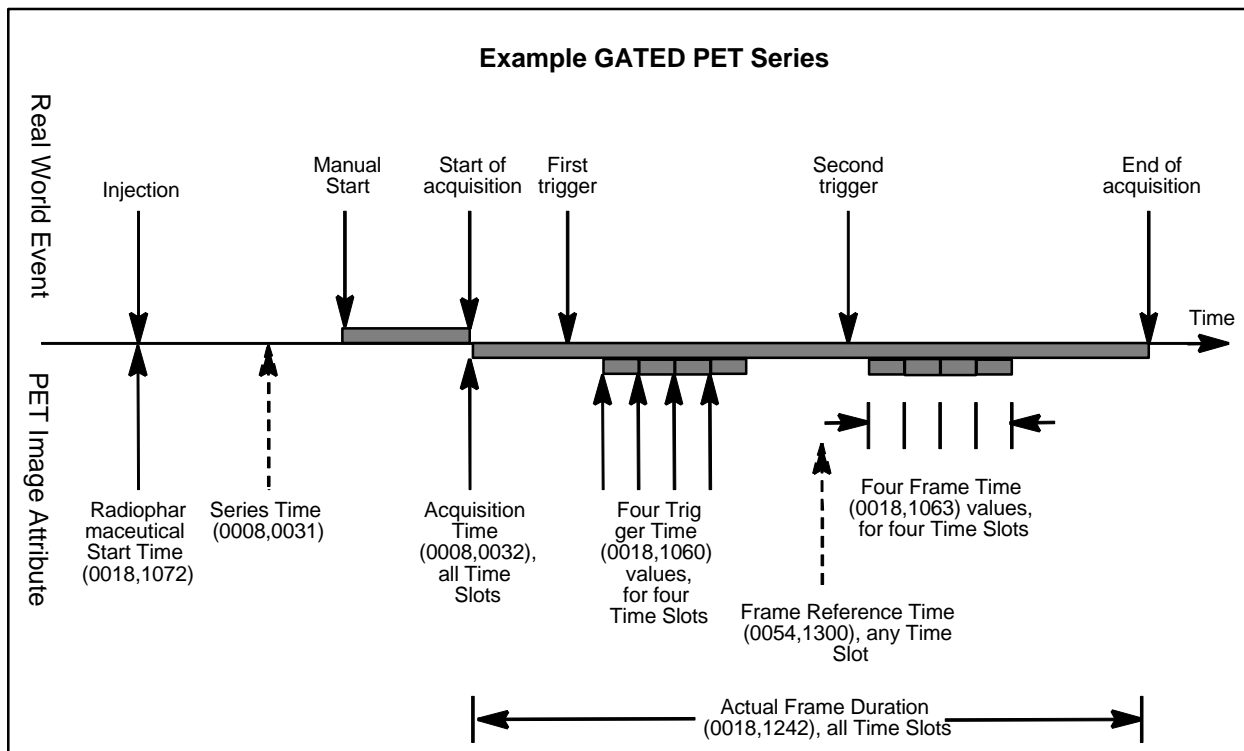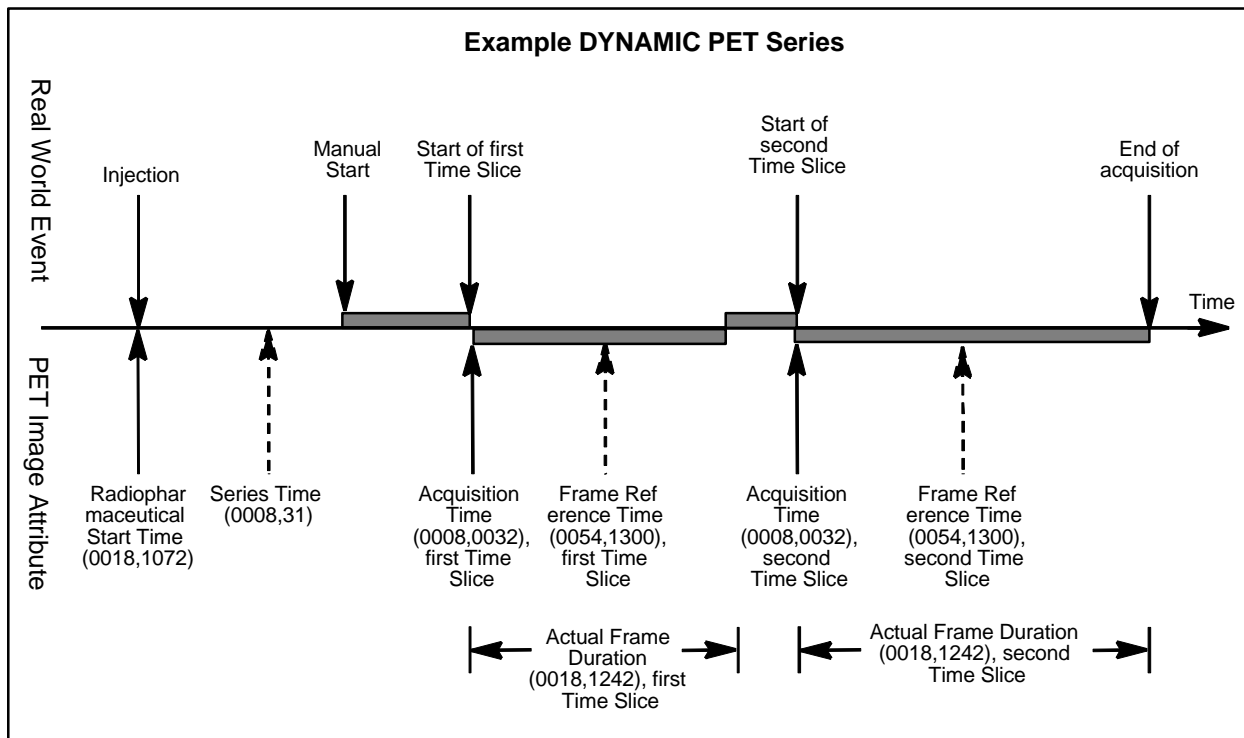
C.8.X.1.1.9 Transverse Mash

Transverse Mash (0054,1202) is defined as the number of unique transverse Lines of Response (LOR) that were mashed together. For discrete crystal scanners, each unique LOR corresponds to a pair of crystals. For continuous detectors whose bin size is variable, the number of LORs mashed is determined by the actual bin size divided by the Detector Element Size (0054,1203), Value 1. The value of Transverse Mash (0054,1202) is the same regardless of whether the mashing was done during acquisition or reconstruction.

C.8.X.1.1.10 Energy Window Range Sequence

Multiple energy windows are allowed in order to allow coincidence events based on additional Energy Windows (e.g. Compton events scattered in the detector). All energy windows are assumed to contribute to all images in the PET Series.

C.8.X.1.1.11 Temporal Relationships of Images in PET Series

The following diagram shows the temporal relationships of images within a PET Series.

Example DYNAMIC PET Series

Real World Event

- Injection
- Manual Start
- Start of first Time Slice
- Start of second Time Slice
- End of acquisition
- Time

PET Image Attribute

- Radiopharmaceutical Start Time (0018,1072)
- Series Time (0008,31)
- Acquisition Time (0008,0032), first Time Slice
- Frame Reference Time (0054,1300), first Time Slice
- Acquisition Time (0008,0032), second Time Slice
- Frame Reference Time (0054,1300), second Time Slice

Actual Frame Duration (0018,1242), first Time Slice

Actual Frame Duration (0018,1242), second Time Slice

Example GATED PET Series

Real World Event

- Injection
- Manual Start
- Start of acquisition
- First trigger
- Second trigger
- End of acquisition
- Time

PET Image Attribute

- Radiopharmaceutical Start Time (0018,1072)
- Series Time (0008,0031)
- Acquisition Time (0008,0032), all Time Slots
- Four Trigger Time (0018,1060) values, for four Time Slots
- Frame Reference Time (0054,1300), any Time Slot
- Four Frame Time (0018,1063) values, for four Time Slots

Actual Frame Duration (0018,1242), all Time Slots

Legend:
- Pause (no accumulation of counts)
- Acquiring counts
- Capable of acquiring counts
- A time fixed to a real-world event
- A time not related to a real-world event

C.8.X.2 PET Isotope Module

Table C.8.X.2 contains IOD Attributes that describe a PET Isotope.

Table C.8.X.2 -- PET Isotope

Attribute Name	Tag	Type	Attribute Description
Radiopharmaceutical Information Sequence	(0054,0016)	2	Sequence of Repeating Items that describe isotope information. This sequence may contain one or more items.
> Radionuclide Code Sequence	(0054,0300)	2	Sequence that identifies the radionuclide. This sequence shall contain exactly one item. See section C.8.4.10.1.3 for explanation.
>> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the radionuclide. Required if Radionuclide Code Sequence (0054,0300) is sent.
>> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Radionuclide Code Sequence (0054,0300) is sent. Enumerated Values: 99SDM
>> Code Meaning	(0008,0104)	3	The radionuclide that is represented by the Code Value (0008,0100).
> Radiopharmaceutical Route	(0018,1070)	3	Route of administration.
> Administration Route Code Sequence	(0054,0302)	3	Sequence that identifies the administration route of the radiopharmaceutical. This sequence shall contain exactly one item. See section C.8.4.10.1.4 for explanation.
>> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the radiopharmaceutical route. Required if Administration Route Code Sequence (0054,0302) is sent.
>> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Administration Route Code Sequence (0054,0302) is sent. Defined Terms: 99SDM
>> Code Meaning	(0008,0104)	3	The radiopharmaceutical route that is represented by the Code Value (0008,0100).
> Radiopharmaceutical Volume	(0018,1071)	3	Volume of administered radiopharmaceutical in cubic cm.
> Radiopharmaceutical Start Time	(0018,1072)	3	Time of start of administration. The actual time of radiopharmaceutical administration to the patient for imaging purposes, using the same time base as Series Time (0008,0031).

> Radiopharmaceutical Stop Time	(0018,1073)	3	Time of end of administration. The actual ending time of radiopharmaceutical administration to the patient for imaging purposes, using the same time base as Series Time (0008,0031).
> Radionuclide Total Dose	(0018,1074)	3	The radiopharmaceutical dose administered to the patient measured in Becquerels (Bq) at the Radiopharmaceutical Start Time (0018,1072).
> Radionuclide Half Life	(0018,1075)	3	The radionuclide half life, in seconds, that was used in the correction of this image.
> Radionuclide Positron Fraction	(0018,1076)	3	The radionuclide positron fraction (fraction of decays that are by positron emission) that was used in the correction of this image.
> Radiopharmaceutical Specific Activity	(0018,1077)	3	The activity per unit mass of the radiopharmaceutical, in Bq/micromole, at the Radiopharmaceutical Start Time (0018,1072).
> Radiopharmaceutical	(0018,0031)	3	Name of the radiopharmaceutical.
> Radiopharmaceutical Code Sequence	(0054,0304)	3	Sequence that identifies the radiopharmaceutical. This sequence shall contain exactly one item.
>> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the radiopharmaceutical. Required if Radiopharmaceutical Code Sequence (0054,0304) is sent.
>> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Radiopharmaceutical Code Sequence (0054,0304) is sent. Defined Terms: 99SDM
>> Code Meaning	(0008,0104)	3	The radiopharmaceutical that is represented by the Code Value (0008,0100).
Intervention Drug Information Sequence	(0018,0026)	3	Sequence of Repeating Items that describes the intervention drugs used. Zero or more items may be included in this sequence.
> Intervention Drug Name	(0018,0034)	3	Name of the intervention drug.
> Intervention Drug Code Sequence	(0018,0029)	3	Sequence that identifies the intervention drug name.
>> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the intervention drug name. Required if Intervention Drug Code Sequence (0054,0306) is sent.

>> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Intervention Drug Code Sequence (0054,0306) is sent. Defined Terms: 99SDM
>> Code Meaning	(0008,0104)	3	The intervention drug that is represented by the Code Value (0008,0100).
> Intervention Drug Start Time	(0018,0035)	3	Time of administration of the intervention drug, using the same time base as for the Series Time (0008,0031).
> Intervention Drug Stop Time	(0018,0027)	3	Time of completion of administration of the intervention drug, using the same time baseas for the Series Time (0008,0031).
> Intervention Drug Dose	(0018,0028)	3	Intervention drug dose, in mg.

Note: Radionuclide Code Sequence (0054,0300) and Radiopharmaceutical Route Code Sequence (0054,0302) specify value 99SDM from Annex D for Coding Scheme Designator. It is expected that this value will evolve when Coding Scheme Designator UIDs are available from a registration authority.

C.8.X.3 PET Multi-gated Acquisition Module

Table C.8.X.3 contains IOD Attributes that describe a PET Multi-gated Acquisition.

Table C.8.X.3 -- PET Multi-gated Acquisition

Attribute Name	Tag	Type	Attribute Description
Beat Rejection Flag	(0018,1080)	2	Heart beat duration sorting has been applied. Enumerated values: Y = yes N = no
Trigger Source or Type	(0018,1061)	3	Text indicating trigger source. Defined terms: EKG
PVC Rejection	(0018,1085)	3	Description of the type of PVC rejection criteria used.
Skip Beats	(0018,1086)	3	Number of beats skipped after a detected arrhythmia.
Heart Rate	(0018,1088)	3	Average number of heart beats per minute for the collection period for this image. This shall include all accepted beats as well as rejected beats.
Framing Type	(0018,1064)	3	Description of type of framing performed. Defined Terms: FORW = forward BACK = backward PCNT = forward/backward by percentage

C.8.X.4 PET Image Module

Table C.8.X.4 contains IOD Attributes that describe PET images.

Table C.8.X.4 -- PET Image

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. See C.8.X.4.1.1 for specialization.
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. This value shall be 1.
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. See C.8.X.4.1.2 for specialization.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. Enumerated values: 16.
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored. The value shall be the same as the value in Bits Allocated (0028,0100).
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Each sample shall have the same high bit. Shall be one less than the value in Bits Stored (0028,0101).
Rescale Intercept	(0028,1052)	1	The value b in relationship between stored values (SV) and pixel value units (U) defined in Units (0054,1001): $U = m*SV+b$. The Rescale Intercept is always zero for PET images.
Rescale Slope	(0028,1053)	1	m in the equation specified in Rescale Intercept (0028,1052).
Frame Reference Time	(0054,1300)	1	The time that the pixel values in the image occurred. Frame Reference Time is the offset, in msec, from the Series reference time. See explanation in C.8.X.4.1.5.
Trigger Time	(0018,1060)	1C	Time interval, in msec, from the start of the trigger to the beginning of data acquisition for this image. Required if Series Type (0054,1000), Value 1 is GATED.
Frame Time	(0018,1063)	1C	Nominal duration per individual frame, in msec. Required if Series Type (0054,1000), Value 1 is GATED. See C.8.X.4.1.3 for explanation.
Low R-R Value	(0018,1081)	1C	R-R interval lower limit for beat rejection, in msec. Required if Series Type (0054,1000), Value 1 is GATED and Beat Rejection Flag (0018,1080) is Y.

High R-R Value	(0018,1082)	1C	R-R interval upper limit for beat rejection, in msec. Required if Series Type (0054,1000), Value 1 is GATED and Beat Rejection Flag (0018,1080) is Y.
Lossy Image Compression	(0028,2110)	1C	Specifies whether an Image has undergone lossy compression. Enumerated values: 00 = Image has NOT been subjected to lossy compression. 01 = Image has been subjected to lossy compression. See C.7.6.2.2.6. Required if Lossy Compression has been performed on the image.
Image Index	(0054,1330)	1	An index identifying the position of this image within a PET Series. See C.8.X.4.1.9 for explanation.
Acquisition Date	(0008,0022)	2	The date the acquisition of data that resulted in this image started. See C.8.X.4.1.4 for specialization.
Acquisition Time	(0008,0032)	2	The time the acquisition of data that resulted in this image started. See C.8.X.4.1.4 for specialization.
Actual Frame Duration	(0018,1242)	2	Elapsed time of the data acquisition for this image, in msec. See C.8.X.4.1.6 for explanation.
Nominal Interval	(0018,1062)	3	Average duration of accepted beats, in msec, of the R-R interval.
Intervals Acquired	(0018,1083)	3	Number of heartbeats that fall within Low R-R Value (0018,1081) and High R-R Value (0018,1082), and were therefore accepted and contribute coincidence events to this R-R Interval.
Intervals Rejected	(0018,1084)	3	Number of heartbeats that fall outside Low R-R Value (0018,1081) and High R-R Value (0018,1082), and do not contribute coincidence events to this R-R Interval. However, they may contribute coincidence events to other R-R Intervals.
Primary (Prompts) Counts Accumulated	(0054,1310)	3	The sum of events that occur in the primary event channel. The counts include Trues +Scatter+ Randoms if Randoms Correction Method (0054,1100) is NONE; otherwise the counts are Trues +Scatter.
Secondary Counts Accumulated	(0054,1311)	3	Sum of counts accumulated in secondary channels. See C.8.X.4.1.7 for explanation.
Slice Sensitivity Factor	(0054,1320)	3	The slice-to-slice sensitivity correction factor that was used to correct this image. The value shall be one if no slice sensitivity correction was applied.

Decay Factor	(0054,1321)	1C	The decay factor that was used to scale this image. Required if Decay Correction (0054,1102) is other than NONE. If decay correction is applied, all images in the Series shall be decay corrected to the same time.
Dose Calibration Factor	(0054,1322)	3	Factor that was used to scale this image from counts/sec to Bq/ml using a dose calibrator. The value shall be one if no dose calibration was applied. See C.8.X.4.1.8 for explanation.
Scatter Fraction Factor	(0054,1323)	3	An estimate of the fraction of acquired counts that were due to scatter and were corrected in this image. The value shall be zero if no scatter correction was applied.
Dead Time Factor	(0054,1324)	3	The average dead time correction factor that was applied to this image. The value shall be one if no dead time correction was applied.
Referenced Overlay Sequence	(0008,1130)	3	A sequence which provides reference to a set of SOP Class/Instance pairs which are related independent Overlays. Uniquely identifies Overlays significantly related to this Image. Encoded as a sequence of items: (0008,1150) and (0008,1155). Zero or more Items may be included in this sequence.
> Referenced SOP Class UID	(0008,1150)	1C	Uniquely identifies the referenced SOP Class. Required if Referenced Overlay Sequence (0008,1130) is sent.
> Referenced SOP Instance UID	(0008,1155)	1C	Uniquely identifies the referenced SOP Instance. Required if Referenced Overlay Sequence (0008,1130) is sent.
Referenced Curve Sequence	(0008,1145)	3	A sequence which provides reference to a set of SOP Class/Instance pairs which are related independent Curves. Uniquely identifies Curves significantly related to this Image. Encoded as a sequence of items: (0008,1150) and (0008,1155). Zero or more Items may be included in this sequence.
> Referenced SOP Class UID	(0008,1150)	1C	Uniquely identifies the referenced SOP Class. Required if Referenced Curve Sequence (0008,1145) is sent.
> Referenced SOP Instance UID	(0008,1155)	1C	Uniquely identifies the referenced SOP Instance. Required if Referenced Curve Sequence (0008,1145) is sent.
Anatomic Region Sequence	(0008,2218)	3	Sequence of one Item that identifies the anatomic region of interest in this image (i.e. external anatomy, surface anatomy, or general region of the body). See Section C.8.4.9.1.5.
> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the anatomic region. Required if Anatomic Region Sequence (0008,2218) is sent.

> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Anatomic Region Sequence (0008,2218) is sent. Defined Terms: 99SDM
> Code Meaning	(0008,0104)	3	The anatomic region that is represented by the Code Value (0008,0100).
> Anatomic Region Modifier Sequence	(0008,2220)	3	Sequence of one or more Items that modify the anatomic region of interest in this image (i.e. prone, supine, decubitus right). See Section C.8.4.9.1.5.
>> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the anatomic region modifier term. Required if Anatomic Region Modifier Sequence (0008,2220) is sent.
>> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Anatomic Region Modifier Sequence (0008,2220) is sent. Defined Terms: 99SDM
>> Code Meaning	(0008,0104)	3	The anatomic region modifier term that is represented by the Code Value (0008,0100).
Primary Anatomic Structure Sequence	(0008,2228)	3	Sequence of one or more Items that identifies the primary anatomic structure of interest in this image. See Section C.8.4.9.1.6.
> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the primary anatomic structure. Required if Primary Anatomic Structure Sequence (0008,2228) is sent.
> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Primary Anatomic Structure Sequence (0008,2228) is sent. Defined Terms: 99SDM
> Code Meaning	(0008,0104)	3	The anatomic structure that is represented by the Code Value (0008,0100).
> Primary Anatomic Structure Modifier Sequence	(0008,2230)	3	Sequence of one or more Items that modify the primary anatomic structure of interest in this image. See Section C.8.4.9.1.6.
>> Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the primary anatomic structure modifier term. Required if Primary Anatomic Structure Modifier Sequence (0008,2230) is sent.

>> Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if Primary Anatomic Structure Modifier Sequence (0008,2230) is sent. Defined Terms: 99SDM
>> Code Meaning	(0008,0104)	3	The anatomic structure modifier term that is represented by the Code Value (0008,0100).

Note: Anatomic Region Sequence (0008,2218), Anatomic Region Modifier Sequence (0008,2220), Primary Anatomic Structure Sequence (0008,2228), and Primary Anatomic Structure Modifier Sequence (0008,2230) specify value 99SDM from Annex D for Coding Scheme Designator. It is expected that this value will evolve when Coding Scheme Designator UIDs are available from a registration authority.

C.8.X.4.1 PET Image Module Attribute Descriptions

C.8.X.4.1.1 Image Type

For PET Images, Image Type (0008,0008) is specified to be Type 1.

Note: For PET images, Image Type (0008,0008) Value 1 will be ORIGINAL for reconstructed images. DERIVED may be appropriate for some other results images. For PET images, Image Type (0008,0008) Value 2 will be PRIMARY.

C.8.X.4.1.2 Photometric Interpretation

For PET images, Photometric Interpretation (0028,0004) shall have one of the following Enumerated Values:

MONOCHROME2

See C.7.6.3.1.2 for definition of these terms.

C.8.X.4.1.3 Frame Time

The Frame Time (0018,1063) is the explicit duration of the gated frame when Framing Type (0018,1064) is equal to FORW or BACK. Frame Time (0018,1063) is the nominal duration of the gated frame when Framing Type (0018,1064) is equal to PCNT.

C.8.X.4.1.4 Acquisition Date, Acquisition Time

For PET Images, Acquisition Date (0008,0022) and Acquisition Time (0008,0032) are specified to be Type 2. The Acquisition Date (0008,0022) and Acquisition Time (0008,0032) use the same time base as Series Time (0008,0031).

For Series Type (0054,1000) Value 1 equal to STATIC, WHOLE BODY, or DYNAMIC, the Acquisition Time (0008,0032) is the real-world beginning of the accumulation of events into this Image. For STATIC, WHOLE BODY, or DYNAMIC Series, the Acquisition Time (0008,0032) may vary from Image to Image within a PET Series.

For Series Type (0054,1000) Value 1 equal to GATED, the Acquisition Time (0008,0032) is the real-world beginning of the *capability* of accumulating events into this Image.   (The *actual* accumulation of events has only occurred during an R-R Interval.) For GATED Series, the Acquisition Time (0008,0032) shall not vary from Image to Image within a PET Series.

C.8.X.4.1.5 Frame Reference Time

Frame Reference Time (0054,1300) is the time that the pixel values in the Image occurred. Frame Reference Time is defined as the time offset, in msec, from the Series Reference Time, where the Series Reference Time is defined by the combination of Series Date (0008,0021) and Series Time (0008,0031).

> Note: Frame Reference Time (0054,1300) is implementation dependent and <u>may</u> or <u>may</u> <u>not</u> be tied to any real-world event. To illustrate the meaning of Frame Reference Time (0054,1300), the following are some examples of possible implementations:
>
> Example 1: For a long-lived radionuclide and a non-time-varying radiopharmaceutical distribution, an implementation sets the Frame Reference Time (0054,1300) to the midpoint of the Actual Frame Duration (0018,1242).
>
> Example 2: For a short-lived radionuclide and a non-time-varying radiopharmaceutical distribution, an implementation sets the Frame Reference Time (0054,1300) to the time at which the average activity occurs for a decaying radionuclide, T_{ave} . If image acquisition started at the Series Reference Time and the image has not been decay corrected, then T_{ave} will be:

$$T_{ave} = \frac{1}{\lambda} \ln \frac{\lambda T}{1-e^{-\lambda T}}$$

> where: lambda = decay constant = (ln 2)/$T_{1/2}$
> $T_{1/2}$ = Radionuclide Half Life (0018,1075)
> T = Actual Frame Duration (0018,1242)
>
> Note that T_{ave} will be sooner than the midpoint of the Actual Frame Duration (0018,1242).
>
> Example 3: For a short-lived radionuclide and a time-varying radiopharmaceutical distribution, an implementation with supplementary data (e.g. scanner count rates or blood sample data) sets the Frame Reference Time (0054,1300) to a derived time determined to be its best estimate of the time that the pixel values occurred.

C.8.X.4.1.6 Actual Frame Duration

The accumulation of counts for a PET Image shall occur entirely between:

(1) the acquisition starting time (as specified by Acquisition Date (0008,0022) and Acquisition Time (0008,0032)), and

(2) the acquisition ending time, which is equal to the acquisition starting time in (1) plus the Actual Frame Duration (0018,1242).

If the Series Type (0054,1000), Value 1 is GATED, then the actual accumulation of counts has only occurred during an R-R Interval.

C.8.X.4.1.7 Secondary Counts Accumulated

Secondary Counts Accumulated (0054,1311) is multi-valued and, if supplied, has Values corresponding to the Secondary Counts Type (0054,1220). The number and order of the Values in Secondary Counts Accumulated (0054,1311) shall be the same as Secondary Counts Type (0054,1220).

C.8.X.4.1.8 Dose Calibration Factor

The Dose Calibration Factor (0054,1322) is the factor that was used to scale this image from counts/sec to Bq/ml using an external dose calibrator. The value shall be one if no dose calibration was applied. The application of a dose calibration correction is specified by Corrected Image (0028,0051) equal to DCAL.

> Note: Dose Calibration Factor (0054,1322) is not equal to the inverse of the sensitivity (kcps/Bq/ml) of the scanner, which is usually measured for a given radiopharmaceutical distribution and excluding the effects of attenuation.

C.8.X.4.1.9 Image Index

Image Index (0054,1330) is an index identifying the position of this image within a PET Series.

> Note: The scheme for encoding Image Index (0054,1330) is as follows. Images within a PET Series can be viewed as a multi-dimensional array whose possible dimensions include R-R Intervals, Time Slots, Time Slices, and Slices. The dimensions of the array are defined by the Series Type (0054,1000) Value 1. Each dimension of the array has an index that identifies the position of this image in the array. The indices are: R-R Interval Index, Time Slot Index, Time Slice Index, Slice Index. The indices are calculated as follows:

Index	Range of Index	Order of Images along that Dimension
R-R Interval Index	1 to Number of R-R Intervals (0054,0061)	Increasing Low R-R Value (0018,1081)
Time Slot Index	1 to Number of Time Slots (0054,0071)	Increasing Trigger Time (0018,1060)
Time Slice Index	1 to Number of Time Slices (0054,0101)	Increasing Frame Reference Time (0054,1300)
Slice Index	1 to Number of Slices (0054,0081)	If Series Type (0054,1000) Value 2 is IMAGE: Order is in increasing position along the normal, where the normal is determined by the cross product of the direction cosines of the row and column of the image. See Image Orientation (0020,0037) in the Image Plane Module. If Series Type (0054,1000) Value 2 is REPROJECTION: Order is in increasing or decreasing angle of the normal, where the normal is determined by the cross product of the direction cosines of the row and column of the image. See Image Orientation (0020,0037) in the Image Plane Module. (Note that reprojection images rotate about only a single axis as described in C.8.X.1.1.1. Therefore, all normals are co-planar and make a single angle with respect to each other.)

Using these index values the position of this image within the multi-dimensional array (the Image Index (0054,1330)) is calculated as follows:

Series Type (0054,1000), Value 1	Dimensions of Array (Last dimension is most rapidly changing)	Encoding of Image Index (0054,1330)
STATIC	Slice	Slice Index
WHOLE BODY	Slice	Slice Index
DYNAMIC	Time Slice \ Slice	((Time Slice Index - 1) * (Number of Slices (0054,0081))) + Slice Index

GATED	R-R Interval \ Time Slot \ Slice	((R-R Interval Index - 1)
		     * (Number of Time Slots (0054,0071))
		     * (Number of Slices (0054,0081)))
		+ ((Time Slot Index - 1)
		     * (Number of Slices (0054,0081)))
		+ Slice Index

C.8.X.5 PET Curve Module

Table C.8.X.5 contains IOD Attributes that describe a PET Curve.

Table C.8.X.5 -- PET Curve Module

Attribute Name	Tag	Type	Attribute Description
Curve Dimensions	(50xx,0005)	1	Number of dimensions for these data. The dimensions may be any number from 1 to n. See C.8.X.5.1.2 for specialization.
Type of Data	(50xx,0020)	1	Type of data in this curve. See C.8.X.5.1.3 for specialization of Defined Terms.
Curve Data	(50xx,3000)	1	Curve data. See C.10.2.1.4 and C.8.X.5.1.4 for further explanation.
Axis Units	(50xx,0030)	1	Units of measure for the axes. See C.8.X.5.1.5 for specialization of Defined Terms.
Dead Time Correction Flag	(0054,1401)	1C	Dead time correction has been applied to Curve Data (50xx,3000). Required if Type of Data (50xx,0020) is BLDSMPL. Enumerated Values: Y = yes N = no
Counts Included	(0054,1400)	2C	Type of counts included in this count rate data. Enumerated Values: TRUES SCATTER RANDOMS SINGLES Required if Axis Units (50xx,0030) contains CPS or CNTS.
Processing Function	(0018,5020)	3	A textual description of the processing that has been applied to this curve. (e.g. smoothing, time interpolation)

C.8.X.5.1 PET Curve Attribute Descriptions

C.8.X.5.1.1 Specialization of Curve Module Attributes

For PET Curves, all Curve Data (50xx,3000) values that are temporal are defined as time offsets from the Series Reference Time, where the Series Reference Time is defined by the combination of Series Date (0008,0021) and Series Time (0008,0031).

> Note: Because the PET Curve is related to a single PET Series, all Curve Data (50xx,3000) points must be decay corrected (or not) to the same real-world event as defined in Decay Correction (0054,1102).

C.8.X.5.1.2 Curve Dimensions

If the Type of Data (50xx,0020) is SYSRATE, then the Curve Dimensions (50xx,0005) shall equal 2.

If the Type of Data (50xx,0020) is SLICERATE, then the Curve Dimensions (50xx,0005) shall equal 3.

If the Type of Data (50xx,0020) is BLDSMPL, then the Curve Dimensions (50xx,0005) shall equal 2.

If the Type of Data (50xx,0020) is CPM, then the Curve Dimensions (50xx,0005) shall equal 3.

C.8.X.5.1.3 Type of Data

A description of the Type of Data (50xx,0020) in this Curve. Defined Terms:
    SYSRATE = system count rate
    SLICERATE = slice count rate
    BLDSMPL = blood samples
    CPM = cardiac polar map

> Note: Cardiac Polar Maps will be supported under the Standalone PET Curve IOD. This does not preclude the transmission of Cardiac Polar Maps in Secondary Capture images when preservation of quantitative information is not required.

C.8.X.5.1.4 Curve Data

If Type of Data (50xx,0020) is SYSRATE, then Curve Data (50xx,3000) is specified as x1\y1\x2\y2\... where:
    xn = time since Series Date (0008,0021) and Series Time (0008,0031)
    yn = system count rate at time xn.

If Type of Data (50xx,0020) is SLICERATE, then Curve Data (50xx,3000) is specified as x1\y1\z1\x2\y2\z2\... where:
    xn = time since Series Date (0008,0021) and Series Time (0008,0031)
    yn = position of slice
    zn = slice count rate of slice yn at time xn
Values of yn shall be increasing from patient inferior to superior.

If Type of Data (50xx,0020) is BLDSMPL, then Curve Data (50xx,3000) is specified as x1\y1\x2\y2\... where:
    xn = time since Series Date (0008,0021) and Series Time (0008,0031)
    yn = blood activity at time xn.

If the Type of Data (50xx,0020) is BLDSMPL, then Axis Units (50xx,0030) Value 1 shall be MILS or SEC, and Axis Units (50xx,0030) Value 2 shall be BQML or CPS.

If Type of Data (50xx,0020) is CPM, then Curve Data (50xx,3000) is specified as x1\y1\z1\x2\y2\z2\... where:

xn = distance from apex along long axis of heart
yn = start angle of sector
zn = value for sector in appropriate units.

Sector boundaries (yn) are measured in degrees clockwise relative to the antero-lateral wall. The end angle for a sector is the start angle of next largest yn value for the same xn. The end angle for the last sector is the start angle of the smallest yn for the same xn.

C.8.X.5.1.5 Axis Units

   Axis Units (50xx,0030) are the units of measure for the axes. One value for each dimension. The order for the units is the same as the dimensions for the curve data in Curve Data (50xx,3000).

   Defined Terms:
      SEC = seconds
      CNTS = counts
      MM = millimeters
      NONE = unitless
      CM = centimeters
      CM2 = cm**2
      DEG = degrees
      MILS = milliseconds
      PCNT = percent
      CPS = counts/second
      BQML = Becquerels/milliliter
      MGMINML = milligram/minute/milliliter
      UMOLMINML = micromole/minute/milliliter
      MLMING = milliliter/minute/gram
      MLG = milliliter/gram
      1CM = 1/centimeter
      UMOLML = micromole/milliliter
      PROPCNTS = proportional to counts
      PROPCPS = proportional to counts/sec
      MLMINML = milliliter/minute/milliliter
      MLML = milliliter/milliliter
      GML = grams/milliliter
      STDDEV = standard deviations

   If the Type of Data (50xx,0020) is SYSRATE, then Axis Units (50xx,0030) Value 1 shall be MILS or SEC, and Axis Units (50xx,0030) Value 2 shall be CPS.

   If the Type of Data (50xx,0020) is SLICERATE, then Axis Units (50xx,0030) Value 1 shall be MILS or SEC, Axis Units (50xx,0030) Value 2 shall be MM or CM, and Axis Units (50xx,0030) Value 3 shall be CPS. Values of Axis Units (50xx,0030) Value 2 shall be increasing from patient inferior to superior.

   If the Type of Data (50xx,0020) is BLDSMPL, then Axis Units (50xx,0030) Value 1 shall be MILS or SEC, and Axis Units (50xx,0030) Value 2 shall be BQML or CPS.

   If the Type of Data (50xx,0020) is CPM, then Axis Units (50xx,0030) Value 1 shall be MM or CM, Axis Units (50xx,0030) Value 2 shall be DEG, and Axis Units (50xx,0030) Value 3 shall be one of:

   CNTS, NONE, CM2, PCNT, CPS, BQML, MGMINML, UMOLMINML, MLMING, MLG, 1CM, UMOLML, PROPCNTS, PROPCPS, MLMINML, MLML, GML, STDDEV

ACR-NEMA

DIGITAL IMAGING AND COMMUNICATIONS

IN MEDICINE (DICOM)

PART 4 ADDENDUM

POSITRON EMISSION TOMOGRAPHY
SOP CLASSES

CHANGES FOR PART 4, SECTION B.5 - STANDARD SOP CLASSES

Item #7
Add the following to Section B.5 of Part 4

SOP Class Name	UID Value
Positron Emission Tomography Image Storage	1.2.840.10008.5.1.4.1.1.128
Standalone PET Curve Storage	1.2.840.10008.5.1.4.1.1.129

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DIGITAL IMAGING AND COMMUNICATIONS

IN MEDICINE (DICOM)

PART 6 ADDENDUM

POSITRON EMISSION TOMOGRAPHY
DATA DICTIONARY

CHANGES FOR PART 6, SECTION 6 - PET DATA DICTIONARY

Item #8
Add the following Data Elements to Part 6, Section 6

Tag	Name	VR	VM
[0018,0073]	Acquisition Start Condition	CS	1
[0018,0074]	Acquisition Start Condition Data	IS	1
[0018,0075]	Acquisition Termination Condition Data	IS	1
[0018,1075]	Radionuclide Half Life	DS	1
[0018,1076]	Radionuclide Positron Fraction	DS	1
[0018,1077]	Radiopharmaceutical Specific Activity	DS	1
[0018,1121]	Gantry/Detector Slew	DS	1
[0054,0101]	Number of Time Slices	US	1
[0054,1000]	Series Type	CS	2
[0054,1001]	Units	CS	1
[0054,1002]	Counts Source	CS	1
[0054,1004]	Reprojection Method	CS	1
[0054,1100]	Randoms Correction Method	CS	1
[0054,1101]	Attenuation Correction Method	LO	1
[0054,1102]	Decay Correction	CS	1
[0054,1103]	Reconstruction Method	LO	1
[0054,1104]	Detector Lines of Response Used	LO	1
[0054,1105]	Scatter Correction Method	LO	1
[0054,1200]	Axial Acceptance	DS	1
[0054,1201]	Axial Mash	IS	2
[0054,1202]	Transverse Mash	IS	1
[0054,1203]	Detector Element Size	DS	2
[0054,1210]	Coincidence Window Width	DS	1
[0054,1220]	Secondary Counts Type	CS	1-n
[0054,1300]	Frame Reference Time	DS	1
[0054,1310]	Primary (Prompts) Counts Accumulated	IS	1
[0054,1311]	Secondary Counts Accumulated	IS	1-n
[0054,1320]	Slice Sensitivity Factor	DS	1
[0054,1321]	Decay Factor	DS	1
[0054,1322]	Dose Calibration Factor	DS	1
[0054,1323]	Scatter Fraction Factor	DS	1
[0054,1324]	Dead Time Factor	DS	1
[0054,1330]	Image Index	US	1
[0054,1400]	Counts Included	CS	1-n
[0054,1401]	Dead Time Correction Flag	CS	1

CHANGES FOR PART 6, ANNEX A - REGISTRY OF DICOM UNIQUE IDENTIFIERS (UID)

Item #9
Add the following UIDs to Part 6, Annex A, Table A-1

UID Value	UID Name	UID Type	Part
1.2.840.10008.5.1.4.1.1.128	Positron Emission Tomography Image Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.129	Standalone PET Curve Storage	SOP Class	PS 3.4

<Supplement 12 Ends Here>

Revision History

Revision	Date	Description
1.0	5/12/95	First draft.
1.1	6/26/95	Updated per comments that were reviewed during 6/14/95 and 6/22/95 meetings.
1.2	7/27/95	Updated per comments that were reviewed during 7/26/95 meeting.
1.3	10/5/95	Updated per comments from Working Group VI (WG VI) and user review, and based on changes made between Nuclear Medicine Image IOD drafts 1.11 and 1.12.
1.4	10/20/95	Updated per comments that were reviewed during 10/18/95 meeting. Includes revision bars for changes from version 1.3.
1.5	10/20/95	Draft submitted to WG VI for public review. Revision bars and issues list cleaned up.
1.6	11/3/95	Draft for public review. Update per comments received from WG VI on 10/25/95.
1.7	3/8/96	Updated per comments received from public review and changes agreed to during joint PET and NM committee meeting in Dallas 2/28-3/1.
1.8	4/8/96	Updated per comments that were reviewed during 4/4/96 teleconference. Added the Standalone PET Curve IOD and the PET Curve Module.
1.9	4/30/96	Updated per comments that were reviewed during 4/29/96 teleconference. Finalized the PET Curve Module. Broke apart the PET Series Module, creating the PET Isotope and PET Multi-gated Acquisition Modules.
1.10	5/23/96	Updated per comments received from WG VI on 5/14/96.
Text for Letter Ballot (1.11)	6/6/96	Updated per comments reviewed during SNM meeting 6/3/96. All outstanding issues resolved.

Outstanding Issues

    1.