DICOM Change Proposal

STATUS	Letter Ballot
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Change Number CP-2567
Log Summary: Extend X-Ray Frame Acquisition Macro
Name of Standard PS3.3
Rationale for Change: • In the X-Ray Angiographic Image there is the X-Ray Acquisition Module (Table C.8-27) which contains among others KVP, Exposure Time, X-ray Tube Current, and Exposure in uAs. This is a multi-frame image, but the values are stored per image. • In the Enhanced XA Image there is the XA Acquisition Module (Table C.8.19.3-1) which contains about the same parameters but referring to average/accumulative values instead: KVP is defined as the *average* voltage, X-Ray tube current as the *average* current, Exposure Time as the *cumulative* X-ray time, etc. • For the Enhanced XA Image there is also an X-Ray Frame Acquisition Macro (Section C.8.19.6.8) which enables storage of dose values on a frame-by-frame basis. Unfortunately, this specifies only two attributes, KVP and X-Ray Tube Current, compared to many more attributes in the X-Ray Acquisition Module. At the time this macro was defined, Frame Acquisition Duration (0018,9220) was considered equivalent to per-frame Exposure Time; however, this equivalence does not hold when a frame is formed from multiple X-ray pulses, where Frame Acquisition Duration includes inter-pulse intervals while Exposure Time reflects only X-ray-on time. Exposure in mAs was not included because it can be derived from Exposure Time and X-Ray Tube Current. To improve interoperability on storage of these dose-related values per frame, and to prevent that vendors store this kind of information in private attributes/sequences, it is proposed to add well-known attributes to the X-Ray Frame Acquisition Macro. These Attributes shall reflect per-frame values only. Average or accumulative values across all Frames shall be encoded in the corresponding Attributes of the XA/XRF Acquisition Module. WG-02 reviewed this proposal and concurs with adding Exposure Time in ms (0018,9328) and Exposure in mAs (0018,9332) as per-frame Type 3 Attributes. These additions do not duplicate existing per-frame attributes.
Change Wording: See below.

Update PS3.3, Section C.8.7.2.1.1 Exposure Time

C.8.7.2.1.1 Exposure Time

Exposure time is the cumulative time the patient received X-Ray exposure during this image (Multi-frame Image acquisition). Calculation is pulse width * number of Frames **when there is one pulse of constant width per Frame; otherwise it is the sum of the pulse widths of all pulses contributing to the image**.

When encoded in a per-frame context (e.g., within the Per-frame Functional Groups Sequence (5200,9230) of the Enhanced XA Image IOD), Exposure Time denotes the X-ray-on time for that Frame (i.e., the pulse width, or the sum of pulse widths within the Frame).

Update PS3.3, Section C.8.19.6.8 X-Ray Frame Acquisition Macro

C.8.19.6.8 X-Ray Frame Acquisition Macro

Table C.8.19.6-8 specifies the Attributes of the X-Ray Frame Acquisition Macro.

Table C.8.19.6-8. X-Ray Frame Acquisition Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Frame Acquisition Sequence	(0018,9417)	1	Sequence containing the acquisition parameters for this Frame. Only a single Item shall be included in this Sequence.
>KVP	(0018,0060)	1	Exact peak kilo voltage output of the X-Ray generator used for this Frame.
>X-Ray Tube Current in mA	(0018,9330)	1	Exact Nominal X-Ray tube current in milliamperes applied during **Frame** Acquisition Duration (0018,9220) for this Frame.
>Exposure Time in ms	**(0018,9328)**	**3**	**Duration of X-Ray exposure in milliseconds for this Frame. See Section C.8.7.2.1.1.**
>Exposure in mAs	**(0018,9332)**	**3**	**The exposure expressed in milliampere seconds for this Frame, for example calculated from Exposure Time and X-Ray Tube Current.**

C.8.19.6.8.1 X-Ray Frame Acquisition Sequence Macro Attribute Descriptions

These Attributes may only be used if the information is available on a Frame-by-frame base. The average **or accumulative** values for these Attributes of all Frames shall be stored in the same Attribute in the XA/XRF Acquisition Module or in the Enhanced Mammography Image Module.

Update PS3.17, Section FFF.1.4 X-Ray Generation

FFF.1.4 X-Ray Generation

This chapter illustrates the relationships between the X-Ray generation parameters:

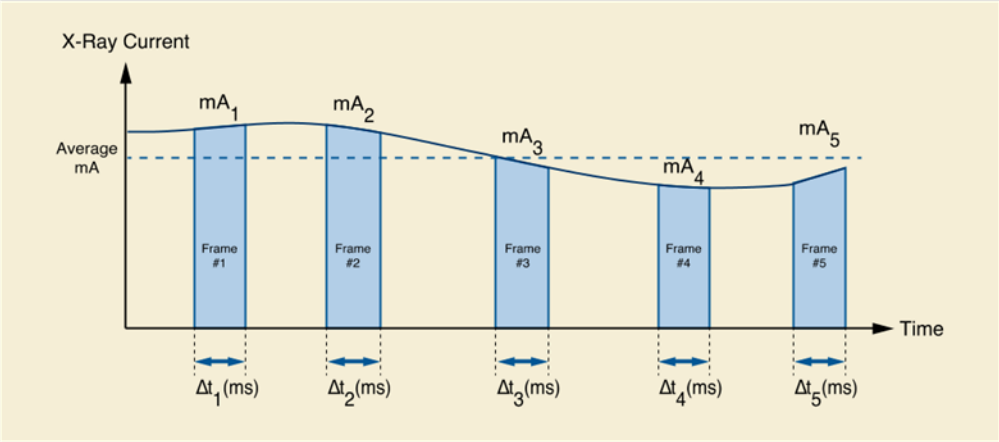

Figure FFF.1.4-1. Example of X-Ray Current Per-Frame of the X-Ray Acquisition

Values **per frame** are represented by the following symbols in this section:

In the Frame Content Sequence (0020,9111):

· Frame Acquisition Duration (0018,9220) in ms of frame « i » = **Δ~~D~~**t_i

In the Frame Acquisition Sequence (0018,9417):

· KVP (0018,0060) of frame « i » = kVp_i

· X-Ray Tube Current in mA (0018,9330) of frame « i » = mA_i

· Exposure Time in ms (0018,9328) of frame (if encoded) « i » = Et_i

· Exposure in mAs (0018,9332) of frame (if encoded) « i » = mAs_i

The following shows an example of calculation of the cumulative and average values per image relative to the values per-frame:

- Number of Frames (0028,0008) = N
- Exposure Time (0018,9328) **(cumulative)** in ms = SUM_N (**~~Dt_i~~ Et_i**)
- X-Ray Tube Current (0018,9330) in mA = 1/N * SUM_N (mA_i)
- Average Pulse Width (0018,1454) in ms = 1/N * SUM_N (**~~Dt_i~~ Et_i**)

Note **The average pulse width is equal to the exposure time in the case of a single pulse per frame. If there are multiple pulses within a frame, the average pulse width will be smaller, as the total X-ray-on time is distributed across multiple pulses.**

- KVP (0018,0060) = 1/N * SUM_N (kVp_i)
- Exposure (0018,9332) in mAs = **~~SUM_N (Dt_i * mA_i / 1000)~~ SUM_N mAs_i, where $mAs_i = (mA_i \cdot Et_i) / 1000$**

Note **Et_i (X-ray on time within the frame) may be shorter than Δt_i (Frame Acquisition Duration), which includes non-exposed intervals (e.g., readout).**