

DICOM Correction Proposal

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Correction Number	CP-2430
Log Summary:	Add Examples of Ion Control Point Sequence for Arc Treatment Techniques
Name of Standard	PS3.3 2024e
Rationale for Correction:	<p>Arc Treatment technique is being actively developed for Ion Radiation Therapy. An unambiguous representation of the Ion Control Point Sequence (300A,03A8) should be described to avoid different representations among vendors.</p> <p>This CP adds examples of Ion Control Points for arc treatments to the existing section already containing an example for static treatments.</p>
Correction Wording:	

Update PS 3.3, section C.8.8.25.7 Ion Control Point Sequence

C.8.8.25.7 Ion Control Point Sequence

The control point sequence for RT Ion Beams is defined using the same rule set as in the RT Beams Module (see Section C.8.8.14.5). Specifically, the following rules apply:

- All parameters that change at any control point of a given beam shall be specified explicitly at all control points (including those preceding the change).
- All parameters of an irradiation segment (i.e., with values of the Cumulative Meterset Weight (300A,0134) different at the beginning and at the end of the segment) shall therefore be specified in 2 separate control points denoting the beginning and at the end of this segment. Each irradiation segment is therefore represented by 2 control points.
- Parameters changing during the segment shall be represented by their different values at those control points. Parameters that do not change during the segment shall be represented with equal values at both control points (unless they are constant for all control points of the beam). For example, a beam delivery involving two independent irradiation segments will require 4 control points. Control Points 0 and 1 define the first irradiation segment. Between control points 1 and 2, no radiation is given (Meterset is constant), but other parameters may change. Finally, the second irradiation segment occurs between control points 2 and 3.

This definition allows unambiguous and explicit determination of those parameters changing while irradiation is occurring, as opposed to those parameters that change between irradiation segments. No assumptions are made about the behavior of machine parameters between specified control points, and communicating devices shall agree on this behavior outside the Standard.

Some examples of ion scanning beam specification using control points are as follows:

For each segment, the positions in the Scan Spot Position Map (300A,0394) are identical for the corresponding pair of control points.

a) Static delivery:

The following example illustrates this rule (not all parameters are shown), in the case of a STATIC scanning beam with 2 segments for the beam energy layers and Final Cumulative Meterset Weight (300A,010E) of 70.

~~Control Point 0: All applicable treatment parameters defined, Cumulative Meterset Weight (300A,0134) = 0
Nominal Energy: 200 Scan Spot Position Map: (-40, -35), (-40, -30) [Positions for 1st segment] Scan Spot Meterset Weight: 10, 20. Values add up to Meterset difference between Control Points 0 and 1.~~

~~Control Point 1: All applicable treatment parameters defined, Cumulative Meterset Weight (300A,0134) = 30.0
Nominal Energy: 200 Scan Spot Position Map: (-40, -35), (-40, -30) [Positions for 1st segment] Scan Spot Meterset Weight: 0.0, 0.0. All values are 0.0, because the Cumulative Meterset Weight difference between Control Point 1 and 2 is 0.0.~~

~~Control Point 2: All applicable treatment parameters defined, Cumulative Meterset Weight (300A,0134) = 30.0
Nominal Energy: 180 Scan Spot Position Map: (-55, -40), (-55, -35) [Positions for 2nd segment] Scan Spot Meterset Weight: 25, 15. Values add up to the Cumulative Meterset Weight difference between Control Points 2 and 3.~~

~~Control Point 3: All applicable treatment parameters defined, Cumulative Meterset Weight (300A,0134) = 70.0
Nominal Energy: 180 Scan Spot Position Map: (-55, -40), (-55, -35) [Positions for 2nd segment] Scan Spot Meterset Weight: 0.0, 0.0. All values are 0.0, because there is no following control point (end of sequence).~~

Table C.8.8.25.7-1. Example of static delivery in RT Ion Beams Module

<u>Control Point Index (300A,0112)</u>	<u>Nominal Beam Energy (300A,0114)</u>	<u>Cumulative Meterset Weight (300A,0134)</u>	<u>Scan Spot Position Map (300A,0394)</u>	<u>Scan Spot Meterset Weights (300A,0396)</u>
<u>0</u>	<u>200</u>	<u>0</u>	<u>(-40, -35), (-40, -30)</u>	<u>10, 20</u>
<u>1</u>	<u>200</u>	<u>30</u>	<u>(-40, -35), (-40, -30)</u>	<u>0, 0</u>
<u>2</u>	<u>180</u>	<u>30</u>	<u>(-55, -40), (-55, -35)</u>	<u>25, 15</u>
<u>3</u>	<u>180</u>	<u>70</u>	<u>(-55, -40), (-55, -35)</u>	<u>0, 0</u>

1st segment is described by Control Points 0 and 1 pair.

For Control Points 0, Scan Spot Meterset Weights (300A,0396) values add up to Meterset difference between Control Points 0 and 1.

For Control Points 1, Scan Spot Meterset Weights (300A,0396) values are 0.0, because the Cumulative Meterset Weight (300A,0134) difference between Control Point 1 and 2 is 0.0.

2nd segment is described by Control Points 2 and 3 pair.

For Control Points 2, Scan Spot Meterset Weights (300A,0396) values add up to Meterset difference between Control Points 0 and 1.

For Control Points 3, Scan Spot Meterset Weights (300A,0396): 0.0, 0.0. All values are 0.0, because there is no following control point (end of sequence).

b) Stepped arc delivery:

The following example illustrates the case of a scanning beam with 3 segments for 3 fixed gantry angles, each with a single beam energy level, and Final Cumulative Meterset Weight (300A,010E) of 90. As the Gantry Angle (300A,011E) value remains unchanged between consecutive pairs of control points with changing Cumulative Meterset Weight (300A,0134), such a scanning beam shall have Beam Type (300A,00C4) value equal to STATIC.

Table C.8.8.25.7-2. Example of stepped arc delivery in RT Ion Beams Module

<u>Control Point Index (300A,0112)</u>	<u>Gantry Angle (300A,011E)</u>	<u>Gantry Rotation Direction (300A,011F)</u>	<u>Nominal Beam Energy (300A,0114)</u>	<u>Cumulative Meterset Weight (300A,0134)</u>	<u>Scan Spot Position Map (300A,0394)</u>	<u>Scan Spot Meterset Weights (300A,0396)</u>
<u>0</u>	<u>0</u>	<u>NONE</u>	<u>200</u>	<u>0</u>	<u>(-40, -35), (-40, -30)</u>	<u>10, 20</u>
<u>1</u>	<u>0</u>	<u>CW</u>	<u>200</u>	<u>30</u>	<u>(-40, -35), (-40, -30)</u>	<u>0, 0</u>
<u>2</u>	<u>2</u>	<u>NONE</u>	<u>180</u>	<u>30</u>	<u>(-55, -40), (-55, -35)</u>	<u>25, 15</u>
<u>3</u>	<u>2</u>	<u>CW</u>	<u>180</u>	<u>70</u>	<u>(-55, -40), (-55, -35)</u>	<u>0, 0</u>

<u>4</u>	<u>4</u>	<u>NONE</u>	<u>160</u>	<u>70</u>	<u>(-45, -30), (-50, -40)</u>	<u>15.5</u>
<u>5</u>	<u>4</u>	<u>NONE</u>	<u>160</u>	<u>90</u>	<u>(-45, -30), (-50, -40)</u>	<u>0, 0</u>

1st segment is described by Control Points 0 and 1.

For Control Points 0, Scan Spot Meterset Weights (300A,0396) values add up to Meterset difference between Control Points 0 and 1. Rotation direction is NONE because there is no rotation of gantry between Control Points 0 and 1.

For Control Points 1, Scan Spot Meterset Weights (300A,0396) values are 0.0, because the Cumulative Meterset Weight (300A,0134) difference between Control Point 1 and 2 is 0.0. Rotation direction is specified because the gantry rotates between Control Points 1 and 2 while beam energy is modified.

2nd segment is described by Control Points 2 and 3.

3rd segment is described by Control Points 4 and 5.

For Control Points 5, Scan Spot Meterset Weights (300A,0396): 0.0, 0.0. All values are 0.0, because there is no following control point (end of sequence). Rotation direction is NONE because there is no following control point (end of sequence).

c) Continuous arc delivery:

The following two examples illustrate the case of a DYNAMIC scanning beam with 3 segments with continuous rotation of the gantry, each with a single beam energy level, and Final Cumulative Meterset Weight (300A,010E) of 90. As the Gantry Angle (300A,011E) value changes between consecutive pairs of control points with changing Cumulative Meterset Weight (300A,0134), such a scanning beam shall have Beam Type (300A,00C4) value equal to DYNAMIC.

Table C.8.8.25.7-3. Example 1 of continuous arc delivery in RT Ion Beams Module

<u>Control Point Index (300A,0112)</u>	<u>Gantry Angle (300A,0112)</u>	<u>Gantry Rotation Direction (300A,011F)</u>	<u>Nominal Beam Energy (300A,0114)</u>	<u>Cumulative Meterset Weight (300A,0134)</u>	<u>Scan Spot Position Map (300A,0394)</u>	<u>Scan Spot Meterset Weights (300A,0396)</u>
<u>0</u>	<u>0</u>	<u>CW</u>	<u>200</u>	<u>0</u>	<u>(-40, -35), (-40, -30)</u>	<u>10, 20</u>
<u>1</u>	<u>1</u>		<u>200</u>	<u>30</u>	<u>(-40, -35), (-40, -30)</u>	<u>0, 0</u>
<u>2</u>	<u>2</u>		<u>180</u>	<u>30</u>	<u>(-55, -40), (-55, -35)</u>	<u>25, 15</u>
<u>3</u>	<u>3</u>		<u>180</u>	<u>70</u>	<u>(-55, -40), (-55, -35)</u>	<u>0, 0</u>
<u>4</u>	<u>4</u>		<u>160</u>	<u>70</u>	<u>(-45, -30), (-50, -40)</u>	<u>15.5</u>
<u>5</u>	<u>5</u>		<u>160</u>	<u>90</u>	<u>(-45, -30), (-50, -40)</u>	<u>0, 0</u>

In this first example, both the energy and the gantry angle change between segments leading to changing gantry angles at successive Control Points.

1st segment is described by Control Points 0 and 1.

For Control Points 0, Scan Spot Meterset Weights (300A,0396) values add up to Meterset difference between Control Points 0 and 1. Rotation direction is defined because the gantry rotates between Control Points 0 and 1.

For Control Points 1, Scan Spot Meterset Weights (300A,0396) values are 0.0, because the Cumulative Meterset Weight (300A,0134) difference between Control Point 1 and 2 is 0.0. Rotation direction is not defined because the gantry continuously rotates in the same direction between Control Points 1 and 2 while beam energy is modified.

2nd segment is described by Control Points 2 and 3.

3rd segment is described by Control Points 4 and 5.

For Control Points 5, Scan Spot Meterset Weights (300A,0396): 0.0, 0.0. All values are 0.0, because there is no following control point (end of sequence). Rotation direction is not defined as the value is not relevant because there is no following control point (end of sequence).

Table C.8.8.25.7-4. Example 2 of continuous arc delivery in RT Ion Beams Module

<u>Control Point Index (300A,0112)</u>	<u>Gantry Angle (300A,0112)</u>	<u>Gantry Rotation Direction (300A,011F)</u>	<u>Nominal Beam Energy (300A,0114)</u>	<u>Cumulative Meterset Weight (300A,0134)</u>	<u>Scan Spot Position Map (300A,0394)</u>	<u>Scan Spot Meterset Weights (300A,0396)</u>
<u>0</u>	<u>0</u>	<u>CW</u>	<u>200</u>	<u>0</u>	<u>(-40, -35), (-40, -30)</u>	<u>10, 20</u>
<u>1</u>	<u>2</u>	<u>NONE</u>	<u>200</u>	<u>30</u>	<u>(-40, -35), (-40, -30)</u>	<u>0, 0</u>
<u>2</u>	<u>2</u>	<u>CW</u>	<u>180</u>	<u>30</u>	<u>(-55, -40), (-55, -35)</u>	<u>25, 15</u>
<u>3</u>	<u>4</u>	<u>NONE</u>	<u>180</u>	<u>70</u>	<u>(-55, -40), (-55, -35)</u>	<u>0, 0</u>
<u>4</u>	<u>4</u>	<u>CW</u>	<u>160</u>	<u>70</u>	<u>(-45, -30), (-50, -40)</u>	<u>15, 5</u>
<u>5</u>	<u>5</u>	<u>NONE</u>	<u>160</u>	<u>90</u>	<u>(-45, -30), (-50, -40)</u>	<u>0, 0</u>

In this second example, only the energy changes between segments.

1st segment is described by Control Points 0 and 1.

For Control Points 0, Scan Spot Meterset Weights (300A,0396) values add up to Meterset difference between Control Points 0 and 1. Rotation direction is defined because the gantry rotates between Control Points 0 and 1.

For Control Points 1, Scan Spot Meterset Weights (300A,0396) values are 0.0, because the Cumulative Meterset Weight (300A,0134) difference between Control Point 1 and 2 is 0.0. Rotation direction is NONE because the gantry angle does not change between control point 1 and 2.

2nd segment is described by Control Points 2 and 3.

3rd segment is described by Control Points 4 and 5.

For Control Points 5, Scan Spot Meterset Weights (300A,0396): 0.0, 0.0. All values are 0.0, because there is no following control point (end of sequence). Rotation direction is NONE for consistency though the value is not relevant because there is no following control point (end of sequence).

Notes

1. Arc delivery could also be performed with a rotation of the patient support instead of a rotation of the gantry. In such a case, Gantry Rotation Direction (300A,011F) and Gantry Angle (300A,0112) should be replaced by Patient Support Rotation Direction (300A,0123) and Patient Support Angle (300A,0122) in the previous examples.
2. Continuous arc delivery could include a change of gantry angle direction in which case each control point shall define the Gantry Rotation Direction (300A,011F).
3. Continuous arc delivery could include some segments with the gantry remaining stationary in which case each control point shall define the Gantry Rotation Direction (300A,011F) with the value NONE for the first control point of a stationary segment.
4. For continuous arc delivery a value of NONE for the Gantry Rotation Direction (300A,011F) does not explicitly require that the gantry has to physically stop moving, but it is necessary to avoid requiring that the gantry performs a full clockwise rotation (360 degrees) as expected from Section C.8.8.14.8. DICOM does not specify the behavior of the treatment machine within a segment or between segments.