Quality Assurance/Acceptance Test for Un-flat (FFF) beam

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2012

Acceptance tests/QA for Un-flat (FFF) beam

Following tests for un-flat beam needs to be carried out:

1. Treatment using Flattening Filter Free (FFF) mode (un-flat beam) should be done with TPS and Record & Verify system through a networked arrangement. Manual planning and calculation shall not be adopted in clinical use of un-flat beam.
2. Following measurements shall be carried out for the purpose of submitting report on un-flat beam to AERB:
    a. **Beam Energy**

    Nominal beam energy along with measured $TPR_{20/10}$ values for 10 cm x 10 cm collimator setting shall be indicated for all available un-flat beam energies.

    b. **Surface dose**

    Surface dose shall be measured for collimator settings of 10 cm x 10 cm and 20 cm x 20 cm and compared with the corresponding nominal flat beam energy.

    c. **Field size, penumbra, flatness* and symmetry for Accelerators having un-flat beam with field size less than 10 cm x 10 cm** .

    For Accelerators having un-flat beam with field size less than 10 cm x 10 cm, the dosimetric parameters such as field size, penumbra, flatness, symmetry etc shall be measured and evaluated following the methods applied for flat beam. *Alternatively, the flatness, symmetry, penumbra etc. for these field sizes where flatness is > ± 3%, the evaluation criteria for the un-flat beam shall be adopted.*

    d. **Off Axis Ratio (OAR)**

    OAR at ±3 cm from central axis at the depth of 10 cm for 10 cm x 10 cm collimator setting shall be measured and indicated for all available un-flat beam energies.

    e. **Depth dose profiles**

    Depth dose profiles for 5 cm x 5 cm, 10 cm x 10 cm and 20 cm x20 cm collimator setting shall be measured. The depth of maximum dose (d_{max}) and percentage depth dose (PDD) at 10 cm depth shall be indicated for all available un-flat beam energies.

f. **Beam Profiles**

Beam profiles for 20 cm x20 cm collimator setting at depth of 10 cm in isocentric setup (SAD) for all available un-flat beam energies shall be measured for evaluating following dosimetric parameters:

i. **Field Size**

Field size(s) shall be defined by collimator settings only. For verifying the constancy of the beam profiles, lateral separation between *inflection points*[$] along major axes shall be recorded.

***Flatness:** As per IEC 976 (IEC 60976), the flat region for field sizes less than 10 cm x 10 cm along major axes defined by subtracting 1 cm from either side of the beam profile e.g. For a field size of 5 cm x 5 cm, the flat region is central 3 cm.*

[$]***Inflection Point:** Inflection Point shall be identified as per its mathematical definition. However, for practical purposes it can be approximated as the mid point on either side of the high gradient region (sharply descending part) of the beam profile. Its location can be identified as follows; Refer figure 1, locate start point (S) and end point (E) of high gradient region of the beam profile. The separation between S & E is the height (h) of the high gradient region of the beam profile. IP is located at h/2 from either location(S or E)*

ii. **Symmetry**

Symmetry should be evaluated following the methods recommended for flat beams.

iii. **Degree of un-flatness**

To quantify the degree of un-flatness, the lateral distance from the central axis at 90%, 75% and 60% dose points on either side of the beam profile shall be recorded along major axes for all available beam energies [Refer Figure 2].

iv. **Penumbra**

For determining penumbra, dose value at inflection point (IP) shall be taken as reference dose value (RDV). Points P_a and P_b which are located at 1.6 and 0.4 times of RDV respectively shall be identified [Refer Figure 1]. Lateral separation

between P_a and P_b on either side of the profile will be the measure of the penumbra. The penumbra shall be indicated along major axes for all available beam energies.

<u>The above values shall be tabulated as per Table 1 and to be used as baseline values for periodic QA tests. Periodic QA tests shall be carried out on monthly basis and proper records to be maintained.</u>

3. **Daily QA tests**:
   a) **Energy check:** $TPR_{20/10}$ for 10 cm x 10 cm collimator setting
   b) **Measurements of Off Axis Ratio(OAR):** at +/-3 cm for 10cmx10cm collimator setting
   c) Measurements of profiles using multiple detector system/any other suitable device for 20 cm x 20 cm collimator setting

Appropriate dosimetric and RFA system shall be used which can work reliably in high dose rate operation (1000 – 3000 MU/min) compatible for high dose.

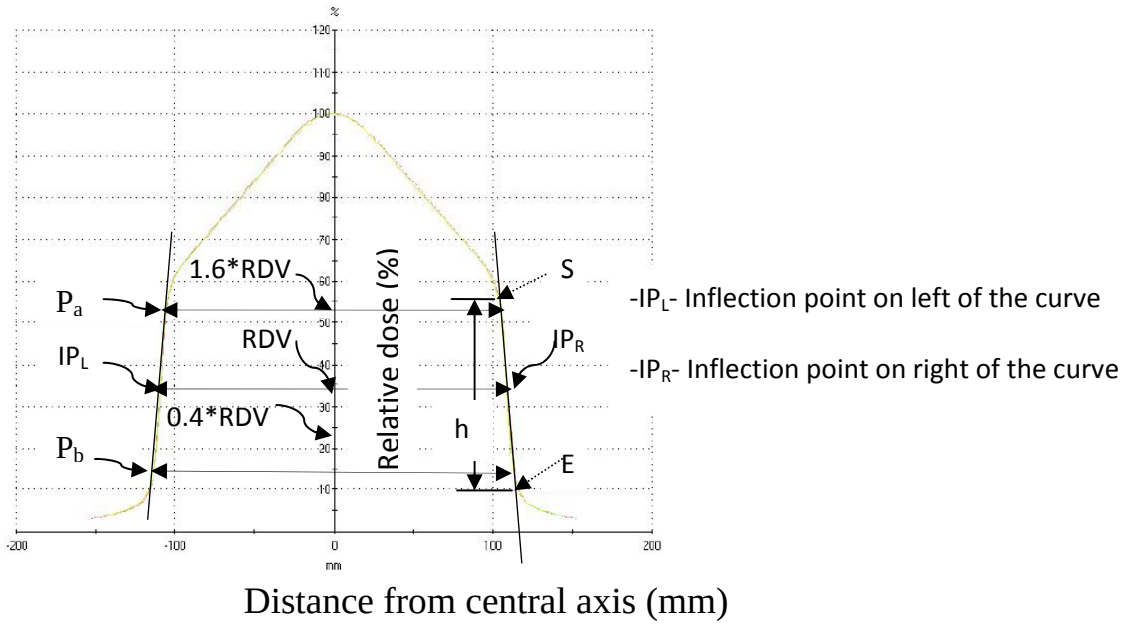
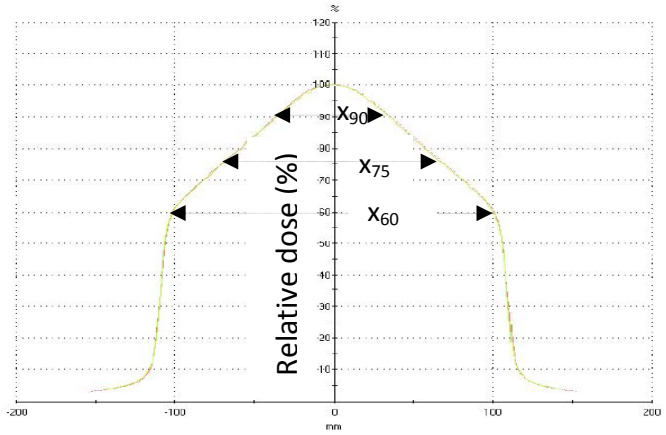


Figure 1- Schematic diagram for determining inflection point and penumbra



Distance from central axis (mm)

Figure 2- Schematic diagram for determining degree of un-flatness

Table 1

Collimator set field size (cm x cm)	Separation between IP_L & IP_R (cm)	$X_{90\,\%}$ (cm)	$X_{75\,\%}$ (cm)	$X_{60\,\%}$ (cm)	Tolerance	Symmetry		Penumbra (mm)	
						Measured	Tolerance	Measured	Tolerance
					± 2 mm*		± 2%*		± 2 mm*

* Tolerance w.r.to baseline values