CLINAC iX ACCELERATOR

INNOVATIVE TECHNOLOGY THAT GROWS WITH YOU

SPECIFICATIONS

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SPECIFICATIONS

Introduction

This specification sheet provides information for the Clinac® iX linear accelerators.

1.0 Photon Beams

1.1 Energy: Up to three photon beams may be selected in accordance with the beam combinations listed in Table 1. The base Clinac iX configuration features a single photon energy. See High-Intensity Mode configuration table in section 36 under Additional Options for available HIM beam configuration.

Table 1: Available X-ray Beam Energy Combinations (MV)

Beam I	Optional Beam II BJR 17/BJR 11	Optional SRS Beam[6]	Optional High-Intensity Mode 6X[5,6]	Optional High-Intensity Mode 10X[5,7]
4	10/10	N/A	N/A	N/A
6	10/10	6	Yes	Yes
6	16/15	6	Yes	No
6	23/18	6	Yes	No
6	25/20	6	Yes	No
8	16/15	N/A	N/A	N/A
8	23/18	N/A	N/A	N/A

Table 2: X-ray Beam Performance

Nominal Energy (MV) BJR 17	Nominal Energy (MV) BJR 11	D_{max} (cm)[1]	% Depth Dose at 10 cm Depth[1]	Flatness[2]	Symmetry[3]
4	4	1.20 ± 0.20	63.0 ± 1.0	± 3.0 %	2.0 %
SRS6	SRS6	1.60 ± 0.15	66.9 ± 1.0	± 3.0 %	2.0 %
6	6	1.60 ± 0.15	67.2 ± 1.0	± 2.5 %	2.0 %
6 HI	6 HI	1.50 ± 0.15	64.3 ± 1.0	Footnote 8	2.0%
8	8	2.0 ± 0.15	71.0 ± 1.0	± 2.5 %	2.0 %
10	10	2.40 ± 0.15	74.1 ± 1.0	± 2.5 %	2.0 %
10 HI	10 HI	2.34 ± 0.15	71.8 ± 1.0	Footnote 8	2.0 %
16	15	2.90 ± 0.15	77.4 ± 1.0	± 2.5 %	2.0 %
23	18	3.30 ± 0.15	80.2 ± 1.0	± 2.5 %	2.0 %
25	20	3.50 ± 0.15	82.0 ± 1.0	± 2.5 %	2.0 %

[1] Depth of ionization applies to 10 x 10 cm^2 field size measured at 100 cm Target-Skin Distance (TSD).

[2] Flatness is defined as the maximum variation from the mean dose delivered within the central 80% Full Width Half Maximum (FWHM) region measured at 100 cm TSD at a depth of 10 cm. The mean is the average of the maximum and minimum points within the central 80% FWHM region. The specification of ± 2.5% applies to both the radial and transverse axes of all square field sizes from 20 x 20 cm^2 to 40 x 40 cm^2, inclusive. A specification of ± 3.0% applies to all square field sizes between 10 x 10 cm^2 and 20 x 20 cm^2.

[3] Symmetry is defined as the maximum difference between the X-ray dose delivered to any two points which are equidistant and symmetrical about the central axis and within the central 80% FWHM region measured at 100 cm TSD at a depth of 10 cm. This specification applies to the radial and transverse axes of all square field sizes from 10 x 10 cm^2 to 40 x 40 cm^2.

[4] Beam matching between 6 MV Beam I and the optional SRS 6 MV beam is provided and defined as follows:

[4.1] The depth of D_{max} along the central axis in a water phantom at 100 cm TSD is within ± 1.5 mm of the average of the two beams. The relative dose at 10 cm depth on the central axis in a water phantom at 100 cm TSD is within ± 0.5% of the average of the two beams.

[4.2] The dose at any point within the central 80% of the field along the major axes, normalized to the central axis, is within ± 1 percentage point of the average of the two beams. This specification applies to beams at 10 cm depth and field dimensions of 10 x 10 cm^2 and above.

[5] Refer to section 27 for details.

[6] One of the two modes can be selected: the SRS Beam or the Optional High-Intensity Mode 6X

[7] Optional High-Intensity Mode 10X replaces the Optional BEAM II

[8] The High-Intensity Modes specifications refer to the Field Intensity instead of Flatness. Refer to Section 36 for details

1.2 Dose Rate: For Beam I and optional Beam II, the dose rate can be selected in fixed steps of 100 MU/min up to a maximum dose rate of 300, 400, or 600 MU/min. For the optional SRS 6 MV Beam, the dose rate is 800 MU/min. Refer to section 5.0 under Additional Options for further information. An optional low dose rate mode is also available. Refer to section 6.0 under Additional Options for further information.

Photon Energy (BJR17)	Photon Dose Rate (MU/min)
4 MV (optional)	50, 100, 150, 200, 250
6 -25 MV (standard)	100, 200, 300
6-25 MV (optional)	100, 200, 300, 400
6-25 MV (optional)	100, 200, 300, 400, 500, 600
SRS 6 MV (optional)	800
6-25 MV (optional)	5, 10, 15, 20, 40, 60, 80
An "MU" is defined for these specifications as one centiGray delivered to a tissue-equivalent material at D_{max} and 100 cm SSD, with a 10 x 10 cm^2 field size.	

1.3 Maximum Field Intensity at D_{max}: The intensity at the depth of maximum buildup (D_{max}) does not exceed 109% of the central axis intensity anywhere in the measurement plane of any field size.

1.4 Leakage: The X-ray absorbed dose does not exceed 0.1% of the absorbed dose at the isocenter measured anywhere in the patient plane outside of the maximum useful beam. The neutron dose equivalent (Sievert) does not exceed 0.2% of the X-ray absorbed dose (Gray) at the isocenter.

The patient plane is defined as a circular plane with a radius of 2 m, centered on and perpendicular to the axis of the beam at isocenter. The X-ray measurements may be averaged over an area not to exceed 100 cm^2. In all other directions, the X-ray absorbed dose 1 m from the path of the electrons between the electron gun and the target or electron window does not exceed 0.1% of the absorbed dose at isocenter.

1.5 Collimator Transmission: The X-ray transmission of the upper and lower movable collimator does not exceed 0.5%.

1.6 Spot Size: The electron spot size is less than 3 mm in diameter at the X-ray target.

1.7 Penumbra: Less than 4.0 mm at leaf end. Penumbra is defined as 20-80% leaf end, measured using 10 cm x 10 cm field size, 6 MV at D_{max}, 100 cm SAD.

* For additional IEC performance specifications for the MLC, please refer to 1000056876-01 Clinac IEC accompanying documents 60976 Functional Performance Characteristics V 9.0.

1.8 Field Size: The field size is continuously variable from 0.5 x 0.5 cm^2 to 40 x 40 cm^2 as measured at 100 cm TSD. Field sizes larger than 35 x 35 cm^2 are limited to a 49.5 cm diagonal (the diameter of the circle defined by the primary collimator at 100 cm TSD). The field size is defined as the distance along the radial and transverse axes between the points of 50% density on an X-ray film taken at 100 cm TSD with minimum buildup. The optional SRS 6 MV beam field size is limited to a maximum of 15 x 15 cm^2.

1.9 Upper and Lower Independent Collimators:
Asymmetrical collimation is provided for upper and lower sets of collimators.

1.9.1 Independent, asymmetrical Upper Collimator travel range: 30 cm (-10 cm to +20 cm relative to central axis)

1.9.2 Independent, asymmetrical Lower Collimator travel range: 22 cm (-2 cm to +20 cm relative to central axis)

2.0 Electron Beams

2.1 Clinac iX offers a range of electron energy choices. Clinac iX comes with four (4), five (5), or six (6) electron beams that can be selected in accordance with the specifications and combinations listed in Table 2. The specifications apply to a 15 x 15 cm^2 electron applicator and 100 cm TSD.

2.2 Dose Rate:

Electron Dose Rate (MU/min)
100, 200, 300 (standard) 100, 200, 300, 400 (optional) 100, 200, 300, 400, 500, 600, 1000 (optional) 888 AT 1.6 M (OPTIONAL FOR 6 MEV AND 9 MEV)
An optional high electron dose rate is available at 6 MeV and 9 MeV electron energies. Refer to section 1.1 in Additional Options for further information.

2.3 Field Sizes: A set of five electron applicators is provided, with selection from 6 sizes: 6 x 6 cm^2, 6 x 10 cm^2, 10 x 10 cm^2, 15 x 15 cm^2, 20 x 20 cm^2, and 25 x 25 cm^2. Field sizes are defined at the isocenter plane, 5 cm from the final field-defining aperture. Hardware is provided to facilitate the fabrication of custom final field defining apertures.

Electron Energy Groups

Table 1: Electron Energy Groups					
4-Electron Groups (standard)	**Nominal Electron Energy (MeV)**	**5-Electron Groups (optional)**	**Nominal Electron Energy (MeV)**	**6-Electron Groups (optional)**	**Nominal Electron Energy (MeV)**
Group I Group II Group III	4, 6, 9, 12 6, 9, 12, 15 6, 9, 12, 16	Group I Group II Group III Group IV	6, 9, 12, 15, 18 4, 6, 9, 12, 15 6, 9, 12, 16, 20 4, 6, 9, 12, 16	Group I Group II Group III	4, 6, 9, 12, 15, 18 6, 9, 12, 15, 18, 22 4, 6, 9, 12, 16, 20

Table 2: Electron Beam Performance								
	Depth of Ionization[1]				**Depth of Dose Value**		**Flatness[3]**	**Symmetry[4]**
Nominal Energy	**90%**	**80%**	**50%**	**30%**	**85%/2 (cm)[2]**	**80% (cm)**		**(MU/min)**
4MeV	0.89 ±0.1 cm	1.00 ±0.07 cm	1.26 ±0.1 cm	≤2.00	0.61	1.00	±7%	2%
6 MeV	1.71 ±0.1 cm	1.90 ±0.07 cm	2.32 ±0.1 cm	≤2.60	.93	1.95	±4.5%	2%
9 MeV	2.68 ±0.1 cm	2.95 ±0.07 cm	3.52 ±0.1 cm	≤3.90	1.45	3.00	±4.5%	2%
12 MeV	3.77 ±0.1 cm	4.15 ±0.07 cm	4.91 ±0.1 cm	≤5.40	2.02	4.25	±4.5%	2%
15 MeV	4.67 ±0.1 cm 3	5.20 0.07 cm	6.19 ±0.1 cm	≤6.80	2.57	5.35	±4.5%	2%
16 MeV	4.87 ±0.1 cm	5.45 ±0.07 cm	6.52 ±0.1 cm	≤7.30	2.67	5.60	±4.5%	2%
18 MeV	5.29 ±0.1 cm	6.09 ±0.07 cm	7.41 ±0.1 cm	≤8.15	3.04	6.40	±4.5%	2%
20 MeV	5.52 ±0.1 cm	6.57 ±0.07 cm	8.16 ±0.1 cm	≤9.30	3.26	6.90	±4.5%	2%
22 MeV	5.59	6.82	8.65	≤10.00	3.37	7.20	±4.5%	2%

[1] Depth of Ionization values apply to 15 x 15 cm^2 applicator field size. Electron measurements are made at 100 cm TSD and a nominal 5 cm gap between the bottom of the open field aperture and the water surface. Measurements are defined with a 0.1 cm^3 PTW ionization chamber, or equivalent.

[2] D85%/2 is the depth at which flatness and symmetry are specified. Values are defined at 100 cm TSD using a 15 x 15 cm^2 electron applicator field size. No inverse square corrections are assumed.

[3] Flatness is defined as the maximum variation from the mean electron ionization within the central 80% FWHM region. The mean is the average of the maximum and minimum points within the central 80% FWHM region. This specification applies to square electron applicator field sizes from 10 x 10 cm^2 to 25 x 25 cm^2 measured on the radial and transverse axes. A specification of ±5% is applied to 6 MeV for 10 x 10 cm^2 applicator field size. The diagonal flatness specification for the above applicator field sizes is ±5%, except 4 MeV. The 4 MeV flatness specification applies only to the radial and transverse axes.

[4] Symmetry is defined as the maximum difference between the ionization delivered to any two points that are equidistant and symmetrical about the central axis and within the central 80% FWHM region. This specification applies to the plane normal to the central axis and to square electron applicator field sizes from 10 x 10 cm2 to 25 x 25 cm2, except 4 MeV. The 4 MeV specification applies only to the radial and transverse axes.

2.4 X-ray Contamination: For nominal energies up to 10 MeV, the X-ray contamination is less than or equal to 2%. For nominal energies greater than 10 MeV, the X-ray contamination is less than or equal to 5%. This specification is defined in water with a 100 cm TSD, at a depth of 10 cm beyond the depth of the 10% isodose line, with a 15 x 15 cm^2 electron applicator.

2.5 Patient Plane Leakage: Electron leakage is less than or equal to 2% of the absorbed dose on central axis. This specification is defined in air, at 100 cm TSD with 1 cm buildup, in an area 4 cm outside the 50% isodose line.

2.6 Applicator Side Plane Leakage: The leakage does not exceed 9% of central axis ionization at D_{max}. This specification is defined along a plane coincident to the side of the electron applicator, measuring 10 cm up from the bottom of an applicator.

3.0 Accelerator System Features

3.1 RF Power Source: Varian's high-efficiency klystron is operated in linear amplifier mode and driven by a solid-state oscillator, with power and frequency automatically locked to required operating levels.

3.2 Electron Gun: The unique triode design of the electron gun allows exact and safe control of electron beam levels in the accelerator. It provides the ability to rapidly and precisely vary output dose rate and turn the beam on or off. This capability is especially important in dynamic dose delivery, where high-speed beam gating and elimination of dark current during beam-off time periods is important. The gun is demountable, resulting in minimum system downtime during replacement.

3.3 Standing Wave Accelerator: The Varian sidecoupled cavity accelerator structure has been developed for optimum use of RF power and narrow output spectrum at the design energy for the guide. Spectrum characteristics, with and without use of an energy switch, have been matched to the transport requirements of the downstream bend magnet to ensure high dose rate capability.

3.4 Patented Non-Contacting Energy Switch: In each of the X-ray treatment modes where this is utilized, the switch functions to change the ratio of electric fields between two sections of the accelerator guide. This is done in such a way as to ensure a tight energy spectrum over a wide range of photon energies, with consequent high output capability and stable operation.

3.5 Solenoid: A full-length magnetic solenoid assures high electron beam transmission through the accelerator structure, resulting in reduced stray-radiation and efficient use of RF power.

3.6 Bend Magnet: This patented 270° bend magnet is fully achromatic, with one-to-one imaging for superior transport and control of the beam from the accelerator. The magnet is also equipped with energy slits fixed at ±3%, enabling output beams of consistently high quality and precise dosimetry.

3.7 Radial and Transverse Steering Systems: These systems ensure basic beam alignment in all modes, as well as gantry orientation. Ion chamber sensors, in conjunction with the steering coils and servo electronics, maintain beam symmetry changes to within 2% under all conditions.

4.0 Dosimetry System

The following specifications apply for both independent dosimetry channels:

4.1 Reproducibility with Energy: Precision of the dosimetry measurement system for each energy is ±1% or ±1 MU, whichever is greater, at a fixed dose rate.

4.2 Dose Calibration Linearity versus Total Dose:

The linearity is as follows:
- 1% for 20-999 MU
- 2% for 10-20 MU
- 3% for 5-10 MU

4.3 For photon Beam I and optional Photon Beam II, doses up to 999 MU can be delivered. For the optional SRS 6 MV Beam, doses up to 6,000 MU per field can be delivered. For all electron beams, doses up to 999 MU (4,000 MU optional) can be delivered. For photon arc beams, doses up to 999 MU (1,999 MU optional) can be delivered.

4.4 Reproducibility of Dose vs. Gantry Angle: The precision of the dosimetry system is ±1.5% at any gantry angle from 0 to 360 degrees.

4.5 Reproducibility with Dose vs. Dose Rate: The dose rate dependence of the dosimetry system with variations in dose rate from minimum to maximum is less than ±1% or ±1 MU, whichever is greater.

4.6 Beam-Off Interlocks: The radiation beam automatically terminates in the event of any of the following:

- Monitor Units 1 complete
- Monitor Units 2 complete
- Treatment time complete
- Radial symmetry exceeds 2%
- Transverse symmetry exceeds 2%
- Excess dose rate
- Excess dose per pulse
- Excess dose per degree
- Loss of ion chamber bias voltage
- Under dose rate

5.0 Mechanical Features

5.1 Gantry

5.1.1 Rotation Range: ±185° from the vertical

5.1.2 Target to Axis Distance: 100 ±0.2 cm

5.1.3 Mechanical and radiation isocenter accuracy - Standard beam isocenter accuracy (Optional Fine beam isocenter accuracy available, see Additional Options section 37)

5.1.3.1 ≤1 mm radius sphere for gantry and collimator axes without Retractable Beam Stopper

5.1.3.2 ≤2mm radius sphere for gantry, collimator and couch axes without Retractable Beam Stopper

5.1.4 Position Indicators

5.1.4.1 Scale Conventions

5.1.4.1.1 IEC Scale convention per IEC Publication IEC 60601-2-1

5.1.4.1.2 IEC 1217 Scale convention per IEC Publication IEC 61217

5.1.4.1.3 Varian Scale

5.1.4.2 Digital Readouts

- Accuracy: ±0.5°
- Resolution: 0.1°

5.1.4.3 Mechanical Scales:

- Accuracy: ±1.0°
- Resolution: 1.0°

5.1.5 Target to Surface Distance Indicators

5.1.5.1 Optical Distance Indicator:

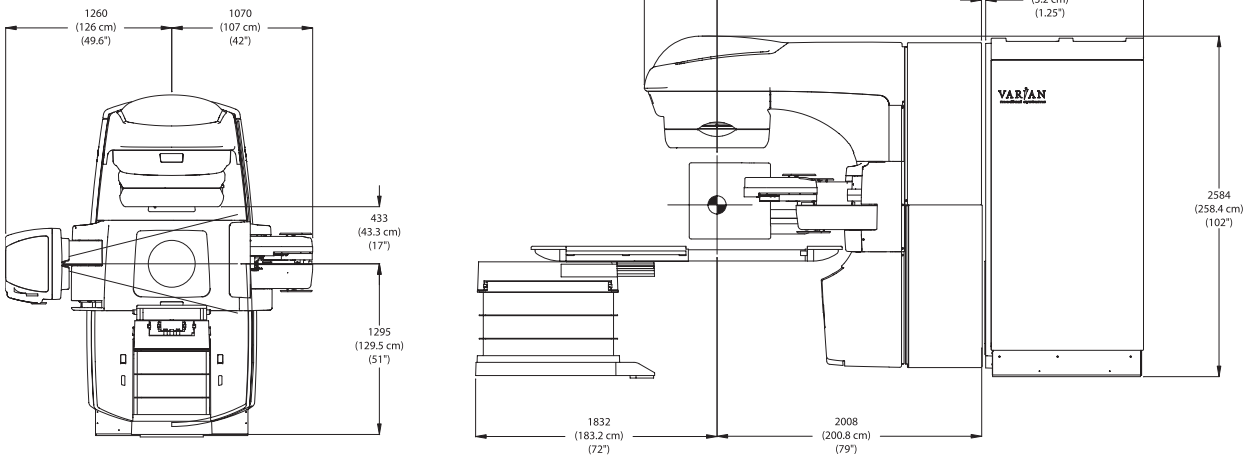
- Accuracy: ±0.1 cm at 100 cm
  ±0.5 cm at 70 cm and 156 cm
- Resolution: 0.5 cm

5.1.5.2 Mechanical Front Pointer:

- Range: 70-110 cm
- Accuracy: ±0.1 cm at 100 cm
- Resolution: 0.2 cm

5.1.6 Isocenter Height (nominal): 129.5 cm

Clinac iX Dimensions



* Optional OBI is shown on these dimensions
Illustration not to scale.

5.2 Collimator

5.2.1 Extended Rotation Range: ± 165°

5.2.2 Position Indicators (gantry and console)

5.2.2.1 Digital Readouts:

- Accuracy: ± 0.5°
- Resolution: 0.1°

5.2.2.2 Mechanical Scales:

- Accuracy: ± 1.0°
- Resolution: 1.0°

5.3 Field Size Collimation

5.3.1 Range: The field size is continuously variable from 0.5 x 0.5 cm^2 to 40 x 40 cm^2 as measured at 100 cm TSD. Field sizes larger than 35 x 35 cm^2 are limited to a 49.5 cm diagonal (the diameter of the circle defined by the primary collimator at 100 cm TSD). The field size is defined as the distance along the radial and transverse axes between the points of 50% density on an X-ray film taken at 100 cm TSD with minimum buildup.

5.3.2 Position Indicators

- Accuracy: ± 0.2 cm
- Resolution: 0.1 cm

5.3.3 Light and X-ray Field Coincidence: The field-defining light coincides to within 1.5 mm of the 50% isodensity line on an X-ray film. This is defined at 100 cm TSD with minimum buildup for any field size.

5.4 Exact® Couch with Indexed Immobilization® and the IGRT Couch Top

5.4.1 The Exact Couch is standard with Clinac CX accelerators. (Specifications and standard vs. optional accessories for the Exact Couch are provided on specification sheet RAD 1951A.)

5.4.2 Specifications and standard versus optional accessories for Exact IGRT couch top are provided in Specifications Sheet RAD 2661.

5.4.3 Motion Controls

The hand pendants and the couch side panels provide a variable speed control.

- Two Hand Pendants control both Clinac CX and Exact Couch
  All axes of the Exact Couch can be moved simultaneously through the pendants
- Two Couch Side Panels

5.5 Compact stand assembly

5.5.1 Single access and through-door viewing of all gas and water system status indicators

6.0 4D Integrated Treatment Console

The 4D Integrated Treatment Console provides a streamlined front end to the Clinac iX delivery system. The console integrates use of the Clinac iX accelerator, Millennium™ MLC (MLC 80 and MLC 120), and MV imager into one application on a single workstation. For image-guided radiotherapy using kV images, the console is used in combination with the On-Board Imager® kV imaging system workstation. The 4D Integrated Treatment Console uses a DICOM RT interface to communicate with the ARIA® oncology information system and other information system databases.

7.0 Accessories

The following accessories are included as standard with Clinac iX and the Exact Couch:

7.1 Collimator Accessories:

- Interface Mount
- Accessory Mount
- Port Film Graticule
- 4-Way Wedge Set (four wedges 15°, 30°, 45°, 60°)
- Five Electron Applicators: A set of five electron applicators is provided, with selection from 6 sizes: 6 x 6 cm^2, 6 x 10 cm^2, 10 x 10 cm^2, 15 x 15 cm^2, 20 x 20 cm^2, and 25 x 25 cm^2.
- Custom Aperture Fabrication Hardware
- Mechanical Front Pointer (holder and 4 rods)
- Drilled Star or solid block trays (Qty 10-0.635 cm thickness)

7.2 Accessory Spare Parts Kit

ADDITIONAL OPTIONS

1.0 Treatment Procedures

1.1 High Dose Total Skin Electron Mode: The Clinac iX accelerator is capable of delivering electron treatments at high dose rates for the purpose of total body skin irradiation with electrons. The dose rate at 1.6 m is 888 MU/min, corresponding to nominally 2,500 MU at isocenter. This mode is available in 6 MeV or 9 MeV.

1.1.1 X-ray contamination at calibration point is <1%.

1.1.2 Symmetry at isocenter is ±2%.

1.1.3 Integrated dose monitor: 1 to 9,000 MU.

1.1.4 Exposure time: 0.1 to 99.9 min.

1.2 Total Body Electron Mode: Delivers 9,000 MU at isocenter with all normal machine safety and dosimetry interlocks operational, and delivers standard energies at standard dose rate ranges.

1.2.1 Special TBE accessory tray is provided.

1.2.2 All beams are calibrated at machine isocenter.

1.2.3 Integrated dose: 1 to 9,000 MU.

1.2.4 Exposure time: 0.1 to 99.9 min.

1.3 Total Body Photon X-ray Mode:

Delivers 9,000 MU at isocenter with all normal machine safety and dosimetry interlocks operational, and delivers standard energies at standard dose rate ranges. Special TBI accessory tray is provided.

1.3.1 All beams are calibrated at machine isocenter.

1.3.2 Integrated dose: 1 to 9,000 MU.

1.3.3 Exposure time: 0.1 to 99.9 min.

2.0 Auto Field Sequencing

Auto Field Sequencing (AFS), for use with the 4D Integrated Treatment Console (refer to 4D Integrated Treatment Console Product Brief, RAD 2768A for information and specifications), is optional with the Clinac iX accelerator, and provides automated delivery of multiple coplanar and non-coplanar fields. With this time saving feature, Clinac iX automatically acquires the mode up signal and machine setup information from the 4D Integrated Treatment Console, and then allows the operator to remotely move the gantry, jaws, collimator, and Exact Couch axes (with purchase of optional Remote Couch Motion capability) between coplanar and noncoplanar treatment fields. This feature eliminates the need to go back into the treatment room to alter the machine setup between treatment fields. AFS works in concert with the Millennium MLC to deliver both static and dynamic plans efficiently and smoothly. (Refer to Auto Field Sequencing, RAD 6045.)

3.0 Dynamic Treatment Procedures

3.1 Standard Photon Arc Mode and optional Electron Arc Mode: The Clinac iX accelerator is capable of delivering the following dose over a preset gantry rotation of up to 360 degrees or any fraction thereof. MU per degree (MU/DG) is automatically computed based on the preset total dose and the preset arc segment.

Photon Beam I	0.30 MU to 20 MU per degree
Photon Beam II (optional)	0.30 MU to 20 MU per degree
SRS 6 MV Beam (optional)	0.30 MU to 60 MU per degree
All electron beams	0.30 MU to 20 MU per degree
High-Intensity Mode	0.30 MU to 60 MU per degree

31.1 Precision: During Arc treatment, the position of the gantry deviates no more than 0.5 degrees from the desired instantaneous gantry angle, and the dose deviates no more than 0.20 MU from the desired instantaneous total dose, as specified by the user-preset total dose and arc segment.

If these tolerances are exceeded, the dose delivery is suspended and the gantry position is targeted to the position dictated by the actual dose delivered. When the gantry is again within 0.5 degrees of the desired position, the treatment will resume. The Dose Position Interlock (DPSN) is asserted if the gantry is not positioned within 0.5 cm of the desired position within 3 seconds.

The DPSN will terminate the beam immediately if the position deviates 3.0 degrees or more from the desired position, or the dose delivered exceeds 0.45 MU for dose rates less than 600 MU/min (0.54 MU for dose rate 600 MU/min and 0.72 MU for dose rates greater than 600 MU/min, applies to version 7.8 and above).

3.1.2 Arc Dose Rate: The dose rate during a dynamic arc treatment is automatically modulated between zero and the ceiling dose rate selected in Physics Mode.

3.1.3 Arc Direction: The Clinac iX may be programmed to perform arc therapy in either a clockwise or counterclockwise direction.

3.2 Enhanced Dynamic Wedge (EDW) Mode: Optional EDW can be used with either Beam I or optional Beam II. EDW utilizes Y-jaws to create wedge shaped dose distributions. Enhanced Dynamic Wedges of 10, 15, 20, 25, 30, 45, and 60 degrees are included, with up to 30 cm (wedge direction) by 40 cm field sizes. (Refer to Enhanced Dynamic Wedge Specification, RAD 1880C.)

4.0 Dynamic MLC Techniques

Intensity-modulated radiation therapy (IMRT) and conformal arc therapy are optional advanced dynamic procedures in which the leaves of the optional Millennium MLC move during treatment. Refer to MLC Dynamic Control Specification, RAD 5610B for additional information and specifications.

4.1 Arc Dynamic MLC allows delivery of MLC fields as a function of gantry arc angle, also known as conformal arc therapy. An MLC shape change every 2° is supported. The MLC shape is interpolated between the 2° control points.

4.2 Dose Dynamic MLC allows delivery of MLC fields as a function of percent dose delivered, also known as IMRT. Both dynamic IMRT (i.e., sliding window) and segmental IMRT (i.e., step-and-shoot) techniques are supported. Combinations of the two IMRT techniques also are supported. In addition, Dose Dynamic MLC enables treatment delivery with electronic compensation, in which MLC leaf motion simulates the dosimetric effect of a physical compensator.

5.0 Stereotactic Mode

The Clinac iX accelerator is capable of delivering stereotactic treatments at high dose rates and with remote couch motion. This mode is available with purchase of the optional SRS 6 MV photon beam. Both cone and MLC-based treatment delivery is supported. Beam flatness, symmetry, and other specifications can be found in Table 2, Photon Beams, on page 2.

5.1 Dose Rate: 800 MU per min at D_{max}

5.2 Maximum dose per field: 6,000 MU

5.3 Maximum field size: 15 x 15 cm^2

5.4 Maximum dose per degree for arc treatments: 60 MU per degree

5.5 Stereotactic Motion Disable

5.5.1 Mechanical couch locks

5.5.2 Electrical disable for gantry and couch

6.0 Low Dose Rate (LDR)

The Low Dose Rate option allows dose rate selection of 5, 10, 15, 20, 40, 60, 80 MU per min in addition to the standard dose rate set of 100-600 MU per min. The option is available for Beam I and optional Beam II.

Reproducibility vs. Dose Rate
- ≤10 MU/min: ±10%
- 15-20 MU/min: ±5%
- ≥40 MU/min: ±2%

Reproducibility vs. MU
- ≤10 MU: ±3%
- 15-20 MU: ±2%
- ≥20 MU: ±1%

7.0 Extended Programmable MU

Increases the maximum number of MU which can be associated and delivered for a single field (or subfield) for a static gantry IMRT delivery, up to 1999 MU.

8.0 Treatment Command Center

Ergonomic command center configuration places all control modules, monitors, and user interaction devices within easy reach of the operator. Direct access application selection simplifies the workspace by reducing the number of input devices (e.g., keyboard and mouse), while allowing continuous viewing of all applications.

9.0 In-Room Display

A high-resolution, flat screen, color display monitor is included for in-room display of Clinac iX accelerator parameters and patient-specific information.

10.0 Clinac iX Treatment Console Area Packaging

Compact packaging and cable management of Varian-provided workstations, control modules, and other ancillary devices for easy site preparation and enhanced treatment console area space management. A variety of packaging configurations are available for optimal utilization of the available space.

11.0 Millennium 80 Multileaf Collimator (MLC 80)

The MLC 80 offers 1.0 cm leaf resolution at isocenter for a 40 cm x 40 cm field. The Millennium MLC operates in static, dynamic, and conformal arc modes. The static mode provides efficient beam shaping for 3D conformal radiation therapy. The dynamic mode enables IMRT with both step-and-shoot and sliding window delivery. The conformal arc mode enables conformal arc therapy in which the leaves always conform to the outer boundary of the target as the gantry rotates around the patient.

Refer to the MLC specifications table on page 12 for detailed information.

12.0 Millennium 120 Multileaf Collimator (MLC 120)

The MLC 120 offers 0.5 cm leaf resolution at isocenter for the central 20 cm of the 40 cm x 40 cm field. The Millennium MLC operates in static, dynamic, and conformal arc modes. The static mode provides efficient beam shaping for 3D conformal radiation therapy. The dynamic mode enables IMRT with both step-and-shoot and sliding window delivery. The conformal arc mode enables conformal arc therapy in which the leaves always conform to the outer boundary of the target as the gantry rotates around the patient.

Refer to the MLC specifications table on page 12 for detailed information.

Millennium 80 and 120 Multileaf Collimators (MLC 80, MLC 120)

All scale references below are per IEC 61217

Performance Specifications	Specification	
	MLC 80	MLC 120
MLC leaf end position accuracy at all leaf positions relative to the collimator axis[1] MLC leaf end position reproducibility at all leaf positions relative to the collimator axis[1]	±1 mm ±0.5 mm	±1 mm ±0.5 mm
Descriptive Specifications	**Specification**	
	MLC 80	**MLC 120**
Number of leaves	80	120
Central high resolution leaf width (central 20 cm, leaf width projected at isocenter)	10 mm	5 mm
Outboard leaf width (outer 20 cm, leaf width projected at isocenter)	10 mm	10 mm
Maximum static field size[3]	40 cm x 40 cm	40 cm x 40 cm
Maximum static aperture field size[3]	30 cm x 40 cm	30 cm x 40 cm
Maximum IMRT field size[3]	34 cm x 40 cm	34 cm x 40 cm
Maximum leaf retract position	20.1 cm from centerline	20.1 cm from centerline
Maximum leaf extend position	-20.0 cm over beam centerline	-20.0 cm over beam centerline
Maximum displacement between adjacent leaf ends at a single carriage position	15 cm	15 cm
Average leaf transmission[2]	< 2.5%	< 2.5%
Maximum interleaf leakage[2]	< 3.0%	< 3.0%
Maximum combined collimator leakage (jaws and MLC closed), all energies[6]	< 0.02%	< 0.02%
Mean leakage-area product per Gy delivered[7]	< 0.15 mGy-m^2	< 0.15 mGy-m^2
Maximum carriage speed	Variable from 0 to 1.2 cm/sec	Variable from 0 to 1.2 cm/sec
Maximum leaf speed	Variable from 0 to 2.5 cm/sec	Variable from 0 to 2.5 cm/sec
Relative leaf accuracy, leaf end to leaf end	0.25 mm	0.25 mm
Minimum static leaf gap (leaf end to leaf end)	0.0 mm	0.0 mm
Minimum dynamic leaf gap (leaf end to leaf end)	0.5 mm	0.5 mm
Leaf end penumbra at D_{max}[4,5]	< 4.0 mm	< 4.0 mm
Leaf interdigitation	Yes	Yes
Independent leaf and carriage motion	Yes	Yes

1 Projected at the isoplane.

2 Leakage specified as percentage of total dose per field or dose segment, measured with jaws fully retracted, using 4 MV through 10 MV energy configurations and 6X and 10X High Intensity energy configurations. Significant reduction in interleaf transmission is provided with static jaw shielding outside the treatment aperture or dynamic jaw tracking of aperture.

3 Maximum physical field size, projected at the isoplane.

4 Penumbra defined as 20-80% leaf end, measured using 10 cm x 10 cm field size, 6 MV at D_{max}, 100 cm SAD.

5 For additional IEC performance specifications for the MLC, please refer to 1000056876-01 Clinac IEC accompanying documents 60976 Functional Performance Characteristics V 9.0.

6 Maximum combined collimator leakage includes MLC and jaws and is measured for all energies. Mean leakage is 0.01%.

7 Mean leakage-area product represents integral leakage dose over the combined aperture area defined by the MLC and jaws. Leakage area product is calculated based on using 1 Gy dose output, a 5 cm radial MLC aperture and a jaw aperture of 10.4 cm x 11.6 cm.

13.0 Large Field IMRT (LFIMRT):

Allows the maximum allowable IMRT field to be delivered as a single planned field.

14.0 Custom Coding

Custom Coding provides Clinac iX system recognition of the presence of one or more beam-shaping accessories. Accessory recognition includes confirmation of the presence of a beam-shaping accessory in one of four possible accessory positions and identification of the type of accessory. Standard Varian beam-shaping accessories (e.g., 30-degree wedges) are identified by name. Custom beam-shaping accessories (e.g., blocks in Varian-provided block trays or custom final field defining apertures for electron applicator systems) are identified by a custom code for that accessory.

15.0 PortalVision aS500-II MV Imaging System

The PortalVision™ aS500-II is an MV imaging system that allows for verification of patient setups, treatment portals, and Portal Dosimetry.

The amorphous silicon detector has an active imaging area of 40 cm x 30 cm with a pixel resolution of 512 x 384. Image acquisition is supported before, during, and after treatment.

Match and Review IGRT software is included for image analysis.

A motorized, robotic arm is used to position and hold the detector.

Refer to PortalVision aS500-II Specification, RAD 2600B for information and specifications.

16.0 PortalVision aS1000 MV Imager

The PortalVision™ aS1000 is an MV imaging system that allows for verification of patient setups, treatment portals, and Portal Dosimetry.

The amorphous silicon detector has an active imaging area of 40 cm x 30 cm with a pixel resolution of 1024 x 768. Image acquisition is supported before, during, and after treatment.

Match and Review IGRT software is included for image analysis.

A motorized, robotic arm is used to position and hold the detector.

Refer to PortalVision aS1000 Specification, RAD 2553A, for information and specifications

17.0 MV Image Based IGRT

The MV-repositioning option offers 2D/2D Match and Marker Match (orthogonal paired images) using Digitally Reconstructed Radiographs (DRRs) or simulator images as reference and remote arm options for easy and safe operation. Uses remote couch motions for easy patient repositioning.

18.0 On-Board Imager kV Imaging System

The On-Board Imager provides high-quality kV images in the treatment room for target localization, patient positioning, and motion management. Refer to On-Board Imager Specification, RAD 9502G, for information and specifications. The following clinical capabilities are supported:

- Online setup correction based on either a kV-kV or kV-MV pair of radiographs
- Automated and manual alignment of a pair of radiographs to their reference images
- Acquisition of gated radiographs
- Online setup correction based on radiopaque markers
- Pretreatment verification of gated treatment portals using kV fluoroscopy
- Remote couch motion to correct patient setups
- Acquisition of Cone-beam CT (CBCT) scans

19.0 Remote Couch Motion

Control of couch motion at the treatment console for

- Corrective motions: small translations (in x, y, and z) and small rotation of the couch to fine-tune patient setups
- Planned motions: large rotations of the couch to sequence between non-coplanar fields and arcs

20.0 Real-time Position Management (RPM) System

The RPM system enables passive, real-time monitoring of patient respiration for the purpose of intrafraction motion management. Two gating systems are provided. Each system includes an infrared tracking camera, external marker block, and RPM system workstation. The RPM system supports gated treatment delivery and image acquisition on Clinac iX accelerators, gated simulation on compatible simulators (not all simulators are supported), and gated CT acquisition on compatible third-party CT scanners (not all CT scanners are compatible). Depending on the capabilities of the CT scanner, the RPM system supports both retrospective and prospective gating of CT scans. Refer to Real-time Position Management™ Specification, RAD 5616A for additional information.

21.0 LaserGuard Collision Detection System

LaserGuard™ monitors the MLC collimator face with a plane of infrared light that emanates from a device located within the gantry. Any object that intrudes into this area, called the protection zone, triggers an emergency stop of all accelerator motion.

Refer to Auto Field Sequencing with LaserGuard Specification, RAD 6046 for information and specifications.

22.0 Portal Dosimetry

Portal Dosimetry enables use of the MV imager to record the intensity patterns of IMRT and RapidArc® radiotherapy technology fields for pretreatment quality assurance of IMRT planning and delivery.

Refer to RAD 2559C.

Portal Dosimetry includes integrated image acquisition mode for recording of IMRT and RA fields and image viewing and analysis software. (*Use of the image analysis software is optimized when the reference dose image is calculated as dose to amorphous silicon. Currently, only the Eclipse™ treatment planning system offers this capability.)

Portal Dosimetry does not support High-Intensity Mode. Portal Dosimetry for RapidArc requires aS1000.

23.0 Silhouette® Edition

Clinac iX configuration that fits into an existing vault with a minimum room size of 16 feet (4.9 m) width by 19 feet (5.8 m) length. A variety of configuration and artistic panel options are available for creation of a customized radiation therapy treatment environment.

24.0 Laser Alignment System

- Wall and ceiling laser kits for patient positioning are available in red, blue and green color options
- A diode back pointer line laser is available

25.0 CCTV Camera System

This two-camera CCTV system is used for monitoring patient activity inside of the treatment room and patient activity from outside the room at the treatment console.

26.0 Patient Intercom System

The Patient Intercom System is used for audio communication with the patient in the treatment room from the treatment console area.

27.0 Retractable Beam Stopper

Transmission and leakage beyond the edge of the beam stopper, for field sizes up to 35 x 35 cm^2, does not exceed 0.1%. With larger fields, leakage over a limited region beyond the diagonals can exceed this value to a maximum of approximately 0.3% for a 40 x 40 cm^2 field.

28.0 Factory Beam Data Set

The optional Factory Beam Data Set is provided in hard copy and ASCII file formats. The data include physical wedge profiles, machine mechanical parameters, and representative beam data. Clinac iX accelerators are expected to match the data set per the Basic Beam Matching specifications in Section 5.0. The data set is not a substitute for the commissioning process but an aid to speed that process as well as data entry to treatment planning systems. The factory data are representative of the Clinac iX accelerator manufacturing standard, not the specific machine delivered.

29.0 SmartConnect Technology

All Clinac iX systems are SmartConnect® ready. SmartConnect remote access technology connects the Clinac iX accelerator with Varian Customer Support for expert assistance and online remote analysis. Diagnostic and Morning Checkout Logs can be viewed remotely and transferred to Varian for report generation and trend analysis.

30.0 RapidArc Radiotherapy Technology Treatment Delivery

RapidArc generates IMRT quality dose distributions in a single optimized arc providing optimized treatment conformity. Dose per degree can be varied per degree of gantry motion.

Includes Extended Programmable MU option:

- Standard beams: Up to 7200MU
- 6X - SRS: up to 9999 MU

(Refer to MLC Dynamic Control Specifications, RAD 5610B)

31.0 Gated RapidArc

Gated RapidArc treatment has the capability to simultaneously modulate aperture shape, dose rate, and gantry speed continuously through 360 degrees of gantry rotation, while triggering beam-hold to limit the beam-on time to those points in the respiratory cycle where the target volume is within acceptable motion limits during an arc beam delivery.

32.0 Motion Management Interface

The Motion Management Interface allows external devices to “gate the beam delivery” and/or initiate requests for “couch shifts”. (Refer to RAD 10155)

33.0 ISOCAL

ISOCAL is a geometry calibration application that measures the treatment isocenter and the kV/MV rotation centers and their projections on the imagers over a 360° gantry rotation. It is used to correct subtle isocenter misalignments between the treatment plan, MV and kV Imagers. It uses a phantom with marker inserts of known geometry and a collimator plate insert. (Refer to RAD 10171)

34.0 Delta Couch Shift

Delta Couch is a system capability that allows the automatic application of predefined shifts to the couch position axes. Either Eclipse or 4D Integrated Treatment Console can provide the couch shifts that will be displayed on the In-Room monitor.

35.0 Integrated Conical collimator Verification and Interlock system

The Integrated Conical collimator Verification & Interlock system (ICVI) provides a robust and verifiable method of mounting and electronically verifying conical collimators. ICVI correlates the physically inserted conical collimator with the requirements of the treatment plan. An incorrect cone size triggers an interlock for increased patient safety. The ICVI includes 7 conical collimators of the following sizes: 4, 5, 7.5, 10, 12.5, 15 and 17.5 (all sizes in millimeters).

Fine beam Isocenter Accuracy is required for ICVI on Clinac iX.

36.0 High-Intensity Mode (HIM)

The 6X and 10X High Intensity energies have the same linear accelerator electron energies as their flattened beam counterparts, 6 MV and 10 MV, but their bremsstrahlung energy spectra are lower. The "6" indicates that the same accelerator electron energy for High Intensity is used as the electron energy for 6 MV standard/filtered beam energy. The following tables and graphs contrast the High Intensity beams with their flattened beam counterparts.

36.1 Available beam combinations for HIM

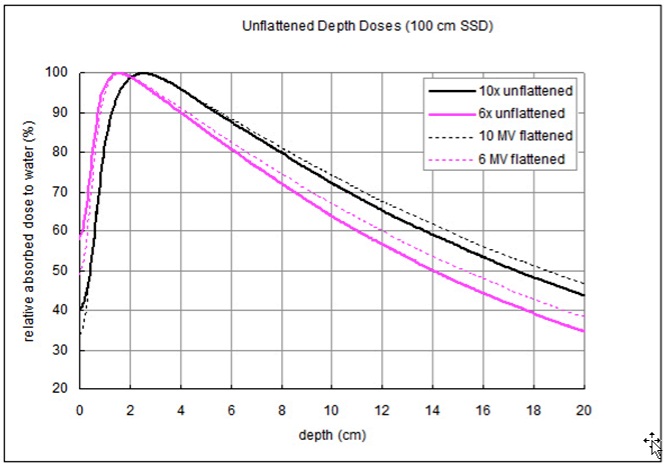
Beam I	Beam II	Beam III
6X	6X HIM	10X
6X	6X HIM	10X HIM
6X	6X SRS	10X HIM
6X	6X HIM	Any other single high energy

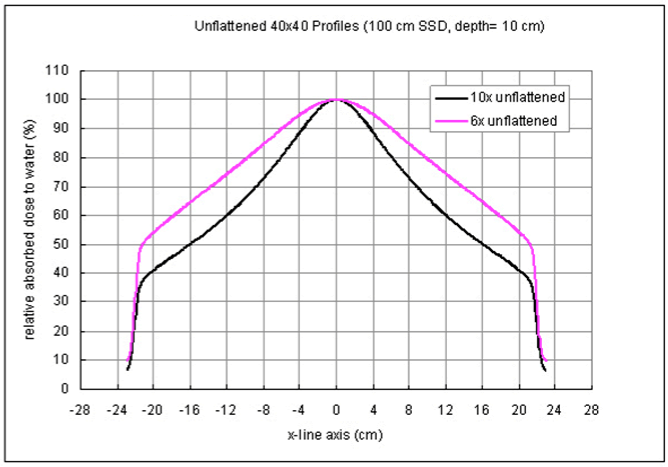
36.2 6 MV Flat Field Energy vs. 6X High Intensity Energy

Parameter	6MV Standard Flat Field	6X High Intensity
Bremsstrahlung target	Tungsten	Tungsten
Flattening filter	Copper	None
Maximum Dose rate on beam axis, at D_{max} (cGy/min)	600	1400
Mean electron energy on target	6.1	6.1
Dose at depth 10 cm (%)	67.2	64.3

36.3 10 MV Flat Field Energy vs. 10X High Intensity Energy

Parameter	10MV Standard Flat Field	10X High Intensity
Bremsstrahlung target	Copper	Tungsten
Flattening filter	Copper	None
Maximum Dose rate on beam axis, at D_{max} (cG y/min)	600	2400
Mean electron energy on target	10.5	10.5
Dose at depth 10 cm (%)	74.1	71.8





36.4 High-Intensity X-ray Energy Configurations

Performance Description	Specification							
	6X				10X			
D_{max} (cm)[1,7]	1.50 ± 0.15				2.34 ± 0.15			
% Depth dose at 10 cm Depth[1]	64.3 ± 1.0				71.8 ± 1.0			
Field intensity at 10 cm depth[6, 8]	± 2 cm	± 4 cm	± 6 cm	± 18 cm	±2 cm	± 4 cm	± 6 cm	± 18 cm
% dose (10 x 10 cm²)[2, 3]	97.5 ± 2.0	90.5 ± 2.0	-	-	95.5 ± 2.0	85.5 ± 2.0	-	-
% dose (40 x 40 cm²)[2, 3]	-	-	90.0 ± 2.0	59.5 ± 2.0			80.0 ± 2.0	45.0 ± 2.0
Symmetry (%)[4]	2.0				2.0			
Minimum dose rate (MU/min)[5, 7]	140				400			
Maximum dose rate (MU/min)[5, 7]	1,400				2,400			
Maximum field size	40 x 40 cm²				40 x 40 cm²			

[1] Depth of ionization applies to a 10 x 10 cm² field size measured at 100 cm source-to-surface distance (SSD).
[2] Relative dose and symmetry are specified at 100 cm SSD using 10 x 10 cm² and 40 x 40 cm² field sizes.
[3] Nominal field intensity distributions for high intensity X-ray energies are measured as shown in figures 3 and 4 below.
[4] Symmetry is defined as the maximum difference between the X-ray dose delivered to any two points which are equidistant and symmetrical about the central axis and within the central 80% FWHM region, measured at a depth of 10 cm.
[5] Dose output (MU) is defined as 1 cGy delivered to tissue-equivalent material at D_{max} and 100 cm SSD, with a 10 x 10 cm² field size. Measurement of dose output under conditions different than those defined herein may result in a higher or lower dose output than specified.
[6] Field intensity is relative to the central axis dose normalized to 100%.
[7] Maximum and minimum dose rates are specified at D_{max} and central axis. Dose rate will fall off lateral to the central axis in accordance with the lateral fall off of the field intensity.
[8] The % dose (30 x 30 cm²) is:
- for 6X at 4 cm (94.5 ± 2)%; at 14 cm (66.0 ± 2)%
- for 10X at 4 cm (88.5 ± 2)%; at 14 cm (53.0 ± 2)%

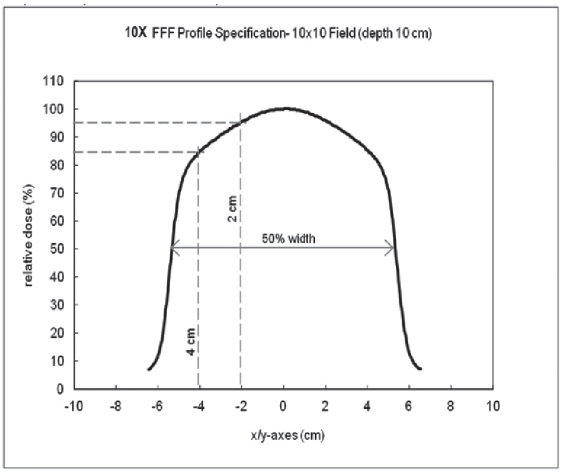


Figure 3: 10X FFF profile specification - 10 x 10 field (depth= 10 cm)

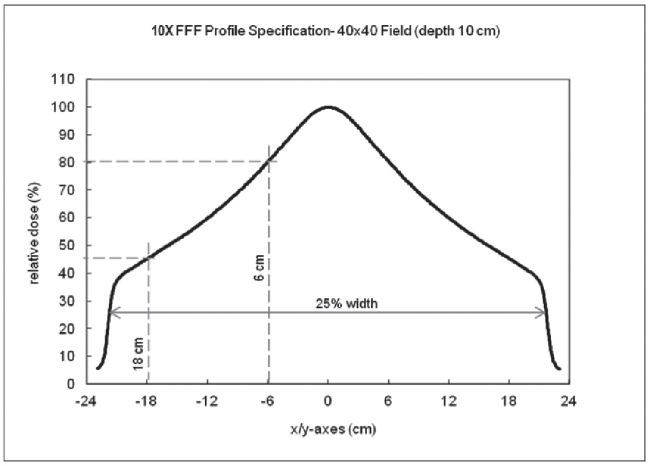


Figure 4: 10X FFF profile specification - 40 x 40 field (depth= 10 cm)

36.5 High-Intensity X-ray Energy Dosimetry System Specifications.

The following performance specifications apply to both the 6x and 10x energy configurations, unless noted otherwise

Performance Specifications	Specification
Reproducibility with energy: Dose output per monitor unit repeatability[1, 2]	± 1% or ± 1 MU
Dose output per monitor unit linearity vs. total dose[1] *(Note: diff spec for 6X 140 to 1400 and 10X 400-2400)*	6x: 1% for 50MU and above 10x: 1% for 100MU and above
Reproducibility of Dose versus Dose rate from minimum to maximum[1]	± 1% or 1MU whichever is greater
Reproducibility of Dose output per monitor unit vs. gantry angle	± 1.5%

[1] Measured with gantry at 0 per IEC 61217.

[2] Whichever is greater.

References

[1] Commissioning of Photon beams of a Flattening Filter-Free Linear Accelerator and the Accuracy of Beam Modeling using an Anisotropic Analytical Algorithm, Hrbacek, J., Lang, S., Klock, S., Int. J. Radiation Oncology Biol. Phys., 2011, in press.

[2] Dosimetric characteristics of unflattened 6 MV photon beams of a clinical linear accelerator: a Monte Carlo study, Appl Radiat Isot, 2007; 65(9).

37.0 Fine Beam Isocenter Accuracy

(52 inch base frame required)

37.1 Not available with Retractable Beam Stopper

37.2 <0.5 mm radius sphere for gantry and collimator

37.3 <0.75 mm radius sphere for gantry, collimator, and couch axes

Specifications subject to change without notice.

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