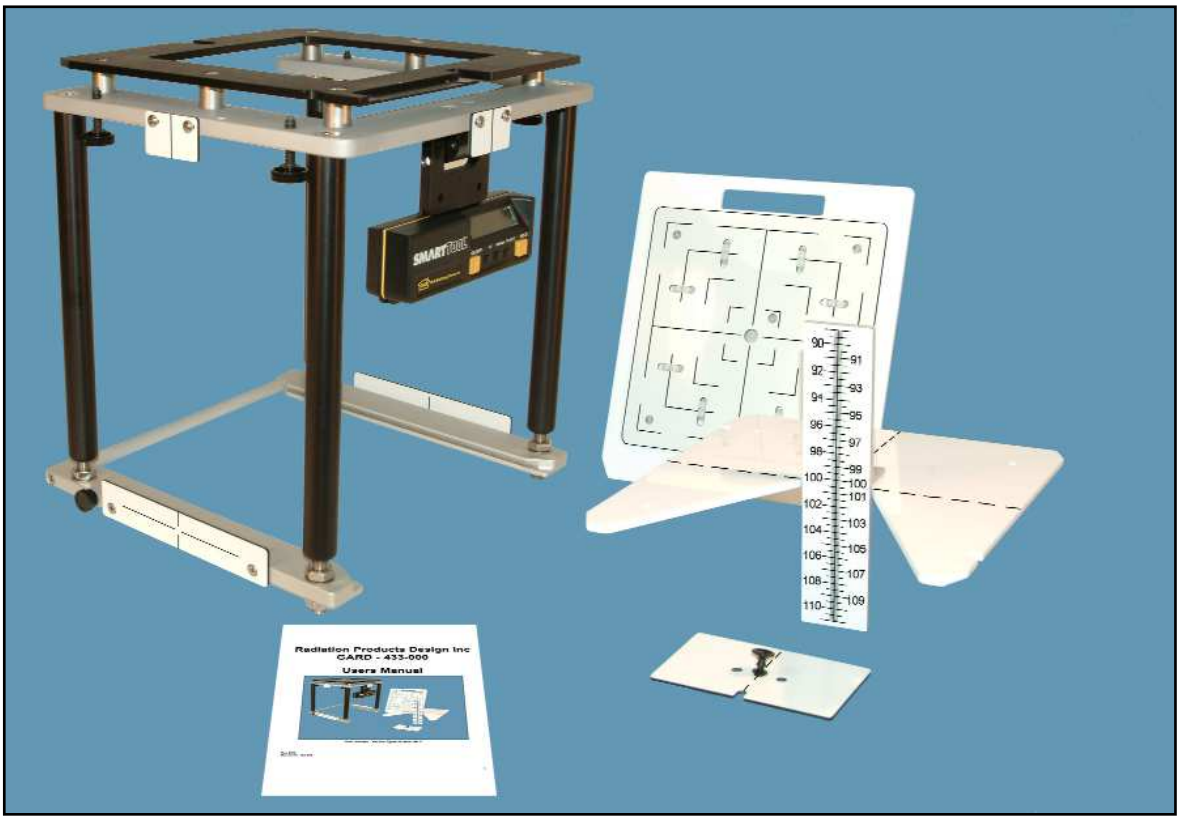
Radiation Products Design Inc
GARD - 433-000

Users Manual



Unit shown: Varian Type III with MLC

May 2013
Manual No. 433-000

GARD

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1.1 Introduction

A comprehensive quality assurance (QA) program is necessary to ensure that a radiotherapy machine can accurately reproduce and deliver the prescribed radiation dose to the target volume. It is of fundamental importance to test and verify the geometric accuracy of a radiotherapy machine in order to achieve this goal.

GARD is a tool designed to check the mechanical position and precision of movements of the modern isocentric radiotherapy machines. It fits into the block tray slot of a therapy machine, providing a fixed reference point for all measurements. This eliminates errors associated with using independent devices for the verification of each geometric parameter. GARD can be used to check field-positioning aids such as digital readouts, lasers, Optical Distance Indicator (ODI), light field and radiation field coincidence, and field flatness.
Option: Double Check Pro Holder.

Carefully unpack GARD and check that all the components are present. You should have the following pieces as pictured in Figure 1 to 8:

1. The main GARD unit with digital angle indicator.

2. A white plastic tray (Plate P1) for holding the cross-hair alignment plate and optical distance indicator. (Item 433-981)

3. Cross Hair Alignment Plate. (Item 433-983)

4. Optical distance indicator test scale. (Item 433-982)

5. Film Cassette tray for verification of light/radiation field (Item 433-980) coincidence,field size indicators, and cross-hair position (use film type Kodak #1822089 XTL-2, 8” x 10” Ready Pack).

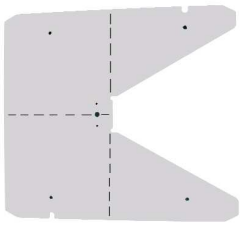
6. Cord Tray. (Item 434-983)

7. Hex key 5/32” (Item 80-018-01)

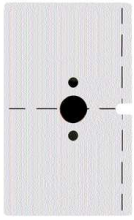
8. Instruction Manual No. 433-000.

If you are missing any component, please notify Radiation Products Design, at 763-497-2071 immediately.

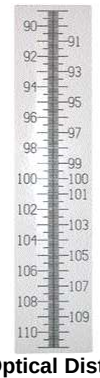
1. GARD



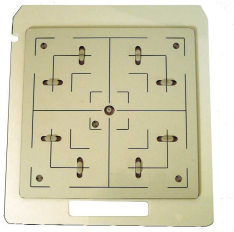
2. Plate P1 White Plastic Tray



3. Cross-Hair Alignment Plate



4. Optical Distance Indicator Scale



5. Film Cassette Tray (Front)

6. Cord Tray

1.2 Initial Calibration and Alignment of the GARD

A. The GARD unit is shipped specific for each model accelerator, completely assembled and ready for final adjustment, alignment verification and calibration of digital angle indicator, specific, for each accelerator as outlined below.

1. Alignment with isocenter and the isocentric frame of reference: Minor variations in the accelerator's accessory mounting device may exist.
   The distance from target to tray may have slight variations from unit to unit and alignment of the blocking tray slots with the collimator reference frame, etc., may vary slightly from machine to machine. For best results, it is, therefore, important to test and align the GARD to your treatment machine.

2. Patient positioning lasers may not have been installed in a precisely co-linear fashion. The laser positioning templates on the sides of GARD have been installed with the assumption of laser co-linearity, and will easily detect this.

   The following paragraphs include the step-by-step procedures for the installation and alignment of GARD. It is assumed that sufficient equipment and medical physics expertise is available to establish the standard isocenter reference frame against which GARD will be calibrated.

   The equipment used to align/adjust GARD:

   a. A precise four sided gantry level sensitive to changes of ± 0.025° - Optional -- **Item 352-200 and 352-201**
   b. Optical Distance Verification and Alignment Tool with ball pointer. Optional -- **Item 710-000**
   c. Plumb Bob with Cord -- **Item 352-120**
   d. A radiographic film packet (Kodak #1822089 XTL-2, 8” x 10” Ready Pack) for the initial light/radiation field alignment determination.

B. Prior to installing GARD, the accelerator gantry and collimator should be checked using the following conventional procedures:

- **Alignment of Cross hairs:** Rotate collimator CCW until it stops. Turn collimator light on. Place paper with black dot in center on the treatment table at isocenter and align with the center of the cross hairs. Rotate collimator CW and watch cross hairs so they do not move off the black dot. If movement occurs, cross hair adjustment is necessary. Repeat test. Make sure the cross hairs are parallel with the X & Y jaws.

- **Alignment Between the Collimator Visible Light and the Radiation Field:** Conventional radiographic film techniques as described in the literature should be referenced (see reference list at the end of manual). When adjusting collimator light source to the radiation field, use Kodak PPL-2 film and tape down to the couch. Use ball point pen and straight edge to outline the light field and cross-hair, and mark the film R, L, Gantry, and Foot on ready pack cover. Process the film. If the light field is not on the radiation field marked location, cover and place back on couch aligned with cross hair and R/L Gantry/Foot orientation. Adjust light field to radiation field on the ready pack cover.

- **Gantry Angle Adjustment:** The gantry should be placed in the upright position 0° with the beam pointing in the precise downward (vertical) direction. This can be accomplished with a precise four-sided gantry level. Gantry angle should read 0° Rotate to 90° and check gantry angle which should read 90°. Rotate to 180° and check gantry angle which should read 180°. Rotate to 270° and check gantry angle which should read 270°.

- **Gantry Vertical Check:** Rotate gantry to 0°. Verify using precise four-sided gantry level **Item 352-200**. Rotate collimator CCW until it stops; turn collimator light on. Tape white paper with black dot in the center to the floor, aligned with the center of the cross hairs. Rotate collimator CW and watch cross hairs so they do not move off the black dot. Rotate gantry to 180°. Verify using the precise gantry level. Mark center of cross hairs on ceiling. Hold the plumb bob cord at spot marked on ceiling; the weighted end should point to the center of the cross hairs on the floor. Any discrepancy on the head/foot direction means the gantry is not vertical.

- **Collimator Zero Angle Indicator Alignment:** Set the gantry at 0°. Set the collimator at zero. Set the couch top at isocenter. Turn on the collimator light and use the projected cross hairs to trace a line head to foot on the couch top mylar panel or thin paper placed over the tennis racket, then rotate gantry 180° - the cross hairs now project over the anterior cross hairs. **IF NOT**, adjust collimator zero indicator half the distance between anterior and posterior cross hair position. Check the collimator zero indicator at the new zero position. Repeat test.

- **Optical Distance Verification Check:** Use the Optical Distance and Verification Alignment Tool with Ball Pointer **Item 710-000.** This will be used to verify or adjust the ODI light source and locate the isocenter.

• **Determination of Accelerator Isocenter:** A stable pointing device must be positioned at the isocenter **Item 710-000**. Once precise alignment between the visible light and the radiation fields has been established, the positioning of this pointer at the isocenter can be accomplished by the technique of aligning the ball of the pointer to the center of the cross-hair shadow with the gantry positioned vertically and horizontally then rotating around the pointer. The cross hairs should remain on the ball. Holding a white paper card behind the ball pointer allows for easy visibility of cross hair shadows.

Once the ball of the pointer has been established at the gantry isocenter, extreme caution should be followed to avoid displacing it. The patient support/couch should not be bumped into or leaned on, etc.

• **SAD Check:** The distance to the isocenter should be measured using the therapy machine manufacturer's supplied calibration rod or check that the front pointer is correct to rotation center.

Care should be taken not to move the patient support couch, gantry, or collimator until the installation is complete.

• **Laser Alignment:** Rotate gantry to 45°. The side and top lasers should now be adjusted so that they precisely intersect at the isocenter (i.e., coincide at the ball of the pointer). If laser lines or cross patterns are used, these should be adjusted using levels so that the intersecting lines are in the horizontal and vertical axes. Hold thin paper or tissue paper, allowing the lasers to project through. The alignment is correct if both lasers project as a single image; a double image signifies misalignment of the lasers.

C. Installation of GARD

• **Insertion:** Plate P1 should be inserted into the slot at the bottom of GARD and locked in place with the spring plunger (Figure 8). (The direction of insertion of the Plate P1 should be as shown with its open side facing the pointer at the isocenter.) The cross-hair alignment plate should be snapped onto Plate P1 (Figure 9). GARD can then be inserted into the collimator head with the open side of the Plate P1 facing the ball pointer at the isocenter. (Be careful not to disturb this pointer!) Stop when closely approaching the ball pointer.

• **Adjusting/Verifying Height (Z):** If GARD is accurately aligned with respect to the isocenter; the pointer will be precisely in the center of the cross-hair alignment plate on Plate P1 (Figure 9). If necessary, the height of Plate P1 can be changed by making use of the height adjustment support rods. The nuts (Figure 10) at the bottom of these rods can be loosened and the height of the frame adjusted by turning the large hex nuts. During this adjustment, the user should make sure that the plate is perfectly level by resting a suitable level on the plate P1.

Figure 8
Spring Plunger

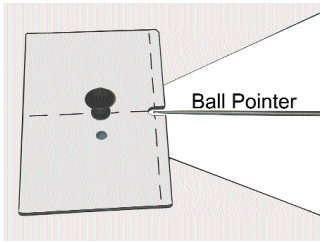


Figure 9
Plate P1 with crosshair alignment plate

• **Transverse and Longitudinal Adjustment/Verification (X-Y):** The X-Y direction of GARD should also be at the center of the open cross hair alignment plate on Plate P1 coinciding with the ball of the pointer and the cross hairs. This can be adjusted, if necessary, by means of the six bolts “A” (Figure 11), at the top of the GARD. Alignment of the accelerator cross hair shadows with the engraved center lines should be observed and maintained. The above procedure is continued until the cross hair alignment plate is in perfect alignment with respect to the pointer and cross hairs (Figure 9). The ball pointer can now be removed. The GARD should be tightened against the collimator head faceplate with the four nylon-tipped screws at “S” (Figure 12). Remove Plate P1 and insert film cassette holder. The accelerator cross hair shadows should align over the cassette engraved center lines.

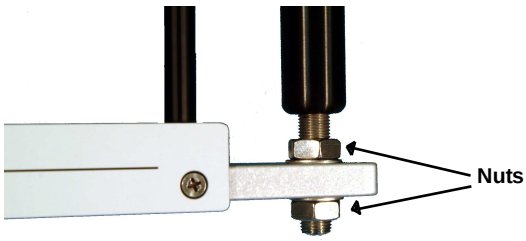


Figure 10

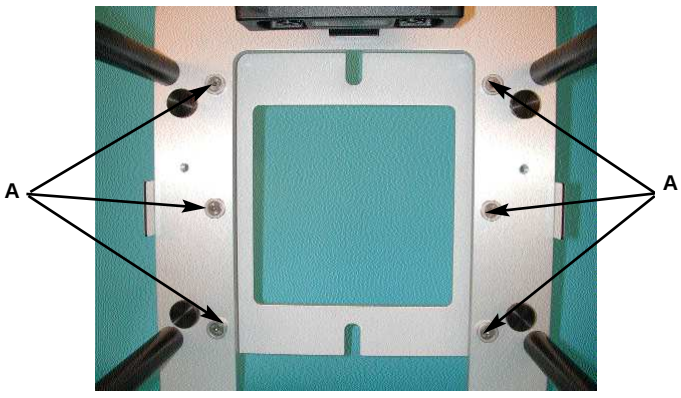


Figure 11

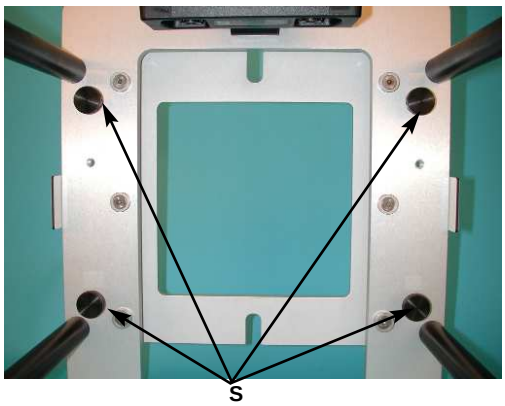


Figure 12

- **Laser Alignment Scales:** There are several laser alignment scales on the GARD. These are for the side lasers: two with black crosses to indicate the centers of the laser beam, as well as two at the top to add precision to the constancy check of the laser vertical lines. Since the lasers have been previously adjusted to meet at the isocenter and since GARD is now aligned to the isocenter, the side lasers should precisely align with the indicator marks on the sides of GARD. If they do not, it is an indication that the lasers are not precisely co-linear. If this is the case, the user should re-adjust the laser mountings so that they are co-linear.

- **Digital Angle Indicator Calibration:** Adjust gantry to zero, install GARD, rotate collimator to 0°. Stand with back against gantry and view digital angle indicator (Figure 13). Stop all motions for 10 seconds. To calibrate, Push and hold the “Calibrate” button for two seconds. Support hand with fingers from the back when pushing the CALIBRATE button so the angle indicator does not move. (CAL1) will appear briefly on the display then flashes numbers. Rotate collimator 180°. Stand at couch side facing gantry (Figure 13). Stop all motions for 10 seconds. Push the CALIBRATE button again. (CAL2) will appear briefly on the display then falshes numbers The digital angle indicator has now been calibrated for level.

- **Digital Angle Indicator Alignment:** A final check on the agreement between the angle indicator on GARD and the precise four sided gantry level should be made. The digital angle indicator can be used in two positions by rotating the angle indicator bracket. These two positions are used to verify and measure gantry angle (electronic level positioned parallel to the central axis with the gantry vertical, Figure 13) or for collimator angle measurements (gantry in horizontal position with electronic level positioned perpendicular to central axis, Figure 14). The electronic level readings should be checked against the digital indications for the vertical and horizontal gantry positions to confirm their agreement.

  If all of the above tests are performed and verified satisfactorily, GARD can be considered to be calibrated and ready for use on that particular accelerator. This calibration should be repeated as needed.

Figure 13

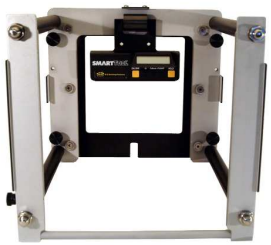


Figure 14

1.3 Routine QA Tests Using the GARD

The calibrated GARD is inserted into the collimator head as shown in Figure 15 and is machine locked to the collimator tray mount with four nylon-tipped thumb screws “S” (Figure 12) which are tightened against the bottom of the collimator mount to reduce all play.

Figure 15

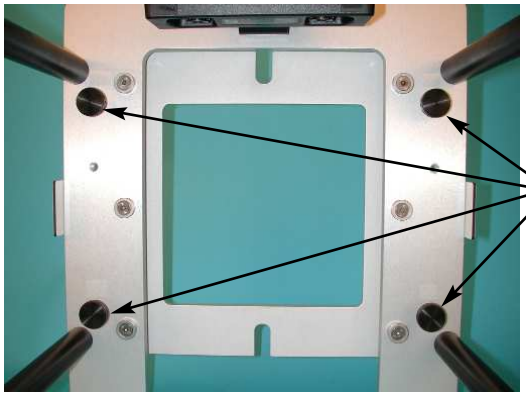


Figure 12

S

Test 1:

- **Optical Distance Indicator Check:** Snap the ODI test scale onto Plate P1 (Figure 16). Insert Plate P1 into the rails at the bottom of the GARD as shown in Figure 16 so that the accelerator optical distance indicator scale is projected onto the GARD ODI test scale. If the ODI is correctly adjusted, the two scales will match in the range of indicated SSD (90 cm to 110 cm).

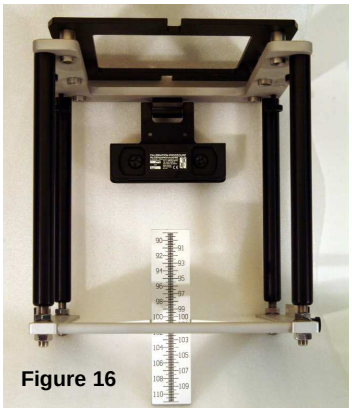


Figure 16

Test 2:

- **Gantry Angle Readout:** The digital angle indicator on the GARD is used to check the gantry angle readout at any arbitrary angle. The gantry angle readouts should then be checked for agreement with the digital angle indicator. Digital angle indicator reads +0° or -0° to +90° or -90°. Example: Gantry Vertical, Digital angle indicator reads -1°, Gantry readout reads 359°. (Figure 17)

Figure 17
Digital Angle Indicator in the Gantry Angle Position

Test 3:

- **Collimator Angle Readout:** In order to measure and verify collimator angles using the GARD, it is necessary for the gantry to be rotated to the horizontal (90° or 270°) position. The digital angle indicator must be lowered into its new position perpendicular to the central axis of the beam (Figure 14). The collimator angle readouts can be tested for any angle by reading the digital angle indicator. Agreement between the collimator readout and the specified collimator angle can then be determined.

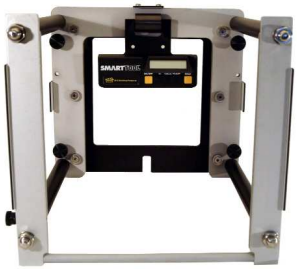


Figure 14
Digital Angle Indicator in the Collimator Angle Position

Test 4:

- **Side Laser Alignment**: For checking the alignment of the side lasers, it is important for the gantry to be in the (downward) vertical position and the collimator angle at 0° or 180° (parallel to the longitudinal axis). This orientation must be precisely determined using the built-in digital angle indicator as described in two previous tests. The side laser alignment can then be determined by matching the projection of the lasers to the two laser alignment templates on each side (left and right) of the GARD. (Figure 18)

- **Ceiling Laser Alignment:** Insert the white plastic tray (Plate P1) into the GARD upside down, snap the cross hair alignment plate into Plate P1. Rotating the gantry 180° precisely to the upward vertical position, check the alignment of the laser to the center of Plate P1 with cross hair alignment plate.

  An alternative method for checking side and ceiling laser alignment close to the isocenter is as follows:
  Insert Plate P1 with Cross Hair Alignment Plate upside down so the engraved cross pattern is facing away from the gantry head. Set the collimator to 0° rotation. Rotate the gantry to 0°, 90°, 180°, and 270°. At each position check the laser image against the engraved cross pattern on the Cross Hair Alignment Plate.

- **Sagittal Laser Alignment:** Rotate the collimator to 90°. The alignment of the sagittal laser can be determined using the white template at the top of GARD (vertical line) and the laser alignment template. Accurate couch alignment must be done with Test 9.

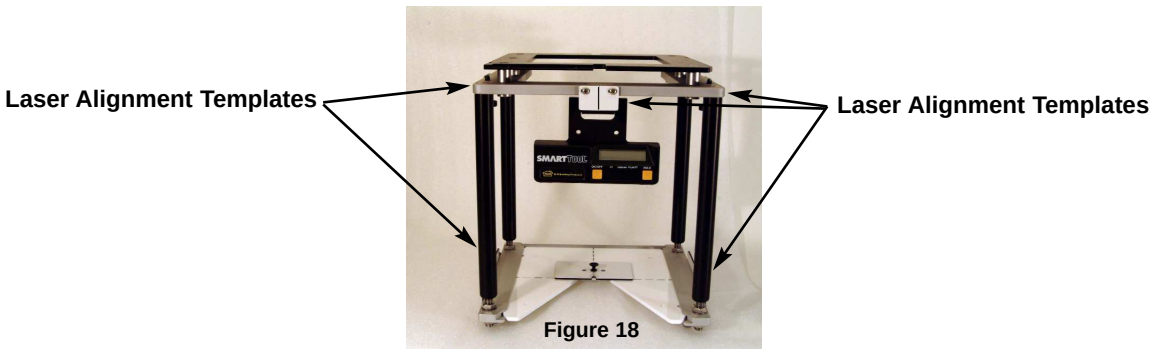


Figure 18

Test 5:

• **Cross-Hair Alignment and Field Size:** Insert film cassette tray into the GARD (Figure 19) with the field size verification side toward target (Figure 20).

Figure 19 Inserting the Film Cassette Tray

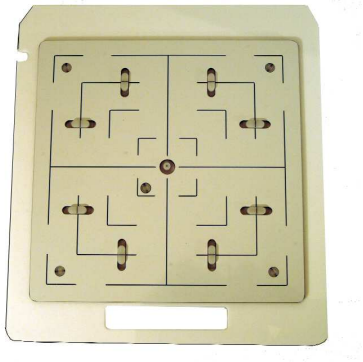


Figure 20 Front of Film Cassette Tray

• **Cross-hair Alignment Check:** If the visible light projection of the cross hair is correctly aligned, its shadow will coincide with the engraved black cross hair marks on the white surface of the film cassette tray.

• **Light Field Size Check:** The accuracy of the digital readouts for the light field size can be checked using the top of the film cassette tray. The white surface of the plate is scribed with standard square field sizes of 5, 10, 15, and 20 cm. Since the surface of this plate is at 100 cm SSD, these can be used to check the accuracy of the collimator jaws digital readout. The upper and lower collimator jaws should be adjusted until the edges of the visible light field best coincide to the calibration squares. The collimator jaws digital readouts should then be observed to check for agreement.

Test 6:

• **Light Field/Radiation Field Coincidence:** Insert the film cassette tray into the GARD with the field sizes toward the target. In order to check the coincidence between the visible light and radiation beams, a Kodak #1822089 XTL-2 - 8” x 10” Ready Pack film should be inserted into the film cassette. Set the collimator jaws to a 15 x 15 cm square field size. The film cassette contains nine (9) plastic sliders, two on each of the four field edges of a 15 cm field (Figure 20). The eight sliders contain five (5) tungsten rods spaced 2 mm apart which project an image onto the film inserted inside the cassette. Adjust the plastic sliders so that the black line (corresponding to the third or center tungsten-rod) is exactly at the corresponding edge of the light field. The center slider with a single tungsten pin is used to verify the position of the intersection of the cross hairs. It should be adjusted so that it corresponds to the center of the projected cross hair image.

Expose the film to the radiation beam so as to achieve an optical density of approximately 1.2 above background. After processing the film, the light/radiation field alignment can be verified by comparing the dark radiation field edge to the positions of the images of the tungsten rods. Clearly, perfect alignment is indicated by the radiation field edge passing exactly through the central tungsten rod. Since these rods are spaced center to center in 1 mm intervals, the exact discrepancy, if any, can be determined by eye to within 1 mm.

Test 7:

• **Multi-leaf Collimator:** Adjust multi-leaf collimator to a 15 cm square field. Adjust the eight sliders to the edge of field. Take film using Kodak #1822089 XTL-2, 8” x 10” Ready Pack.

Test 8:

• Couch Alignment:

Place a piece of masking tape on the center line of the couch surface and mark the center line of the couch on the piece of tape. Raise the couch surface to isocenter. Rotate Gantry to 0° using a precise level, turn collimator light on. Move couch L/R so cross hairs are on center line. Mark a black dot on the center line. Verify that the couch L/R readout is zero.

Rotate the collimator 180° while verifying that the cross hairs stay on the black dot. If movement occurs adjust the collimator. Rotate the couch base 270° or full rotation while verifying that the cross hairs do not move off the black dot. If movement occurs adjust couch base mechanically to center of rotation. To check the couch vertical movement, raise and lower the couch through full travel. The cross hairs should not move off the black dot. If needed adjust the couch vertical drive unit. Check scales and digital read out. Using weight on the table similar to that of a patient, check for sag by raising and lowering the couch through full travel.The cross hairs should not move from the black dot.

With the Gantry still at 0°, turn the collimator light on and verify that the cross hair is still on the black dot.
Rotate couch base to zero (Figure 24). Insert Cord Tray into the treatment tray slot. Rotate Gantry 90° CW, pull cord tight toward foot end of couch while putting a ballpoint pen through the hole in the tab for marking the arcs. Mark an arc line on the masking tape over the center line of the couch. Rotate Gantry to 270° CCW. Pull cord tight toward foot end of couch and mark an arc over the previous arc line. The intersection of the arcs is perpendicular to Gantry Rotation and must be on the center line of the couch when the base rotation is at zero. If arcs are not on the centerline of the couch, rotate couch base until arcs meet on the centerline of the couch. Repeat arc markings. Adjust the mechanical and digital zero locations in the couch base.

Cord Tray

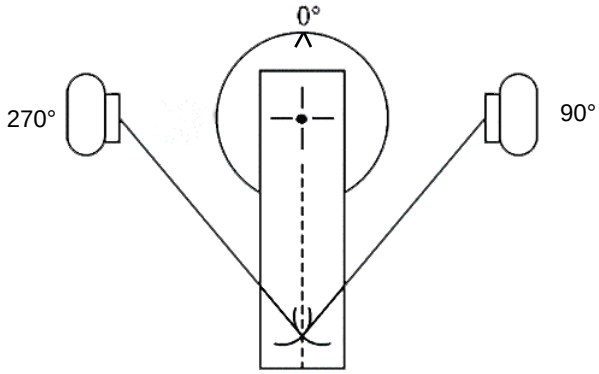


Figure 24

1.4 Summary

In summary, by integrating the GARD into a QA program, you can easily and quickly verify/check the following geometric parameters on a therapy machine:

1. Optical Distance Indicator (ODI for SSD Accuracy Range 90 cm to 110 cm) (Test 1)
2. Digital Readouts of
   - Gantry Angle (Test 2)
   - Collimator Angle (Test 3)
   - Field Size (Test 5)
3. Laser Alignment
   - Side Lasers (Test 4)
   - Ceiling Lasers (Test 4)
   - Sagittal Lasers (Test 4)
4. Light Field Localizer
   - Light/Radiation Coincidence (Test 6)
   - Cross-Hair Position Accuracy (Test 5)
   - Field Size Positional Accuracy (Test 5)
   - Multi-leaf Accuracy for 15 cm square field (Test 7)
5. Couch Alignment (Test 8)

1.5 Specifications

Electronic Digital Level Resolution: 0.1°
Optical Distance Indicator Resolution: 1.0mm
Field Size Indicators:
5 x 5 cm
10 x 10 cm
15 x 15 cm (with adjustable tungsten markers)
20 x 20 cm
Approximate Size: 33cm L x 32cm W x 38cm H
Weight: 9.5 lbs

1.6 References

AAPM Task Group 24, Svensson, G., Chairman, "Physical Aspects of Quality Assurance in Radiation Therapy," AAPM Report No. 13, May (1984).

Lutz, W.A., R.D. Larsen, and B.E. Bjarngard. "Beam Alignment Tests for Therapy Accelerators," Int. J. Rad. Onc. Phys. Biol. 7:1727 (1981).

Reinstein, LE., ed. Proceedings of the Workshop in Quality Control in the Radiotherapy Department, Cancer and Leukemia Group B, New York (1979).

1.7 Optional Equipment

Nickel-Plated Plumb Bob With Cord

The Plumb Bob can be used to align gantries, couches, laser lights, etc. Gantry vertical alignment can be accomplished by marking the cross hair projection spot on the ceiling and floor, then dropping a Plumb Bob line from the ceiling spot to the floor spot. The machine alignment is vertical when the Plumb Bob line intersects with the ceiling and floor spots.

Item #	Description
352-120	Plumb Bob with Cord

High Precision Four-Sided Gantry Level
1/40 Degree Accuracy

The four-sided High Precision Gantry Level (6” square x 3/4” thick) has a main vial that has graduated divisions of 0.005” per foot per division and is wrench adjustable. The level housing consists of a satin chrome brass tube with a friction fit closing cover to prevent breakage. The level frame is made of aluminum with a black anodized finish, accurately machined and finished on all four sides.
This level is used to check the gantry angle indicators at four locations: 0, 90, 180, and 270 degrees, with accuracy to 1/40 of a degree.

Item #	Description
352-200	Four-Sided Gantry Level
352-201	Case for Four-Sided Gantry Level

Optical Distance Verification and Alignment Tool With Isocentric Ball Pointer

This system will calibrate all optical distance indicators on accelerators, cobalts and simulators. The ball pointer is used to determine the rotational isocenter of the treatment machine collimator head and gantry. The ball pointer is also visible in fluoroscopy on simulators.

Instructions
Step 1
Determine the most useful range (40 cm or less) of the Optical Distance Indicator (ie. 80 cm to 120 cm range with a 100 cm isocenter). Set the white plastic tray five steps (20 cm) down from the top. Use an Accurate Mechanical Distance Rod (Model 700-000) adjusted for 100 cm isocenter and adjust the couch height until the pointer just touches the white plastic tray.

Step 2
Rotate the white plastic tray around 180º out of the field and adjust the cross hairs so that they align on the black dots.

Step 3
Raise the white plastic tray up 20 cm. This tray would show field light cross hairs intersecting with 80 cm. The black dots on the base represent the cross hairs and will intersect with 120 cm.

Step 4
Adjust the Optical Distance Indicator so that 80 cm and 120 cm are obtained at the same time. When both points are precisely on, linearity can be checked in 5 cm steps by moving the plastic tray down the rod.

Specifications

Optical Distances: 5 cm steps to 40 cm
Material: White plastic with matte finish and black dots
Ball Pointer: 12” L with 1/16” dia. ball
Rod Clamp
Base: 13 cm x 10 cm x 1/2” zinc plated steel w/rubber feet
Height: 43 cm
Weight: 4 lbs.

Item #	Description
710-000	Optical Distance Verification and Alignment Tool