## Table of Contents

Section 1: **Introduction** ................................................................................................ 1-1
1.1 Introduction ............................................................................................................... 1-1
1.2 Initial Calibration and Alignment of the GARD ....................................................... 1-2
1.3 Routine QA Tests Using the GARD .............................................................. 1-4
1.4 Summary ................................................................................................................ 1-7
1.5 Specifications.................................................................................................... 1-7
1.6 References ......................................................................................................... 1-7
1.1 Introduction

A comprehensive quality assurance (QA) program is necessary to ensure that a radiation therapy facility can accurately and reproducibly deliver the prescribed radiation dose to the target volume. It is of fundamental importance to test and verify the geometric accuracy of a radiotherapy unit 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 shadow tray 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), and also to inspect light and radiation field coincidence.

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

1. The main GARD unit.
2. A clear plastic tray (Plate P1) for holding the optical distance indicator and cross-hair alignment tool.
3. Optical distance indicator.
4. Cross-hair alignment tool.
5. Moire-Pattern Goniometer.
6. Film Cassette (Plate P2) for verification of light/radiation field coincidence, field size indicators, and cross-hair position.

If you are missing any component, please notify Fluke Biomedical, Radiation Management Services at 440.248.9300 immediately.

Figure 1-1. Main GARD Unit
1.2 Initial Calibration and Alignment of the GARD

A. Every effort has been made to deliver GARD in a precise calibrated and aligned status; however, it is the user's responsibility to verify the accuracy of the indicators. Minor adjustments may be necessary for the following reasons:

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 GARD to an established reference frame.

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. GARD, however, allows the user the choice of, a) reinstalling and aligning the lasers so that they are precisely co-linear, or b) adjusting the laser alignment templates to account for this "offset" and establishing a constancy test with respect to this new standard.

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 required to align/adjust GARD is:

1. A precise level sensitive to changes of $\pm 0.1^\circ$.
2. A stable "pointer" to be positioned at the isocenter.
3. A radiographic film packet for the initial light/radiation field alignment determination.
4. A calibration rod for precise SSD indication.

B. Prior to installing GARD, the accelerator reference frame should be established with the following conventional procedures:

- **Alignment Between the 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).

- **Determination of Accelerator Isocenter**: A stable pointing device must be positioned at the isocenter. 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 tip of the pointer to the center of the cross-hair shadow with the gantry positioned vertically and horizontally.

Once the tip of the point 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 ruler.

- **Collimator Alignment**: The collimator should be set at its standard orientation (either 0° or 180° so that the faces of one of the collimator pairs are parallel to the axis of gantry rotation (the longitudinal axis). This can be accomplished by orienting the gantry so that the beam is pointing in the horizontal direction and using a level to precisely adjust the collimator angle.
• **Gantry Adjustment**: The gantry should be placed in the upright position with the beam pointing in the precise downward (vertical) direction. This can be accomplished with the aid of a precision level.

NOTE

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

• **Laser Alignment**: The side and top lasers should now be adjusted so that they precisely intersect at the isocenter (i.e., coincide at the tip 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.

C. Installation of GARD

• **Insertion**: Plate 1 should be inserted into the slot at the bottom of GARD and locked in place with the locking key L1 (Figure 1-2A). (The direction of insertion of the plate should be as shown in Figure 1-2B with its open side facing the angle indicator of GARD.) The plastic “half-circle” cross-hair attachment used for the initial alignment should be snapped onto the plate as shown in Figures 1-2A and 1-2B. GARD can then be inserted into the collimator head with the open side of the plate and the angle indicator of GARD facing the pointer at the isocenter. (Be careful not to disturb this pointer!) GARD should be tightened against the collimator head faceplate with the help of four screws at its top S1, S2, S3, and S4.

![Figure 1-2A.](image1)

![Figure 1-2B.](image2)

• **Adjusting/Verifying Height (Y)**: If GARD is accurately aligned with respect to the isocenter; the "pointer" will be precisely in the center of the cross-hair attachment on plate P1. If necessary, the height of the plate P1 can be changed by making use of the height adjustment support rods. The bolts A1, A2, A3, and A4 at the bottom of these rods can be loosened and the height of the rods 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. Once the height adjustment is made, the rods can be fixed in place using the hex socket bolts and the lock-nuts.

• **Transverse and Longitudinal Adjustment/Verification (X-Z)**: The X-Z direction (see Figure 1-3) of GARD should also be the center of the open cross-hair circle on plate P1 coinciding with the tip of the "pointer". This can be adjusted, if necessary, by means of the six bolts A1, A2, A3, A4, A5 and A6 at the top of the GARD. (Alignment of the accelerator cross-hair shadows with the center lines etched into plate P1 should be observed and maintained.) The above
procedure is continued until the cross-hair attachment on plate P1 is in perfect alignment with respect to the "pointer". The "pointer" can now be removed.

- **Laser Alignment Templates**: There are several laser alignment indicators on 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 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 has the choice of re-adjusting the laser mountings so that they are co-linear or slightly offsetting the laser templates at the sides of GARD to account for this misalignment. This can be easily accomplished once the metal alignment pins on the laser templates are removed.

- **Angle Indicator (Moire Goniometer) Alignment**: A final check on the agreement between the angle indicator on GARD and the precision level should be made. The Moire Goniometer can be used in two positions by releasing the locking key L2 (Figure 1-3). These two positions are used to verify and measure gantry angle (goniometer positioned parallel to the central axis with the gantry vertical) or for collimator angle measurements (gantry in horizontal position with goniometer positioned perpendicular to central axis). The Moire Goniometer readings should be checked against the level indications for the vertical and horizontal gantry positions to confirm their agreement. Two adjustment screws are provided for precise calibration of the Moire Goniometer with respect to the reference level.

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

### 1.3 Routine QA Tests Using the GARD

The calibrated GARD is inserted into the collimator head as shown in Figure 1-3 and is fastened to the collimator with the help of the screws S1, S2, S3, and S4.

![Figure 1-3. GARD Inserted into the Collimator Head](image)

**Test 1: Optical Distance Indicator Check**

The ODI test scale to check the optical distance indicator is snapped onto the plate P1. The plate P1 can be inserted into the rails at the bottom of the GARD as shown in Figure 1-3 so that the 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 120 cm).
Test 2: Gantry Angle Readout Test

The Moire Pattern Goniometer on GARD is used to check the gantry angle readout at any arbitrary angle. Be sure that this device is locked onto the correct gantry angle mode using the lock key L2 to place it so that the plane of the goniometer is parallel to the central axis. To check the gantry angle readouts for any arbitrary angle, the goniometer should be set to a particular angle by rotating the black knob so that the zero indication on the fixed scale lines up with the desired value on the rotating scale (see Figure 1-4).

With the goniometer set to the desired angle, the gantry can be rotated until the Moire Pattern Lines appear parallel indicating that the desired angle has been achieved. The gantry angle readouts should then be checked for agreement with this setting.

Figure 1-4. GARD in the Gantry Angle Mode

Test 3: Collimator Angle Readout

The Moire Pattern Goniometer can also be set up for measuring collimator angle by releasing the lock key L2 and adjusting the goniometer so that it is positioned perpendicular to the central axis of the beam. In order to measure and verify collimator angles using GARD, it is necessary for the gantry to be rotated to the horizontal (90° or 270°) position. The collimator angle readouts can be tested for any arbitrary angle by setting the goniometer to that particular angle. The user then rotates the collimator until the Moire Pattern appears parallel in order to establish the desired collimator angle. Agreement between the collimator readout and the specified collimator angle can then be determined.

Test 4: Laser Alignment

A. 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 degrees (parallel to the longitudinal axis). This orientation must be precisely determined using the built-in Moire Goniometer as described in two previous tests. The side laser alignment can then be determined by matching the projection of the lasers to the laser alignment templates on the sides (left and right) of the GARD.

The alignment of the sagittal laser can be determined using the white template at the top of GARD (vertical line) above the Moire Goniometer.

The ceiling laser can be aligned in one of two ways -- a) by rotating the gantry to the horizontal position (90° or 270°) and aligning it with the side laser alignment template, or b) rotating the gantry precisely to the upward vertical position and aligning the laser to the center of plate P1.

B. An alternative method for checking side and top laser alignment close to the isocenter is as follows: Insert Plate P2 so that the etched cross pattern is facing away from the gantry head. Rotate the gantry so that the plate P2 is orthogonal to the laser in question. Adjust the collimator angle to a multiple of 90°. The laser image can be checked in comparison to the cross-etched on plate P2.

Test 5: Cross-Hair Alignment and Field Size Test
Plate P1 is removed and plate P2, the field size verification plate, is inserted into GARD as shown in Figure 1-5.

![Figure 1-5. Inserting the Field Size Verification Plate](image)

**Cross-hair Alignment Check** - If the visible light projection of the cross-hair is correctly aligned, its shadow will coincide with the black cross-hair mark on the white surface of plate P2.

**Field Size Check** - The accuracy of the digital readouts for the light field size can be checked using plate P2 as well. 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 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 digital readouts should then be observed to check for agreement.

**Test 6: Light Field/Radiation Field Coincidence (Option)**

In order to check the coincidence between the visible light and radiation beams, a "Ready-Pack" 8 x 10 inch radiographic film (e.g., XTL-2) should be inserted into the support rails at the bottom of the light/radiation cassette of Plate P2. Set the collimator to a 15 x 15 cm square field size. The optical light and radiation field cassette contains eight (8) plastic sliders, two (2) on each of the four field edges of a 15 cm field. Each slider contains five (5) tungsten rods spaced 1 mm apart which project an image onto the film inserted beneath the plate.

Adjust the plastic sliders so that the central mark (corresponding to the third tungsten-rod) is exactly at the corresponding edge of the light field. The central slider, used to verify the position of the intersection of the cross-hairs 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 out in 1 mm intervals, the exact discrepancy (if any) can be determined (by eye) to within 1 mm.
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. Digital Readouts of
   - Gantry Angle
   - Collimator Angle
   - Field Size

2. Laser Alignment
   - Side Lasers
   - Ceiling Lasers
   - Sagittal Lasers

3. Optical Distance Indicator (ODI for SSD Accuracy (Range 90 cm to 110 cm)

4. Light Field Localizer
   - Light/Radiation Coincidence
   - Cross-Hair Position Accuracy
   - Field Size Positional Accuracy

1.5 Specifications

**Goniometer Accuracy/Resolution** 1.0°

**Optional Distance Indicator Resolution** 1.0 mm

**Field Size Indicators**
- 5 x 5 cm
- 10 x 10 cm
- 15 x 15 cm
- 20 x 20 cm

**Approximate Size** 13.5 x 13.5 x 14.5 in

**Weight** 9.5 lbs

1.6 References
