



Centralite[®] CT

**Moving Laser Patient
Positioning System (MRR-1)**

Installation and Setup Manual



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This manual contains the latest information at the time of publication. Diacor, Inc. reserves the right to revise this manual without notice.

WARNING

The Diacor® Centralite®/CT Moving Laser Patient Positioning System uses the output of a laser as its source of visible light. While every precaution has been taken to make exposure to this light safe, serious injury to the eyes could occur if a person were to stare directly at the beam. Please study Section 3, Laser Safety Considerations, before installing or operating the Diacor Centralite/CT system.

The Centralite/CT Moving Laser Patient Positioning System is intended for use only by physicians qualified in diagnostic radiology and radiation therapy and experienced in marking patients utilizing patient positioning lasers or by therapists at the specific direction of such a qualified physician. It is the sole responsibility of the physician to judge whether the use of the Centralite/CT Moving Laser Patient Positioning System is clinically appropriate.

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SECTION INTRODUCTION

1

The Centralite® CT Moving Laser Patient Positioning System typically consists of either three moving lasers (CML-3) or a single moving laser and two fixed lasers (CML-1). The moving lasers are connected to a central system controller. Operator interface to this controller is through a hand-held terminal. The controller can also be configured for a network interface to the treatment planning system. The purpose of this manual is to provide instructions on the installation and setup of the moving lasers and the system controller. Specific instructions on controlling the system by means of the hand-held terminal can be found in the *Centralite® CT Moving Laser Patient Positioning System Hand-Held Terminal Operator Manual*. Instructions for installing and operating the fixed lasers in a CML-1 system can be found in the *Centralite® Patient Positioning Light Instruction Manual*.

SECTION SYSTEM OVERVIEW

2

The Centralite CT Moving Laser Patient Positioning System enables successful treatment of patients in radiation therapy departments that use CT scanners for virtual simulation. The system allows the use of treatment planning data to directly identify tumor locations and mark patients for treatment.

The Centralite CT Moving Laser Patient Positioning System generates laser lines in three orthogonal planes in a treatment room. In the CML-3 system, the position of the laser lines in two of the planes is controlled by the moving lasers. The three planes for a CML-3 system are shown in Figure 1.

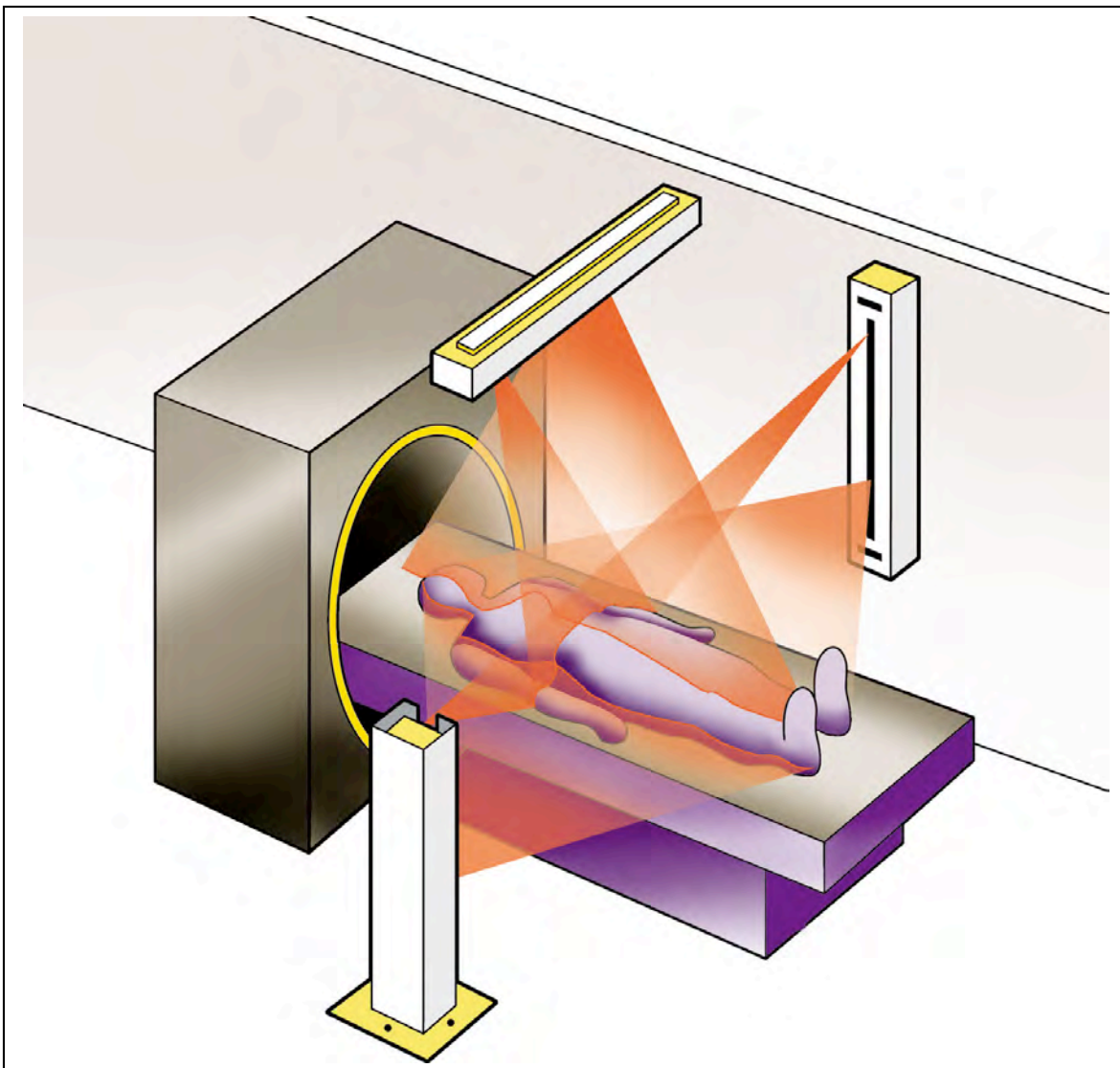


Figure 1 -CML-3 system

The three planes in the CML system are designated as the X, Y and Z planes. Each of these planes of light creates a line on the patient's body that corresponds to the intersection of the plane of light with the external contour of the patient's body. The X line is defined by a single line generated from a laser diode in a ceiling-mounted actuator (X actuator). The long axis of this laser positioning actuator is perpendicular to the long axis of the CT couch.

Figure 2 illustrates this X plane from the X actuator, and the X line that is generated along the length of the patient's body.

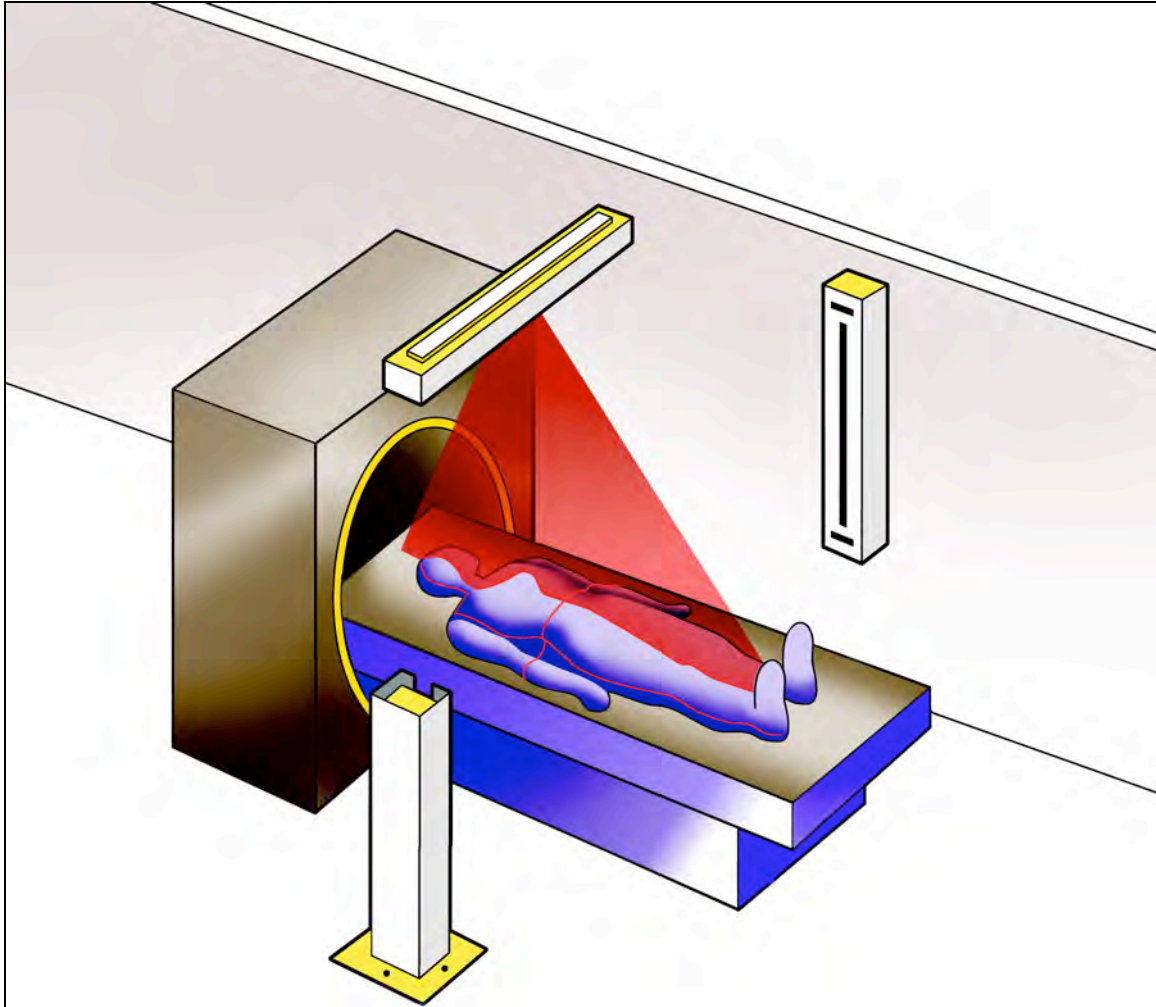


Figure 2 - X Plane generated by the X (ceiling) moving laser actuator

The Z line is defined by two lines generated from laser diodes on each side of the treatment couch. These two actuators are referred to as the “Z1” and “Z2” actuators. The long axes of these two actuators are oriented in a vertical direction. The motions of the Z1 and Z2 lines are coordinated so that these two laser diodes always define the same vertical height.

Figure 3 illustrates this Z plane from the two Z actuators, and the Z lines that are generated on both sides of the patient’s body

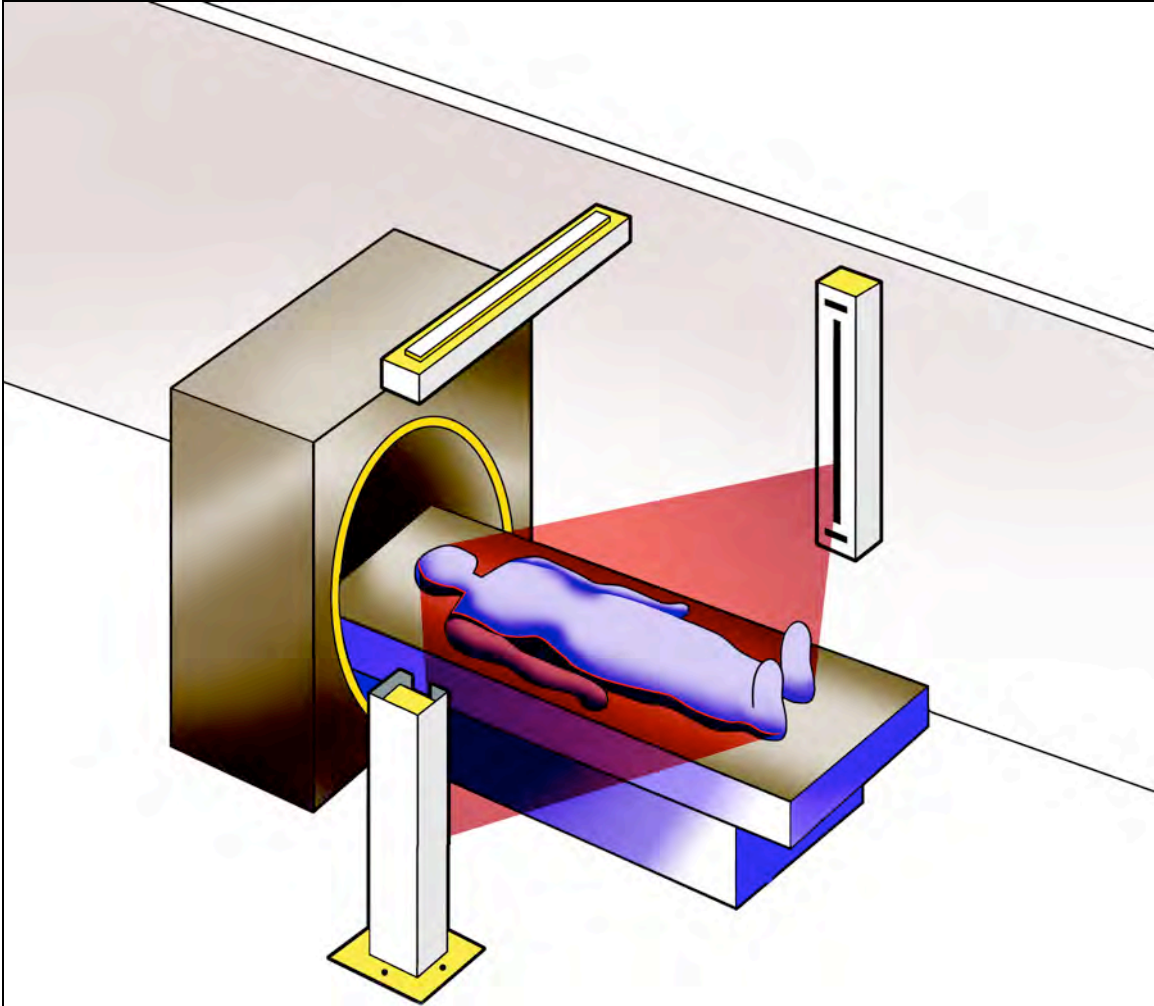


Figure 3 - Z lines on the patient's sides, from the side lasers

Either two or three lasers define the Y line. In an installation where the long axis of the X actuator is mounted in the same plane as the Z1 and Z2 actuators (i.e. directly over the treatment couch), a fixed laser on each of these three actuators (X, Z1 and Z2) defines the Y line from three directions. When the X actuator is mounted in a sagittal position, only the fixed lasers on either side of the treatment couch (Z1 and Z2) define the Y line.

Figure 4 illustrates this Y plane from the fixed lasers in the X, Z1 and Z2 moving laser actuators, and the Y line that is generated across the patient's body.

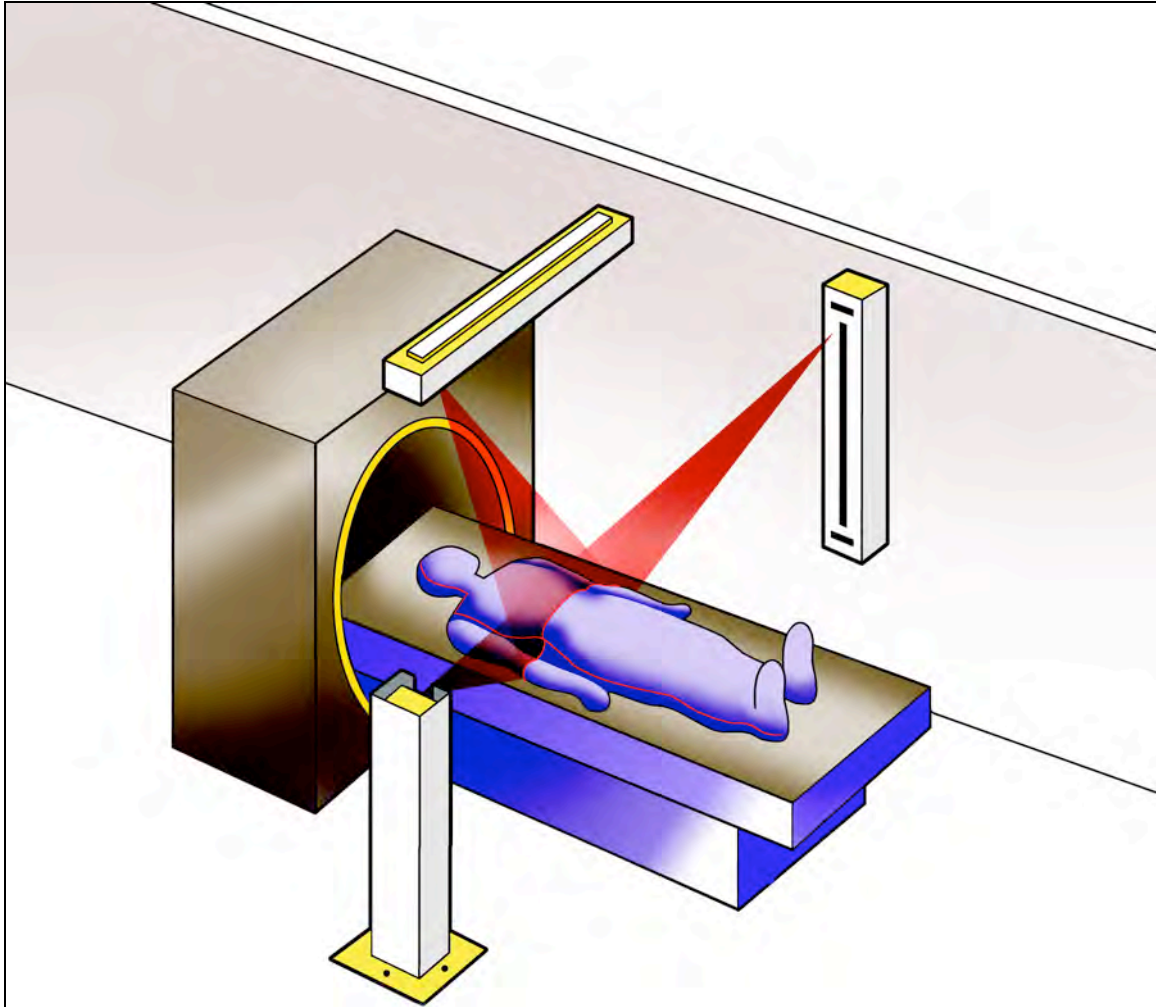


Figure 4 - Y line across the patient's body generated by the fixed lasers in the three moving laser actuators.

The CML-1 System (figure 5) is referred to as a single-axis system because there is only one moving laser actuator in the system. It is configured with two fixed planes (Y & Z) and one moving plane (X). This single-axis system still generates the same three orthogonal lines on the patient as in the three-axis system. In this application, however, the two moving lasers that generate the Z line in the three-axis system are replaced by two Centralite fixed lasers (DLL-2) mounted on either side of the room. The moving laser moves the X line on the patient. Moving the CT couch up or down moves the Z line relative to the patient. Moving the couch in or out moves the Y line relative to the patient, as in the three-axis system.

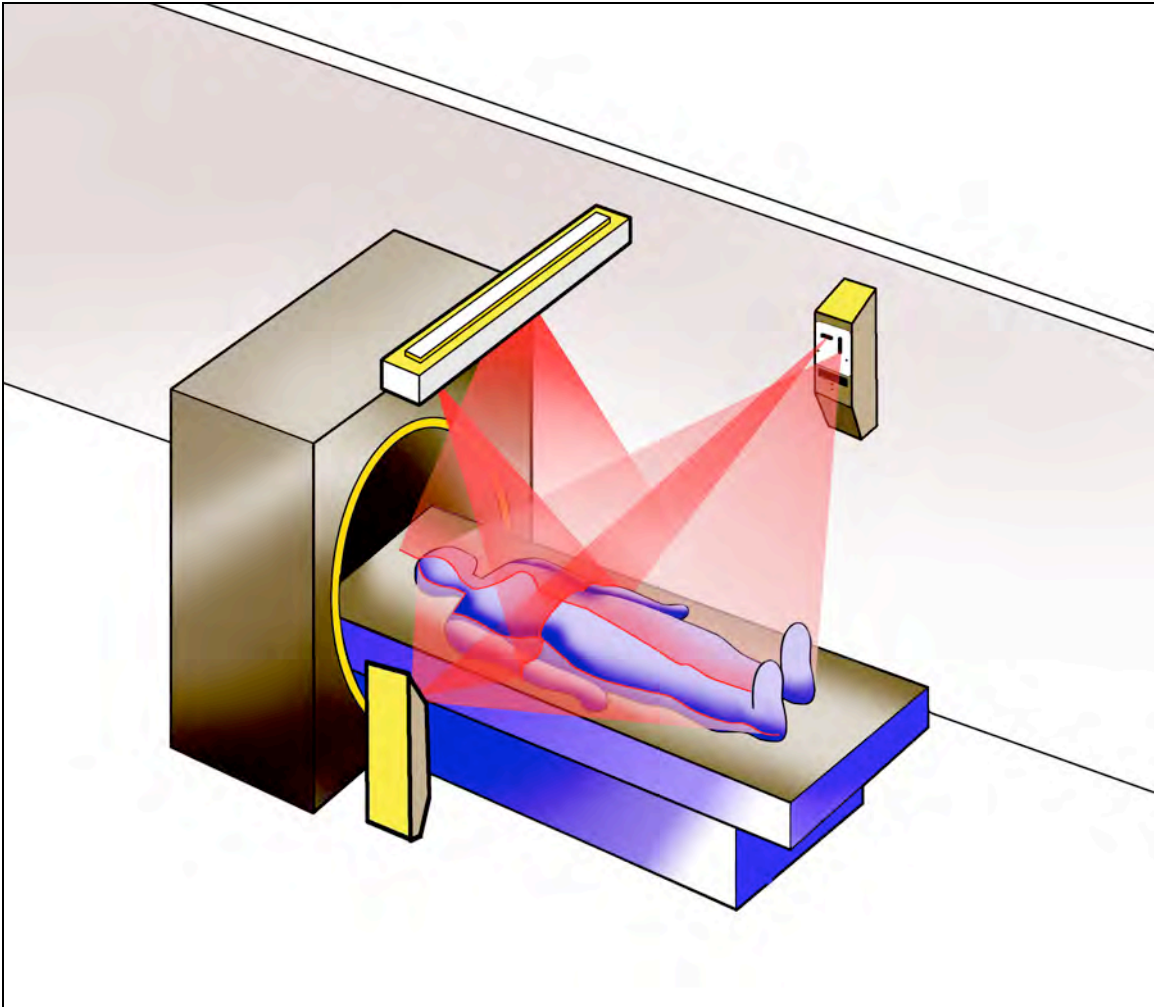


Figure 5 - CML-1 system (One moving laser actuator and two fixed lasers)

Figure 6 shows the components included in a CML system. The system controller controls the movement of all moving lasers in the system (1 in a CML-1 system, and 3 in a CML-3 system). This controller is typically mounted on one wall of the treatment room. Operators communicate and control the system using either a hand-held terminal or through a network connection to the treatment planning system. Each moving laser actuator must be connected to the system controller by means of an actuator cable.

Each of the moving laser actuators has a “home” or “zero” position. This zero position can be set up to be any position along the actuator travel. The laser system zero can also be configured to correspond to the CT simulator radiographic center, or to some other reference point in the room.

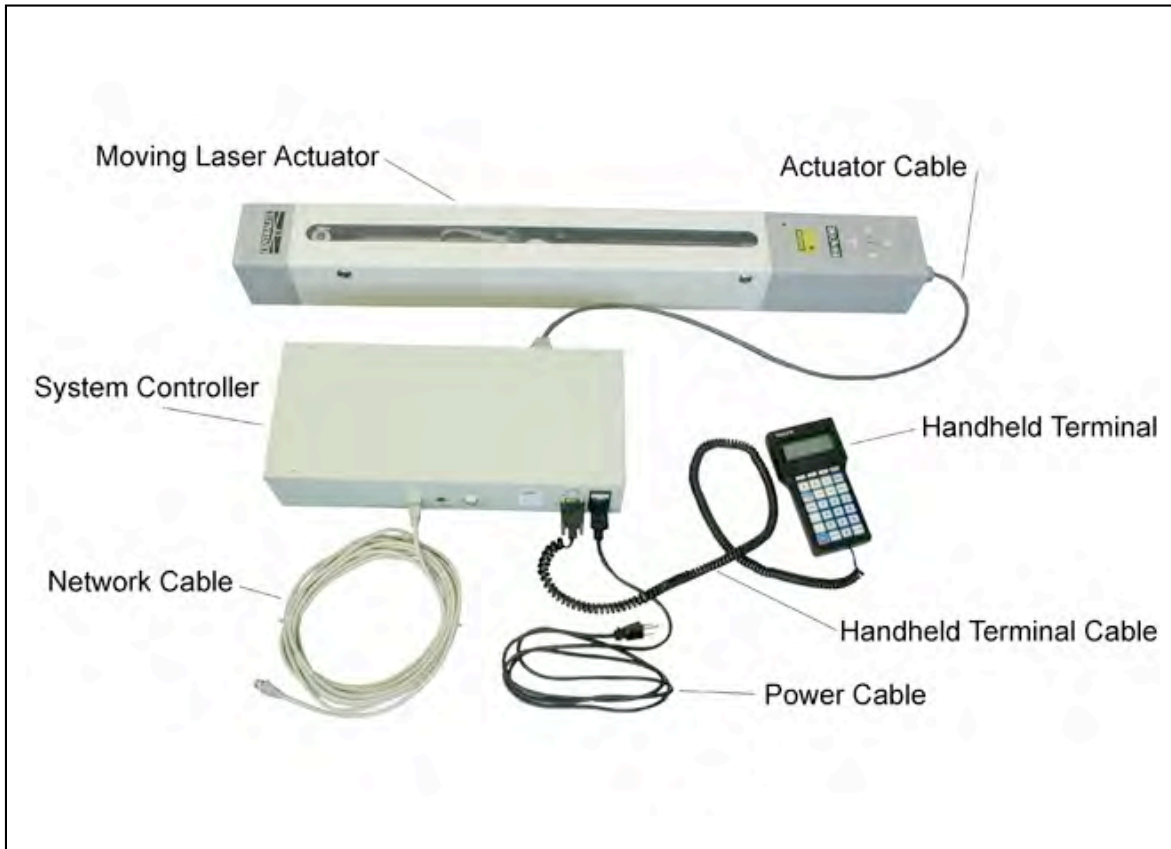


Figure 6 - CML system components

SECTION 3 LASER SAFETY CONSIDERATIONS

3.1 GENERAL

To help ensure safe operation of your Centralite system, please read this section carefully and follow the instructions and procedures in this manual before installing and operating the units. For most routine uses a sufficient “rule of thumb” is ***DO NOT STARE INTO BEAMS*** or other sources of bright light emanating from a Centralite unit. When alignment of the patient results in direct papillary impingement, the patient’s eyes should be protected. This consideration is particularly important for the ceiling unit. The following are required precautionary statements for Class II lasers.

WARNING

At all times during installation, operation, or adjustment of a Centralite unit, avoid possible eye exposure to laser or collateral radiation in excess of the accessible emission limits listed in the Federal Register, volume 40, No. 148, July 31, 1975: Tables I-A, I-B, I-C, and III.*

*Collateral radiation, as defined by the Bureau of Radiologic Health Laser Products Performance Standard, is “any electronic product radiation, except laser radiation, emitted by a laser product as a result of or necessary for the operation of a laser incorporated into that product.”

WARNING

The use of control or adjustments or the performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

3.2 LABELS REQUIRED FOR CENTRALITE UNITS

Figure 3 shows the labels on the case of the Centralite CT actuators comply with federal regulations for laser products. These labels include a yellow “**CAUTION**” label, mounted at one end of the top surface of each actuator cover, and a white serialization label mounted on one end plate of each actuator in the system.

The labels on all Centralite units are ***required*** for compliance with federal regulations. ***Do not remove these labels.***

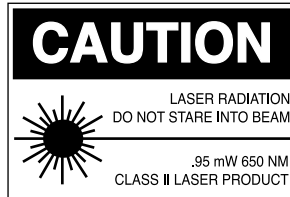


FIGURE 3

3.3 LASER SPECIFICATIONS

Specifications for individual laser assemblies used in Centralite CT actuators are as follows:

Input power (Watts):	0.60
Output power (mW):	0.48
Wavelength (Nm):	650

3.4 PROTECTIVE EYEWEAR

Protective eyewear is not necessary for typical applications where direct papillary impingement by the beams is a random momentary event. Under typical conditions requiring more protracted ocular exposure, protective eyewear or other protective measures may be required. Consult the user standards of the American National Standards Institute (ANSI), the Laser Institute of America, and/or the Occupational Safety and Health Act (OSHA) for guidance.

3.5 COMPLIANCE

The Centralite CT units comply with Title 21 of the United States government CDRH Performance Standards, Chapter 1, Subchapter J, Section 1040, as applicable. These products are categorized as Class II.

SECTION SYSTEM COMPONENTS

4

A general system configuration for a CML-3 is shown in drawing 700002 in appendix B. For each system, the configuration table on this drawing should be completed at the time the system is purchased. Before beginning installation of the moving laser system, verify that all of the system components shown on the system configuration chart have been provided. If any required system components are missing, contact Diacor.

A description of the major system components in a moving laser patient positioning system is given in the following paragraphs. Figure 6, in Section 2 shows the typical CML system components.

4.1 MOVING LASER ACTUATOR (MRR)

The moving laser actuator is the system component that generates and positions the laser lines. The general arrangement of these actuators is shown on drawing 400139, included in Appendix B of this manual. Each moving laser actuator generates a pair of orthogonal laser lines, one parallel to the long axis of the actuator, and one perpendicular to the long axis of the actuator. The laser line that is perpendicular to the axis of the actuator is generated by a laser diode that can be moved along the axis of the actuator, and is referred to as the moving laser. The line parallel to the axis of the actuator is generated by a laser diode that is fixed in position at one end of the actuator, and is therefore referred to as the fixed laser.

The moving laser is mounted to a carriage that is mounted to a precision guide rail. The carriage is moved along the guide rail by means of a stepper motor-driven ball screw. An encoder monitors the position of the carriage at all times. The moving laser has a total travel distance of 500 mm.

The internal components of the moving laser actuator are shown in figure 7 below.

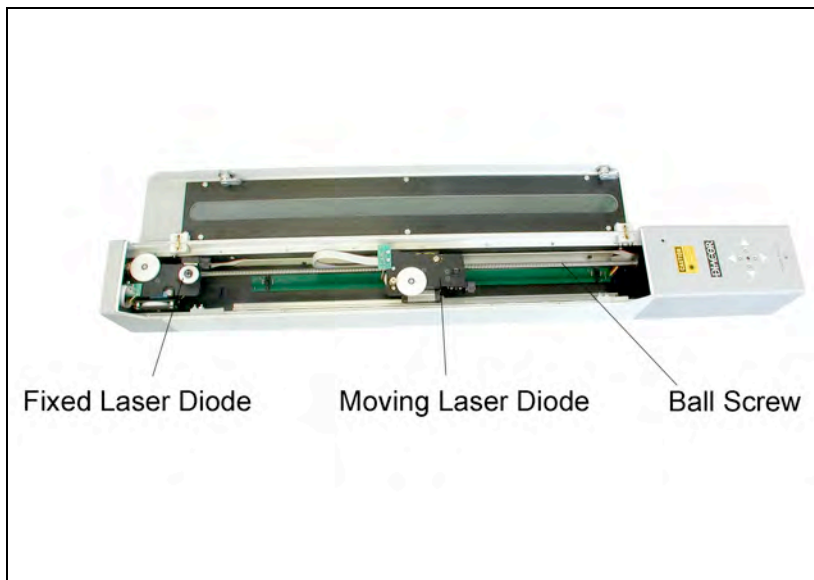


Figure 7 - Internal components of a moving laser actuator

4.1.1 Laser Line Adjustment

Proper alignment of the laser lines in a treatment room requires precise adjustment of the laser lines. Three individual adjustments are possible for each laser diode, laser origin position (LOP), rotation, and tilt. In general, LOP and rotation adjustments are made only one time by the installer when the MRR is first installed. The knobs to make these two adjustments are therefore internal to the MRR, and the cover to the MRR must be open to make these adjustments. The tilt adjustment may need to be made on a periodic basis over time. Pushbuttons are therefore located on the front surface of the MRR.

4.1.1.1 Internal Adjustments

The MRR cover must be opened to access the knobs to adjust LOP or rotation.

4.1.1.1.1 Laser Origin Position (LOP) Adjustment

The Laser Origin Point (LOP) is the point where the laser line exits the line generating optics on the laser diode. Generally this is a point at the end of the laser diode, in the center of the laser diode barrel. If there are more than one laser diode that define a particular plane (e.g. the “Y” Plane of a CML moving laser system), then the LOP for each of the lasers must lie in that plane before other alignment adjustments can be made effectively.

The fixed laser creates a line that is parallel to the length of the MRR housing. The LOP adjustment wheel (see Figure 8) allows this laser to be moved side to side inside the MRR housing. The width of the MRR housing limits this position adjustment to approximately $\pm 3/8$ in. from the center of the housing. If larger movements are required to move the fixed laser LOP into the correct plane, then the entire MRR housing must be moved.

The moving laser creates a line that is perpendicular to the length of the MRR housing. In this case, LOP adjustment is accomplished by using the “ALIGN” function on the hand held terminal to set the “zero” position of the laser anywhere along its direction of travel.

4.1.1.1.2 Rotation Adjustment

Rotation adjustment allows the laser diode barrel to be rotated about its projection axis. The result is that the projected line is rotated about its midpoint, either clockwise, or counter-clockwise. The rotation adjustment knob uses a worm gear to rotate the laser diode. This knob is used to adjust the fixed laser line so that it is parallel to the direction of travel of the moving laser. The moving laser line is adjusted perpendicular to the fixed laser line. Rotation adjustment knobs for the fixed and moving lasers are identified in the figures 8 and 9 respectively.

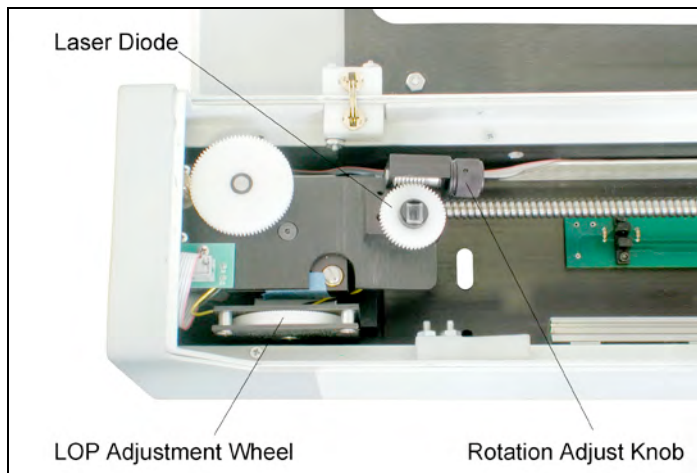


Figure 8 - LOP and rotation adjustment knobs for the fixed laser.

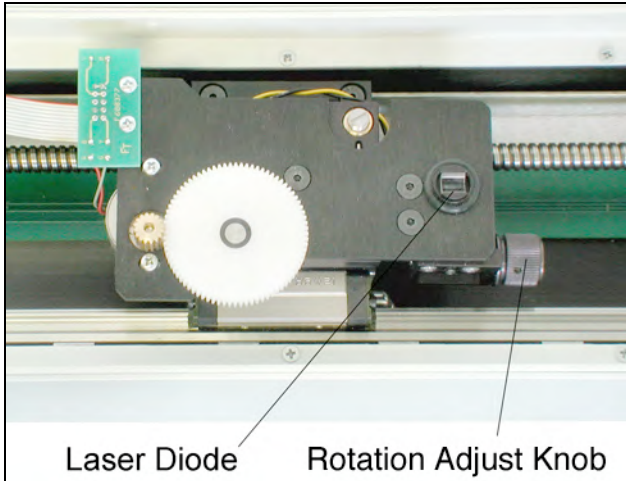


Figure 9 - Rotation adjustment knob for the moving laser.

4.1.1.2 External Adjustments

In installations where the MRR cannot be mounted on a perfectly rigid structure, the position of the projected line may drift over time, due to very small changes in the angle of the MRR mount surface. These changes can be compensated for by making tilt adjustments so that the projected line is positioned correctly at isocenter. Because these adjustments may need to be made on a periodic basis, buttons for tilt adjustment of both the fixed and moving laser are located on the front cover of the MRR (see figure 10).

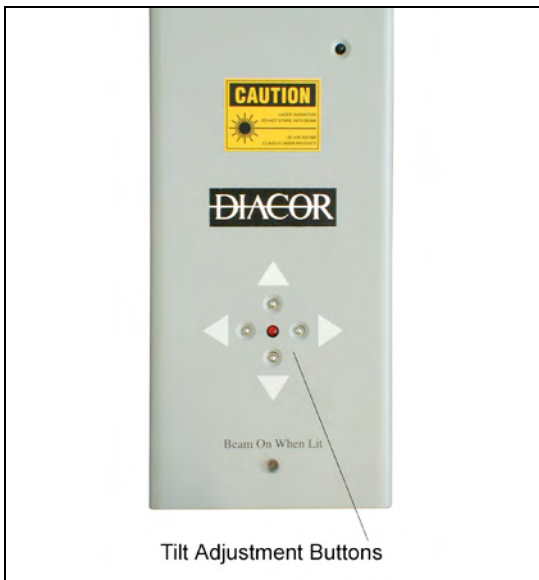


Figure 10 – Tilt Adjustment Buttons

4.1.1.2.1 Tilt Adjustment

Tilt adjustment moves the projected laser line from side to side in the case of the fixed laser, or up and down, in the case of the moving laser. To allow this, the laser diodes are mounted to a beam steering platform. The tilt of the beam steering platform is controlled by a tilt adjustment motor, which is in turn, controlled by the push buttons on the front cover. These tilt adjustment motors can also be controlled by means of a remote control transmitter in cases where the MRR is mounted such that the buttons on the MRR cover are not easily accessible.

To adjust the tilt of one of the MRR lasers, simply press the button next to the arrow which points in the direction you desire the line to move. Up and Down arrows are associated with the moving laser. Left and Right arrows are associated with the fixed laser. When the button is first pressed, the line will move slowly at first to allow very fine control of the line position. If the button is pressed for more than a few seconds, the line will begin to move at a higher speed, to allow more course adjustment. In the case of fine adjustment, the line moves slowly enough that movement may not be immediately apparent to the casual observer. The LED in the center of the four-button pattern lights whenever a button is pressed, indicating that one of the lines is moving. This LED also lights when the remote transmitter is used to adjust the tilt of one of the laser diodes.

4.1.2 Actuator LED

A “power-on” LED is located at one end of the MRR. The orientation of an MRR is defined by describing the end of the actuator where the LED is located as the “LED end.” The MRR end plate at the LED end of the actuator contains connectors for the actuator cable, the remote align cable, and a laser power switch. The laser power switch controls power only to the LED and the laser diodes. When this switch is off, the LED is turned off, and the laser diodes cannot be turned on. When this switch is turned on, the LED is on and the laser diodes can be turned on or off by the system controller. Thus, the LED is an indicator that the laser diodes are enabled, not necessarily that they are on. Whenever the moving laser is being re-positioned, the controller turns off both laser diodes. The laser diodes are turned on again when the controller has determined that the moving laser is in the correct position. This provides the operator with positive feedback that the laser lines are correctly positioned. The LED remains on during this entire process.

4.1.3 MRR Connections

Connectors for the MRR are located in the end plate at the LED end of the actuator. The MRR cable connector is a 15-pin “D” connector (DB15). The actuator cable must be connected from this connector to the connector on the system controller that corresponds to the actuator “X”, “Z1”, or “Z2”. This cable contains all power and control signals from the controller to the MRR.

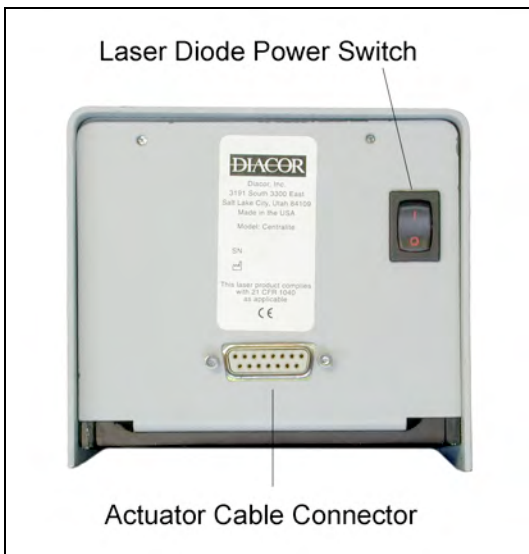


Figure 11 – End View of MRR

4.2 SYSTEM CONTROLLER

The system controller is available in either a three-axis or single-axis configuration. The three-axis controller allows control of up to three moving laser actuators. The single-axis controller will control a single moving laser actuator. Both of these controllers include a power supply, which provides DC power for various system components, a motion control PCB (either single-axis or three-axis), and a system interface PCB, which provides the connectors for the actuator cables.

Either the three-axis or the single-axis controller can be configured to include a single board computer, which allows the controller to be networked with other computers in the system, and allow laser coordinates to be transferred to the controller directly over the network connection.

Figures 12 and 13 show the internal components for two controller configurations, a three-axis controller without the single board computer, and a three-axis controller with the single board computer.

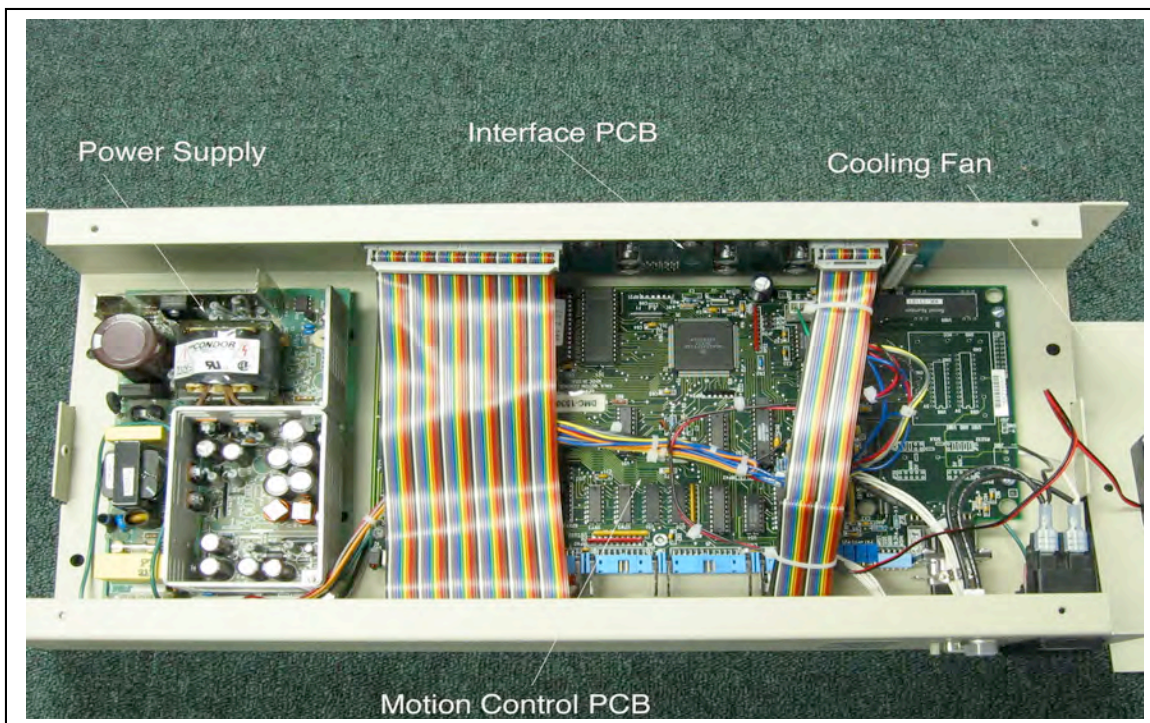


Figure 12 - Internal components of a three-axis controller.

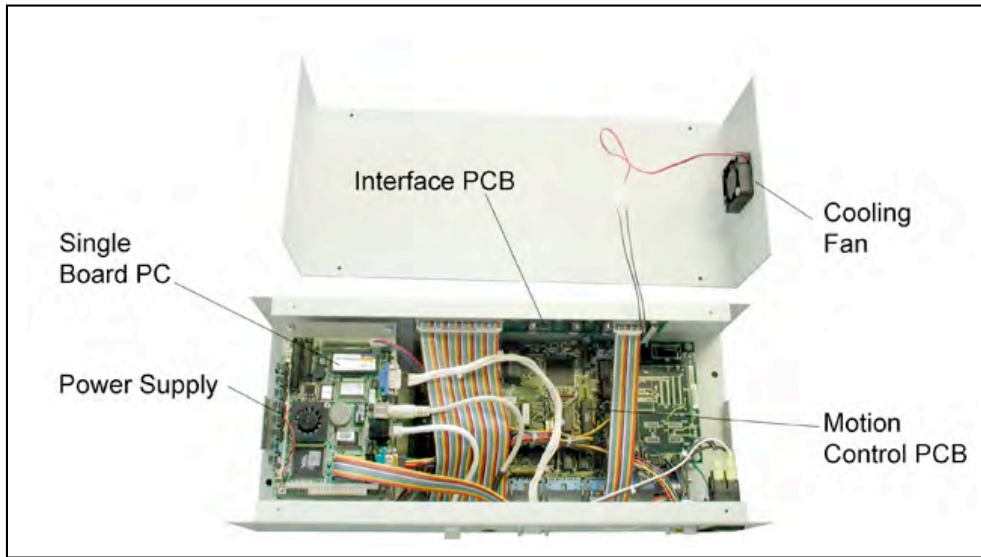


Figure 13 - Internal components of a three-axis controller with single board computer.

4.2.1 Controller Connections

Actuator cables are connected to one side of the controller. Power and serial communications are connected to the other side of the controller. There are three actuator cable connectors, labeled “X Actuator,” “Z1 Actuator” and “Z2 Actuator.” See figure 1 in section 2 for a definition of “X,” “Z1” and “Z2.” All three connectors are mounted on both the single-axis and the three-axis controller. On the single-axis controller, only the connector labeled “X Actuator” may be used.

Power and serial communications connections are made on the left side of the controller. The power connector includes an on/off switch and a “power on” indicator light. The serial communications connector is a standard 9-pin “D” connector. The hand-held terminal cable is connected to this connector. Power to the hand-held terminal, as well as serial communications, is provided through this serial port. These connections are shown in the figure below.

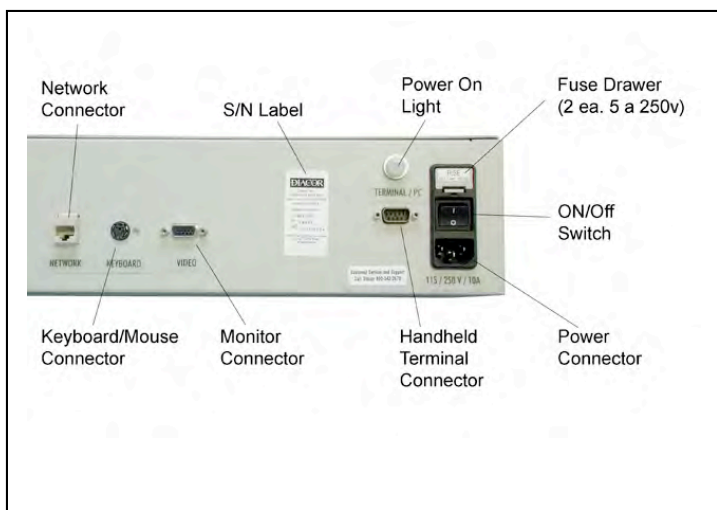


Figure 14 - Connections to the left side of the CML system controller.

SECTION

CT ROOM PREPARATION

5

Proper CT room preparation is very important to a successful installation of a patient positioning system. This preparation work should be completed before the system components are shipped to the site for installation. This preparation work includes the following:

- Determining where various system components will be located,
- Determining the mounting configuration to be used for each laser unit,
- Providing an adequate structure to mount all of the laser units in the system,
- Determining routings for cables, and
- Providing power required for the system.

In the case where the treatment room is not yet constructed, Diacor recommends that a rigid steel support frame for the moving lasers be incorporated into the room construction. Drawing 400128 shows a frame and associated architectural details for a CML-3 system. Drawing 400130 shows a similar frame for a CML-1 system. Additional details on CT room preparation can be found in Diacor document 800324 – Room Preparation for CML System Installation.

5.1 GENERAL ROOM LAYOUT

Room layout begins by identifying the location of the point in the room that will be center for the patient positioning system (Note: This is not the same point as the radiographic center for the CT Scanner. The CT radiographic center and the patient positioning center generally have the same “X” and “Z” coordinates, but are offset from each other in the “Y” direction. In this manual, unless specified otherwise, iso-center refers to the center of the patient positioning lines). Based on this iso-center location, the location of the system lasers can be determined. If at all possible, the X actuator should be mounted directly over the iso-center point, using a ceiling mount configuration. In this position, the X line is most likely to be visible over the entire length of the patient’s body, without being occluded by body contours. In addition, the fixed laser from the X actuator can be aligned in the Y plane in the room, co-planar with the fixed lasers from the two side (Z) lasers. The Z lasers are located on either side of the treatment couch, in a line that is perpendicular to the long axis of the treatment couch. It is ideal if these side lasers can be mounted to, or close to, the walls, to keep them out of the way of personnel in the room. Consideration should be given to the focus distance of the lasers. Typically, the lasers are focused to give the optimum laser line quality at a distance of approximately 3 meters. If the treatment couch is not parallel to the walls of the treatment room, a pedestal mount can be used for the Z1 and Z2 actuators, or the Z1 and Z2 laser can be mounted to the wall with an angle bracket.

Location of the system controller should also be considered carefully. An actuator cable must be run from the controller to each of the moving laser actuators. The hand-held terminal is connected by a coiled cable to the system controller. The holster for the hand held terminal should be located at or near the position from which the operator would control moving laser line positions, near the location where the patient will be marked.

If the controller is to be mounted in a remote location (e.g. above the ceiling), a serial extension cable must be provided to connect the hand-held terminal cable to the controller.

5.2 MOVING LASER AND FIXED LASER BASE PLATES

Base plates, either steel or aluminum, must be installed in the walls and ceiling where laser units are to be mounted. The location, size, and stability of these base plates are critical to a satisfactory installation of a moving laser system. Appendix A outlines the requirements for these base plates.

5.3 MRR MOUNTING OPTIONS

Two mounting options are available for the X actuator in the system. The preferred option is ceiling mounting, directly over the treatment table. This option allows the fixed laser in the X actuator to be aligned as part of the Y plane in the system. It also minimizes the possibility of the X line being occluded in some areas due to contours of the patient's body. A second option for the X actuator is sagittal mounting. In this case, the X actuator is still mounted to the ceiling, but is moved toward the foot of the treatment couch. The actuator is rotated so as to point towards the center of the treatment couch. In a sagittal mounting arrangement, the X actuator has a moving laser to generate the X line in the system, but does not have a fixed laser.

Two mounting options are also available for the Z actuators in the system. If the walls of the treatment room are parallel to the treatment couch, the actuators can be mounted directly to the walls. Some consideration should be given to the distance from the walls to the treatment couch. Typically the laser lines are focused for a distance of 2 - 3 meters from the actuator. If the actuators must be mounted at an angle relative to the wall, or at a distance closer to the treatment couch than the wall, a pedestal mount arrangement should be used for the Z actuators. In these cases, the Z actuators can also be mounted to the wall using the same angle mount bracket kit that is used for the sagittal mount of the X actuator.

In a single-axis system, where fixed lasers are used for the side lasers, wall and pedestal mounting options are both available. In addition, an angle-mount kit is available that allows the lasers to be mounted at an angle to the side walls.

5.3.1 Wall / Ceiling Mount

The wall/ceiling mount arrangement is shown in drawing 400137 in Appendix B. In this case, two separate mount plates are fastened to the wall or ceiling structure. Dimensions of these mount plates, and their locations relative to the center of travel of the actuator are shown on drawing 200442. A rigid structure must be provided in the wall or ceiling to which these two mount plates can be attached. Typically this structure is a single metal plate which can be drilled and tapped to attach the two mount plates. This rigid structure is required because any movement of the mounting structure for the actuator will result in movement of the laser lines.

5.3.2 Sagittal Mount

The sagittal mount arrangement is shown in drawing 400135 in Appendix B. This arrangement includes a pivoting mount bracket, which allows the actuator to be rotated to the desired angle so that the laser line is approximately in the center of the treatment table. The same ceiling mount plate is used for the sagittal mount as for the ceiling mount above. Drawing 200440 shows appropriate mounting dimensions and information. A rigid structure must be provided in or above the ceiling to which the ceiling mount plate can be attached. Typically this rigid structure is a metal plate which can be drilled and tapped for installation of the ceiling mount plate.

5.3.3 Pedestal Mount

An MRR can be mounted to the floor in a vertical configuration using a pedestal mount. This arrangement is shown in drawing 400138. The pedestal mount can be used for the Z1 and Z2 MRR's in the CML-3 system, or for the Centralite fixed lasers in the CML-1 system. The mounting location of the pedestal is slightly different for these two cases. In the case of the moving laser actuator, the centerline of the pedestal and the centerline of the laser lines are identical. The hole pattern for the pedestal base and installation instructions are shown on drawing 200441 for this case. In the CML-1 system, where the Centralite fixed lasers are used for the side lasers, the laser line is offset slightly from the centerline of the pedestal base. The hole pattern for the pedestal base and the offset distance for the laser line is shown in drawing 200456. (Note: The offset direction is the same relative to the laser housing – thus the center line of the pedestals is offset in the opposite directions on opposing sides of the room in order for the laser lines to be in the same plane.)

5.4 CABLE ROUTING

Each actuator in the system must be connected to the system controller by an actuator cable. These cables are approximately 5/16" diameter and have fifteen-pin "D" connectors at each end. The maximum length of these cables is 100 ft. Provisions should be made in the treatment room to route these cables as directly as possible to the system controller. They should be routed in such a way as to not pose any hazard to personnel working in the room. Drawing 400139 in Appendix B shows the location of the connector on the actuator. In the case that the actuator cables are to be routed through conduit, conduit should be a minimum of 1 1/2 inch inside diameter and any bends should be a large radius to allow the cable connectors to be pulled through the conduit.

A hand-held terminal is used to interface to the system controller, it is connected to the controller by means of a coiled cable. The maximum length of this cable (coils extended) is 25 ft. The system controller should therefore be located in close proximity to the area where the hand-held terminal will be used. In installations where it is desirable to mount the system controller in a remote location, a remote connection for the hand-held terminal cable can be mounted in a standard electrical junction box in the wall. In this case, provision must be made to run a serial extension cable from this junction box to the system controller. This cable length should not exceed 75 ft.

In the case of the CML PC systems, a network correction must also be made to the system controller.

5.5 POWER REQUIREMENTS

For the CML-3 system, AC power is required only for the system controller. The system controller requires 110/220 VAC 50/60 Hz power. Cables connected to the system controller carry low voltage DC power to the actuators and to the hand held terminal. No additional power is required for the MRR's. The system controller includes a power on/off switch. If the controller is to be located where this switch is not accessible, the power to the controller should be switched, to allow power to be turned off and on easily.

In the CML-1 system, the Centralite DLL-2 fixed lasers on either side of the treatment room require separate 110/220 VAC power. See the *Centralite® Patient Positioning Light Instruction Manual* for details. Thus, for the CML-1 system, three separate power outlets are required, one for the system controller, and one for each of the side laser units. It may be desirable to have all three of these power outlets switched from the same switch to allow all of the lasers to be turned on or off from a single switch.

SECTION LASER INSTALLATION

6

The system iso-center must be identified and corresponding reference marks placed on the wall before moving laser actuators or fixed lasers can be installed correctly in the CT room. These reference marks will be used to determine the laser mounting location, and as an aid in aligning laser lines once the lasers are installed. Accurate placement of the marks is very important.

6.1 ESTABLISHING ISO-CENTER REFERENCE MARKS

The first task in system installation is to establish reference marks for each of the three planes for the moving laser system. Ideally, the X and Z coordinates of the laser system center will correspond with the radiographic zero of the CT system. Some distance from the center of the radiographic scan plane will offset the Y-axis of the laser system. This offset distance typically is set in the range of 500 to 600 mm, usually a convenient round value, i.e., 500, 550 or 600 mm. Determining the best offset distance is a function of the specific CT system that is installed. The distance must be large enough so that no part of the laser line in the Y plane is blocked by a part of the CT system, and to allow the technicians access to mark the patient at the intersection of the laser lines. Note: If the offset distance is too large, it may limit the length of the patient that can be scanned after the patient has been set up to the moving laser system lines.

6.1.1 Finding the CT radiographic center

Depending on the capability of the CT system, three different options can be used to determine the CT radiographic center. The first choice would be to scan a phantom. The second choice would be to use the CT internal lasers. The third choice would be to use the physical dimensions of the CT system. These options are outlined below.

6.1.1.1 Using a scan to find radiographic center

Scanning a phantom is the most accurate way to determine radiographic center of a CT system. This can be accomplished as follows:

1. Set the installation phantom on its base plate on the CT couch.
2. Make sure that the base plate is level in both directions.
3. Orient the phantom so that its center plane is aligned with the internal lasers in the CT.
4. Scan the phantom, using the minimum slice thickness available on the CT system, starting approximately 5 mm above (superior to) the center of the phantom, and ending approximately 5 mm below (inferior to) the center of the phantom (to be sure that the center plane of the phantom is included in one of the scan planes).
5. Find the slice that corresponds to the center of the phantom (the slice where the two 1 mm holes are visible in the top surface of the phantom).
6. If both 1 mm holes are not visible in the same slice, then the phantom has not been oriented perpendicular to the scan plane. Adjust the position of the phantom and repeat the scan process until both 1 mm holes can be seen in the same scan plane, indicating that the phantom is aligned with the scan plane.
7. Identify the position of the center slice as the radiographic zero in the Y direction.
8. Chose a slice near the center slice where the grooves on the sides and top of the phantom are visible. Place a grid on the scanned image, with the origin of the grid at the radiographic center of the scan.
9. Compare the grid with the centers of the grooves on the sides and the top of the phantom.
10. Adjust the phantom position up or down (using couch motion) and/or side to side (by manually sliding the phantom base plate) and repeat the scan until the grid indicating radiographic center indicates that the phantom is aligned in both the X and Z directions with the center of the radiographic scan. Note:

When moving the phantom side to side, be careful not to change the angle of the phantom. Otherwise the steps to align the phantom with the scan plan will need to be repeated.

While performing the above scan procedures, the grooves on the sides of the phantom may not line up with the grid on the scan image, i.e. the image of the phantom is rotated relative to the grid. If this occurs, first verify that the phantom is level. If the phantom is level, and the image of the phantom is still rotated relative to the grid, then the CT does not indicate the horizontal plane correctly. If this error is more than 1 degree, the manufacturer of the CT system should be contacted to correct the problem. The patient positioning lasers should be installed in a correct horizontal orientation, consistent with the patient positioning lasers that are installed in the treatment room. If the image in the CT simulator is not oriented correctly with respect to the horizontal plane, it will be difficult or impossible to correctly mark and position the patient for treatment.

6.1.1.2 Using CT internal lasers to find radiographic center

If it is not possible to use a scan to set the installation phantom at radiographic center (e.g. the CT system does not have the capability to place a grid at radiographic center), the next best option is to use the CT internal lasers for this purpose. The internal lasers may or may not be correctly aligned with radiographic center. There is no way to determine alignment without a scan. In this case, simply move the installation phantom inside the CT until the internal lasers line up with the external grooves on the sides and top of the phantom that corresponds with the center of the phantom.

6.1.1.3 Using physical measurements to find radiographic center

The last alternative to finding the radiographic center is to use physical measurements of the CT to find the center. There may be CT systems where one or more of the internal lasers is not working, or is obviously not aligned correctly. In this case, one must assume that the radiographic center of the scan corresponds to the physical center of the opening in the CT. Measurements to the edges of the opening in the CT can be used to locate the installation phantom as close to the center as possible.

Note that alignment of the CML laser system center with the CT radiographic center is not necessary from the point of view of patient setup and marking. In the typical setup procedure, before the patient is scanned, CT markers are placed on the patient's skin at the intersection of the laser lines from the CML system. After the scan—in the process of finding the zero point from which the new iso-center for treatment will be located—the CT markers that were placed on the patient prior to the scan are used to indicate the zero position of the CML lasers. Offset values for new laser line positions for marking the new iso-center on the patient are measured relative to this zero position. When the patient is set up to be re-marked, he is aligned so that the three CT markers that were placed on his skin prior to scanning are again aligned with the intersection of the laser lines from the CML system. Offsets for the new laser line position are moved from this zero position. Thus, the iso-center position and laser line movements are both calculated relative to the CT markers, and any differences between the radiographic center and the CML system center are compensated for with this method.

Although making the CML system center and the CT radiographic center coincident is not required, it is important that the three CT markers that are placed on the patient prior to scanning are visible in the same CT slice of the patient scan. This allows an accurate zero position scan plane to be determined for the patient. In order for this to be accomplished, the CML laser system must be set up so that the Y plane of the CML lasers is parallel to the CT scan plane. This can be accomplished by aligning the installation phantom with the scan plane as described in section 6.1.1.1 above, and then aligning the CML laser system to the installation phantom as described in the paragraphs below.

If CT markers are not used to mark the location of the intersection of the laser lines on the patient's skin, then the procedure for determining the location of the laser zero position in the patient scan will vary slightly from that described above. One option is to place visible marks on the patient's skin that correspond with the CML laser lines. The patient would then be aligned in the CT simulator so that the

internal lasers on the CT line up with these visible marks. In this case, the internal lasers on the CT must be aligned correctly to correspond with the radiographic center or some other known point on the scan. Alternatively, the patient could simply be aligned with the CML laser lines, and then moved the known offset distance from the CML system to the radiographic scan plane. This new position is then assumed to be the zero position of the laser lines in the scan. This technique requires that the CML laser lines be aligned precisely with the radiographic center of the CT. Any CT couch sag will result in errors in the laser offset positions that are ultimately calculated.

Quality control and verification of laser movement is simplified if the CT radiographic center and the CML system center are aligned with each other, and the offset between the scan plane and the laser system zero is a round number.

6.1.2 Establishing the Y Plane for the CML system

Once the installation phantom has been aligned with the radiographic center of the CT scan plane, the Y plane for the CML system must be aligned with this plane at some offset distance. (See paragraph 6.1 for a discussion of the correct value for this offset distance.) Steps for setting up the Y plane parallel to the install phantom once the phantom has been aligned with the scan plane depend on the tools that are available for the installation. Two different methods are described in this manual. Note: All tools that are used should be in accordance with manufacturer's instructions and calibrated at regular intervals to assure that beams, pointers, etc. are level, vertical, orthogonal and so on as required for an accurate installation.

6.1.2.1 Using the Rotating Laser

A rotating laser such as Topcon model RL-VH3A can be used to establish the Y plane for the CML system based on the scan of the installation phantom. The steps to establish reference marks for this plane using the rotating laser are as follows:

1. Replace the installation phantom with the rotating laser. While the installation phantom is oriented correctly at the center of the CT radiographic center, and aligned with the CT scan plane, remove the installation phantom from its base plate, being very careful not to change the position of the base plate. Place the rotating laser on the base plate with its center pointer set in the indentation between the centering pins for the installation phantom. This places the center of the rotating laser at the same point as the center of the installation phantom.
2. Pivot the rotating laser about the center pointer until the plane of the rotating laser is parallel with the CT scan plane. This can be verified by comparing the position of the rotating laser beam with the internal rotating laser beam on the CT on both sides of the CT opening or with marks on the base plate. This can also be accomplished by using a base plate with specially machined indentation marks for each of the three feet of the rotating laser, where these indentation marks assure that the rotating laser is parallel to the mounting pins for the installation phantom, and also parallel to the scan plane of the CT.
3. Move the rotating laser out to the correct offset distance for the Y plane of the CML system. With the rotating laser set at the scan plane for the CT, set the couch position longitudinal indicator to zero. Without changing the couch vertical position, move the couch out the required offset distance (e.g. 500, 550, or 600 mm).
4. Use the rotating laser to mark the Y Plane for the CML system. Make a minimum of two marks on the floor, the ceiling and on each of the two walls.
5. Mark the wall behind the CT where the pointer out of the end of the rotating laser hits the wall.

6.1.2.2 Using the RoboVector

The Y plane for the CML system can also be established using a RoboVector model RT7610-1. This device provides 5 orthogonal laser beams to help locate perpendicular and parallel planes. The steps to establish the Y plane for the CML system using the RoboVector are as follows:

1. Replace the installation phantom with the RoboVector. When the installation phantom is oriented correctly at the center of the CT radiographic center, and aligned with the CT scan plane, remove

- the installation phantom from its base plate, being very careful not to change the position of the base plate. Place the RoboVector on the base plate with its bottom beam centered on the indentation between the centering pins for the installation phantom. This places the center of the rotating laser at the same point as the center of the installation phantom. Pivot the RoboVector about this center pointer until the two side beams from the RoboVector are aligned with the internal rotating laser beam on the CT on both sides of the CT opening. The side beams of the RoboVector should now be parallel to the scan plane of the CT.
2. Move the RoboVector out to the correct offset distance for the Y plane of the CML system. With the RoboVector set at the scan plane for the CT, set the couch position longitudinal indicator to zero. Without changing the couch vertical position, move the couch to achieve the required offset distance (e.g. 500, 550, or 600 mm).
 3. Use the pointers from the RoboVector to mark the walls, floor, and ceiling. Make a mark on the ceiling, floor, and each of three walls (two sides and the wall behind the CT) where the RoboVector pointers hit the surface.
 4. Add additional marks to the side walls, floor, and ceiling. Using a plumb bob, suspended so that one of the RoboVector beams intersects the plumb bob string, make two additional marks on the floor, the ceiling and on both of the side walls. All three surfaces (floor, ceiling, and two side walls) should now have three marks each, defining a line on that surface that is the intersection of the Y plane with that surface.

6.1.3 Establishing the X Plane for the CML system

The X plane of the CML system must be perpendicular to the Y plane just established. Once again, the method for establishing this plane will depend on the tools being used for the installation.

6.1.3.1 Using the Rotating Laser

Begin with the installation phantom base plate located as it was to set up the Y plane, and the center pointer of the rotating laser located in the indentation between the phantom-centering pins on the base plate.

1. Rotate the base of the rotating laser 90 degrees about the center pointer until the laser pointers at the two ends of the rotating laser coincide with the marks on both walls for the Y plane.
2. Verify that the rotating laser is level.
3. Use the rotating laser line to make a minimum of two marks on the ceiling in the X plane.
4. Use a plumb bob to transfer these marks on the ceiling to corresponding marks on the floor.

6.1.3.2 Using the RoboVector

Begin with the installation phantom base plate located as it was to set up the Y plane with the RoboVector centered over the centering indentation on the base plate.

1. Mark the ceiling at the point indicated by the vertical pointer on the RoboVector.
2. Slide the RoboVector along the line marked on the installation phantom base plate, with the bottom pointer on the RoboVector pointing at this line.
3. When the RoboVector has been moved about 25 cm along this line, mark a new point on the ceiling.
4. Move the RoboVector to the end of the base plate nearest the head of the couch, and move the base plate towards the head of the couch until the bottom pointer on the RoboVector can be seen on the floor.
5. Move the couch and the RoboVector until the vertical pointer again coincides with the point on the ceiling that is in the Y Plane.
6. Make a mark on the floor where the bottom pointer on the RoboVector indicates. This point should be in both the X and Y planes.

6.1.4 Establishing the Z Plane for the CML system

The Z plane for the CML system must be level, and if possible, at the same height as the center of the radiographic scan. Once again, the method for establishing this plane will depend on the tools being used for the installation

6.1.4.1 Using the Rotating Laser

1. Set up the rotating laser so that the rotating laser is in the horizontal plane. Be sure that the rotating laser is sitting level on the base plate.
2. Adjust the table height up or down until the rotating laser corresponds with the mark that was made on the wall behind the CT when the rotating laser was first set up to coincide with the radiographic center. Alternatively, the height of the rotating laser could be set to coincide with the height of the internal side lasers on the CT.
3. Use the rotating laser to make at least two marks on each of the two side walls that define the Z plane. These marks should be far enough apart to allow the rotation angle of the CML lasers to be adjusted accurately.

6.1.4.2 Using the RoboVector

1. Set the RoboVector on the base plate so that it corresponds approximately with the Y plane that has been established.
2. Adjust the table height up or down until the height of the horizontal pointers correspond with the height of the internal side lasers on the CT. The RoboVector can be pivoted on its base so that one of the horizontal pointers points at the CT internal side laser or at the line it generates at the center of the CT.
3. Once the horizontal pointers on the RoboVector are at the correct height, rotate the base of the RoboVector to move the horizontal pointers to different locations on the side walls. Make a minimum of two marks on each side wall to indicate the intersection of the Z plane with that wall. Make the marks far enough apart so that the rotation angle of the beam from the far wall can easily be judged and adjusted to the marks.

6.2 INSTALLING LASERS

Once the room has been marked with appropriate reference marks, the various lasers (fixed and/or moving) can be mounted in the room. Z1 and Z2 lasers can be installed using either a wall mount or a pedestal mount. The X actuator can be installed using either a ceiling mount or a sagittal mount. Note: If the walls are not parallel to the CT table motion, an angled-bracket mount, similar to the sagittal mount for the moving laser, can be used for the Z1 and Z2 lasers instead of a pedestal mount.

In the following sections on laser installation, it is assumed that a mounting base plate has already been installed in the correct location to mount the lasers. Requirements for these base plates are described in appendix A.

The process of mounting the lasers can be divided into two steps; correctly locating the mounting hardware, and mounting the laser. The process for each of these steps depends on the laser type (fixed or moving) and how that laser will be mounted.

6.2.1 Locating the Mounting Hardware

A paper template is provided with each MRR or DLL-2. This template indicates the center of the lasers for those units relative to the mounting holes on the laser mount plate. In all cases the objective is for the laser origin to be placed in the correct CML reference plane (X, Y or Z).

6.2.1.1 Wall and Ceiling Mounting

If the laser will be mounted directly to a base plate on the wall or ceiling (no angled mounting bracket), the process of locating the mounting hardware is very straightforward. Simply draw perpendicular lines through the point on the template that corresponds with the center of the lasers. Tape this template on the base plate so that the lines corresponding with the center of the lasers are aligned with the X, Y and/or Z plane marks that were established in the preceding procedure.

6.2.1.2 Pedestal Mounting

For pedestal mounts, the mounting template used for wall or ceiling mounting cannot be used. In order for the laser center to be located in the CML Y reference plane, the base of the pedestal must be mounted in the correct location. The base of the pedestal is marked with two lines. One line (through the center of the pedestal base) corresponds to the center of the laser line for an MRR. The second line (offset from the center of the pedestal base) corresponds to the center of the laser line for a DLL-2. (See sheet 2 of drawings 200441 and 200456 for the location of these two lines.) Align the pedestal base on the floor so that the line corresponding to the center of the laser that will be mounted to the pedestal corresponds with the line determined by the two marks made on the floor to define the CML Y reference plane.

6.2.1.3 Angle-Bracket Mounting

For angle-bracket mounting, the objective is to place the center of the laser(s) in the correct CML reference plane. Follow these steps to accomplish this task:

1. Assemble the angle bracket and mount the laser to the angle bracket.
2. Adjust the angle bracket so that the plate that mounts to the base plate is parallel to the base plate on the wall or ceiling.
3. Adjust the angle bracket so that the side of the laser housing is parallel to the CML reference plane of interest.
4. Tighten the angle bracket in this position.
5. Hold the angle bracket (with laser attached at the correct angle) against the base plate and move the unit until the center of the laser is coincident with the CML reference plane of interest. To verify that the center of the laser is in the correct plane, use another laser unit, or any line-generating device, to project a plane that corresponds with the CML reference plane of interest. This projected line will intersect the reference marks placed on the wall behind the laser you are installing, as well as at least one other reference point in the same plane—but not on the same wall.
6. When the unit is held in the correct position as indicated above, mark the position of the angle bracket.

6.2.2 Mounting the Lasers

You have two mounting options: wall or ceiling mounting or pedestal mounting. Using the templates or other marks that indicate mounting plate locations, mount the laser mounting plates to the base plates in the ceiling or walls. Or, in the case of the pedestal mount, mount the pedestal base to the floor. Specific details for each mounting arrangement are described below.

6.2.2.1 Wall or Ceiling Mounting

Drawing 400137 shows the components required for wall-mounting a moving laser actuator. Drawing 400136 shows the ceiling mount configuration. The *Centralite Patient Positioning Light Instruction Manual* shows the mounting for fixed lasers.

Moving laser actuators are mounted to a vertical wall using two wall-mount plates (items 3 and 4). One of these plates has a fixed stud; the other plate has an adjustable stud. Both of these plates are mounted to the wall using identical three-hole patterns for 1/4" flat head machine screws. The hole pattern for these mount

plates and their location relative to the center of travel of the actuator is shown on drawing 200442 and on the paper template shipped with the unit. Carefully align the two triangular hole patterns perpendicular to the actuator mounting line and parallel to each other.

To mount the MRR to the two mount plates, first open the cover of the MRR. Slots in the base of the MRR correspond to the two studs protruding from the two mount plates. Place two flat washers over the fixed stud. Place the MRR over the fixed stud first, holding the other end of the MRR slightly away from the wall. Then slide the adjustable stud into position to line up with the second slot in the back of the MRR, and push the MRR over this stud. Install washers and nuts on the studs' finger tight. Align the MRR side to side using the slots in the base of the actuator; then tighten the nuts securely. Position the MRR so that the fixed laser is aligned exactly in the Y plane established above.

6.2.2.2 Pedestal Mounting

Pedestal mounting allows lasers to be mounted vertically, but attached to the floor. This configuration offers the advantage of being able to easily orient the actuator at any angle with respect to the room. This is particularly convenient in rooms where the CT couch is installed at some angle other than ninety degrees relative to the walls of the room.

Installation of a pedestal-mount MRR requires four studs to be installed in the floor. Drawing 200441 shows the pattern for these studs and pedestal alignment and mounting instructions when the pedestal is to be used to mount an MRR. Drawing 200456 provides the same information for cases where a Centralite DLL-2 fixed laser is to be pedestal mounted. The pedestals are identical for both installations, but alignment of the laser line relative to the center line of the pedestal is different in each case. Care should be taken to align the pedestal base hole pattern with the desired location of the Y line in the room, and at an angle so that the laser points correctly towards the zero reference point for the laser system. The holes in the base plate of the pedestal are over-sized to allow for some adjustment of both angle and the lateral position. Before the base plate is secured tightly to the floor, shim under the base plate as required to make the pedestal vertical.

Drawing 400138 shows how the MRR is mounted to the pedestal.

1. Two pedestal clamps slide over the top of the pedestal.
2. Slide the bottom clamp to the approximate final height, and tighten the clamp screw (item 8) to hold the clamp in position.
3. Tighten the clamp screw on the top clamp to the point that the clamp will still slide up and down the pedestal, but will stay in position when it is not being pushed.
4. Remove the cover from the laser actuator. Use a single #10-32 screw through the slot in the base at the LED end of the MRR to mount to the center hole in the bottom clamp.
5. Slide the upper clamp up or down the pedestal until the mounting holes in the base line up with the two outside holes in the top clamp. As with the bottom clamp, use two #10-32 screws and washers to mount the actuator base to the clamp.
6. Once the MRR has been mounted to both clamps, loosen the two clamp screws and position the MRR to the correct position. Final positioning will require turning on the laser lines and aligning these lines with reference lines in the room.

6.2.2.3 Angle Bracket or Sagittal Mounting

Drawing 400135 shows the components required and the general arrangement for angle bracket or sagittal mounting. A ceiling mount plate is required, and this plate must be installed so that its long axis is parallel to the Y line in the system. In this case, of course, it cannot be in the same plane as the long axis of the two Z actuators. The hole pattern for the ceiling mount plate is shown on drawing 200440. Note: Laser assemblies intended for sagittal mounting have only a single functioning laser. The laser that would normally help define the Y plane in a ceiling mount is either turned off or removed. This is because in a sagittal position, this laser cannot be mounted in the Y plane.

For sagittal mounting, the ceiling mount plate includes two pivoting angle mounts attached to the face of the ceiling mount plate. A hex head bolt tightens the joint of each of these pivoting angle mounts. Attached to the moving end of the pivoting angle mounts are the same mount plates that are used for the wall mount and ceiling mount configurations. The purpose of these pivoting angle mounts is to allow the MRR to be mounted so that the midpoint of the line that is projected along the length of the CT couch (in the X plane) is near the center of the CML laser system.

1. Remove the two mount plates (adjustable and fixed stud) from the back of the MRR.
2. Mount them to the actuator adapter side of the pivot mount assembly.
3. Attach the ceiling adapter side of the pivot mount assemblies to the ceiling mount plate as shown in drawing 400135.
4. Mount the ceiling plate to the base plate in the location marked in the previous procedure (6.2.1.3). This is done by drilling and tapping six 1/4-20 holes in the base plate to correspond with the counter-sunk holes along the edges of the ceiling plate.
5. Place two washers over the fixed stud and install the moving laser actuator over the two studs.
6. Secure the moving laser with the studs centered in the mounting slots as in the wall or ceiling mount. Once the actuator is secured to the mount plates, loosen the two hex head bolts in the pivot point of the angle mounts. The actuator can now be rotated freely about these pivots, moving the midpoint of the X line generated by this laser up and down along the length of the CT couch.
7. Rotate the MRR until the midpoint of this X line is approximately in the center of the CT couch, and the ends of the X line extend to each end of the couch.
8. Re-tighten the two hex head bolts in the angle mounts to secure the MRR at the desired mounting angle. This final angle adjustment is most easily made after the system has been connected and the lasers are turned on. See the following section for system connection procedures.

SECTION SYSTEM CONNECTION

7

7.1 SYSTEM CABLE CONNECTIONS

Before final alignment of the three actuators can be completed, the system must be connected together so that the laser lines can be turned on. The following system connections must be made to allow the laser lines to be turned on and their position controlled. These connections can be seen in figure 6.

1. Connect the moving laser actuators (either one or three, depending on the system configuration) to the control enclosure using the actuator cables provided. These cables have 15 pin connectors (DB 15) on each end. One end connects to the 15-pin connector on one end of the actuator; the other end of the cable connects to the 15-pin connector on the control enclosure. Be certain that the cable from each actuator is connected to the connector that corresponds to that particular actuator (X, Z1, or Z2).
2. Connect the 9-pin connector on one end of the hand-held cable to the 9-pin connector on the controller (next to the power connector and switch). Connect the other end of this cable to the bottom of the hand-held terminal.
3. Tighten screws on both ends of the Actuator cables and on the 9-pin end of the hand-held cable to secure the cables to the connectors.
4. Connect the power cord to the power connection on the controller.

7.2 SYSTEM POWER-UP

The system is now ready to have power turned on. Automatic power-up procedures are executed any time power is applied to the system. Power-up operations for the system controller and for the hand-held terminal are outlined below.

NOTE: BEFORE APPLYING POWER TO THE SYSTEM, OPEN THE ACTUATOR COVERS ON EACH ACTUATOR AND BE CERTAIN THAT STRAPPING TAPE THAT SECURES THE BEAM STEERING PLATFORMS DURING SHIPMENT HAS BEEN REMOVED.

7.2.1 System Controller Power-Up

The system controller provides power to the entire system. Power is applied by turning on the power switch on the side of the control enclosure. The following will occur whenever power to the controller is turned on:

1. Amber "Power On" light on the controller lights up.
2. LED's on the front of each of the system MRR's light up.
3. Each system actuator will begin to execute a "Home" routine. In the "Home" routine the laser lines are turned off while the lasers are moving. The lasers travel toward the LED end of the MRR until they reach the limit switch at that end of the actuator. They then reverse direction and travel until they reach the home switch in approximately the center of the MRR. Finally, the lasers move from the home limit switch to the position that has been defined as zero. The factory setting for this zero position is the center of travel. When the zero position has been reached, the laser lines are again turned on, indicating that the correct position has been reached. Note that the switch at the bottom of the actuator must be on (towards front of actuator cover) for the lasers and the LED to turn on.
4. The hand-held terminal will power up. The terminal first displays the version number of the software installed, and then it displays "CHECKING STATUS" until the actuator comes to a stop at "zero." The hand-held terminal will then display "DIACOR LASER POSITIONER" and indicate the current position as 0.0 mm. Note that if the configuration of actuators connected to the system controller has changed since the hand-held terminal was last powered up, a message will appear on the display asking for confirmation of the new configuration.

The entire system can be re-initialized by turning the power switch on the controller off and on again. The above sequence will occur each time the system is powered up. The hand-held terminal can be re-initialized just by unplugging the connector in the base of the handheld terminal and plugging it back in again.

SECTION SYSTEM ALIGNMENT

8

8.1 BASIC LASER ALIGNMENT CONCEPTS

The following basic principles apply to alignment of laser lines independent of the model or application. For each individual laser diode, the following steps must be followed in sequence:

8.1.1 Laser Origin Point must be in the correct plane.

The Laser Origin Point (LOP) is the point where the laser line exits the line generating optics on the laser diode. Generally this is a point at the end of the laser diode, in the center of the laser diode barrel. If there are more than one laser diode that define a particular plane (e.g. the “Y” Plane of a CML moving laser system), then the LOP for each of the lasers must lie in that plane before other alignment adjustments can be made effectively.

8.1.2 Tilt the laser plane to the correct alignment

The tilt adjustment for each laser allows the laser diode barrel to be tilted about the LOP. The LOP does not change position as a result of this adjustment. The requirements for this adjustment are slightly different for each plane in the system. Tilt adjustment cannot be made correctly until the LOP has been located accurately in the correct plane

8.1.2.1 Y Plane

Lasers that form the Y plane in the CML system (e.g. the fixed lasers on the two actuators mounted on either side of the CT couch) must be tilted to be co-planar. This can be accomplished by using the tilt control on the fixed laser (see figure 8) to move the laser line until it passes through the LOP of the laser on the opposite wall. Note, that if the rotation adjustment of the two opposing lasers is not correct, then the tilt adjustment described above may not be quite correct. Therefore, in the case of the Y plane, it may be more efficient to adjust rotation before tilt is adjusted.

8.1.2.2 Z Plane

The Z plane is a horizontal plane. These two lasers (e.g. the moving lasers on the two actuators mounted on either side of the CT couch) must be in the same horizontal plane (i.e. level across the room). If the two opposing lasers have been located with their LOP located correctly in the Z plane (level with respect to each other), then the tilt control (see figure 9) can be used to move the projected laser line until it passes through the origin of the opposing laser.

8.1.2.3 X Plane

The X plane is defined by the moving laser on the ceiling laser actuator. The tilt control for this laser is used to adjust the X Plane so that it is perfectly vertical (plumb).

8.1.3 Rotate the laser plane to the correct alignment

If the first two adjustments have been made correctly, rotation of the laser plane should be the final adjustment that is required. This adjustment consists of rotating the laser diode barrel about its long axis, effectively rotating a line that is generated by a perpendicular intersecting plane about the center point of the line. In the case of the Y plane, laser alignment is most effectively accomplished if rotation adjustment of the side lasers precedes the tilt adjustment of these lasers. Again, the requirements for this adjustment are slightly different for each plane of the system.

8.1.3.1 Y Plane

In the case of the two lasers on either side of the room that help define the Y plane, the laser lines must be rotated so that the lines are vertical (plumb). In the case of the laser in the ceiling actuator that helps define the Y plane, the line must be rotated so as to be parallel with the Y plane defined in the room.

8.1.3.2 Z Plane

The rotation adjustment for the two lasers that define the Z plane for the CML system allow these lines to be adjusted so that the line that is generated on the opposite wall is horizontal (level) from end to end (in the direction perpendicular to the long axis of the laser diode).

8.1.3.3 X Plane

Rotation of the X line (generated by the moving laser on the ceiling actuator) allows it to be made perpendicular to the Y Plane.

8.2 SPECIFIC LASER ALIGNMENT PROCEDURES

With power applied to the lasers and the MRR moving lasers positioned in the zero position, final system alignment can take place by following these three basic steps:

1. Locate each laser actuator or fixed laser in the system so that the LOP for each laser is accurately located in the correct plane.
2. Use tilt and rotation controls to align laser lines so that they are vertical and horizontal, and aligned with each other.
3. Adjust the zero position of the moving laser on each actuator so that the moving laser zero corresponds with the CML system zero and that the Z1 and Z2 actuators are aligned at the same zero position.

8.2.1 Locating the LOP for All MRR Fixed Lasers in the Correct Plane

The purpose of this task is to physically move the actuators so that the origin of each laser is in the correct plane. Once the origins of all of the lasers are correct, the rotation and tilt of each laser can be adjusted so that all of the laser lines in the room fall within the correct plane. If this task is not completely accurately, the subsequent adjustment cannot be made correctly. The procedures for this task vary again, depending on the equipment that is being used to align the CML system.

8.2.1.1 LOP Location of Moving Laser Actuators Using the Rotating Laser

The primary purpose of the rotating laser in this procedure is to locate the fixed lasers on the laser actuators in the correct Y plane. In the case where there are moving laser actuators that are pedestal-mounted, the rotating laser can also be used to get the height of these side lasers located correctly.

8.2.1.1.1 Z Plane

If there are pedestal-mounted lasers in the system, the first step is to position these actuators in the correct vertical position. This can be done using the rotating laser, set in a horizontal orientation on the CT couch. The couch is moved up or down until the rotating laser light passes through all four of the marks that were made on the side wall to define the Z plane in the room. The vertical position of the Z actuators can then be adjusted so that the rotating laser passes through the origin of the moving laser (when it is positioned at the center of travel). A pedestal installation fixture can be used to be certain that the Z actuators remain at this correct height when subsequent rotational adjustments are made.

8.2.1.1.2 Y Plane

The rotating laser can be used to locate the LOP for the fixed lasers on the MRR's that form the Y plane in the CML system. For a CML-1 system, this is the fixed laser from the ceiling-mounted MRR. For a CML-3 system, this includes the fixed laser from all three MRR's. This is accomplished as follows:

1. Set up the rotating laser so that it is rotating in the Y plane.
2. Adjust the rotating laser position until the rotating laser passes through all eight marks that were initially made on the floor, ceiling, and walls to define the Y plane (see section 6.1.2.1).
3. Use the LOP adjustment wheel to make position the fixed laser in each MRR so that it is approximately centered, side to side, in the MRR housing.
4. Reposition each MRR in the system until the rotating laser passes directly through the origin of the fixed laser on the actuator. (It is not essential that the rotating laser pass through the origin of moving lasers on the MRR's.)
5. Tighten the 1/4-20 nuts that hold the MRR's to the mount plates to approximately 50 in-lbs. The MRR's should not be moved from this location in any of the subsequent alignment steps.
6. Use the LOP adjustment wheel to make any final adjustments necessary to move fixed laser such that the rotating laser passes exactly through the origin of the fixed laser.

8.2.1.2 LOP Location of MRR Fixed Lasers Using the RoboVector

If a RoboVector was used to define the location of the CML Y plane, the RoboVector cannot be re-setup to duplicate the original Y plane because the marks on the floor, ceiling and walls that correspond to the initial position of the RoboVector are now covered with laser units. A different procedure must therefore be followed to correctly position the MRRs. This procedure is different for a ceiling-mounted MRR than for those mounted on the sides of the room.

8.2.1.2.1 Ceiling-Mounted MRR

To locate the LOP of the fixed laser on the ceiling-mounted MRR, proceed as follows:

1. Use the LOP adjustment wheel to move the fixed laser so that it is approximately centered, side to side, in the MRR housing.
2. Use the rotation control on the MRR fixed laser (see figure 8) to adjust the line until it is parallel with the two marks on the floor that identify the Y plane.
3. Use a plumb bob and the tilt control on the MRR fixed laser (see figure 8) to adjust the plane of the laser until it is vertical. (If the plane is vertical, the laser will illuminate the plumb bob string over the entire length of the string at the same instant in time, if the plumb bob is held in the laser plane.)
4. With the fixed laser rotated parallel to the Y plane, and tilted vertical, the entire MRR housing must now be moved until the laser line intersects both Y plane marks on the floor, then tighten the 1/4-20 mounting nuts to the correct torque (50 in-lbs.)
5. Repeat steps 2 and 3 above, to make sure that the plane of the laser is still vertical and that the laser line is still parallel to the marks on the floor, now that the MRR is permanently mounted to its base plate.
6. Use the LOP adjustment wheel to move the laser line so that it passes directly through the two marks on the floor that identify the Y plane.
7. When the LOP of the fixed laser has been positioned so that the line it generates passes through the two marks on the floor, recheck that the laser plane is still vertical, using a plumb bob. If the plane is not vertical, it must be made vertical using the tilt control, and step 6 must be repeated again.

8.2.1.2.2 Side MRR's

The opposing fixed lasers on the sides of the CT couch can be used to correctly locate the opposite laser LOP. Follow the procedure outlined below:

1. Begin by using the rotation control for the fixed laser on one MRR (e.g. actuator Z1) to make the laser line vertical. This can be done using a plumb bob as described above, or by making the line parallel to the marks for the Y plane on the opposite wall.
2. Use the tilt control to move the vertical line on top of the two marks for the Y plane on the opposite wall. This line is now the reference line to which the LOP of the fixed laser on the opposing MRR can be aligned.
3. In the MRR to be aligned (e.g. Z2), use the LOP adjustment wheel to move the fixed laser so that it is approximately centered, side to side, in the MRR housing.
4. Adjust the position of the opposing MRR (e.g. Z2) until the LOP of its fixed laser corresponds with the line that is projected from the other side of the room, and which is aligned with the Y plane marks on the wall to which this MRR is mounted.
5. When the first MRR (Z2 in this example) has been positioned correctly, tighten the 1/4-20 mounting nuts to approximately 50 in-lbs.
6. Now use the LOP adjustment wheel to fine-tune the position of the fixed laser in the Z2 MRR so that its origin corresponds exactly with the line projected from the opposing MRR.
7. Repeat steps 1 through 6 to position the second MRR, this time adjusting the line from Z2 over the Y plane marks on the opposite wall, and then using this line as a reference to position the Z1 MRR to get its fixed laser LOP aligned with the Y plane.
8. Repeat steps 1 through 6 one more time to verify that the fixed laser for the Z2 MRR is still located correctly in the Y plane. Adjust the position of the Z2 fixed laser (using the LOP adjustment wheel) if necessary.

8.2.1.2.3 LOP Location for DLL Side Lasers (CML-1 System)

Because both lasers in the DLL are fixed lasers—and any movement of the DLL housing potentially affects the LOP location for both lasers—the procedure to correctly obtain the LOP location for the DLL lasers is different than the procedures described above for MRRs. The LOP for both lasers in the unit must be correctly located at the same time. Fortunately, because the DLLs are always mounted as opposing pairs in a CML-1 system, they can be used to help correctly locate the DLL on the opposite wall. To make this procedure as clear as possible, one DLL will be designated DLL1 and the other DLL2. This designation is purely arbitrary, and is made simply for the purpose of distinguishing the two DLLs in the procedures below.

1. Locate both DLL1 and DLL2 so that the LOP for all four lasers are approximately aligned with the marks for the Y and Z planes on the wall behind them.
2. Turn on both DLLs.
3. Use the rotation control for the vertical laser on DLL1 to make the laser line vertical. This can be done using a plumb bob, or by making the line parallel to the marks for the Y plane on the opposite wall.
4. Use the tilt control to move the vertical line on top of the two marks for the Y plane on the opposite wall.
5. Use the rotation control for the horizontal laser for DLL1 to make the line horizontal. Making the line parallel to the marks for the Z plane on the opposite wall can do this.
6. Use the tilt control to move the horizontal line on top of the two marks for the Z plane on the opposite wall.
7. Loosen the mounting nuts on DLL2, and move it until both laser LOPs are aligned exactly with the corresponding line (horizontal or vertical) projected from DLL1. Re-tighten the mounting nuts on DLL2 and verify that the laser LOPs are still correctly aligned.
8. Use the rotation control for the vertical laser on DLL2 to make the laser line vertical. This can be done using a plumb bob, or by making the line parallel to the marks for the Y plane on the opposite wall.

9. Use the tilt control to move the vertical line on top of the two marks for the Y plane on the opposite wall.
10. Use the rotation control for the horizontal laser for DLL2 to make the line horizontal. Making the line parallel to the marks for the Z plane on the opposite wall accomplishes this task.
11. Use the tilt control to move the horizontal line on top of the two marks for the Z plane on the opposite wall.
12. Loosen the mounting nuts on DLL1, and move it until both laser LOPs are aligned exactly with the corresponding line (horizontal or vertical) projected from DLL2. Re-tighten the mounting nuts on DLL1 and verify that the laser LOPs are still correctly aligned.

8.2.2 Aligning Lasers in the Y plane

Aligning lasers in the Y plane is usually the most difficult part of CML system laser alignment because you must align all three fixed lasers in this plane. Again, this can only be accomplished successfully if the LOP for these three lasers has been located correctly in the Y plane, as described in the previous procedures. Once this LOP is correct for all three lasers, use the tilt and rotation controls for the lasers for final alignment.

8.2.2.1 Align the Fixed Laser on the Ceiling MRR

Depending on the alignment tools that are being used, some of the steps outlined below may have been completed in previous procedures.

1. Use the rotation control on the MRR fixed laser (see figure 8) to adjust the line until it is parallel with the two marks on the floor that identify the Y plane.
2. Use the tilt control on the MRR fixed laser to move the line until it passes through both marks on the floor that identify the Y plane.
3. Use a plumb bob to verify that the plane of the laser is vertical. (If the plane is vertical, the laser will illuminate the plumb bob string over the entire length of the string at the same instant in time, if the plumb bob is held in the laser plane.)
4. If the laser line is not vertical, then the LOP of the fixed laser is not located in the same vertical plane as the marks on the floor, and corrective steps must be taken to locate the LOP of this laser correctly. (See section 8.2.1)

8.2.2.2 Align Fixed Lasers on the Side MRR's or DLL's

Again, some of the steps outlined below may have been completed in previous procedures.

1. Use the rotation controls on both of the fixed lasers on the sides to make the two projected lines vertical. This can be done using a plumb bob, or by making the line parallel to the marks for the Y plane on the opposite wall.
2. Use the tilt controls for these two opposing lasers to bring the lines directly over both marks on the opposite wall that define the Y plane.

At this point, all three fixed lasers that define the Y plane for the CML system should be co-planar throughout the room. This can be confirmed by turning all three lasers on, walking through the room with a piece of white paper, and verifying that when one laser is obstructed at any given time or position in the room, the position of the line on the paper does not change. If this is not the case, you must determine which of the preceding alignment steps was not carried out correctly or carefully enough.

8.2.3 Aligning Lasers in the Z Plane

Aligning lasers in the Z plane is somewhat simpler than the process for aligning in the Y plane, because only two lasers are involved. Once again, the same principles apply. Once the LOP for the two lasers involved is correct, then only rotation and tilt adjustments must be made. In the case of a CML-3 system, the LOP has not yet been located correctly. Because the lasers that make up the Z plane in the CML-3 system are moving lasers, the ability to move these lasers will be used to set the LOP correctly.

8.2.3.1 CML-3 System

As is always the case, correct laser alignment requires that the laser LOP is first correctly set. The ability to move the Z lasers on the MRRs will be used for this purpose.

1. Begin with both moving lasers at zero, i.e., approximately aligned with the Z plane in the CML system.
2. Use the rotation control on the moving laser (see figure 9) on the Z2 MRR to adjust the line so that it is parallel to the marks defining the Z plane on the opposite wall.
3. Use the tilt control on the moving laser for the Z2 MRR to move the line so that it passes through both marks on the opposite wall that define the Z plane.
4. Use the Align function on the hand-held terminal to move the Z1 moving laser until its LOP corresponds with the Z line projected from the Z2 MRR. Use the hand-held terminal to set this as the new zero position for the Z1 MRR.
5. Repeat the process to set the zero position of the Z2 MRR so that the LOP of the moving laser is correctly located in the Z plane.
6. Adjust the tilt of the repositioned Z2 laser so that the line passes through the marks defining the Z plane on the opposite wall (and through the LOP of the Z1 laser).
7. Make any minor adjustments to rotation and tilt of the two Z lasers so that the two projected lines pass through the two marks defining the Z plane on the opposite wall, and are co-planar with each other throughout the room.

If the two Z lasers are not co-planar throughout the room at this point, you must determine which of the preceding alignment steps was not carried out correctly or carefully enough.

8.2.3.2 CML-1 System

In the case of the CML-1 system, if the steps for locating the LOP for the two DLL's in the system were performed correctly, the Z plane lasers should already be aligned across the room. The process that used the opposing DLL to set the LOP for each laser on the DLL required that rotation and tilt be adjusted correctly as part of the process. If the two lasers that form the Z plane in the CML system are not now co-planar throughout the room, then the process outlined in section 8.2.1.3 should be reviewed, and repeated as necessary.

8.2.4 Aligning the Laser in the X plane

In this case, there is only a single laser to align, the moving laser on the ceiling-mounted MRR. This process is as follows:

1. Use the rotation control to rotate the line until it is parallel to the X plane in the system. This is most easily defined by a line on the installation phantom base plate that is marked perpendicular to the Y plane in the system. Note: This line may not be parallel to the direction of the CT couch longitudinal travel, if the couch has not been installed exactly perpendicular to the CT scan plane.
2. Use a plumb bob and the tilt control on the MRR moving laser (see figure 9) to adjust the plane of the laser until it is vertical. If the plane is vertical and the plumb bob is held in the laser plane, the laser will simultaneously illuminate the entire length of the plumb bob string.
3. Use the Align function on the hand-held terminal to move the moving laser on the X MRR, until its projected line intersects the mark on the floor that corresponds to the X plane in the CML system. Use the hand-held terminal to set this new position as the new zero for the X MRR.

8.2.5 Final Alignment Verification

Once all three planes have been aligned, and the appropriate lasers are co-planar throughout the room, the installation phantom should be scanned one more time to verify system alignment. This verification is most easily accomplished if three CT marker “BB’s” are mounted to the installation phantom, one on each side, and one on the top, all in the same Y plane of the installation phantom. Alignment verification would then proceed as follows:

1. Set the installation phantom on the base plate on top of the CT couch.
2. Set all the CML system lasers to zero.
3. Align the installation phantom so that the two CT markers on the side are located at the intersection of the Y and Z lines, and the CT marker on the top is located at the intersection of the X and Y lines.
4. Without changing the couch height, move the couch in until the CT markers are aligned with the CT scan plane.
5. Perform a scan.
6. Verify that all three CT markers are visible in the same CT slice. If they are not, either an error was made in setting up the installation phantom, or the Y plane of the CML system has not been made properly parallel to the CT scan plane. If this is the case, the CT room must most likely be re-marked, and lasers re-positioned and re-aligned.
7. Verify the offset distance between the scan plane and the CML Y plane. This number does not need to be any specific number, or a round number, but its value should be noted for future use in patient setup.
8. Verify that the center of the CT markers corresponds at least approximately to the center of the radiographic scan.

Final Alignment Verification should be included in the normal room verification procedures initiated and maintained by the end user and should be performed and documented regularly.

SECTION ACTUATOR CALIBRATION

9

Each MRR is calibrated at the factory prior to shipment to the installation site. No additional calibration should be required on site. However, if large errors are detected in the line position, at any point along its travel, a provision for field calibration is built into the system. The following process would be followed to calibrate an MRR on site.

The position correction system is designed to allow an operator to calibrate an actuator so that the line moved by the actuator moves to a correct location at some fixed distance from the actuator. Calibration coefficients are determined at 20 mm intervals along the full travel length of the actuator. To determine these calibration coefficients, the moving laser is moved from 0 to 500 mm (absolute coordinate system) in increments of 20 mm. At each of these 26 positions, the actual laser line position is compared to the commanded position. The difference between these two positions is the calibration coefficient for that rail location. For example, if the actuator is commanded to move to the 20mm position (stop no. 1), and the line position at 2 meters is measured to be 19.50 mm, a correction coefficient of 0.50 mm is calculated for that point. Following completion of the calibration, these correction coefficients are added to the commanded position, so that in the above example, when the MRR is commanded to move to the 20 mm position, the line movement corresponds to 20.00 mm. Since only 26 points are measured during the calibration, a linear interpolation is used to calculate a correction factor for any point between the actual calibration points.

The calibration menus on the hand-held terminal are protected by level-two passwords. If you are using a terminal that has just had software loaded, no password will be set. Pressing “ENTER” when the terminal prompts for a password will allow access to password-protected menus.

The hand-held terminal includes the AutoCal program that automatically steps the actuator through the 20 mm intervals and prompts the operator to enter a position for each step. To calibrate an actuator, there must be a standard against which to calibrate the actuator. At the factory, a precision height gauge, mounted on a granite block, is used as the standard. Detailed procedures for running the AutoCal program are available in the *Centralite / CT Moving Laser Patient Positioning System Hand-Held Terminal Operator Manual*.

APPENDIX

Base Plate Requirements



Properly located and mounted base plates are critical to a successful CML system installation. The moving laser actuators and fixed lasers are mounted to these base plates. If the base plates are not mounted in the correct location, the lasers cannot be located correctly in the room. If the base plates are not adequately rigid, then the laser lines may not remain at a fixed location relative to the radiographic center of the CT simulator.

These base plates are not provided by Diacor, but are generally installed as part of the CT room construction. Their purpose is to provide a stable, rigid mounting surface for the laser units. In order to locate the lasers in the precise location required to align to the CT radiographic center, CML system installers drill and tap mounting holes for the laser units in these base plates. For this reason, the base plates are somewhat oversized to allow the installers some latitude in correctly positioning the laser units.

Material

Base plate material may be either steel or aluminum. Aluminum makes the task of on-site drilling and tapping easier for the installers.

Size

The minimum recommended size for the base plate is as follows:

Fixed Laser (DLL-2): 18 inches high by 10 inches wide

Moving Laser (MRR-1) 48 inches high by 12 inches wide

The minimum material thickness for the base plates is 1/4 in.; 3/8 in. is preferred.

The above sizes are minimum requirements. Depending on the structure in the wall or ceiling to which these base plates will be installed, it may be desirable to make the base plates wider than the minimum to provide a more stable mounting structure. For example, if the base plate will be mounted to an existing wall, it may be desirable for the base plate to be wide enough to connect to three wall studs.

Mounting

The primary requirement in mounting is that the base plate is stable and rigid. This helps ensure that laser lines remain aligned with a fixed location in the room, regardless of changing events such as opening and closing doors, variable loads on walls, floors, and ceilings due to thermal effects, equipment being moved, etc. The ideal mounting structure for the base plates is a structural steel frame that is independent of the wall and ceiling structure in the room. Examples of this type of frame are shown on drawings 400128, 400129 and 400130 in appendix B. Alternatively, unistrut members can be installed in the walls to which base plates can be installed. In this case, the unistrut members should run floor to ceiling and be secured to building structural elements, independent of the walls. Likewise, the base plate installed in the ceiling should be mounted to a rigid steel structure that is securely mounted to the building structure above the ceiling (e.g. concrete or steel beams above the ceiling).

Location

Although the base plates are oversized to allow some latitude in the location of the laser units, accurate location of the base plates is still important. And, of course, aesthetics in the room are improved if the laser units appear centered on the base plates.

For the vertical height of the base plates for the Z1 and Z2 laser units, it is generally desirable for the laser lines to correspond with the radiographic center of the CT Simulator. This height varies from manufacturer to manufacturer of CT simulators, and must be verified for each installation. For moving laser actuators (MRR), the center of the base plate should correspond to the height of the radiographic center in the room (the height of the center of the doughnut on the CT simulator). However, for fixed lasers (DLL-2), the center of the laser line does not correspond to the center of the mount plate. Figure 4.3 in the *Centralite Patient Positioning Light Instruction Manual* shows the location of the laser line origin relative to the DLL-2 mount plate. It is this alignment point that must be at the same height as the center of the CT simulator.

The long axis of the base plates on the walls and on the ceiling base plate must be aligned with the Y plane defined in section 2 of this manual. The Y plane is a plane parallel to the scan plane of the CT simulator, but offset towards the foot of the couch by a distance of 50 to 60 cm. This offset distance is a function of the CT simulator and its physical dimensions and must be verified for each installation. To correctly locate the base plates in the Y plane, the location of the CT simulator must be known, as well as the offset distance to the lasers (50 to 60 cm).

The height of the base plate for the ceiling laser should generally be such that the bottom face of the base plate is flush with the ceiling.

APPENDIX

INSTALLATION DRAWINGS

B

The following drawings are included in this appendix:

700002	LASER POSITIONER SYSTEM CONFIGURATION
400135	LASER POSITIONER SAGITTAL MOUNT ASSEMBLY
400137	LASER POSITIONER WALL MOUNT ASSEMBLY
400138	LASER POSITIONER PEDESTAL MOUNT ASSEMBLY
400139	MOVING LASER ACTUATOR GENERAL ARRANGEMENT
200411	CEILING PLATE (LASER POSITIONER)
200440	CEILING PLATE HOLE PATTERN FOR CEILING OR SAGITTAL MOUNT ACTUATOR
200441	HOLE PATTERN FOR PEDESTAL MOUNT MOVING LASER
200442	HOLE PATTERN FOR WALL MOUNT ACTUATOR
200443	HOLE PATTERN, WALL MOUNTING MOVING LASER CONTROLLER
200456	HOLE PATTERN FOR PEDESTAL MOUNT CENTRALITE
400128	MOUNTING SYSTEM CML-3xx OPTION 1
400129	MOUNTING SYSTEM CML-3xx OPTION 2
400130	MOUNTING SYSTEM CML-1