PORTALCAST®

Block Cutting and Casting System

REFERENCE MANUAL

DIACOR

DIACOR, INC, 2550 DECKER LAKE BLVD., SUITE 26, WEST VALLEY CITY, UTAH 84119

800 342-2679 / 801 467-0050 / FAX: 801 487-3258
www.diacorinc.com
info@diacorinc.com

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WARNING

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Figure 1.1  Diacor Model BCS-1 Block Cutting and Casting System
# TABLE OF CONTENTS

## INTRODUCTION
1.1 GENERAL 1

## SYSTEM OVERVIEW
2.1 GENERAL 3
2.2 BLOCK CUTTER ASSEMBLY 3
2.3 WORKSTATION ASSEMBLY 3
2.3.1 Block Cooling System 4
2.3.2 The Horizontal Hot Wire 4
2.4 TRAY SYSTEM 4
2.4.1 Blocking Tray 4
2.4.2 The Standard Tray 5
2.4.3 The Reference Frame 5

## BLOCK CUTTER ASSEMBLY
3.1 GENERAL 7
3.2 POWER CONTROL SYSTEM 7
3.2.1 Controls 7
3.2.2 Fuses 8
3.2.3 Cutting Wire Pedal Switch 8
3.3 BLOCK CUTTER FRAME (SFD/STD ADJUSTMENT) 9
3.4 C-ARM 10
3.4.1 Cutting Wire 11
3.4.2 Control Aperture 11
3.4.3 Warning Aperture 11
3.5 ELECTRON MODE/PHOTON MODE SWITCH 12
3.5.1 Aperture Adjustment 12
3.5.2 Electron Blocks 12
3.6 COOLING FAN 13
3.7 STYROFOAM BLANK HOLDER 13
3.8 CENTERING JIG 13
3.9 LIGHT PANEL 14
3.10 FIELD LIGHT 14
3.11 “JIG-SAW” PANEL 14

## WORKSTATION ASSEMBLY
4.1 GENERAL 17
4.2 POWER CONTROL SYSTEM 17
4.2.1 Controls and Indicators 17
4.2.2 Fuses 19
4.2.3 Circuit Breakers 19
4.2.4 Outlets 20
4.3 POURING AND COOLING STATION 20
4.3.1 Stainless Steel Interior 20
4.3.2 Hinged Splash Panel 20
4.3.3 Spill/Dust Tray 20
4.3.4 Melting Pots and Trolley 20
4.3.5 Cooling Tray 21
4.3.6 Hydraulic Presses 21
4.4 HORIZONTAL HOT WIRE AND CUTTING RAMP 22
4.5 REFERENCE FRAMES 23
4.5.1 Reference Frames 23
4.6 TOOLS AND ACCESSORIES 23
4.6.1 Drill Press 23
4.6.2 Vacuum Cleaner 23
4.6.3 Hand Drill 23
4.6.4 Cordless Drill 23
4.6.5 Spring-Loaded Punch 24
4.6.6 Miscellaneous Tools 24
4.6.7 Dust Pan and Bin 24
4.7 OTHER WORKSTATION ASSEMBLY FEATURES 24
4.7.1 Shelf Storage 24
4.7.2 Lockable Drawer 24
4.7.3 Cerrobend Block Storage 24
4.7.4 Ventilation 24
4.8 STORAGE CABINET 25

THE STYROFOAM BLANK 27
5.1 GENERAL 27
5.2 STYROFOAM BLANK SPECIFICATIONS 27
5.3 RECOMMENDED MATERIAL 27
5.4 SIZE 27
5.5 THICKNESS 27
5.6 CUTTING BLANKS TO SIZE 28
5.7 TOLERANCES FOR CUT BLANKS 28

OPERATING PROCEDURES 29
6.1 GENERAL 29
6.2 PREOPERATIONAL CHECKS 29
6.2.1 Centering the Light Panel 30
6.2.2 Adjusting the Apertures 31
6.2.3 Adjustment of C-Segment Attachment to Telescopic Tubes 32
6.3 SET-UP PROCEDURES 32
6.3.1 Setting the STD 33
6.3.2 Determining and Setting SFD 33
6.4 CUTTING A BLOCK 33
6.4.1 Selecting a Styrofoam Blank 33
6.4.2 Surfacing a Styrofoam Blank 33
6.4.3 Adjusting the C-Arm 35
6.4.4 Inserting the Styrofoam Blank in the Block Cutter
6.4.5 Positioning the Simulator Film
6.4.6 Tracing the Lines with the Pointer
6.4.7 Cutting a Mold
6.5 PREPARING A MOLD AND CASTING
6.5.1 Cleaning the Mold
6.5.2 Taping the Mold
6.5.3 Spraying the Mold
6.5.4 Clamping the Mold
6.5.5 Filling the Mold
6.5.6 Cooling the Casting
6.6 PREPARING THE BLOCKING TRAY
6.6.1 Aligning the Tray and Casting with the Reference Frame
6.6.2 Locating the Mounting Holes
6.6.3 Drilling Mounting Holes in the Tray
6.6.4 Marking Positions for the Mounting Holes in the Casting
6.6.5 Drilling Holes in the Casting
6.6.6 Finishing the Completed Block
6.6.7 Fastening the Blocks to the Tray

MAINTENANCE PROCEDURES
7.1 REFERENCE FRAME ALIGNMENT
7.2 LIGHT PANEL ADJUSTMENT
7.2.1 Centering-Jig Alignment
7.2.2 Rotational Alignment and Cable Tension Adjustment
7.3 FIELD LIGHT ADJUSTMENT
7.4 CLEANING THE APERTURES AND CUTTING WIRE
7.4.1 Cleaning the Apertures
7.4.2 Cleaning the Wire
7.5 REPLACING THE CUTTING WIRE
7.6 REPLACING/ADJUSTING THE HORIZONTAL HOT WIRE
7.6.1 Replacement Procedure
7.6.2 Adjustment Procedure
7.7 CLEANING PROCEDURES
7.7.1 Light Panel
7.7.2 Stainless-Steel Surfaces
7.7.3 Plastic-Laminated Surfaces
7.7.4 Melting Pot
7.7.5 Fan Grills
7.7.6 Steel Tray
7.7.7 Lubrication/Cleaning of Vertical Block Cutter Rods
7.8 FLUORESCENT BULB REPLACEMENT
7.9 REPLACING THE FIELD LIGHT
7.10 CLEANING CONTAMINANTS FROM THE MOLTEN METAL
7.11 RECYCLING METAL SCRAPS
SPECIAL TECHNIQUES AND TIPS  57
8.1 CASTING PHOTON BLOCKS  57
8.1.1 Thin Blocks  57
8.1.2 Double Blocking  57
8.1.3 Suggestions for Designing Blocks  58
8.1.4 Repositioning Blocks on a Tray  58
8.1.5 Partitioning Large Blocks to Facilitate Remelting  59
8.2 ELECTRON BLOCKS  59
8.2.1 Numerical Correction for STD's < 95 cm  59
8.2.2 Special Use of the ELECTRON MODE/PHOTON MODE Switch  60
8.2.3 Pouring Electron Blocks  60
8.3 MANUAL POSITIONING OF BLOCKS  61
8.4 CORRECTION FOR OUT-OF-RANGE SFD  61
8.5 ADDING METAL TO THE MELTING POT  61
8.6 MOUNTING THE TRAY TO THE CASTING  62
8.7 SOURCES OF ERROR FROM BLOCK ATTACHMENTS TO TRAY  62
8.8 SOURCES OF ERROR IN POSITIONING TRAY WITH RESPECT TO BEAM  62
8.9 PROBLEMS WITH ELECTRON SCATTERING FROM BLOCKING TRAYS  65

WARRANTY  67
9.1 WARRANTY  67
9.1.1 Warranty Disclaimers  67
9.1.2 Warranty Performance  67

THE STANDARD TRAY  69

SCHEMATIC DIAGRAMS  71

OUT-OF-RANGE SFD  81
1.1 GENERAL

Precise radiation therapy treatment requires precision secondary field collimation using custom shaped blocks that reproduce beam geometry relative to the patient’s anatomy exactly as it was represented on the simulator. These blocks are formed using high-density alloys that have low melting points, and the formed blocks are fixed to plastic trays that lock into the accelerator’s accessory mount.

The Diacor Portalcast® Block Cutting and Casting System, hereinafter referred to as the “System,” (Figure 1-1), was developed specifically to allow custom-shaped blocks to be formed and blocking trays to be constructed with minimum delay and maximum efficiency and accuracy. Direct benefits of this System include expediting the initiation of patient treatments and improving the accuracy and reproducibility of those treatments. Even complex multiport treatments can be performed expeditiously using this System. Additional benefits include a reduction in labor costs, increased efficiency in the use of million-dollar treatment equipment because of increased throughput, and overall improvement in patient and technologist satisfaction.
2.1 GENERAL

This Section contains a brief functional overview of the two major elements of the Diacor Portalcast Block Cutting and Casting System, the Block Cutter Assembly and the Workstation Assembly. This Section also includes a brief discussion of the Tray System that registers and holds the finished blocks.

2.2 BLOCK CUTTER ASSEMBLY

Basic design features of the Block Cutter include:

- A rigid and straight “C-arm” with a spring-loaded cutting wire.
- A means of varying the source-tray distance (STD) and source-film distance (SFD).
- An adjustable light panel with an inscribed central axis on which the X-ray film is placed, and a means of determining proper alignment of the light panel.
- A unique cutting-wire power control mechanism.
- A field light for projecting the image of the completed mold onto the X-ray film onto the light panel.

To facilitate production of extremely accurate molds without extensive training or practice, the power control mechanism provides automatic control of the heating rate of the C-arm cutting wire in response to the cutting rate. Without such control, the production of an accurate mold becomes very dependent on the good technique of the operator and the constant tracing speed of the pointer.

In the case of the Block Cutter, the speed of the pointer is important only if it is moved too fast and the wire is dragged behind — no matter how slowly the pointer is moved, the wire will not melt-out the mold. An audible pulsating tone indicates when the wire is being heated but requires no attention on the part of the operator. If the pointer is moved too quickly (indicating the wire is dragging behind the pointer) a constant audible warning tone is emitted.

The System enables translational adjustment of the light panel to avoid potential problems resulting from the cutting wire being slightly non-coaxial with the pointer and C-arm axis of rotation. For any given setting of SFD or STD, you can ensure that the cutting wire is at the center of the Styrofoam blank, and the light panel can be adjusted so that the pointer is on the central axis.

2.3 WORKSTATION ASSEMBLY

The Workstation Assembly is designed to enable space- and time-efficient pouring of Cerrobend
into custom molds and the production of finished blocking trays. It contains all of the features and tools necessary for the entire process including a Cerrobend melting pot, stainless steel worksurfaces, proper lighting and ventilation, a vacuum cleaner, a drill press, other critical power and hand tools, a spare melting pot and trolley, and storage space for Styrofoam blanks and Cerrobend. Two special features of the Workstation Assembly are described in paragraphs 2.3.1 and 2.3.2.

2.3.1 Block Cooling System

The Workstation includes a stainless-steel enclosed area designed to minimize and contain splattering or spillage of molten metal during the pouring process. The Workstation also has an integral refrigerated cooling plate that enables block-cooling time to be reduced to a minimum.

The block-cooling system becomes an especially important feature in any situation where space constraints and rapid production time are important considerations. Rapid cooling is needed not only for solidifying the Cerrobend, but so that the blocks may be handled more quickly for further processing. During the initial cooling process, the mold is held against the cooling surface by hydraulic clamps to prevent leakage.

When the cooling plate is cooled with refrigerant to approximately 10° C and the mold is filled with a low-melting-point alloy, the casting typically will solidify and be cool enough to handle comfortably within about 25 minutes after the molten Cerrobend was poured.

2.3.2 The Horizontal Hot Wire

The horizontal hot wire (HHW) can be used to cut Styrofoam blanks to virtually any thickness. The most common application for the HHW is removing a thin Styrofoam layer in order to produce a flat surface that will seal well against the cooling plate. Another frequent use is for cutting 1-cm thick slices to make molds for shaping electron beam fields. The HHW also can be used to create integrated shielding and compensating blocks that can be used to administer a partial radiation dose to the lungs, liver, spinal cord, or kidneys while a full dose is delivered to other tissues in the field.

2.4 TRAY SYSTEM

2.4.1 Blocking Tray

The plastic tray used for supporting the Cerrobend blocks is usually predetermined by the user’s equipment and conventions. Trays are typically 1/4-inch to 3/8-inch plastic, either acrylic (Plexiglas) or polycarbonate (Lexan). Plexiglas trays work well, as long as they are not overloaded with particularly heavy blocks, and there is adequate support near the edges of the tray. However, a Plexiglas tray should be discarded if it develops any significant cracks.
Lexan trays have the advantage of being virtually unbreakable, but they are slightly less rigid than Plexiglas trays. This means there is the potential for slightly greater positional errors when Lexan trays are used. Lexan also is soluble in acetone, which is frequently used in Radiation Oncology departments for removing wax pencil marks.

Either material is acceptable within its limitations. Added strength and rigidity are provided by 3/8-inch trays, but the edges usually must be milled to fit the 1/4-inch slots of the treatment machine’s tray holder, which adds additional expense. Any tray up to 12-inches square that does not have handles or protrusions on the beam side will generally adapt satisfactorily to the reference frame discussed in paragraph 2.4.3.

2.4.2 The Standard Tray

The standard tray is a representative tray with the position of the treatment machine field axis marked on it. The standard tray is used for all applicable quality control procedures and alignment checks. Refer to Appendix A for additional information on the standard tray.

2.4.3 The Reference Frame

The reference frame provides a precise method of mounting the casting to blocking trays of nearly any design. This device is used to position the tray with respect to the edges of the mold so that the mounting position of the blocks can be marked. The major advantage of this method is to virtually eliminate human error in the tray-mold alignment process. Additional information provided in paragraph 4.5.
3.1 GENERAL

This Section contains a description of the major physical and functional characteristics of the Block Cutter Assembly (Figure 3-1), which include:

- The power control system for the Block Cutter Assembly.

- The block cutter frame, which can be adjusted to achieve proper source-film-distance (SFD) and source-tray-distance (STD).

- The telescopic segmented C-arm, which includes the heated wire for cutting Styrofoam blocks.

- A centering jig for determining the exact position of the cutting wire that would correspond to the center of the Styrofoam blank.

- An adjustable light panel with X-Y coordinates to allow proper alignment with the X-Y coordinates on the patient X-ray.

- A field light that enables the image of a finished mold to be projected onto the simulator film or computer generated templates to check accuracy of the mold before it is poured.

3.2 POWER CONTROL SYSTEM

Most of the elements of the power control system for the Block Cutter Assembly are housed in the power control module (Figure 3-2). The control module, which contains the controls for the Block Cutter Assembly, a power indicator, and two fuses, is a self-contained unit that can be removed from the Block Cutter Assembly for maintenance purposes by loosening the retaining screws for the plastic knee-guard around the module, and then disconnecting three electrical connectors. A schematic diagram for the control module is provided in Appendix B.

3.2.1 Controls

**MAIN POWER Toggle Switch and Indicator.** This two-position switch is used to apply primary power to the electrical circuits in the Block Cutter Assembly. When the switch is set to the “on” position (up), the white indicator to the left of the switch turns on.

**PANEL LIGHT Toggle Switch.** When this two-position switch is set to the “on” position (up), power is applied to the lights in the light panel.

**FIELD LIGHT Toggle Switch.** When this switch is activated, power is applied to the field light. (On earlier units, this is a push-button switch.)
PHOTON MODE/ELECTRON MODE Toggle Switch. The function of this switch is explained in paragraph 3.5 following discussion of the function of the C-arm.

WIRE TEMP Control. This potentiometer is used to increase and decrease the current flow through the cutting wire, which increases and decreases the temperature of the wire. Turning the control clockwise increases the temperature of the wire.

3.2.2 Fuses

The 4-ampere LIGHTS, FANS fuse is used to protect the power circuits for the lights, the cutting wire fan, and the field light fan against current overload. Do not replace this fuse with one that has a higher current rating. The 2-ampere WIRE fuse is a used to protect the cutting wire against current overload. Do not replace this fuse with one that has a higher current rating.

3.2.3 Cutting Wire Pedal Switch

The Block Cutter Assembly is equipped with a foot-pedal switch that is part of the power-control circuit for the cutting wire (Figure 3-2). However, as explained later in this Section, the control aperture also is part of this circuit, which means current flows through the cutting wire only when the wire is in contact with the edge of the control aperture and the pedal switch has been pressed.

Figure 3.1 Diacor Model PBC-1 Block Cutter Assembly
3.3 BLOCK CUTTER FRAME (SFD/STD ADJUSTMENT)

The frame of the block cutter consists of two 1-inch diameter precision steel rods (Figure 3-1). Both the upper and lower horizontal elements ride on linear ball-bearing races and are spring counterbalanced to provide smooth linear motion. Positioning of the upper element provides adjustment for the source-film-distance (SFD), whereas movement of the lower element provides adjustment for the source-tray-distance (STD).

After the position of the lower element has been adjusted, the lower element is locked in position relative to the upper element. Therefore, when the STD is established, both upper and lower elements can be moved as a unit to subsequently adjust the SFD. Many users establish and maintain a constant STD for all applications and adjust only the SFD as part of their daily routine.
3.4 C-ARM

The telescopic segments of the C-arm (Figure 3-3) are made from precision aluminum tubing to accommodate various source-film and source-tray distances, and the thin-walled steel C-section provides optimum rigidity, but is light-weight. The C-arm is designed specifically to ensure that the two portions of the telescopic tubing on either side of the C-section will be as linear and coaxial as practically possible. The pivot point for the C-arm is 9.5 mm below the top surface of the upper horizontal element.

There is a slot in the left side of the Block Cutter Assembly cabinet to allow the C-arm to extend beyond the confines of the cabinet. This allows the cutting wire to be moved well out of the way during the insertion of a large Styrofoam blank. A positionally adjustable coil-spring clamp on the left vertical support rod acts as a retainer to hold the C-arm in the slot so that both of the operators hands are left free to insert the blank with no risk of the C-arm suddenly swinging inward and

![Figure 3.3 C-Arm](image-url)
damaging the cutting wire.

### 3.4.1 Cutting Wire

**Wire Tension.** Tension on the cutting wire is maintained by a coil spring to compensate for wire expansion during heating and with repeated use.

**Wire Replacement.** During average use, the cutting wire will last for months. The attachment points are fully exposed and the wire can be easily replaced in a few minutes. Specific instructions for replacing the cutting wire are provided in Section 7.

### 3.4.2 Control Aperture

The cutting wire passes through a hole in a small brass component called the control aperture located near the top of the wire (Figure 3-3). The hole in this component is about twice the diameter of the wire. The function of the control aperture is to regulate the amount of current applied to the cutting wire so that the wire draws only sufficient current to maintain the cutting action.

The control aperture should be positioned so that it is coaxial with the wire (the position is adjustable). As the cutting wire comes in contact with the Styrofoam, the wire is deflected against the edge of the control aperture. This contact completes an electrical circuit that allows full power to be applied to the cutting wire if the pedal switch also has been pressed (the pedal switch should remain activated throughout the cutting process). With power applied to the cutting wire, the wire heats sufficiently to cut the Styrofoam.

As cutting occurs, the deflection decreases, the wire straightens, and contact with the edge of the control aperture usually is broken, removing power from the wire. Since the heating process has been temporarily suspended, pressure against the wire increases, the wire deflects against the control aperture, power is again applied to the wire, and the cutting action is resumed.

This process occurs so quickly as to be unnoticeable to the operator, except as an irregularity in the pulsating audible tone generated when the wire is being heated. The result is that power is applied to the cutting wire only as required to perform the cutting action. The direct benefit of this technique is that there is not a continuous flow of current through the cutting wire, which means the wire does not get hot enough to cause the Styrofoam to melt, except as a result of direct contact with the wire.

### 3.4.3 Warning Aperture

The cutting wire also passes through a hole in another brass component called the warning aperture located near the lower end of the wire (Figure 3-3). The hole in the center of the warning aperture is larger in diameter than the hole in the center of the control aperture, which means the wire must deflect even further to contact the edge of the warning aperture.

When the wire deflects enough to contact the edge of the warning aperture, it completes an electrical circuit that produces a constant audible tone to warn the operator that wire deflection is too
great. Wire deflection becomes too great when the pointer is moving too fast for the selected wire heating rate. This causes the wire to drag behind the position of the pointer and results in rounding of corners of the mold intended to be square, as well as other possible inaccuracies.

The position of the warning aperture also is adjustable; it also should be positioned so that the aperture is coaxial with the cutting wire.

3.5 ELECTRON MODE/PHOTON MODE SWITCH

This switch is used to electrically reverse the functions of the control aperture and warning aperture. When the switch is in position PHOTON MODE (the “normal” position), the upper aperture functions as the control aperture and the lower aperture functions as the warning aperture, as described in paragraphs 3.4.2 and 3.4.3. The function of the two apertures is electrically reversed when the switch is set to position ELECTRON MODE. Reversing the function of the two apertures is useful when attempting to center the wire within the control aperture, and necessary when cutting electron blocks.

A light located at the right rear of the light table turns on when the switch is set to position ELECTRON MODE.

3.5.1 Aperture Adjustment

When the switch is set to position PHOTON MODE, a constant audible tone is produced when the cutting wire contacts the edge of the warning aperture, as explained in paragraph 3.4.3. This tone can be used as a guide when adjusting the warning aperture to center the wire within the aperture.

NOTE: The constant audible tone is produced whether or not the pedal switch is activated, and occurs independent of wire heating.

To use this same audible tone as a guide when adjusting the control aperture, first set the ELECTRON MODE/PHOTON MODE switch to position ELECTRON MODE to reverse the roles of the two apertures. The tone will then be produced when the wire contacts the edge of the control aperture, because that aperture is now functioning as the warning aperture.

3.5.2 Electron Blocks

Cutting molds for electron blocks from a simulator film is performed in a manner analogous to the routine for cutting photon blocks. A Styrofoam blank that is approximately 1 cm thick typically is used, and the STD is set as large as possible (up to 95 cm). With the apertures functioning “normally,” the thin Styrofoam slab strikes near bottom of the cutting wire, thus causing the lower aperture to be more sensitive to wire deflection than the upper aperture (despite the fact that the lower aperture is slightly larger in diameter). Under these conditions it is more appropriate for the lower aperture to function as the control aperture (the switch set to position ELECTRON MODE).

The question “Why not just cut at a shorter STD setting, position the Styrofoam in the middle of the cutting wire and cut in the normal photon mode?” is a reasonable one to ask. This may work
perfectly well. However, depending on the SFD at which the simulator film was taken, you may find that you will be constrained to work at an SFD setting on the block cutter that is too short to be accommodated by the available range of the telescopic tubing.

3.6 COOLING FAN

Power is applied to the cutting wire only when it is in physical contact with the Styrofoam blank (during the actual cutting process). Power is removed from the cutting wire when the cutting action stops, which helps prevent the wire from overheating. In addition, a fan connected to the lower horizontal element further cools the portions of the wire that are exposed to the air. The result is that the edges of the mold do not “balloon,” or melt out from contact with the wire either during the cutting process or when the cutting action stops as shown in Figure 3.4. This results in a more accurate mold. It also helps prevent melted plastic from running down the wire and contaminating the warning aperture, and extends the useful life of the wire.

![Diagram of cutting wire and cooling system](image)

Figure 3.4 Benefits of Cooling Cutting Wire

3.7 STYROFOAM BLANK HOLDER

Three different sizes of Styrofoam blanks can be used with the System, 7-5/8 inches square, which is generally large enough for most fields, 10 inches square, and 11-1/2 inches square. The holder for large blanks is a permanent part of the lower frame assembly Figure 3-5). The holder for the 7-5/8 inch blanks is supplied with the System, and is fixed in position within the holder for large blanks when the System is shipped. The small holder is removable to allow installation of the holder for 10-inch blanks, which is not supplied as part of the standard System, but is available as an option.

3.8 CENTERING JIG

The centering jig provides a means of adjusting the light panel so that when the cutting wire is located at the center of a Styrofoam blank, the pointer also will aim at the precise intersection of the crosshairs on the light panel. This jig is a hinged panel with an L-shaped metal plate attached. When the jig is swung into a position parallel to the lower horizontal element to check for proper alignment, the L-shaped plate is positioned so that the inner edges of the “L” are at the two vertical orthogonal planes through the middle of the Styrofoam blank. Figure 3-5 shows the Centering Jig Standard in place. This is an L-shaped metal plate attached to a plastic panel that mates to the
centering jig as shown in Figure 7-1 when the centering jig is properly adjusted.

The L-shaped metal plate is part of an electrical circuit that functions in the same manner as the circuit for the warning aperture. When the cutting wire contacts the plate, a constant audible tone is activated. The wire can be touched against the inner edges of the plate by moving the C-arm pointer. When properly adjusted, a constant tone sounds when the pointer touches the cross hairs on the light panel. If there is a misalignment, the light panel can be repositioned as described in the following paragraph.

3.9  LIGHT PANEL

The light panel, Figure 3-6, has the unique feature of being positionally adjustable. The centering jig (discussed in the preceding paragraph) provides a simple means of determining the exact position of the cutting wire that would correspond to the center of the Styrofoam blank. By loosening a single large knob, the light panel cross-hairs can be positioned to correspond with the C-arm pointer at the position corresponding to this central location. The panel can be moved translationally from front to back and side to side, but it cannot be rotated. There is a crossed cable system under the light panel that prevents it from being rotated when the knob has been loosened. This cable system also allows the light panel to be locked in position using the single knob.

3.10  FIELD LIGHT

The field light, Figure 3-6, is designed to project the image of a finished mold onto the simulator film so the accuracy of the mold can be checked before it is poured. Light from a high intensity quartz bulb is focused on an 1/8-inch diameter fiberoptic “light-pipe”. The other end of this fiber bundle is positioned at approximately the rotational axis of the C-arm (the exact position is adjusted to properly project the shadow of a finished mold on a simulator film (refer to the discussion on “field light adjustment” in Section 7).

The position of the origin of the light remains fixed regardless of the motion of the C-arm, and the field light projects through a window in the side of the C-arm. When use of the field light is required, the C-arm pointer is moved to the left and the FIELD LIGHT switch is activated (this also activates a cooling fan that prevents overheating of the field light bulb). There is no need to reposition the light source or C-arm origin point. The field light should be turned off not need to preserve the life of the high intensity bulb.

3.11  “JIG-SAW” PANEL

The optional jig-saw panel is a clear plastic plate that fits on top of the Styrofoam blank holder. This panel is notched for the cutting wire, thereby permitting the wire to be used like a jig-saw for free-hand cutting of electron-block molds. Some users have found it useful to draw the field outline directly on the Styrofoam and then to cut the mold by guiding the wire along these marks. The jig-saw panel also includes a mechanism for holding the C-arm pointer in the central-axis position. The clear plastic jig-saw panel also may be used to draw “templates” for manual positioning of blocks. The procedure for accomplishing this is provided in Section 8.
Figure 3.5 Styrofoam Blank Holder and Centering Jig
Figure 3.6 Light Panel and Field Light
4.1 GENERAL

This Section contains a description of the major physical and functional characteristics of the Workstation Assembly (Figure 4-1), which include:

- The power control system for the Workstation Assembly.
- The equipment required for pouring and cooling of Cerrobend blocks.
- The horizontal hot wire used for trimming one side of Styrofoam blanks, or for cutting various thickness of blanks.
- The reference frames used to position the casting with respect to the blocking tray.
- The power tools, hand tools, and accessories provided with the System.

4.2 POWER CONTROL SYSTEM

The nerve center of the Workstation Assembly is the power control module (Figure 4-2), which contains the controls, indicators, and fuses for the Workstation Assembly. The power control module is a self-contained unit that can be removed for maintenance purposes by removing two mounting screws and disconnecting a single twist-lock electrical connector at the back of the module. A schematic diagram for the power control module is provided in Appendix B.

4.2.1 Controls and Indicators

NOTE: All switches mounted on the power control module are two-position toggle switches. The “on” position for these switches is the up position.

WIRE Switch and Indicator. This switch is part of the power control circuit for the horizontal hot wire. This circuit also includes two microswitches located on the cutting ramp (these two switches are discussed in paragraph 4.4). Power is applied to the horizontal hot wire when the WIRE switch is set to the “on” position and either of the two microswitches on the cutting ramp is activated. When the WIRE switch is set to “on,” the fan used to ventilate the work area also is activated, and the indicator above the switch turns on.

WIRE TEMP Control. This potentiometer is used to control the temperature of the horizontal hot wire. Turning the control clockwise increases current flow through the wire, which increases the temperature of the wire.

2ND POT Switch and Indicator. When this switch is set to the “on” position, power is applied to the heating element for the second melting pot, the fan that is used to ventilate the work area is activated, and the indicator above the switch turns on. The ventilation fan is discussed in paragraph
4.7.4.

**COOLING Switch and Indicator.** When this switch is set to the “on” position, the solenoid valve that controls the flow of cooling water is activated to allow water to flow through the cooling tray or a power relay is activated that applies power to the refrigeration system that cools the cooling tray, and the indicator above the switch turns on.

**VACUUM Switch.** When this switch is set to the “on” position, power is supplied to the dedicated AC power plug for the vacuum cleaner provided with the Workstation Assembly.

**FAN Switch.** When this switch is set to the “on” position, the fan used to ventilate the work area is turned on (the fan also is turned on when either the WIRE switch or the 2ND POT switch is set to the “on” position).

**LIGHTS Switch.** When this switch is set to the “on” position, the fluorescent lights in the Worksta-
tion Assembly are turned on.

4.2.2 Fuses

There are four fuses mounted on the power control module. Each fuse protects the circuit corresponding to the switch mounted above that fuse from current overload. The c, f & l fuse also protects the circuits for the cooling solenoid, the ventilation fan, and the fluorescent lights. Do not replace these fuses with ones that have a higher current rating.

4.2.3 Circuit Breakers

In addition to the fuses in the control module, there is a circuit-breaker panel located behind the Styrofoam-blank trimming ramp. To gain access to the circuit-breaker panel, detach the horizontal
hot wire from the left side by sliding the connector on the wire off of the conical screw, loosen the set screw that positions the ramp, and lift the ramp as far as it will go. The circuit breaker panel is behind the door located behind the ramp. Refer to the wiring schematics in Appendix B for further information.

4.2.4 Outlets

Electrical outlets are supplied in the main work area behind the control module, in the melting pot area, and in the cabinet for the vacuum cleaner. (In some older models, outlets controlled by the 2ND POT switch also are located in the cabinet for the second melting pot.)

4.3 POURING AND COOLING STATION

4.3.1 Stainless Steel Interior

The pouring and cooling station is lined with stainless steel or other very hard laminate to provide a surface that can be quickly and easily cleaned to prevent contamination of the general work area by splashed metal.

4.3.2 Hinged Splash Panel

A hinged stainless steel door at the front of the pouring area helps protect the operator from being splashed by molten Cerrobend when molds are being filled. The panel also can be lowered to gain unobstructed access to the cooling platform behind the panel. The hinged splash panel is shown lowered in Figure 4-3.

4.3.3 Spill/Dust Tray

A removable channel is located underneath the forward lip of the cooling tray. The primary purpose of this channel is to provide a reservoir for possible metal spills. Metal fragments also can be swept into this channel and recycled into the melting pot.

4.3.4 Melting Pots and Trolley

The melting pot (Figure 4-1) is mounted on a movable trolley so that it may be positioned in front of either of the two pouring stations. In addition to minimizing the length of tubing necessary to reach the mold being filled, the trolley also provides a convenient method of moving the melting pot out of the way when it becomes necessary to gain access to the mechanism for the hydraulic presses for maintenance purposes (the mechanism is located beneath the panels that are under the trolley).
4.3.5 Cooling Tray

The cooling tray (Figure 4-3) is supplied with a self contained refrigeration system. With a system using a refrigeration system, this time is typically 20 minutes.

**Technical Note:** It is a common misconception that the removal of a great many calories are necessary to harden a Cerrobend block. In fact, the heat of fusion of the alloy is not very great and, since the hardened metal is a relatively poor conductor, the rapidity of the cooling process depends mainly on the maintenance of a large temperature gradient that does not require much power. Rapid, high temperature-gradient cooling from the bottom of the block is best. Cooling in this manner assures that the last part of the block to harden will be the top surface and any shrinkage and cavitation that occurs generally will be manifest as a distributed foamy layer at the top. If the top of the block is allowed to harden before the middle, focal central cavitation may result that may not be apparent from the outside of the block but which may significantly effect the beam attenuation through the cavitated region of the block.

4.3.6 Hydraulic Presses

**Pump and Valve Mechanisms.** Two hydraulic presses (figure 4-1) are provided to sandwich the Styrofoam molds against the cooling panel until the metal has hardened enough to prevent leakage. The controls for the two presses are mounted in the panel directly beneath the presses. To activate either press, turn the corresponding control knob fully clockwise, and then pump the adjacent lever to bring the press down onto the Styrofoam.

**Spring Loading.** The lever mechanism for the hydraulic press is spring-loaded. Therefore, after the hydraulic press comes in contact with the Styrofoam, the lever may be pumped one or two strokes
further. However, a significant increase in resistance indicates that the limit of the spring loading has been reached, and the lever should not be pumped any further.

**Range of Mold Thicknesses.** The hydraulic presses are designed to accommodate a broad range of Styrofoam mold thicknesses.

**Block Cooling**

**Effect of Thermal Gradient**

### Disadvantages

- Slow cooling
- Cavitation central, invisible and localized
- Beam may be inhomogeneously effected

### Advantages

- Faster Cooling
- Cavitation distributed and visible near surface
- Beam homogeneously effected

*Figure 4.4 Cerrobend Cooling Characteristics*

**Access Ports.** The mechanism for the hydraulic presses can be accessed either through the panels located under the melting-pot trolley, or by removing the panel behind the hydraulic controls (refer to Section 7, Maintenance Procedures). The mechanism also can be accessed by removing the large panel directly behind the hydraulic section at the back of the Workstation Assembly. However, this involves moving the Workstation Assembly away from the wall.

**4.4 HORIZONTAL HOT WIRE AND CUTTING RAMP**

The horizontal hot wire (HHW) is spring loaded and air cooled. The HHW is used primarily to trim one side of a Styrofoam blank so that it is flat and will not leak when sandwiched against the cooling tray. The associated cutting ramp (figure 4-1) can be adjusted to allow virtually any thickness of Styrofoam blank to be cut, including those required for electron blocks, and for the various thicknesses of molds used for the thin-block compensator technique.

The ramp contains two microswitches that are part of the power control circuit for the HHW (figure 4-1). The two microswitches are connected in parallel. Therefore, when the WIRE switch is set to the “on” position and a Styrofoam blank is being trimmed, power is applied to the HHW continuously from the time the leading edge of the blank activates the upper microswitch until the trailing edge of the blank clears the lower microswitch. The temperature of the wire is adjusted by the means of the WIRE TEMP control on the power control module.
A ventilation fan is provided for air cooling for the HHW and to minimize the accumulation of any smoke that may occur while a block is being cut. The action of the fan, coupled with the air ports on the air manifolds at the ends of the HHW, help to prevent occlusion and superheating of the HHW in a manner that would weaken it and cause it to break prematurely. With these cooling features, the HHW typically will last for many months, even with frequent usage.

4.5 REFERENCE FRAMES

4.5.1 Reference Frames

Special frames are provided that can be adjusted to accommodate trays of various sizes. Two frames are provided, one for small Styrofoam blanks and one for large blanks. Each frame can be adjusted so that the field center on the blocking tray corresponds precisely to the geometric center of the Styrofoam blank. The reference frame is used for positioning the tray on the casting so that the tray can be marked and drilled. The casting then can be accurately marked, drilled, and mounted in the proper position. Additional frames may be ordered from Diacor, Inc. if they are needed for additional machines that use different trays or tray machine orientations.

4.6 TOOLS AND ACCESSORIES

4.6.1 Drill Press

The System includes a dedicated drill press (figure 4-1) for drilling the mounting holes in the plastic trays used for holding the finished Cerrobend blocks. The throat depth of the drill press easily will reach the middle of a 12-inch square tray. In addition, the “foot” of the drill press is adjustable for 1/4-inch to 3/8-inch thick trays. When the foot is adjusted properly, the tray will not “ride up” the drill bit, even when the drill press is operated by someone not generally familiar with the operation of a tool of this type. The power “on-off” switch for the drill press is an integral part of the drill press.

4.6.2 Vacuum Cleaner

A vacuum cleaner is located conveniently in the cabinet underneath the work space area. Power to the vacuum cleaner is controlled by means of the VACUUM switch on the power control module.

4.6.3 Hand Drill

A hand drill is provided with a retractile cord should be used to set proper drilling depth for the screws used to mount the Cerrobend blocks. When the hand drill is being used, it is important that the drill be held as vertical as possible.

4.6.4 Cordless Drill

A battery-operated cordless drill and a socket tip for the drill are provided with the System. The tip fits the recommended sheet metal screws used for block mounting (a supply of these screws also is
provided with the System). The wrench has an adjustable clutch so that the proper tightness of the mounting screws is achieved easily, even by those who are not experienced in the use of tools of this type. The battery for the electric wrench is rechargeable.

**4.6.5 Spring-Loaded Punch**

A spring-loaded punch with a specially machined tip is provided to mark the positions where holes for mounting screws must be drilled in the Cerrobend blocks.

**4.6.6 Miscellaneous Tools**

Additional tools and articles supplied with the System include files, a small screwdriver, pliers, a set of hex wrenches, a large measuring cup, a rubber mallet, extra Nichrome wire, a melting pot scraper, a putty knife for scraping loose Cerrobend, a slotted spoon for cleaning debris from the melting pot, men’s and women’s gloves a pair of safety goggles and a brush.

**4.6.7 Dust Pan and Bin**

The purpose of the work space in the Workstation Assembly is to provide a solid steel surface where the heavy metal blocks can be worked on without excessive damage to the work surface. It also provides an area where metal scraps and dust can be collected, swept into the dust bin, and then recycled. The dust bin can be removed from inside the drawer by simply pulling the bin straight out.

**4.7 OTHER WORKSTATION ASSEMBLY FEATURES**

**4.7.1 Shelf Storage**

Shelf storage is conveniently located for the necessary tools so that the retractile cords remain out of the way but the tools are readily accessible.

**4.7.2 Lockable Drawer**

A lockable drawer is provided for tool storage.

**4.7.3 Cerrobend Block Storage**

A cabinet lined with stainless steel is provided for storage of previously used Cerrobend blocks. The metal lining is required because of the weight and sharp edges of these blocks.

**4.7.4 Ventilation**

A fan mounted above and behind the cutting ramp provides ventilation while the Workstation As-
assembly is in use. The primary need for ventilation is to remove smoke and fumes that result from plastic melting when the horizontal hot wire is in use. The fumes from the melting pot are a minor problem and can be handled satisfactorily with general room ventilation, although an air duct is provided for the fan to draw from this section of the Workstation Assembly cabinet as well. The fan is on when either the FAN switch, the 2ND POT switch, or the WIRE switch is activated.

4.8 STORAGE CABINET

The storage cabinet (Figure 4-1) provides a space efficient way of conveniently storing Styrofoam blanks or other items. The interior of the cabinet is partitioned into two sections.
SECTION 5
THE STYROFOAM BLANK

5.1 GENERAL

Styrofoam blanks that are precision cut to fit the Block Cutter Assembly are available from several sources. The information in this Section is provided for users who wish to have detail specification for the blanks they purchase.

5.2 STYROFOAM BLANK SPECIFICATIONS

MATERIAL: Dow Chemical Company No. XUS 44000.01 (or equivalent)

CUT BLANK SIZES: 7-5/8 inches square, and 3 inches (min) thick
10 inches square, and 3 inches (min) thick
11-1/2 inches square, and 3 inches (min) thick

CUT BLANK TOLERANCES: +0, -1/32 inch

SPECIAL INSTRUCTIONS: When bulk Styrofoam is being cut to final blank size, specify and emphasize to your vendor or to your internal personnel that at least one of the two large surfaces must be a flat plane. This will eliminate the requirement later for surfacing of the blanks. Also specify and emphasize that the thickness must be at least 3 inches after cutting.

5.3 RECOMMENDED MATERIAL

A high-density Styrofoam is recommended for use with the System. Open-celled foam or foam boards made from expanded plastic beads (“bead-board”) are unacceptable; the metal becomes trapped in the spaces, forms a rough edge, and will not release from the mold.

5.4 SIZE

Primary considerations in the selection of the sizes for the blanks used with the System are:
- Economical use of bulk Styrofoam.
- Efficient use of storage space for the Styrofoam blanks.

Because bulk Styrofoam sheets typically are supplied in 2-foot widths, a nominal 8-inch width is optimal. The actual size of 7-5/8 inches square permits wastage during cutting on a saw. The small blank size is satisfactory for about 80 percent of the fields. Blanks that are either 10 inches square (optional) or 11-1/2 inches square satisfy the requirement for larger custom blanks.

5.5 THICKNESS

Three inch (7.6 cm) thick material has become the standard. Although thicker material may be required occasionally in unusual circumstances where less than 5% transmission is required, for beam energies above 6 MV much thicker blocks are not generally necessary because the penetra-
tion of high-Z materials peaks around 6 to 10 MeV (monoenergetic beams) because of the mode of interaction. Although X-ray beams are not monoenergetic, the penetration of an 18 MV beam is not that much greater than substantially lower energy machines and there would seem to be little justification to go to a thicker block for higher beam energies on account of a 1 to 2% increase in penetration.

5.6 CUTTING BLANKS TO SIZE

The Styrofoam blank holders used with the System are precisely 7-5/8 inches, 10 inches, and 11-1/2 inches square, respectively. Your hospital should contact any one of several companies that manufacture and supply custom-cut Styrofoam blanks.

5.7 TOLERANCES FOR CUT BLANKS

Tolerances for blanks cut from bulk Styrofoam are +0, -1/32 inch, and the blanks must be square. No tolerance is permitted on the plus side, because the blank holders provided with the System are precision devices.

A tolerance of -1/32 inch may result in an error of about plus or minus 0.6 mm at 100 cm. If less potential error is required, a tighter tolerance that -1/32 inch also is required.
6.1 GENERAL

This Section contains operating instructions for the System, including various methods and techniques that are based on long experience at a single institution. These methods and techniques have proven to work well, and in general are felt to be the quickest and most utilitarian way of producing accurate field-shaping blocks. Although these methods do not necessarily represent the only way of using the System, please consider any alternate approaches very carefully before using them instead of the suggested methodology. However, if you think your ideas are better, please let us know, as we are constantly in search of ways to improve our procedures, as well as the System itself.

The procedures in this Section are presented under the following headings:

- Preoperational Checks
- Set-up Procedures
- Cutting a Block
- Preparing a Mold and Casting
- Preparing the Blocking Tray
- Using the Styrofoam Blank Storage Cabinet

6.2 PREOPERATIONAL CHECKS

Before beginning the block cutting process, make sure that the C-arm and light panel are aligned properly, and that the control aperture and warning aperture are aligned and functional. Alignment of the light panel should be done at least once a day, and more frequent alignment may be required, depending on application and usage.

When making the necessary adjustments to the Block Cutter Assembly, it is important to bear in mind the geometry of the essential task being performed by this instrument. When the cutting wire is located in the center of a Styrofoam blank, the C-arm pointer must aim at the intersection of the lines on the light panel. Furthermore, the blank should be square with respect to these lines. When the field light is turned on, the projected image of a mold that has just been cut should be of the proper magnification, and it should directly overlay the area traced from the simulator film during the cutting process.

Under ideal circumstances, the cutting wire would lie on a straight line connecting the fulcrum of the C-arm and the pointer. Although the arm is manufactured to achieve this goal, in practical terms the goal is unattainable. If the geometry were perfect, the wire would always be properly aligned in the center of the blank irrespective of the source-tray-distance (STD) and source-film-distance.
(SFD) settings, and the fiber-optic bundle which acts as the light source would always be geometrically centered at the mechanical fulcrum of the cutting arm. In practical terms, the correct position of the field light source and the centering of the light-panel must be empirically determined, and may hold true only for limited STD and SFD excursions.

For large excursions and treatments with critical geometry, the centering should be rechecked for the specific STD and SFD being used. However, for most routine applications, the centering will remain accurate enough so that adjustments will be needed infrequently. You should verify the alignment variation and be aware of this potential source of error as would be the case with any piece of radiation therapy hardware. Furthermore, a routine quality assurance program should be employed on a regular basis to verify the block cutter alignment. At the very least, light panel centering should be checked and adjusted daily (a task that typically requires only a few minutes).

6.2.1 Centering the Light Panel

1. Set the MAIN POWER switch to the “on” position. The associated indicator should turn on.

2. Set the ELECTRON MODE/PHOTON MODE switch to position PHOTON MODE.

3. Adjust the STD and SFD so the corresponding pointers are positioned on their respective rulers at the approximate mid-point of the ranges you anticipate using.

4. Adjust the telescoping segments of the cutting arm so that they are about equally extended, and the C-segment is in the proper position for cutting a Styrofoam blank. (When the C-arm is in the vertical position, the warning aperture should be about 1 to 1-1/2 inches in from the Styrofoam.)

5. Make sure the cutting wire is centered in the control and warning apertures, and that no audible tone is being generated by the System. If centering of the wire is required, refer to paragraph 6.2.2.

6. Move the C-arm to the left and out of the way.

7. Raise the hinged centering jig to the horizontal position and tighten the thumb screw so that it remains horizontal.

8. Swing the C-arm into position and approach the lines on the light panel so that the wire will touch the plate on the centering jig, as shown in Figure 6-1. When the wire barely touches the plate, the constant audible tone will sound; this tone is identical to that generated by contact of the wire with the warning aperture. Be absolutely certain that the tone is generated only by the lightest possible touch of the wire. Remember that contact between the wire and the warning aperture also causes a tone to sound, but the wire must not be deviated during this procedure.
If a tone does not sound, the wire may be insulated with plastic, in which case cleaning of the wire probably is required (the procedure for cleaning the wire and apertures is provided in Section 7).

9. Observe the position of the pointer when the tone sounds. It should be pointing to one of the lines on the light panel. If it is not, loosen the knob on the light panel and shift the panel until it is positioned properly. Do the same for both lines and then retighten the knob.

6.2.2 Adjusting the Apertures

**WARNING**

*Do not press the pedal switch when adjusting the position of the control aperture or the warning aperture. When the cutting wire is at operating temperature, it can cause a severe burn if skin contact occurs.*

If the heating of the cutting wire varies with cutting direction, or the warning signal does not function correctly, adjustment or cleaning of the apertures or wire probably are required (the procedure for cleaning the wire and apertures is provided in Section 7).

![Figure 6.1 Use of Centering Jig for C-Arm to Light Panel Alignment](image)

The function of the warning aperture can be checked by sweeping the cutting wire in a circular manner against the circumference of the aperture to see if a constant tone is emitted throughout. If not, the contact may be insulated with plastic. The control aperture can be checked in the same manner, if the ELECTRON MODE/PHOTON MODE switch is set to position ELECTRON MODE.

Both apertures should be centered accurately on the cutting wire using the spring-loaded thumb screws (some older models have three-point thumb screws without spring loading). The aperture taper should be oriented up. Most people prefer to adjust the apertures while looking down on them, and this is easier with the flat surface of the aperture facing up (this is also the easiest aperture ori-
entation for wire replacement). Always be certain the screws are properly and completely seated in the groove encircling the aperture element.

There are two basic methods of adjusting the apertures — visual or tactile. When using the visual method, use of a magnifying glass may be necessary, and proper lighting is important. It is recommended that the apertures be viewed from orthogonal angles when they are being adjusted visually.

The tactile method is somewhat like tuning a radio. Press the wire back and forth against the aperture, and listen to the audible tone that sounds when there is electrical contact between the wire and the aperture. By sensing the amount of pressure and degree of movement in orthogonal planes that are required to produce the tones, you can make the adjustments necessary to ensure that the wire is positioned in the center of the aperture.

6.2.3 Adjustment of C-Segment Attachment to Telescopic Tubes

The distance between the control aperture and the warning aperture normally should be about 5 inches. However, a proportionately greater separation is required when layered Styrofoam blanks thicker than 3 inches are used. To adjust the distance between the two apertures, perform the following steps:

1. Loosen the cutting wire (it may need to be replaced with a longer wire).
2. Loosen the two nylon thumb screws at each end of the C-segment.
3. Adjust the lower telescopic tubes for maximum separation.
4. Adjust the upper telescopic tubes to achieve the required distance between the apertures.
5. Rotate the tubes so that the electrical insulator boards that hold the apertures to the rest of the C-arm assembly are parallel to the C-segment.
6. Retighten the thumb screws.
7. If necessary, replace the cutting wire (refer to Section 7).

6.3 SET-UP PROCEDURES

NOTE: The simulator film typically will have wax pencil markings on it indicating the field edges specified by the radiation oncologist. The STD will depend on the STD of the treatment machine, and the SFD must be calculated from magnification scales on the film. The outside edges of the blocks must extend beyond the primary collimator edge at the intended field size.

NOTE: When setting STD or SFD, keep in mind that the pivot point for the C-arm is 9.5 mm below the top surface of the upper horizontal element.
6.3.1 Setting the STD

The STD is the distance from the radiation source to the nearest surface of the plastic tray that will support the finished blocks. To adjust the STD, loosen the STD lock and raise or lower the horizontal assembly to the appropriate distance as indicated by the pointer and scale (located on the vertical tie-rod that extends between the upper and lower horizontal members). Then retighten the lock enough to prevent movement (generally 1/8th turn beyond the point of contact).

6.3.2 Determining and Setting SFD

Before positioning the simulator film on the light panel, determine the SFD at which the film was obtained. Most simulators have a magnification scale as part of the central-axis wires. The most convenient method for measuring the SFD is to measure the distance on the film that should correspond to 10 cm at the source-axis distance of the simulator and accelerator (typically 100 cm for most modern machines). For a 100 cm machine, a measurement of 14 cm corresponds to a magnification factor of 1.4, or an SFD of 140 cm.

Loosen the SFD lock and move the interlinked upper and lower horizontal assemblies on the vertical rods until the proper SFD is achieved, as indicated on the “SFD” scale by the small pointer on the right side of the upper horizontal assembly. Then retighten the lock enough to prevent movement (generally 1/8th turn beyond the point of contact).

6.4 CUTTING A BLOCK

6.4.1 Selecting a Styrofoam Blank

To determine whether a small (7-5/8 inch) blank may be used, move the C-arm pointer to the extreme edges of the indicated block outlines. If the cutting wire is at least 1/4 inch from the edge of the small-blank insert, a small blank may be used. If the cutting wire is closer than 1/4 inch from the edge, a large (11-1/2 inch) blank must be used.

6.4.2 Surfacing a Styrofoam Blank

It is recommended that when procuring Styrofoam blanks, you specify that at least one of the large surfaces must be a flat plane. If you do not, surfacing of the blanks may be required before they can be cut accurately for molds. If your blanks do not have at least one flat surface, use the following procedure to surface them.

**WARNING**

*When the horizontal hot wire is at operating temperature, it can cause a severe burn if it comes into contact with the skin. Therefore, when trimming blocks, it is strongly recommended that protective canvas work gloves be worn, and that appropriate caution be exercised. Unless one of the two microswitches in the cutting ramp is activated by a blank in position for*
cutting, current to the wire is interrupted. Nevertheless, as an added precaution, it is recommended that the WIRE switch be turned “on” only when blanks are actually being cut.

1. Make sure the WIRE switch is set to the “off” position.

2. Loosen the thumb screw on the cutting ramp, adjust the ramp to the proper cutting thickness, and then retighten the thumb screw.

3. Check the blank for irregularities. If you are planning to trim as little as possible from the surface, you can judge the cutting clearance of the irregularities by rotating the blank so that each side in turn touches the wire. It is usually possible to trim off as little as about 1 mm.

4. Place a Styrofoam blank on the ramp above the upper microswitch. The flattest surface of the blank with the least tendency to rock should be placed against the ramp. If the blank will not rest flat on either surface, try to hold it so that it will not wobble during the cutting process, or else the resulting cut surface will not be a flat plane and may leak.

5. Set the WIRE switch to position “on.” The indicator above the switch should light.

6. Turn the WIRE TEMP control fully counter-clockwise (to the “0” position), and then turn the control clockwise to “3.”

**NOTE:** Once you begin the cutting process, additional adjustment of this control may be necessary to achieve a satisfactory heating rate for the horizontal hot wire. However, it is recommended that you always start at the low end of the scale until you become accustomed to using the System.

7. Slide the blank down the ramp until it is over the upper microswitch and the blank contacts the cutting wire. When the upper microswitch is activated, the wire begins to heat.

**NOTE:** Most users have found a one-handed operation to be most convenient. For that reason, the steps 8 and 9 assume that type of operation.

8. Place your four fingers just above the center of the blank and move the blank slowly across the wire at a uniform speed just fast enough to bow the wire with a
constant deviation.

9. When the wire nears your fingers, place your thumb beyond the wire, lift your fingers and place them beyond the wire, and then complete the cut. This action should be performed while maintaining a constant cutting rate.

**NOTE:** The wire normally will bow substantially during the cutting operation.

10. After the blank clears the wire but before it has cleared the second microswitch, stop the downward movement of the blank momentarily to allow the wire to super-heat just for a moment, and then pull the blank away quickly. The short pause causes the filaments of plastic drawn out of the blank by the wire to melt and prevents them from being drawn out into long threads when you remove the blank.

11. To further minimize the mess, instead of lifting the trimmed portion off of the blank, sweep it laterally off the surface with your hand directly into a waste container. This method tends to roll the filaments off and compact them, rather than lifting and dispersing them. Sweep any remaining threads away with your hand. (Vacuuming the blank generally is less efficient than simply brushing them off by hand). The blank is now ready for use or storage.

**6.4.3 Adjusting the C-Arm**

Adjust the telescopic segments on the C-arm so the cutting wire will be approximately centered on the blank during the cutting process (the warning aperture generally will be about 1-1/2 inches from the lower surface of the Styrofoam with the C-arm vertical). Make sure the extension of the upper and lower telescopic segments is about equal. This is particularly important for long extensions, because the more each segment is extended, the more flexible it becomes, thus diminishing the rigidity of the C-arm.

It is especially important to not overextend the pointer segment, which is normally less rigid than the other segments. Because this segment must slide smoothly, the twist-lock or clamp for the pointer segment should be tightened minimally, which means that if this pointer is over-extended, it will become highly unstable.

**6.4.4 Inserting the Styrofoam Blank in the Block Cutter**

To insert a Styrofoam blank into the block cutter, it is normally necessary to move the C-arm out of the way first, so that there is adequate clearance for the blank. The C-arm is hinged at the top to allow lateral movement, and the slot in the left side of the cabinet allows enough lateral movement to achieve the required clearance. After the C-arm has been moved through the slot, the coil spring retainer that is mounted on the left vertical steel rod is used to hold it in place.

Before the C-arm can be moved into the slot, it may be necessary to move the retainer out of the way first. To move the retainer, squeeze its two arms together. This releases the grip of the retainer from the rod and allows free movement of the retainer on the rod.
After the C-arm has been moved into the slot, release the retainer from the rod again, swing it back around so that it locks the C-arm in the slot, and then release the arms to re-clamp the retainer to the rod. The C-arm will be held in place until the retainer is released.

When inserting the Styrofoam blank into the Block Cutter, make sure the smooth (surfaced) side is down.

6.4.5 Positioning the Simulator Film

1. Be absolutely certain that the film is oriented with the proper side up (representing the beam’s eye view of the film).

2. Position the film so that it is oriented in accordance with whatever convention you have adopted (e.g. the direction of the patients feet toward the operator), and so that the beam central axis is positioned orthogonally on the cross-hairs of the light panel.

3. Tape the film to the light panel using masking tape at the corners of the film.

Proper centering of the light panel should permit any rotational positioning of the film without resulting errors in block position. However, experience indicates that consistently applying an established convention is best, as this avoids confusion about block orientation. Also, if alignment problems do develop, the resulting blocking errors will be consistent, which makes it easier to detect the problem and identify the root cause of the problem.

6.4.6 Tracing the Lines with the Pointer

In most circumstances you will find it necessary to trace the pointer along the inside edge (with respect to the inner surface of the mold) of the wax pencil lines. This is because the cutting wire and the resulting cut in the Styrofoam have a finite thickness that cannot be compensated for by any other means. Therefore, as a general rule it is preferable to cut the mold as if the blocks were to be slightly smaller than intended (but only about 1/16 inch (1.5 mm) on the simulator film).

6.4.7 Cutting a Mold

1. If you have not previously used the block cutter, begin with WIRE TEMP control set fully counterclockwise.

2. Plan your cutting path so the wire will cut through the Styrofoam in a manner that will permit logical positioning of the masking tape for sealing the mold (taping
the mold is discussed in paragraph 6.5.2).

3. Activate the pedal switch to begin the cutting process. Remember, the pedal switch is not used to regulate the cutting process, but the cutting wire will not be heated unless the pedal switch is pressed.

4. Move the pointer until the wire comes in contact with the edge of the Styrofoam blank and the control aperture.

At this point you should hear an intermittent tone indicating that the wire is beginning to heat. If you stop moving the pointer, you will notice that the intermittent tone ceases, indicating that the wire is no longer being heated. The wire is heated only when the pointer is moved and the wire is deflected into the edge of the aperture by pressure against the Styrofoam. Remember, you cannot move the pointer too slowly, but it is possible to move it too quickly.

If you move the pointer too fast, you will hear a constant tone along with the intermittent tone. This means that the wire deflection is too great and that you are likely to “drag” the wire behind the proper cutting position. This usually results in an inaccurate mold with, for instance, rounded corners where sharp corners may have been intended. If you find that the constant tone occurs too often and you are unable to move the pointer as rapidly as you would like, increase the wire temperature by turning the WIRE TEMP control clockwise.

Although it is possible to get satisfactory molds with the WIRE TEMP control set at maximum, there are several problems that can occur as a result of setting the temperature too high.

First, it is possible to create some melting-out of the mold edges through overheating of the wire.

Second, portions of the wire that are exposed to the air will become hotter than necessary, thus shortening the service-life of the wire.

Third, and most important, when the wire is too hot, a film of molten plastic will flow down the wire and contaminate the warning aperture so that it no longer functions properly (the insulating layer of plastic prevents electrical contact with the cutting wire). If the warning aperture does not seem to be functioning properly, this is generally the cause, and cleaning of the wire and aperture may be necessary (refer to Section 7 for procedures for cleaning the wire and apertures).

NOTE: If the air intake to the cooling fan becomes clogged, it can have the same effect as operating with the WIRE TEMP control set too high.

6.5 PREPARING A MOLD AND CASTING

**WARNING**

*Finished blocks can have extremely sharp edges. Use of canvas work gloves is highly recommended to avoid cuts when removing Styrofoam from finished blocks and when handling finished blocks before edges have been filed.*
6.5.1 Cleaning the Mold

After you have finished cutting the mold and have retraced the cutting wire out through the original entry point in the Styrofoam, remove the mold from the block cutter, remove the loose pieces, and then try to brush away as many of the Styrofoam threads from the internal surface of the mold as possible. This minimizes unnecessary contamination of the Cerrobend when the molded parts are melted and reused.

6.5.2 Taping the Mold

Place 3/4-inch masking tape over every position where the cutting wire cut through the edges of the mold. The purpose of the tape is to prevent leakage of molten metal out of the mold. Make sure the tape is flat on the bottom of the Styrofoam, which will be placed against the cooling surface (the side of the casting that is the largest).

6.5.3 Spraying the Mold

After the taping process is complete (never spray prior to taping — the tape will not stick), lightly spray the inside surface of the Styrofoam with water as it will help to release the mold.

NOTE: A light spray that completely covers the inside surface of the Styrofoam should be adequate.

6.5.4 Clamping the Mold

After the mold is taped and sprayed, it is ready to be filled with Cerrobend.

1. Lower the splash guard and insert the mold under a hydraulic press (remember, Lexan tray surface side down).

2. Clamp the mold against the cooling panel by closing the hydraulic-press valve (do not overtighten) and pumping the actuating lever until the metal frame of the hydraulic clamp assembly comes in contact with the mold.

3. When the clamp comes in contact with the mold, pump 2 or 3 additional strokes to clamp the Styrofoam mold firmly. You should notice a significant increase in resistance at this point. DO NOT pump any further, as additional pumping could damage the pumping mechanism.

NOTE: The hydraulic presses are spring loaded, and 2 or 3 strokes beyond contact with the mold are generally all that are necessary to fully compress the springs and clamp the mold firmly.
6.5.5 Filling the Mold

1. Set the COOLING switch to position “on” to activate the refrigeration of the cooling tray before filling the mold. The indicator above the switch should turn on.

2. Roll the melting pot in front of the mold so that the attached vinyl hose will reach down into the mold.

3. Direct the tip of the hose against the side of the mold. This will minimize splashing when the molten metal flows into the mold.

4. Gently pour a small amount of molten metal into the mold; pour until the metal is about 1 cm deep, and then stop pouring for 5 or 10 seconds before resuming. This short delay will allow the metal in contact with the cooling panel to harden before high pressure is produced at the bottom of the mold when the remaining metal is poured, and the metal will be less likely to creep out between the mold and the cooling panel.

5. Fill the various chambers of the mold to the top. Because the metal will shrink with cooling, slight over-filling with a protruding meniscus of metal will avoid the necessity of topping off to maintain adequate block thickness.

6.5.6 Cooling the Casting

The time required for the casting to cool enough to be handled comfortably depends on the temperature of the cooling tray. The casting typically hardens and is cool enough to handle in 20 to 25 minutes. However, slight additional cooling may be advisable to avoid drilling in metal that is close to melting temperature, as this will rapidly clog the drill bit.

6.6 PREPARING THE BLOCKING TRAY

6.6.1 Aligning the Tray and Casting with the Reference Frame

1. Release the hydraulic press by turning the valve counter-clockwise a half turn (a slight pull on the metal frame of the hydraulic press may be necessary occasionally to assist the spring loading in elevating the frame).

2. Lower the splash panel and remove the casting from the cooling tray.

3. Turn the casting over and place it on the work surface.

4. Place the reference frame on the Styrofoam casting.

The frame must be oriented so that the direction for insertion of the blocking tray into the treatment machine will be correct with respect to the blocks. This will depend on your local conventions, but
many users prefer inserting the tray from the side of the treatment couch most directly accessible from the treatment console area when the machine is in the overhead position.

If this convention is adopted and the film was originally on the light panel as suggested (refer to Positioning the Simulator Film, paragraph 6.4.5) with the patients feet toward the operator, then the frame should always be placed so that the trailing edge (for left-sided insertion) or the leading edge (for right-sided insertion) of the tray will lie over the position where the cutting wire entered and exited from the Styrofoam. Then place a properly oriented tray in the reference frame.

**NOTE:** The orientation of the frame and tray also will depend on whether wedges will be used in the patients treatment. If the fields are to be wedged, it will be necessary for you to know the wedge orientation, unless you are unusually fortunate in having entirely symmetric trays and a machine that has a beam central axis that is in the absolute center of the trays.

### 6.6.2 Locating the Mounting Holes

Each independent block segment should have two mounting screws. The holes should be located in such a way that the block segment will be firmly attached and will not rotate. After a given tray has been used many times, it is often possible to reuse existing mounting holes so that new holes do not have to be drilled.

If an old hole is to be used, place a circle around the old hole using a wax pencil. If a new hole is to be drilled, mark the position for the new hole using a wax pencil, and then place a circle around the mark. It also may be necessary to remove marks from previously-used holes to avoid any confusion.

Outline the blocks on the tray with the wax pencil. This is especially important if there are many old unused holes in the tray, because after the Styrofoam has been removed, trying to reposition blocks correctly with respect to the mounting holes also can be confusing.

### 6.6.3 Drilling Mounting Holes in the Tray

Remove the tray from the reference frame and drill the mounting holes using the drill press provided with the System. Do not drill so rapidly that the drill bit becomes overheated and begins to melt the plastic. Avoid applying excessive drilling pressure, as this is likely to cause the tray to crack as the bit cuts through the far side. Use only drill bits that are properly tipped for drilling plastic; ordinary bits tend to cut too rapidly and crack the plastic.

### 6.6.4 Marking Positions for the Mounting Holes in the Casting

Reposition the tray in the reference frame, and perform the following steps to mark the positions for the mounting holes in the casting using the punch provided with the System.

1. Set the punch on maximum striking force.

2. Place the punch tip through one of the mounting holes in the tray.
3. Hold the punch vertically, and press firmly down on it until the spring trigger mechanism releases creating an indentation in the metal.

4. If necessary, repeat the process to leave a deep enough impression in the metal so that the drill bit will seat accurately without wandering.

5. Repeat steps 2, 3, and 4 for the other mounting hole.

### 6.6.5 Drilling Holes in the Casting

Remove the tray and reference frame and use the drill provided with the System to drill mounting holes in the casting. The hole depth should be the length of the mounting screw less the thickness of the Lexan tray. Try to drill as vertically as possible. Do not drill any more rapidly than necessary, as this creates excessive heating of the drill bit, which is more likely to cause the metal to fuse into a solid piece and clog the tip of the drill bit. As mentioned previously, this is more likely to happen if the blocks are still hot.

### 6.6.6 Finishing the Completed Block

**WARNING**

*Finished blocks can have extremely sharp edges. Use of canvas work gloves is highly recommended to avoid cuts when removing Styrofoam from finished blocks and when handling finished blocks before edges have been filed.*

1. Use a screwdriver or similar tool to crack the Styrofoam away from the finished blocks.

2. After the Styrofoam has been removed, lightly file the edges of the blocks so they are safer to handle, and so the block precisely represents the finished shape desired.

3. Brush the filings into the dust bin under the grill in the work surface for later recycling.

### 6.6.7 Fastening the Blocks to the Tray

Fasten the blocks to the tray using 3/4-inch long, 5/16-inch #10 hex screws and the electric wrench provided with the System (the screws and a magnetic nut driver for the screws also are provided with the System). The wrench has a clutch mechanism that can be adjusted to provide proper tightness of the screws. The screws should seat firmly against the plastic, but do not over-tighten the screws, as this may crack the plastic or strip the threads in the metal.
7.1 REFERENCE FRAME ALIGNMENT

There are at least two reference frames, one for the small Styrofoam blanks and one for large blanks. Additional frames are required blocking trays of different designs are used, or if you have more than one treatment machine with a common tray design, but that have field light central axes that project differently on the trays. If additional frames are required, more than one standard tray also is required. The procedure for alignment of the reference frame is as follows:

1. Fit the frame to a representative Styrofoam blank. The frame should fit snugly onto the blank without wobbling or jamming.

NOTE: The metal strips fastened to the frame permit a slight adjustment, if the mounting screws for the strips are loosened and then retightened.

2. Select a blank that has sides perpendicular to the reference surface (the surface that was trimmed with the horizontal hot wire). Use a small carpenter’s square to check the blank for squareness.

3. Make sure the block cutter is aligned properly (refer to Section 6).

4. Cut a central axis mark into the blank with the block cutter by running the pointer along the intersecting lines in the light panel. If necessary, use a straight edge to make sure this is done accurately.

5. After the blank is cut, check to see that the cuts made by the hot wire are equidistant from the edges of the block (i.e., in the center). The error should be less than 0.5 mm.

6. Place the frame on the blank.

7. Place the standard tray on the frame. Make sure that rotational orientation of the tray is in accordance with the convention established for that frame. (The procedure for preparing a standard tray is provided in Appendix A.)

8. Mount the three black bars and the silver bar supplied with the System around the edges of the tray to position it so the central axis on the tray corresponds to the central axis on the blank. The silver bar has been provided so that departmental conventions for mounting blocks on the tray and for insertion of the tray into the treatment machine can be applied consistently. This bar typically is placed on the edge of the tray with the handle. If the tray has no handle, the silver bar typically is placed on the trailing edge of the tray (the edge that is held as the tray is inserted into the treatment machine).
9. Align the tray both rotationally and translationally, and mount the bars around the edges using double-sided adhesive foam mounting tape. Foam tape is useful, as it permits tolerance of trays that might be very slightly larger than the standard tray and would otherwise jam in the completed frame.

7.2 LIGHT PANEL ADJUSTMENT

7.2.1 Centering-Jig Alignment

The centering jig is aligned at the factory prior to shipment. No further adjustment should be required, unless the centering jig is dropped or otherwise mishandled. An alignment tool for the centering jig is supplied with the System. This tool is a 3/16-inch thick clear polycarbonate square with an aluminum bar fastened to it. The procedure for aligning the centering jig is as follows:

1. Raise the jig to the horizontal position and secure the jig.

2. Place the alignment tool in the small Styrofoam-blank holding frame with the aluminum bar facing down and rotationally oriented so that the bar mates with the aluminum plate on the centering jig, as shown in Figure 7-1. Make sure the tool seats properly in the holding frame, but do not force the tool against the jig. When the jig is aligned properly and the tool is seated properly, the tool should mate precisely with the jig (there should be no significant gaps between the tool and the jig).

3. If the jig jams against the bar or there is a significant gap, loosen the screws on the aluminum plate of the centering jig, adjust the position of the plate so that it seats firmly against the bar, and then retighten the screws.

7.2.2 Rotational Alignment and Cable Tension Adjustment

Rotational alignment of the light panel and adjustment of the tension on the cables underneath the light panel should not be necessary after the System has been set up, unless the light panel assembly is taken apart for cleaning or repair. In general, if the panel appears to be square with respect to the front edge of the cabinet, this is sufficient.

There is a crossed-cable pulley system underneath the light panel that allows it to be moved translationally, but does not allow it to be rotated. This pulley system is accessed through the door leading to the fluorescent lights.

As shown in Figure 7-2, two small turn-buckles are used to adjust the relative lengths of the two cables. When one turn-buckle is loosened and the other tightened, the panel will rotate; when both turn-buckles are tightened equally, the cables will tighten without changing the position of the panel.

Cable tension should be just enough so the panel will not move significantly when the thumbscrew clamp is tightened. Greater tension places needless stress on the cables and their attachments and
increases the resistance to translational adjustment. The light panel should be adjusted rotationally so the intersecting lines are square with respect to the Styrofoam blank holding frames. Use the field light to project the shadow of the aluminum plate on the alignment jig discussed in paragraph 7.2.1 onto the light panel and rotationally align the panel with respect to the edge of the shadow.

Figure 7.1 Centering Jig Alignment
Figure 7.2 Crossed Cable Pulley System

7.3 FIELD LIGHT ADJUSTMENT

The primary purpose of the field light is to check the shape of the mold (e.g. to be certain that corners are not rounded and arced surfaces are not straightened). Therefore, if the projected image of a finished mold is shifted slightly (< 0.5 cm) from the outline on the simulator film, it is perfectly permissible to move the simulator film to proper register to check the field shape. Do not adjust the field light unless you are sure the light panel is adjusted properly. Whenever a significant adjustment of the light panel is necessary, it is highly probable that the field light also will require adjustment. However, bear in mind that the intended uses of the field light rarely if ever require such precise central alignment.

The fact that the field light is not in perfect alignment is far more likely to indicate that field light adjustment is not perfect for the particular STD-SFD combination being used than that the mold has not been cut properly, if the light panel is aligned properly.
To check alignment of the field light, swing the centering jig into horizontal position and turn on the field light. The image of the edges of the aluminum plate should project on the lines on the light panel. However, centering alignment is difficult to judge due to the penumbra. Therefore it may be necessary for several adjustments to be made to properly align the shadow of the alignment jig with the two cross lines on the light panel.

Loosen the two screws that hold the fiberoptic bundle in position within the upper end of the C-arm, move the tip of the bundle until the projected image is positioned correctly, and then retighten the screws.

The vertical position of the light source also can be adjusted by loosening the Allen set screw that holds the metal tip of the fiberoptic bundle. This will probably never require adjustment. However, if the tip is inserted too far, the edges of the mold nearest the outer edge of the blank will appear too large, despite the fact that the mold seems to be cut accurately near its center. If instead, the tip of the light source is above the hinge point of the cutting arm, the outer edges of the mold will appear to have been cut too small.

If adjustment is required, cut a large mold in a figure-eight pattern with the intersection point at the center of the blank. Adjust the insertion depth of the light source until the relationship of the shadow to the traced outline is the same near the center of the figure-eight as it is at the outer edges. Remember that Styrofoam threads can interfere with the image. Therefore, it is recommended that you always clean the inside of the mold before deciding that adjustment of the field light is necessary.

7.4 CLEANING THE APERTURES AND CUTTING WIRE

If the portion of the cutting wire within the warning aperture becomes coated with plastic (typically caused either by cutting with the aperture too close to the Styrofoam or by operating with the cutting-wire too hot), the contact will become insulated and the warning tone will cease to operate. This also may happen to the control aperture, but it is much less likely. If only one side of the wire or aperture is coated, the malfunction will be direction dependent.

**WARNING**

*Never handle the cutting wire when the pedal switch is pressed. When the pedal switch is pressed, power is applied to the cutting wire, and when this wire is at operating temperature, it can cause a severe burn.***

**CAUTION**

*Do not use cleaning instruments that could score the apertures and produce metal burrs. Remember, too, that acetone and similar organic solvents are highly flammable.*
7.4.1 Cleaning the Apertures

To clean the electrical contacts, first remove the wire and apertures. The procedure for removing the wire is provided in paragraph 7.5. Both apertures are held in place by three positioning screws. To remove either aperture, hold the aperture with one hand to keep it from falling when it becomes loose, and loosen the two positioning screws with your other hand. Turn the screws counter-clockwise to loosen them.

Soak the apertures in acetone, and use unwaxed dental floss or a Q-tip soaked in acetone. If a Q-tip is used, pull the tip into a strand that can be poked through the apertures. A powerful magnifying glass is useful to inspect the internal surfaces of the apertures for contamination.

If gross contamination occurs that cannot be cleaned in the manner described, the apertures may be reamed out with the same drill sizes used to create them. The control aperture is 0.035 inch (drill #65) and the warning aperture is 0.052 inch (drill #55).

7.4.2 Cleaning the Wire

To clean the cutting wire, use a Q-Tip soaked in acetone, and rub the wire until it is clean. If you cannot completely remove the residue using the acetone, use sharp-bladed instrument such as a knife blade or razor blade to scrape the residue from the wire, and then repeat the acetone treatment.

7.5 REPLACING THE CUTTING WIRE

It is recommended that the apertures be cleaned (as described in the preceding paragraph) whenever the cutting wire is replaced (see Figure 3). The procedure for replacing the cutting wire is as follows:

1. Loosen the thumb screw holding the wire at the upper wire chuck

2. Unwind the cutting wire from the lower wire Spring Tensioning Device.

3. Remove the cutting wire.

4. Cut an 11-inch length of new wire.

5. Insert the new wire upward through both apertures. Make sure the wire passes through the groove in the Upper Wire Chuck and passes straight down through the control aperture.

6. Insert the wire into the hole in the turning post of the wire Spring Tensioning Device. Place the wire into the lower Grooved Post and tighten the wire by turning the tightening handle several rotations clockwise.
7. Wrap the wire around the Upper Wire Chuck.

8. While pulling straight down on the end of the wire, firmly tighten the thumb screw of the Upper Wire Chuck.

**NOTE:** Step 8 is somewhat critical. If the wire is not pulled down during tightening or if the control aperture is grossly out of adjustment, the upper wire chuck may grip the wire at an angle that is different than when the wire is fully installed and the apertures properly adjusted. This angle may then gradually change with use, thereby requiring more frequent adjustment of the control aperture position than should be necessary. This potential problem has been largely eliminated by the latest design of the Upper Wire Chuck.

9. Finish tightening the wire by turning the tightening handle several times until the spring tension device has moved approximately one inch toward the Grooved Post.

10. Slightly pull the wire away from the Grooved Post to relieve friction between the wire and the post.

### 7.6 REPLACING/ADJUSTING THE HORIZONTAL HOT WIRE

#### 7.6.1 Replacement Procedure

The horizontal hot wire (HHW) is spring loaded and should remain taught while it is hot. If it goes slack while it is hot (or if it breaks), replacement is required. The procedure for making a replacement HHW is illustrated in Figure 7-3.

#### 7.6.2 Adjustment Procedure

Horizontal adjustment of the HHW generally is required after a new wire has been installed. Loosen the ramp set screw and raise it until it almost touches the wire. If it does not appear to be parallel to the ramp, use a small straight-bladed screw driver to adjust the position of the right side of the wire. (The adjustment screw is located behind the small hole in the plastic laminate that is located near the point where the wire is attached).

### 7.7 CLEANING PROCEDURES

#### 7.7.1 Light Panel

If the surfaces between the translucent light panel and its supporting clear plastic panel become dirty, both panels may be removed for cleaning. To remove these two panels:

1. Remove the knob and associated washer used to clamp the light panel in place.
Figure 7.3 Horizontal Hot Wire Replacement
2. Loosen the two wingnuts holding the fluorescent light panel in place and lower the panel (perform this step carefully; the light fixtures are mounted on the panel, and the panel is heavy).

3. Loosen and disconnect the two turnbuckles used to adjust tension on the cross-cable pulley system.

4. Release the cables from the pulleys.

5. Shift the position of the translucent panel so it clears the turnbuckle holding screws, and then lift the translucent panel straight up from the clear panel.

6. Remove the clear panel.

7. Clean both panels.

8. Reinstall both panels.

9. Reinstall the pulley system as shown in figure 7-2.

10. Reconnect the two turnbuckles, and then perform the procedure for adjustment of the light panel provided in paragraph 7.2

7.7.2 Stainless-Steel Surfaces

Use canvas gloves or a canvas cloth to remove splashed metal fragments from the stainless-steel work surfaces. Do not use any kind of sharp tool that may scratch the surface.

After the metal fragments have been removed, use a commercially-available stainless-steel cleaner to wipe the surfaces clean. Most of these cleaners leave a slight waxy residue that helps prevent adherence of metal fragments and makes them easier to remove the next time.

7.7.3 Plastic-Laminated Surfaces

Use the large plastic scraper supplied with the System to remove splashed metal fragments from the plastic-laminated surfaces. Do not use any kind of sharp tool that may scratch the surface. After the metal fragments have been removed, use a commercially-available stainless steel cleaner to wipe the surfaces clean. Do not use abrasives.

7.7.4 Melting Pot

**WARNING**

*Always wear work gloves when working with Cerrobend, and always wear safety glasses when working with molten Cerrobend.*
The melting pots need periodic attention to keep them in good operating condition. The System was designed to facilitate such routine service. The internal surfaces, including those of the valve, develop a residue that is often strongly adherent and may eventually need to be peeled away from the metal with a sharp tool, such as a flat-bladed screwdriver. Accumulations of this residue also are prone to occur on the valve seat and on the metal surrounding the orifice at the bottom of the metal reservoir.

Use the large putty knife supplied with the System to scrape the sides and bottom of the melting pot on a weekly basis. After scraping the pot, strain the molten metal, as described in paragraph 7.10.

It is recommended that the pot used on a regular basis be emptied and cleaned thoroughly every 60 to 90 days. The procedure for emptying and cleaning the pot is as follows:

**WARNING**

*Insulated work gloves must be worn while performing this procedure. The surfaces being handled are hot enough to cause significant discomfort, and may cause a burn if more than momentary skin contact occurs.*

1. Place the second pot and its trolley on the track and plug in the pot.

2. Use the plastic cup to transfer the molten metal to the clean pot.

3. When no more metal can be emptied from the spigot, the pot is usually light enough so you can pick it up. Unplug the pot and transfer it to the work surface.

4. Tip the pot on its side and carefully pour out any remaining metal through the top of the reservoir into the plastic cup, and then pour the remaining metal into the clean pot.

5. Plug the pot to be cleaned into the electrical supply again (it is almost useless to try to clean it after the metal and residue harden).

6. Turn the pot on its side and use the scraper tool to remove as much of the metal and residue as possible from the sides and bottom. Rotate the pot as you clean, so the surface you are working on remains at the bottom.

7. Unscrew the valve assembly, and remove and clean the plastic diaphragm by first banging the removed valve mechanism against the inside of a plastic garbage can and then wiping off any remaining metal or residue with a gauze pad or other disposable cloth. The diaphragm can be replaced, but it is rarely the cause of a leaking valve.

8. Inspect the inside of the valve for debris, and remove any that is present. Use
a flat-bladed screw driver with an undamaged tip to scrape around the valve seat. The valve seat is stainless steel and is not easily damaged, but a screwdriver tip with sharp metal burrs could possibly cause some damage. The valve seat will be bright silver when it is clean. The residue on the valve seat can be as much as 0.5 mm thick, as tough as vinyl plastic, and will need to be peeled away from the metal.

9. Reassemble the valve. You may finish cleaning the inside of the reservoir with steel wool if you like, but there is not much point in doing too good a job. Unplug the pot and store it for the next exchange.

7.7.5 Fan Grills

Dust should be removed periodically from the fan grills and other air-flow apertures. The wire-cooling fan in the block cutter has a finger guard on the rear that can collect substantial amounts of dust that will prevent the fan from functioning properly.

7.7.6 Steel Tray

The steel work-surface tray is designed to be removed for cleaning or service. Remove it by sliding it straight out. Don’t slide it upward, or it may scar the plastic laminate in a visible location.

7.7.7 Lubrication/Cleaning of Vertical Block Cutter Rods

The vertical steel rods in the block cutter should be wiped clean and lubricated with a light oil or silicone spray every few months to prevent rusting.

NOTE: Do not fasten anything to these rods with tape - if the linear bearings become jammed with tape the unit may have to be disassembled to clean them.

7.8 FLUORESCENT BULB REPLACEMENT

The fluorescent bulbs for the light table are mounted on a hinged panel located at the bottom of the light table. The panel is secured by two latches. To gain access to the fluorescent bulbs, turn the latches approximately 90 degrees and lower the panel. Because the fixtures for the fluorescent bulbs are mounted on the panel, it is quite heavy; lower it carefully to avoid a sudden drop of the panel and an abrupt stop at the back wall of the Block Cutter Assembly.

Removal and replacement of the bulbs is performed in the same manner as you would bulbs found in standard household fluorescent light fixtures.

7.9 REPLACING THE FIELD LIGHT

The field light bulb is an ETJ 120-volt, 250-watt quartz projector lamp with an integral reflector. When replacing this lamp, be careful not to touch the surface of the replacement bulb; the normal
oil from your skin may shorten its service life.

To replace the bulb, use just your fingers to remove the four screws retaining the fan-lamp assembly on the back of the upper horizontal assembly of the block cutter. Remove this panel and the attached lamp and fan. Note that the bulb holder has an extractor arm. When you press down on this arm, the bulb will slide out of the socket. Reposition the extractor arm before inserting the new bulb. Replace the fan-lamp assembly.

7.10 CLEANING CONTAMINANTS FROM THE MOLTEN METAL

WARNING

Always wear work gloves when handling Cerrobend, and always wear safety glasses when working with molten Cerrobend.

The metal in the melting pot should be cleaned at least once a week. This step only requires a few minutes, and can save time in the long run through avoiding melting pot malfunctions such as an obstructed valve.

1. Start by draining enough metal into an appropriate container (the cup supplied with the System might not hold enough) so that the level is about 8-10 cm from the top.

2. Scrape the edges and bottom of the reservoir with the large putty knife supplied with the System.

3. Use the strainer supplied with the System to skim the floating contaminants from the surface of the metal.

4. Tap the ears of the strainer on the edge of the reservoir until most of the molten metal has been extracted from the material in the strainer (the reason for draining the reservoir to begin with should now be evident).

5. While the metal is still molten, empty the strainer into a waste receptacle lined with a plastic bag.

6. Rap the strainer against the inside surface of the waste receptacle to remove any still-molten metal from the screen of the strainer. This simple process is a reasonable compromise that avoids wasting significant amounts of metal, and it is not nearly as time consuming as more thorough methods of metal recovery.

7.11 RECYCLING METAL SCRAPS

Metal scraps collected over a period of time can be usefully recycled. A procedure for easily separating the metal from the debris that also collects is as follows:
1. Place the scraps in two doubled, heavy-gauge garbage bags (one inside another).

2. Partially fill the second melting pot with water.

3. Drape the scraps in the unsealed bags into the second melting pot.

4. Support the bags so that the scraps are located in one corner of the bags and are suspended in the water and not resting on the bottom of the pot.

5. Plug in the second melting pot, and allow the metal to melt and percolate downward for at least 8 hours.

6. Remove the bags from the pot.

7. Snip a small hole in the dependent corner of the bags, and collect the molten metal as it flows out.

8. Discard the bags and remaining debris, unplug the second melting pot, and empty the water.
8.1 CASTING PHOTON BLOCKS

8.1.1 Thin Blocks

Casting thin blocks or integral block-compensators can be accomplished easily using the Portalcast System. This technique is particularly useful for delivering a low dose to entire lung while treating the mediastinum, or limiting the dose to the spinal cord or kidney, by interposing a layer of Cerrobend of proper thickness to provide the necessary beam attenuation within the low-dose portion of the field.

Begin by cutting a mold for the unattenuated part of the field, just as you ordinarily would. After the mold is cut, use the horizontal hot wire to slice off the bottom of the mold (the portion closest to the tray) at a thickness appropriate to provide the necessary beam attenuation. Replace this thin section back into the block cutter and cut out the extension of the mold encompassing the low-dose areas. Tape the two sections back together again, place them in a pouring frame, and pour them as you usually would.

The thin block should always be at the bottom of the mold where it will cool into a solid metal slab of uniform thickness and density. The mold structure should never be reversed with the thin block near the top where the metal thickness and consistency cannot be predicted. It will be necessary for you to determine the HVL of your metal supply with the characteristics of your beam.

8.1.2 Double Blocking

In rare circumstances when 4 to 5 percent transmission is unacceptable, thicker blocks may be constructed by cutting an additional layer of Styrofoam from a blank and taping it to another blank. Be sure that the adjacent surfaces of the two layers are properly trimmed on the horizontal hot wire and are flat so that no leaks will occur when the mold is filled. Always keep the thickest layer of Styrofoam on the bottom of the mold to minimize the pressure of the molten metal at the junction.

If the treatment plan calls for both a thicker block and a wedge or custom-compensating filter, there may not be enough room to permit the use of both a thick block and a compensator in the accessory mount. This can be overcome by mounting the block extension (the secondary block) on the distal surface of the tray.

Pour the primary blocks as you ordinarily would. Pour the secondary blocks as a separate unit with the STD set at the usual STD plus the tray thickness and the thickness of the secondary blocks. Use a double-surfaced Styrofoam blank for the secondary mold and pour it with the small side of the mold down (opposite from usual). Make sure the secondary blocks have mounting ears that stick out beyond the primary block. This allows the secondary blocks to be attached to the tray after the primary blocks are mounted.

When marking the position for the mounting screw for the secondary blocks, be sure that the tray
8.1.3 Suggestions for Designing Blocks

There are a number of technical goals to be achieved in designing blocks:

1. The resulting blocks should be no heavier than necessary. There is a potential hazard both in lifting and in possibly dropping a heavy blocking tray, both to the technologist and the patient.

2. The blocks should generally be small enough to fit back into the melting pot.

3. The blocks should generally not be cast as a monolith that outlines the port independent of the primary collimators.

The basic principal is to use the primary collimators as a part of the final field shape whenever possible. The principal advantage to this is that the mold remains as a single piece. If the block as cast as a monolith so that it entirely defines the field, the portion of the Styrofoam corresponding to the field shape will become an island unattached to the surrounding mold, and this island will have to be individually positioned with a reference X on the mold. This is a more time consuming and error prone method. Furthermore, if the field is very irregular in shape, the Styrofoam is often very difficult to remove from such castings.

Furthermore, sensible partitioning of the blocks on a tray leaves some flexibility to reposition the blocks without having to recast them entirely. Experience has shown that fields are sometimes drawn with insufficient margins. After the first port-film or two, it will become evident that the patient cannot be reproducibly positioned with sufficient accuracy and a request may be made to widen the margins. If the blocks are cast in more than one part (as shown in the following illustration), this can often be done by shifting the blocks slightly on the tray. However, the blocks should not be overly fragmented or the subsections will become too small to fasten them accurately to the tray. The amount of work involved also increases with each anchoring screw required. Especially small subsections should be included with another block even if the bridging section has to lie outside the shadow of the primary collimators.

The outer edges of the drawn block should extend about 1 cm beyond the primary collimator edge on the simulator film. Where the blocked field-edge closely approaches the primary collimators, the outer edge of the drawn block should be bulged outward more than 1 cm beyond the primary collimators so that no section of a drawn block will be thinner than 2 to 3 cm on the simulator film. This generally corresponds to an actual block thickness of about 1 cm. Thinner blocks than this can be fragile, unstable and hard to fasten to the tray and the molds difficult to tape and clean prior to pouring.

8.1.4 Repositioning Blocks on a Tray

Despite all best efforts, there will be occasions when it becomes necessary to adjust the position of
blocks. The most common circumstance is that the amount of margin required around the tumor volume was underestimated by the radiation oncologist drawing the field. It is sometimes easier to move a block slightly than to start from scratch with a new mold. One approach is:

Mark the desired position of the block on the tray relative to its old position. Fill in the old screw holes with Cerrobend, and file the surface of the block flat. Re-mark the block with the punch while holding the block in the proper position, and then redrill and remount the block.

8.1.5 Partitioning Large Blocks to Facilitate Remelting

If the suggestions for drawing and shaping blocks are followed, it will be rare that you will have blocks to be remelted that will not fit into the melting pot. However, circumstances do arise where very large blocks are needed. When this happens, select a dividing line in the block, and cast a small sheet of aluminum foil into the block at this position. If the block breaks in preparation at this weak point, it can be soldered back together with some extra metal for reinforcement. When you are done with the block, it can be fractured easily across this point by dropping it on a hard surface or striking it at the weak point with a hammer.

8.2 ELECTRON BLOCKS

8.2.1 Numerical Correction for STD’s < 95 cm

On some machines, it is not possible to quite reach an STD setting of 95 cm. This is not a significant problem and is only a minor inconvenience. Assuming that the correct tray distance for your electron block will be 95 cm, adjust the STD to the largest convenient setting and then determine the proper adjustment for the SFD from the following. It will be necessary to calculate your SFD setting as:
SFD setting = SFD actual (STD chosen/95)

This maneuver will produce a block that does not have exactly the right taper (divergence characteristics), but because the block is only about 1 cm thick, the introduced error is insignificant.

8.2.2 Special Use of the ELECTRON MODE/PHOTON MODE Switch

If your simulator film was taken at a sufficiently large SFD actual, you will have no problem using a shorter STD chosen and operating in the normal “Photon” mode. If the SFD actual was relatively short, the resulting SFD setting may be too short to be accommodated if STD chosen is too short.

The ELECTRON MODE/PHOTON MODE switch simply offers a means of coping with this dimensional constraint by allowing you to cut the mold with the Styrofoam near the bottom of the cutting wire while maintaining optimal cutting accuracy.

NOTE: As the contact point of the Styrofoam rises toward the middle of the cutting wire, the upper aperture will become the most sensitive to wire deflection. Since the upper aperture is smaller than the lower aperture, the “balance point” is below the middle of the wire. If the Styrofoam is within 3 to 4 cm from the lower aperture, the “electron” mode will be best. If it is much greater than that, the “photon” mode may be best. This is empirically easy to determine. Bear in mind that if there seems to be little difference in the sensitivity to wire deflection regardless of the setting of the switch at settings you are using, then the switch position will be irrelevant. However, expect the warning signal to be overly sensitive and ignore it.

8.2.3 Pouring Electron Blocks

When pouring thin layers of Cerrobend, some users have found it awkward when the cooling tray
is so cold that the metal hardens before a uniform layer of metal can be poured. If you find this to be a problem, turn off the COOLING switch and pour some metal on the panel to warm it up. Then pour your casting and turn the COOLING switch back on.

8.3 MANUAL POSITIONING OF BLOCKS

The clear plastic plate that fits on top of the Styrofoam blank holder can be used for drawing “templates” for manual positioning of blocks. Place a thin plastic sheet with a central axis mark on the jig-saw panel and use the field light to align the mark with the light panel. The shadow of a pen held at the level of the template as it is projected by the field light on the simulator film can be used to draw the reduced image of the blocking outline from the simulator film.

This feature is especially useful for starting emergency patients with manual blocking for their first treatment without having to wait for custom blocks to be made.

NOTE: When using this technique, numerical correction is required, because the jig-saw panel does not sit at the indicated STD.

8.4 CORRECTION FOR OUT-OF-RANGE SFD

Occasions may arise where it is necessary to cut molds for treatments simulated at extended distances beyond those encompassed by the Block Cutter Assembly. This can be done with a relatively small error of only 1 or 2 mm for most realistic distances. The means of calculating this error along with a graph indicating the magnitude of the error and a spreadsheet for determining the appropriate STD at which to cut the mold are provided in Appendix C.

8.5 ADDING METAL TO THE MELTING POT

WARNING

Always wear work gloves when handling Cerrobend, and always wear safety glasses when working with molten Cerrobend.

Feed the reservoir continuously as you use the molten metal so that the level in the pot does not drop below half full. If the level drops too low, when you add new ingots or recycled blocks, there will be too little contact between the molten metal, the heated walls of the reservoir, and the newly added metal to provide good heat transfer, and it will take an inordinately long time for the newly added metal to melt.

In an emergency situation, if the pot is drained too low and you need metal right away, add enough tap water (preferably hot) to the reservoir to provide a medium for thermal conduction to the metal ingots. The water can be scooped off the top later (it will eventually evaporate).
WARNING

Be careful when adding water to the melting pot. The edges of the reservoir may have super-heated, and some splattering of water and/or metal may occur.

8.6 MOUNTING THE TRAY TO THE CASTING

Screws are more likely to strip out of the Cerrobend casting when the metal is still very hot, even though it may be hard. When mounting the tray to the casting, don’t over-tighten the screws in hot blocks.

8.7 SOURCES OF ERROR FROM BLOCK ATTACHMENTS TO TRAY

The following diagrams illustrate a number of the most common sources of error associated with the manner of attachment of the blocks to the tray.

The use of small, segmented blocks with reliance on the primary collimators for creation of part of the collimation can result in distortion due to the lack of rigidity of the tray. If the simple convention of orienting the tray so that most of the segmented blocks are positioned with their longest dimension perpendicular to the supporting rails of the tray holder on the machine (as noted below), block-lean will rarely be a problem.

8.8 SOURCES OF ERROR IN POSITIONING TRAY WITH RESPECT TO BEAM

The principal problem here is the mechanical instability of the trays in the tray holder, of the tray holder in the head of the machine and any additional mechanical interfaces with the machine. Suffice it to say that a “chain is only as strong as its weakest link” in this regard. Constant attention to loosening of these linkages is necessary with an appropriate quality assurance program. A “standard tray” should be used daily to test for goodness of fit and field-center alignment. A useful test when there is a question of adequate block alignment in an individual case is to set up an X-ray film in the isocenter plane and expose it with both opposed beams. In general, the fields should overlap unless there is a misalignment. This is a particularly telling test in the opposed lateral configuration where the weight of the tray and accessory holding assembly are most likely to increase any mechanical instability.
In circumstances where this orientation is not possible and especially heavy blocks are a problem, an easily installed soldered brace positioned outside the field of treatment will provide stability without the aforementioned drawbacks of large single castings.
8.9 PROBLEMS WITH ELECTRON SCATTERING FROM BLOCKING TRAYS

Although electron scattering from blocking trays is not generally a clinically significant problem, certain circumstances predispose to increased skin reactions and when they occur, measures should be taken to eliminate this source of superficial irradiation. The following is a list of those circumstances:

1. When two adjacent fields are being treated, the scatter from the tray from field A may contribute to the skin irradiation in field B and vice versa. If one of these fields is already subject to an enhanced skin reaction (e.g. an electron field or bolused photon field) the additional dose due to scattered electrons from the tray may be sufficient to cause a significant clinical problem. A typical example is scattering from a supraclavicular port into an abutting chest-wall or internal-mammary field.
2. Patients with unusual skin sensitivity.

3. Unusually short tray-skin distances such as occur with <100 cm isocenter machines.

4. Small separations between entrance and exit surfaces and resulting higher relative exit doses approaching 50% of the midplane dose.

5. Tangential surfaces.

There are two basic solutions. Either cut away the portion of the tray traversed by the beam or mount the blocks on a wire-mesh tray (usually supplied by the treatment machine manufacturer).
9.1 WARRANTY

The Portalcast Block Cutting and Casting System and all the associated parts for this product is warranted by Diacor for a period of one (1) year from the date of shipment.

The Diacor warranty coverage is limited to defective materials or workmanship. The warranty is void if the Portalcast System has been damaged by accident, unreasonable or improper use, neglect, or other causes not arising out of defects in material or workmanship.

9.1.1 Warranty Disclaimers

The express warranty provided herein is in lieu of any and all implied warranties arising out of the sale of the Portalcast Block Cutting and Casting System, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Diacor shall not be liable for loss of use of the Portalcast Block Cutting and Casting System or other incidental or consequential costs, expenses, or damages incurred by the customer or other user.

9.1.2 Warranty Performance

During the stated warranty period, the Portalcast Block Cutting and Casting System will be repaired by Diacor, Inc. or an authorized representative of the company. Prior to the return of a part for repair or replacement, please contact Diacor, 800-342-2679 or 801-467-0050, for a Return Material Authorization (RMA). Such returns should be addressed to Diacor, Inc., 2550 Decker Lake Blvd., West Valley City, Utah 84119 with the RMA number clearly marked on the shipping container. The repair or replacement of a the Portalcast Block Cutting and Casting System or its parts will not extend the expressed warranty stated herein beyond the original warranty period.
APPENDIX

THE STANDARD TRAY

The standard tray should be geometrically representative of all trays used with the System, and should have the projected image of the field light cross-hairs from the treatment machine marked on its surface. The standard tray should be used to set up the reference frames when the System is initially put into operation. It also should be used as part of the System quality assurance program to check for correct and consistent alignment. A recommended procedure for making a standard tray is provided in this Appendix.

When a tray can be inserted in the treatment machine in more than one direction, it is important to note the rotational orientation of the tray before it is inserted into the machine. Once that rotational orientation has been established, it must remain the same each time that tray is used. This is necessary to ensure that the projected image of the cross-hairs aligns properly.

1. Place two crossed strips of masking tape on the surface of the tray closest to the beam to identify the approximate center of the tray and the approximate location where the field light will be projected.

2. Insert the tray into the treatment machine.

3. Use a ball-point pen or pencil to mark the position of the field light image of the cross-hairs on the masking tape. This will enable you to check for proper alignment of the field light with the tray, as well as align the tray and Styrofoam blank with the reference frame.

A simple method to accomplish the above and also to clearly mark the standard tray so that it will not be used to make a blocking tray is to use two strips of masking tape that are perforated with a linear series of holes using a paper punch, as shown in the accompanying illustration. The cross-hair position can be marked with a ballpoint pen (a dark enough image so that the mark can be clearly seen from both sides of the tape). The utility of this method is better experienced than explained.

Be absolutely certain that your machine is in proper standard alignment and that you are satisfied with the fit of the tray. We recommend that a mark be placed accurately on the tray holder, and that tray movement represent less than ±0.5 mm from the mark in all directions.

Tolerances different than ±0.5 mm are a matter of user preference. However, remember that the accuracy of the System is a function of the aggregate errors in alignment.
This Appendix contains the following electrical schematic diagrams:

- Figure B-1, Workstation System Wiring
- Figure B-2, Workstation Power Control Logic Module and System Wiring
- Figure B-3, Workstation Power Control Micro Module and System Wiring
- Figure B-4, Block Cutter System Wiring
- Figure B-5, Block Cutter Power Control Logic Module and System Wiring
- Figure B-6, Block Cutter Power Control Micro Module and System Wiring
- Figure B-7, Block Cutter Junction Box Wiring
- Figure B-8, Refrigerated Cooling Plate

The schematic diagrams are provided for reference purposes only, and are not intended to be used for servicing of the System.
Figure B-1 Workstation System Wiring
Figure B-2 Workstation Power Control Logic Module and System Wiring
Figure B-4 Block Cutter System Wiring
Figure B-5 Block Cutter Power Control Logic Module and System Wiring
Figure B-6 Block Cutter Power Control Micro Module and System Wiring
Figure B-7 Block Cutter Junction Box Wiring
Figure B-8 Refrigerated Cooling Plate
If it becomes necessary to cut molds for treatments simulated at extended distances beyond those encompassed by the Block Cutter Assembly, the molds can be cut with a relatively small error of only 1 or 2 mm for most realistic distances. This Appendix contains an explanation of how to determine the optimal STID at which to cut a mold from a simulator film taken at a greater distance than that permitted by the Block Cutter Assembly. A definition of the maximum resultant error in field size (assuming a maximum field size of 40 cm at 100 cm) also is provided in this
By Definition:

a) STD₁ = an unknown source tray distance (to be determined) at which the Shaper must be set in to cut a mold appropriate for treating a patient when the simulator film was taken at SFD₂ and with the block positioned at the customary distance of STD₂.

b) SFD₁ = The maximum SFD at which the Shaper can be set.

c) D = The maximum radius (distance from central axis) of the field size on the simulator film.

d) d = The radius (at mid-thickness in the mold) produced at the C-position corresponding to D.

e) d₁ = The radius (at the bottom of the mold) produced at the C-position corresponding to D at STD₁.

f) d₂ = The radius (at the bottom of the mold) produced at the C-position corresponding to D at STD₂.

g) Errorblock = The size of the error (measured at STD₂) produced by cutting at STD₁ and using at STD₂.

and: Errorblock = d₁ - d₂

h) Error_tumor = The size of the error (measured at the source-tumor distance) produced by cutting at STD₁ and using at STD₂, and:

\[ \text{Error}_\text{tumor} = (d₁ - d₂) \left( \frac{\text{Tumor distance}}{\text{STD}_2} \right) \]

Determination of STD₁:

1) \[ d₂ = D \left( \frac{\text{STD}_2}{\text{SFD}_2} \right) \]

2) \[ d = d₂ \left( \frac{\text{STD}_2 - 3.6}{\text{STD}_2} \right) = D \left( \frac{\text{STD}_2}{\text{SFD}_2} \right) \left( \frac{\text{STD}_2 - 3.6}{\text{STD}_2} \right) \]

where: 0.5 x (Styrofoam blank thickness) = 3.6 cm

also:

\[ d = D \left( \frac{\text{STD}_1}{\text{SFD}_1} - 3.6 \right) \]

3) \[ D \left( \frac{\text{STD}_1 - 3.6}{\text{SFD}_1} \right) = D \left( \frac{\text{STD}_2}{\text{SFD}_2} \right) \left( \frac{\text{STD}_2 - 3.6}{\text{STD}_2} \right) \]

4) \[ \text{STD}_1 = \left( \frac{\text{STD}_2}{\text{SFD}_2} \right) \left( \frac{\text{STD}_2 - 3.6}{\text{STD}_2} \right) \frac{\text{SFD}_1 + 3.6}{\text{SFD}_1} \]

Solving for STD₁
Determination of Error\(_\text{tumor}\):

By definition:

6) Error\(_\text{tumor} = |d_1 - d_2| \left( \frac{\text{Tumor distance}}{\text{STD}_2} \right) \)

7) \( d_1 = D \left( \frac{\text{STD}_1}{SFD_1} \right) \)

8) \( d_1 = \left( \frac{D}{SFD_1} \right) \left( \frac{\text{STD}_2}{SFD_2} \right) \left( \frac{\text{STD}_2-3.6}{\text{STD}_2} \right) \frac{\text{STD}_1 + 3.6}{SFD_2} \) by subst. Eq. 4 into Eq. 5

\( d_2 = D \left( \frac{\text{STD}_2}{SFD_2} \right) \) Eq. 1

9) Error\(_\text{tumor} = \left( \frac{D}{SFD_1} \right) \left( \frac{\text{STD}_2}{SFD_2} \right) \left( \frac{\text{STD}_2-3.6}{\text{STD}_2} \right) \frac{\text{STD}_1 + 3.6}{SFD_2} - D \left( \frac{\text{STD}_2}{SFD_2} \right) \left( \frac{\text{Tumor distance}}{\text{STD}_2} \right) \) by subst. Eq. 1 & 8 into Eq. 6

and

Error\(_\text{tumor} = 3.6 D \left( \frac{1}{SFD_1} - \frac{1}{SFD_2} \right) \left( \frac{\text{Tumor distance}}{\text{STD}_2} \right) \) by simplification

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Error Size (for STD\(_2 = 65\): SFD\(_1 = 155\))

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![Graph showing error at source-tumor distance vs. distance at which simulator film taken for different source-tumor distances.]
Table C-1 STD1 as a Function of STD2 and SFD2

| STD2 | 45  | 46  | 47  | 48  | 49  | 50  | 51  | 52  | 53  | 54  | 55  | 56  | 57  | 58  | 59  | 60  | 61  | 62  | 63  | 64  | 65  | 66  | 67  | 68  | 69  | 70  | 71  | 72  | 73  | 74  | 75  | 76  |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SFD2 | 45  | 46  | 47  | 48  | 49  | 50  | 51  | 52  | 53  | 54  | 55  | 56  | 57  | 58  | 59  | 60  | 61  | 62  | 63  | 64  | 65  | 66  | 67  | 68  | 69  | 70  | 71  | 72  | 73  | 74  | 75  | 76  |
|      | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 |
| STD1 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 |

803 REV B