

NU SUSPENSION CASTING TECHNIQUE^a

Fred Hampton, C.P.

Northwestern University
Prosthetic Research Center
Chicago, Illinois 60611

INTRODUCTION

The suspension casting technique developed at Northwestern University Prosthetic Research Center permits the casting of an amputee's stump under controlled weight-bearing conditions. The principle of suspension casting was developed primarily for casting below-knee amputations, but it has been successfully applied also in the casting of hip disarticulations, hemipelvectomies, and Syme's amputations. The technique permits the casting of an amputee's stump under conditions simulating stance-phase weight bearing in a prosthesis.

Casting of below-knee stumps is accomplished by suspending the amputee's stump in a cast sock held by a ring mounted on an adjustable stand.

Many cast molding or contouring techniques may be used as a complement to the suspension casting principle. The technique used at Northwestern University consists of molding the wrap of plaster by the hands without permanently deforming the patellar tendon or popliteal areas. This results in an intimate fit of the cast to the stump with minimal loss of definition in the areas of the medial flare of the tibial condyle or the patella. The location and depth of the patellar-tendon bar and the apex and configuration of the popliteal bulge can be accurately determined during the modification of the male mold.

This casting procedure offers the following advantages:

1. It permits proper orientation of the amputee in the casting stand prior to wrapping of the stump.
2. It does not require a maximum of effort on the part of the amputee.
3. It assists in reducing edema prior to casting.
4. It allows some evaluation of tolerance to distal pressure on the stump.
5. It permits definitive application of relief patches in relation to the stump without fear of displacement.
6. It prevents displacement of redundancy during casting.
7. It allows a firm tension to be applied to the plaster bandage, and it results in a smooth cast.

^aBased on work performed under VA Contract V1005M-1079.

8. It holds the stump in the correct attitude for locating alignment lines.
9. The technique is not complicated and is easily taught.

This report includes:

1. A description of the equipment.
2. A method of preparing and applying relief patches to the appropriate areas.
3. A method of taking a plaster wrap impression of the stump.
4. The process of pouring the male mold.
5. The modification of the male mold.
6. General remarks on laminating and foaming the distal end of the socket.

EQUIPMENT

1. Steel ring, 7-in. outside diameter, 6 $\frac{3}{4}$ -in. inside diameter, 1 $\frac{1}{2}$ -in. width (Fig. 1)
2. 1 adjustable stand, VA or Berkeley type (Fig. 2)
3. 1 rubber gasket (cut from inner tube)
4. 1 hose clamp
5. VA caliper
6. Bathroom scale (optional)

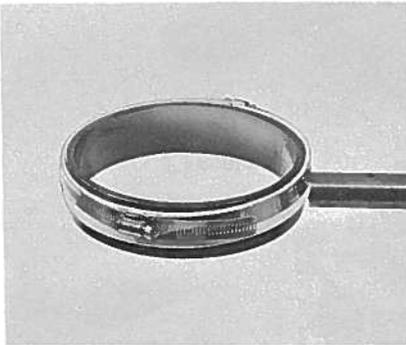


FIGURE 1

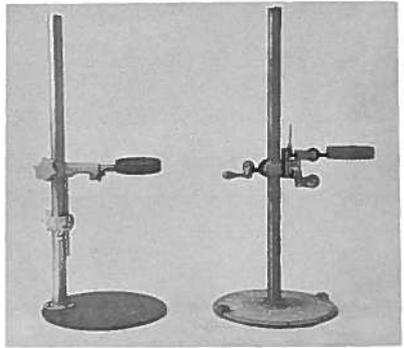


FIGURE 2

MATERIALS

1. 1 or 2 heavy cast socks
2. $\frac{1}{8}$ -in Kembro for relief patches
3. 1 piece of cardboard
4. General purpose glue
5. Indelible pencil
6. Plumb bob
7. 4-in. plaster bandages
8. Water

PROCEDURE

1. Examine the stump and record pertinent information.
2. Seat the amputee and with the stump fully relaxed and supported by the prosthetist, measure the anterior-posterior dimension with the VA caliper, and record (Fig. 3).
3. Measure and record the medial-lateral dimension of the stump (Fig. 4).
4. With firm tension applied by the amputee to a cast sock on the stump, make a tracing of the medial contours of the stump. Support the stump to prevent bulging of the tissues and apply moderate pressure to the stump with the pencil. This will provide a template of the medial flare of the tibial condyle for later reference to the male mold. Mark the medial tibial plateau of the stump on the template (Fig. 5 and 6).

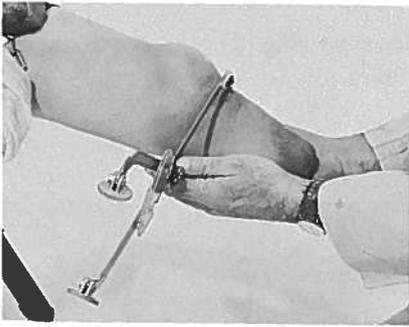


FIGURE 3

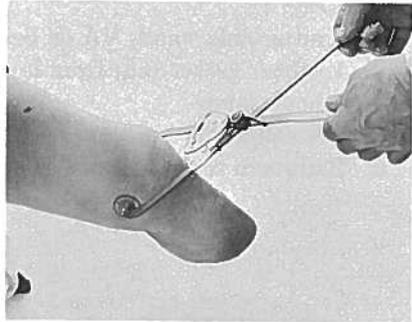


FIGURE 4

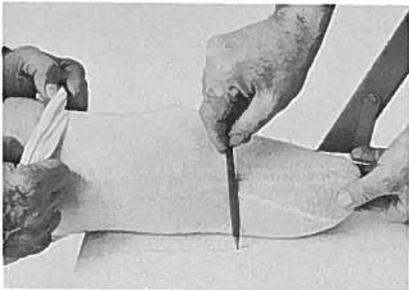


FIGURE 5

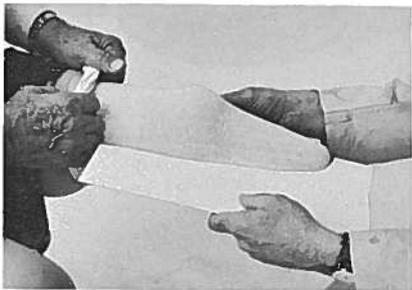


FIGURE 6

5. Outline on the sock areas requiring relief. These areas are usually the tibial tubercle, crest and distal end of the tibia, the leading edge of the flare of the lateral tibial condyle, and the head of the fibula (Fig. 7).

6. Cut and skive appropriate pieces of $\frac{1}{8}$ -in. Kemblo for the areas marked (Fig. 8 and 9).

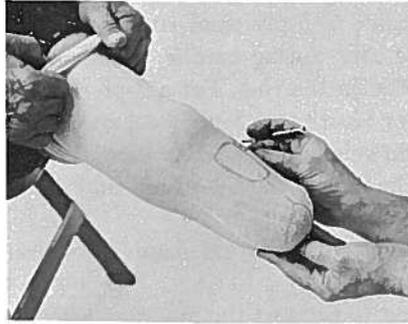


FIGURE 7

7. Mark on a cast sock the distance from the end of the stump to the proximal edge of the patella (Fig. 10).

8. Orient the cast sock centered in the ring with the length marked at the distal edge of the ring. Apply the rubber gasket over the stump sock and secure with the clamp. Remove surplus stockinet (Fig. 11).

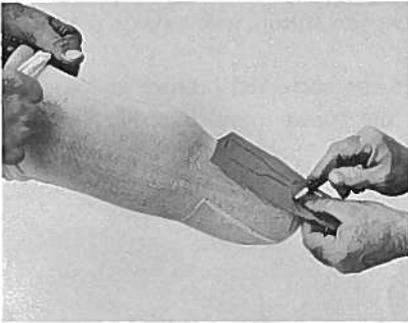


FIGURE 8

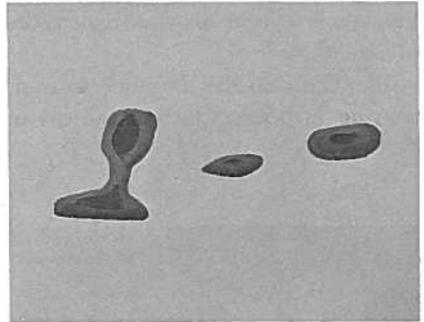


FIGURE 9

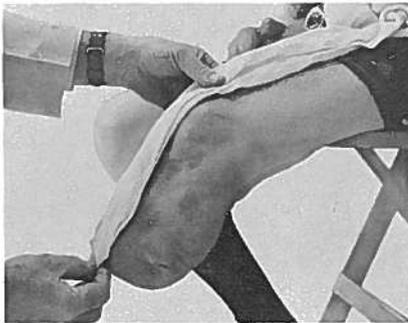


FIGURE 10

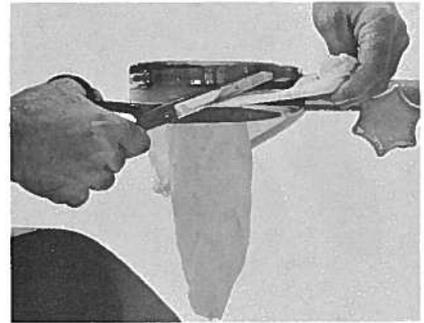


FIGURE 11

9. To accommodate a 5-ply wool stump sock in a hard socket, two heavy cast socks are used during casting. One is applied to the stump and the other is suspended in the ring. For a 3-ply wool stump sock one heavy cast sock is used. For less than a 3-ply wool stump sock (socket with Kemblo insert) one lightweight cast sock is used. When two socks are being used, the sock on the stump must be snug and contact the thigh at least 3 in. proximal to the patella.

10. Lower the ring on the casting stand to facilitate entry of the stump (Fig. 12).

11. Raise the ring to support the amputee with at least $\frac{1}{3}$ of the body weight borne in the suspension sock. A bathroom scale can be used during casting to check the distribution of weight. Check the height of the amputee and raise the ring slightly past the correct level to accommodate stretching of the suspension sock. The suspension sock must contact the thigh 3 in. above the patella. This will prevent bridging of the stockinet in the area of the femoral condyles.

12. In order to obtain a prominent definition of the patella and the crest of the tibia, the stump must be flexed approximately 12 deg. and held in this attitude during weight bearing (Fig. 13). If the amputee is bearing too much weight on the suspension sock, the stump will have a tendency to extend.

13. Caution the amputee to maintain the corrected posture and weight bearing attitude. Outline the areas of the stump requiring relief on the



FIGURE 12

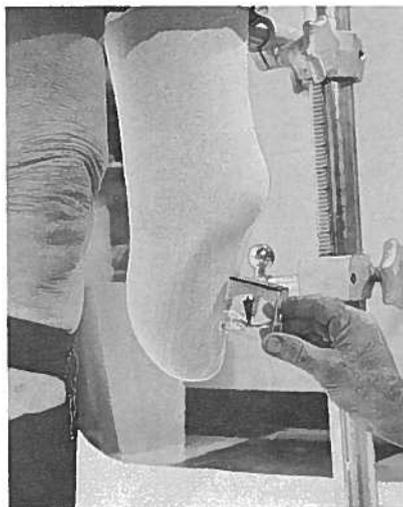


FIGURE 13



FIGURE 14

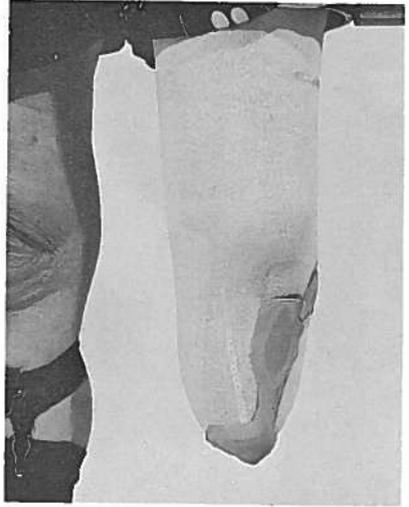


FIGURE 15

suspension sock and apply rubber cement to the areas marked and to the prepared Kemblo patches (Fig. 14 and 15). Recheck the attitude of the amputee for height and the flexion of the stump in the suspension sock.

WRAPPING THE STUMP

The peripheral support of the stump obtained from the suspension sock permits a firm tension to be applied to the plaster bandage during wrapping without deformation of the tissues. The hands are used to mold the plaster wrap to ensure an intimate fit and definition of the stump. Standard 4-in. bandages are used.

The following procedure is used for wrapping the stump:

1. Start the wrap proximally to include all of the patella. The wrap should start anteriorly from the lateral to the medial side thereby emphasizing the tibial crest and the medial flare of the tibial condyle. Four passes of bandages should be applied at this area using firm tension (Fig. 16).
2. Firm, even tension should be applied to the bandage under the medial flare of the tibial condyle (Fig. 17).
3. A firm wrap is applied to the remainder of the stump.
4. The plaster wrap is molded to the stump by hand with an upward spiral motion, being careful to keep tissue away from the medial flare of the tibial condyle (Fig. 18) and the crest of the tibia.

Attention is given to obtain a good impression of the patella and the patellar tendon during the molding procedure as shown in Figure 19. The hands should not be held in this position until the plaster sets.



FIGURE 16



FIGURE 17



FIGURE 18



FIGURE 19

The plaster wrap is allowed to harden, and the amputee is checked for correct orientation in the stand before proceeding to apply the alignment lines to the cast.

ALIGNMENT LINES

After the plaster has set, the amputee is in effect wearing a check socket. The amputee is oriented in an upright position to simulate mid-stance in a prosthesis with approximately one-half weight bearing on the suspension

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cast. The sound foot is placed in a correct position and the level of the amputee is checked and corrected if necessary (Fig. 20).

With the use of a plumb bob or a square, two lines are scribed on the cast. One line is drawn anteriorly and the other is drawn on the lateral aspect of the cast (Fig. 21 and 22).



FIGURE 20

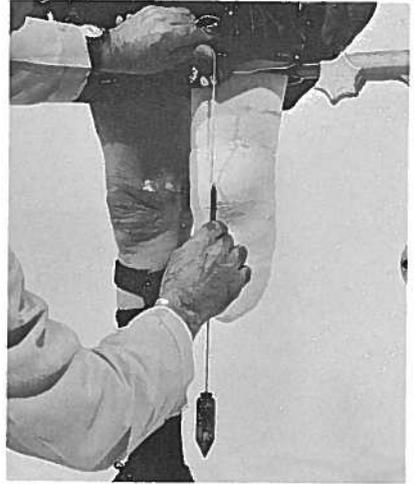


FIGURE 21

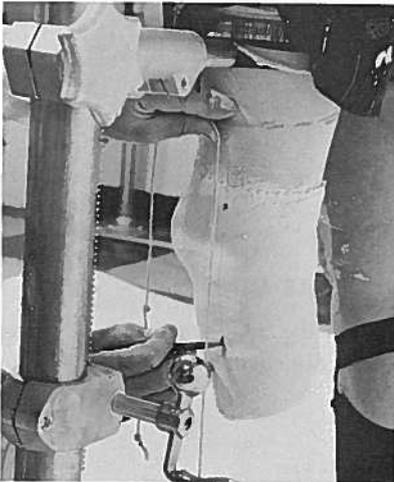


FIGURE 22



FIGURE 23

To remove the amputee from the casting stand, lower the ring and release the clamp holding the bar to allow the ring to pivot and seat the amputee. Remove the clamp and rubber gasket (Fig. 23).

The stump is removed from the cast by the amputee pulling the tissues proximally and the prosthetist pulling the cast distally. The cast stump sock and the suspension sock are removed from the cast. The Kemblo relief patches are removed from the cast with the suspension sock. Remove the Kemblo patches from the sock and they can be used again.

POURING THE POSITIVE

When pouring the positive mold, the pipe inserted in the plaster must be vertical to the lines established on the cast (Fig. 24).

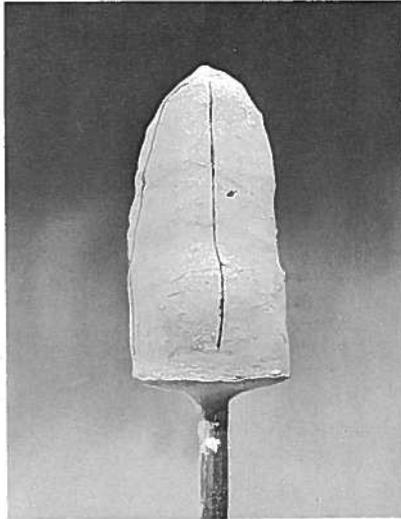


FIGURE 24

MODIFICATION OF THE MALE MOLD

A tentative outline of the socket is drawn on the mold starting from mid-patella. The lateral and medial sides extend approximately 2½ in. above

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the mid-patellar-tendon level. The apex of the posterior wall extends approximately $\frac{1}{2}$ in. superior to the mid-patellar-tendon bar. The radius for the medial hamstring is lower and brought more medially than the radius for the lateral hamstrings. The lateral and medial sides should contribute to femoral condyle support without restriction.

The technique presented is used in conjunction with a hard socket. The same principle of casting is used for making a socket with an insert, but in modifying the male mold the anterior-posterior of the mold is reduced to the anterior-posterior measurement of the stump. The depth of the patellar-tendon bar is determined from the anterior-posterior measurement previously recorded. To permit the amputee to wear a 5-ply wool sock in a hard socket, the measured anterior-posterior of the amputee is increased $\frac{1}{4}$ in. The location of the relief for the patellar tendon is evident from the cast. Usually the depth of this relief is $\frac{1}{2}$ in. and approximately $\frac{3}{4}$ in. wide from the top to the bottom edges. The groove is cut between the inferior edge of the patella and the superior edge of the tibial tubercle at right angles to the line of progression represented by the pipe (Fig. 25). The superior edges of the groove are curved to emphasize the distal, medial, and lateral outline of the patella. The popliteal bulge is located in relation to the patellar-tendon bar (Fig. 26).



FIGURE 25



FIGURE 26

The apex of the popliteal relief is located on the posterior aspect of the cast just distal to the level of the mid-patellar-tendon bar. This popliteal relief is more of a flattening of the cast in this area rather than a definite depression.

A formula for the anterior-posterior measurement of the cast that we have found of value is as follows:

- a) Anterior-posterior measurement of the cast.
- b) Anterior-posterior measurement of the stump $+1/4$ in.
- c) Total amount of plaster to be removed = (a) minus (b).
- d) Three-fourths of this amount (c) to be removed from patellar-tendon area.
- e) The remainder of the plaster is removed from the popliteal area.

The mold is relieved on the medial and lateral side of the tibia in the usual manner.

The template of the medial flare of the tibial condyle is related to the mold and used as a guide in removal of plaster. The stabilizing bar for the fibula has been eliminated. The head of the fibula, the leading edge of the flare of the lateral tibial condyle, and the tibial tubercle and crest of the tibia were all provided with reliefs prior to wrapping the stump. These areas are smoothed and blended into the contours of the mold by judicious removal of plaster.

The medial-lateral of the cast is usually within $1/4$ in. of the measured medial-lateral of the stump. Elimination of the cast sock marks in the mold by smoothing with "Fabricut" paper brings this measurement to within $1/8$ in. of the measured medial-lateral.

The posterior proximal edge of the socket must provide comfort when sitting and comfort and adequate support during stance phase. To ensure this condition, the location of the posterior border of the socket is carefully defined, and a generous flare is constructed on the mold.



FIGURE 27

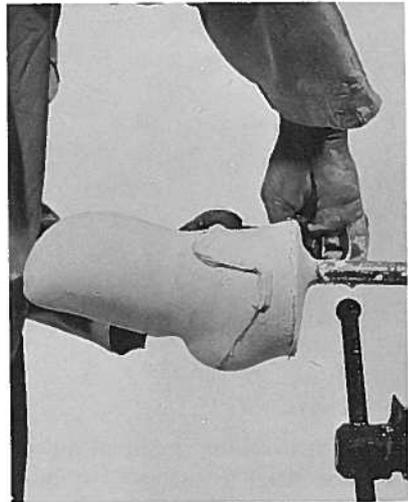


FIGURE 28

A simple technique is to fold a piece of 4-in.-plaster bandage approximately seven times (Fig. 27). Wet this roll and lay it along the medial, posterior, and lateral outline of the cast (Fig. 28). Form this roll by lightly pinching it between the thumb and forefinger, then smooth it over with a plaster slurry.

At this time, relief for the hamstrings is provided. The lateral hamstring relief runs from the lateral radius of the outline to the head of the fibula and forms the lateral border of the popliteal relief. The medial hamstring relief originates from the medial radius of the proximal posterior border of the socket and blends into the outline of the medial border of the popliteal relief (Fig. 29).



FIGURE 29

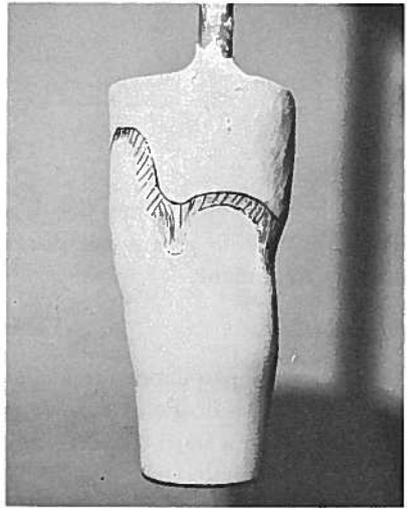


FIGURE 30

The relative motion between the tibial and femoral condyles during ambulation must be accommodated in the socket. The cast was taken with approximately 12 deg. of flexion in the stump which means the posterior aspect of the femoral condyles were not as prominent as they are when the knee is in full extension. To avoid painful pressure in this area, it is advisable to fill in the demarcation line between the body of the mold and the flaring head of plaster bandage. Unless this is done, a rather prominent ridge is created at the distal edge of the flaring in the socket (Fig. 30).

A buildup of plaster $\frac{1}{2}$ - $\frac{3}{4}$ in. deep is added to the cast distally to accommodate a Silastic R.T.V. pad. This buildup provides any additional relief needed for the anterior distal end of the tibia (Fig. 31).

It is not necessary or advisable to extend this buildup proximally more than 1 in. from the distal end of the tibia. All edges must be contoured into



FIGURE 31

the body of the cast. When pouring the plaster, the pipe should be vertical. This will help to give a flat distal surface in the socket with the correct angular alignment.

LAMINATION

A standard patellar-tendon-bearing layup is used for a polyester laminate. Polyvinyl-alcohol separator is used over the cast. There is no insert fabricated for a hard socket. A vacuum laminating procedure is used to ensure an intimate contact between the laminate and the mold.

After the laminate is cured, the alignment lines are reestablished on the socket. This is done by scribing two lines vertical to the pipe holding the mold, one on the anterior surface and one on the lateral surface. These lines are used when setting the socket in a block of foam or wood for mounting on an adjustable leg.

To prevent any distortion of the socket the mold is broken out rather than having the socket blown off. For this reason we have, on occasion, used the slush mold or break-away mold technique. This minimizes the time and effort needed for removal of the mold from the socket. The socket is cut down to the established trim lines.

FOAMING THE DISTAL END OF THE SOCKET

Set the socket on an adjustable leg and achieve a good static alignment. The distal portion of the socket should be foamed prior to dynamic alignment. The following is a brief description of the technique introduced by the VA Prosthetics Center in New York.

The proximal edges of the distal plaster buildup are usually discernible in the laminated socket. On this line, drill three holes equidistant around the periphery of the socket. Use a #29 or #30 drill. These holes prevent air from being trapped between the foam and the stump. Also, they are an escape for superfluous foam. Lubricate the proximal aspect of the socket either with vaseline or silicone spray, etc. This facilitates entry of the stump into the socket.

Stretch a piece of moist polyvinyl-alcohol sheeting over a cast to obtain a preform of the stump. Put the stump sock to be worn in the prosthesis on the stump. If there is a sensitive area at the distal end of the tibia, a patch of skived felt can be applied to the stump sock for a relief. Pull the preformed polyvinyl-alcohol sheet over the stump sock and fasten the ends above the patella by friction tape. Rub talc or water ground mica over the polyvinyl-alcohol to eliminate tackiness. Pull a piece of stockinet over the outside of the socket, covering the holes previously drilled. Tape the proximal and distal edges of the stockinet. This controls the overflow of Silastic material. The Silastic pad used is a mixture of 50 percent 385 which is the solid material and 50 percent 386 which is foam material. Usually, 100 g. is sufficient to form the end pad. For a large cavity, more would of course be required. Mix the two components in a paper cup until they are blended well. Add 6 percent by weight of either the 386 or the 385 catalyst to the mixture and spatulate thoroughly for 20 seconds. Pour the contents into the socket without contacting the vertical surfaces.

Instruct the amputee to insert his stump into the socket and stand erect with at least half of his weight borne on the prosthesis. Allow the foam to set, usually 3 to 4 minutes is sufficient. Remove the prosthesis from the stump and dust the surface of the pad with powder.

These pads when made with a 50-50 mixture are fairly durable, but they are still porous. Because of this they will absorb sweat. It is a good practice to make two pads enabling the amputee to remove one, rinse it in soapy water, and use the other pad during the drying period. A location identifying mark should be placed on the pads and the socket for proper orientation.