

Specifications and Fabrication Details for the ISNY Above-Knee Socket System*

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INTRODUCTION

The Icelandic Swedish New York flexible socket system (ISNY) is one of the most significant advances in lower-limb and upper-limb prosthetics¹ in the last two decades. The ISNY system achieves the goal of enhanced patient comfort by providing a thin, pliable, lightweight socket for tissue containment. The thin socket allows better heat dissipation, increased sensory input, and greater freedom for muscle activity as the socket adapts to residual limb changes. The socket is easy and quick to form and modify, it nests in a rigid laminated frame for weight transmission, and the translucence of the vacuum-formed socket aids the prosthetist by serving as a check socket.

The fitting and fabrication techniques referred to in this article are the result of extensive collaboration which began in August, 1982 between Össur Kristinsson of

Iceland, the Een Holmgren Company of Sweden, and the Prosthetics and Orthotics Program at New York University. The fabrication procedures as well as the instruction manual² represent the cooperative efforts of all these groups.

This collaboration led to the final development of the ISNY Above Knee Socket with initial presentations in September and October 1983 at the ISPO Congress in London and at the AOPA Assembly in Phoenix, respectively. The project culminated with the inauguration of formal courses of instruction at New York University and the Munksjokolan in January and April, 1984.

SOCKET MATERIALS

For maximum benefit, the prosthetist should have a working knowledge of the materials used in the supporting frame and the thermoplastics used for the flexible socket, in order to provide a maximally flexible, yet durable, system.

Two types of sheet thermoplastics are most commonly used to vacuum-form

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flexible sockets: polyethylene and Surlyn.^{®†} Polyethylene is manufactured in many densities; however, low density is preferred for the ISNY socket because of its greater flexibility. Much disparity exists amongst batches of polyethylene with regard to uniformity and formability. It is therefore difficult to obtain plastic of consistent quality from different manufacturers and distributors. As recommended in "Fabrication Procedures for the ISNY Above-Knee Flexible Socket,"² success is more likely with Ethylux,^{®‡} a low density, molecularly aligned polyethylene.

Surlyn[®] is more rigid than low density polyethylene and is optically clear. Although most plastics are flexible if drawn thin enough, Surlyn[®] is more rigid than polyethylene when the same thickness is used.

Each plastic has different molding characteristics. Surlyn[®] tends to draw less easily than polyethylene, but has more memory retention. If vacuum is not applied while Surlyn[®] is heated and stretched, it tends to return to its original dimensions while hot. Polyethylene, however, has less memory, draws more easily, and tends not to return. Polyethylene over-stretches more readily if used with amputated limbs having bulbous distal ends, where the plastic must stretch and then retract in order to achieve a wrinkle-free

socket. For such models, Surlyn[®] is preferable.

The basic characteristics of polyethylene and Surlyn[®] may be summarized as:

Ethylux[®] Polyethylene

Moldability: Relatively easy to mold

Strength: Suitable for average use

Edge finish: Easy to finish

Appearance: Translucent

Cost: Inexpensive

Surlyn[®]

Moldability: Easy to mold

Strength: Suitable for heavy use

Edge finish: Less easy to finish

Appearance: Transparent

Cost: Expensive, triple the cost of polyethylene

Shrinkage characteristics of both plastics differ, as demonstrated by serial measurements taken of polyethylene and Surlyn[®] sockets molded over the same plaster model. Length and volume were measured immediately, one day after, and one week after, molding (Table 1). Polyethylene creates a socket whose volume (measured in cubic centimeters), while slightly less than the model, is closer to that of the original model, providing a more legitimate fit and better suspension if total suction is used. Polyethylene shrinks more than Surlyn[®] in length (measured in milli-

	Percent Change			
	Length		Volume	
	Ethylux [®] Polyethylene	Surlyn [®]	Ethylux [®] Polyethylene	Surlyn [®]
Directly after Molding	-2.0	-0.7	+ .200	+3.500
One Day after Molding	-2.0	-0.7	+0.002	+3.100
One Week after Molding	-2.4	-0.7	-1.300	+2.500

Table 1.

[†]Surlyn[®] is DuPont's trademark for its ionomer resin.

[‡]Ethylux is Westlake Plastic Company's trademark for its low density polyethylene. P.O. Box 127, Lenni, PA 19052.

meters); thus, model preparation may be adjusted to reflect this property of the material.

SOCKET SPECIFICATIONS

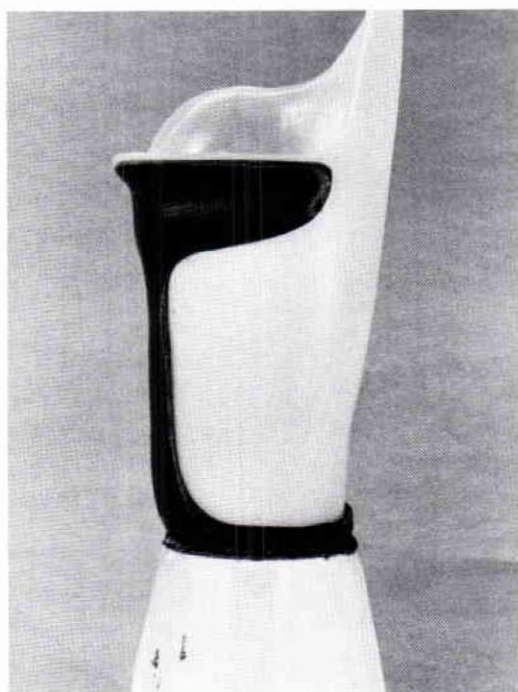
Based on extensive research and clinical services for adults and children and teaching the ISNY system throughout the world, during which hundreds of sockets have been fabricated and worn, socket wall thicknesses may be recommended to generate the desired physical properties. Specifications for the use of polyethylene are based on measurements from 30 sockets, judged by three staff prosthetists as having acceptable flexibility and durability.

Segments of plastic, one square inch in area, were removed from four areas of each socket: mid sections of the posterior, anterior and lateral walls, as well as the proximal-lateral wall in the area of attachment of a Silesian bandage. The average wall thickness for the mid sections were 0.06 inches. The proximal-lateral wall was thicker, approximately 0.88 inches (Table 2). These dimensions were independently corroborated by Jendrzeczk.³

Wall Thickness in Inches		
	Mean	Range
Medial, Posterior and Lateral	0.060	0.045-0.065
Proximal Lateral	0.080	0.060-0.090

Table 2.

In addition to wall thickness, attention must be given to the proper finish of the socket edges. The brim should be carefully rolled over the frame to insure adequate socket-frame interlocking and to minimize the risk of socket tears. The brim rolover should be continued past the socket-frame interface to increase reinforcement of the anterior-lateral and posterior-lateral socket corners.



Figures 1-A & 1-B. Anterior view (top photo), posterior view (bottom photo), of socket.

Patient education regarding doffing the ISNY socket will also extend socket life. The socket should not be doffed by putting pressure on the proximal-lateral socket, as is the practice among wearers of rigid suction sockets. Pushing stresses the anterior and posterior corners, leading to premature socket failure.

FRAME SPECIFICATIONS

The carbon-fiber reinforced laminated frame provides an effective support system with minimal socket coverage. The frame is composed of four unified segments: cup area, medial strut, anterior-proximal extension, and posterior-proximal extension (Figures 1-A and 1-B).

The cup area supports and stabilizes the distal socket. The cup is trimmed horizontally at the level where the socket walls approach the vertical. The trim extends over the valve for socket retention and good appearance.

Width of the medial strut is determined by the two inch carbon-fiber tape. The trim extends $\frac{1}{4}$ inch beyond each edge of the tape. The anterior/proximal extension covers Scarpa's femoral triangle. The proximal border follows the trimline of the socket and extends to the apex of the rectus femoris channel. From this point, the trim returns to the medial strut, passing about $1\frac{3}{4}$ inches below the deepest point of Scarpa's triangle.

Forming the ischiogluteal seat, the posterior/proximal extension terminates at the posterior/lateral corner. At its midpoint, the posterior frame measures about two inches from top to bottom.

These specifications provide a guide to position the structural layup. The layup recommended is 5-12-5 (carbon fiber-fiberglass-carbon fiber) for the medial strut and 3-6-3 (same material make-up) for the anterior and posterior extensions. For an exceptionally active or heavy individual, an additional one or two layers of carbon-fiber tape may be added to each side of the layup.

Since the anterior/medial corner of the frame in the region of the adductor longus channel is subjected to the greatest stress, care should be taken to keep the layup from shifting in this area. The layup in this area should be stitched in place by hand. One may add layers of Dacron felt in areas, such as the medial brim, which may require relief.

Complete saturation of the layup with polyester or acrylic resin is imperative to avoid delamination and structural weakness. Pierce the dense layers of carbon fiber with an awl to separate the fibers in order to form channels for laminate entry. Once laminated, remove the frame from the positive model and socket carefully to avoid bending segments that may result in delamination. Care is especially important in the anterior medial corner. If removal is difficult, the cast should be broken out.

DISCUSSION

As technology and concepts change, the philosophy of prosthetic fitting must also change. Now the socket itself should be considered conveniently replaceable without requiring the cutting or replacement of the current prosthesis. Pricing must also change to reflect the less expensive, faster socket change. The prosthetic profession has entered an era in which the socket can be replaced regularly as we now replace worn socks, to maintain and ensure proper fit and comfort. Attention to the details of design and fabrication to provide the greatest comfort through a proper balance of socket flexibility and durability will markedly increase patient satisfaction and extend the life of the prosthesis as an optimally fitting device.

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