Vitrathene, A Multipurpose Plastic

by Siegfried W. Paul, C.P.O.*

Introduction

Vitrathene, a thermoplastic polythene plastic imported from England, has become one of the most useful additions to the nonorganic materials used at Newington Children's Hospital. This material was first introduced to us by our Canadian neighbors two years ago. The Rehabilitation Institute of Montreal, in particular, had made extensive use of this material for over five years.

Our findings in working with Vitrathene have been most gratifying and we can only confirm the excellent features of Vitrathene claimed by the manufacturer. We would like to tell of our experiences with Vitrathene, discuss its range of application, and share our technique.

The earliest use of this plastic at Newington goes back to the time when a constant pressure lumbar pad (Fig. 1) was developed for the Milwaukee brace. A nontoxic, smooth, non-adhering material was needed and Vitrathene proved to be highly suitable. No skin reactions were reported in over 250 cases. This fact is to be credited to

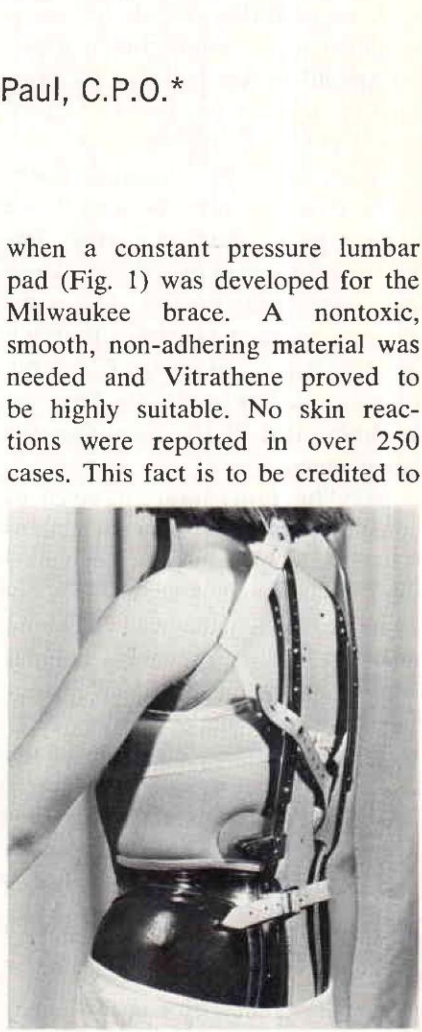

Figure 1

Spring-Loaded Functional Lumbar Pad Applied to Milwaukee Scoliosis Brace.

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its satiny, soaplike surface. We were also able to create the desired material thickness by welding layers of plastic with a heat gun.

The low cost of this material and its easy, time-saving application brought us to the present extensive use of Vitrathene.

Suggested Application Procedure

A cast positive which has been modified in the conventional method should be used. This cast does not have to have the smooth surface required for laminations.

Apply one layer of cotton stockinette over the cast, avoiding loose fit or wrinkles. Prepare a paper pattern and cut out plastic, using a band saw. This pattern can be exact, since the heated plastic will stretch at the time of molding. For large objects, ¼″ material thickness is recommended; $3/16$″ is suitable for small items.

Molding Procedure: An oven of sufficient size should be heated to 350°F. The plastic must be placed in a flat position since it will become most flexible and adhering once hot. To assure even and flat heating of the plastic, place a sheet of aluminum on the oven rack. Heavy canvas placed on top of the aluminum sheet will permit transfer of the hot pliable material. A sheet of stockinette on top of the canvas will permit molding without distortion. The cold plastic placed on the stockinette should not extend over the edges of the aluminum sheet.

Heat the Vitrathene until the entire surface is transparent. Using absestos gloves, remove the plastic from the oven by lifting the canvas from the aluminum sheet. Large objects will require two persons for transfer of the plastic to the mold.

Attempt correct positioning of the plastic on the cast on the first attempt. The hot plastic will stick to the stockinette and it is not possible to remove the material till it has hardened sufficiently.

Remove the canvas after placing the hot plastic on the cast and mold the Vitrathene to the contours of the cast, using slight manual pressure. Wrap Ace bandages over the stockinette. This should be done with a fair amount of pull. Use wide bandages for larger items; narrow ones for small splints and deep undercuts. Check on even contact of the plastic with the mold and apply pressure as long as the plaster is hot.

Avoid excessive tightness of the bandages or too much manual pressure; either would result in an undesirably rough inner surface. Remove bandages and outer stockinette as soon as the plastic has cooled off to the point where its pink color has returned. Early removal eliminates the possibility of difficulties in removing the baked-on stockinette later on. Reapply the Ace bandages till the plastic is cold. Dip the mold in water to expedite the cooling process.

After the plastic has cooled sufficiently, remove the entire lap-up from the cast, then remove the inner stockinette, and trim the appliance to the desired shape. Round the edges with a sand cone.

Fit the appliance on the patient. Local adjustments can be made by heating the surface with a heat gun tipped with a funnel.

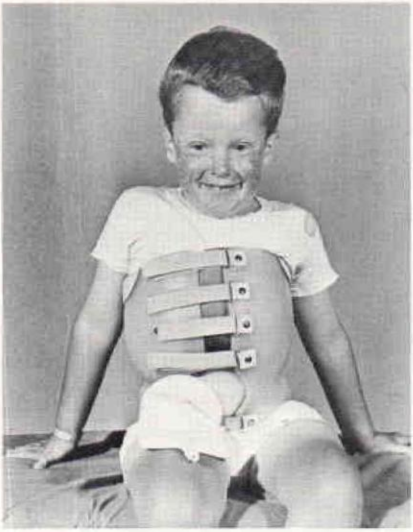


Figure 2

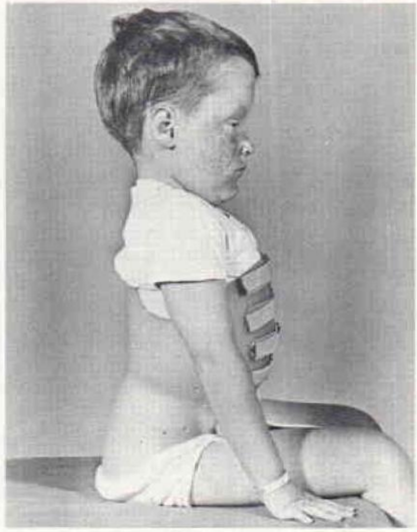


Figure 2A

Body Jacket with Ileal Conduit Worn by a Myelomeningocele Patient.

Finishing will consist of no more than buffing of the edges with a felt or rubber cone, perforation of the entire surface, and application of fasteners.

Vitrathene can be riveted or stitched, glue will not bond to its surface. Slight markings from the stockinette will not irritate the skin, however, excessive imprints should be buffed with a felt or rubber cone.

Tongues can be fabricated of ⅛" Vitrathene, or other suitable materials. Uses of Vitrathene applications for which Vitrathene has been used are as follows:

Body Jacket (Fig. 2)

Indication: Polio, muscular dystrophy myelomeningocele, advanced paralytic scoliosis, primarily for mentally retarded patients not suitable for Milwaukee brace application or surgery.

Anterior or Posterior Body Shell

Indication: Infantile scoliosis, secondary to myelomeningocele. Such shells can be designed as corrective, preventive and supportive appliances.

Recumbency Splint (Fig. 3)

Indication: Congenital hip dislocation and Legg Calve Perthes disease.

The Wu abduction splint used for the recumbent type of treatment of Legg Calve Perthes disease for over twenty years has been replaced at Newington with a plastic splint, eliminating side effects like varus and valgus deformities of knee and ankle.

The new approach also cuts the fabrication time to ⅓ of that of the former design.

Pretibial Shells

Vitrathene has proven of sufficient strength for incorporation in long leg orthoses.

Lower-Extremity Splint (Fig. 4)

Indication: Post-operative application and preventive or protective type of splinting. Application

Figure 3

Legg Calve Perthes Recumbency Splint.

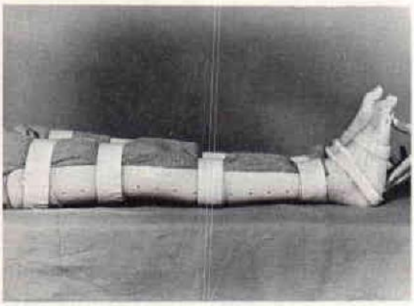


Figure 4

Lower Extremity Splint.

can range from the muscular dystrophy patient to the adult hemiplegic patient for use as a night splint.

Medial Stabilizing Shell (Fig. 5)

Indication: Legg Calve Perthes disease.

The Newington Ambulatory Legg Calve Perthes Orthosis is shown here.

Hand Splint (Fig. 6)

Indication: Volar or Dorsal splints for post-operative application, paralytic and support or protection requiring conditions.

Prosthetic Sockets

With the use of Vitrathene, the fabrication time for a prosthetic socket is reduced considerably. Therefore the cost is also reduced. In addition, Vitrathene does not soften as a result of increased body temperature and can be adjusted

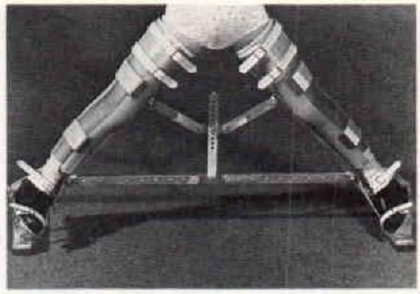


Figure 5

Newington Ambulatory Legg Calve Perthes Orthoses with Medial Plastic Stabilizing Shells.

by using a heat gun.

Dental Retainer

The Dental Department at Newington made use of Vitrathene for dental retainers for a period of over three years. The ⅛″ Vitrathene application resulted in a far less frequent need of replacement of retainers worn by our Milwaukee brace patients. Low cost, nontoxicity, greater durability, much improved prophylacticity and better cosmetic color are among its other advantages.

These are just a few of the possible applications of Vitrathene which required no more than the standard equipment of an Orthotic and/or Prosthetic facility.

New developments have been achieved due to the oustanding features of this material. No nega-

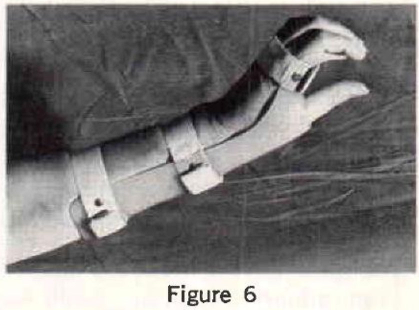


Figure 6

Hand Splint.

tive reports have come to our attention. Our physicians, patients and parents have been the true benefactors of this multipurpose plastic.

TECHNICAL INFORMATION

General

Vitrathene is the trade name for compression moulded polythene sheet manufactured by Stanley Smith & Company.

Vitrathene sheet has outstanding resistance to attack by alkalis, e.g. concentrated caustic soda at 60°C. (140°F.) and acids, e.g. concentrated hydrofluric acid at 20°C. (68°F.). It is odorless, non-toxic and therefore eminently suitable for use in contact with all types of foodstuffs. Further, Vitrathene sheet is dimensionally stable, possesses outstanding electrical properties, maintains its excellent physical properties over the range of −25°C. (−13°F.) to +90°C. (194°F.), exhibits very low water vapour permeability and is easily fabricated by existing and familiar methods for thermoplastic sheet. The recommended maximum service temperature is 60°C. (140°F.) if maximum benefit is to be achieved with these properties due to diminishing resistance to chemical attack with rising temperature and the melting point being 115°C.-120°C. (239°F.-248°F.).

Range

Sheet:

Color & Grade Pink, Grade 2 SSAO Sheet for Orthopaedic Splints. Only the one grade and color is supplied for this application.

Surface Finish Satin Finish.

Thickness 1/8″, 3/16″, 1/4″.

Sheet Size 36″ x 36″. 1/8″ sheet yields approximately 0.60 lbs./sq. ft. or 1.67 sq. ft./lb.—other thicknesses are pro rata.

Specials Other thicknesses and sheet sizes available in carton lots. Write for details and prices. Allow 6 to 8 weeks for delivery.

Composition Backed Sheet The above sheet can be supplied, on special order basis, with a firmly adhering composition backing which successfully overcomes the problems normally associated with sticking polythene to various substrates, i.e., that no glues give really satisfactory adhesion and the expansion and contraction of the sheet under fluctuating temperatures tends to break down what little bond there is.

By applying the composition at the time of manufacture of the sheet, these two components act as one and the composition itself is easily able to be stuck to a variety of subtrates, e.g., steel, aluminum, wood, block-board, plywood, etc., thus enabling polythene to be used as a facing onto other materials. For advice on specific adhesives it is recommended that the adhesive manufacturers themselves be consulted.

Knit-Rite offers composition backed sheets. These are available on a special order basis. Please advise of your interest, supplying details of application and type of backing desired.

Vitrathene Welding Rod Welding rod of 1/8″ nominal diameter is available in 1/2 lb. packs of 18″ lengths.

Chemical Vitrathene at temperatures above 60-70°C. is soluble in organic solvents such as aromatic hydrocarbons, benzene, toluene, xylene; aliphatic hydrocarbons like hexanone, petroleum ether and in chlorinated hydrocarbons such as carbon tetrachloride, trichlorethylene and chlorbenzene.

Environmental Stress Cracking

When polythene is stressed by either external deformation or internal frozen-in strain and is in contact with certain materials, environmental stress cracking may occur. Such cracking may be caused by liquids or vapors (especially the vapors of volatile polar liquids): active compounds are such as alcohols, esters, soaps, liquid hydrocarbons and silicone fluids; inactive are such as water, polyhydric alcohols, sugars, hydrolysed protein, rosin, acid, and neutral inorganic salts.

Painting

Paints will not adhere readily to Vitrathene without special preparation, due to its chemical inertness.

Fabrication

The following general fabrication methods, already well established in the handling of thermoplastic sheet, are equally applicable to Vitrathene polythene sheet.

Cutting Sheet up to ⅛″ can be cut by metal shears or by guillotine (preferably with a clamp to avoid the material pulling into the blade): greater thicknesses can be cut by mechanically clamped power guillotine. All thicknesses can be cut with a circular saw but this is only suitable for straight cuts: bandsaws, on the other hand, can be used to cut all types of shaped blanks.

Drilling Holes up to 1″ in diameter can be drilled with standard drills, using slow speed; and greater than 1″ by means of trepanning tools. Drills should be lifted frequently to allow them to cool and overcome sticking due to overheating.

Punching & Blanking Normal methods, using forge-steel cutters and a fly-press, are suitable.

Bending Localized heating along the line of the desired bend by hot wire allows easy bending of the sheet. Where composition-backed sheet is being used, heating should be from the polythene side only and any bend should have the polythene surface on the outside.

Planing The use of all-metal woodworking planes is satisfactory to finish cut edges, etc.

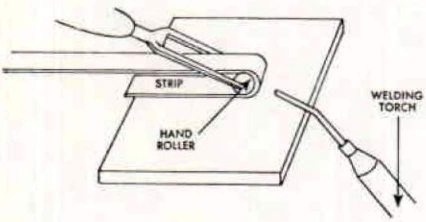
Routing Standard high speed routers, fitted with compressed air cooling and swarf removal, are suitable.

Grinding & Buffing Neither of those processes are recommended.

Adhesive bonding Due to the excellent chemical resistance of "Vitrathene" sheet, it is very difficult to produce an adhesive bond using those systems at present known. Where it is required to bond polythene to other substrates, Vitrathene composition backed sheet must be used.

Butt welding The edges of two sheets to be joined are heated either by radiant heat or a heated tool until nearly molten. The source of heat is then quickly removed and the sheets brought together with a slight sliding movement and under pressure (preferably in a jig) and allowed to cool. It is not considered that this method is as effective as hot gas welding (see below), but can sometimes be used in conjunction with it for flat sheet and also for joining tube to itself or a suitable fitting.

For flat thin sheet, a strip weld is sometimes applied over the butt weld, which is first ground flat. This is best illustrated as follows:



Hot Gas Welding The edges of the sheet to be joined are chamfered to give an included angle of 60-70°. (Where possible a sheet should have a sealing run of rod on the reverse and so a chamfer is necessary to accommodate this too). The sheets should be positioned so that there is a gap of approximately 1/32″ between them. Both the area to be welded and the welding rod must be clean and free from oil, grease, moisture, etc.

A welding torch heated either electrically or by gas, feeding air or nitrogen can be used but it must produce a temperature of approximately 300°C. at a position ¼″ from the nozzle using a gas pressure of approximately 2 lbs./sq. in. (some form of metering device to monitor this is strongly advised).

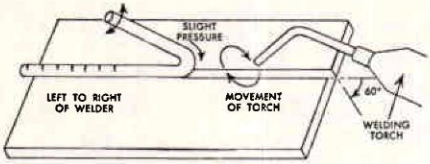
The end of the welding rod is trimmed to an angle of 45° and the rod itself ideally should be sufficiently long for the weld to be made in one piece.

There are three methods of welding Vitrathene sheet: experience will decide which is the most suitable under any given circumstances. They are:

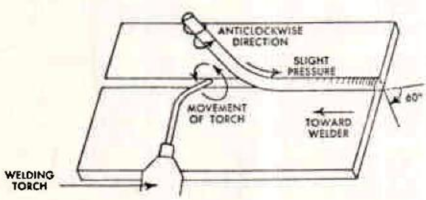
1) Ripple Welding The welder holds the torch in the right hand and the welding rod in the left. The end of the rod is heated with the torch and pressed into the V-groove, then welding commences working from left to right with the rod held in the plane of the V-groove and at right angles to it, but tilted slightly to the left so that it forms a radius as it feeds into the groove: the welding torch is aimed along the groove so that it softens both the sheet and the welding rod and moved in a circular manner at approximately 2 cycles per second to heat both the rod and the sheet—experience will dictate the relative dwell on sheet and rod to give optimum even softening, since this varies with thickness of sheet and diameter of rod: the greater this is, the longer dwell, proportionately, it must receive for softening. As the polythene melts, and fuses, the rod is moved from side to side (approximately 2 cycles/sec.), so that efficient mixing and fusion of the components is achieved. The speed of welding is ⅝″ per minute.

2) Sraight Fillet Welding The method for this is identical with (1) with the exception that the rod is not moved from side to side. This results in a slightly weaker but neater weld and is best suited to multi-runs and fillets: it means further that high speed welding nozzles can be used with Vitrathene sheet.

Both methods (1) and (2) can be illustrated by:

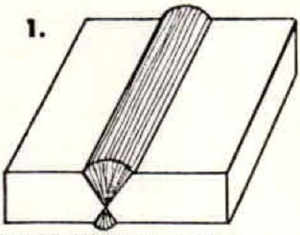


3) Twist Welding In this method, welds are made towards the welder. The rod is held at right angles to the V-groove and at an angle of about 60° to the sheet. The nozzle is pointed along the groove (see para. (1) concerning ratio of heating and movement of the torch) and the rod is slowly but continuously rotated in an anti-clockwise direction: the welding proceeds toward the welder. It is considered that this method ensures better mixing of the molten polythene but options differ on this: speed of welding is about the same as for ripple welding. This may be illustrated by:

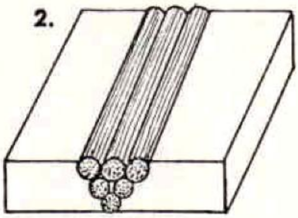


If required, welds may be dressed level with the sheet by means of a sharp knife to improve appearance but, of course, the strength is decreased.

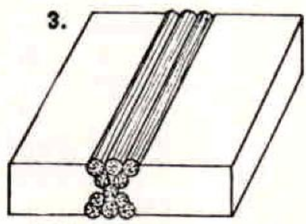
The various types of weld suitable for Vitrathene sheet are:



SQUARE BUTT WELD WITH SEALING RUN ON UNDERSIDE

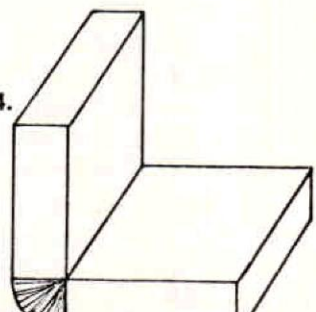


SINGLE V BUTT WELD (MULTIPLE RUN)



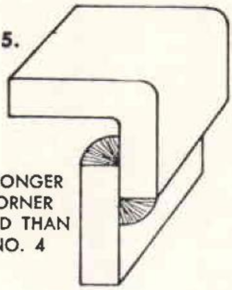
DOUBLE V BUTT WELD

4.



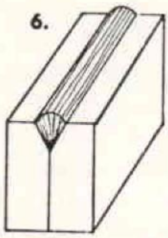
CORNER WELD

5.



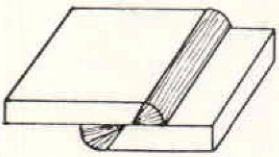
STRONGER CORNER WELD THAN NO. 4

6.



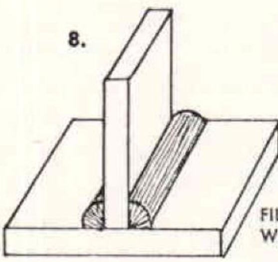
EDGE WELD

7.



LAP WELD

8.



FILLET WELD

Forming Thin gauges of Vitrathene sheet are amenable to vacuum forming although the sharp melting point of the material makes this a rather tricky process. Only experience and trial of any intended forming can decide whether vacuum forming is a viable process at any particular time.

All other types of established forming can be used with the sheet heated prior to forming in a suitable oven.

POLYTHENE SPLINTS

Polythene

Sheet polythene ⅛ inch, $^3/_{16}$ inch, and ¼ inch thick is a most useful material for the manufacture of lightweight semi-rigid orthopaedic appliances. It is a thermosplastic material and has a moulding temperature of 140°C. (284°F.). The sheet material used for surgical appliances (+) is tinted pink by the addition of 0.01 percent of a mixture of cadmium sulphide or cadmium sulphoselenide or both types of pigments; it also contains 0.101 percent of an antioxidant: diorthoisocresyl propane. Polythene is unaffected by fluids commonly used in industry; it is a tough, resilient material which is particularly suitable for use on patients who are able to remain at work during their treatment. Temperatures below 100°C. (212°F.) do not affect the appliances. Splints should not be placed in front of an electric fire or on top of a gas cooker, as temperatures in excess of 100°C. (212°F.) are easily reached and distortion of the appliance will result. While polythene can be ignited with difficulty—it burns with a yellowish smoky flame—the flame can be readily extinguished and its inflammability is in no way a hazard, since a flame has to be held in contact with the splint for up to a minute before ignition will occur. This material has been used for splints for 8 years (see page 5) and no case of allergy or dermatitis is known. Occasionally patients who sweat excessively may complain of irritation, but this is due to lack of ventilation holes in the splint or to inadequate washing of themselves or the splint. Excessive local pressure may cause reddening of the skin. Carefully controlled local heating of the appliance may sometimes relieve this pressure, but, unless extreme care is exercised, distortion of the appliance will result.

Equipment for the Manufacture of Appliances

The equipment required for making splints is minimal, but it is advantageous for speed and ease of manufacture of appliances in quantity to have the following equipment:

1. An infra-red process heating oven, size 4 feet 6 inches by 4 feet 6 inches. 64 x 250 watt internal reflector infra-red process heating bulbs will be required to cover 16 square feet. They should be held in suitable holders to give adequate ventilation of the stems of the bulbs and to give a clearance between the bulbs and the abestos covered floor of the oven of 12-14 inches. Since polythene is a poor heat conductor and the lamps give a high surface temperature, it is advisable to switch the current on and off intermittently by means of a time cycling device. Suitable ovens are now commercially available. Various other types of gas or electric ovens can be improvised, but it is essential that even heating of the polythene is obtained and that the temperature of the material does not rise above 150°C. (302°F.). Experimental work with porous plastic suggests that a hot-air circulating oven may be a more suitable way of heating these materials.

2. A foot-operated punching and riveting machine with a throat of not less than 12 inches. 1/8 inch, 3/16 inch, and 1/4 inch punches are required. This machine can be used for the insertion of tubular rivets, eyelets, press studs, and for punching ventilation holes; the latter operation should be done from the foam surface of the appliance.

3. A bandsaw for cutting the polythene. This machine should have a throat of not less than 18 inches.

4. A 6 inch soft wire mop and sanding discs attached to a standard double-ended polishing head.

5. A leather worker's knife and whetstone.

6. Ribbed surgical stockinet, width 12 inches, as used for plaster work.

7. A medium to coarse metal file and various grades of sandpaper.

Polyurethane Foam

Polyurethane foams are thermoset materials. Various densities of foam are available, the most satisfactory one for orthopaedic purposes having a specific gravity of between 0.055 to 0.065. It is fully porous to water vapor, readily compressed and almost non-inflammable. Temperatures up to 170°C. do not affect its properties and when it is used in combination with polythene, only distortion of its cellular structure occurs during moulding. Because of its extremely low thermal conductivity, polythene-polyurethane laminates can be applied directly to the patient, providing the temperature of the polythene does not exceed 140°C. The laminate is applied with the polyurethane in contact with the skin. If excessive pressure which would collapse the foam is used to form the splint, burns may result; hence only splints having simple curves, for example, cock up splints or leg gutters, can be moulded with safety on the patient. For larger splints, such as spinal jackets, long leg splints, cervical collars and hip spicas, a positive plaster cast is essential.

Forming the Splints

A piece of polythene of the appropriate size is cut with the bandsaw, or less easily with a sharp leather knife. If a knife is used, care should be taken that cuts are not made in the polythene by the knife, as these can cause subsequent cracking in the material. Such cracking is more liable to occur following knife trimming of the splint after moulding. The direction of pull of the knife should always be away from that part of the sheet which is to form the splint. The polythene should be washed with warm water and soap so as to remove any dust or grease which may contaminate the surface and prevent adhesion of either the reinforcing strip or the polyurethane. A sheet of the foam, the overall dimensions of which are about ¼ inch to ½ inch greater than those of the polythene sheet, is placed in the oven and covered with the polythene. Reinforcing strips of polythene which are obtained from offcuts are placed in the appropriate positions on top of the polythene.

To establish the working conditions for a particular oven, the time-temperature relationship should be recorded by inserting in the sheet of polythene a thermo-couple connected to a pyrometer. The temperature of the polythene cannot be recorded by placing mercury thermometers on the surface of the sheet if infra-red heating is employed. When the polythene is ready for moulding, both the reinforcing strip, if present, and the main sheet of polythene should be transparent. If any bubbles occur between the reinforcing strip and the main polythene sheet, they should be pricked with a pin to let out the air. A piece of stockinet is applied, using light pressure, to the surface of the polythene. The stockinet should not be unduly stretched and care should be taken to see that creases are not produced. The stockinet-polythene-polyurethane laminate is lifted from the oven and is applied to the plaster cast. It is then gently stretched into position and a few nails are driven into the cast through the moulding at convenient points to hold it in position. When the moulding has cooled, the stockinet is stripped from the surface of the polythene and the splint removed from the cast. The edges are trimmed, ventilation holes are punched in appropriate places and buckles and straps riveted in position. Ventilation holes, ⅛ inch in diameter, should be drilled or punched in areas which are carrying a load, in other parts of the splint larger holes may be made. Leather or plastic tongues, where the splint edges comes together in encircling splints, should be attached to prevent nipping of the skin.

When moulding small splints direct on the patient, the operator should always check that the laminate is not excessively hot by resting the foam side of the laminate on the back of his own hand for a few seconds prior to moulding it on the patient. For patients who may be apprehensive on this procedure, a sheet of 1/16 inch polyurethane may be applied to the patient and held in position by adhesive tape prior to forming the hot laminate. The laminate is then moulded by applying even, wet 2-inch cotton bandages.

Addendum

Polythene splints have been in use for fifteen years. It has been found that for hot countries it is preferable not to line the splint with a foam material. Unlined splints should be well ventilated with ⅛ inch drill holes and **washed frequently.**

The most secure buckles are those with prongs piercing the strap. However, both splints and clothes are damaged, while the plain buckles without prongs are liable to slip. A most effective fastening which overcomes most buckle problems is the "touch and close" fastener, known as Velcro. The two parts of this nylon fastening material are stuck or sewn on to strips of plastic or leather, or used by itself. Providing it is kept clean, this fastening material will perform satisfactorily for a considerable time.

For neck supports, P.V.C. strapping carrying a ¾ inch adjustable press stud is most useful.

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