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TECHNO-ECONOMIC PROFILE ON SUPPORTED AND UNSUPPORTED PVC SHEETING

(PROJECT NO UC/RAB/90/011

27p.
diagrams

TECHNO-ECONOMIC PROFILE

ON

SUPPORTED AND UNSUPPORTED FLEXIBLE PVC SHEETING

(PROJECT NO UC/RAB/90/011 - CONTRACT NO 90/023P)

AUGUST 1990

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TECHNO-ECONOMIC PROFILE

ON

SUPPORTED AND UNSUPPORTED FLEXIBLE PVC SHEETING

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1.0 EXECUTIVE SUMMARY

This Profile describes the manufacturing requirements to produce supported and unsupported flexible PVC (Polyvinyl Chloride) sheeting. There is a large demand for these forms of PVC sheeting which are used as raw materials for a great variety of manufacturing industries.

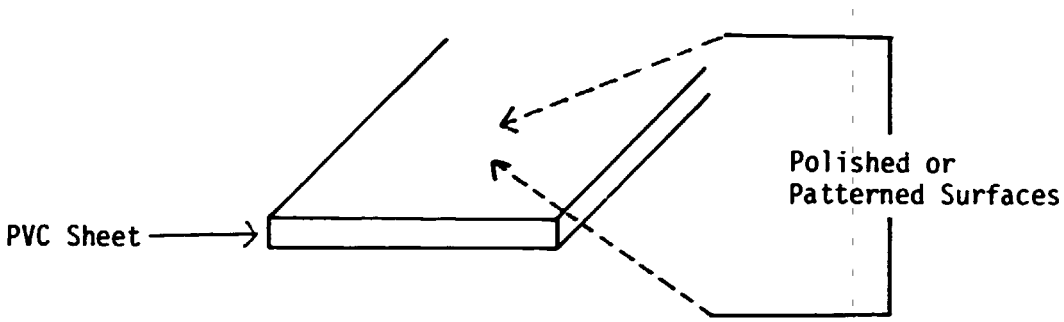
For a start up project, annual production of 3,100 tonnes is envisaged, representing a turnover worth US$ 8.3m. The assumed demand is for equal quantities of supported and unsupported sheeting, based on 3 shifts of 8 hours per day for 5 days per week, to give an effective output of 100 hours per week. Working for about 48 weeks per year gives 240 working days per year. The annual return before depreciation and financing charges would be US$ 1.57m.

The estimated investment cost including the plant, laboratory, installation, and commissioning would be US$ 7.3m plus site, building and local costs.

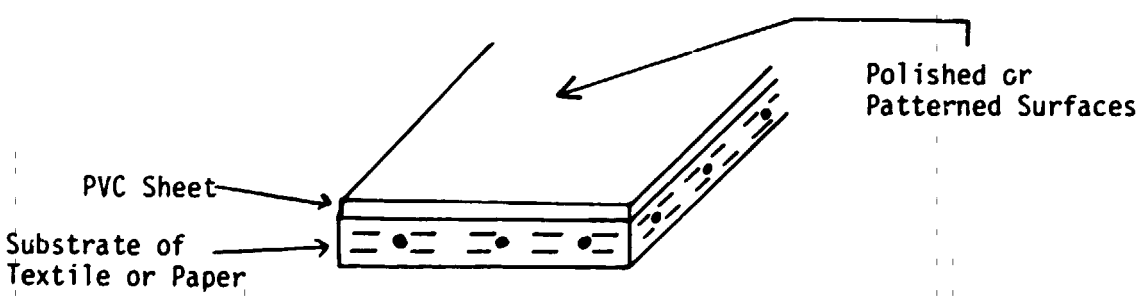
2.0 PRODUCT DEFINITION

2.1 Thin flexible PVC sheet is produced in two forms. These are known respectively as unsupported and supported ("leather cloth") sheet and their respective cross sections are illustrated below in Figure 1.

Unsupported sheet is simply unreinforced pure PVC plastic sheet whilst supported sheet, or as it is more commonly known 'leather cloth', is pure PVC plastic sheet bonded to a reinforcing layer of textile or paper. Less commonly, PVC plastic sheet is bonded to both sides of the reinforcement.



a. Unsupported Film/Foil



b. Supported ('Leather-cloth') Film/Foil

FIGURE 1 - SECTIONS OF FILM/FOIL

Both types of sheeting are manufactured in continuous lengths in the following ranges:-

Thickness: 0.07mm to 0.75mm
Width : 0.5m to 2.0m

2.2 The following are typical finished products for which PVC sheeting is one of the primary raw materials:-

Uses for Unsupported Sheeting

- Clip-board surfaces.
- Electrical insulating tape.
- Kitchen aprons.
- Medical products - blood and urine bags, protective clothing.
- Nursery accessories - nappies, floor mats, bibs, cot covers, baby's pants.
- Office equipment covers.
- Over-shoes.
- Protective clothing (industrial).
- Rain-wear.
- Room ribbon screens.
- Shower curtains.
- Sleeves for office papers.
- Soft adhesive tape.
- Sponge and toilet bags.
- Swimming pool liners and covers.
- Table covers.
- Upholstery covers.

Uses for Supported Sheeting

- Automobile trim.
- Floor coverings.
- Foul-weather protective clothing.
- Furnishings.
- Heavy duty covers.
- Industrial protective clothing.
- Shoe uppers.
- Upholstery.
- Wall papers (paper support).

2.3 Flexible PVC sheeting can be used for a very wide range of applications and service conditions. The physical charateristics (strength, flexibility, heat resistance, colour, etc) of the PVC can be formulated to suit each particular application by the careful selection of the plastic raw materials. Typically, there may be as many as 20 ingredients in a formulation.

The main ingredients are:-

a) PVC polymer, which can be a homo- or co-polymer with about 10% of vinyl acetate. These parameters determine the basic characteristics of the sheet.

b) The plasticiser, which can be a single chemical such as Di-Octyle Phthalate (DOP), or a mixture of different plasticisers. In general, greater use of plasticiser increases the flexibility of the sheet.

c) Heat and light stabilisers, to counter the degradation of the polymer and reduce the risk of it becoming discoloured, weak and brittle. As with other additives, the

choice depends upon service conditions. In general, the more demanding the property, the more costly the stabiliser. The simplest and cheapest are lead, calcium, cadmium, barium and zinc salts such as the stearates, but all these can reduce transparency, may have toxic risks, and are not so effective as other more expensive stabilisers such as the organo-tins. These have low toxicity, give excellent transparency, and impart superior heat and light stability.

d) Lubricants are used in small quantities to aid processing. These are waxes or stearates.

e) Other additives include:-

1. Micro-biocides to ward off attack by bacteria and fungi in humid and warm atmospheres.

2. Co-stabilisers that enhance, even in small percentages, the heat stabilising effect of other additives.

3. Fire retardant additives. Although PVC polymer is non-flammable, most of the plasticisers will burn.

4. Fillers such as chalk or ground limestone. These reduce costs, can improve electrical properties (if required) and add weight where it is an advantage, eg, floor covering.

5. Colorants. These vary according to the end product. Very small amounts give a tint to clear foil while 1%-2% is required for strong colours in supported films.

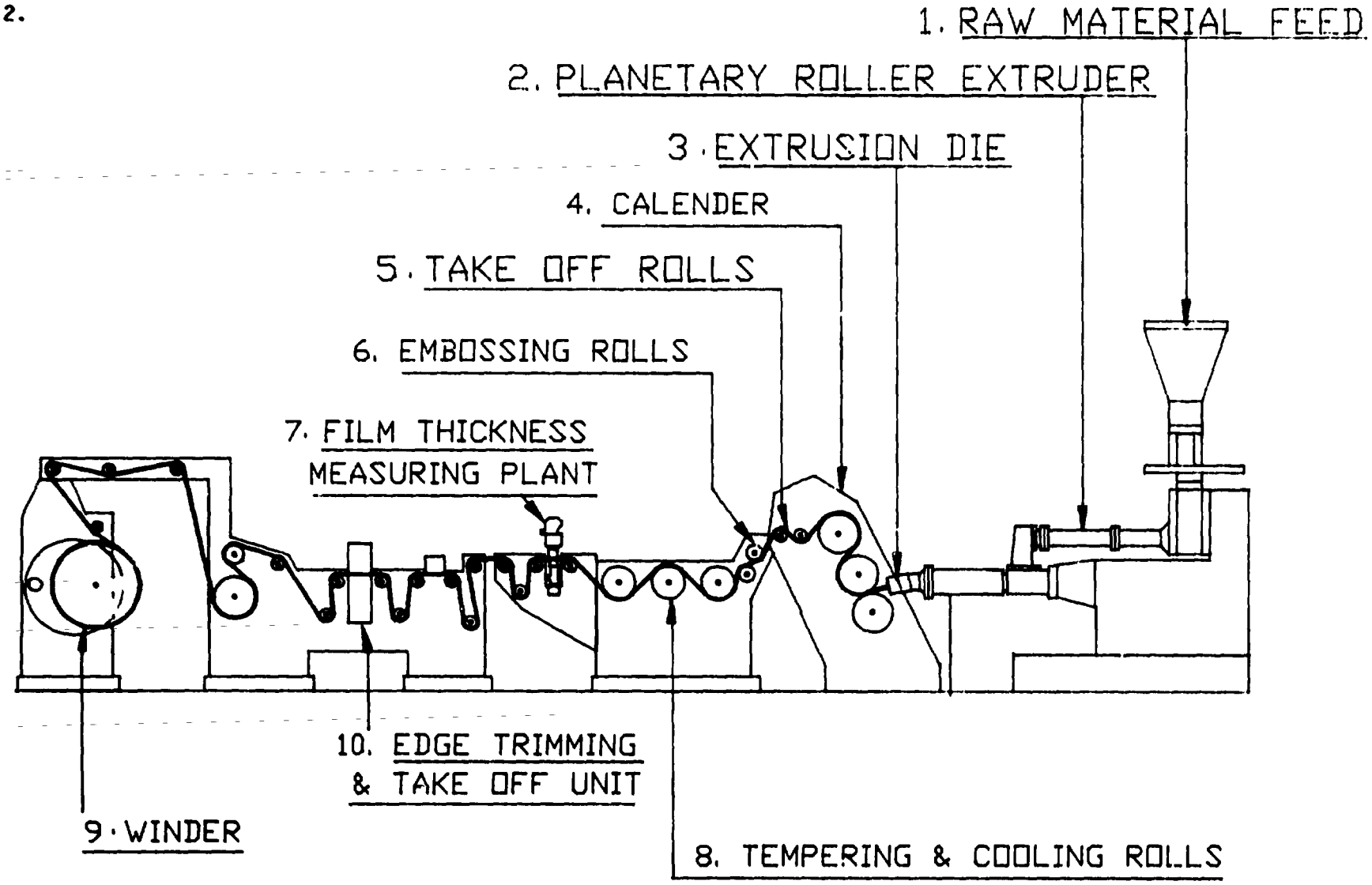
2.4 Typical specifications for the base materials and applications are given in Table I below:-

TABLE I

Specifications for Flexible PVC Sheeting

Supported	
BS 2601	Lists 4 grades of sheeting.
BS 3217	Deals with air permeable products.
BS 3424	Gives details of tests.
BS 3546	Gives requirements for protective clothing.
BS 4216	Deals with sheeting for furniture.
Unsupported	
BS 1763	Details classes of thin (0.05-0.4mm) sheeting (foils).
BS 1774	Details requirements for rain-wear.
BS 1776	Details requirements for light-weight articles, including fabrication and testing.
BS 2571	Details requirements for three classes of compound, properties and tests.
BS 2739	Details classes of thicker sheeting (0.025-0.9mm).
BS 3578	Gives requirements for use in hospitals.
BS 3887	Details requirements for PVC adhesive tapes.

FIGURE 2.



CALENDER ROLLS SCHEMATIC ARRANGEMENT

3.0 TECHNOLOGY REVIEW

3.1 Review of Technological Options

There are two manufacturing methods which are extensively used for, both unsupported and supported PVC sheeting:-

a) Spreading Process

Cold PVC paste is mechanically spread on to a supporting material such as cloth or paper or, for unsupported sheet, on to a temporary "casting" film from which the sheet is subsequently stripped. In each case the PVC is heated after spreading.

b) Calender Process (See Fig. 2)

Pre-heated PVC compound is fed into a special purpose continuous rolling machine known as a 'calender' to directly produce unsupported sheet; or with textile or paper to give supported sheeting.

Method a) is a cheaper plant to set up but the cost of manufacture is higher due to the slightly higher cost of the polymer and the slower rate of production. However the process is quicker and cheaper for the setting up of new products and designs, especially for short production runs.

Method b) needs a higher capital cost but gives faster and cheaper production , and is the choice for long production runs.

3.2 Review of Production Scale and Ranges

Economical levels of production depend upon the sales price which can be achieved. At the moment, world production capacity exceeds the demand with a large proportion of production coming from Asia.

With a popular product width of 1.5 metres and a middle range of thicknesses of, say, 0.4mm, the output of a calender would be 1 tonne per hour. Thus for a 40 hour, single shift week, the production would be 40 tonnes.

In general, manufacturers would make the PVC sheeting to order and sell direct to customers who would use the sheeting as raw material to make their own finished products.

3.3 Recommended Production Technology

For a start up project, it is rcommended that a single calender machine is purchased for the production of both supported and unsupported PVC sheet. If market demand later justified an expansion in the output and range of production, then PVC paste spreading could be introduced say for the lower volume demand for supported PVC sheeting.

3.4 Sources of Technology

There are three sources of technology:-

a) To obtain a licence from an existing manufacturer, with the attendant knowledge. Possible firms are:

Unsupported PVC Sheet

Weston Hyde Limited, Vallis Road, Frome, Somerset, BA11 3EQUK
Tel: 0373 63271

Supported PVC Sheet

Wardle Storeys Limited, Brantham, Manningtree, Essex, CO11 1NJ, UK
Tel: 0206 392401

b) To award a turn-key contract to a manufacturer of the equipment.

c) To employ one or more consultants fully familiar with the process, modern equipment, and raw materials and who would specify the design and supervise the purchase, erection and commissioning of the plant.

3.5 Possible Plant Suppliers

Complete Calender Lines

BATTENFELD EXTRUSIONSTECHNICK GMBH
Josef-Bauman-Strasse 21, Postfach 100663, D4630, W Germany
Tel: 0234 87910 Fax: 0234 8791178 Tlx: 825579 BatexD

COMERCIO ERCOLE SA
Via Silvio Pellico, 3, PO Box 342, 21052 Busto Arsizio, Italy
Tel: 0331 635 473/4/5/6 Fax 0331 635 346

Complete Laboratory Line

BETOL MACHINERY LIMITED
187 Camford Way, Sundon Park, Luton, Bedfordshire, UK
Tel 0582 570501 Tlx: 825233 G

4.0 THE PRODUCTION PROCESS

4.1 Outline of the Process

The core of the process is the calender line where preheated and mixed PVC material is fed between a series of rolls to give a coninuous PVC sheet of uniform thickness, texture and appearance. (See figure 2). The multiplicity of the rolls is to ensure that the product is perfectly uniform and stress free. This process permits unsupported PVC sheet to be manufactured directly, alternatively textile or paper, can be introduced at an early stage in the process to produce supported PVC sheet. The process, after the first weighing and mixing stage, is continous. (See flow chart - fig 3).

4.2 Processing Plant

4.2.1 Weighing and Measuring

The components for the PVC compounds are stored in silos for the polymer, tanks for the liquid plasticisers, and drums or other containers for the various additives. These are weighed or measured to form a batch and transferred to a series of mixing operations.

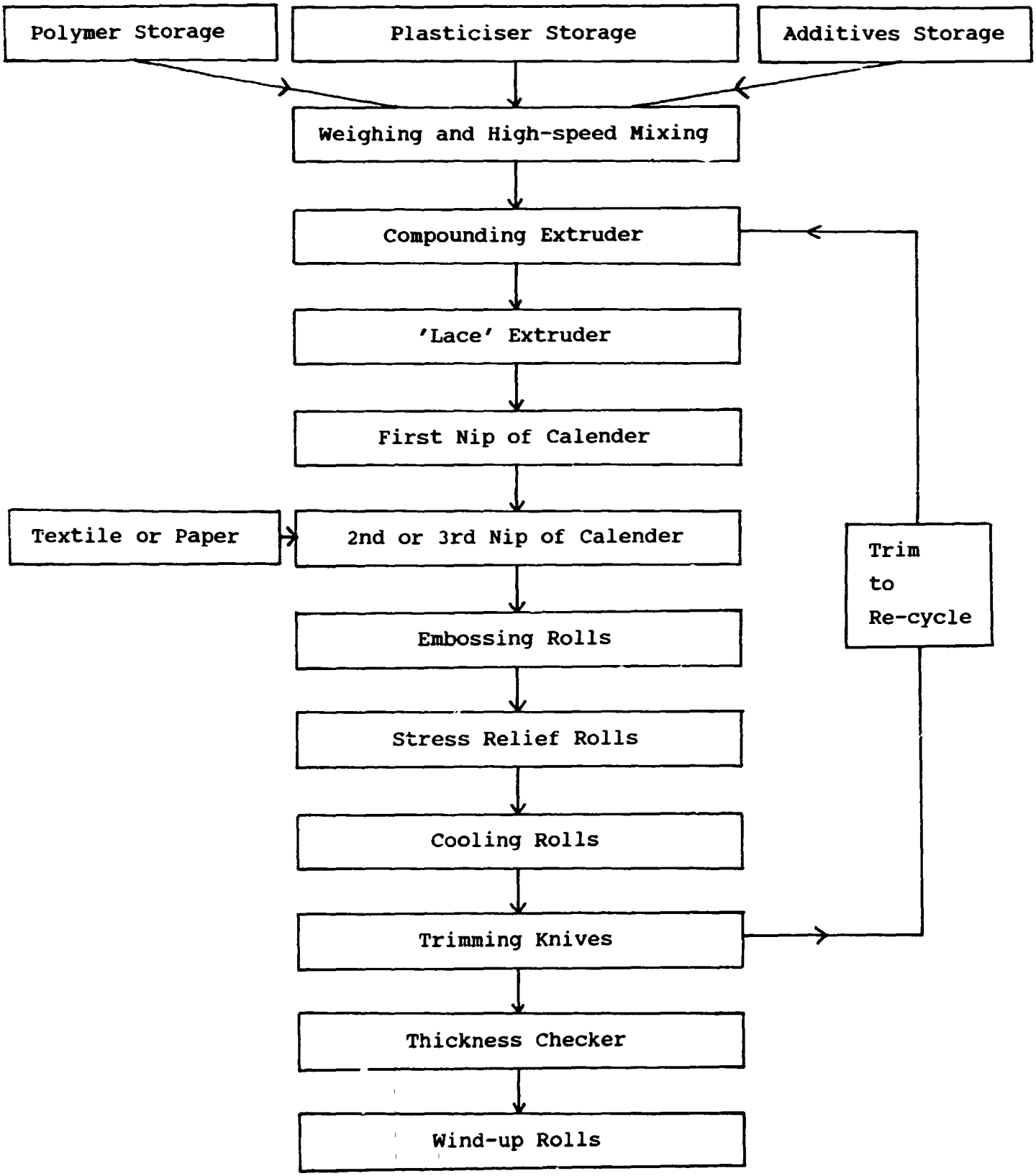


FIGURE 3 - FLOW CHART

4.2.2 Mixing

The batch of PVC raw materials is thoroughly mixed in a high-speed mixer. The contents are then loaded into a hopper which feeds a compounding extruder. The feed hopper acts as a supply buffer. in which the plasticiser is heated and absorbed into the polymer to give a uniform compound.

From this stage the process is continous, the extruder distributes uniformally the pre-heated PVC material across the first pair of rollers on the calender. (See Fig 4). Each pair of rollers is referred to as a 'nip'.

4.2.3 Calendering

From the first nip of the calender, the hot sheet is passed around a number of rolls in order to give a uniform thickness; to impart any texture; to relieve any calendering stresses; to cool the sheet, and to check the thickness. The sheet is trimmed to width, with the trimmings being granulated and re-cycled to the compounding extruder. Finally the sheet is reeled ready for storage.

For supported PVC sheet the process is identical except that the textile or paper support material is fed into the calender machine at an early stage of the rolling process in order to bond it to the sheet. The trimming operation maybe eliminated where the uncoated edge of the textile could be useful for stitching or other bonding methods.

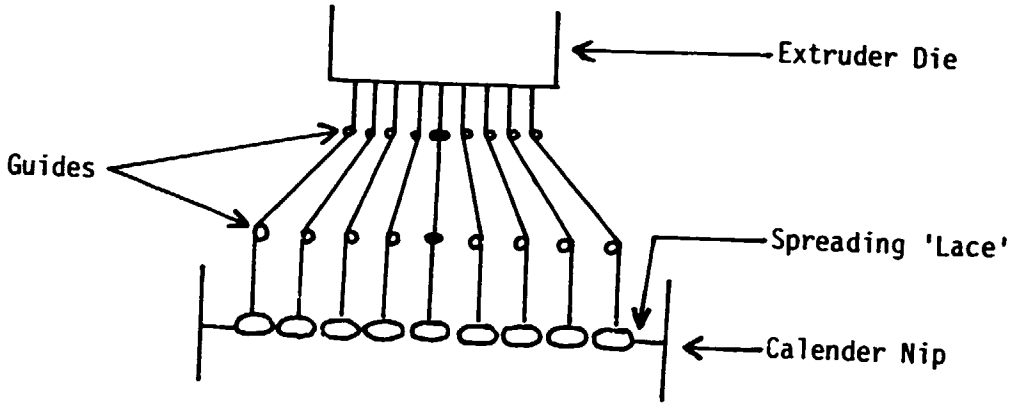


FIGURE 4

4.2.4 Output Rates

These are dependant upon a number of factors:-

a) The composition.

b) The thickness of the sheet.

c) The outputs of the extruders.

d) The quality of the sheet.

Thus, for thin sheets, eg, 0.07 mm thick, outputs could be as low as 400 metres per hour, while with the optimum conditions of the factors above, rates of 1200 metres per hour have been achieved. For sheets 0.2 mm to 0.4 mm thick a typical speed would be 1000 metres per hour.

4.3 Outline List of Equipment and Plant

4.3.1 It is recommended that the complete production line should be supplied, erected and commissioned by one manufacturer. A typical list of equipment would include:

Item 1 Storage silos for bulk solids such as PVC polymers; tanks for bulk liquids such as plasticisers; and smaller containers for additives.

Item 2 Weighing machines for each class of ingredient.

Item 3 High-speed mixer to give a uniform distribution of ingredients.

Item 4 Calender line.

Item 5 Fork lift truck to take finished reels to the store.

Item 6 Fume extractors above the mixer, extruders, and calender.

Item 7 Crane for lifting items of plant for erection and maintenance.

Item 8 Industrial vacuum cleaning equipment to maintain cleanliness.

Item 9 Oil fired boiler.

4.3.2 A laboratory would be needed to evaluate formulations, and to check the consistancy of the plant. It should be equipped with the following:-

Item A Bins to hold solids.

Item B Cans or bottles to hold liquids and small additives.

Item C Weighing machine for the ingredients.

Item D Small (1.5 kilo capacity) high-speed mixer.

Item E Extruder with a film die, which could take compositions from its own mixer, or 'crumb' from the main production line.

Item F Laboratory calender.

Item G Foil micrometer or gauge.

Item H Tensometer to measure strengths and elongations.

4.4 Budget Costs for Machinery and Equipment (ex Europe)

Calendering plant complete	US$	5,625,000
Ancillary equipment	US$	0,375,000
Laboratory equipment	US$	0,170,000
Carriage at 8%	US$	0,493,600

Packaging equipment is not required. The sheeting is wound directly onto returnable cores for the reels of film and covered by polyethylene film to keep the reels clean.

Estimate cost of spare parts (working capital inventory):

1st Year	$ 20,000
2nd year	$ 42,000
3rd year	$ 62,000

4.5 Budget Cost for Erection of Machinery

Estimated installation costs	US$	500,000
TOTAL (Para 4.4 + 4.5)	**US$**	**7,163,600**

4.6 Site Requirements (See Figure 5)

Typical site requirements can be summarised as follows:-

Production area	2,200m²
Stores area	1,160m²
Offices etc.	840m²
Total Building	4,200m²
Hardstanding	3,800m²
Total Land	8,000m²

4.7 Building and Civil Works

The site should be accessible by good main roads. The foundations must be level and adequate for the weight of the plant, particularly the calender unit. Since the plant covers an area of about 70m x 60m the site should be a minimum of 100m x 80m. There needs to be adequate supplies of electricity, water, and sewage. The office and despatch sections should have direct access to the site road.

There are no special civil works/structural features, beyond the weight of the machinery.

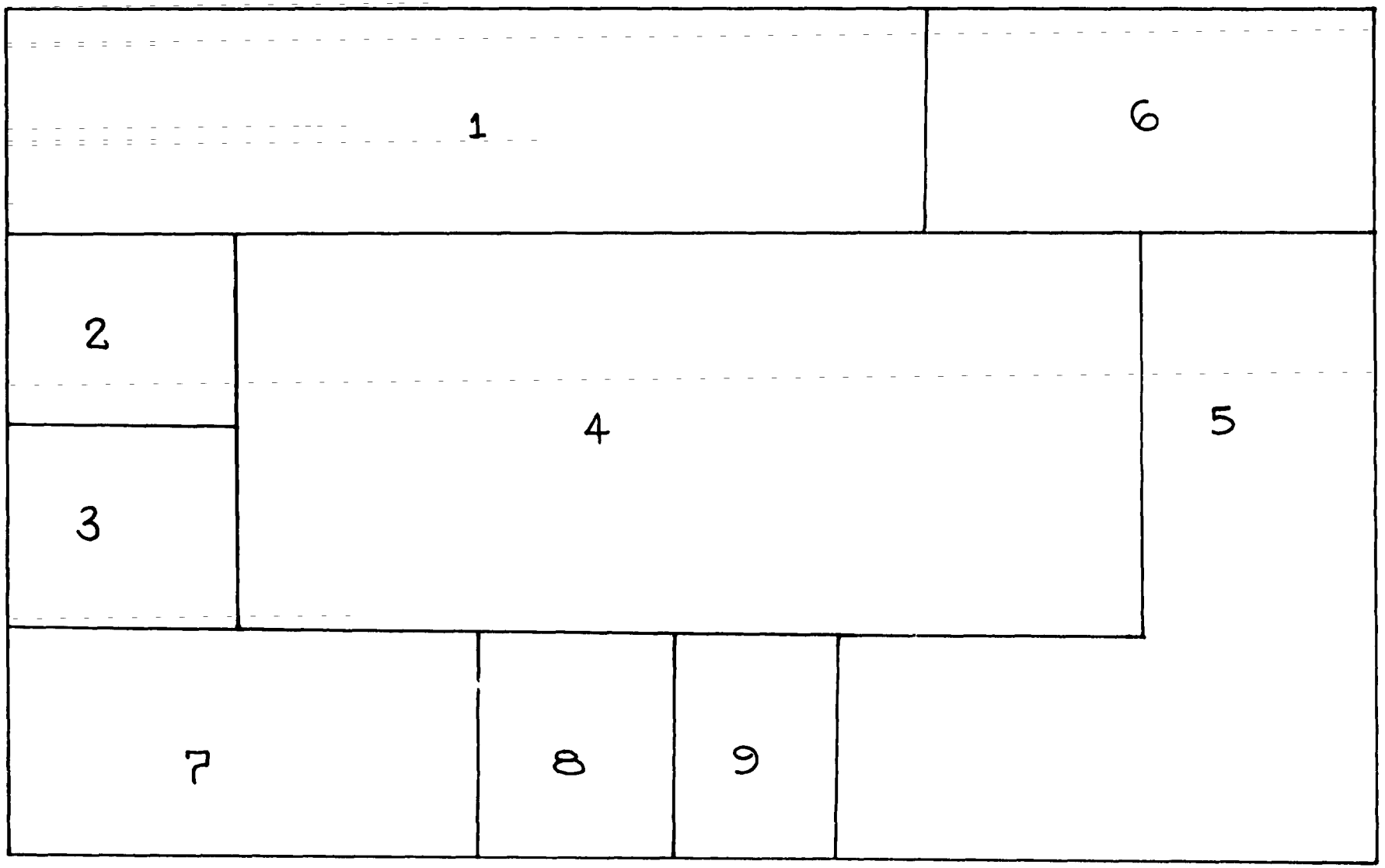


FIGURE 5

INDEX OF NUMBERED LOCATIONS

1. Raw Materials Store - Polymers, Plastics, and additives
2. Mixing and Weighing
3. Fabric Store
4. Calender
5. Finished Goods Store
6. Dispatch
7. Offices and Amentities
8. Laboratory
9. Maintenance Workshop

4.8 Raw Materials

4.8.1 Specifications

Detailed specifications should be agreed with the suppliers but guides to the main ingredients are given below:-

POLYMERS

Homo-polymers should have K values of 65-70 (DIN 53726)

Co-polymers should have K values of 60.

PLASTICISERS

These vary according to their class, but all should comply with ISO 9002 for consistency. Specifications for toxicity and medical use need to be considered carefully.

ADDITIVES

These may not have any international specifications, so buying specifications should be agreed with suppliers. Toxicity and suitability for medical use should be considered carefully.

3.8.2 Possible Raw Material Suppliers

Polymers:-

EUROPEAN VINYLS CORPORATION (UK) LIMITED
Crown Gate, Runcorn, Cheshire, UK
Tel: 0928-714482, Fax: 0928 715101

Plasticisers:-

ICI CHEMICALS & POLYMERS
The Heath, Runcorn, Cheshire, UK
Tel: 0928 513731 Fax: 0928 61008

BP CHEMICALS LIMITED
76 Buckingham Palace Road, London, SW1W OSU, UK
Tel: 071 581 1388

BASF (UK) LIMITED
PO Box 4, East Road, Cheadle Hulme, Cheshire, UK
Tel: 061 485 6222

Stabilisers:-

AKZO CHEMICALS LIMITED
Queens Road, Hersham, Surrey KT12 5NL, UK
Tel: 0932 247891 Fax: 0932 231204

CIBA-GEIGY INDUSTRIAL CHEMICALS LIMITED
Tenax Road, Trafford Park, Manchester M17 1WT, UK
Tel: 061 872 2323

BARLOCHER GMBH
Chemische Werke Munchen, Reisstrasse 16, Postfach 50
01 08, D-8000 Munchen 50, Germany
Tel: 089 1488 0 Fax: 089 1488 312

Cloth for Supported Sheet:-

P & R FABRICS LIMITED
Botraco House, Victoria Lane, Swinton, Manchester, M27 3LF, UK
Tel: 061 793 7037

4.9 Raw Material & Consumable Prices

PVC Homo-polymers	US$	0.888	per kilo
PVC Co-polymers	US$	1.031	per kilo
Plasticisers - general purpose	US$	2.960	per kilo
Plasticisers - non-toxic	US$	3.422	per kilo
Stabilisers - heat	US$	3.885	per kilo
Stabilisers - light	US$	25.90	per kilo
Cloth, cotton, 4.5oz bottom quality	US$	1.11	per m^2
Cloth, cotton, 5oz better quality	US$	1.48	per m^2
Cloth, flax-cotton mixture, 9oz	US$	2.77	per m^2

Major items per tonne of finished product are:

INGREDIENT	UNSUPPORTED SHEET	SUPPORTED SHEET
Polymer	736 KGS	390 KGS
Plasticiser	294 KGS	156 KGS
Stabilisers	022 KGS	12 KGS
Cloth	000 KGS	554 KGS
	1052 KGS	1111 KGS
Raw material efficiency	95%	90%

4.10 Utility Requirements

Oil consumption:	about 20 litres per hour
Electrical consumption:	about 960 K Watts per hour
Cooling water consumption:	about 200,000 litres per hour

4.11 Maintenance Costs

These should be low - about US$ 20,000 - the first year, about US$ 42,000 for the second year and thereafter US$ 62,000 per annum.

The above excludes labour costs.

4.12 Manpower Requirements

Indirect Labour

1 Production Manager (days only)	Skilled
1 Production Engineer (days only)	Skilled
3 Office staff (days only)	Semi-skilled
5 Total	

Direct Labour

1 Foreman per shift	Skilled
2 Weighers and mixer supervision per shift	Skilled
2 Line minders per shift	Skilled
1 for packing and taking to despatch stores per shift	Semi-skilled
1 for general maintenance per shift	Skilled
1 for cleaning and general duties per shift	Unskilled
8 Total	

4.13 Pre-Production Costs

Dependent upon arrangements made with machinery suppliers, it is suggested that a sum of US$ 100,000 be set aside.

4.14 Typical Early Production

Much would depend upon the profile of product. Low volume production runs would require proportionally greater setting up time. It is considered that the minimum viable production should be 40 hours per week, with an effective output time of 62.5% which is equivalent to an output of about 25,000 metres per week (value about US $70,000). This could rise to 100 hours per week, to give an output of 100,000 metres per week (value about US $2 10,000), if demand justified it.

An indicative production profile would be:-

Year 1	1,200,000 metres (875 tonnes)
Year 2	2,900,000 metres (2,100 tonnes)
Year 3	4,300,000 metres (3,100 tonnes)

4.15 Estimated Required Construction Period

It is estimated that the construction period would be between 12 and 15 months, including site preparation and commissioning:

Buildings	10 weeks
Special Machines (Calender)	26/38 weeks
General Plant & Machinery	20 weeks
Shipping	6 weeks

Installation	8 weeks
Commissioning	4 weeks
Production Run-up	4 weeks

4.16 Environmental Aspects

There are no special environmental risks. The fumes generated during production are non-hazardous but should be removed nonetheless to improve the working environment. All plastic waste material can be recycled.

5.0 COMPARATIVE EUROPEAN PRODUCTION COSTS

5.1 Unsupported Sheet

Taking a typical 'middle-of-the-range' product:
1.35m wide, 0.4mm thick - 730 gms per metre.

PVC polymer	507 gms	US$	0.462
Plasticiser	203 gms	US$	0.610
Heat stabiliser	2 gms	US$	0.074
Light stabiliser	1 gms	US$	0.259
Totals	730 gms	US$	1.405

Labour: 10 men @ US$4.625 per hour	US$	0.046
Overheads	US$	0.046
Electricity: 1000 Kw	US$	0.092
Cost per metre run total	US$	1.589

5.2 Supported Sheet

Taking a typical product:
1.35m wide - 500 gms per metre square

Cloth - 5oz @ US$1.48 per m^2	US$	1.48
PVC raw materials as above, but 358 gms	US$	0.69
Labour, overheads and electricity as above but output 500 metres/hour	US$	0.37
Cost per square metre total	US$	2.54

6.0 INTERNATIONAL (UK) PRICES OF COMPARABLE PRODUCTS

Unsupported sheet as example above per metre run (1.35m wide):-

Sales Price	-	US$	2.035
Production Cost	-	US$	1.589
Gross Profit	-	US$	0.446

Supported sheet as example above per square metre:-

Sales Price	-	US$	4.625
Production Cost	-	US$	2.530
Gross Profit	-	US$	2.095