Reflex

TECHNICAL MANUAL

1. Introduction

Reflex is a high grade, graphic overlay film developed to meet the exacting requirements of Screen Printers, Membrane Touch Switch and Fascia-panel manufacturers and their end users. It is coated on one side with a well-proven print receptive layer for UV and solvent-based inks. On the other side it is coated, in a class 1000 cleanroom, with an advanced UV radiation cured resin. The topcoat is a formulation developed to have excellent chemical resistance and hardness, combined with an option of maintaining embossability with an extensive switch life. There is always a compromise between a cured resin's ability to be embossed and the hardness/abrasion resistance of the coating, one requiring flexibility, the other rigidity. Where both characteristics are required, InteliCoat believes it has achieved the optimum balance with Reflex in both LT and CE grades.

Reflex LT is a light textured product with an abrasion resistant finish. The coating has been specially developed to allow embossing and greater flexibility. Reflex LT can be screen printed with lacquers to obtain a clear window.

Reflex CE is optically clear with an abrasion resistant finish. Again the coating has been specially developed so it can be embossed and Reflex CE can be screen printed with lacquers to obtain selctive textures.

1a. Technical Data: Reflex LT

PROPERTIES	TEST METHOD	TYPICAL VALUES		UNITS
General		LT 175	LT 125	
Total Thickness	Caliper	195	145	microns
Optical				
Light Transmission	ASTM D1003	88		%
Gardner Haze	QCTM137**	58		%
Gloss Level (60°)	ASTM D2457	21		%
Yellowness Index	ASTM E313-05	2.0	1.5	
Visual Appearance	See notes a			
Mechanical				
Tensile Strength	ASTM D882	165		N/mm^2
Elongation - MD	ASTM D882	119		%
- TD	ASTM D882	96		%
Tensile Modulus	ASTM D882	3012		N/mm^2
Switch Test	See notes b	>3 Million		Flexes
Mar Resistance:				
Pencil	See notes c	4H		
Taber abrader	QCTM149** See notes d	-4		%
Rub test	See notes e	>1 Million		Rubs
Cross Hatch adhesion	QCTM145**	4B		
Electrical				
Volume Resistivity	ASTM D257*	10^{15}		ohm/m
Surface Resistivity	ASTM D257*	10^{13}		ohm/sq
Dielectric Strength	ASTM D149*	125		kV/mm
Thermal				
Coefficient of Thermal Expansion MD	ASTM D696*	$19*10^{-6}$		cm/cm°C
Usage Temperatures:				
Suggested minimum		-40		°C
Suggested maximum		150 (80°C if embossed)		°C
Dimensional Stability				
MD	30 minutes at 120 °C	-0.3		%
TD	30 minutes at 120 °C	+/- 0.1		%
(Melting point 250°C)				
Flammability	UL Flame Class*	HB		
Chemical				
Spot Test	ASTM 1308	See Table 2.1		
Immersion Test	MEK 24 Hrs	Satisfactory		
Water Vapour Permeability	BS 3177*	2.9		g/m^2/24Hrs
Coefficient of Hygroscopic Expansion	AsDuPont*, between 40-80% RH	$8* 10^{-6}$		per 1% RH
Chemical Resistance	DIN42 115	See Table 2.2		

*Figures derived from DuPont Teijin Films™ (Melinex® O)

**Figures derived from Internal Test Methods

1b. Technical Data: Reflex CE

PROPERTIES	TEST METHOD	TYPICAL VALUES		UNITS
General		CE 175	CE 125	
Total Thickness	Caliper	185	135	microns
Optical				
Light Transmission	ASTM D1003	88		%
Gardner Haze	QCTM137**	2.5		%
Yellowness Index	ASTM E313-05	2.0	1.5	
Visual Appearance	See notes a			
Mechanical				
Tensile Strength	ASTM D882	165		N/mm²
Elongation - MD	ASTM D882	119		%
- TD	ASTM D882	96		%
Tensile Modulus	ASTM D882	3012		N/mm²
Switch Test	See notes (a)	>3 Million		Flexes
Mar Resistance:				
Pencil	See notes c	3H		
Taber abrader	OCTM149** See notes d	-4		%
Rub test	See notes e	>1 Million		Rubs
Electrical				
Volume Resistivity	ASTM D257*	10^{15}		ohm/m
Surface Resistivity	ASTM D257*	10^{13}		ohm/sq
Dielectric Strength	ASTM D149*	125		kV/mm
Thermal				
Coefficient of Thermal Expansion MD	ASTM D696*	$19*10^{-6}$		cm/cm°C
Usage Temperatures:				
Suggested minimum		-40		°C
Suggested maximum		150 (80°C if embossed)		°C
Dimensional Stability				
MD	30 minutes at 120 °C	-0.3		%
TD	30 minutes at 120 °C	+/-0.1		%
(Melting point 250°C)				
Flammability	UL Flame Class*	HB		
Chemical				
Spot Test	ASTM 1308	See table 2.1		
Immersion Test	MEK 24 Hrs	Satisfactory		
Water Vapour Permeability	BS 3177*	2.9		g/m²/24Hrs
Coefficient of Hygroscopic Expansion	As DuPont*, between 40-80% RH	$8* 10^{-6}$		per 1% RH
Chemical Resistance	DIN42 115	See table 2.2		

*Figures derived from DuPont Teijin Films™ (Melinx® O)

**Figures derived from Internal Test Methods

1c. Notes

a) Visual Appearance: The material will be substantially free of all loose or included dirt, polymer gels, scratches or other surface damage, pimples, creases and all coating irregularities.

b) Switch Life: A standard rubber finger (45° Shore hardness) is used to flex an embossed dome switch continuously at a rate of 2 flexes/second. Pressure applied must be sufficient to force the apex of the dome to make contact with the support table. the switch should be examined at regular intervals to check for weight loss due to particles flaking off or cracking.

c) Pencil Test: Increasingly hard grades of pencil lead are scored across the surface of the coated PET. The point of the pencil is moved along the surface of the film with increasing force until the pencil breaks or until the surface of the coated film is scratched. The tests are continued until the pencil scratches the surface. The value given is the highest hardness value which does not scratch the coated film.

d) Taber Test: A Taber abrader (CS10F wheel Type 4; 250g load; 10cycles) is used to abrade the test sample, measurement of the haze value, before and after abrasion, are taken and the % change recorded. The average of three test samples is given.

e) Rub Test: A test sample of the coated film is embossed to give a rim profile. The sample is then tested with repeated rubs with a standard rubber finger (45° Shore hardness) which travels along the surface of the film and over the rim. The "finger" is weighted on a cantilever with a 500g weight. there should be no signs of wear and no evidence of coating delamination.

2.0 Chemical Resistance Table 2.1 & Table 2.2

Reflex polyester films have been tested for their chemical resistance as per DIN 42 115. The products have been tested using an exposure of more than 24 hours to the following chemicals without visible change.

Table2.1 Chemical Resistance Spot Test

Chemical Group	**Examples used**	**Effect on Reflex LT**
Acids (dilute mineral)	10% HCI Acid	Pass
(organic)	95% Acetic Acid	Pass
Alcohols	Methanol	Pass
	Ethanol	Pass
	IPA	Pass
Aliphatic Hydrocarbons	n-Heptane	Pass
Alkalis (dilute)	2% NaOh	Pass
Aromatic Hydrocarbons	Toluene	Pass
Chlorinated Hydrocarbons	1-1-1 Trichloroethane	Pass
	Methylene Chloride	Pass
Esters	Ethyl Acetate	Pass
Ketones	Acetone	Pass

Reflex has been tested with a range of materials typically found in the home. The test involved subjecting Reflex to the following materials for 24 hours at 50°C.

Table 2.2 Resistance to Household Chemicals

Material Used	Examples used	Effect on LT
Domestic Cleaners	"Frish" cleaner	NS
	"Jif" cleaner	NS
Domestic Fat/Oil	Vegetable oil	NS
	Rape seed/Lard	NS
Material Used	**Examples used**	**Effect on LT**
Domestic Foodstuffs	Blackcurrant	NS
	Brown sauce	NS
	Milk	NS
	Tomato puree	NS
	Hot curry powder	SS
	Beetroot juice	NS
	Fabric cleaner	NS
Key	*No Stain*	*NS*
	Slight Stain	*SS*
	Stain	*S*

3.0 Printing Guidelines

3.1. Reflex can be used for solvent based and UV inks. UV inks have the advantage of faster processing speeds and of potentially being more environmentally acceptable.

3.2. Keep printing facilities and equipment free from dust and contamination. A clean working area greatly enhances printing quality.

3.3. The use of static eliminators prevents the attraction of dust onto the substrate surface and improves sheet handling. Film cleaners are also an effective method of cleaning a substrate surface.

3.4. Further dust reduction can be ideally achieved by maintaining levels of relative humidity of around 55% RH and low working temperatures of around 65-70°C.

3.2. Printing of UV lacquers should be carried out away from other UV sources such as direct sunlight and exposure units.

4.0 Drying Guidelines for Solvent Inks

4.1. Because of the impermeable nature of polyester substrates, printing inks may take longer to dry than on substrate's that absorb solvents.

4.2. Ensure that the printed ink is completely dry prior to subsequent printing operations. Failure to do this may result in the build up of retained solvents and lead to deterioration in adhesion.

4.3. If the presence of retained solvents need to be accurately monitored, the use of a gas chromatograph is recommended. Alternatively gravimetric tests can be carried out.

4.4. A number of drying methods are appropriate for drying printing inks. One of the more efficient methods is air jet drying, evaporated solvents being removed by a moving air stream.

4.5. Reflex is based on heat stabilised polyester film, which can withstand drying temperatures up to 120°C without significant residual shrinkage or colour change occurring.
However, some inks may be susceptible to surface skinning when rapidly dried at high temperatures. It should be noted that wherever possible an extended drying time be used. Generally it is found that the longer the dwell time in the dryer the better the results in print adhesion.
If available, multizone ovens should be used which can be adjusted to give lower temperatures in the early zones of 70-80°C, increasing the temperatures to 90-100°C in the final zones. Higher temperatures may be required for conductive inks.
Single zone dryers can be used for temperatures of 90-110°C.

5.0. Curing Guidelines for UV Inks/Lacquers

5.1. Inks and lacquers cured using Ultra Violet radiation are becoming increasingly popular as the demand for fast processing speeds and solvent free systems grow.

5.2. Conveyor speeds depends on the quantity and power of lamps. For example 6-8 m/min is recommended for one lamp, increasing to 9-11m/min for two lamps.

5.3. The light source should be a mercury lamp with a power of 80-120 watts/cm.

5.4. Particular care should be taken to follow safe handling recommendations for UV inks.

The printing/drying recommendations given here cannot cover all eventualities. It is recommended that all inks are tested in production type conditions before usage. If printing problems continue consult either your ink supplier or contact your local Reflex supplier.
Please follow all Health and Safety precautions suggested by ink/lacquer suppliers.

6.0. Compatible Ink System Suppliers

The following graphic ink, lacquer and varnish manufacturers produce products that are recommended for use on Reflex products.

Manufacturers

Argon Inks	Coates Special Products	Dubuit
E T Marler	Farbenfabrik Proll	KC Coatings
Marabuwerke	Mid West	Naz Dar
Nor-Cote	Sericol Group Limited	

7.0. Cutting Guidlines

The Reflex range of coated films is based on optical quality, heat stabilised, print receptive polyester. The nature of polyester makes it extremely strong and durable, giving Reflex enhanced longevity and reliability. The hardcoat has been formulated to give maximum adhesion to the base film.
Particular care should be taken when cutting materials based on polyester films. The hardness and structure of polyester polymers can cause internal delamination when the polyester is subjected to the shear forces present during cutting operations. Provided the correct precautions are taken when cutting polyester there should be no occurrence of delamination.
The two most extensively used methods for cutting polyester are guillotining and die-cutting. The following recommendations are based on the experience of manufacturers who have successfully cut and processed Reflex polyester films.

7.1 Die-Cutting
Steel-rule die cutting is a popular and inexpensive cutting process used for polyester.

Points to optimise this cutting method are outlined below.

7.1.i Blade Profile

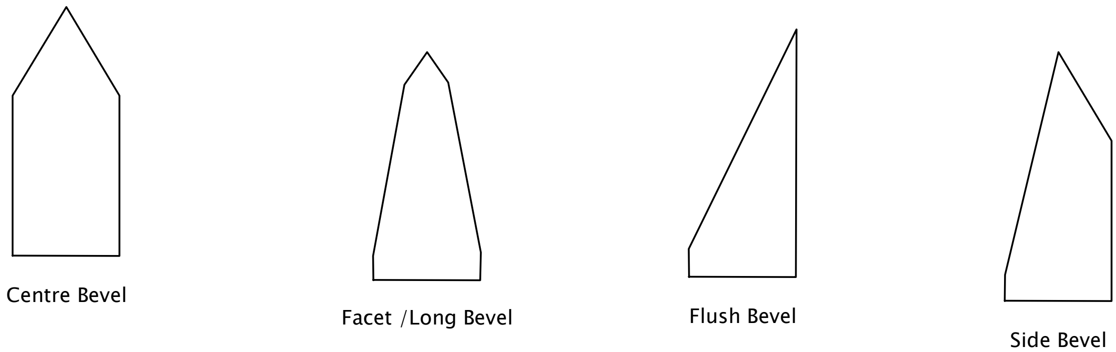


Figure 7.1. Steel-rule die designs

Several different steel-rule bevel designs are available as illustrated above.
Centre bevel is more common and should provide the longest wear-life.
A facet or long bevel can give a cleaner cut because the longer bevel reduces material displacement whilst the broad tip stays sharp. A facet bevel is particularly recommended when cutting thicker gauges of polyester.
Side bevel profile is recommended for cutting assembled membrane touch switches and other multilaminates of polyester. The long bevel side should face the trim or scrap of the material being cut.
The flush bevel rule can provide a clean cut but care must be taken that the weak tip is not damaged.

7.1.ii. Blade Specification

A 2-point rule (0.7mm thick) is generally recommended for cutting Reflex polyester. The blade edge should be maintained in excellent condition. It is recommended that the blade should be regularly sharpened by grinding the edge.
Steel-rule dies are manufactured by two different methods: laser and jig. More accurate tolerances are achieved with a laser cut die (±0.1mm) compared to a jig-cut die (± 0.4mm). Independent tool manufacturers should be consulted for advice on suitable tools for different applications.
The tool hardness can be varied, however, Reflex polyester is best cut using a tool with a hardness of between 420 and 450 VPN.

7.1.iii. Die Design

It is likely that the part being cut from the die will have slightly different dimensions from the die itself, the difference depending on the rule design, size and shape of part and film thickness.
It is likely that cut out shapes will be larger and stamped holes smaller.
It is therefore recommended that dies are designed with dimensions at either end of the tolerance range of the material to be cut. Dies to cut out shapes should be made slightly smaller than the part size indicated on the print drawing. Dies to cut out holes should be slightly larger.

7.1.iv. Press Operation

The more common press used is a platten type. The platten should be made with hardened steel with a steel or Formica make ready plate.
The use of a softer material can improve blade life. However, it is important to ensure that the film is held firmly throughout the cutting operation. This can be achieved by using a foam of around 40¨° Shore hardness or a composite of foam and a more rigid material. The following precautions should maximise cut quality during press operation:

a) Cut each piece individually.

b) Avoid any contact between the steel rule die and the platten by applying ejector foam rubber over the entire tool area.
c) If possible the film should be cut before laminating other layers.
d) Apply heat to either the film or the tool.
e) Ensure that the hardcoated surface faces the tool.
f) Design parts to be cut to have radius corners, avoiding sharp angled corners and complex shapes.
g) Cuts made less than 3mm apart may cause weakness in the film and should be avoided.

7.2 Guillotining

Guillotining is a less common method for cutting polyester, although it can be an efficient method for preparing stacks of sheet material.
The following recommendations will ensure that satisfactory results are achieved.

7.2.i. Blade Material

A flame hardened low alloy steel blade is an appropriate material for guillotine blades. Good blade properties can be obtained by using heat-treated high-speed steel with a VPN value of 700.

7.2.ii. Blade Maintenance

Providing the blade is of correct material type and is maintained and used properly it should give up to 80 hours of continuous use before needing re-sharpening.
Polyester film is susceptible to internal delamination, this characteristic is worsened when blunt or chipped blades are used. The blade quality should be closely monitored, particularly when thicker films are being cut. As with die cutting the blade profile should be ground as a double bevelled edge to optimise cutting performance.
When stacks of sheets are to be cut they should be limited to the quantities shown below:

175 micron polyester	250 sheets per stack
125 micron polyester	300 sheets per stack

8. Embossing Recommendations

8.1 Introduction

The Reflex range of coated films is based on optical quality, heat stabilised, print receptive polyester. The nature of polyester makes it extremely strong and durable, giving Reflex enhanced longevity of switch life and an enhanced tactile response. This property makes it ideal for embossed membrane touch switches.
Embossing is used to raise areas, letters or designs. If Reflex films, designed for embossing are used, there should be no loss in the very high switch life of polyester. Because of the different mechanical properties of polyester, allowances should be taken when embossing Reflex to ensure good results.
There are a number of methods to satisfactorily emboss Reflex polyesters to achieve a first rate finish and performance.
Due to the high strength of polyester, male/female embossing tools designed for polycarbonate may not give the same sharpness of finish. To compensate for the difference between polyester and polycarbonate the following recommendations should be followed.

8.2 Tool Design

8.2.i. The space between the male and female tools should be designed to be the same thickness of the printed film (ink + film). It is important that the tool tolerances are tight to improve emboss definition.

8.2.ii. Minimum draft angles of 4 degrees should be designed into both female and male walls as shown in Figure 8.1- attached

8.2.iii. A draft or bevelled edge can enhance the aesthetics of an embossed switch. A small draft angle on the finished part is controlled by the draft angle of the male tool, combined with a tight tolerance fitting tool set. Care should be taken with very low draft angles because of the potential damage to the graphics ink layer.
A finished part with a high draft angle can be achieved by increasing the female tool aperture. In this case precautions should be taken to avoid a reduction in the clamping effect of the tool.

8.2.iv. Movement around the embossed area should be minimised by ensuring the male and female tools hold the film tightly.

8.2.v. The male tool should be approximately 25% higher than typically needed for polycarbonate. The depth of the female tool must accommodate this greater tool height.

8.2.vi. Tool specification and manufacture can be simplified by only matching the dimensions horizontally.

8.2.vii. Tool dimensions should be designed so they are correct at the typical working temperature of the tool, not at room temperature.

8.2.viii. Because of the nature of the difference in yield behaviour of polyester compared to polycarbonate the profile achieved by the same tool differs as shown in Figure 8.2. below

Figure 8.1. Typical draft angle

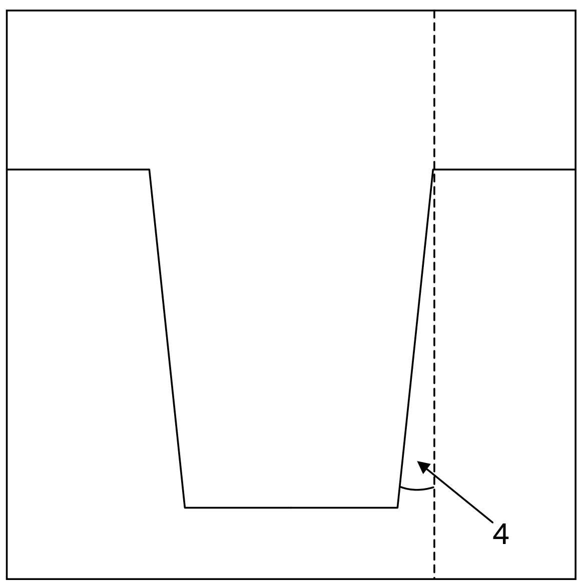
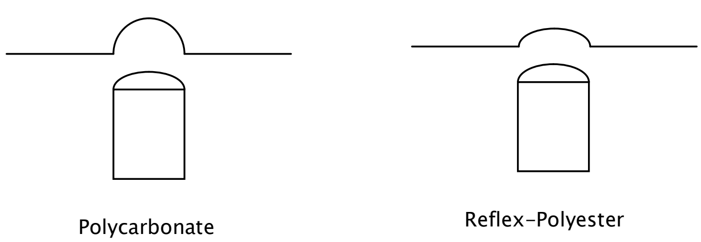


Figure 8.2. Polycarbonate / Reflex Polyester

The profile achieved using polycarbonate is similar to the tool profile, whereas profiles embossed using polyester tend to be flatter and wider.



8.3Temperature Control

8.3.i. Ideally heat should be applied to the embossing area. The film should be heated to around 80-90°C (i.e. above the Tg of 68°C) around the embossed area but remain below the Tg in the background areas. This can be achieved on plate tooling by introducing an insulating layer in non-embossed areas.

8.3.ii. The heat being applied to the tool depends on the dwell time, and the depth of emboss required. It is recommended that a small batch trial be carried out to assess optimum temperatures and dwell time.

8.3.iii. The optimum emboss temperatures are around 80°C, particularly for tactile embossing. At low temperatures the embossed height is low due to stress surrounding the emboss area. At high embossing temperature s (110+°C) the embossed profile may change as shown in Figure 8.3.

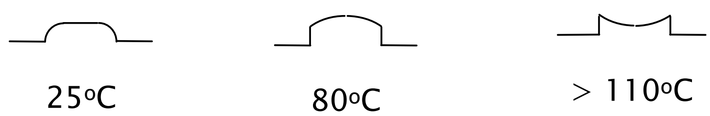


Figure 8.3. Emboss profiles at different temperatures

8.4 Tool Manufacture

Materials with high hardness, such as magnesium, are appropriate for manufacturing embossing tools. Plate tools may be produced by etching, machining or moulding.

8.4.i. Etched Plate Tooling
Etching is a cost effective and widely used tool manufacturing method. As indicated earlier, greater depth is required in tools to be used for embossing polyester. Particular care must be taken to ensure the tight tolerances in the design are retained.

8.4.ii. Machined Plate Tooling
Tools can be manufactured with more precision and with more detail if they are machine made. This process can be more expensive but allows more complex shapes, such as control dome profiles, to be produced.
Matched glass reinforced plastic (GRP) tooling, discussed below, can be used to avoid wearing down a machine master.

8.4.iii. Cast Plate Tooling
A cast tool can be manufactured from rubber or GRP. Rubber tooling can give badly defined profiles. It is unnecessary to allow for the normal tool clearances because of the flexibility of rubber.
GRP cast tools can give excellent results although care should be taken to operate GRP tools at higher temperatures to ensure the 80+°C operating temperature is achieved. This is due to the poor thermal conditions of GRP versus metals.

8.4.iv. Non Matched Plate Tooling (Hydroforming)
This type of tooling involves the use of one tool with the required profile embossing onto a resilient surface. A particularly satisfactory method uses metal female/fluid filled reservoir. This involves applying high pressure to a fluid filled reservoir, which forces a flexible diaphragm to form the profile of the polyester to that of the female tool. Both hot and ambient temperatures may be employed; the best results coming from a hot emboss. This increasingly popular method of embossing demands significant capital investment, which may be avoided by using companies specialising in this type of work on a custom basis.

8.5 Press Usage

Reflex polyesters can be embossed using a number of different types of press. These should be maintained in first class condition to fully maximise emboss quality. The press used may be a typical clamshell or platten press or a more specialised unit, such as a pillar press. These require the use of flat plate tools as previously discussed. The following recommendations should help in the embossing process.

8.5.i. Clamshell Press Recommendations

A clamshell press is commonly used for other applications such as die cutting. It should be noted that a worn or badly set up press will give badly registered finished parts. A normal clamshell press may need to be modified to include a heated platten and variable dwell adjustment. Press manufacturers are usually able to carry out such modifications.

The plattens should be completely flat, square and parallel throughout the press stroke.

8.5.ii. Pillar Press Recommendations

A pillar press can also be used for other work such as hot foil stamping and cutting film substrates. The maintenance on such machines is less critical.

As with clamshell presses a heated platten and variable dwell adjustment are important features.

8.6 Summary

8.6.i. Tools designed for polyester need to take account of its strength and elasticity. They should have tight tolerances and be designed to firmly clamp the substrate.

8.6.ii. The polyester should be heated to above its Tg of 68°C. Temperatures of 80-90°C are preferable.

8.6.iii. Presses typically used in industry can be used but they need to be well maintained and carefully used.

9. Availability

Reflex is available in either sheets or rolls from local distributors. These distributors have been selected because of the excellent service they offer in terms of delivery and back up.
They are also familiar with other substrate material used in the graphic overlay market so can give balanced, unbiased advice about the best material to use for different applications.
In-house converting facilities allow them to offer products in a wide range of sheet and roll sizes up to a normal maximum width of 1220mm.
Both sheets and slit reels are available in custom sizes to suit your specific requirements from your local Reflex distributor.
Sheets can be supplied boxed, in quantities to suit individual requirements. Paper interleaving can be incorporated on request. Enquiries and orders should be directed towards your local distributor.