Issue 2007 / Replaces issue 2002

Working directions for FOREX®classic

(also applicable to FOREX®print)

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Cutting by hand

FOREX®classic sheets up to 3 mm thick can be cut easily with rigid general purpose knives (cutter knives).

- Several light cuts give a better result than one single firm cut. Secure the metal ruler against slipping.

Cutting by machines

- The vertical sheet material cutters available in many workshops of the graphics industries are very well suited for rapidly and accurately formatting FOREX®classic sheets up to about 10 mm thickness. The major advantages of these machines are the cutting action on stationary sheets (no scratching) and the absence of dust particles.
- If guillotine shears are used, buckling and some rounding on one side of the cutting edges are inevitable.

Die-cutting

FOREX®classic sheets up to 5 mm thick can be die-cut.

- For example 3 mm sheets: The best choice is a die-cutting tool (steel rule die) with cutting blades made of steel strip which are mounted in a body of 15 mm thick plywood. Toothless, micro-polished cutting blades (1.05 x 23.8 mm), bevelled both sides give good results. 10 mm thick elastic foam inserts (hardness 35 Shore A) are used as strippers for ejecting the cut part. The cutting blades would in this case be positioned about 1.2 mm below the surface of the ejector foam.
- FOREX®classic sheets should not be die-cut at temperatures below 20℃. Warming to about 40℃ improves the quality of the cut and prevents f racturing at the edges.

Computer controlled cutting processes

- ❖ **Water-jet cutting**
  FOREX®classic sheets lend themselves well to water-jet cutting.
- ❖ **Laser cutting**
  Because of the heat released into the material during laser cutting, this process is not recom-mended for expanded rigid plastic sheet material.

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Sawing - Drilling - Milling

Safety first

- In view of the high rotational speeds of cutting tools, it is very important for all protective devices on the machinery to be in good working order and also that they are being used.
- It is mandatory that the prescribed personal safety equipment - at the very least a pair of safety goggles - be worn at all times during chip generating cutting operations.

Sawing

FOREX®classic sheets can be cut with jigsaws, band saws and circular saws. A combination of high cutting speed and a slow feed rate gives good results. Suitable are machines without liquid cooling but with chip and dust extraction devices as commonly used in the wood and plastic processing industries.

- Use only jigsaw blades specifically designed and marked for use with plastics.
- Band saw blades with slightly cross-set teeth at a pitch of 2.5 mm give good quality cuts but require comparatively slow feed rates.
- The most suitable circular saw blades for expanded rigid sheet material are those with tungsten carbide tipped teeth and having an alternate flat and trapezoidal tooth design at a pitch of about 15 mm. Clearance angles between 10° and 15° a nd rake angles up to 6° are recommended. The cutting speed should be around 3000 m/min.

Drilling

FOREX®classic sheets can be drilled easily with normal twist drills. Particularly good results are obtained if the point angle is ground to 100° and t he helix angle is 30°. Do not use liquid cooling, but regularly withdraw the drill bit from deep holes to prevent overheating.

Milling and CNC machining

FOREX®classic sheets can also be machined on CNC machine tools provided the workpieces can be securely clamped. Overheating of the material must be avoided by employing appropriate tool design and observing suitable machining conditions.

Quality aspects

- Except before bonding operations, the surfaces of expanded rigid sheet material shouldn't be sanded or polished.

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Bending

Manufacturing direction (anisotropy)

FOREX®classic sheets are slightly anisotropic, i.e., they may behave differently or have different characteristics dependent on the manufacturing direction. Bending edges, deep cuts and grooves should always run crossways to the manufacturing direction in order to decrease the risk of breakage.

Cold bending

FOREX®classic sheets up to 6 mm thick can be subjected to cold bending within the limits imposed by the material's stretching capabilities.

- The temperature of the sheets must not be less than 20°C (warmer is advantageous).
- For FOREX®classic sheets, the minimum bending radius (cold bending radius) is around 100 times the thickness of the sheet (e.g. 300 mm for a 3 mm thick sheet).
- On a horizontal panel saw, thick gauge material can be made flexible for bending by cutting about ten parallel kerfs with a pitch equal to the width of the saw blade in a sheet, leaving 1 to 2 mm of material remaining. In this way, even very thick FOREX®classic sheets can be bent to any desired angle without heating them up.

Heat bending

FOREX®classic sheets are made of thermoplastic material. That is to say, they can be softened by heat and then formed with the new shape being retained after cooling. Dependent on the width of the heated zone even large radii are possible and drape forming can be achieved if the entire sheet is heated.

- The hot forming temperature is always dependent on the type of the material. For FOREX®classic sheets, the forming temperature is around 120° to 130°C.
- To prevent excessive stretching of the cell structure, a minimum bending radius of about 2 times the thickness of the sheet should be maintained.

Before attempting to bend thick FOREX®classic sheets (8 mm or thicker), the excess material at the inside of the fold must be removed by milling out a V groove. Following this, the outside of the bending line can be carefully heated, one leg raised and the resulting seam bonded together.

- With FOREX®classic sheets, the V groove should leave 1 to 2 mm of material remaining.
- Mill the V groove 1° wider than the desired bendin g angle (e.g. 91° for obtaining a 90° angle).
- Use just enough adhesive for a good bond. The least possible quantity of glue should be squeezed out of the V groove when folding up the legs.
- Distortion of short legs can be prevented by over-dimensioning the legs for the bending action and afterwards sawing off the excess lengths.

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Thermoforming

General information

FOREX®classic sheets can be thermoformed and embossed by either vacuumforming or mechanical pressure and drape forming. It should be born in mind that the air entrapped in the closed cells imposes limitations on formability, stretching and the reproduction of detail.

Parts and mould design

FOREX®classic sheets are especially suited for large components with soft, rounded contours. The moulds should be designed as follows:

- Radii at least 1 to 2 times the original sheet thickness.
- Slanted walls with draft angles between 5 and 8°.
- Drawing ratios must not exceed 1 : 1.2 (h:d).
- Avoid local overstretching of the material (thin projections, narrow recesses, etc.) and premature mould contact.
- Mould shrinkage between 0.5 and 0.8% must be taken into account as well as the anisotropy (orientation) of the material.
- Since expanded sheet materials have a narrower processing window than solid sheets, temperature controlled moulds will result in significantly better results.
- Always keep machines well shielded from air draughts.

Forming temperatures

The decisive factor is the sheet temperature, not the heater temperature set on the machine. Important is a complete and uniform heating of the sheets. Machines with separately adjustable upper and lower heater banks and prestretching or plug-assist devices are recommended.

- FOREX®classic sheets are best moulded in the thermo-elastic range between 120° and 130°C.
- Attention: Temperatures in excess of 180°C will first lead to discoloration due to overheating but ultimately cause thermal destruction of the material.
- Attention: FOREX®classic sheets should not be formed at temperatures much below 120°C since this would cause damage to the cell structure and subsequent warpage.

Hints for successful thermoforming

- FOREX®classic sheets don't need to be pre-dried.
- Counteract webbing, bridging or wrinkling by reorientation of the sheet, modifications on the mould design and lower forming speeds.
- Do not place formed parts on cold surfaces (metal table tops) and trim shortly after removal from the mould to minimize the risk of deformation.

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Adhesive bonding

General information

FOREX®classic sheets can be bonded to themselves as well as to other materials.

- Due to the variety of adhesives with their entirely different characteristics, expert advice by their manufacturers should be sought in order to identify the adhesive best suited to the parts and the particular application.
- The guidelines published by the manufacturers must be followed to the point and cleanliness at the work place is essential.
- To ensure perfect adhesion, the surfaces to be bonded must be cleaned before each gluing operation. They must be dry and free of dust and grease.

Bonding FOREX®classic to other PVC items

For fast, constructional bonding (also known as cold welding) of FOREX®classic with material of the same kind, a **UV-stabilised, transparent, diffusion adhesive based on the solvent THF** (tetrahydrofurane) is the most suitable adhesive.

- Attention: Standard "PVC adhesives" are designed for bonding jobs in the construction industry. They are neither transparent nor UV-stabilised. Joints would remain visible and may even discolour when exposed to outdoor conditions.
- Attention: THF is inflammable - ventilate well!

Bonding FOREX®classic to ...

- **Wood, Chipboard**
  Contact adhesive / 2-component PU adhesive
- **Metals (Aluminium, galvanised Steel)**
  elastic 2-component acrylate adhesive
- **Brickwork, Concrete, Glass**
  Silyl Modified Polymer (SMP) adhesive / 2-comp. tile adhesive
- **Thermoplastics, Perspex**
  double-sided adhesive tapes / 2-component PU adhesive
- **Expanded Polystyrene**
  2-component PU adhesive
- **Rubber, Elastomers, Soft PVC (foam)**
  Contact adhesive (plasticizer resistant)
- **Paper, Cardboard, Textiles, Leather**
  Contact adhesive / dispersion adhesive / spray adhesive

- In addition, double-sided adhesive tapes can be used for bonding FOREX®classic sheets to entirely different materials. The best suited adhesive tape must be found by carefully matching the materials to be joined with the nature of the load.

Mechanical fastening

Tacking and nailing

Unlike the majority of compact plastic sheets, expanded rigid sheet material can be tacked with wire staples and if necessary even nailed close to the edge of the sheets without splitting.

Riveted joints

The clenching of riveted joints must ensure free, unrestricted movement in the joints, permitting thermal expansion and contraction in all directions.

- Blind rivets (pop rivets) made of aluminium with a stainless steel mandrel are best suited to this purpose. The closing head must always be positioned on the support structure or metal side. The clearance holes in the expanded rigid sheets must be 2 mm larger (use a step drill) than the shank diameter of the rivet.
- Only panhead rivets with large heads (or washers) should be used in order to avoid tensions and material creeping. Countersunk rivets must not be used under any circumstances.

Screwed joints

- Screws for use with chipboards having a diameter of 3 to 4 mm are best suited for fixing components to the surfaces of FOREX®classic sheets.
- Stainless steel facade screws with pre-fitted washers and rubber seals are ideal for fixing external signs onto wooden or metal structures.
- Drill the clearance holes approximately 5 to 6 mm larger than the diameter of the screw shank. Tighten the screws only firmly enough for the rubber washers to snugly fit onto the sheet and seal the hole without exerting too much pressure on the sheet.

Shape and spacing of holes

- To facilitate the free dimensional change (thermal expansion) of mounted sheets, circular locating holes are drilled in the middle (centre) of the edges while oblong holes are milled to the left and right of this centreline.
- A margin of about 20 mm should be left between the holes and the edge of the sheet.
- The spacing between the holes depends on the thickness of the sheet and should not exceed:
    - 200 mm with 2 mm sheets
    - 300 mm with 3 mm sheets
    - 400 mm with 4 mm sheets
    - 500 mm with any thicker sheets

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Working with sheet material

Edge finishing

There are a number of ways to conceal the visible cell structure on the cut edges of thick FOREX®classic sheets:

- Cut strips of 1 mm thick FOREX®classic and bond them to the edges with a THF-based adhesive, then trim off the excess material with a sharp blade.
- Melamine edge banding (coated with heat activated fusion adhesive) can be applied with an industrial iron or a special machine. Trim off the excess material with a blade.
- Fill the open cells at the edges with a suitable putty and sand over carefully when dry.

Fixing to support structures

- Attachment profiles and entire frame systems are available for mounting expanded rigid sheet material on metal or wooden framework. These are based on the clamping principle and frequently include sealing strips. They are available from suppliers of facade and general building materials.
- Individual sheets are usually fixed by means of one (circular) fixing hole and several oblong holes which facilitate any dimensional changes due to thermal expansion. Unforced assembly with unrestricted movement is essential when installing large pieces, e.g. in cladding applications.
- For concealed (invisible from the front) attachment of sheets, a number of special mounting elements are readily available. For special constructions or for very thin sheets, 10 mm thick pieces of FOREX®classic can be glued to the back as intermediate elements for the actual mounting elements.

Decorative surface finishes

FOREX®classic sheets possess such prime surface qualities that they provide an excellent base material (substrate) for a wide range of decorative finishing techniques.

- FOREX®classic sheets can be given an altered appearance by hot stamping decorative patterns into the surfaces at temperatures around 120°C.
- FOREX®classic sheets can be fabricated into stiff decorative composite sheets which are ideally suited for furniture-making and interior works. After grinding both surfaces to good flatness, a 2-component PU adhesive can be used to bond sheet metal or synthetic resin sheets to the core of FOREX®classic.
- In boat-building, components and substructures made of FOREX®classic can be laminated with the hand-lay-up method, using unsaturated polyester resin and glassfibre mats.

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Outdoor applications

Dimensional change (thermal expansion)

The variation in sheet length due to heat (usually from sunshine) is known as thermal expansion. Especially the expansion due to rising temperature is very important to consider in outdoor applications. The coefficient of linear expansion specifies by how much a sheet of 1 metre expands if the temperature increases by 1 Kelvin (i.e. 1℃). For e very day's purposes, **FOREX®classic sheets have a coefficient of linear expansion of 0.07 mm/mK.**

The thermal expansion can be calculated

- In Central Europe a maximum temperature variation of 60℃ (-20℃ in winter, +40℃ in summer) must be taken in account.
- Dark sheets and those with dark decorations heat up much more in the sun (up to 60℃) than white sheets or those decorated with light colours.
- Sheets and cuts mounted in unventilated spaces like shop windows can heat up to as high as 80℃ due to solar irradiation. This may even lead t o the deformation of the sheets.

A 2 metre long, dark FOREX®classic sheet fitted on a spring day at an ambivalent temperature of 20℃ will reach at least 50℃ in midsummer. This te mperature increase of 30℃ will cause the sheet to become longer by:

0.07 mm x (2 [m] x 30[℃]) = approximately 4 mm

It is essential to consider such variations in length (expansion) when installing FOREX®classic sheets, otherwise distortion, buckling or warping will occur. Keep in mind that this expansion affects not only the length but of course also the width of a sheet.

UV stability

- White FOREX®classic sheets resist the sunlight very well. Unfavourable environmental influences may, however, lead to heavy dirt accumulation or intensified ageing. Use UV stabilised inks and possibly protective lacquers.
- Grey and black FOREX®classic sheets are conditionally suited for outdoor applications. Coloured FOREX®classic sheets are unsuitable for long term outdoor applications because the UV fraction in the sunlight may provoke colour changes.

Exterior signs

- Temperature fluctuations and wind loads (pressure and pull) must be assessed before deciding on the method of fastening.
- Thin sheets are frequently mounted in a frame for greater strength. Here too, the thermal expansion must be considered.
- Use only stainless steel fastening elements to prevent brown rust marks.

Cleaning

Safety first!

The majority of substances used for cleaning aren't that harmless! Skin and eye contact as well as accidental consumption can cause medical problems. Moreover, many cleaning agents are also inflammable and must only to be used in well-ventilated areas far from ignition sources or heat.

Cleaning

In principle, the surfaces of FOREX®classic sheets are ready for use. However, in order to ensure prime conditions for the adhesion of paints, bonding agents and adhesive films, the surfaces must be free of dust, greasy filth, fingerprints and so on before carrying out any decorative work.

- Use only isopropyl alcohol (IPA) for cleaning the surfaces of the sheets.
- Use only non-fluffy paper towels and change them frequently.
- Stubborn filth (e.g. felt pen marks) can be removed with a fibrous cleaning pad, accepting a slight dulling of the surface.

Avoid at all cost!

- With the exception of isopropyl alcohol, all liquid cleaners must be checked for suitability before use. They frequently leave residues (even methylated spirit), dull the surfaces (especially acetone) or embrittle the material (many solvents contain a high proportion of aromatic components).
- Attention: Sanding and grinding cause irreversible changes of the surfaces.

Antistatic treatment

FOREX®classic sheets are good electrical insulators. For this reason static charges incurred by handling or cleaning can only be discharged by artificial means.

- Passing the sheets through a stream of ionised air is an effective physical method.
- Wiping the sheets with a liquid antistatic agent prevents the build-up of new static charges and in turn the attraction of dirt particles for a certain period of time. As this "protective film" has a detrimental effect on the adhesion of paints and adhesives, it should only be applied at the end of all surface treatment processes.

Painting

Painting offers advantages

Many applications of FOREX®classic sheets call for precisely matched colours (e.g. house colour). Such colorations are best achieved by film lamination or painting. Effective light stabilising in the topcoats can significantly improve the weathering resistance, i.e. delay UV damage. The additional cost for such long-term protection quickly pays off in outdoor applications.

Recommendations for paints and lacquers

Different types of paints are used for painting FOREX®classic sheets:
- For indoor applications: Water-dilutable one component paint systems
- For outdoor applications: Two component polyurethane enamel paint systems
- Solvent-based spray paints for rigid PVC
  (Attention: Danger of embrittlement !)
- Acrylate paints, acrylic-PVC paints, acrylate-PU paints

Only generic designations are given here because any specific recommendation of products or manufacturers would quickly be outdated by the rapid pace of product development. However, all major suppliers offer several different varieties, e.g. for indoor and outdoor use, solvent based paints, water-based paints, primers, topcoats, transparent lacquers, etc.

Notes on application

The responsibility for an acceptable result lies with the user. It is therefore imperative to consult the paint manufacturer's advisory service before using a product for the first time.
- If necessary, degrease the surfaces, then sand them slightly (abrasive paper K320).
- For removing grease use only isopropyl alcohol, never acetone, trichlorethylene, paint thinners or other cleaning agents which attack the surface. Then allow the surface to dry off before continuing.
- A primer coat is recommended for most applications and particularly for outdoor applications. Always follow the paint manufacturer's instructions.
- The drying temperature must not exceed 50℃.

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Printing

Screen printing

Virtually all inks formulated for rigid PVC adhere very well to the white, mat surfaces of FOREX®classic sheets. UV curable inks and solvent-based inks are both well suited for the job. Thixotrope varieties are somewhat more beneficial for printing on FOREX®classic sheets than liquid types. Epoxy and enamel paints have proved unsuitable. New or unfamiliar combinations of inks and substrates should always be matched with the envisaged printing process before launching a series production. This applies especially with respect to the achievable resolution. A 150-31 mesh in combination with a dot size of 23 certainly results in good quality prints. However, also the conditions of use (e.g. outdoor use), the abrasion resistance or the subsequent processing of the printed item need to be taken into account. The surfaces must of course be totally free of dust and grease.

- <u>Attention:</u> The combination of intense UV and IR energy in the drying tunnel may result in discoloration and cause warping is the print remains in the drying tunnel for too long. Care must be taken that the prints are not over-cured as this may lead to adhesion problems. The drying temperature must not exceed 50°C.
- <u>Attention:</u> Unsuitable screen printing inks, i.e. those which are excessively hard or aggressive because of their solvent content may cause substrate brittleness and even breakage if the printed item is subjected to impact (e.g. also by die-cutting). Checking the compatibility of the envisaged ink with the FOREXclassic sheets is essential.

Direct digital printing

FOREX®classic sheets are increasingly chosen as substrates for direct digital printing. However, the FOREX®classic sheets are only one of several influencing variables in the context of this printing technology. Protection film, image layout, printing machine, ink, machine operator and a variety of environmental influences are just as crucial for producing a quality print.

- <u>Bulb age, number of bulbs and lamp settings:</u> Too low UV energy output results in insufficient cross-linking and consequently in inadequate ink adhesion. Too high UV energy output may cause yellowing of the substrate whereas the IR energy which is also emitted by the bulbs may lead to overheating and possibly cause warping of the substrate.
- <u>Image and colour value:</u> Due to different crosslinking properties, bright and transparent shades adhere better to the substrate than dark and opaque shades. Another reason for inadequate ink adhesion might be excess ambivalent humidity. The ink adhesion can reliably be assessed earliest 24 to 48 hours after printing.
- <u>Protection films:</u> Though they prevent staining of the surfaces, protection films also increase the static charge in the sheets when they are ripped off. This might lead to non-uniform print images ("clouding"). Recommendation: Use unfilmed sheets for direct digital printing jobs of bright, monochrome images (e.g. background panels).

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Application of adhesive films

Adhesive films and vinyl graphics

The surfaces of FOREX®classic sheets are ideally suited to the application of lettering films and vinyl graphics. In order to choose the right film for the purpose, the location (indoor or outdoor use), the desired period of use (durability) of the film, the type of bond (permanent or removable) and the processability of the film (printing, weeding) need to be taken into account.

Mounting of photographs and prints

- Clean the surfaces carefully and allow ample time for drying prior to any mounting work.
- Prevent the build-up of static charges (attraction of dirt particles).
- Work with cotton gloves if necessary.
- Use only a cold process for mounting photographs and prints onto the substrate.
- Use a quality permanent mounting film with an appropriate glue spread.
- Always recondition / pre-dry images and inkjet prints before mounting them.
- Regularly check the settings on the laminator (pressure, parallelism of the rollers).
- If a transparent encapsulating film is used, the formation of air bubbles can be prevented by warm lamination at 50°C.
- Leave freshly mounted photographs and prints to rest flat for at least 3 hours and don't flex them within the first 24 hours (beware of transport damages).

Troubleshooting

- Poor adhesion and bubbles can usually be counteracted by improved or modified working techniques (correct cleaning and drying, higher roller pressure and, above all, allowing a longer waiting time before transport).
- Bowing may be caused by too fresh, i.e. "wet" prints (shrinkage) or too much tension (over-drawing) on the adhesive film due to excessive braking of the unwinding roller.
- Wrinkles are often caused by distorted adhesive film, poorly aligned rollers or excessive roller pressure.

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Important notes

Storage

- FOREX®classic sheets must be stored flat and in a dry place at temperatures around 20°C.
- Packaged sheets must not be stored in the open because of the risk of deformation due to heat build-up in sunlight.

The responsibility remains with the user

- The information contained in this publication is based on our current level of knowledge and is, in our opinion, reliable. However, we cannot guarantee the correctness of this information for every application and for the results arising from their use.
- The user or processor is always responsible for ensuring that the materials and processes are appropriate, cost-effective and suitable for the intended purpose and location, and that they comply with the local laws and regulations.
- Technical knowledge and skills as customary in trade and industry, a normally developed capacity to make judgements as well as knowledge and observance of the applicable regulations appertaining to work safety and hygiene are assumed.
- To ensure up-to-date relevance and impartiality of this publication, Alcan Airex AG has decided to neither recommend any particular ancillary product and material nor their manufacturers, but always provide generic terms instead. This way, the purchasers remain free to obtain these products from suppliers of their choice.

Quality also after-sales!

The FOREX®classic expanded rigid sheets are produced by Alcan Airex AG in Switzerland to the stringent quality control measures imposed by the ISO 9001 standard. Nevertheless, should you encounter problems or simply wish to ask additional questions concerning the processing or use of these sheet materials, the Technical Services Department at Alcan Airex AG will be pleased to offer further information. Please do get in touch with us! We have put all modern communication facilities at your disposal and will do our utmost to help and provide additional assistance. In any case we wish you .....

SUCCESS WITH YOUR WORK