

**Impregnation with  
PTFE aqueous dispersions**

**Technical Service Note F6**



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## Summary

This note outlines the techniques of impregnation with Fluon®\* aqueous dispersions and describes in detail the impregnation of glasscloth and braided substrates.

## Introduction

Fluon® aqueous dispersions used for impregnation are normally stabilised with non ionic surfactants and contain about 60% PTFE by weight. The PTFE particles are negatively charged and have a mean size in the range 200 - 300 nm.

The PTFE in an aqueous dispersion is chemically similar to that supplied for moulding or extrusion and possesses all the properties characteristic of Fluon® PTFE: excellent chemical resistance, a low coefficient of friction, outstanding electrical properties and a wide working temperature range (-250 to +260°C; -420 to +500°F). A variety of absorbent materials, e.g. glasscloth, braided substrates, graphite and porous metals, can be impregnated with Fluon® aqueous dispersions in order to combine their properties with those of PTFE. Sintering at 380 - 420°C (715 - 790°F) is usually required to achieve optimum properties but impregnation with Fluon® dispersion and subsequent drying at 90°C (195°F) will provide low friction characteristics and a certain amount of chemical resistance. It is therefore possible to impregnate a variety of absorbent materials, e.g. hemp, flax, which will not withstand the PTFE sintering temperature.

\*Fluon® is a trademark of the Asahi Glass Company

# Section 1. Impregnation of glasscloth

Because glasscloth does not become ionised when immersed in water, it is porous rather than absorbent, has a smooth surface, hence the amount of PTFE which it picks up during the first dip is relatively low. Many coats are therefore needed to achieve the smooth glossy surface demanded by most Fluon®-impregnated glasscloth applications. Glasscloth impregnated with Fluon® is normally sintered. Glasscloth is often coated with a sizing agent which has the double purpose of keeping the glass fibres together and acting as a lubricant during the cloth weaving process. Because the size becomes charred during the sintering process, causing discolouration, its prior removal will be necessary for those applications where colour is of prime importance. The size may be removed by passing the cloth slowly through the sintering oven at approximately 400°C (750°F) prior to impregnation.

## Equipment

Typical equipment for impregnating glasscloth with Fluon® dispersion is shown diagrammatically in **Figure 1** (overleaf). The following points should be noted:

- (1) The equipment should be installed in a place where it will be shielded from draughts.
- (2) The system should be designed so that vibration is minimal to avoid agitation of the dispersion in the dip tank and of the cloth passing through the tank.
- (3) The drive must be capable of being maintained at a constant speed to avoid uneven pick-up and agitation of the dispersion in the tank.
- (4) The dip-tank should be filled through an entry point near the bottom from a header tank. Attention to points (1) to (4) will help minimise foam formation in the dip-tank.
- (5) The dip-tank should be constructed of stainless steel and designed for ease of cleaning. The guide bars immersed in the dispersion should preferably be static.

(6) A waterjacket should be fitted round the dip-tank to maintain the dispersion temperature at 20 - 25°C (68 - 77°F).

(7) The dip-tank should be designed so that the minimum possible surface area of dispersion is exposed to the atmosphere, i.e. a deep tank of narrow width (see **Figure 1**).

Attention to points (6) and (7) will help to reduce water loss by evaporation.

(8) The oven tower should have three separately controlled zones: A drying zone operating at 90 - 100°C (195 - 212°F). A baking zone at 200 - 250°C (390 - 480°F). A sintering zone at 380 - 400°C (715 - 750°F). The sintering zone should be half the length of the tower. A sintering zone length of 5 metres (16.5 feet) should permit production rates of 2 metres/minute.

(9) An annealing chamber should be installed at the exit of the oven to prevent the impregnated glasscloth cooling too rapidly; this will help to reduce wetting problems when applying additional coatings.

(10) The oven tower should be exhausted to atmosphere to remove all fumes arising during the baking and sintering of the Fluon® impregnated glasscloth (see page 9, **Handling Precautions**).

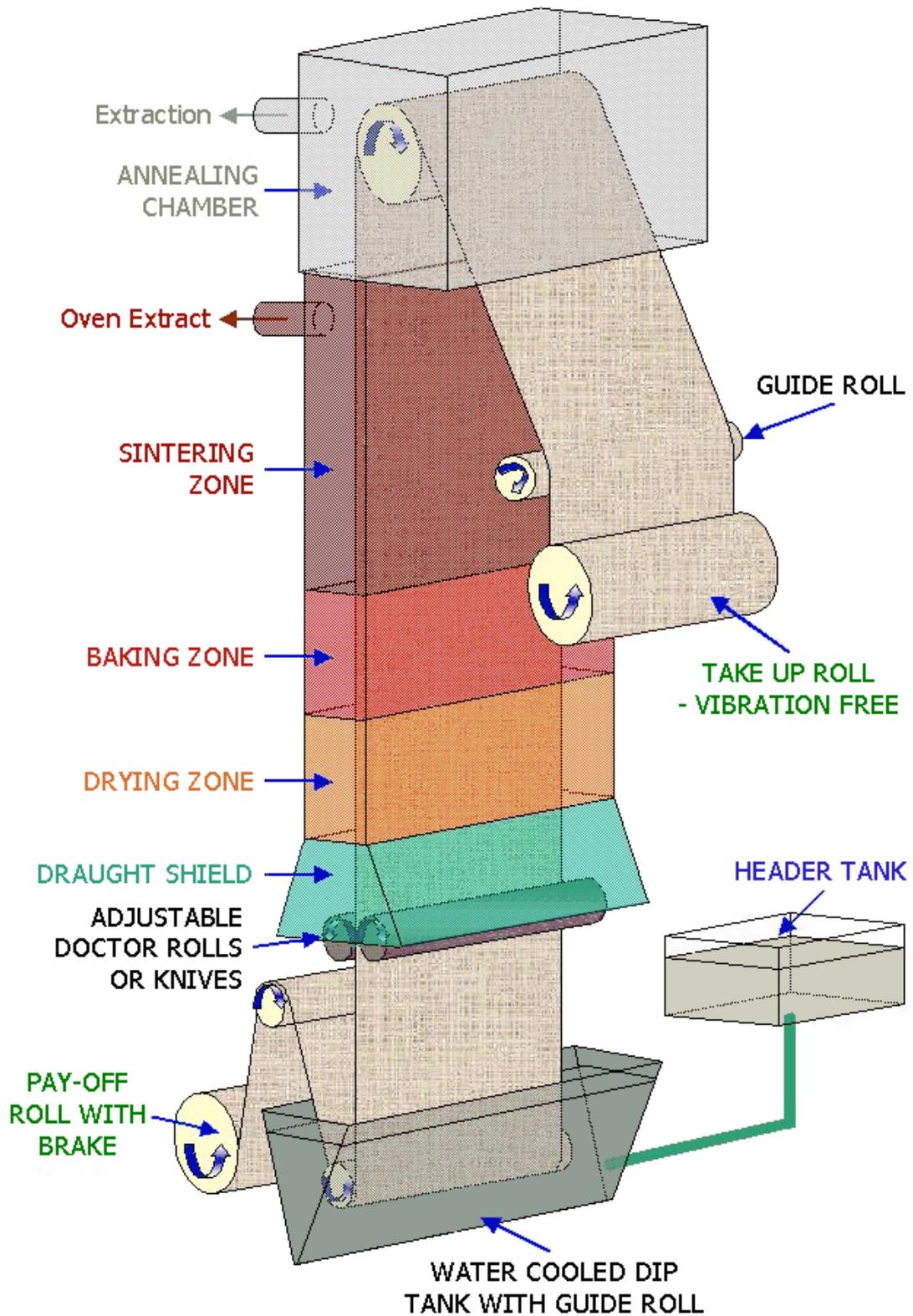
## Processing

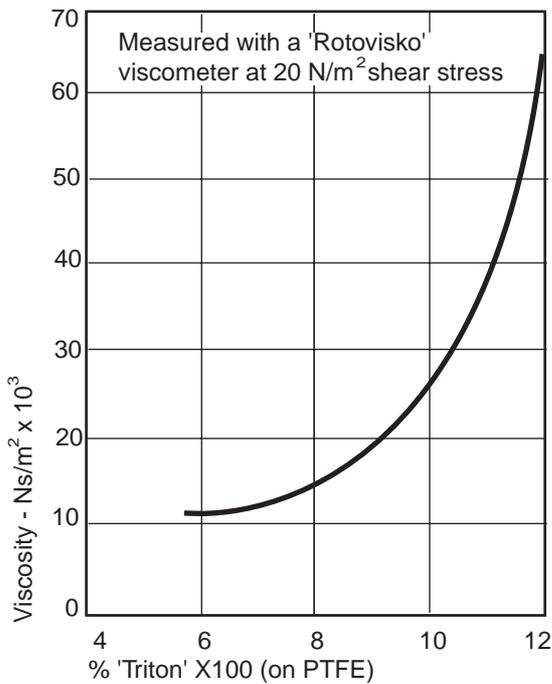
Fluon® dispersion should always be rolled or stirred gently for approximately five minutes, then passed through a 100-mesh sieve (BS 410-1: 2000) having a 150 µm aperture size, before use. A typical glasscloth impregnation run with (based on finished product) would be as in **Table 1**. The number of passes through the dip-tank will vary with the type of glasscloth and with the final appearance required. A normal (based on finished product). impregnated glasscloth is likely to contain 50 - 60% PTFE by weight (based on finished product).

**Table 1.**

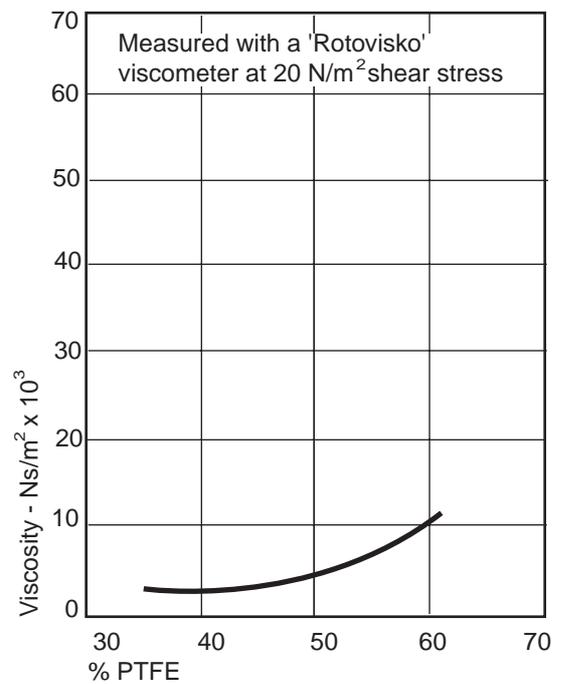
Passes through tank	PTFE content of dip tank %	Additional surfactant	Glasscloth speed m/min	Temperatures (attained by the glasscloth)		
				Drying	Baking	Sintering
1, 2, 3	45 - 50	No	1 - 2	90 - 100°C 195 - 212°F	200 - 250°C 390 - 480°F	380 - 400°C 715 - 750°F
4, 5, 6	55 - 60	Yes	1 - 2	90 - 100°C 195 - 212°F	200 - 250°C 390 - 480°F	380 - 400°C 715 - 750°F

Fig 1. Glasscloth impregnation





**Fig 2. Viscosity measurements of a Fluon® dispersion (60% PTFE) at 20°C (68°F) for various percentages of 'Triton' X100**



**Fig 3. Viscosity measurements of a Fluon® dispersion at 20°C (68°F) for various percentages of PTFE (6% 'Triton' X100 on the PTFE)**

The first two or three coats are best achieved by passing the glasscloth through a tank containing 45 - 50% by weight PTFE dispersion. Fluon® dispersions normally contain 55 - 60% by weight PTFE, depending on the grade, and may be diluted by the addition of demineralised (or distilled) water. The relationship between concentration and relative density at 20°C (68°F) is given in **Table 2**.

**Table 2.**

% solid	Relative density
30	1.20
35	1.24
40	1.29
45	1.34
50	1.39
55	1.45
60	1.51

Subsequent coats may require the addition of extra non-ionic surfactant (e.g. 'Synperonic'\* OP 10 or 'Triton'† X100) to aid wetting of the impregnated glasscloth. It should be noted that the addition of surfactant will also modify the viscosity of a typical Fluon® dispersion. **Figure 2** shows how the viscosity of a typical Fluon® dispersion varies with surfactant addition. **Figure 3** shows how the viscosity of the same dispersion varies with PTFE content.

The temperatures indicated in **Table 1** for drying, baking and sintering are those to be attained by the glasscloth as it passes through the oven. The drying operation removes water from the impregnated glasscloth whilst the baking operation assists in the removal of surfactant prior to sintering. The baking zone should be extended to ensure maximum removal of surfactant if carbonaceous residues, caused by decomposition of the surfactant, are to be avoided in the finished glasscloth. Higher sintering temperatures are not advisable as they will tend to reduce the mechanical strength of the glasscloth. Where faster throughput is required, it will be necessary to increase the oven zone temperatures but care should be taken to ensure that the cloth temperatures given in **Table 1** are not exceeded.

The production speed is partially governed by the rate at which the excess dispersion on the glasscloth runs back into the dip-tank. Excess dispersion on the doctor rolls is likely to dry and then be carried onto the glasscloth. In an extreme case the excess dispersion may cause uneven and blistered PTFE coatings on the glasscloth.

Foam formation in the dip-tank also governs the production speed. While foaming may be minimised by close attention to the points listed earlier (Equipment, page 5) it cannot be prevented since air is carried into the dispersion in the interstices of the glasscloth. The production speed must therefore be adjusted to ensure that foam is minimal and is not carried into the ovens on the glasscloth. The addition of anti-foam agents is not normally recommended, as they may prevent subsequent coats of dispersion from wetting out.

\*'Synperonic' OP 10 is available from Uniqema

†'Triton' X 100 supplied by Union Carbide

## Section 2. Impregnation of braided substrates

Braided packings are permeable and do not possess low friction surfaces; they are therefore conventionally impregnated with oil which reduces the permeability and acts as a lubricant. The life of such a packing is limited because it is inevitable that oil will be squeezed or washed from the packing. The resultant reduction in packing volume will promote leakage as the packing shrinks and hardens until it is no longer capable of providing an effective seal. Replacement of the conventional oil with Fluon® PTFE ensures that the lubricant cannot be squeezed or washed from the packing. Impregnation is simply achieved by dipping the packing into a tank containing diluted Fluon® aqueous dispersion. Alternatively, the yarn can be coated before braiding.

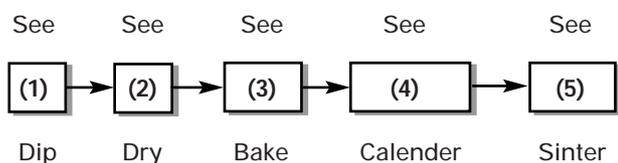
Fluon® aqueous dispersion GP1 stabilised with non-ionic surfactant and having a primary particle size of 250 - 280 nm (nm = nanometres, 1 nm = 10<sup>-9</sup> m) is commonly used for the impregnation of braided substrates.

Should Fluon® GP1 prove to be not entirely satisfactory for a particular process or packing construction it is possible that an alternative Fluon® dispersion will be more acceptable. Information concerning the availability of non-standard dispersions may be obtained from the local AG Fluoropolymers Office.

Fluon® dispersion should always be rolled or stirred gently for approximately five minutes, then passed through a 100-mesh sieve (BS 410-1: 2000) having a 150 µm aperture size, before use.

### Processing

The basic process is shown diagrammatically below.



#### (1) Dip

Pass either the braided packing or yarn through a tank containing Fluon® dispersion or diluted dispersion. Additional passes through the dip tank may be required if the initial surface pick-up is low.

Fluon® dispersion may be simply diluted by the addition of demineralised (or distilled) water. If desired, approximately 4% by weight of a non-ionic surfactant may be added to the water used for dilution. Suitable surfactants are 'Synperonic' OP 10 and 'Triton' X100. The degree of dilution of the Fluon® dispersion will depend on the end use for the item to be impregnated. Items with a large surface area, e.g. yarns, will pick up high percentages of PTFE from undiluted Fluon® dispersion and therefore diluted dispersion is preferable. Dilution of the Fluon® dispersion will also assist penetration of the PTFE into the yarn or packing. Some packing constructions may require impregnation with small particle size dispersion to ensure optimum penetration of PTFE. When uniform impregnation is required throughout a braided packing the individual yarns must be impregnated prior to braiding.

#### (2) Dry

Dry the impregnated packing at 80 - 90°C (175 - 195°F) to remove the water. The drying time for a particular type of packing is best determined by drying to constant weight. This time is then adopted as the minimum for that particular type. In a continuous process the rate at which the packing can be dried governs the speed of the impregnation.

#### (3) Bake (optional)

Bake the dried article at approximately 250°C (480°F) to assist removal of the surfactant. This operation is necessary when a Fluon® impregnated packing essentially free of surfactant is required. Care should be taken to ensure that the yarn or packing will withstand 250°C (480°F).

#### (4) Calender (optional)

Calender the impregnated packing. This operation presses the unsintered Fluon® into the impregnated article resulting in a smooth surface well adhered to the substrate.

#### (5) Sinter (optional)

Sinter the impregnated article at 380 - 420°C (715 - 790°F). Packings are rarely sintered since this produces a relatively rigid product which lacks the flexibility and compressibility normally required in packing and sealing applications. There are, however, occasions when this operation is necessary, e.g. in the manufacture of high temperature gaskets.

## Section 3. Impregnation of graphite and porous metals

Vacuum impregnation may be used in order to achieve the deep impregnation necessary to render graphite impermeable for applications such as heat exchangers. Bearings of porous metal may also be vacuum impregnated so that they have a reservoir of Fluon® for lubrication.

### Processing

The basic process is as follows:

- (1) Immerse the article to be impregnated in Fluon® aqueous dispersion within a vacuum chamber.
- (2) Reduce the pressure in the chamber to remove the air from the porous article.
- (3) Allow the air to return slowly into the chamber forcing the dispersion into the pores of the article.
- (4) If possible apply a positive air pressure to achieve deeper impregnation. Repeat (2), (3) and (4) if further impregnation is required.
- (5) Dry the article gradually, taking care to avoid too rapid removal of the water. Surplus PTFE may be removed from the dried article by brushing.
- (6) Increase the temperature gradually to approximately 250°C (480°F) to volatilise the surfactant.
- (7) Sinter the Fluon® by gradually increasing the temperature of the article to 380 - 400°C (715 - 750°F).



Fig 4. Above: normal dispersion appearance

Fig 5. Below: coagulated dispersion appearance



## Section 4. Storage and handling

Fluon® aqueous dispersions should be stored at temperatures between 5 - 20°C. Drums should be rolled, agitated or stirred gently once every month.

Dispersion supplied in Intermediate Bulk Containers (IBCs) should also be gently stirred once every month and immediately before use to ensure maximum homogeneity. Unless otherwise stated Fluon® dispersions will have a shelf-life of one year if these recommendations are observed.

Experience has shown that any of the following conditions are likely to cause irreversible coagulation of Fluon® dispersion:

- (1) Incorrect storage temperature, either too high (>30°C; 86°F) or too low (frost conditions).
- (2) Storage for an excessively long time.
- (3) Storage for long periods without rolling or stirring.
- (4) Over-vigorous mechanical agitation.
- (5) Addition of certain chemicals and solvents.

If there is any doubt about the condition of the dispersion the following simple test is recommended as a means of checking whether any coagulation has taken place:

- (1) Degrease a 100 mm x 100 mm glass plate with suitable solvent.
- (2) Support the glass plate at an angle of approximately 45° in a suitable dish.
- (3) Roll or gently stir the suspect sample for five minutes.
- (4) Check that the temperature of the sample is within the range 20 - 25°C (68 - 77°F).
- (5) Pour the sample down the glass plate.
- (6) Examine the coating on the glass plate, whilst still wet, for evidence of coagulated lumps of PTFE.

The appearance of normal dispersion and coagulated dispersion is compared in **Figures 4 and 5**. If coagulum is present, the material should be discarded and the reason for coagulation determined.

Within its working temperature range Fluon® is a completely inert product, but when heated to its sintering temperature it gives rise to decomposition products which can be toxic and corrosive. These fumes start to be produced during processing: for example, when the material is heated to sinter it or when brazed connections are being made to cables insulated with PTFE. The inhalation of these fumes is easily prevented by applying local exhaust ventilation as near to the source of the fumes as possible.

Smoking should not be permitted in workshops where Fluon® is handled because smoking tobacco contaminated with PTFE will give rise to polymer fumes. It is therefore important to maintain a good standard of personal cleanliness and to avoid contamination of clothing, especially the pockets, with polymer dust.

More detailed information on these points is included in the APME (Association of Plastics Manufacturers in Europe) publication 'Guide for the Safe Handling of Fluoropolymers', and in the relevant Fluon® Material Safety Data Sheet.

The following is a comprehensive list of Technical Service Notes on Fluon® PTFE. They are available from the AG Fluoropolymers sales office.

- F1** The Moulding of PTFE granular powders
- F2** The Extrusion of PTFE granular powders
- F3/4/5** The Processing of PTFE coagulated dispersion powders
- F6** Impregnation with PTFE aqueous dispersions
- F8** Processing of filled PTFE powders
- F9** Finishing processes for polytetrafluoroethylene
- F11** Colouring of polytetrafluoroethylene
- F12/13** Physical properties of unfilled and filled polytetrafluoroethylene
- F14** Isostatic compaction of PTFE powders
- F15** Cast Film from Fluon® PTFE dispersion GP1
- FTI500** Fluon® - A Guide to Applications, Properties & Processing
- FTI800** Potential Material & Equipment Suppliers

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Fluon® grades are general industrial grades. It is the responsibility of the purchaser to check that the specification is appropriate for any individual application. Particular care is required for special applications such as pharmaceutical, medical devices or food. Not all grades are suitable for making finished materials and articles for use in contact with foodstuffs. It is advisable to contact the AG Fluoropolymers sales office for the latest position. Users of Fluon® are advised to consult the relevant Health and Safety literature which is available from the AG Fluoropolymers sales office.



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