

PROCESSING GUIDE

Presintered Granular PTFE

INTRODUCTION

INOFLON[®] 515 is a presintered grade for making moulded porous PTFE sheets and parts which gives excellent optical reflectance and high air ventilation properties. It is processable by compression moulding. This resin has been produced using PTFE that has been melted once. The melting point of INOFLON[®] 515 decreases from the original nominal temperature of 342°C (648°F) to 327°C (621°F). Crystallinity of the PTFE also decreases from 95-98% to 50-70% as a result of the manufacturing process.

Compression moulding process used to produce part or component of desired shape. INOFLON[®] 515 allows production of billets, skive film and other machined profiles.

TYPICAL END USE PRODUCT

Many end products are fabricated by moulding and machining in to desired shapes. Example include, components used as electrical insulators, fluid handling seals, bearings, bush and many other parts.

FDA COMPLIANCE

When products made from INOFLON[®] 515 are correctly processed, that is sintered at high temperatures as practiced by the industry; they may comply with FDA Regulation 21CFR 177.1550 for use in contact with food.

Typical Properties of INOFLON[®] 515

Properties	Test Method	Unit	Nominal Value
Bulk density	ASTM D 4894	g/l	600
Average particle size (d ₅₀)	ASTM D 4894	µm	150
Powder flow	ASTM D 1895	g/min	350
Std. specific gravity (SSG)	ASTM D 4894	-	2.155
Melting point	ASTM D 4894	°C (°F)	327 (621)
Tensile strength	GFL Internal Method	MPa (psi)	20 (2901)
Elongation	GFL Internal Method	%	200

Note-These are typical properties and not to be used for specification purpose

PREFORMING

Before using the powder, it must be conditioned above 19°C (66°F). Preforming at temperatures in the range of 23–28°C (73–82°F) is most preferable. Resin temperature must be above 19°C (66°F) during moulding because of a special molecular transition of PTFE at 19°C (66°F) (see figure 2). PTFE molecule, which has a helical shape, tightens up by transition from a helix where 15 carbons are required for 180° turn to 13 carbons. Below 19°C (66°F) PTFE becomes stiff and less conformable, thus there is a chance that moulded parts could end up cracked. PTFE powder becomes sticky, forms lumps and flow is reduced at temperatures above 28°C (82°F).

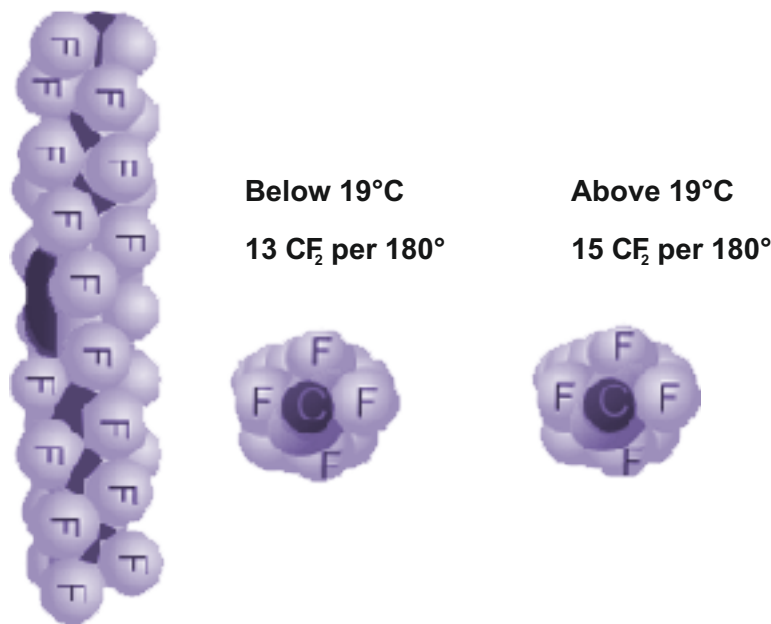


Figure 1- Transition of PTFE Molecule

First the mould is filled manually with the resin. Next, it is compacted into a preform that has a shape similar to the final shape of the desired moulding. The preform is then placed in an oven where it undergoes heating and cooling cycles in which heating and cooling rates and dwell times are defined and programmed. The two cycles together are commonly called sintering cycle. The preform is heated to a temperature above the crystalline melting point of the resin during the sintering cycle. The cooling cycle is used to control the crystallinity of the part. The properties of a part are function of preforming pressure, dwell time, sintering time and temperature, and the cooling rate.

One important observation is that INOFLON® grades are highly moldable resins and yield excellent properties at relatively low preform pressures. A note of caution, processors must determine the optimal pressure in their own equipment. The exact required preform pressure depends on the type of process, part size, shape and application requirements.

Generally, the lower range of the preform pressure is likely to result in lower end use properties of the finished part, especially in large parts. Preform pressure has a direct bearing on void closure and part properties in applications such as electrical insulation uses. Preform pressure has to be optimized for an application as mold shrinkage and tensile properties vary with preform pressure, sintering conditions and

Table 1- Recommended preforming pressure

INOFLON® Grade	Recommended preforming pressure (MPa)
515	20-25

SINTERING

A PTFE preform has limited cohesive strength and is essentially useless; sintering allows coalescence of the resin particles, which provides strength and void reduction. Sintering cycle profiles of time and temperature affect the final properties of the billet. Sintering temperatures exceed the melting point of PTFE 342°C (648°F) and range from 360°C to 380°C (680–716°F).

Various steps of the sintering process are described here. First the preform completes its elastic recovery and begins to thermally expand past the PTFE melting point, 342°C (648°F). The expansion can reach up to 25–30% by volume depending on the type of resin, powder, preforming pressure and temperature.

Above 342°C (648°F), PTFE is a transparent gel due to the absence of a crystalline phase. At the sintering temperature, adjacent melted PTFE particles fuse together and coalesce. After two particles have completely coalesced, they would be indistinguishable from a larger particle and voids are eliminated under the driving force of surface tension. Smaller particle resins and higher preform pressures improve coalescence

Coalescence and void elimination require time because of the limited mobility of PTFE molecules. The sintering temperature is held for a period of time to allow fusion, coalescence and void elimination to proceed and maximize properties in the part. A time is reached beyond which the part properties no longer improve and degradation begins. Property development should be balanced against cost in selecting a sintering cycle.

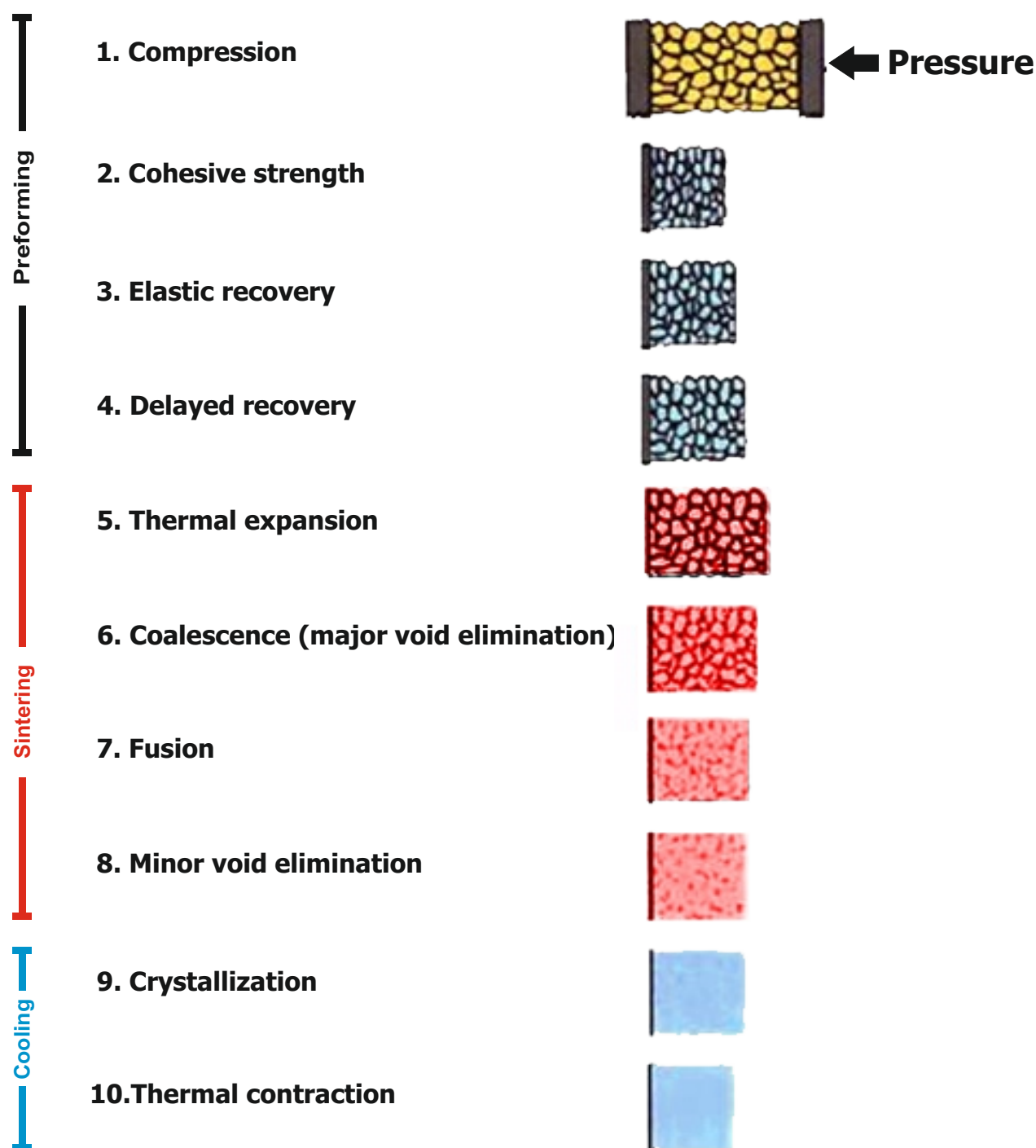


Figure 2- Schematic diagram of preforming and sintering sequence with PTFE

Figure 3 and Figure 4 provide examples of sintering cycles for a variety of cylindrical shapes and dimensions. These examples should be used as a conservative starting cycles, which allow a margin for shortcomings in the moulding and degassing operations. They can be further refined, optimized and possibly shortened by processors.

Figure 3- Typical sintering cycle for INOFLON® PTFE, Solid billets (Ref. - Table 2)

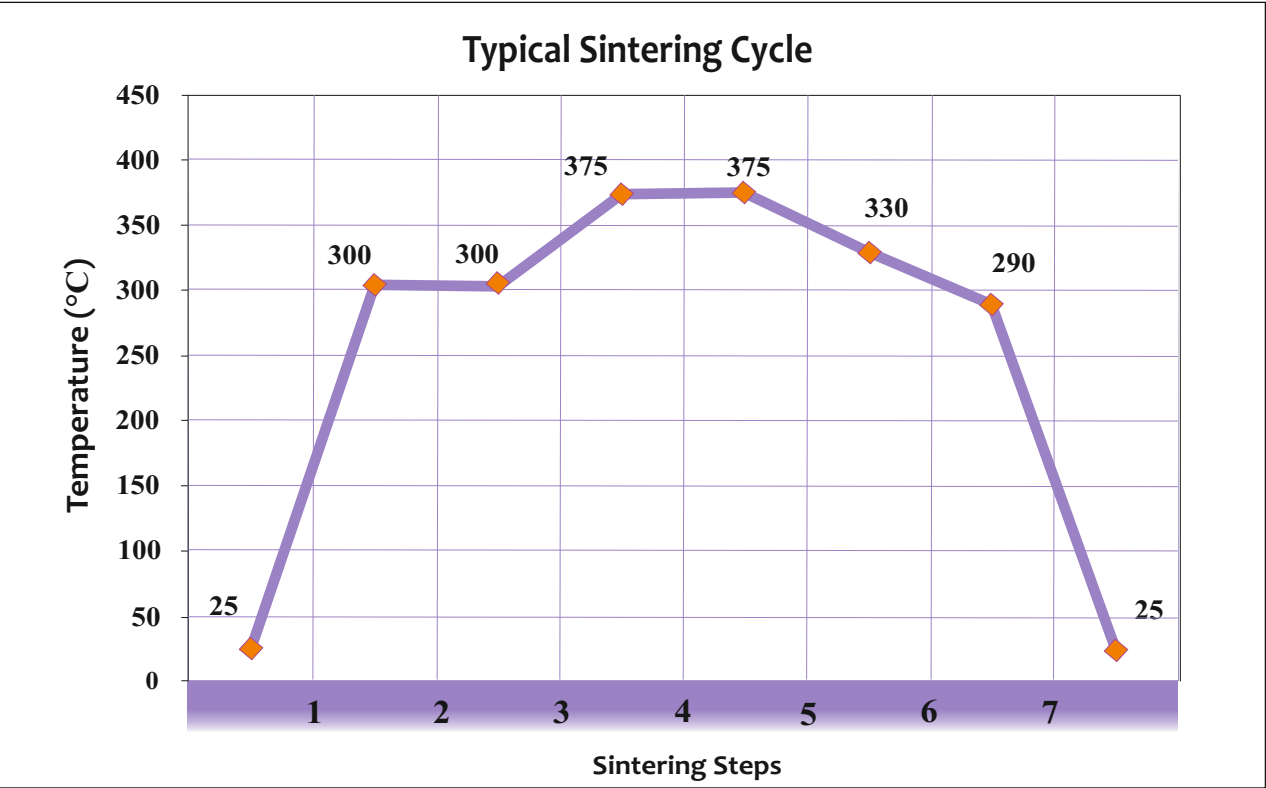


Table 2-Typical sintering cycle for INOFLON® PTFE, Solid billets:

Cycle	Diameter (mm)	Time Duration (Hours)							Total
Sintering Steps →		1	2	3	4	5	6	7	Time (hrs)
A	25	3	1	1	3	1	1	3	13
B	50	3.5	2	1.5	4	2	1.5	3.5	18
C	75	4	2.5	2	5	2.5	2	4	22
D	100	4	3.5	2.5	6	3.5	4.5	4	28
E	125	4.5	4	3	7	5	5	4.5	33
F	150	5.5	4.5	3.5	9	6	6	5.5	40

Figure 4- Typical sintering cycle for INOFLON® PTFE, Annular billets (Ref. - Table 3)

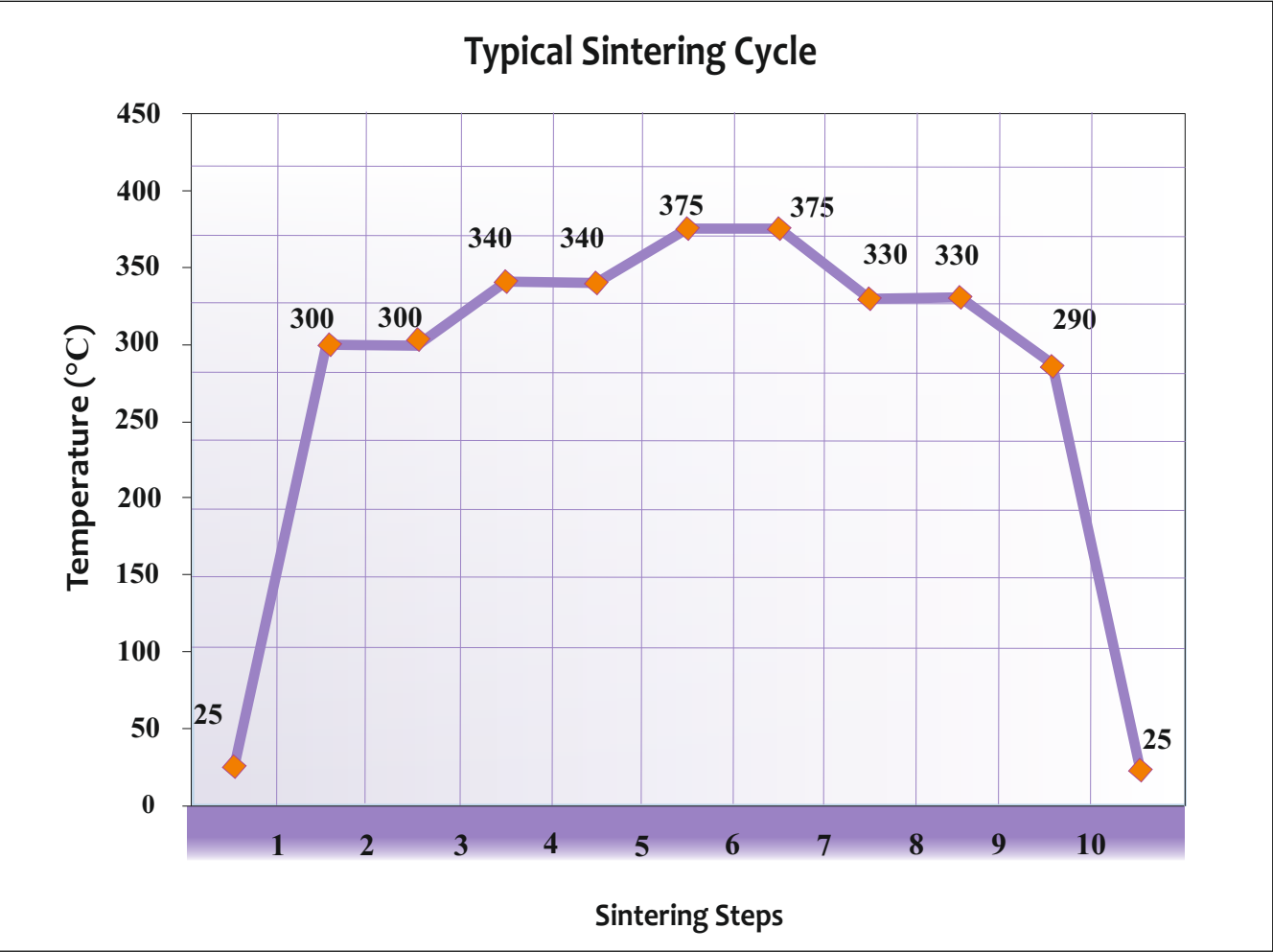


Table 3 -Typical sintering cycle for INOFLON® PTFE, Annular billets:

Cycle	Wall Thickness (mm)	Time Duration (Hours)										Total
Sintering Steps	→	1	2	3	4	5	6	7	8	9	10	Time (hrs)
A	25	3	1	1	0.5	1	3	2	0.5	2	3	17
B	50	3.5	3	1.5	1	2	6	3.5	1	4	3.5	29
C	75	5.5	4	2	1	2	9	5.5	1.5	6	5.5	42
D	100	6.5	6	3	1.5	2	11	7.5	2	8	6.5	54
E	125	8.5	8	4	2	2.5	14	9	2.5	10	8.5	69
F	150	10.5	10	4.5	2.5	3	17	11	3	12	10.5	84

SAFETY PRECAUTIONS

Handling and processing of PTFE must be done in ventilated area to prevent personnel exposure to the fumes liberated during sintering and heating of the resin. Fumes should not be inhaled and eye and skin contact must be avoided. In case of skin contacts wash with soap and water. In case of eye contact flush with water immediately and seek medical help. Smoking tobacco or cigarettes contaminated with PTFE may result in a flu-like condition including chills, fever and sore throat that may not occur for a few hours after exposure has taken place. This symptom usually passes within about 24 hours.

Vapors and gases generated by PTFE during sintering must be completely removed from the factory areas. Mixtures of some metal powders such as magnesium or aluminum are flammable and explosive under some conditions. Please read the Material Safety Data Sheet and the detailed information in the "Guide to the Safe Handling of Fluoropolymer Resins" published by the Fluoropolymer Division of The Society of the Plastics Industry available at www.fluoropolymers.org

HANDLING AND STORAGE

For best results the powder processing areas should be kept clean and free of all contamination. Organic contamination and foreign matter usually appear as dark spots often easily visible against the white PTFE background. Organic contamination material degrades at the sintering temperatures and forms discolored spots. They oxidize away as carbon dioxide wherever sufficient oxygen exposure takes place. It is, therefore, not unusual to encounter discoloration inside a part away from the surface where hardly any oxygen is present. Storage of PTFE at 20°C (68°F) or lower prevents lump formation as a result of movement and transportation.

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NOTE warning: Do not use any of INOFLON® PTFE resins in medical devices that are designed for permanent implantation in the human body. For other medical uses, prior permission of GFL may be sought.

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