Overview of Teflon™ PTFE

April 27, 2023

Teflon™ : Our brand

Non-melt processable

- PTFE Fluoropolymers
  - Fluoro-additives
  - Aqueous Dispersions
  - Fine Powders
  - Granular moulding resins

Melt-Processable

- FEP & PFA
  - Resins & Dispersions

Molecular weight PTFE product lines

Why PTFE resins have high molecular weight?

- Low interaction of PTFE molecules
- Low molecular weight PTFE resins are brittle, used as additives
- Physical properties increase with increasing molecular weight

Zonyl™ PTFE additives

Zonyl™ PTFE micropowders are added to other solid or liquid materials in order to provide inherent PTFE properties like:

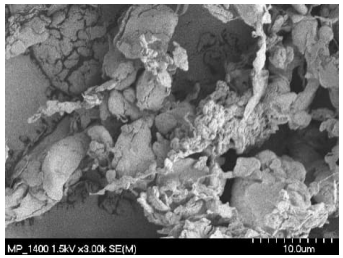
→Abrasion resistance

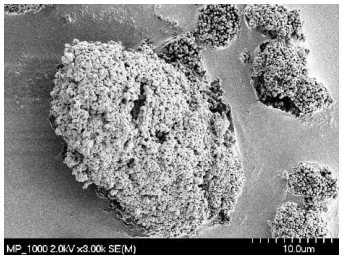
→Friction

→Surface appearance

Zonyl™ PTFE micropowders are characterized by:

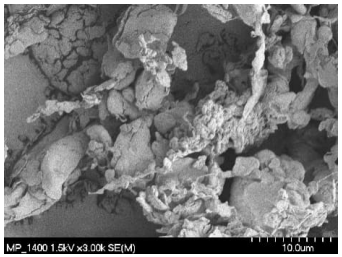
→ Particle size, ranging from 2 to 12µm
→Relatively low molecular weight, 10^4 – 10^5 g/mol (versus 10^6 - 10^7 for standard PTFE)
→Different particle shapes and morphology





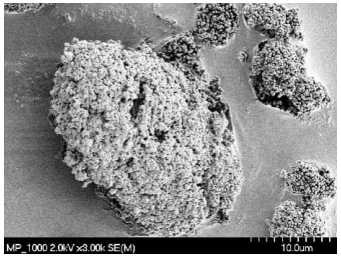
Types of Zonyl™ micropowders

Irradiated and grinded based on PTFE granular feedstock



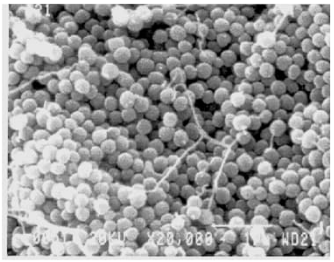
→Low surface area
→Less porous
→Irregular shape
→Active endgroups
→MP1200, 1300, 1400

Irradiated and grinded based on PTFE fine powder feedstock



→High surface area
→Porous
→Active end-groups
→MP1000, 1100

Directly polymerized to low molecular weight



→High surface area
→Porous
→No active end-groups
→Very consistent quality
→MP1600

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Zonyl™ grade summary chart

Property	MP1000	MP1100	MP1200	MP1300	MP1400	MP1400F	MP1600	MPD1700 (aqueous dispersion)
Average Particle Size (um)	12	4	3	12	10	10	7	0.2
Specific Surface Area (m2/g)	7-10	7-10	1.5-3	1.5-3	1.5-3	1.5-3	8-12	
Base Polymer	Fine powder	Fine Powder	Granular	Granular	Granular	Granular	Dispersion	Dispersion
Supported for food contact	No	No	No	No	Yes, if processed above 265degC	Yes	Yes, if processed above 265degC	Yes, if processed above 265degC
Principal Application	Elastomer	Coating	Coating Inks	Thermoplast	Thermoplast Elastomer	Thermoplast Elastomer	Lubricants	Coating

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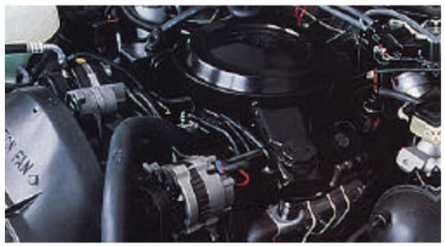
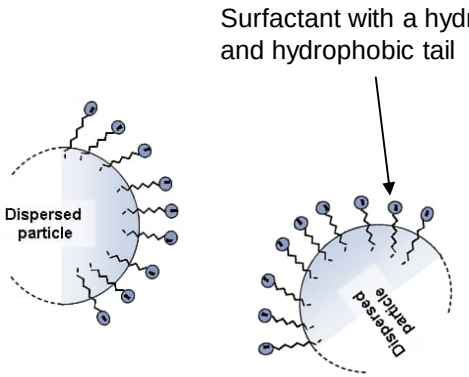
Applications

- Thermoplastics
- Elastomers
- Coatings and paints
- Inks
- Greases and oil



Brief description of dispersions

- A mixture of water, PTFE particles and surfactants
- The surfactant is there to keep the PTFE particles in dispersion and to avoid coagulation of PTFE particles
- The PTFE particle size is around 200 nm
- The PTFE concentration is typically 60wt%
- The surfactant concentration is generally around 3.6wt%
- Appearance similar to milk



Key properties of dispersions

- Film formation
  - How well the PTFE dispersion wet the surface
- Film build
  - How thick layer of PTFE dispersion can be applied on the surface without cracking occur upon drying
- Chemical compatibility
  - The capability of the dispersion to be mixed with other components without coagulating

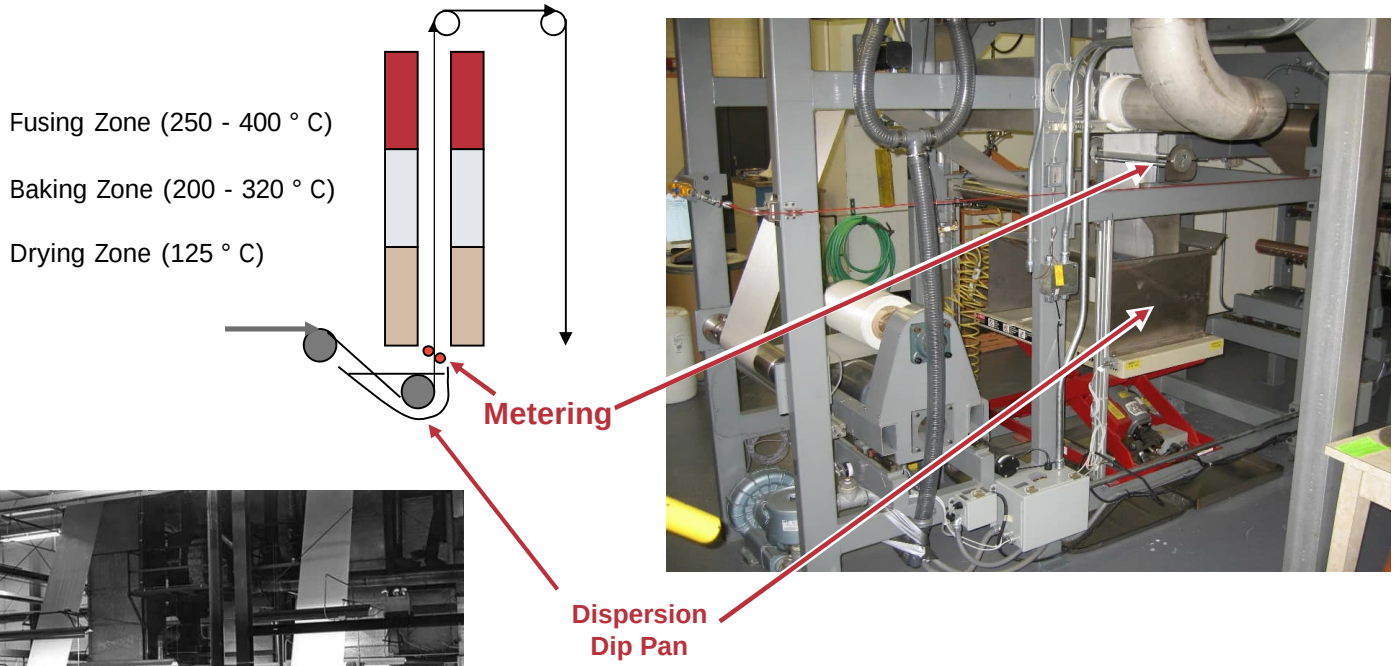
Black PTFE dispersion on white PTFE sheet.

Cracking of dried PTFE coating because of too thick layer.

Teflon™ dispersion applications

- Glass cloth coatings
- Metal coatings
- Impregnation
- + many other low volume applications

Glass Cloth Coating: manufacturing process

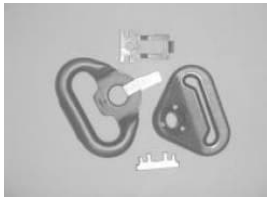


Glass Cloth Coating: applications

- Conveyer belts
- architectural fabrics, tensile roofing
- electrical insulation in motors generators and transformers
- wrapped insulation on wires for high temperature applications
- non-adhesive sheets for laminating
- flexible wiring board

Metal Coating Applications

- Consumer cookware
- Industrial bake ware
- Tanks and pipes
- CPI; pumps & valves
- Mold release coatings



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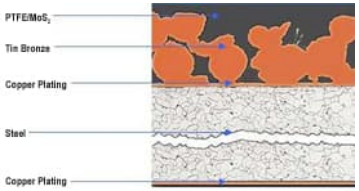
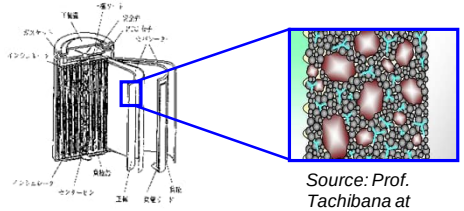
Other dispersion applications

- Non lubricated bearings
- Impregnated yarns and fabrics
- Anti drip additive
- Binder in batteries





Source: Prof. Tachibana at Yamagata Univ

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Teflon™ dispersion portfolio

Type	Main uses	Main characteristics	Solids content (wt%)	Dispersion particle size (nm)	Surfactant content (wt% on solids)	Surfactant type	Melt Flow Rate (g/10min)
PTFE DISP 30	Impregnation, Glasscloth base coat, Anti-drip, de-dusting, binder	General use	60 ± 1.5	220 ± 25	6 ± 0.5	Non-ionic	---
PTFE DISP 33	Glasscloth coating – top and base coats	Good gloss, weldability	60.8 ± 1.1	220 ± 25	6.5 ± 0.5	Non-ionic	---
PTFE DISP 35	Co-coagulation with fillers, dry bearings		35 ± 3	245 ± 25	2.2 ± 0.2	Anionic	---
PTFE DISP 40	Metal coating formulations	Good shear stability	60 ± 1.5	230 ± 20	6 ± 0.5	Non-ionic	
FEPD 121	Glasscloth, film coating	FEP polymer	55.5 ± 1	195 ± 30	5.5 ± 0.9	Non-ionic	**7.5 ± 2.5**
PFAD 335D	Glasscloth, metal coating, welding	PFA polymer	60 ± 2	215 ± 30	5.3 ± 0.9	Non-ionic	**2 ± 0.7**
PTFE MPD 1700	Additive for paints, coatings, mould release	Low Molecular weight	56 ± 3.5	200 ± 100	6 ± 1.5	Non-ionic	17 ± 13

Packing, handling and storage of dispersions

→dispersions are supplied in 1000 liter IBCs or 30 liter drums (PTFE) or 114 liter drums (FEP, PFA)

→Dispersions should be stirred regularly (ideally once a month) in order to prevent sedimentation

→Stirring should be done at low shear (slow speed) in order to prevent particle coagulation

→The dispersion should be stored between 7-32ºC

→ Its good practice to filter the dispersion prior to use, generally a 50µm filter is sufficient

→ The pH should be kept above 9 otherwise microorganisms will attack the surfactant and create a “sour dispersion”. Ammonium hydroxide can be added to adjust the pH

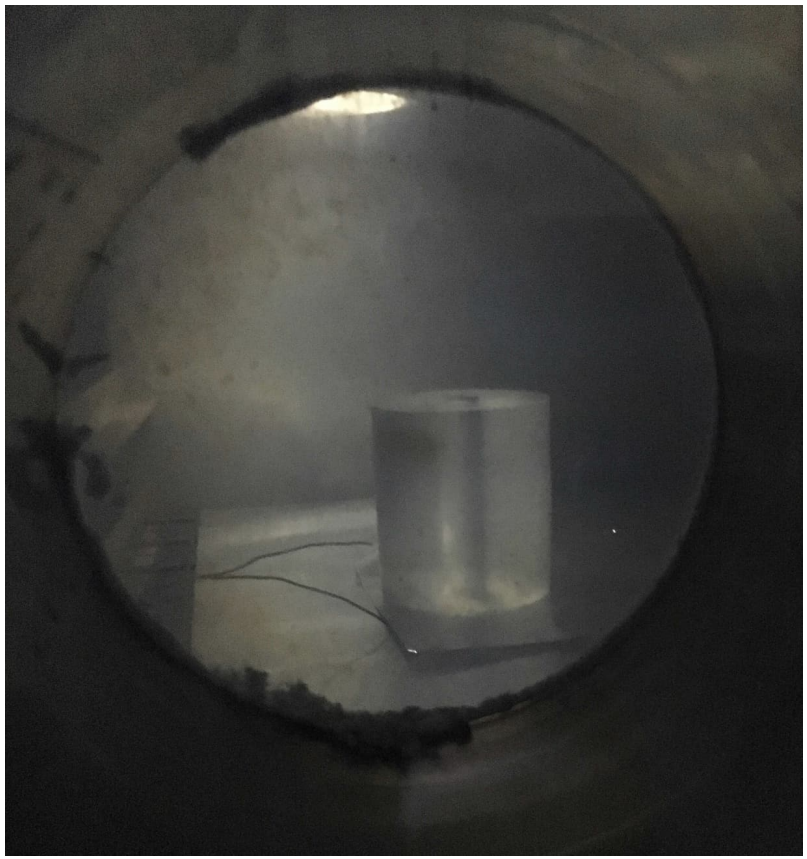
→ When the guidelines in the product information sheet are followed, the dispersion will keep its functionality for many months or even years. Due to gravity the dispersed PTFE particles will eventually sink to the bottom of the container. If the dispersion is not periodically re-agitated, the PTFE particles will coagulate and irreversible settle in the bottom. Periodical gentle re-agitation of the dispersion, will re-distribute the PTFE particles in the dispersion and it will function as normal

Teflon™ PTFE Resins

PTFE 807N X
Ø 100 mm

@ 380 C
Fully sintered

Total cycle 20 h



Why is PTFE “different” to process?

PTFE: multitude of use in different phases

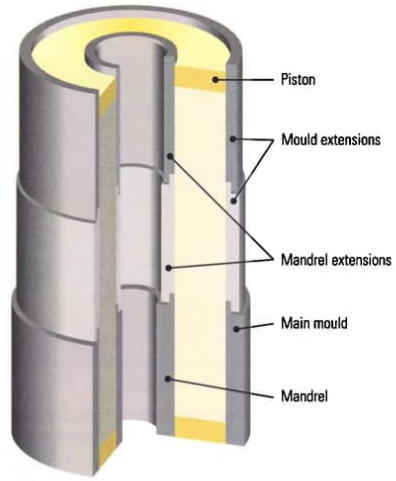
• Powder:	Additive
• Unsintered or partially:	Thread sealing Tape / Electrical Grade Tape
• Unsintered Stretched:	ePTFE, Gaskets, Membranes
• Sintered:	Wire & Cable insulation, Tubes, Profiles, Sheets, Film, Machined Parts, Simple Shape Parts (large series) & Complex Shaped Parts (small series)

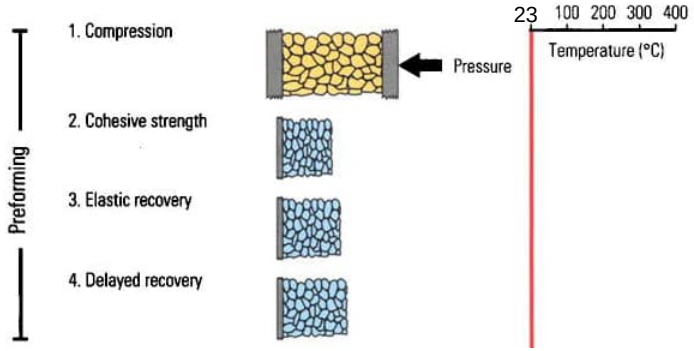
Teflon™ PTFE Granular

Major processing techniques:

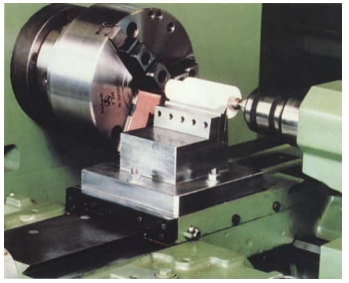
- Compression molding
- Isostatic molding
- Automatic molding
- Ram extrusion

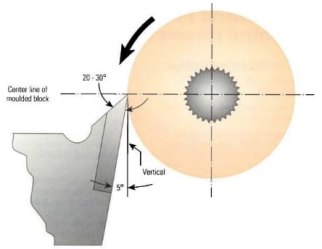
Compression molding



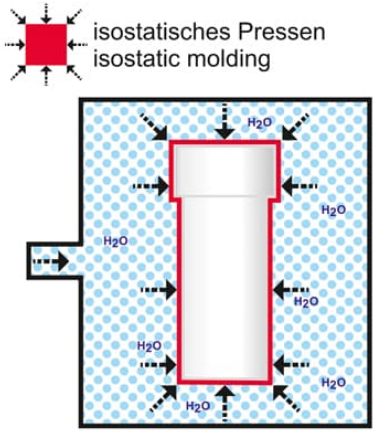


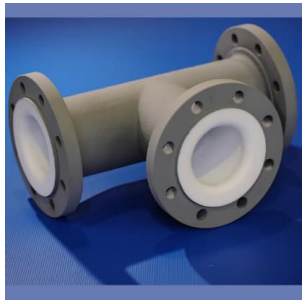
Machining or
Skiving of billet





Isostatic molding





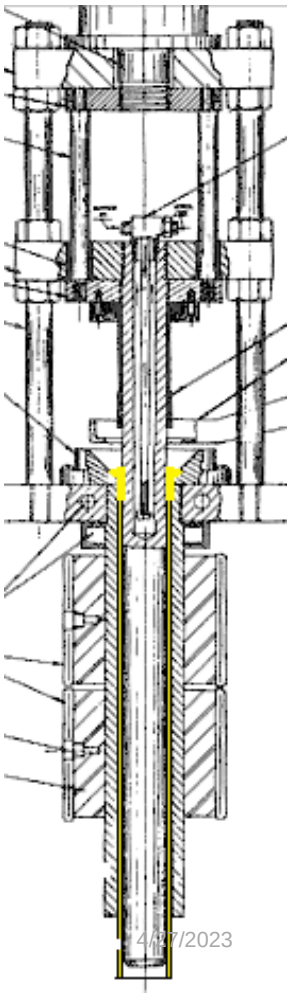
Isostatic molding
- Allows production of complex shapes
- Tight dimensions
- Uniform physical properties
- Cost savings
- Shorter cycle times

Automatic Molding
- Mould filling, compression of PTFE into part, part removal of mold in one machine.
- Simple shape, very large series

Ram extrusion

- Compaction, cooling and sintering done in same equipment
- Rods, tubes, etc

Continuous process



Teflon™ PTFE granular product line - standard

Characteristic	Unit	PTFE 7A X	PTFE 7C X	PTFE 8A X	PTFE 807N X
Bulk Density	g/l	460	260	680	900
SSG		2.16	2.16	2.15	2.16
Particle Size	µm	38	31	490	550
Themral Instability Index		3	3	8	5
Tensile Strength	MPa	48.3	31	41.4	33
Elongation	%	375	350	330	320
Hardness, Shore D		59			59
Dielectric Strength short duration	kV/mm	50.1			45.5
Application					
Compression moulding	Large billets for skived tapes				
	Sheets				
	Small billets and shapes				
	Other basic shapes				
Isostatic moulding					
Automatic moulding					
Ram extrusion	High back pressure				
	Low back pressure				
Compounding					
Comments		Fine cut resin	Fine cut, low particle size	Free flow resin	Free flow resin

Recommended

Suitable

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Teflon™ PTFE granular product line - modified

Characteristic	Unit	PTFE NXT 70	PTFE NXT 75	PTFE NXT 85
Bulk Density	g/l	400	400	700
SSG		2.17	2.17	2.17
Particle Size	µm	33	33	550
Tensile Strength	MPa	38.6	41.4	27.6
Elongation	%	550	600	450
Deformation Under load 14 Mpa	%	4.0	3.4	3.5
23 °C, 24 h				
Application				
Compression moulding	Large billets for skived tapes	■	■	■
	Sheets	■	■	■
	Small billets and shapes	■	■	■
	Other basic shapes	■	■	■
Isostatic moulding				■
Automatic moulding				■
Ram extrusion	High back pressure			■
	Low back pressure			■
Compounding		■	■	
Comments		Fine cut resin, modified	Fine cut, modified +	Free flow resin, modified+
Recommended	■			

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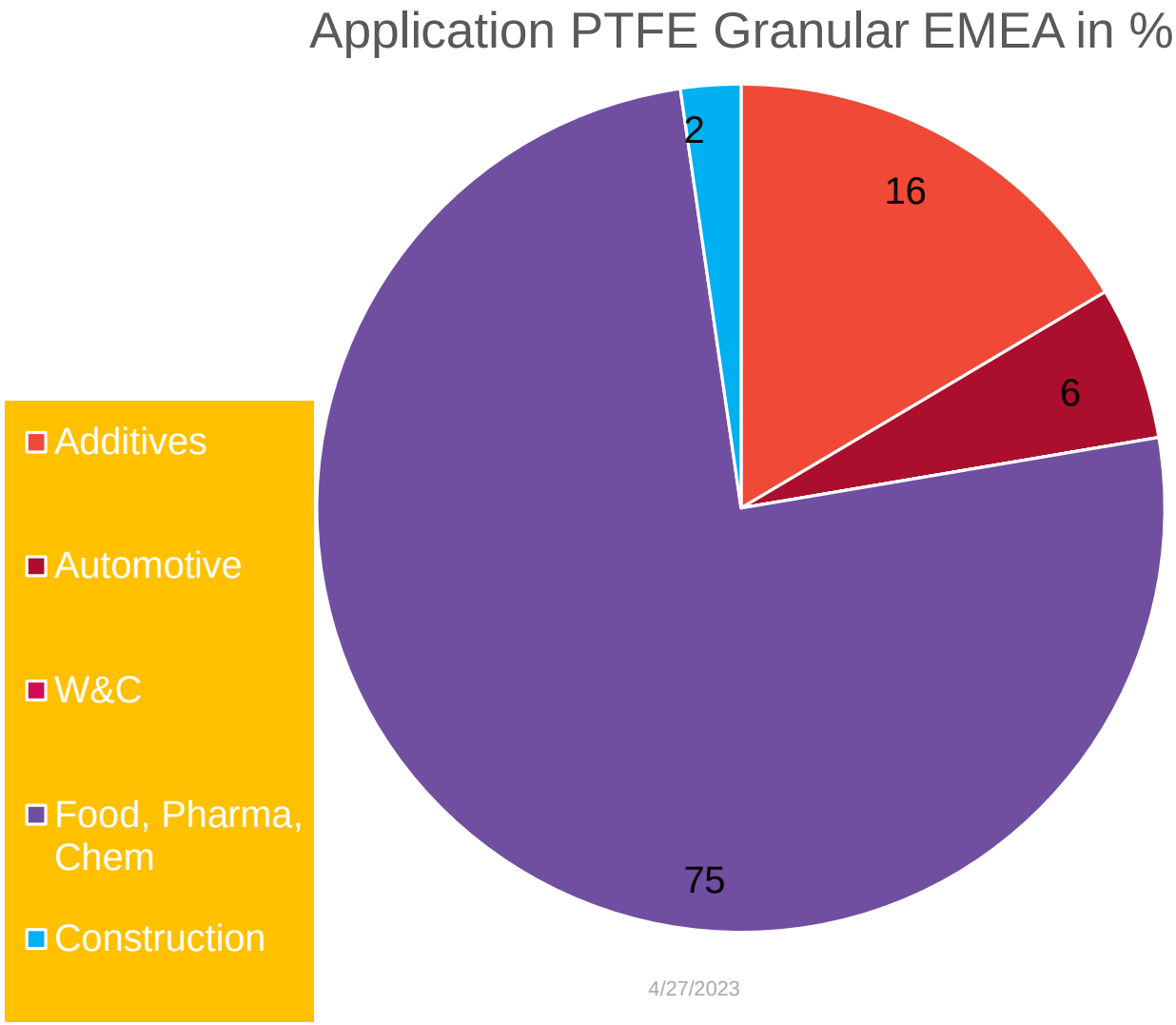
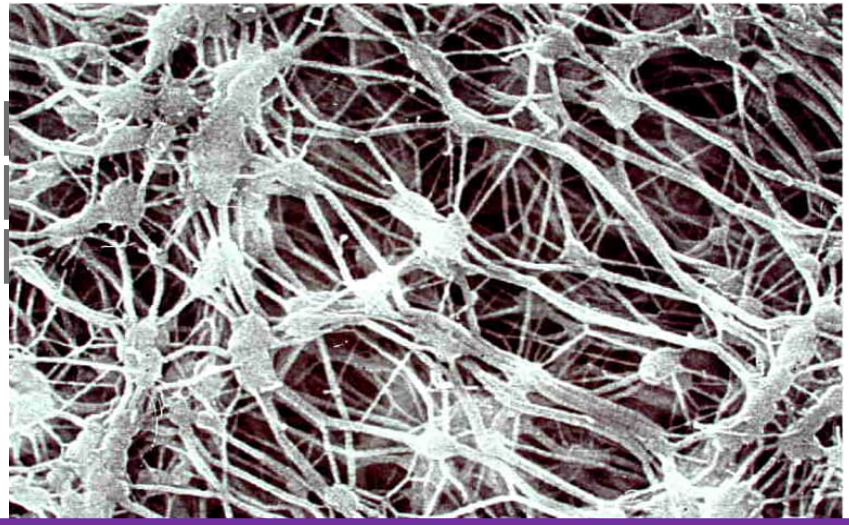

Application PTFE Granular EMEA in %
2
16
6
75
Additives
Automotive
W&C
Food, Pharma, Chem
Construction

Teflon™ PTFE Fine Powder

Teflon™ PTFE Fine Powder

PTFE fibrillation – !! IRREVERSIBLE !!



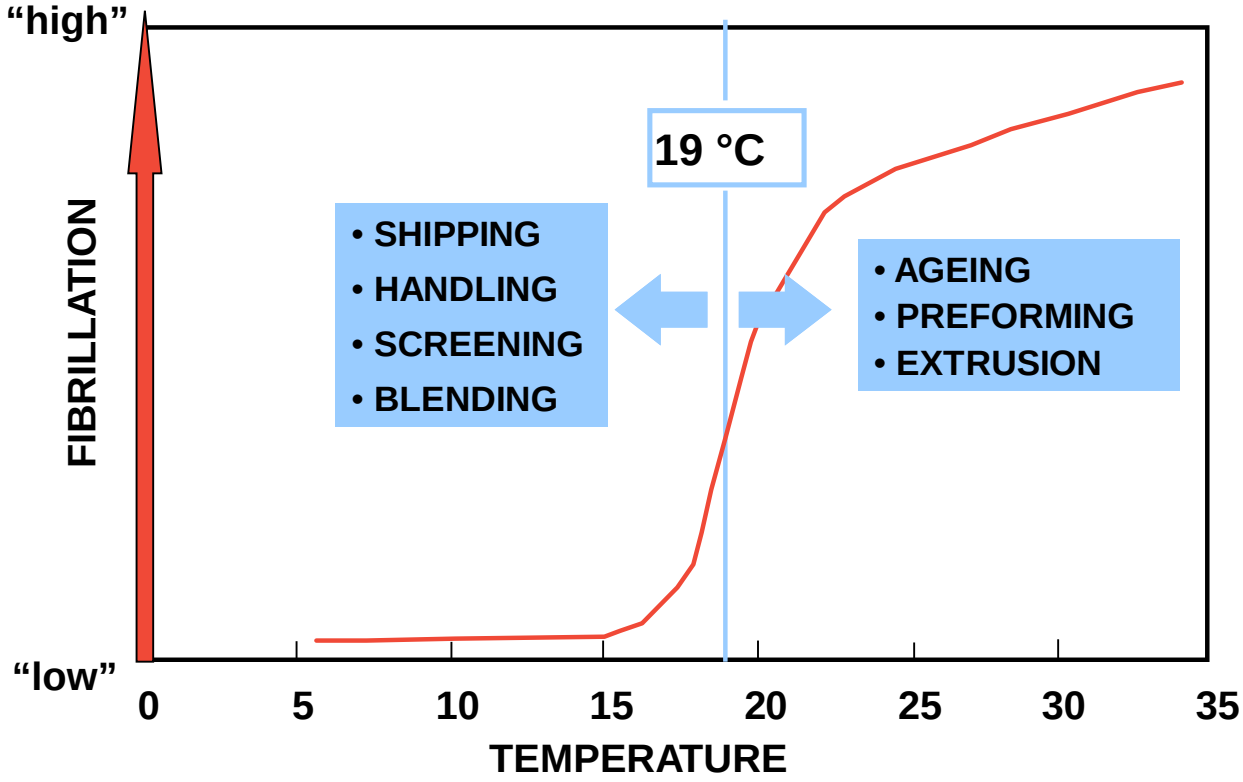
→ PASTE EXTRUSION PROCESS

PTFE Fine powder Paste Extrusion

- Ram extruder
- Lubricated PTFE with hydrocarbon
- Reduction in flow section for controlled fibrillation of PTFE
- Drying of hydrocarbon
- Sintering of PTFE, if needed
- Fibrillated PTFE maintains shape for drying and sintering
- Cooling of PTFE

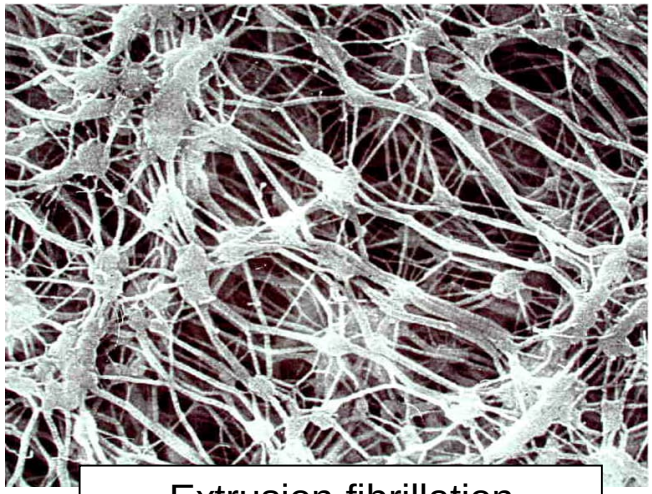
Why do we advise customers to handle carefully and transport fine powders cooled?

FIBRILLATION CURVE

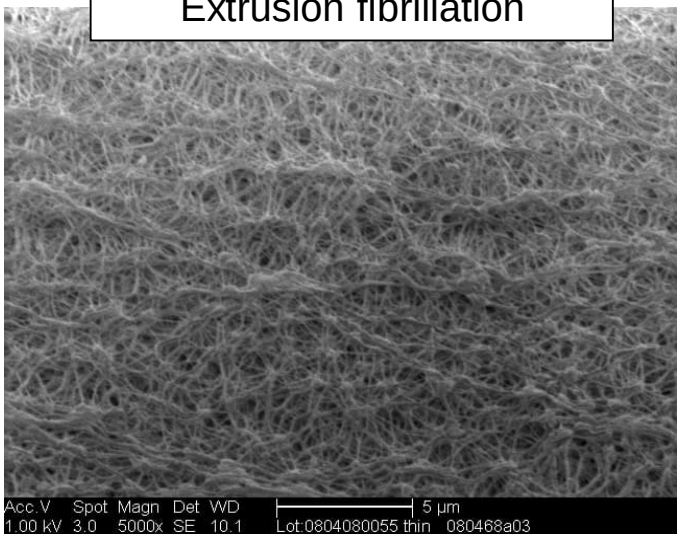


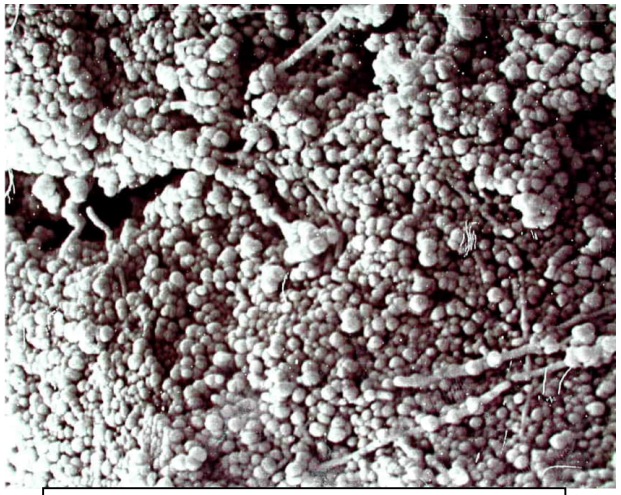
T > 19 ° C	⇨	PTFE Fine Powder	- More tendency to agglomerate - Ability to fibrillate

PTFE fibrillation



Extrusion fibrillation





Resin damaged by excessive handling above 19 ° C transition

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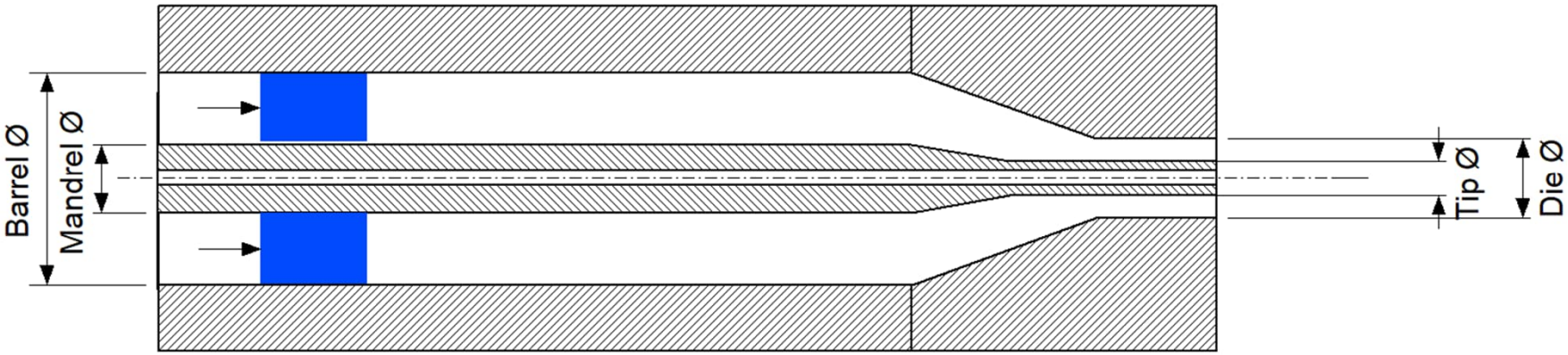
Fine Powder paste extrusion – different steps

1. STORAGE
2. CONDITIONNING @ T< 19 ° C
3. SIEVING
4. BLENDING WITH LUBRICANT
5. AGEING @ T ~ 35 ° C
6. PREFORMING
7. EXTRUSION
8. DRYING
9. SINTERING (MELTING)
10. COOLING

PTFE Paste extrusion



$$\text{Reduction Ratio (RR)} = \frac{((\text{Barrel Ø})^2 - (\text{Mandrel Ø})^2)}{((\text{Die Ø})^2 - (\text{Tip Ø})^2)}$$

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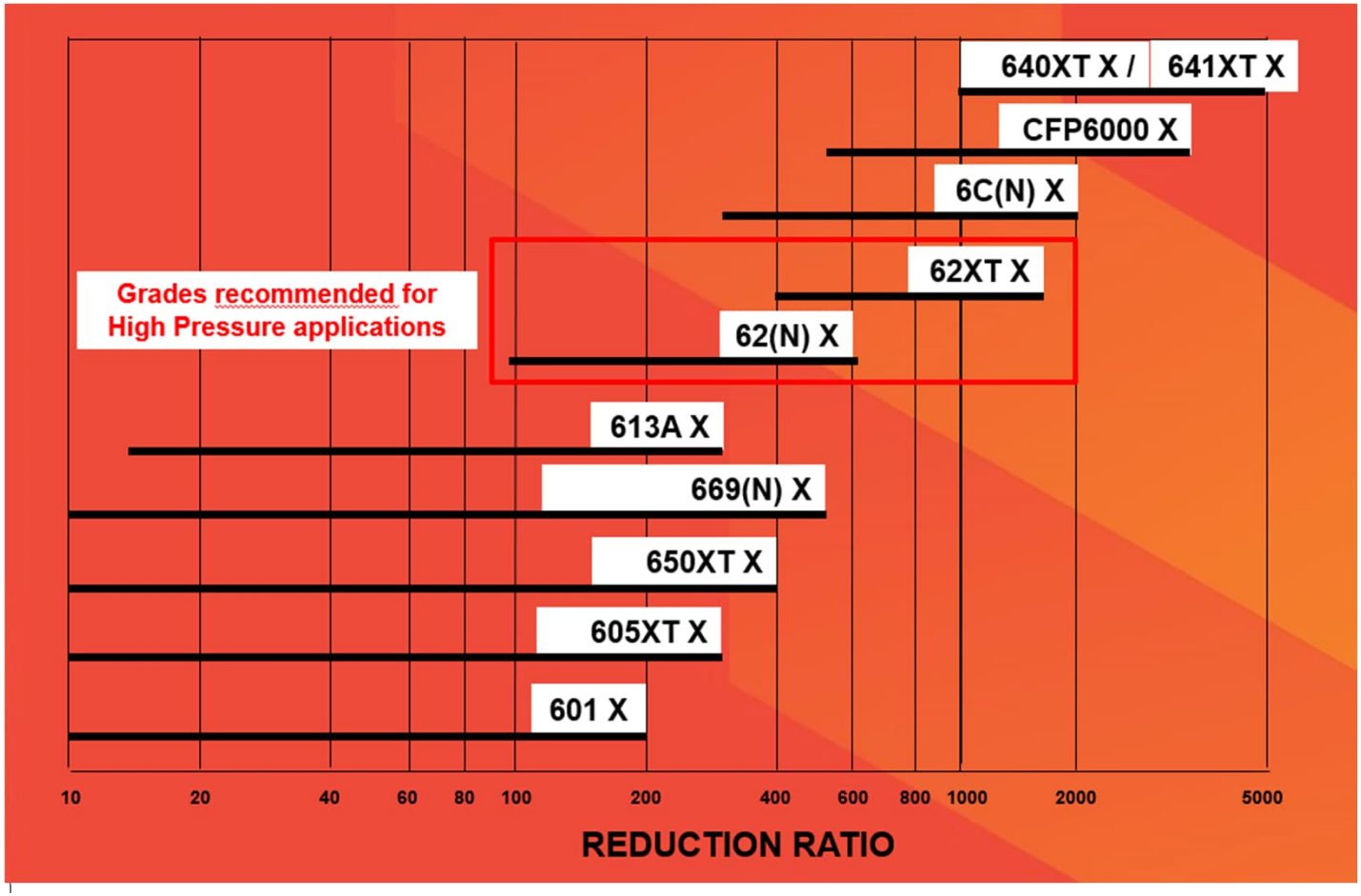
Teflon™ PTFE Fine Powder portfolio



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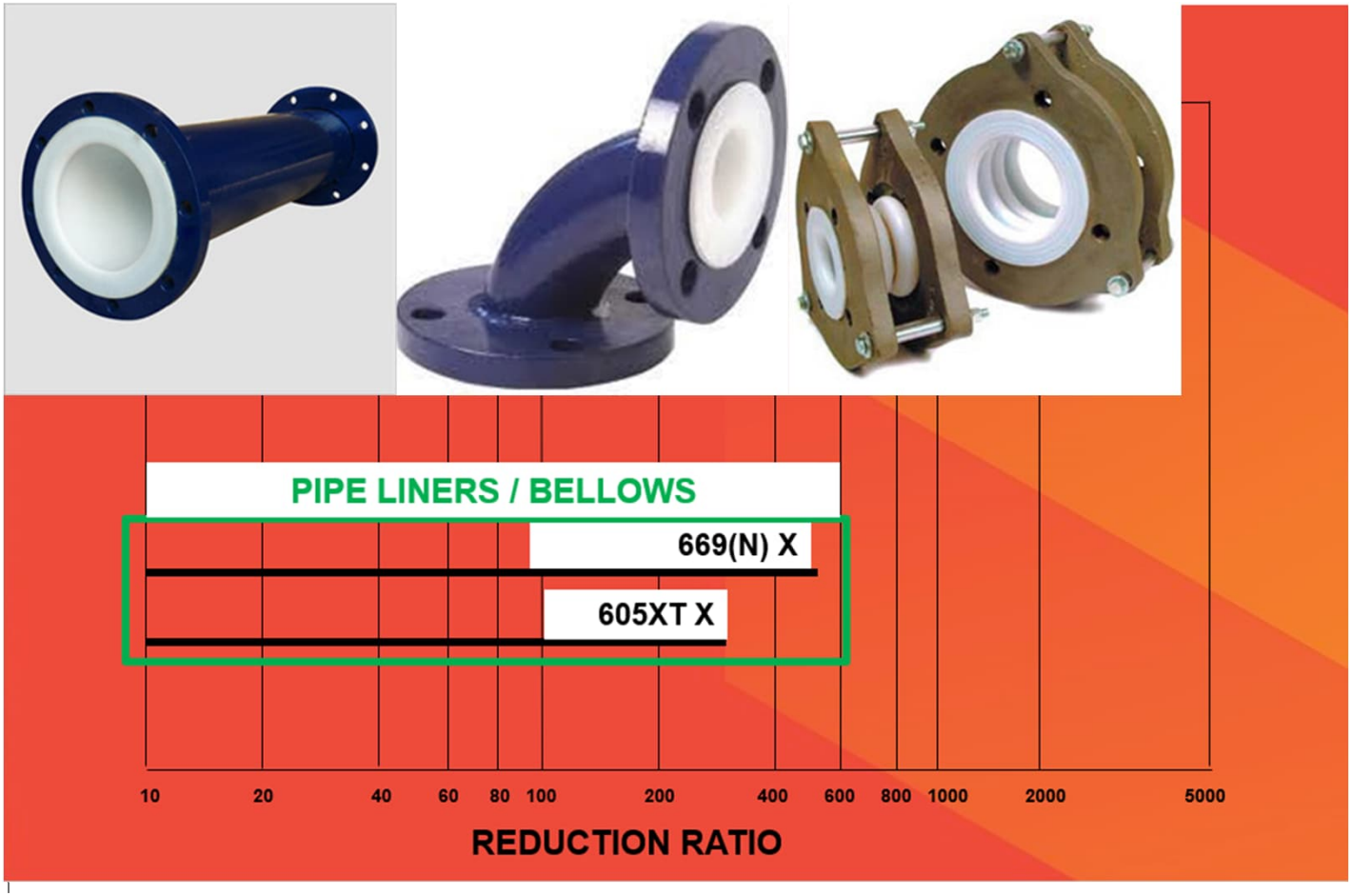
Teflon™ PTFE Fine Powder portfolio



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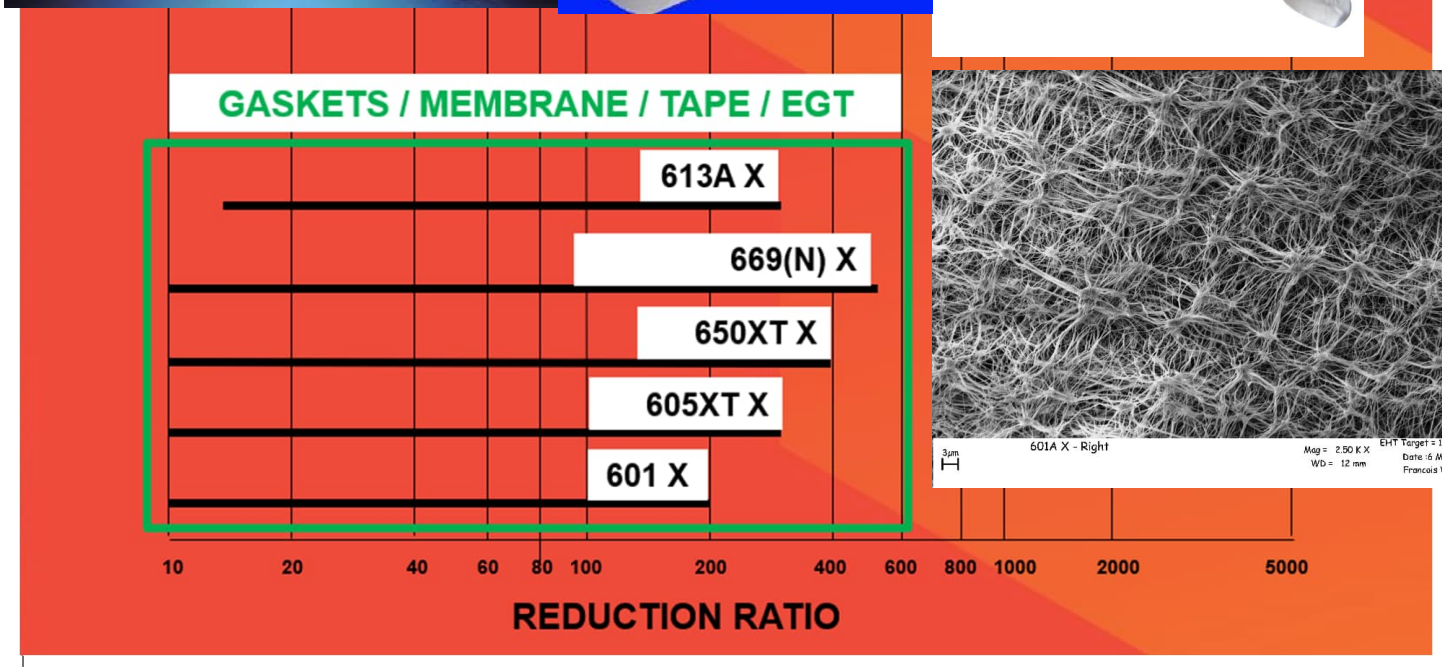
Teflon™ PTFE Fine Powder portfolio



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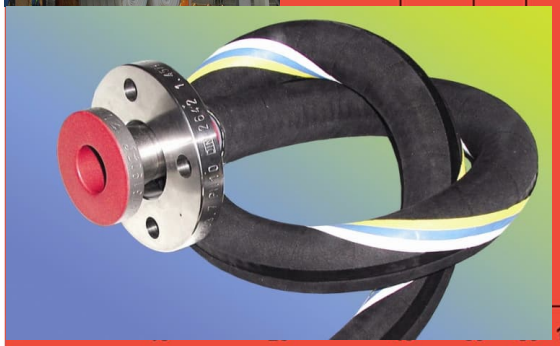
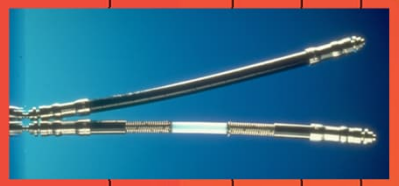
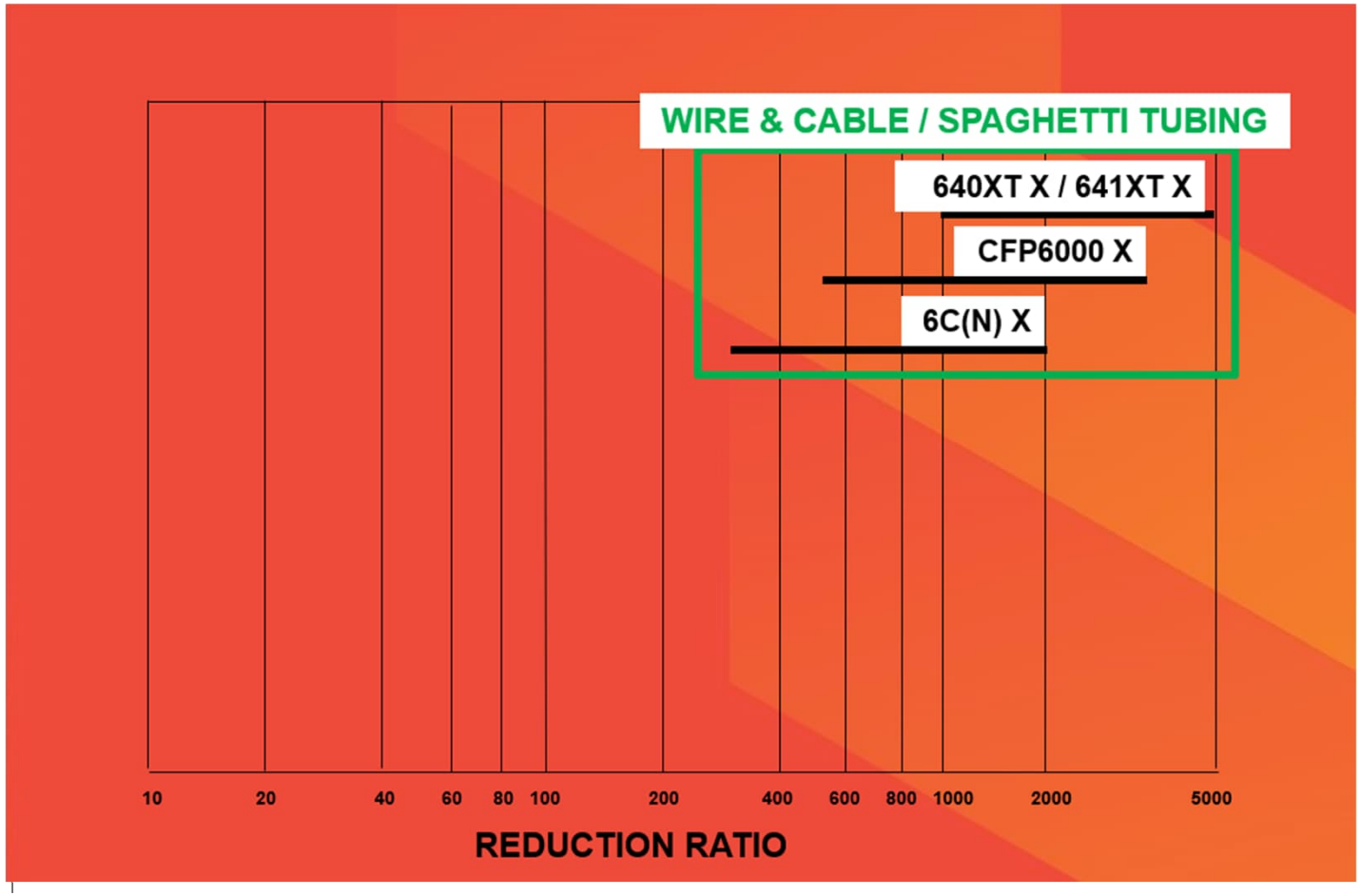
Teflon™ PTFE Fine Powder portfolio





Teflon™ PTFE Fine Powder portfolio



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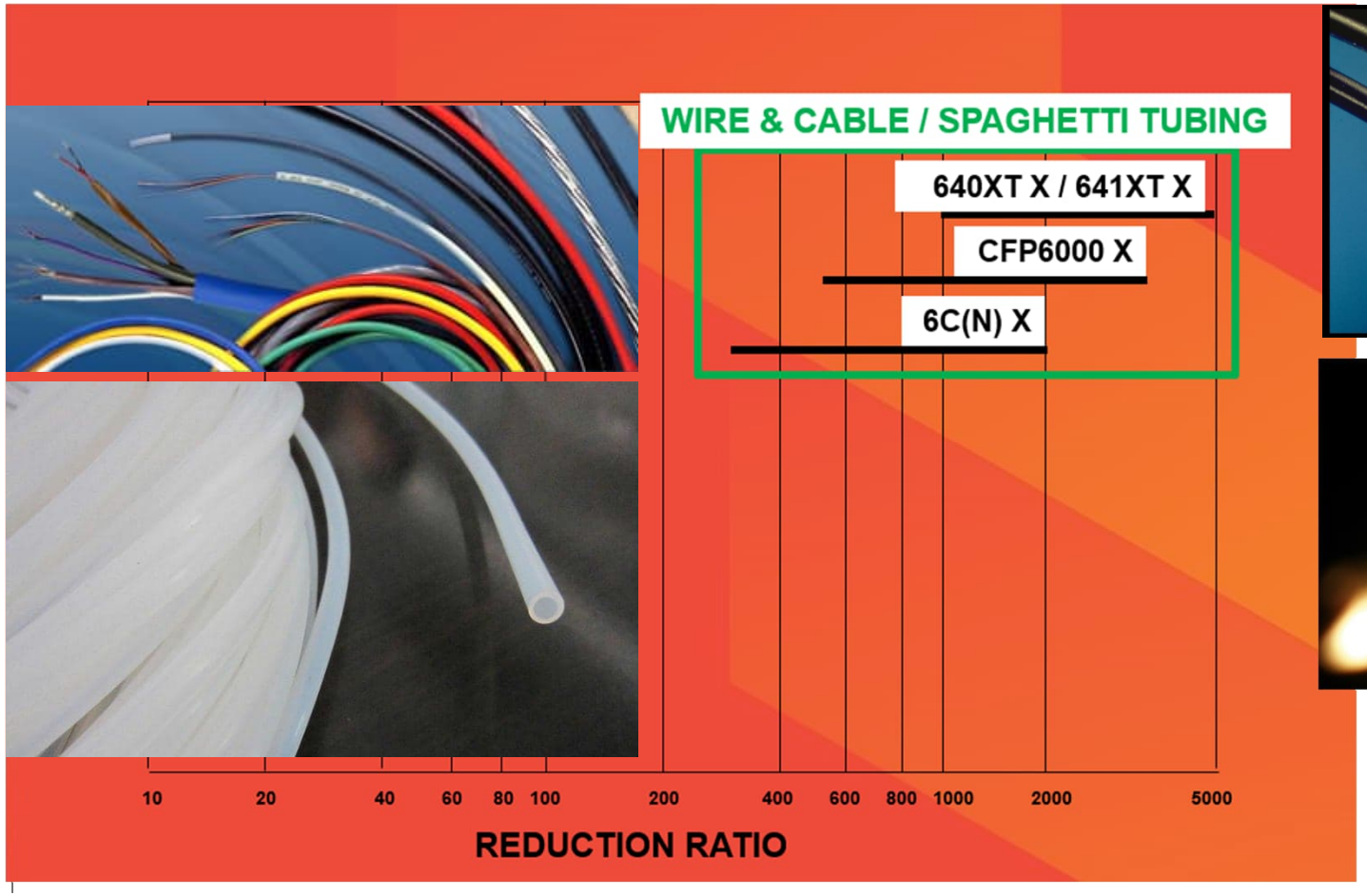
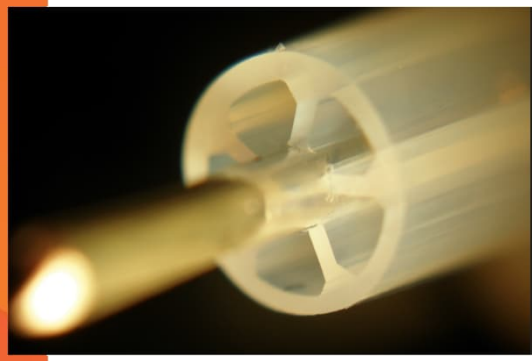
Teflon™ PTFE Fine Powder portfolio





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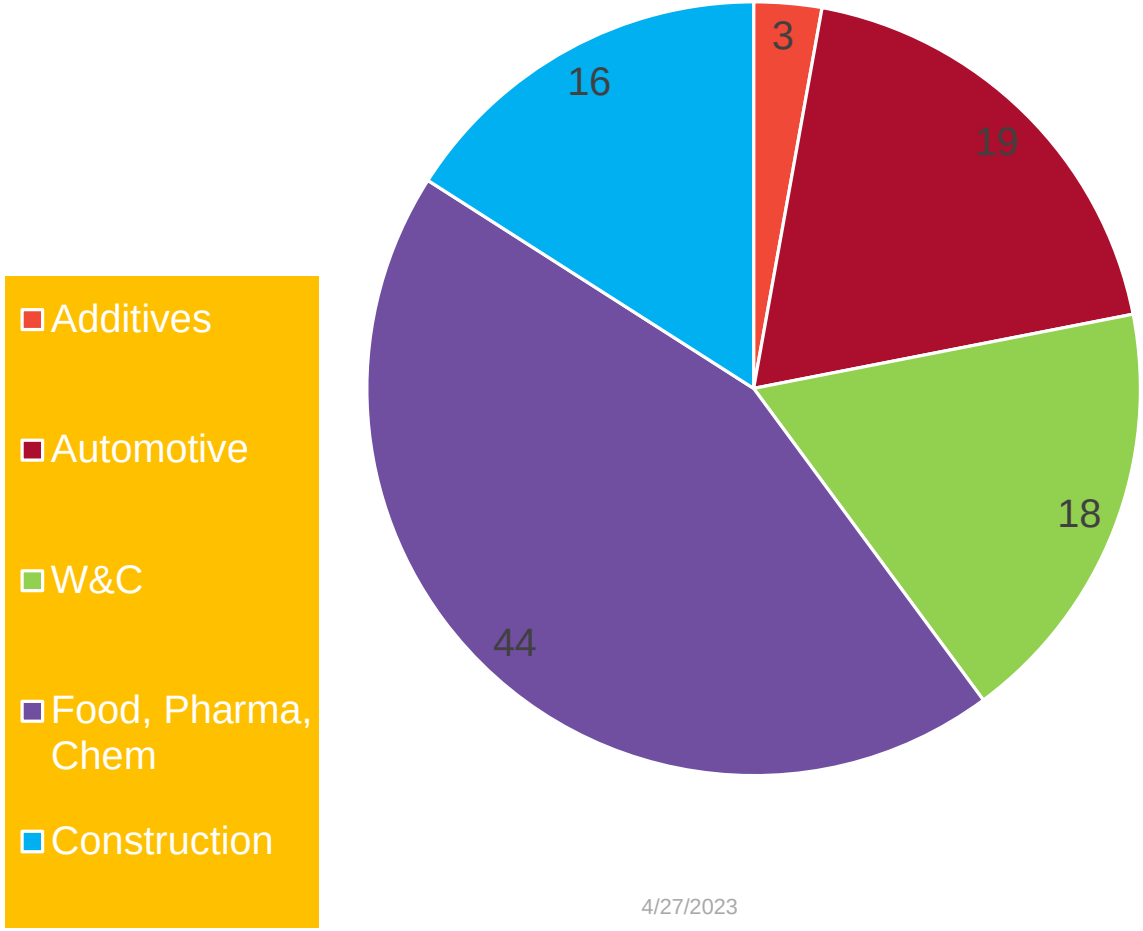
Application PTFE Fine Powder EMEA in %



QUESTIONS ?

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Thank you for your attention

REPLACE WITH PHOTOGRAPH

Impact of Molecular weight, Crystalinity & Void content on Physical Properties

TEFLON™ PTFE FLUOROPOLYMERS

Physical Property	Molecular Weight	Crystallinity	Void Content
Flex fatigue life	+ 100-fold	- 100-fold	- 1000-fold
Compressive stress at 1 % deformation	0	+ 50 %	0
Compressibility	0	- 50 %	-
Recovery	0	- 70 %	-
Permeability to carbon dioxide	0	- 30-fold	+ 1000-fold
Flexural modulus	0	+ 5-fold	- 30 %
Hardness: Durometer	0	+ 20 %	-
Rockwell	0	- 20 %	- 30 %
Tensile impact strength	0	- 15-fold	- 80 %
Dielectric strength	0	0	- 70 %
Proportional limit	0	+ 80 %	- 20 %
Yield stress	0	+ 15 %	- 20 %
Yield strain	0	- 15-fold	0
Tensile strength	+ 25 %	- 50 %	- 50 %
Ultimate strength	+ 50 %	- 70 %	- 50 %
Ultimate elongation	- 20 %	+ 100 %[1)]	- 80 %

[1)] reaches maximum at 85 % crystallinity

Teflon™ PTFE Fine Powder portfolio

HOSE & TUBING

Product	Application	Market segment
6C X, 640XT X, 641XT X	SPAGHETTI	AUTOMOTIVE AEROSPACE CHEMICAL PROCESSING FOOD & PHARMACEUTICAL INDUSTRY HEAT-EXCHANGERS
640XT, X 669N X, 605XT X, 650XT X, 6C X	GENERAL PURPOSE	
605XT X, 669N X	LINED PIPE	
62N X, 62XT X	HIGH PERFORMANCE	

Teflon™ PTFE Fine Powder portfolio

WIRE & CABLE

Product	Application
640XT X, 641XT X	HIGH RR
6C X, 62XT X	MEDIUM RR
6C X, 62N X	LOW RR

Market segment

AUTOMOTIVE

AEROSPACE

TELECOMMUNICATIONS

COMPUTERS

ELECTRONICS

Teflon™ PTFE Fine Powder portfolio

UNSINTERED TAPE

Product	Application	Market segment
605XT X, 669N X	ELECTRICAL GRADE	CONSTRUCTION ELECTRICAL EQUIPMENT AEROSPACE INDUSTRIAL
605XT X, 669N X	THREAD SEALANT TAPE	
650XT X, 605XT X 669N X	GASKETS, FILTER MEMBRANE	