P84®

Unique Performance in Filtration Efficiency

P84® Polyimide Fibres for
High Temperature Filtration

EVONIK
Leading Beyond Chemistry

CONTENTS

THE COMPANY

EVONIK FIBRES GMBH – THE P84® POLYIMIDE FIBRE PRODUCER

Evonik Fibres GmbH is the sole producer of the polyimide fibre known under the trade name of P84®. With its unique multi-lobed cross section and high thermal-chemical resistance to a variety of operating conditions, P84® has become a popular choice in hot gas filtration media for Cement, Lime, Waste to Energy, Power and Metallurgic industrial applications.

The unique multi-lobed cross section of P84® offers the highest filtration efficiency providing significant savings in the operation of an industrial flue gas treatment system. The growing attention of operators to energy saving also makes P84® the ideal choice in low temperature process filters where it is used in combination with all other available filtration fibres (PET, PAN, PPS, meta-aramide, PTFE).

Worldwide more than 500 plants are cleaned with P84® filter bags. Based on the energy savings resulting from the use of P84® filter media, these reference plants of Evonik reduce CO_2 emission by approximately 120.000 metric tons a year.

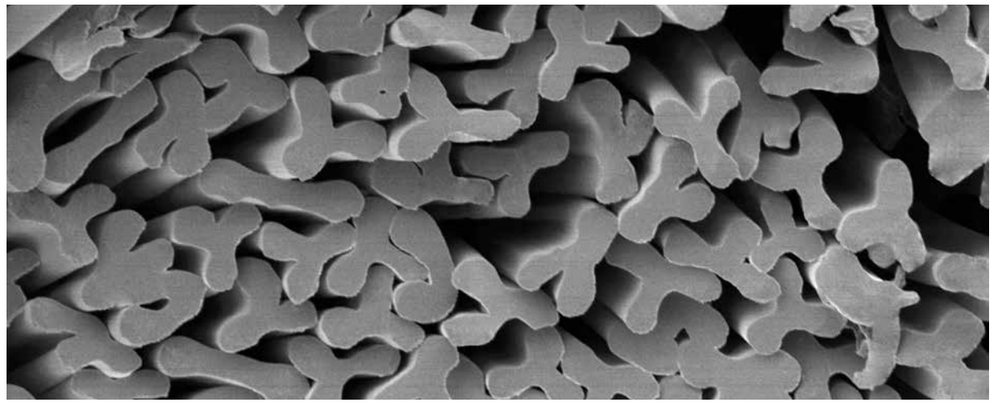
Evonik Fibres GmbH is part of Evonik Industries AG, a creative industrial group based in Germany having obtained global leadership in specialty chemicals.

P84® fibres are also applied in insulation products, protective clothing and technical sealing products.

In addition, Evonik Fibres GmbH offers polyimide powder under the brand name P84®NT to the market. This powder is used for processing sintered parts and stock shapes in applications where low-friction wear parts (e.g. bearings, bushings) with high thermal stability are needed. The powder can be blended with graphite, PTFE or other functional fillers to address specific requirements. For very challenging applications, the type P84®UHT with even increased temperature resistance is recommended.

The youngest member of the P84® family are our high selective polyimide based hollow fibre membranes which are used for different gas separation applications like nitrogen generation or natural gas treatment. The modules are marketed under the brand name Sepuran®.

P84® FIBRE CHARACTERISTICS

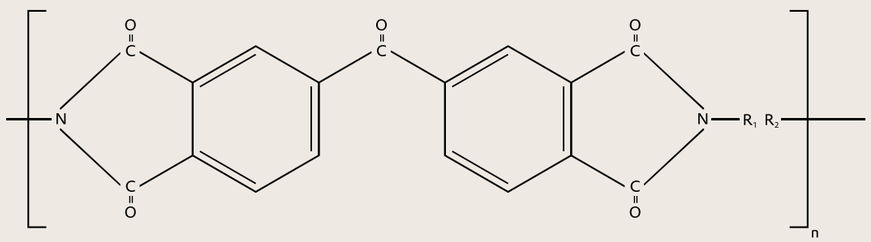


The P84® fibre is a polyimide based fibre with a typical textile character. Polyimides are known to be used in a wide range of operating temperatures starting from cryogenic applications and ending at high temperature applications at the limits of polymer based materials.

The thermal stability is based on the aromatic backbone of the polymer. The fibres do not melt. Despite their halogen free structure they exhibit a high LOI of 38 %, which means the P84® fibres are classified as non flammable.

P84® fibres have a rather unique cross section offering the highest specific surface of all available standard textile fibres.

CHEMICAL STRUCTURE



FIBRE CHARACTERISTICS

As the fibre characteristics of P84® fibres show a typical textile character the fibre can be processed on standard carding and needling equipment.

Tenacity (dry): 38 cN/tex
Elongation: 30 %
Shrinkage (@240 °C, 15 min): < 3 %
Density: 1.41 g/cm³
Moisture gain at 20 °C (60 % rel. hum.): 3 %

PRODUCT RANGE

P84® fibres are available as staple fibres and multifilament yarn.

STAPLE FIBRE
Available Types: 0.6, 1.0, 1.3, 1.7, 2.2, 3.3, 5.5 and 8.0 dtex
Cut Lengths (Standards): 53, 60, 80 mm
Special Cut Lengths: 2.5–120 mm
Bales: 150 kg and 200 kg
Colour: natural golden yellow

FILAMENT YARN
Available Type: 1060 dtex, 480 single threads
Twist: 80 t/m
Packaging: 12 cones, 3.5 kg each
Colour: natural golden yellow

FUNCTIONAL CHARACTERISTICS OF P84® FOR DRY FILTRATION

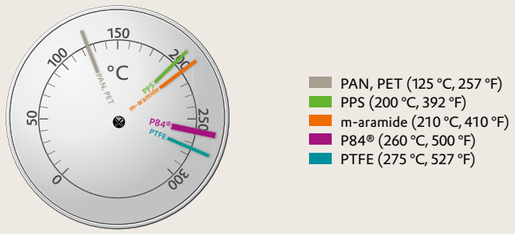
SERVICE TEMPERATURES

The aromatic backbone ensures temperature stability over a wide range of operating conditions. The peak temperature for the P84® fibre is limited to 260 °C. This is well below the glass transition temperature of 315 °C.

Chemical decomposition starts beyond 450 °C without formation of significant amounts of harmful substances.

The acceptable average temperature in the actual application depends on the composition of the environment and the expected service life.

Max. Service Temperatures of Different Fibre Materials



The acceptable average temperature depends on the environment and can be significantly lower than the maximum service temperature.

CHEMICAL ENVIRONMENT

P84® polyimide fibres can be used in a wide range of chemical environments. Due to its chemical composition P84® polyimide fibres are a preferred material in dry filtration processes.

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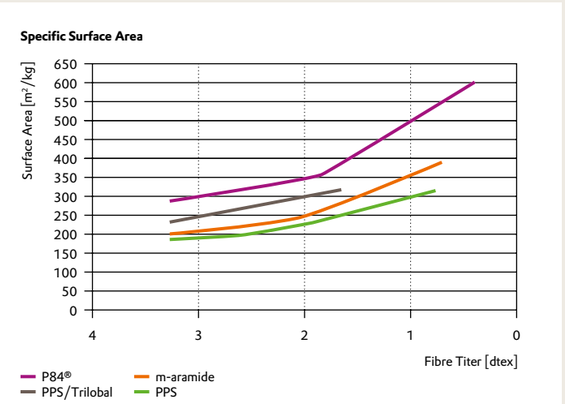
SPECIFIC SURFACE AREA

Specific surface of different fibre materials as function of the fibre fineness.

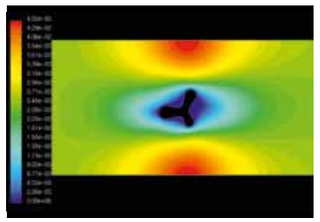


Blend of P84® standard [2.2 dtex] and P84® microfibres [0.6 dtex]

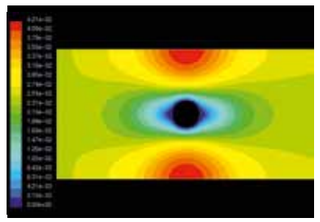
FILTRATION EFFICIENCY OF P84® FIBRES

FLOW PROFILE

The theoretical background of the filtration efficiency of multilobal P84® fibres was investigated by means of CFD analysis. It is shown, that the flow profile around the P84® fibre creates more "low velocity" areas compared to round shaped fibre. This increases the probability for particulate to be collected on the fibre.



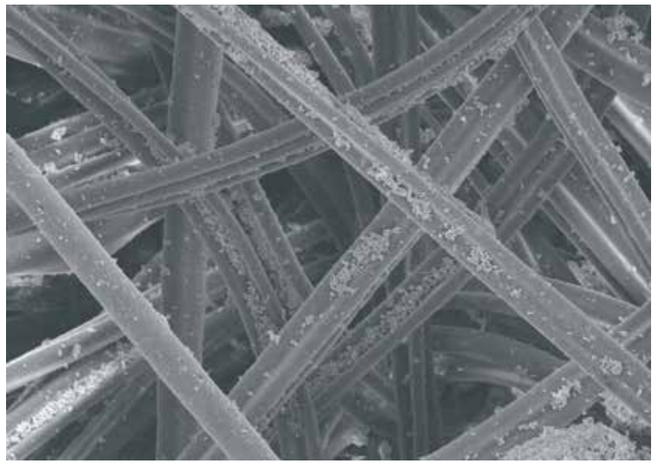
Flow profile around P84® fibres



Flow profile around round shaped fibres

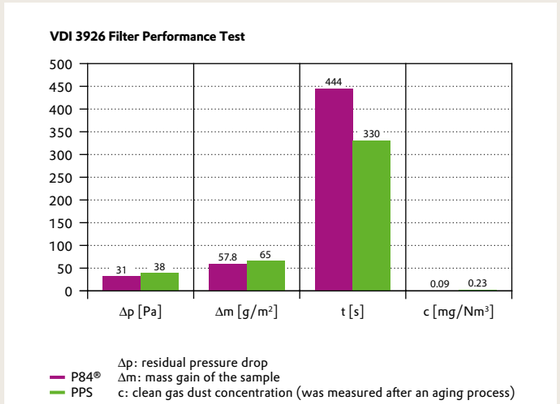
PREFERRED ADHERENCE OF PARTICLES IN THE LOBES OF THE P84® FIBRES

As a macroscopic effect the dust cake is built up in a small surface oriented area on a P84® felt. This keeps the residual pressure drop (after cleaning) of a filter media low and stable. Furthermore, P84® filter media are known to ensure high filtration efficiency and low emissions over the entire life cycle of the filter bag. As a side effect the mechanical wear is minimized, as the internal friction is less pronounced when the dust is not penetrating through the felt construction.



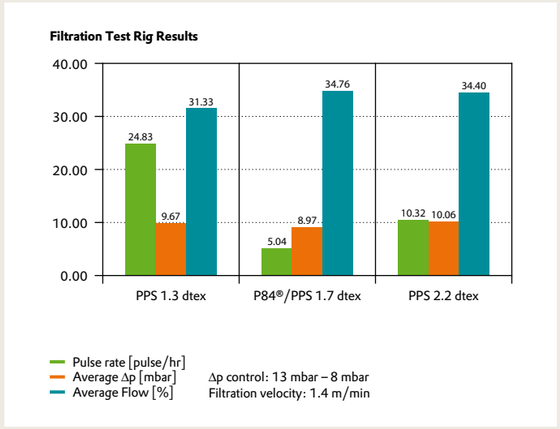
VDI TEST RIG

A common method to determine the performance of filter media is to make tests in a test rig according to VDI 3926.



INDUSTRIAL SCALE FILTRATION TEST RIG

As artificial test procedures cannot reflect all relevant parameters of filtration, especially in terms of material aging, further tests performed in industrial applications allow a cross comparison of filter media at relevant operating conditions. In the test set-up the filter bags are placed among the normal standard filter bags in the industrial scale filter unit. The investigated bags are covered with hoods, so the gas flow through them is extracted separately. This allows control of the gas flow and all relevant parameters including Δp, temperature and dust emissions.

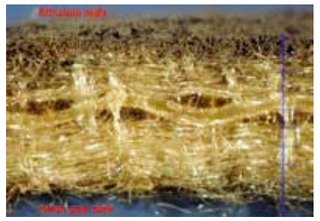


The above diagram shows the results of a comparative testing of 3 different filter media. Two of them are based on PPS fibres. The third contains P84® fibres to increase the filtration performance. As a result, the filter bag containing P84® shows the lowest pulse rate and pressure drop compared to the other bag materials in the test.

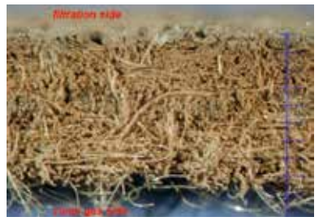
FILTRATION EFFICIENCY OF P84® FIBRES

EXAMPLES FROM INDUSTRIAL FILTER UNITS

P84® based needle felts were installed among other types of needle felts to investigate the performance of different materials in a steel application. The P84® felt was able to establish a stable cake on the surface, whereas all other examined materials showed bleeding of dust through the structure.



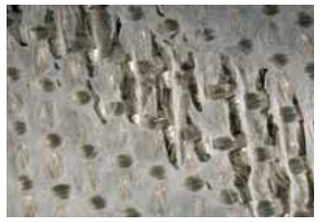
Cake formation on a P84® needle felt



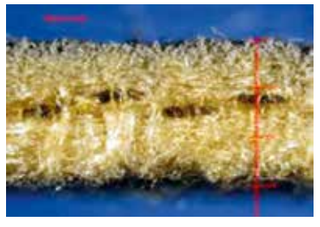
Blinding of a PET felt in the same installation

In another installation (cement mill filter unit) several filter media were installed to look for suitable materials. The results show the different behaviour of a P84® needle felt compared to a ePTFE membrane on a glass fabric. The P84® material exhibits a stable filtration behaviour, whereas the membrane is delaminating from the glass fabric, resulting in dust bleeding through the cross section.

P84® bag without any damage after 29 months



Damaged membrane surface after 29 months



No dust penetration into the P84® needle felt after 29 months

Dust contaminated cross section of a glass fabric as a result of membrane damage

THE ADVANTAGES OF P84® FIBRE BASED NEEDLE FELTS

LOW MAINTENANCE COSTS

The key figure for low maintenance costs is a long service life. Chemical and physical properties of P84® ensure this, if the filter material is selected properly for the application.

LOW OPERATING COSTS

Whenever dust is penetrating the filter media, it leads to several negative effects. All of them result in increased operating costs due to higher energy consumption of the cleaning system and the fan.

HIGH AVAILABILITY OF THE PLANT

A malfunction of the filter bags results in increased emissions or increased pressure drop. In this case only a change of the affected filter bags can overcome the problems. P84® is known to offer stable long term behaviour in a wide range of operating conditions.

HIGH FLEXIBILITY IN USE

The high acceptable peak temperature, the chemical stability and the excellent filtration efficiency makes P84® suitable for a large variety of filtration processes.

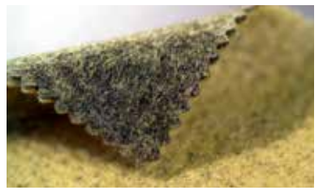
ROBUST SOLUTION

The 3 dimensional structure of a needle felt containing P84® fibres is in general an extremely flexible material which is not affected by delamination. Standard cages are sufficient and the filtration properties of P84® allow a wide range of A/C ratios for the filter bags.

EASY DISPOSAL OF THE BAGS

The halogen free structure of P84® based filter bags ensures that formation of harmfull substances is avoided when the bags are burnt. This improves plant safety in case of a bag house fire. P84® bags can be incinerated without special precautions.

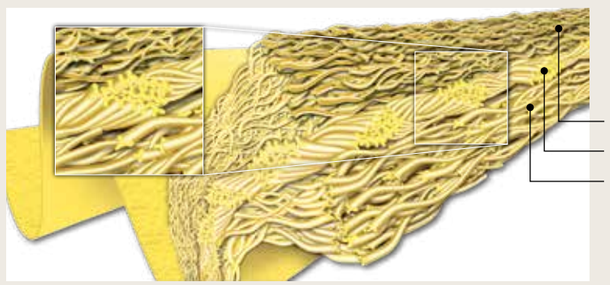
DIFFERENT FELT DESIGNS OF P84® BASED NEEDLE FELTS



BASIC FELT DESIGN

Modern needle felts for filter bags have a 3 layer construction. The outer layer, a densified fleece, is responsible for the filtration performance. Therefore it is common to use fine- and microfibres for this layer. In the middle of the construction a scrim is used as a mechanical backbone, keeping the felt dimensionally stable. The inside layer of a felt is mainly responsible for the mechanical protection of the felt construction. It has to withstand the forces occurring during the pulse jet cleaning and the flexing during the filtration cycle.

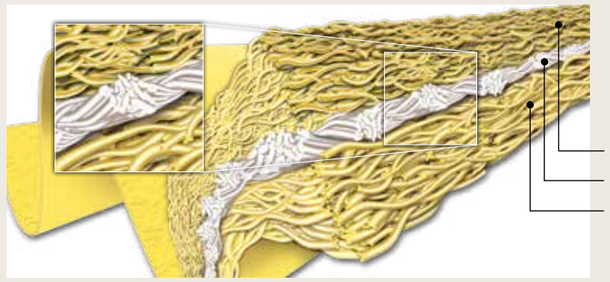
The most common construction of P84® based needle felts is to have all 3 layers made of P84® fibres. This ensures a very high filtration performance which can be improved by using P84® fine- and microfibres in the filtration layer of the felt.



P84® felt

P84® filtration side
P84® scrim
P84® clean gas side

VARIATION OF SCRIM MATERIAL



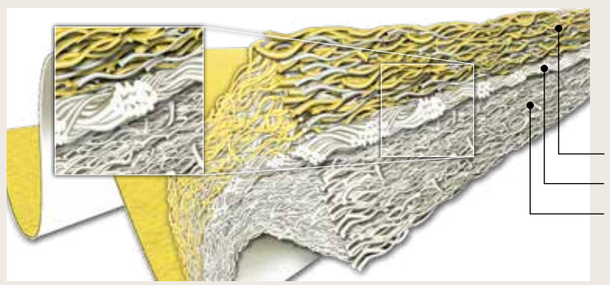
P84® felt on PTFE scrim
If demanded, a PTFE scrim can be used.

P84® filtration side
PTFE scrim
P84® clean gas side

FIBRE BLENDS IN THE FELT LAYERS

Besides the chemical and thermal properties, the unique cross section of P84® is the reason for a widening field of P84® applications. To increase the filtration performance of felts based on other polymer fibres, P84® standard grade or P84® fine fibres are blended into the surface layer of the needle felt. By substituting a part of the original material, the increase of surface area and the increase of filtration performance are significant. The chemical and temperature resistance of the base material is not influenced by blending P84® fibres into other materials. The chemical performance of a P84®/PTFE blended material is close to pure PTFE with the benefit of a significant increase of filtration efficiency provided by P84®.

P84® fibres are used as blending partner for all other polymers in industrial filtration to increase filtration efficiency and to extend the operating range (regarding dust load, dust fineness and A/C ratio). Among them are polyester, polyacrylic, polyhenylenesulfide, PTFE, …



Blend of P84® into base materials from other fibres, e.g. PPS

P84®/PPS filtration side
PPS scrim
PPS clean gas side

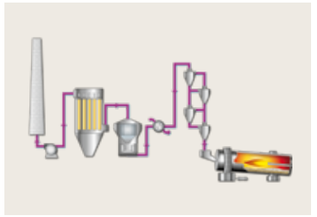
P84® APPLICATIONS IN DRY FILTRATION

CEMENT

Changing flue gas conditions are caused by using a variety of fuels, as well as switching the kiln filter from direct mode to compound mode. High CO and Volatile Organic Compounds (VOC) values can be generated by the extensive use of secondary fuels in the precalciner. The partly abrasive dust is a crucial parameter for the filter media in terms of delamination. Because of the high alkaline content, the bypass filter is a true challenge for the filter media.
The ever increasing demand for higher cement quality is a challenge for the grinding system and the high amount of fine dust requires a highly effective filter media.

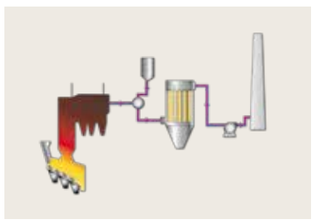
Therefore P84® based filter media can be found in following filter units of a cement plant.

Kiln Filter:
P84®
Clinker Mill Filter:
P84® blended with PET and PAN
Alkali Bypass Filter:
P84®/PTFE blends
Clinker Cooler Filter:
P84®



WASTE TO ENERGY

Increased dust emissions are an absolute disaster for a WTE plant. Inhomogeneous fuel quality requires a highly flexible flue gas treatment system, including the bag filter unit being the barrier for all solid substances.
Due to its filtration performance, P84® based filter bags are used in all common process variations of flue gas treatment systems of WTE plants.



The main benefits are a low and stable residual pressure drop and long filtration cycles. High collection efficiency is achieved for fine particulate also. This ensures low emissions and an efficient use of the absorbent.

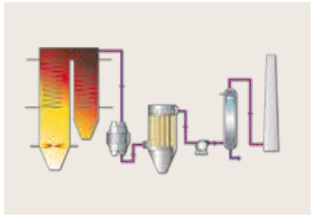
Where are P84® based filter media installed?
In the main filter unit of semi dry and conditioned dry sorption systems.
In the primary or tail end filter unit of 2 stage wet scrubbing systems.

POWER

Flue gas treatment systems are a necessary component of energy plants. In order to keep the overall performance high, the energy consumption of the FGD plant has to be low. P84® based needle felts are known to ensure low emissions and a stable pressure drop of the filter plant.

When using biomass, the operation load of the plant varies in a wide range. Operation at low boiler load sometimes causes high values of unburnt hydrocarbons and temperature fluctuations.

The design of the flue gas treatment system can be different. The bag filter can be operated without neutralisation of acidic components, or the desulphurisation unit is downstream of the filter unit, like it can be found in most coal fired boiler systems.



Further it can be combined with the filter unit. This is done by using a dry sorption system, which is common for biomass fired plants. No matter how the FGD system is designed, P84® is suitable to be at least one of the basic components of the filter media.

PROCESS FILTER

A wide range of operating temperatures and the presence of explosive environments are the characteristics of flue gases in the steel industry. Covering temperature peaks up to 260 °C and having a limiting oxygen index of 38 %, P84® is capable to deal with sparks, varying oxygen contents and high temperatures.

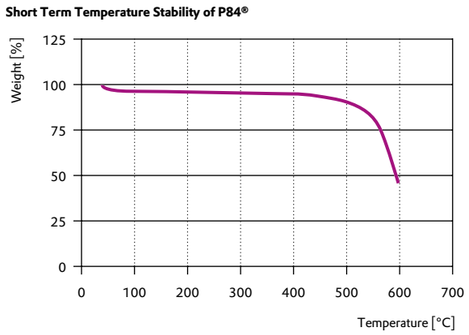
The glass transition temperature of 315 °C ensures the physical integrity of the fibre, even when the temperature limits are exceeded. Volume flows change due to the discontinuous operation of many processes. P84® prevents from dust penetration if the A/C ratio or the dust load reach peak values.

Metallurgical Processing
Whenever filtration processes are realized at elevated temperatures, P84® is a viable option. Due to its combination of physical and chemical performance, P84® is the superior fibre for a wide range of applications. Further, P84® is the ideal partner in blends with other fibres, whenever another base material is used for technical or economical reasons.

P84® TECHNICAL FIBRE PROPERTIES

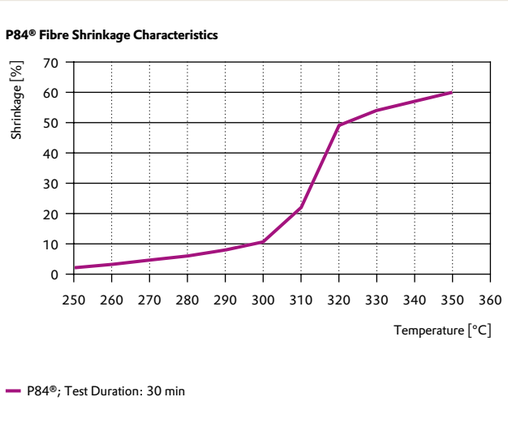
SHORT TERM TEMPERATURE STABILITY OF P84®

When subjected to high temperatures, P84® degrades the same way as many other organic polymers, leaving a carbon structure. However, the decomposition temperature is extremely high, as shown in the diagram.



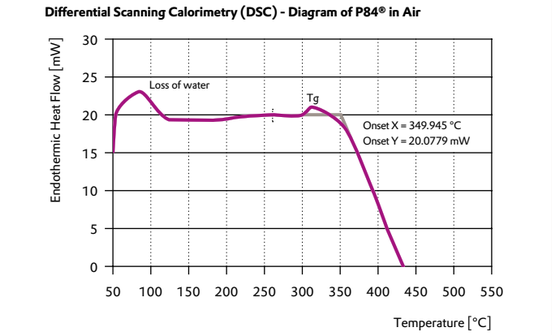
P84® FIBRE SHRINKAGE CHARACTERISTICS

During the manufacturing process, the fibres are stretched and the polymer molecules are getting oriented to a certain extent. When exposing the fibres to temperatures near the glass transition temperatures, a reorientation of the molecules takes place and the fibres shrink. The diagram shows the significant increase of the shrinkage after 30 minutes exposure at temperatures at and beyond 315 °C (599 °F).



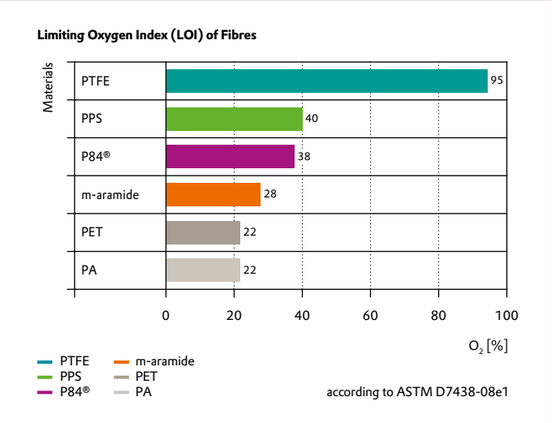
DIFFERENTIAL SCANNING CALORIMETRY (DSC) - DIAGRAM OF P84® IN AIR

This diagram shows, whether a material consumes or generates thermal energy during a defined temperature program. Especially changes of the structure and melting temperatures can be detected by using this method. P84® has no peaks indicating crystalline regions or melting behaviour, only a glass transition temperature is observed.



LIMITING OXYGEN INDEX (LOI) OF FIBRES

The LOI indicates the level of oxygen needed to keep the material burning after ignition. P84® is classified as non flammable in atmospheric conditions.

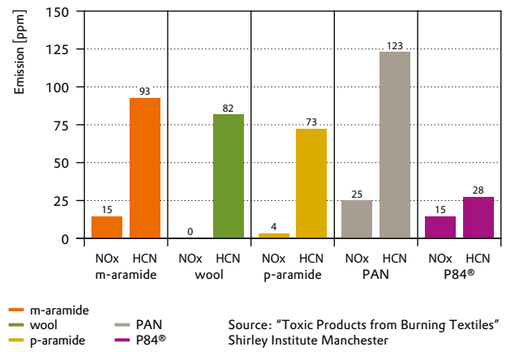


P84® TECHNICAL FIBRE PROPERTIES

EMISSION OF TOXIC GASES DURING DEGRADATION

Gas volume and gas composition are strongly depending on conditions like excess or shortage of oxygen. Under the chosen conditions, P84® fibres show the lowest generation of toxic HCN (cyanic acid).

Emission of Toxic Gases during the Degradation of Fibres



Source: "Toxic Products from Burning Textiles" Shirley Institute Manchester

CHEMICAL PROPERTIES OF P84®

P84® provides good chemical stability to all common solvents, such as alcohols, ketones, chlorinated hydrocarbons and a wide range of other chemicals. It also offers high resistance to fats, oil and fuel. In addition, P84® fibres have a proven record of good resistance in a broad range of the pH-scale.

Chemical Properties of P84®

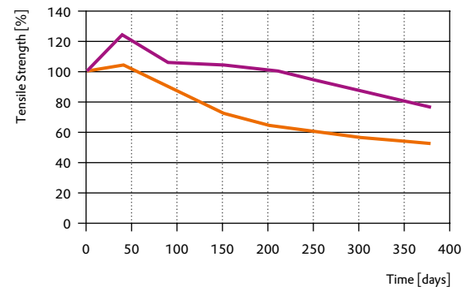
Chemicals	Concentration [%]	Temp. [°C/°F]	Time [hrs.]	Effect on tenacity
Sulphuric acid	10	20/68	100	no
Nitric acid	10	20/68	100	no
Hydrochloric acid	20	50/122	24	minimal
Hydrobromic acid	37	20/68	100	no
Hydrofluoric acid	40	20/68	100	no
Acetone	100	20/68	1000	no
Benzene	100	20/68	1000	no
Perchloroethylene	100	70/158	168	no

no = 0 to 15 % Loss in tenacity, minimal = 16 to 30 % Loss in tenacity

OXIDATIVE AGING

Fibres exposed to air at high temperatures are deteriorated by oxygen. The experimental results shown in the chart were carried out at 210 °C (410 °F) and show superior performance of P84® compared to m-aramides.

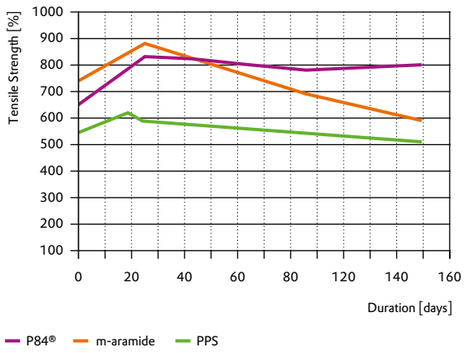
Loss of Tensile Strength of Needle Felts due to Oxidative Aging



HYDROLYSIS STABILITY

Even under extremely high moisture contents, P84® outperforms many of its competitors, being available for high temperature filtration applications.

Hydrolysis Stability of Filter Fabrics @ 50 vol % Moisture, 170 °C



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LEGAL REFERENCES

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