General guidelines

The use of Apyrum® in woven and nonwoven fabrics

Version 2018.1

This document is intended to be used as a guideline and recommendation for the use of Apyrum in woven and nonwoven fabrics (from now on, both referred as fabrics). It should be used as an informative tool for R&D departments, development and production engineers for the preparation, testing and evaluation in the use of Apyrum as a flame retardant.

All companies use different equipment and terminology but, the basic principle usually remains the same. This guideline can be used, in part, as a model for other material and immersion /impregnation processes. Please consult your Deflamo service engineer or contact person for additional advice.

Fire properties of fabrics

The fire properties of fabrics are largely determined by the fire properties of the fibre material, such as cellulose, polyester, cotton, wool, fibre glass, etc. In addition, several other parameters such as the following contribute to determining fabric characteristics and its fire properties:

- Fibre type and quality
- Density
- Fabric weight
- Surface, coating, layers
- Filler
- Binder
- Additive for process and properties

The inherent fire properties of a fabric can be changed by adjusting these parameters, which can also influence the performance of the flame retardant and how well it can be expected to meet competitive specifications.

Traditionally used flame retardants

The traditional approach used to reduce the flammability of fabrics is to add borates, phosphates or nitrogen containing, e.g. ammonium polyphosphate and urea. Other ways are based on the use of highly toxic halogenated hydrocarbons which are widely found in different products for example in back coating pastes. The halogenated flame retardants is also substituted with organophosphorus compounds that is also questionable from an environmental and health perspective. These traditional methods should be avoided when taking into consideration the stricter environmental and health requirements that now exist throughout Europe.

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Fire properties and specific requirements

The application must meet a standard test procedure for fire properties. The standard test method consists of a standardized procedure to be able to evaluate and compare the compound fire behaviour of the application. The real-life fire behaviour of the material is not actually tested.

The fire behaviour could be described by distinct physical processes. See list below.

The Test method is often focused on a specific physical process or a combination.

- Ignitability
- Time of ignition
- Smouldering
- Dripping
- Smoke density
- Amount and speed of energy transfer (Heat release, total heat release, rate…)
- Loss of mass
- Structural stability, barrier properties, thermal insulation properties
- Durability of application in use. Indoor, outdoor
- Moisture balance of application
- Etc.

Apyrum could be adjusted to meet one or more of these requirements. Some of the requirements is contractionary and will require a trade of. Improving one will reduce performance in another.

General guidelines for the use of Apyrum in fabrics

Apyrum itself possesses several flame-retardant properties that are highly functional in fabrics. Depending on the fabric properties and other requirements, the needed load of Apyrum is usually around 5 to 25 % by weight.

Selecting a good starting point

Not all fabric qualities are suitable as a base for making them fire resistant. For example, a glossy repellent fabric with high loads of binder, latex or barrier film will require a very high load of flame retardant in order to be effective. Synthetic fibre is always more complicated. Generally, the following applies:

BETTER	**WORSE**
Higher density	Lower density, splint fibre
Higher fabric weight	Lower fabric weight
High amount of inorganic filler (CaCO3, etc.)	
Use of ATH [Al(OH)3] as the only filler	
	Organic filler / binder (latex, wax, etc.)
	Fluor carbon coating, polymer coating
Heat stable glue	
	Melting layer of polymers, oil or wax, films and coatings

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Note: To design an optimal FR fabric, you must prioritize among several properties and economy

Thicker materials

If you are working with thick materials such as wood or planks it is possible that Apyrum does not penetrate fully. This could be good or bad depending on your objective. It could be a strategy to optimize properties and load. Apyrums functionality as a barrier could be enhanced by a higher load close to the surface that is exposed to fire. At the same time the amount of Apyrum could be reduced.

Adapting to the requirements

To evaluate and adjust all parameters in the fabric to have it ready for its final application, complying with the required standards with regards to its fire properties will prove very valuable for optimizing costs, function and performance. By working with the suggestions stated above, one can expect to meet UL94 or similar with an approximated load of 4-10% Apyrum with almost no afterglow.

Type of Apyrum

The standard product for fabric materials is generally designed as APYRUM 201 Heavy or APYRUM LIQUID.

It is a PH neutral water based solution used to impregnate the fabric by spraying or dipping it. After that process, the fabric is dried, leaving Apyrum salt crystals within the fabric, therefore changing its fire resistance properties.

Some of its properties

Physical state	Water based solution
Physical appearance	Liquid, transparent to slightly yellowish
Odour	Vinegar / citric, subsides after drying
Total content of active substance (wt. %)	>50%
Density (g/L)	1.33 ± 0.03
Soluble in water	Yes
pH	7.2 ± 0.6
Sedimentation, crystallization	Not visible
Physical state after drying (evaporation of water)	Very small white to transparent salt crystals*

*Important: The appearing colour of Apyrum may be affected by the host material residue, drying time and drying procedure. These variables can make it change a lot.

Handling in the laboratory and production

Mixing and handling

The Apyrum salt is dissolved in water. After drying, the solution will leave salt crystals, once the water has been evaporated. Apyrum liquid is designed to be used as an impregnating liquid where the water is used as a carrier for the dissolved salt molecules to move into the fibre or material.

The goal is to find a process that distributes Apyrum liquid evenly and so, after drying, the salt crystals are distributed in the right amount and in the right place within the fabric fibres. Please, consult the

document “Industrial and laboratory Impregnation”. The normal procedure is to dilute with water until reaching a suitable concentration. Please, be aware that mixing Apyrum with water requires a long mixing time.

Apyrum liquid can also be mixed in other water based products. This could be complicated due to a high ionic strength and the possibility of modifying the pH. This is often a source of error that is only observable by showing lower fire retardant properties than expected. Therefore, before mixing with other liquids, please consult Deflamo. Also, be aware that the high amount of water (50%) is needed to properly dissolve the salts.

When the concentration increases due to the evaporation of water or due to the impregnation process, the salts will crystalize within the fabric fibres. This process is critical to the end results

of your application. Crystal residing in the fibre will influence the physical properties of the fabric. The objective is to define a process on how to distribute the salts as evenly and as finely as possible. The solution must penetrate the fabric. As a rule of thumb, everything that will be wetted by water can be impregnated by Apyrum liquid.

A water repellent surface cannot be successfully flame retarded with Apyrum. Eventually, a surfactants/wetting agent can increase penetration. Please, consult Deflamo.

There are different strategies to impregnate the fabric: Time, pressure, physical force, wetting agent products.

Moisture and drying

1000g of Apyrum liquid contains 500g of water. During the process, this water must be evaporated. The concentration is measured at 105^0C, a suitable drying temperature. The drying time is somewhat longer with Apyrum compared to water due to Apyrum properties.

After drying, Apyrum still contains some crystallization water (≈8wt% released at 200^0C). In high temperature processes the weight can be reduced when crystalline water is released. However, in normal temperatures and moisture conditions, crystalline water will be picked up by Apyrum after a while, returning to its initial weight.

Apyrum 201 is a hygroscopic salt and at higher loads in the finished fabric, the humidity of the fabric can be increased. For example, if a fabric has a humidity of 8% by weight, it can increase humidity after impregnation with Apyrum to 9 or 10% by weight. The humidity of the fabric is highly dependent on Apyrum load, impregnation results, fabric quality and moisture in the working environment.

Therefore, conditioning and stabilizing after impregnation is important. For standard fire testing all natural fibre and fabric are conditioned to normalize the sample before testing. The standard method is to place the sample in a climate chamber until the weight is stable.

Calculations and concentrations

100g Apyrum Liquid 50%: Contains 50g water + 50g Apyrum salt.

Density is 1.33. 100g is equal to 75,19 mL, or 100mL is equal to 133g.

One useful strategy out of many is to know the pick-up of the fabric. If you start with a 100g fabric and your impregnation process results in a wet fabric weight of 150g, your pick-up is 50g (Pick-up rate is 50%). When using Apyrum Liquid 50% it is known that 25g is water and 25g is Apyrum salts. In this case, we have a fabric of 100g with 25g added Apyrum.

If you would like to reduce the amount of Apyrum to 10g, you will need an Apyrum liquid where 50g contains 10g. This could be prepared by using 40g Apyrum liquid 50% (contains 20g Apyrum salt) and

adding 60g water. Now you have a 20% Apyrum liquid solution. Using the same procedure with the same pick-up rate, pick up 50g liquid containing 10g Apyrum salt.

Typical starting point recipe

We recommend that you start with a high load of Apyrum to find out about functionality and a general test of the method. Cellulose should be self-extinguishing with 25% load of Apyrum. Continue testing at lower load until you find the threshold of none-compliance set by your specific fire protection standards. The first series of tests could be 20%, 15%, 10%. 5%. The next step could involve fine tuning within those acceptable intervals.

Possible sources of error

Inadequate penetration within the fibre

- Apyrum salt has not penetrated the fibre and crystals are visible on surface
- Apyrum salt has penetrated the material but has not penetrated the fibres. In this case, large crystals have formed between the fibres.

Uneven distribution

- Uneven distribution due to gravity during drying
- Surface tension/capillarity effects at edges can redistribute the liquid before drying

Chemicals or processes interfering with Apyrum chemistry

- Acids or alkalis, or just a deviation in pH can interfere with Apyrum.