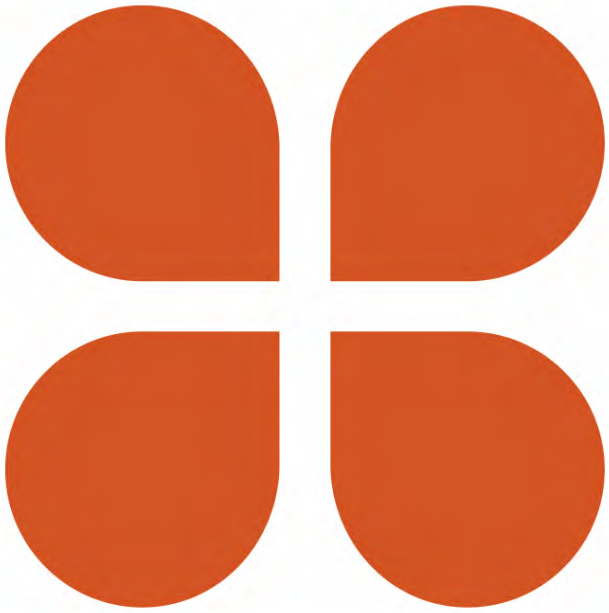
SWEDISH NATIONAL HERITAGE BOARD
RIKSANTIKVARIEÄMBETET

Report from the Swedish National Heritage Board

Flame retardants and wool – long term effects

Evaluating fabrics for the ECOSOC curtain



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Riksantikvarieämbetet 2014
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Summary

Currently the U.N. building complex in New York, built in 1952, is undergoing a massive renovation. The Swedish National Public Art Council and the Ministry for Foreign Affairs have decided on a donation of a contemporary work of textile art for the United Nations, to replace earlier works. Conservators from the Swedish National Heritage Board take part in the planning and now act as advisors on historical and artistic values of the Economic and Social Council Chamber - ECOSOC, as well as on the quality and long-term stability of the proposed new artwork. The New York City Fire Code as well as the Security department of the UN Capital Master Plan call for the new work of art to be fire safe. Modern textiles for interiors such as curtains or upholstery material are often treated with fire retardants but are usually not expected to last longer than ten years, but the Swedish National Public Art Council has asked for the new ECOSOC curtain to last for sixty years. The new curtain is going to be made entirely of wool. Since earlier studies at the Swedish National Heritage Board had proved that flame retardants in the long run can be harmful to cellulose material an evaluation of the effects of flame retardants on wool was needed.

Introduction

Currently the U.N. building complex in New York, built in 1952, is undergoing a massive and much needed renovation. Conservators from the Swedish National Heritage Board and the Moderna Museet have evaluated the condition of the Swedish donations to the building. Those donations form a landmark in Sweden´s modernistic design. The Economic and Social Council Chamber - ECOSOC, designed by Sven Markelius, was furnished with an artwork by Marianne Richter. This very large woven curtain was destroyed by a combination of flame retardant treatment, sunlight and humid climate conditions (Finch, 1969). It was replaced by a velvet curtain with the print "Pythagoras", a pattern designed by Sven Markelius in 1952. The Swedish National Public Art Council and the Ministry for Foreign Affairs have decided on a donation of a contemporary work of art for the United Nations, to replace the lost curtains. Conservators from the Swedish National Heritage Board have taken part in the planning, acting as advisors on the historical and artistic values of the ECOSOC chamber, as well as on the material quality and long-term stability of the proposed new artwork, by Swedish artist Ann Edholm.

Flame or fire retardants (FR) are in many ways damaging to textile material as well as to the environment and to human health, but have been deemed necessary in order to save lives and property from the outbreak of fire. Textiles are considered a risk in public buildings and laws and regulations for fire safety are becoming more demanding. It has for a long time been known that the original fire proofing treatment was a contributing factor to the damage of the first curtain in the ECOSOC. With the ongoing restoration of the United Nations building complex (2009–2013) conservators and scientists from the Swedish National Heritage Board Conservation Department have performed a closer study of the two earlier curtains from the ECOSOC as well as two other textile works of art.

The New York City Fire Code as well as the Security department of the UN Capital Master Plan call for the new work of art to be firesafe. Modern textiles for

interiors such as curtains or upholstery material treated with fire retardants are usually not expected to last longer than ten years but the Swedish National Public Art Council has asked for the new ECOSOC curtain to last for sixty years.

According to an earlier study from the Swedish National Heritage Board (Bergstrand, 2013) where four existing flame retardants were examined, flame retardants are harmful to cellulose textiles. Wool on the other hand appears to be in a better condition after flame retardant treatment. The study points to the complexity of the flame retardant issue. Flame retardant products vary widely and are applied to materials with very different properties. Many flame retardants are based on organic and inorganic salts that, in the long term, will make the material acidic. Cellulose fibres, cotton and linen, are very sensitive to acidity, which in some cases has caused severe degradation. Environmental factors such as light, humidity and temperature seem to accelerate the degradation process. Wool, a protein fibre, is not as sensitive to acidity as cotton. Although wool in itself has flame retardant properties, flame retardants are sometimes used for wool when extra security measures are deemed necessary. Since the new curtain is going to be made entirely of wool it would be useful to evaluate two commercial flame retardants for this material. One of these products may be used for the new U.N. curtain.

Justification for the study

The aim is to arrive at conclusions which will enable the Swedish National Heritage Board to evaluate which flame retardant can be used on the new curtain should the security regulations of the U.N. so demand. The life expectancy of the curtain, the mechanical strength of the material and the impact of light and flame retardants on the colours as well as the overall aesthetic impression, will be estimated. The conclusions will help in establishing a maintenance plan for the U.N. curtain. In the future the recommendations made in this study will be of value to those who commission works of art as well as to those who make the objects, the artists and craftspeople, and to those who take care of the objects in museums, the curators and conservators. However this investigation does not aim at explaining

why flame retardants influence wool in a harmful way. As mentioned above flame retardants vary widely and explaining all the effects of all their components calls for a broader study.

Objectives of the study

The objective of the study is to further explore the possible use of flame retardants for wool. The aim is to arrive at recommendations for the new ECOSOC curtain, should the U.N. Capital Master Plan arrive at the conclusion that the new curtain must be treated with a flame retardant. The study will compare two flame retardants and indicate which flame retardant will cause the least damage. The study will also explore the projected lifespan of the new curtain.

The main objective is to ensure that the intentions of the artist and the aesthetic values of the textile work are not obscured by the effects of flame retardants.

Selection of treatments

In an earlier study performed at the Swedish National Heritage Board (Bergstrand, 2013) four flame retardants were chosen and applied to cotton. The results were disappointing as the cotton was severely damaged by the application of flame retardants. Based on this study a decision was made to use two of these flame retardants, Apyrum and Secura. In the study Apyrum had been found to be the least damaging to the cotton material. Secura was available on the Swedish market, while the two other prodcts from the earlier study no longer were available. Apyrum and Secura also represent two different types of flame retardants - organic salts (Apyrum) and ammonium phosphates (Secura). Because only two flame retardants were used the number of samples in this study was kept to a minimum.

Experimental Work

Fabric selection and preparation

Samples were obtained from HV Ateljé, the studio that was commissioned to make the curtain for the ECOSOC. Two fabrics that were chosen for the new U. N. curtain, one orange felted wool (UN 1) and one sand-coloured crêpe wool (UN 2).

The orange felted wool was chosen from a range of colours offered by the firm Kvadrat but the sand-coloured fabric was dyed to order and reactive dyes were used. As a control reference a tabby weave wool (Wool adjacent as per ISO 105-F01) was chosen. This fabric was not dyed.

Selection of flame retardants

Two flame retardants on the Swedish market in 2012 were chosen for experimental work. *Apyrum R Bio-FF* (FR1) is fairly new on the Swedish market. According to the marketing of the brand it is not harmful to the environment. The main components are “citrate and acetate” and it has a pH of 7–8 according to the product data sheet. See appendix 1.

The other flame retardant used in this study was *Secura Anti-Flame FRT* (FR 2), which has a more traditional composition containing mainly “modified ammonium phosphate” according to available information on the product. According to the data sheet the product is not harmful to health or the environment and has a pH of 6.2. See appendix 2.

Preparation and application of flame retardants

Samples of the three fabrics were placed lying flat and sprayed with deionised water and 0.1% tenside *Änglamark. Fintvättmedel från Coop*, pH 6.5 to 7. After being thoroughly wetted the fabrics were dried lying flat in the washing table.

Drying time was less than 24 hours. This set of fabrics was used as a control and for comparable studies.

A second set of the three fabrics was used and the two flame retardants were applied to the fabrics in a similar way. The fabrics were placed lying flat and sprayed with flame retardants according to the recommendations made by the suppliers. The samples treated with Apyrum (FR1) took a long time to dry and smelled strongly of vinegar. The Secura (FR 2) treated samples dried in less time. It was observed that on the surface of the fabric was the remnance of what seemed to be salt crystals.

All samples treated with flame retardants had an oily unpleasant feel.

pH

pH was measured using a *Horiba B212 Twin pH meter* before and after treatment with flame retardants after accelerated ageing and after wet-cleaning.

Flammability test

A flammability test to make sure that the flame retardants were applied correctly according to the manufacturers recommendations was made, using small samples approximately the size of 140 mm x 26 mm. The samples were tested hanging vertically and subjected to a gas burner using propane (C^3H^8) gas for 60 seconds. After the flame from the gas burner was extinguished observations were made to see if the sample kept burning or forming coal. The test was modelled after SIS 65 00 82.

Dimensional stability and rigidity of fabrics after application of flame retardants

The samples were observed and evaluated by several colleagues at the Swedish National Heritage Board but no formal Flexural rigidity test according to the standard was performed.

Accelerated ageing

One series of samples was subjected to accelerated ageing for 10 years and another series for 60 years. After accelerated ageing 10 years a series of samples was wet-cleaned in deionised water and a neutral wetting agent (see details under Wet-cleaning).

The accelerated ageing was performed using light ageing with a *430 watt Sol500 lamp from Hönle UV technology* with a metal halide light bulb with radiation efficiency in the ultraviolet and visible range (295–780 nm). The samples were placed flat on a table. The ageing period was set to 4 days which corresponds to 10.6 years with 100 lux 8 hours per day, 7 days a week, 365 days per year (museum exposure) and to 21 days, which corresponds to 61.2 years with 100 lux 8 hours per day, 7 days a week, 365 days per year (museum exposure). Lux levels and UVA levels were measured once a week whilst RH and temperature were measured once a week using 22 measuring points and the samples were rotated once a week to create even exposure. The samples were exposed to an average of 30 700 lux and 13 W/ m^2 per 24 hours at 21–25°C and 45% - 50% RH.

Tensile test

Breaking strength and elongation at break of fabrics were determined in principle according to SS-EN ISO 13934-2 using a Shimadzu AutoGraph AGS-X tensile tester.

Sample preparation for tensile testing

The sample specimens were prepared according to the Swedish standard SS-EN ISO 13934-1. The specimens were cut to a size of 140 mm x 35 mm and frayed leaving 5 mm on either side of the sample. The gauge length was 100 mm.

Test procedure and conditioning of samples for tensile testing

RH should be kept to an average 60% (± 2.1%) and the temperature to an average 23 °C (±1 °C) during the tensile testing differing from the standard atmosphere of the Swedish Standard SS-EN ISO 139:2005. The specimens were pre-conditioned according to the SS-EN ISO 139:2005. See also sample preparation regarding the size of the specimens. The samples were tested only in the warp direction.

Spectrophotometer

Colour measurements were carried out using a *Konica-Minolta CM-2600d spectrophotometer with an 8mm aperture mask* before and after treatments with flame retardants and before and after accelerated ageing (10 and 60 years).

Wet cleaning

Samples from the 10 years accelerated ageing session were wet cleaned after the ageing using deionised water and 0.1% tenside *Änglamark. Fintvättmedel från Coop*, pH 6.5 to 7. Any colour change during the wet-cleaning was observed and recorded by Spectrophotometer. After drying the size of the samples were measured.

Other

Samples of the treated and not treated fabrics were exposed to natural daylight for one year from August 28 2012 to August 27 2013. The samples were mounted with metal staples on Coroplast® sheet and placed in a window facing north at the Swedish National Heritage Board in Visby.

Results

pH

The pH values of the treated fabrics before and after treatment as well as before and after accelerated ageing are shown in table 3. The pH of the control test weave after wetting in water was 6.30.

Table 1. pH measurements
Mean of five measurements.

Fabrics	TW Test Weave	UN 1 Orange	UN 2 Beige
Not treated	6.52	4.16	3.88
FR 1	8.40	7.58	7.38
FR 2	5.38	6.00	5.80
Fabrics aged 10 years			
Not treated	6.24	3.80	3.90
FR1	8.74	8.34	7.50
FR 2	4.96	5.06	4.92
Fabrics aged 10 years, wet-cleaned			
Not treated	6.48	4.12	3.90
FR 1	8.26	8.60	7.54
FR 2	4.66	4.20	4.00
Fabrics aged 60 years			
Not treated	5.80	3.88	3.92
FR 1	8.98	9.02	7.30
FR 2	4.46	4.46	4.00

Flammability test

The flammability test performed at the Swedish National Heritage showed no significant difference in the flammability of the treated fabrics and the not treated wool fabrics. The untreated orange fabric UN1 showed a better resistance to flammability than samples of the fabric treated with flame retardants FR1 and FR2.

Figure 1. The untreated orange fabric UN1 (specimens in the middle) showed a better resistance to flammability than samples of the fabric treated with flame retardants Apyrum (FR1) to the right and Secura (FR2) to the left. Note the spots of moisture from Apyrum (FR 1). Photo Margareta Bergstrand.

Dimensional stability

Dimensional measurements were taken in warp and weft directions after application of the flame retardants and after the samples had dried. An increase in weight was observed in all the treated samples. Shrinkage after flame retardant treatment was also observed. See tables 2 to 3.

Table 2. Weight increase.
A single prepared sample (with or without frayed edges) was weighed before and after the flame retardant application. Measurements in grams.

	Before FR treatment	+ FR1	+ FR2
UN 1	2.31 frayed edges	3.99 frayed (+1.68 g) 73%	-
UN 1	3.37 not frayed	-	3.45 not frayed (+ 0.8) 23%
UN 2	2.29 frayed	2.8 g frayed (+ 0.55) 24%	-
UN 2	2.82 not frayed	3.46 not frayed (+ 0.64) 23%	3.08 g not frayed (+0.26) 9%
TW Test weave	0.58 frayed	1.01 frayed (+ 0.43) 74%	-
TW Test weave	0.75 not frayed	1.20 not frayed (+ 0.45) 60%	0.82 g not frayed (+ 0.07) 9%

Shrinkage and length and width changes

After application of water;

The orange felted fabric (UN1): shrinkage 7% in the warp direction and 2% in the weft direction.

The sand-coloured crêpe fabric (UN2): shrinkage 3% in the warp direction and 2% in the weft direction.

Control Test weave (TW): A minimum shrinkage in the warp direction of 0.2% and 1% increase in the weft direction.

After application of flame retardants;

Flame retardant Apyrum (FR1), pH 7, applied to UN1 orange fabric made the fabric increase by 2% in the warp direction. No increase or shrinkage in the weft direction was observed.

UN 2 beige fabric increased by 3% in the warp direction and did not increase or

shrink in the weft direction.
The control test weave did not change in the warp direction but increased by 1% in the weft direction.

Flame retardant Secura (FR2), pH 7 applied to UN1 orange felted fabric made the fabric increase by 2% in the warp direction and shrink by 0.3% in the weft direction.
UN 2 sand-coloured crepe shrunk in both the warp and weft directions by 2%.
The control test weave did not change in the warp direction but shrunk by 0.7% in the weft direction.

Shrinkage after 10 years accelerated ageing and after wet-cleaning

Shrinkage after 10 years accelerated ageing and after wet-cleaning was measured. After wet - cleaning the shrinkage in the warp direction of the fabrics was most significant in the fabrics treated with flame retardants.

Table 3. Shrinkage after 10 years accelerated ageing and after wet-cleaning. Measurements in cm. Mean of 5 measurements.

	Test Weave		UN 1		UN 2	
Fabrics aged 10 years						
Not treated	14.20		14.00		14.10	
FR1	14.34		13.90		14.18	
FR 2	14.30		14.28		14.04	
Fabrics aged 10 years, wet-cleaned						
Not treated	14.16	-0.28%	13.38	-4.43%	14.00	-0.71%
FR 1	13.80	-3.77%	12.82	-7.77%	13.50	-4.80%
FR 2	14.00	-2.10%	13.16	-7.84%	13.60	-3.13%

Flexural rigidity

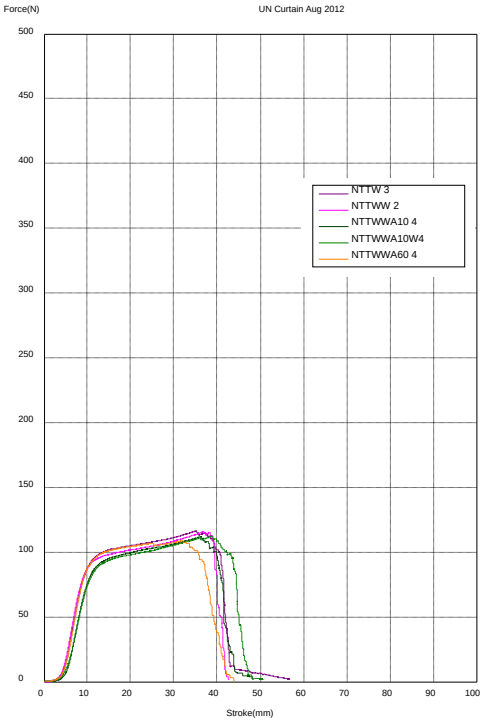
The fabrics treated with flame retardants became very stiff after application of the flame retardants and remained so even after accelerated ageing for 10 and 60 years. This was a general subjective evaluation made by several colleagues at the Conservation Department but the samples were not subjected to a standardized flexural rigidity test.

Tensile tests

Tensile tests show that elongation at break is altered more after accelerated ageing in the specimens treated with flame retardants than in specimens not treated with flame retardants. In all, samples treated with flame retardants aged 10 year and wet-cleaned showed the most significant difference from the not treated not aged samples.

Diagrams

Comparison of tensile tests after no treatment, FR treatment, FR treatment aged 10 years and aged 60 years. FR treated fabric aged 10 years and wet-cleaned is also measured.

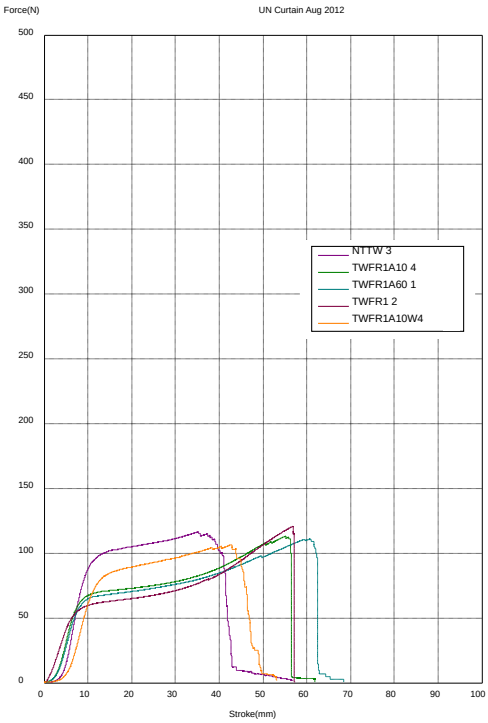


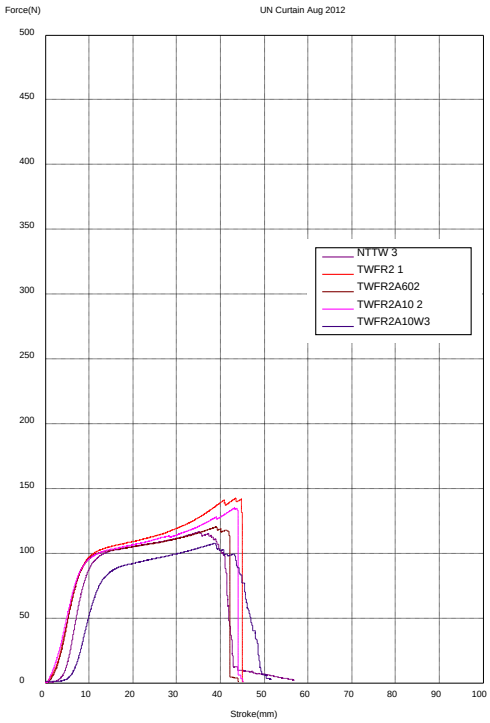
Diagrams 1-3 showing changes in tensile strength of the test weave after application of water, flame retardants 1 and 2 and after artificial ageing, 10 and 60 years, and after wet-cleaning.

Diagram 1, above left: Not treated.

Diagram 2, below left: Apyrum FR1

Diagram 3, below right: Secura FR2





Spectrophotometer

Colour changes of the treated fabrics directly after application, before and after accelerated ageing were measured and recorded. The 10 year aged samples were measured before and after wet-cleaning as well.

Diagrams

dE*values over or below 1 indicate a colour change visible to the human eye.

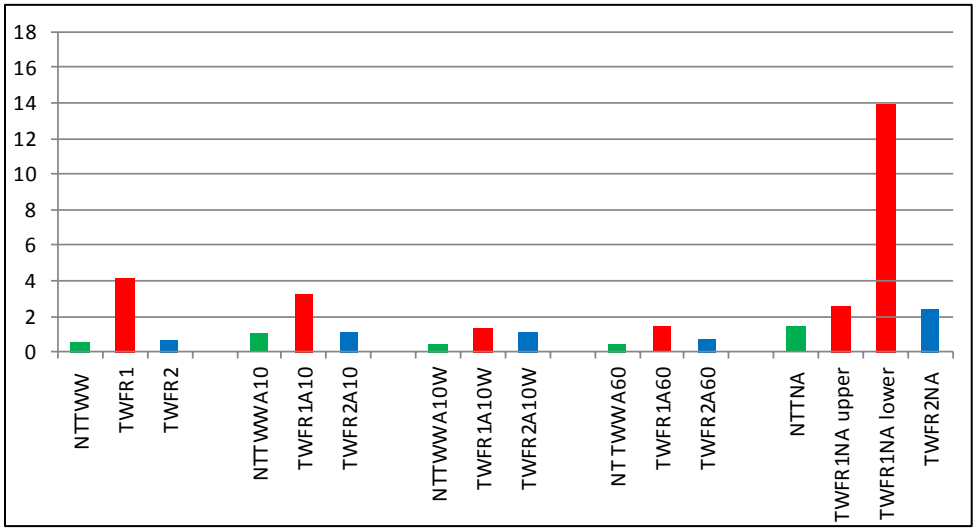


Diagram 4. Test weave dE*ab(D65) mean of 5 measurements.

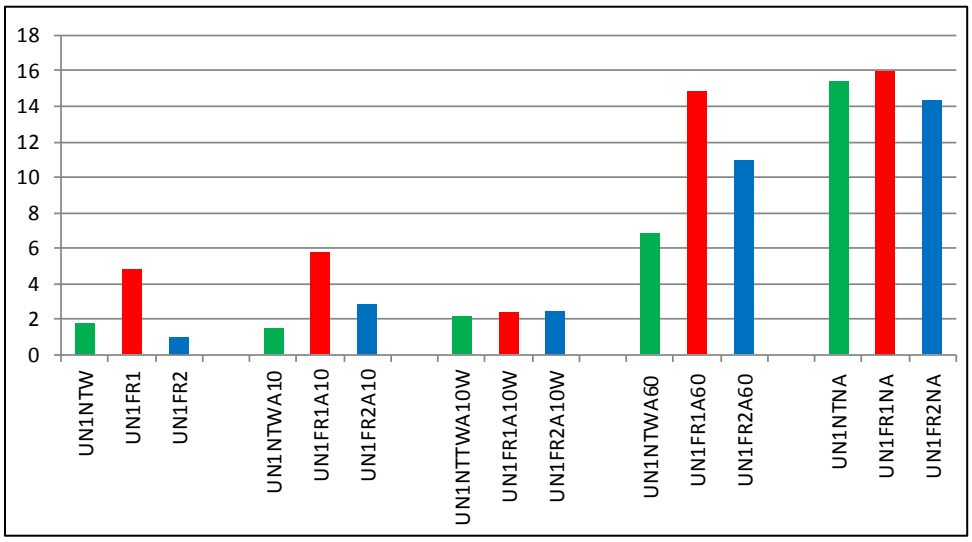


Diagram 5. UN1 orange fabric dE*ab(D65) mean of 5 measurements.

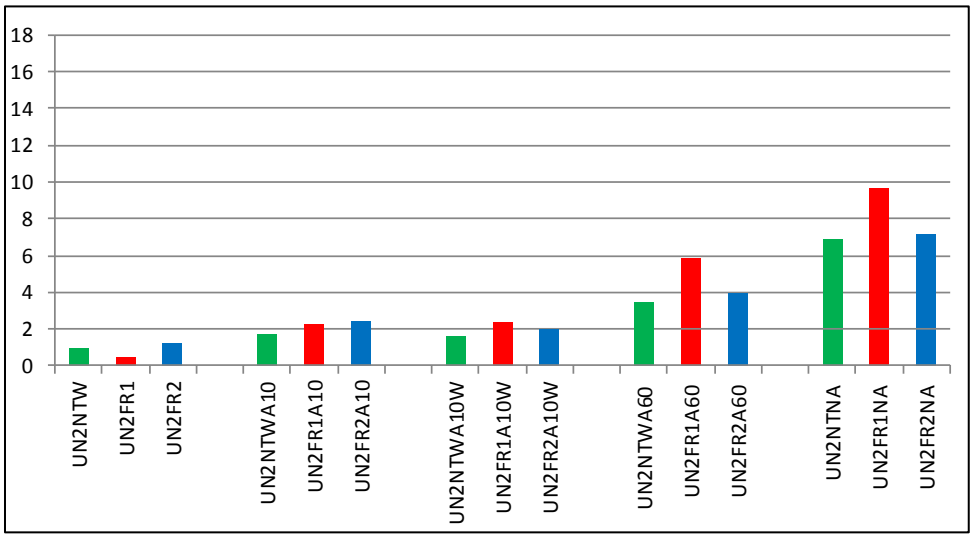
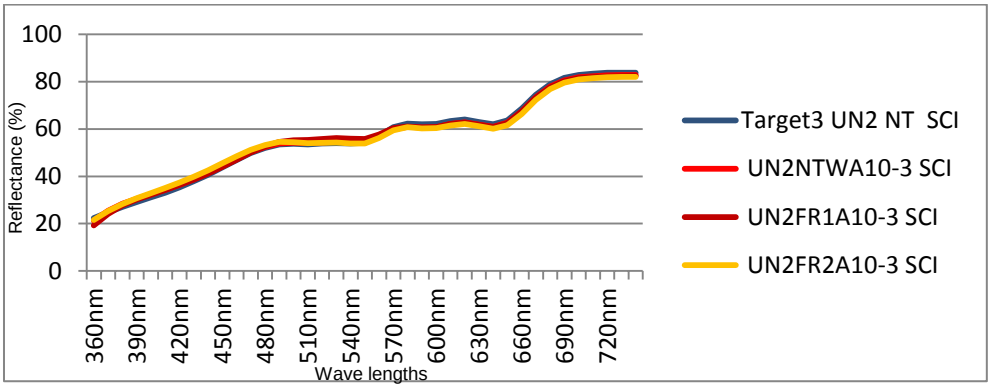


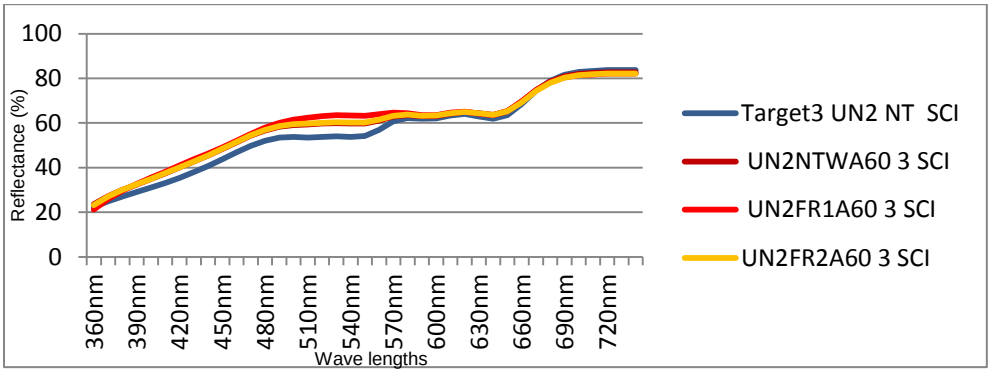
Diagram 6. UN2 sand-coloured dE*ab(D65) mean of 5 measurements.

Spectra

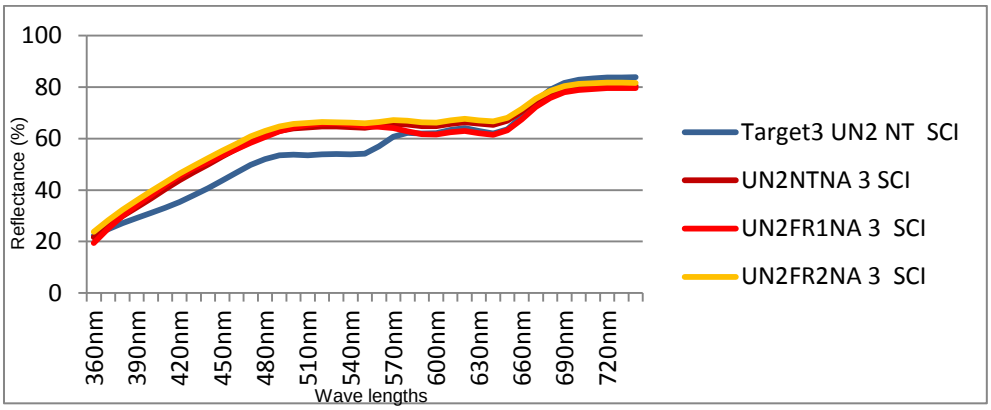
These spectra show colour change of the sand-coloured fabric UN2.



Spectra 1. UN2 artificially aged 10 years



Spectra 2. UN2 artificially aged 60 years



Spectra 3. UN2 naturally aged 1 year

Wet-cleaning

When wet-cleaning UN1 orange fabric samples aged 10 years and treated with flame retardants Apyrum (FR1) and Secura (FR2) a dye component visibly leaked into the water. The sample treated with Secura (FR2) emitted a strong smell of sulphur as observed by Judith Bannerman who performed the wet-cleaning in July/August 2012. Shrinkage was observed as described above.

Discussion

Dimensional stability

Water made all the investigated fabrics shrink to varying degrees. Contrary to this, flame retardants, although they contain a rather high amount of water, did not make the fabrics shrink but made them stretch in the warp direction with a small increase in the weft direction in some cases. Doreen Rockliff and Nancy Kerr, (Rockliff, Kerr, 1984) made the same observation when investigating three flame retardants in the 1980s. They suggest that changes in dimension of the fabric are caused by the wetting action of the water. The presence of the fire retardant agents in solution appears to reduce the shrinkage caused by water.

Drape

The fabrics treated with flame retardants became very stiff. They remained so even after washing and after exposure to daylight. This altered the appearance as well as the drape of the fabric and may make the curtain difficult to handle, for example, when pulling it to and fro in front of the window. The oily feel of the treated fabrics also remained.

Flammability

The small scale flammability test performed at the Swedish National Heritage Board showed no significant difference in the flammability between the treated fabrics and the untreated wool fabrics. Samples of the orange fabric UN1 even showed a better resistance to fire than samples of the same fabric treated with Apyrum and Secura.

In a thesis from Luleå tekniska universitet (Luleå University of Technology) Marcus Lagerkvist (Lagerkvist, 2010) investigated the properties of four flame retardant treatments among them were Apyrum and Secura. Apyrum does not

provide the resistance to fire expected from a flame retardant treatment while Secura on the other hand provides better resistance to ignition in Lagerkvist's study. It is interesting that although his study was on upholstery fabrics his findings correspond to the experiments performed at the Swedish National Heritage Board. However in our experiments neither Apyrum nor Secura applied to wool performed better than untreated wool fabrics.

In 2012 a full scale model of the curtain (7 x 1.40 m), made at HV Ateljé out of the two wool fabrics intended for the ECOSOC curtain and not treated with any flame retardant, was tested at the Southwest Research Institute, SwRI, San Antonio, Texas, USA according to *ASTM E 84 – 12, Standard test method for surface burning characteristics of building material*. According to the evaluation of the test report from SwRI made by Per Thureson, Deputy Head of Section, SP Fire Technology at SP Technical Research Institute of Sweden, the wool fabrics fulfil the requirements of class B according to the 1968 Building Code of the city of New York. This strengthens the assumption that wool in general does not need flame retardants to add to its flame retardant properties.

pH and chemical changes after accelerated light ageing

According to the aforementioned study from the Swedish National Heritage Board, analysis showed that Apyrum (FR1) contains potassium and not only "citrate, acetate and water" as was stated in the product data sheet. Potassium content may explain the relatively high pH values of the solution. However the pH does not sink to a more acidic level after accelerated ageing. A pH level as high as 9 may damage wool fibres.

The fabrics treated with Secura (FR2) and aged for 10 and 60 years became more acidic over time. Acidity may in the long run damage the fabric even if wool is more resistant to acidity than cotton and linen.

All the untreated fabrics show a slight change in pH to a more acidic level after accelerated ageing, 60 years more than 10 years. See also table 3.

Colour

Colour changes, even very small changes, on a textile work of art may affect the aesthetical appearance of the art work and alter the intended impact of the art work on the observer. The application of Apyrum (FR1) visibly changed the sand-coloured fabric UN2 from a beige or very light brown colour to a greenish hue. On the other hand the colour of the not treated fabric faded and became lighter after exposure to light but did not visibly change the colour tone as much as the fabrics treated with FR1 or FR 2. Both flame retardants turned the bright orange colour of fabric UN1 to a more dull orange hue. These colour changes could be visibly observed in the fabrics that were accelerated aged for 10 and 60 years as well as in those subjected to daylight for one year.

The samples treated with flame retardants which had been exposed to daylight for one year, mounted in vertical position, showed significant visible colour changes as seen in the diagrams of spectrophotometer measurements. However this is not as visibly evident as the spectrophotometer measurements show.

The influence of flame retardants on the wet-fastness of dyes

The leaking of the dye when wet-cleaning the samples may be a reaction to the lowered pH of the fabric but is more likely due to the influence of the flame retardant on the reactive dye. Similar leaking was observed when wet-cleaning a piece of velvet from a curtain that had been hanging in the ECOSOC in the UN headquarters in New York. (See introduction).

Tensile tests

A previous study on the tensile strength of naturally aged textiles (Bergstrand, 2013) showed that flame retardant treatment will weaken cellulose fibres. This was easily proved by looking at the breaking strength results from the tensile tests. Protein fibres differ from cellulose fibres and evaluating tensile tests with wool is more complicated than cellulose fibres. By looking at only the breaking strength it may in some cases seem that flame retardants make the material stronger. However elongation at break results may point in another direction. There are indications that for wool, per cent elongation is a more sensitive indicator of change. (See for example Peacock 1999) The tensile tests in this study all show significant changes in elongation at break, especially in the samples treated with flame retardants, aged 10 years and wet-cleaned.

Other observations

It was observed that in some cases dark spots formed around the staples on the samples that were mounted with metal staples on Coroplast® sheet. In one case, the sample treated with Secura (FR1), the staple corroded after a very short time (see figure 2).

Figure 2. Samples exposed for one year placed vertically in window facing north. Effects of Secura (FR2) on test weave (to the left), orange fabric (1) and sand-coloured fabric (2). Salt migration can be seen in the lower part on test weave and fabric 2 (to the right). To the far left; brown discoloration on test weave sample treated with Apyrum (F1). Photo Margareta Bergstrand.

Ammonium salts, especially ammonium chloride, corrodes metals. This causes spots on textiles but may also be a threat to curtains that are often mounted with metal devices.

In addition, the sand-coloured fabric (UN1) and the control weave (TW) treated with Secura (FR2) showed signs of so called salt migration (see figure 2). Salt migration has been observed in textiles treated with flame retardants, but has often been deemed the result of flooding or water damage. The salt migration often appears in the lower parts of hanging textiles. It is possible that it is caused by the humidity in air which even under relatively normal indoor climate conditions may release the salts in the flame retardants thus forming spots and colour changes.

The salt crystals on the surface of fabrics treated with Secura (FR2) remained after accelerated ageing 10 and 60 years and were not entirely removed in the wet-cleaning process. It is possible that the salt crystals would wear off from the surface under normal indoor use, influence of air currents from ventilation and from handling the textile, but these samples have been kept in protective plastic cases. However many fire retardants do emit from the surface that is why many manufacturers recommend that the treatment is repeated after a couple of years.

Inauguration of the ECOSOC chamber in April 22, 2013. Photo: Margareta Bergstrand.

Conclusions

The two tested flame retardants Apyrum and Secura both show shortcomings from a conservation perspective as well as from an aesthetical view. Neither do they add much to the flame resistant properties of the wool fabrics. Apyrum (FR1) showed least damage when looking at tensile strength. On the other hand it caused a significant and unacceptable change in colour to the sand-coloured fabric UN2. It also added weight and made the fabrics quite stiff altering the drape. Secura (FR2) altered the drape and handle of the two fabrics as well as changing the colour. Secura caused corrosion on metal and the treated fabrics also showed signs of salt migration. The two flame retardants caused changes in pH values as discussed above.

Considering that the curtain will be installed in an indoor climate that may, at times be warm and humid, as found in the ECOSOC, these shortcomings may be accelerated. Shrinkage and colour running as well as loss of fibre strength when wet-cleaning make cleaning and remedial conservation a challenge.

The Swedish National Art Council has asked for the curtain to be in good condition for at least 60 years but as a result of the study performed at the Swedish National Heritage Board, it appears that neither Apyrum nor Secura, or any other flame retardants containing the same chemicals (that is phosphate, acetate or other organic and inorganic salts), can be considered for the new textile work of art for the ECOSOC as they will reduce hanging life significantly.

Furthermore the evaluation of the flammability test performed at Southwest Research Institute (SwRI) by SP Technical Research Institute of Sweden adds to the recommendations of the Swedish National Board, that no flame retardant will be required for the new curtain installed in the ECOSOC.

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Rockliff, D. & Kerr N. 1984. Fiber retardant finishes for fiber art: a conservation perspective. Preliminary findings. *ICOM Committee for Conservation: 7th Triennial Meeting, Copenhagen 10-14 September 1984: Preprints*. Paris. 84.9.46 – 84.9.50.

Materials

Fabrics

Orange felted wool fabric
“Divina 3” 4-end broken twill from Kvadrat A/S

Sand-coloured crêpe wool fabric
“Topas 2” crêpe binding from Kvadrat A/S. Dyed to order at Kvadrat.

Test weave
Wool Adjacent Fabric as per ISO 105-F01 (Warp 22 tr/cm Z-sp, weft18 tr/cm Z-sp) from Testfabrics Inc. represented in Sweden by Cromocol AB.

Chemicals

Apyrum
From Deflamo AB, Sollentuna
See also Product data sheet appendix nr X

Secura
From Svensk flamskyddsteknik, Västerås
See also Product data sheet appendix nr X

Wetting agent and surfactant
Änglamark, fintvättmedel from Coop.

Standards

Svensk standard SS-En ISO 6940:2004

Textile fabrics – Burning behaviour – Determination of ease of ignition of vertically oriented specimens (ISO 6940:2004).

Svensk standard SS-EN ISO 139:2005/A1:2011

Textiles – Standard atmospheres for conditioning and testing – Amendment 1 (ISO 139:2005/AMD 1:2011).

Svensk standard SS-EN ISO 13934-2

Textiles – Tensile properties of fabrics – Part 2: Determination of maximum force using the grab method (ISO 1 3934-2:1999).

Appendices

Appendix 1. Sample codes

Samples	Sample code
Test weave ISO wool Adjacent Fabric	
Not Treated Test Weave1-5	NTTW 1-5
Not Treated Test Weave Wet	NTTWW 1-5
Not Treated Test Weave Wet Aged 10 years	NTTWWA10 1-5
Not Treated Wool Test Weave Wet Aged 10 years Washed	NTTWWA10W 1-5
Test Weave treated with Flame Retardant 1	
Test Weave FR1	TWFR1 1-5
Test Weave FR1Aged 10 years	TWFR1A10 1-5
Test Weave FR1Aged 10 years Washed	TWFR1A10W 1-5
Test Weave FR1Aged 60 years	TWFR1A60 1-5
Test Weave treated with Flame Retardant 2	
Test Weave FR2	TWFR2 1-5
Test Weave FR2Aged 10 years	TWFR2A10 1-5
Test Weave FR2Aged 10 years Washed	TWFR2A10W 1-
Test Weave FR2Aged 60 years	TWFR2A60 1-5
Orange felted wool	
UN1 Not Treated	UN1NT 1-5
UN1 Not Treated Wet	UN1NTW 1-5
UN1 Not Treated Wet Aged 10 years	UN1NTWA10 1-5
UN1 Not Treated Wet Aged 10 years Washed	UN1NTWA10W 1-5
UN 1 fabric treated with Flame Retardant 1	
UN1 FR1	UN1FR1 1-5
UN1 FR1Aged 10 years	UN1FR1A10 1-5
UN1 FR1Aged 10 years Washed	UN1FR1A10W 1-5
UN1 FR1Aged 60 years	UN1FR1A60 1-5
UN 1 fabric treated with Flame Retardant 2	
UN1 FR2	UN1FR2 1-5
UN1 FR2Aged 10 years	UN1FR2A10 1-5
UN1 FR2Aged 10 years Washed	UN1FR2A10W 1-5
UN1 FR2Aged 60 years	UN1FR2A60 1-5
Sand-coloured fabric	
UN2 Not Treated	UN2NT 1-5
UN2 Not Treated Wet	UN2NTW 1-5
UN2 Not Treated Wet Aged 10 years	UN2NTWA10 1-5
UN2 Not Treated Wet Aged 10 years Washed	UN2NTWA10W 1-5
UN2 fabric treated with Flame Retardant 1	
UN2FR1	UN2FR1 1-5
UN2FR1Aged 10 years	UN2FR1A10 1-5
UN2FR1Aged 10 years Washed	UN2FR1A10W 1-5
UN2FR1Aged 60 years	UN2FR1A60 1-5
UN2 fabric treated with Flame Retardant 2	
UN2FR2	UN2FR2 1-5
UN2FR2 Aged 10 years	UN2FR2A10 1-5
UN2FR2 Aged 10 years Washed	UN2FR2A10W 1-5
UN2FR2 Aged 60 years	UN2FR2A60 1-5

Produktblad Apyrum®Bio-FR

Detta är ett produktblad för Apyrum®Bio-FR med information kring produkten, dess egenskaper, användningsområden och handhavande.

PRODUKTBESKRIVNING

Apyrum®Bio-FR är ett vattenbaserat flamskyddsmedel klassificerat som harmlöst och därmed ofarligt för miljö och hälsa. Apyrum®Bio-FR är lätt att använda och ger ett flamskydd åt fiberösa material såsom trä, papper och textilier. Resultatet är ett material som är mer svårantändligt och vars tillförda egenskaper fördröjer ett brandförlopp. DEFLAMO AB har utvecklat ett antal olika produkter i Apyrum®Bio-FR-serien och produktvalet beror på användningsområden. Flera faktorer som påverkar valet av Apyrum®Bio-FR är följande:

Viktiga faktor som påverkar valet av Apyrum®Bio-FR
Uppsugningsförmåga av materialet
Tidsåtgången för impregnering
Komfortfaktor
Penetrationsegenskaper
Beståndsdelar av materialet
Brandegenskaper
Brandskyddskrav
Närheten till brandkällor

ANVÄNDARINSTRUKTIONER

Apyrum®Bio-FR är en färdig brukslösning som ej skall spädas före användning. För full effekt mot brand, måste Apyrum®Bio-FR tränga in i materialet och därefter torka. Detta tar olika lång tid och kräver olika teknik beroende på materialets beskaffenhet. Olika appliceringsmetoder bör testas och resultaten jämföras.

Förberedelse

För bästa effekt måste materialet som ska behandlas vara rent och torrt. Material som är målade, skyddade mot väta eller har hög densitet kan ej flamskyddas med Apyrum®Bio-FR. **Nya tyger ska alltid tvättas** minst en gång före behandling för att avlägsna fabriks- och leveransimpregneringsmedel. Dessa kan vara mycket brandfarliga och kan omöjliggöra flamskyddsbehandling.

Impregneringsförfarande

För att kunna säkerställa en jämn kvalitet av flamskydd i slutprodukten, måste alltid impregnering med Apyrum®Bio-FR utföras på ett kontrollerat och reproducerbart sätt.

Spraya

På mycket sugande material sprayas ett tunt lager. Tjockare och mer brännbara material kan behöva mer Apyrum®Bio-FR. Spraya på armlängds avstånd (ca 30-40cm). Spraya rikligt, men aldrig mer än vad materialet klarar av att suga åt sig. Testa på en mindre bit av materialet först, som även torkas och brandprovas, för att klargöra behovet.

Doppa

Måttligt sugande material kan doppbehandlas för att uppnå en mycket god flamskyddsbehandling. Tidsåtgången för doppning varierar med materialets uppsugningsförmåga. Testa på en mindre bit av materialet först, som även torkas och brandprovas, för att uppskatta en lämplig doppningstid.

Måla

Måttligt sugande material kan även målas med Apyrum®Bio-FR. Antalet strykningar varierar med materialets uppsugningsförmåga. Testa på en mindre bit av materialet först, som även torkas och brandprovas, för att uppskatta en lämplig exponeringstid.
Se även avsnittet **"Brandprovning/Brandkrav"**

Observera: Om ett material behandlas med för mycket Apyrum®Bio-FR som ej avlägsnas, kan det kännas stelt och ytan upplevas som fet eller fuktig. Överflödigt Apyrum®Bio-FR torkas bort med ren, torr trasa efter att materialet sugit upp vad det klarar av.

Tänk på att...

- Klargöra att Apyrum®Bio-FR trängt in i materialet innan ett eventuellt överflöd torkas bort. Penetrationen tar olika lång tid beroende på materialets egenskaper.
- Apyrum®Bio-FR är vattenlöslig. Flamskyddet går därför inte längre att säkerställa i ett material som efter behandling utsatts för någon form av väta. **En ny behandling kan vara nödvändig!**

Torkning/Torktid

Apyrum®Bio-FRs funktionalitet som flamskyddsmedel förutsätter en fullständig torkning efter behandling. Torktiden varierar med temperatur-, luftfuktighets- och ventilationsförutsättningar. **Låt materialet torka ordentligt efter impregneringen!**
Observera: Materialet bör ej tillåtas att "övertorka".

Förbrukning

Åtgången av flamskyddsmedel bestäms dels av materialets uppsugningsförmåga (ytegenskaper) och dels av materialets vikt och brännbarhet. Ju mer lättantändligt ett material är, desto mer Apyrum®Bio-FR kan krävas för att uppnå ett fullgott flamskydd.

Brandprovning/Brandkrav

För att säkerställa ett fullgott flamskydd bör antändningsprov i laboratoriemiljö genomföras, eftersom olika material har varierande egenskaper avseende deras uppsugningsförmåga och brännbarhet.

Ett indikerande brandprov kan dock vara att hänga ett stycke av materialet över en öppen låga, t.ex tändare eller gaslåga under ca 10-12 sekunder. Tag sedan bort eldslågan. Preliminära indikationer till ett gott flamskydd: om materialet inte antänder alls eller om lågan genast slocknar utan efterglöd efter det att den tillförda eldslågan tagits bort.
I de fall nivån av brandskydd regleras i standarder, hänvisar DEFLAMO till gällande regelverk för respektive material och miljö.
Material som behandlats med Apyrum®Bio-FR har testats och i många sammanhang har ställda brandkrav uppnåtts. Men som en orsak av stor variation mellan olika materials egenskaper i allmänhet (brandtekniska egenskaper i synnerhet), kan dock ingen garanti ges på att efterfrågat brandskydd uppnås. **För att säkerställa att önskade brandskyddsegenskaper uppnås måste alltid individuella brandprov genomföras!** (För mer information om krav på brandskydd, kontakta lokala brandskyddsmyndigheter.

Efterbehandling

Efter behandling med Apyrum®Bio-FR kan materialet övermålas, limmas eller på annat sätt täckas.
Observera:

- Överflödig Apyrum®Bio-FR skall avlägsnas för bästa vidhäftningsförmåga.
- Det finns ingen garanti för att alla former av efterbehandling är möjlig. Den specifika applikationen bör testas noggrant, gärna i samråd med DEFLAMO.

Efterbehandling kan påverka flamskyddsegenskaperna! Utför därför alltid antändningsprov efter efterbehandling!

Rengöring av Utrustning

Verktyg rengörs med vatten.

FAKTARUTA

Fysikaliskt tillstånd: Vätska, vattenlösning.
Färg: Klar, ofärgad.
pH: 7-8.
Lukt: Förnimbar ättiksyra, avtar vid torkning.
Densitet: 1,3 -1,4 g/ml.
Viskositet: Något högre än vatten.
Förtunning: Förtunnas ej, färdig brukslösning.

Innehåll: Vatten, citrat, acetat.
Lagring: Lagras inomhus i väl försluten förpackning vid normal rumstemperatur. Kvalité och funktion garanteras till 12 månader från tillverkning i obruten förpackning.
Förpackningar: 1-liter, 5-liter, 15-liter, Kontakta återförsäljare eller DEFLAMO för större förpackningar.

Tillverkas av: Eurenco Bofors AB.
Certifieringar: ISO 9001.

DEFLAMO
Providing Innovative Environmentally Friendly Flame Retardant Technology

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SÄKERHETSDATABLAD
(SDB)

Versiondatum	Ersätter tidigare version	Denna version	Sida
2006-03-01	**FRT 1:20041101**	**FRT 2:20060301**	**1 (6)**
Artikel nummer	Handelsnamn		
SC FRT	**Secura Anti-Flame FRT**		

1. Namnet på produkten och företaget

Produkt namn Secura Anti-Flame FRT

Adressupgifter
Svensk Flamskyddsteknik AB, Fågelbacken, 725 95 Västerås
Utfördat av
Miljö & kvalitet i Västerås Telefon +46 021-147273, Fax +46 021-305701
I nödsituation - på icke arbetstid - ring: SOS alarm 112

Kemisk beskrivning / användning Flamskydd av absorberande natur material t.ex. papper, textil mm

Detta SDB gäller för följande artiklar:
Secura FRT 25 | 50

Registrerat varumärke för Svensk Flamskyddsteknik AB

2. Sammansättning / uppgifter om beståndsdelar

CAS-nr	EG-nr	Benämning	Halt %	Symbol	R-Fraser
7722-76-1	2317645	Modifierad ammoniumphosphate	10-30%	EM	EM
7732-18-5	2317912	Ytaktiv vattenemulsion	< 100%	EM	EM

Produkttyp
Produkten är en modifierad beredning av halogenfri gasformig oorganisk - organisk kväve samt emulsion av olika fosforbaserade råvaror.

Ämnen med farliga egenskaper i beredning
Innehåller inga ämnen som ger produkten hälso,- miljö eller brandfarliga egenskaper.

Övrig information
För R-fraser och Symboler i klartext, se avsnitt 16

3. Farliga egenskaper

Klassificering:
Ej hälsofarlig produkt
Andra egenskaper / symptom
Produkten är bedömd som ej miljöfarlig
Risk för brand och explosion
Ej brand eller explosionfarlig produkt

4. Första hjälpen

INANDNING: Frisk luft.
STÄNK I ÖGON: Skölj rikligt med ljummet vatten t.ex. från dricksglas.
HUDKONTAKT: Tag av nedsmutsade kläder, tvätta huden med tvål och vatten.
VID FÖRTÄRING: Skölj munnen och ge vatten rikligt för att dricka (om den skadade är vid fullt medvetande) Framkalla ej kräkning

Allmän information: Vid minsta osäkerhet eller om besvär kvarstår, kontakta alltid läkare. Ge aldrig en medvetslös person något att dricka eller förtära. Vid uppsökande av läkare, visa om möjligt detta varu informationsblad eller produktetiketten.

Medicinsk information: Ordinarie hälsokontroll, behandling baseras på läkares bedömning och patient reaktioner.

Om besvär kvarstår kontakta läkare, ta om möjligt med detta SDB blad, produktblad samt produkten.

5. Åtgärder vid brand

Lämpliga släckningsmedel	:	Samtliga förekommande släckningsmedel.
Släckningsmedel som inte bör användas av säkerhetsskäl		Inga
Särskild exponeringsrisker vid brand	:	Kontakt med starka alkaliska produkter kan frigöra ammonium.
Övriga anvisningar	:	Standard procedur för kemikaliebrand, behållare kyls med vatten.

6. Åtgärder vid spill - oavsiktliga utsläpp

Personskydd	:	Vid långvarig hantering använd skyddshandskar och skyddskläder.
Miljöskydds åtgärder	:	Förhindra att produkten når avlopp, ytvatten, grundvatten eller mark.
Saneringsåtgärder	:	Vid stora utsläpp, valla in med sand, jord eller absorberingsmedel och samla upp. Spola rent med mycket vatten.

7. Hantering och lagring

Hantering : Använd alltid när så är möjligt sådana arbetsmetoder att långvarig och upprepad hudkontakt kan undvikas. Följ alltid bruksanvisningen för produkten.

Lagring : Förvara produkten i orginalförpackning, väl tillsluten och förvarad avskilt från barn. Förvaring skall ske frostfritt. Lagring om ej orginalförpackning finns tillgänglig skall ej ske i stålfat, stålförpackningar etc. Plast emballage skall användas. Skall inte förvaras brevid starkt alkaliska produkter.

Tillstånd : Krävs inga tillstånd.

8. Begränsning av exponeringen / personligt skydd

Tekniska anvisningar för att minimera exponering : Inga

Övervakningsparametrar : Inga

Hygieniska gränsvärden enligt AFS1993:9 finns för bl.a. följande ingående ämnen : Inga

Beståndsdelens benämning : Inga

Personlig skyddsutrustning : Personlig skyddsutrustning är inte nödvändig, men vid yrkesmässig användning med långvarig eller ofta upprepad hudkontakt med produkten bör skyddshandskar av gummi användas samt skydds glasögon.

Skydds och hygienåtgärder : Allmän hygien

Andningsskydd : Inga

Handskydd : Vid risk för direktkontakt eller stänk bör skyddshandskar användas.

Ögonskydd : Vid risk för direktkontakt eller stänk bör skyddsglasögon användas.

9. Fysikaliska / kemiska egenskaper (obs, ingen specifikation)

Egenskaperna avser hela beredningen

Utseende	:	Klar vätska
Färg	:	Ingen
Lukt	:	Svag lukt
pH i koncentrat	:	7,2 +/- ,2
Kokpunkt °C	:	100 - 110 °C
Lägsta flyttemperatur °C	:	c:a - 9
Brännbarhet	:	Ej brännbar
Explosiva egenskaper	:	Ej explosiv vara
Oxiderand egenskaper	:	Koppar, mässing, aluminium skall täckas väl vid risk för kontakt. Om kontakt sker skall riklig sköljning med vatten ske, torka därefter torrt med trasa.
Densitet	:	1134 kg/m³ , +/- 20 kg/m³
Löslighet i vatten	:	Blandbar i alla propotioner
- lösningsmedel	:	Ja

10. Stabilitet och reaktivitet

Stabilitet : Produkten är stabil under normalt förvaring

Förhållanden som skall undvikas : Frost

Material och kemiska produkter som bör undivkas : Koppar, mässing, zink, aluminium legeringar bör täckas väl vid risk för stänk eller kontakt. Vid kontakt skälj riktigt med rent vatten och torka torrt med ren trasa.
Undvik kontakt med stark alkaliska produkter, möjlighet finns till frigörning av fosfor och ammoniumoxid.

Farliga omvandlings produkter : Vid temperaturer > 300°C, finns möjlighet till frigöring av ammonium och fosforoxid.

11. Toxikologisk information

Inandning : Inga besvär

Hudkontakt : Produkten kan verka uttorkande och vid långvarig och ofta uppre pad hudkontakt kan hudens naturliga skyddsbarriär skadas.

Ögonkontakt : Stänk i ögonen kan ge övergående lätt sveda.

Förtäring : Kan ge sveda i mun och svalg samt om större mängd förtärts illamående och eventuellt kräkning.

Produkten är klassificerad som ej hälsofarlig vara enligt KIFS 1994:12

Toxologiska undersökningsdata finns enbart för farliga ingående ämnen, inte för beredningen.

Akut toxitet : Inga kända

Allerigegenskaper : Inga kända

Kroniskt toxitet : Nej

12. Ekotoxikoligisk information

Produkten är bedömd och klassificerad som " Ej märkningspliktig "
Ekotoxologiska undersökningsdata finns enbart för ingående ämnen, inte för beredningen.

Ekotoxologiska data för miljöfarliga ämnen i produkten
Inga miljöfarliga ämnen ingår i produkten

Notering
Inga negativa miljöeffekter är att vänta. Lokala större utsläpp till vattendrag har en gödande effekt.

13. Avfallshantering

Risker med avfallet : Inga kända risker.

Metoder för omhändertagande av produktrester : Produktrester är inget miljöfarligt avfall.

Metoder för omhändertagande av förpackningsrester : Tömda förpackningar kan lämnas för återvinning.
Tömda förpackningar är inte transport eller miljöfarligt gods.

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(SDB)

14. Transportinformation

Transportklassificering : Produkten är inte transportfarligt gods enligt bestämmelserna om transport i ADR, ADR-S, IMDG, ICAO-TI och IATA-DGR.

:

15. Gällande bestämmelser

EEC direktiv : Ej klassificerad som hälso eller miljöfarlig produkt enligt EEC direktiv 91/155/EEG

Symbol : N/A

R - fras : N/A

S - fras : S2, Förvaras väl frånskilt från barn

16. Övrig information

Förteckning över R-fraser för ämnen under punkt 2.

Risk och skyddsfraser

EM	:	Ej märkningspliktig
N/A	:	Ej tillgänglig
R11	:	Mycket brandfarlig
R36	:	Irriterar ögonen
R67	:	Ångor kan göra att man blir dåsig och omtöcknad
S(2)	:	Förvaras oåtkomlig för barn
S7	:	Förpackningen förvaras väl tillsluten
S16	:	Förvaras åtskilt från antändningskällor - Rökning förbjuden
S24	:	Undvik kontakt med huden
S25	:	Undvik kontakt med ögonen
S26	:	Vid kontakt med ögonen, spola genast rikligt med ljummet vatten och kontakta läkare

Debatterad information : **Produkten innehåller inte brom, klor, klorparaffiner, PBB, PBDE, HBCCD**

Utbildningskrav vid hantering av produkten : Produkten hanteras enbart av egen utbildad personal.

Som underlag till varublad har använts

- Råvaruleverantören/tillverkarens produktinformation
- Kemikalieinspektionens författningssamling
- Arbetarskyddstyrelsens kungörelser
- Toxnet

Kompletterande uppgifter fås av : Svensk Flamskyddsteknik AB, Teknisk support 0707-420420 support@flamskydd.com. www.flamskydd.com
Secura Anti-Flame registrerat som SPW Secura brandskyddsvätska