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WEATHERING OF PVC COATED FABRICS

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MSAA/LSAA Conf Proceedings

"WEATHERING BEHAVIOUR OF VINYL COATED INDUSTRIAL POLYESTER FABRICS"

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The open air weathering behaviour of vinyl coated industrial Polyester fabrics is of outstanding importance, as these materials are applied in most cases under open air conditions. In order to clear up the influence of coating and location of weathering we started a couple of years ago with a test program.

After having already presented the two years results of this program on the occasion of IFAI's coaters and laminators division meeting May, 1980, in New York, N.Y., this publication will give the 5 years results. Further on an explanation of these findings will be tried.

Experimental

The tests were performed in five different locations; the variables in these tests were the thickness of the top coat and the concentration of the UV absorber component. The substrate used was a polyester fabric of 1100 dtex (1000 den) (DIOLEN 174 S, plainweave 1/1, fabric sett 9/9/cm (22/22/inch)) (fig. 1). The colour of the coating was white. Details of the composition of the coating material are given in fig. 2. As one can see, this is a formulation normally used for the coating of industrial fabrics.

As already mentioned it was our goal to select five different test locations which would serve as models, so that their data could be used for judging the effects of ageing in other regions as well. Fig. 3 shows what climatic conditions prevailed in each location.

The Florida location represents a tropical climate, whereas Ebnet in Austria represents a moist alpine climate. Dormelletto (Lago Maggiore) is situated in a humid mediterranean zone, and as the main road to Milan runs close by this site is also subject to influences from exhaust gases, whereas Tel Aviv represents a dry mediterranean climate with an extreme amount of annual sunshine hours. Wuppertal represents a moderate central European climate in an industrial environment. It was the objective of this study to determine for the first time to what extent the top coat influences strength deterioration in various climates. Consequently, the fabrics received top coats of three different thicknesses (fig. 4), the thickness of the top coat being measured from the apex of the weft thread. This was done because due to their high position the weft threads are more exposed to environmental influences.

Modification 1 received a very thin top coat (20 μm /0,8 mil), modification 2 received a coating of standard thickness (50 μm /2,0 mil), and modification 3 received an extremely thick top coat (230 μm /9,0 mil). Moreover, as has been mentioned before, all three modifications were manufactured with three different UV absorber concentrations in order to determine the influence of that stabiliser.

After 1, 2 and 5 years samples have been returned in order to determine residual tensile strength, residual leg tear strength and remaining coating thickness.

Results and Discussion

A complete compilation of these results forms part of the documentation; I shall confine myself to discussing the most essential results. Fig. 5, 6 and 7 show the residual strength and tear strength measurements obtained from samples coated with a compound containing 0,5 % UV absorber at a thickness of 20/0,8, 50/2,0 and 230/9,0 $\mu\text{m}/\text{mil}$, measured over the apex of the weft thread. The Tel Aviv results are not figured out in this diagram, as at the time being only the two years samples have been evaluated.

As one can see, the thinly coated samples - with thicknesses of 20/0,8 and 50/2,0 $\mu\text{m}/\text{mil}$ - have lost much of their strength and tear strength, the worst damage having been sustained by the fabrics from Dormeletto (Italy), while the mountain climate of Ebnet in Austria seems to have caused the least damage of the PVC-coated fabrics.

In this respect, the Wuppertal and Miami results do not differ overmuch. In addition to these mechanical data, the diagrams also show our microscope measurements of the coating thicknesses left after five years. One can see that in Wuppertal and Dormeletto the samples which originally had received coatings of low and medium thickness lost their coating entirely on the exposed side. This result is independent of the UV absorber concentration involved. This also explains the bad level of performance of the Dormeletto samples. It seems that the Wuppertal samples have not yet been affected in this way, obviously because of the lesser number of sunshine hours.

As opposed to these findings, the thickly coated samples from Dormeletto have merely lost some of their coating thickness, but not yet to an extent which affects their strength in any way worth mentioning. One special point is that after five years of exposure in Florida the tear strength of the samples actually increased, a fact which we are unable to explain at the moment. This ageing behaviour cannot be explained by UV radiation or sunshine alone. Thus, the performance of the Miami samples is comparable to the Wuppertal samples in spite of the greater number of sunshine hours, which serves to confirm that air pollution plays a not unimportant role in this respect. The results from Dormeletto, where our weathering stand is located right next to a much-frequented road leading to Milan, are pointing in the same direction. This assumption is corroborated by the visual aspect of the samples. While the samples from Miami and Ebnet are merely soiled but still retain a flexible coating, the samples from Wuppertal and Dormeletto are much discoloured and very brittle.

These results show quite clearly that the long-term durability of PVC-coated fabrics depends to a high degree on whether the coating layer on the exposed side is of sufficient thickness. These findings indicate that the coating thickness should not be less than 150/6,0 $\mu\text{m}/\text{mil}$ in any case. The German approval regulation for vinyl coated industrial polyester fabrics for textile building applications does already consider these correlations.

In this context, I should like to discuss the influence of UV absorbers. Fig. 8 contains a few figures of importance. Taking into account the totality of all our findings which, as I said before, form part of the documentation, it is obvious that the influence of UV absorbers is minimal. In some instances, samples without UV absorbers actually did better. This, however, is not in line with the results obtained after two years of weathering, which leave no doubt as to the efficiency of these additives.

The next diagrams (figs 9, 10, 11, 12) show the strength and tear strength measurements as related to time. As already demonstrated on the occasion of the coaters and laminators meeting 1980 in New York, N.Y., it was impossible after two years to find any significant difference between the five locations, as far as the relationship between sunshine hours and sample performance is concerned (fig. 9 and 10). The situation after five years now is much more complex.

There is now a tangible difference between the various sites, which is demonstrated by the curves (fig. 11) drawing apart. As expected, the samples from those sites where the coating disappeared after five years fared very badly. It does not seem to matter whether the original coating thickness above the weft thread apex had been 20/0,8 or 50/2,0 $\mu\text{m}/\text{mil}$. The samples from these sites show performance curves which run into one at the lowest possible level.

In those cases where there was a sufficient thickness of coating left even after five years, there are still differences between the performances of the 20/0,8 and 50/2,0 $\mu\text{m}/\text{mil}$ samples. This means, that as long as coating thickness is not considerably reduced, long time behaviour is merely a function of total sunshine hours. These diagrams do not show any results from 230/9,0 $\mu\text{m}/\text{mil}$ samples because, as I said before, residual strengths here range between 90 and 100 % anyway.

Fig. 11 shows the residual tear strength of the samples. The behaviour of the samples in these two respects is very similar; there is no mistaking the influence of the sites and of air pollution.

A frequently discussed matter is in how far field tests can be replaced by artificial weathering. Therefore the test materials were exposed to 2.000 hours of Xenotesting (continuous exposure, 10 minutes of rain per hour).

The results are summed up in fig. 13. It was confirmed what had been expected, namely that there is a correlation between the influence of the coating thickness and of the UV absorber concentration on the residual strength. These findings additionally are figured out in fig. 9 and 10 in order to find a correlation between field test and artificial weathering. They indicate that there is not any general correlation at all. Thus, for instance, fig. 9 shows that the samples coated at a thickness of 50/2,0 $\mu\text{m}/\text{mil}$ react approximately similarly to 2.000 hours of sunshine and 2.000 hours of Xenotesting. Related to a test duration of 1 year, this corresponds to an acceleration factor of between 3 and 6. With the thinly coated materials, 2.000 hours of Xenotesting correspond to 500 hours of sunshine exposure, so that there is virtually no gain in Xenotesting. This proves that acceleration factors differ from one material to another. It is evident that our findings prove the importance of field tests, and that they open up the possibility of obtaining results under unknown climatic conditions.

Let me also mention that none of the samples was visibly damaged after Xenotesting, whereas in some of our field tests - we assume through the influence of SO_2 - the PVC coating had been destroyed by polyenes. This again underlines the importance of field testing.

Conclusion

Five years open air weathering of vinyl coated industrial Polyester fabric with different coating thicknesses and different formulations indicate that durability of these class of materials is mainly dependent on coating thickness. A rough critical value of 150/6,0 $\mu\text{m}/\text{mil}$ can be estimated. Compositions aspects seem to be of minor importance. As long as a considerable reduction of coating thickness does not take place results of different exposure sites can be made compatible if the residual datas are correlated to the total amount of sunshine hours.

If a reduction of coating thickness has to be considered, for example in all cases of materials with lower coating thickness exposed at locations with high pollution, corresponding general correlation cannot be found.

A correlation between field tests and artificial weathering hardly seems to be possible for this type of materials.

WEATHERING TESTS

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| | | | |
|-----------------------------|---|------------------------------------|------------------------------------|
| WEIGHT | 540 g/m ² 16 oz/sy | 600 g/m ² 17,7 oz/sy | 900 g/m ² 26,5 oz/sy |
| COATING THICKNESS | 20 μm 0,8 mil | 50 μm 2,0 mil | 230 μm 9,0 mil |
| UV - ABSORBER CONCENTRATION | — | 0,5% | 1,0% |
| CLIMATIC AREA | FLORIDA, MIAMI (USA) | EBNIT (A) | TEL AVIV (IL) |
| SUBSTRATE | DORMELETTO (I) | WUPPERTAL (D) | |
| COATING | PES 1100 dtex DIOLEN 174 S L 1/1 SETTING 9/9/cm - 22/22/inch | | |
| | COLOR : WHITE | | |

Fig. 1



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COMPOSITION

OF THE PVC - COMPOUND

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BASE COAT

| | |
|-----------|---|
| 100 parts | PVC |
| 33 " | DOP |
| 22 " | C ₇ -C ₁₁ - PHTHALATE |
| — | CaCO ₃ - FILLER |
| 5 " | TiO ₂ |
| 3 " | FUNGICIDE |
| 1 " | STABILISER |
| 6 % | PLASTOLEIN 9739 |
| 4 % | DESMODUR N 100 |

TOP COAT



| |
|-----------|
| 100 parts |
| 33 " |
| 25 " |
| 10 " |
| 10 " |
| 3 " |
| 2 " |
| — |
| — |

THESE FORMULATIONS WERE MODIFIED BY ADDING
0,5 phr OR 1,0 phr UV - ABSORBENTS

Fig. 2

CLIMATIC CONDITIONS OF WEATHERING TESTS

D WUPPERTAL
 A EBNIT
 I DORMELETTO
 USA MIAMI, FLORIDA
 IL TEL AVIV

| | | D | A | I | USA | IL |
|---------------|---|--------------------|------|---------------------------------|------|------|
| m | | | | | | |
| ALTITUDE | NN | 130 | 1100 | 380 | 0 | 25 |
| ft | | 430 | 3610 | 1250 | | 80 |
| mm |  | 1110 | 1130 | 1840 | 1170 | 570 |
| PRECIPITATION | inch | 44 | 45 | 73 | 46 | 22 |
| h |  | 1470 | 1760 | 2230 | 2950 | 3290 |
| SUNSHINE | | | | | | |
| OTHERS | | INDUSTRIAL AREA | — | NEAR MAIN ROUTE TO MILANO | — | — |

LONG TERM AVERAGES 1931-1960

Fig. 3

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THICKNESS OF TOP COAT MATERIAL FOR WEATHERING TESTS

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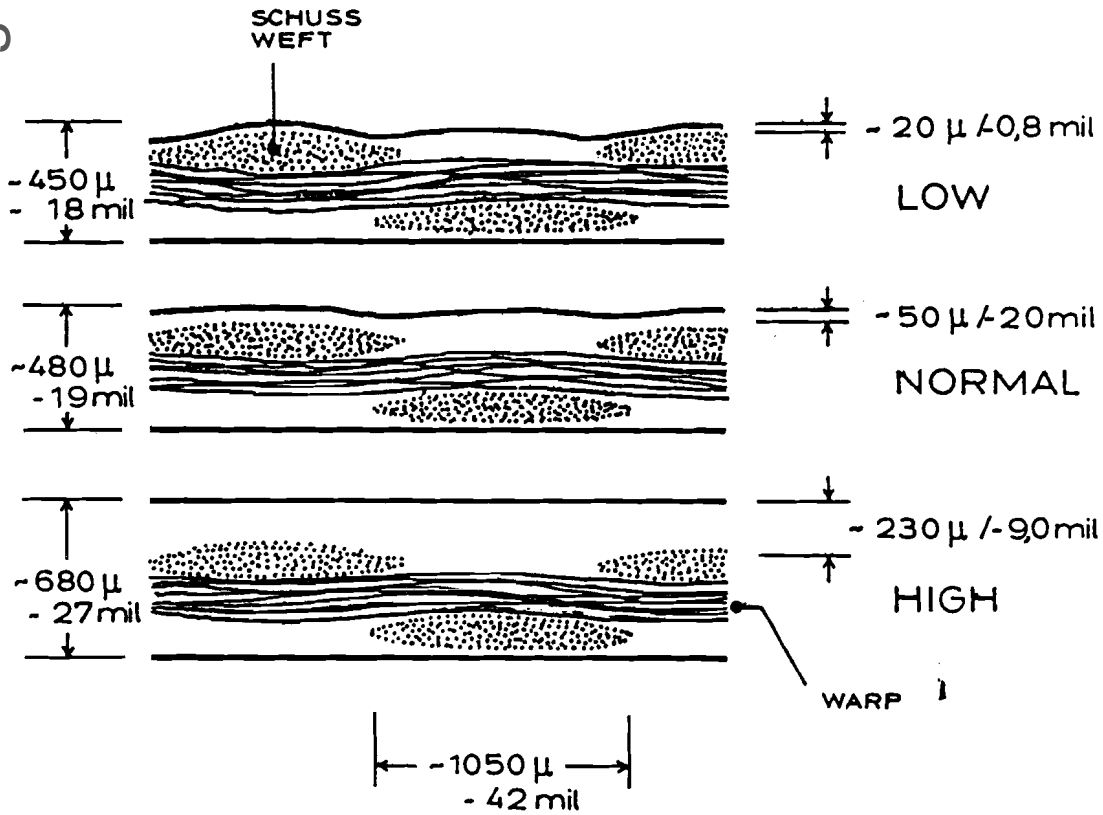


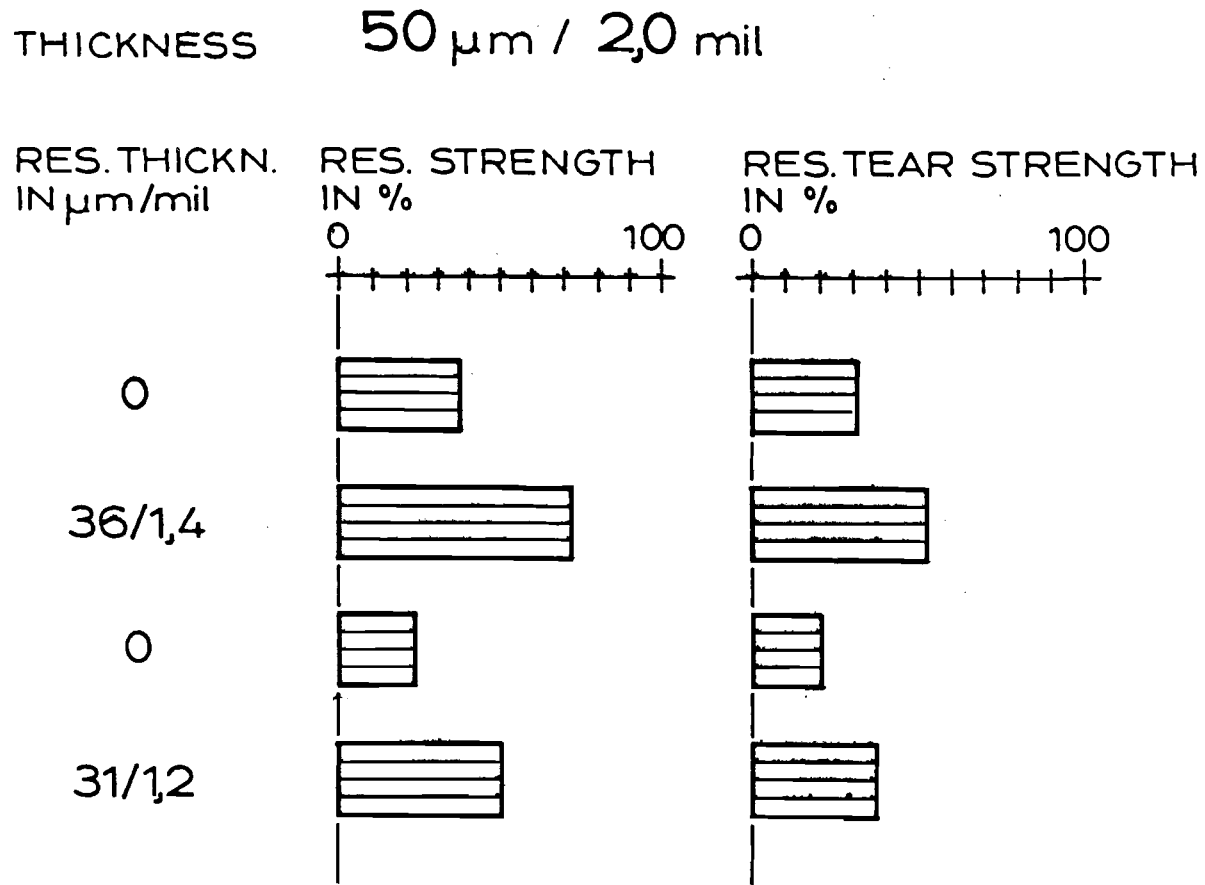
Fig. 4



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RESIDUAL STRENGTHS/RES. THICKNESS AFTER OPEN AIR WEATHERING - 5 YEARS

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UV-ABSORBER = 0,5 %

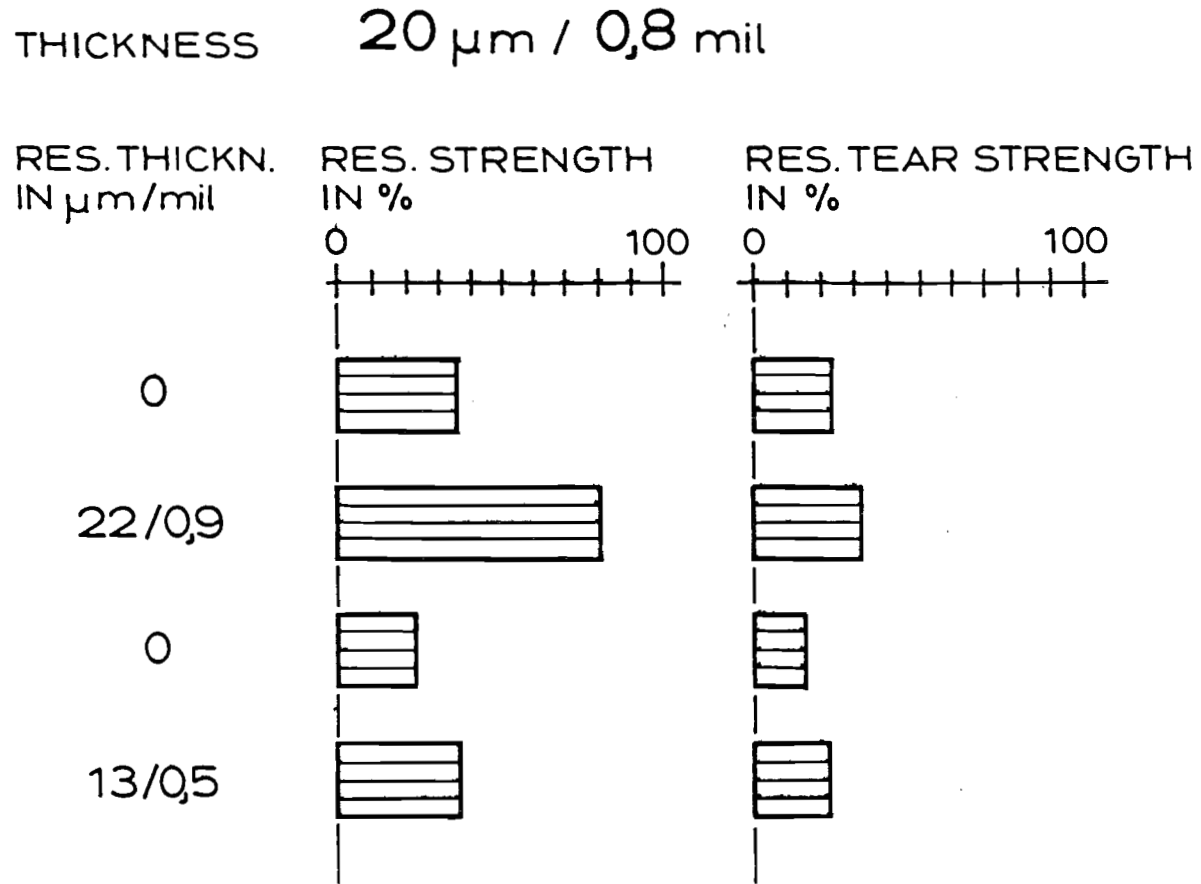
Fig. 5



TEXTILE TECHNOLOGY FORUM 1982, LAS VEGAS

RESIDUAL STRENGTHS/RES. THICKNESS AFTER OPEN AIR WEATHERING - 5 YEARS

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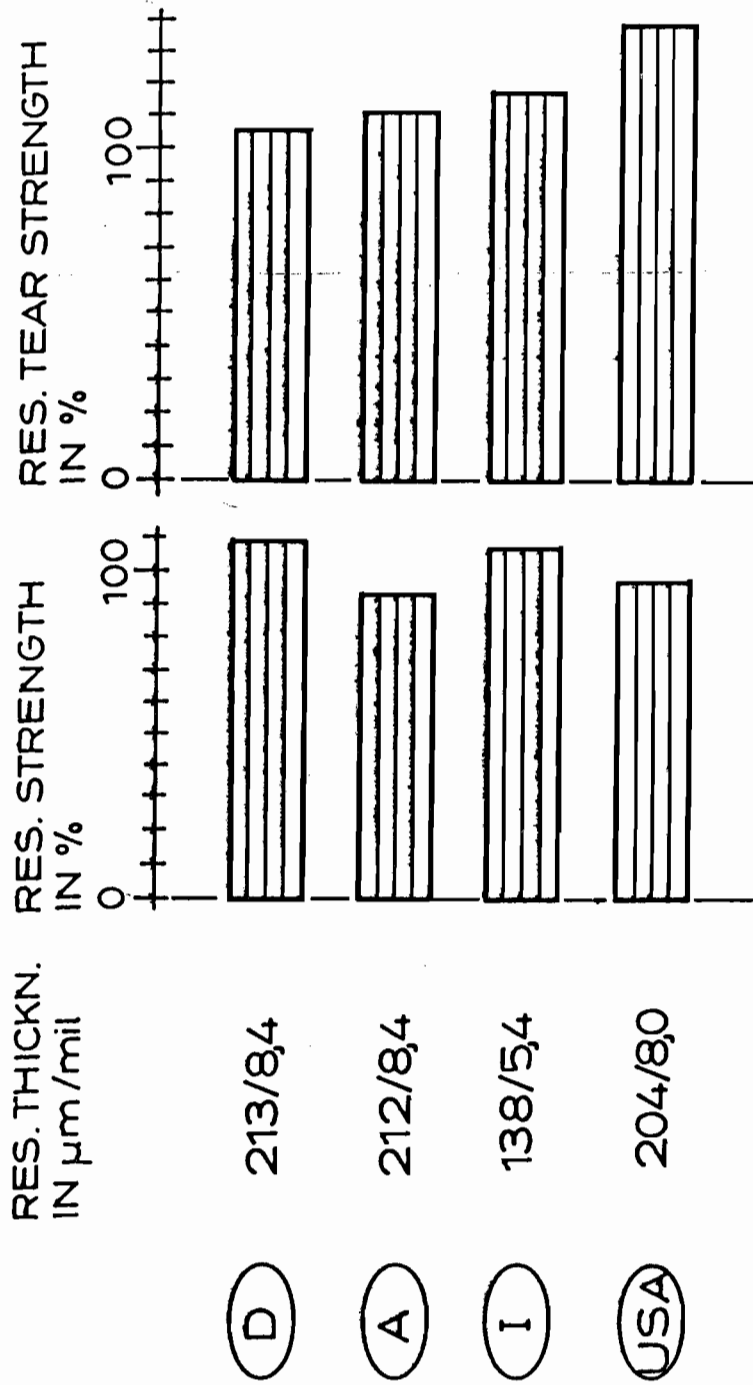


UV-ABSORBER = 0,5%

Fig. 6

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RESIDUAL STRENGTHS/RES. THICKNESS
 AFTER OPEN AIR WEATHERING - 5 YEARS

THICKNESS 230 μm / 9,0 mil



UV-ABSORBER = 0,5 %

Fig. 7



TEXTILE TECHNOLOGY FORUM 1982, LAS VEGAS

RESIDUAL STRENGTH AFTER OPEN AIR WEATHERING

5 JAHRE / YEARS IN FLORIDA

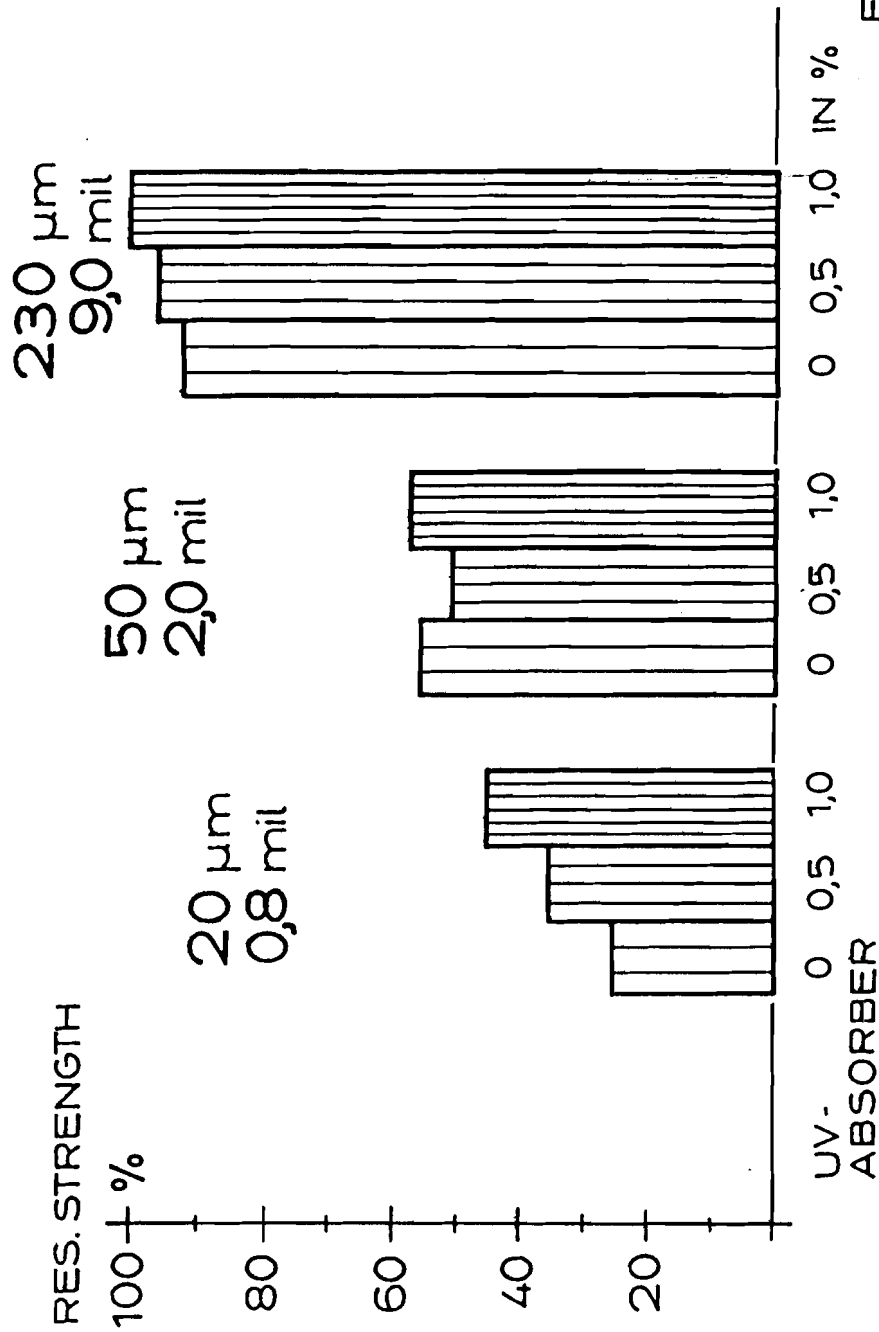


Fig. 8



WEATHERING TESTS

SUNSHINE HOURS / XENOTEST

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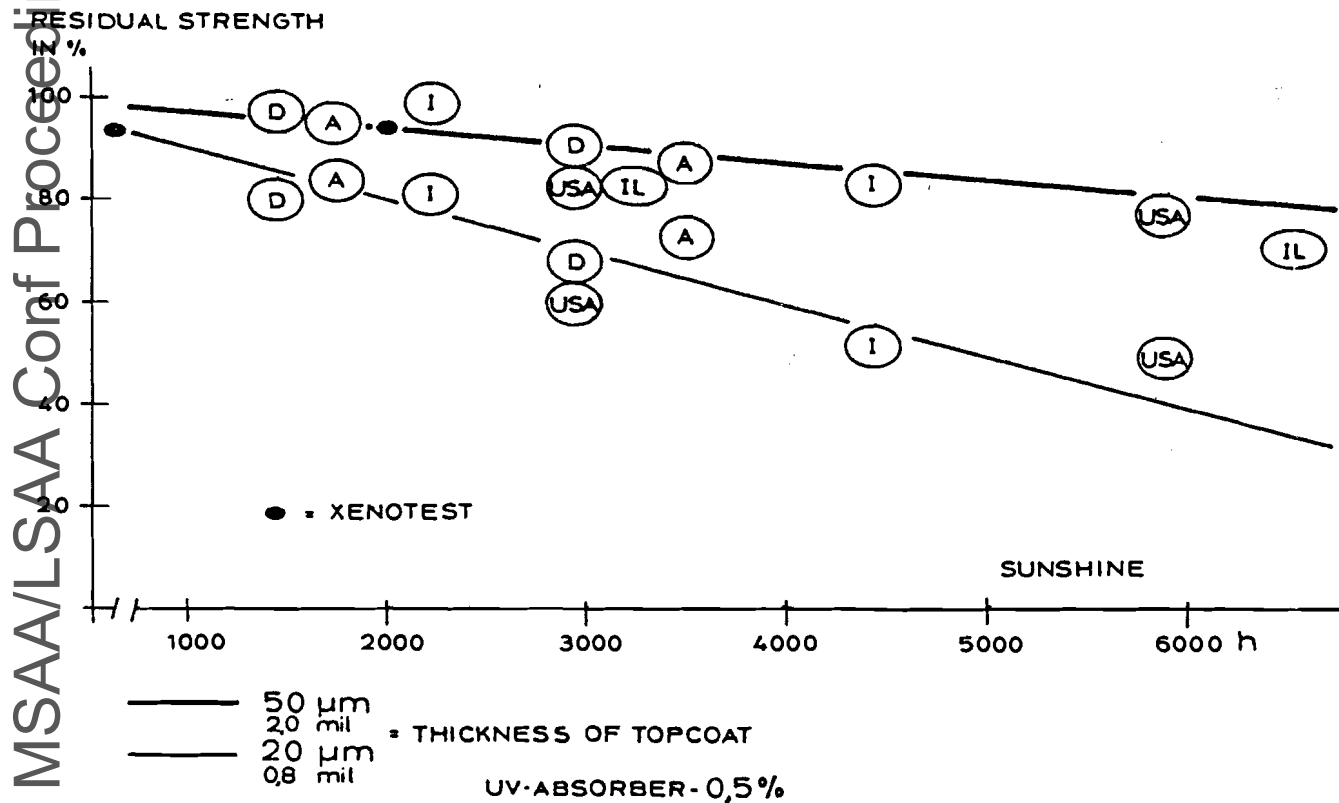


Fig. 9



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WEATHERING TESTS

SUNSHINE HOURS / XENOTEST

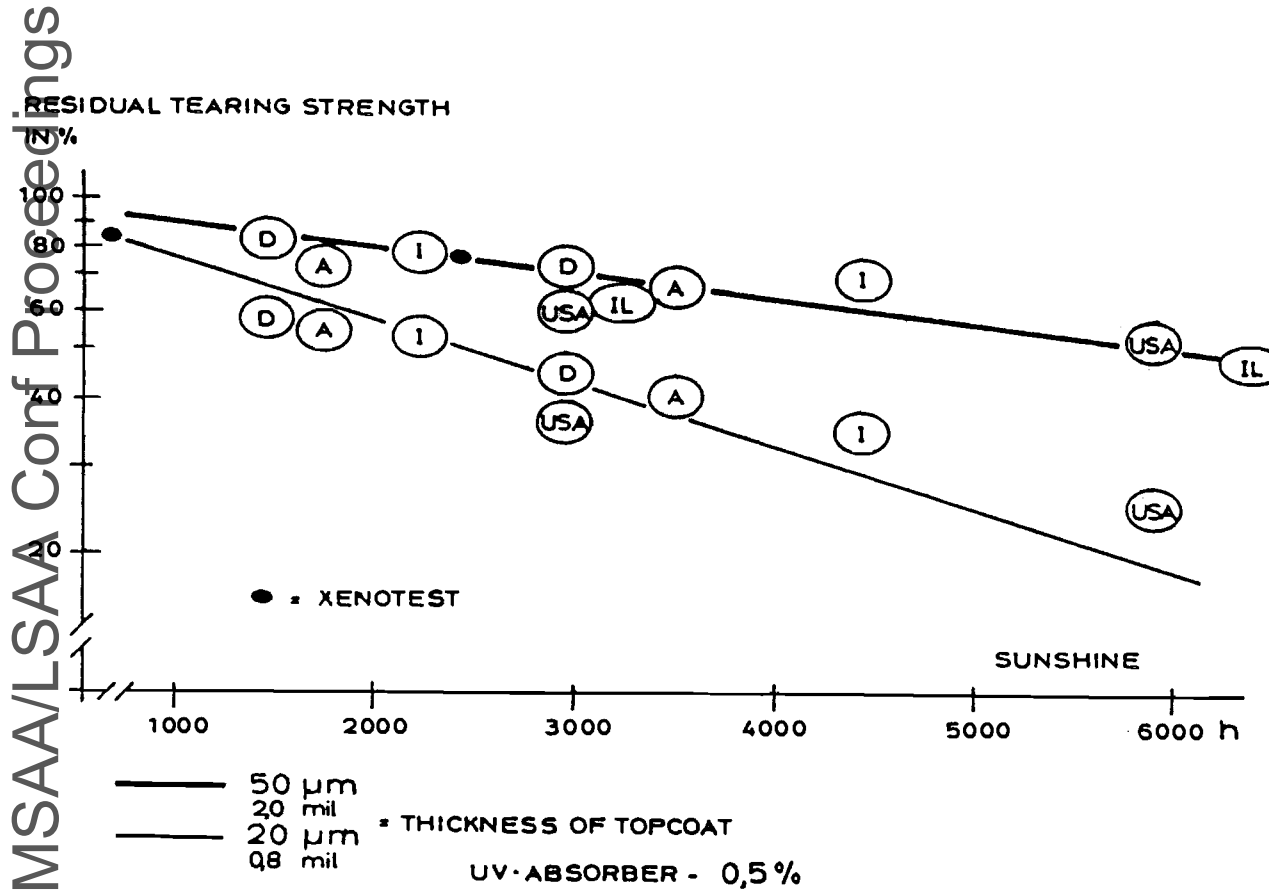


Fig. 10

RESIDUAL STRENGTH AFTER OPEN AIR WEATHERING

UV - ABSORBER = 0,5 %

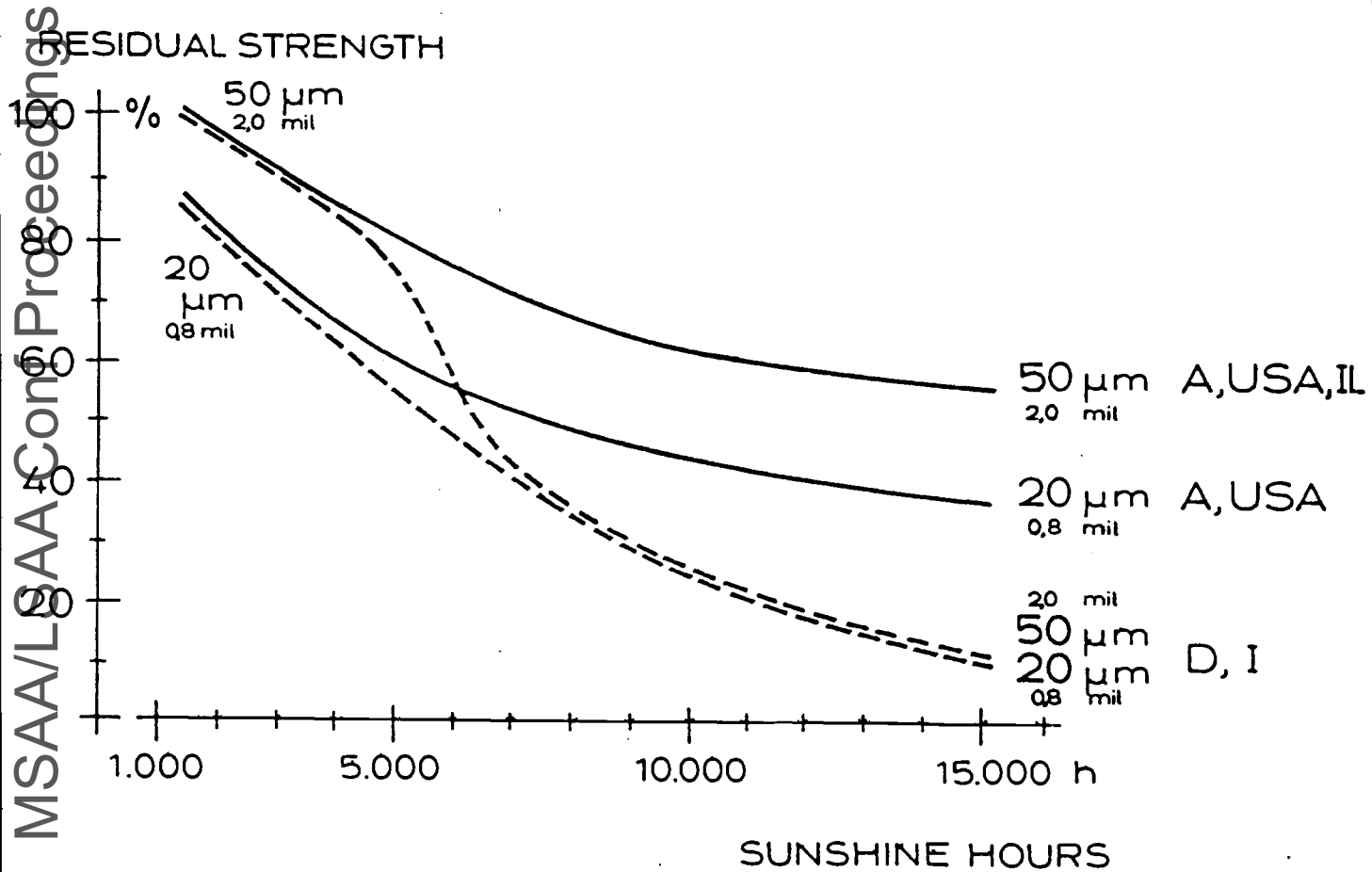


Fig. 11

Enka

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RESIDUAL TEAR STRENGTH AFTER OPEN AIR WEATHERING

UV - ABSORBER = 0,5 %

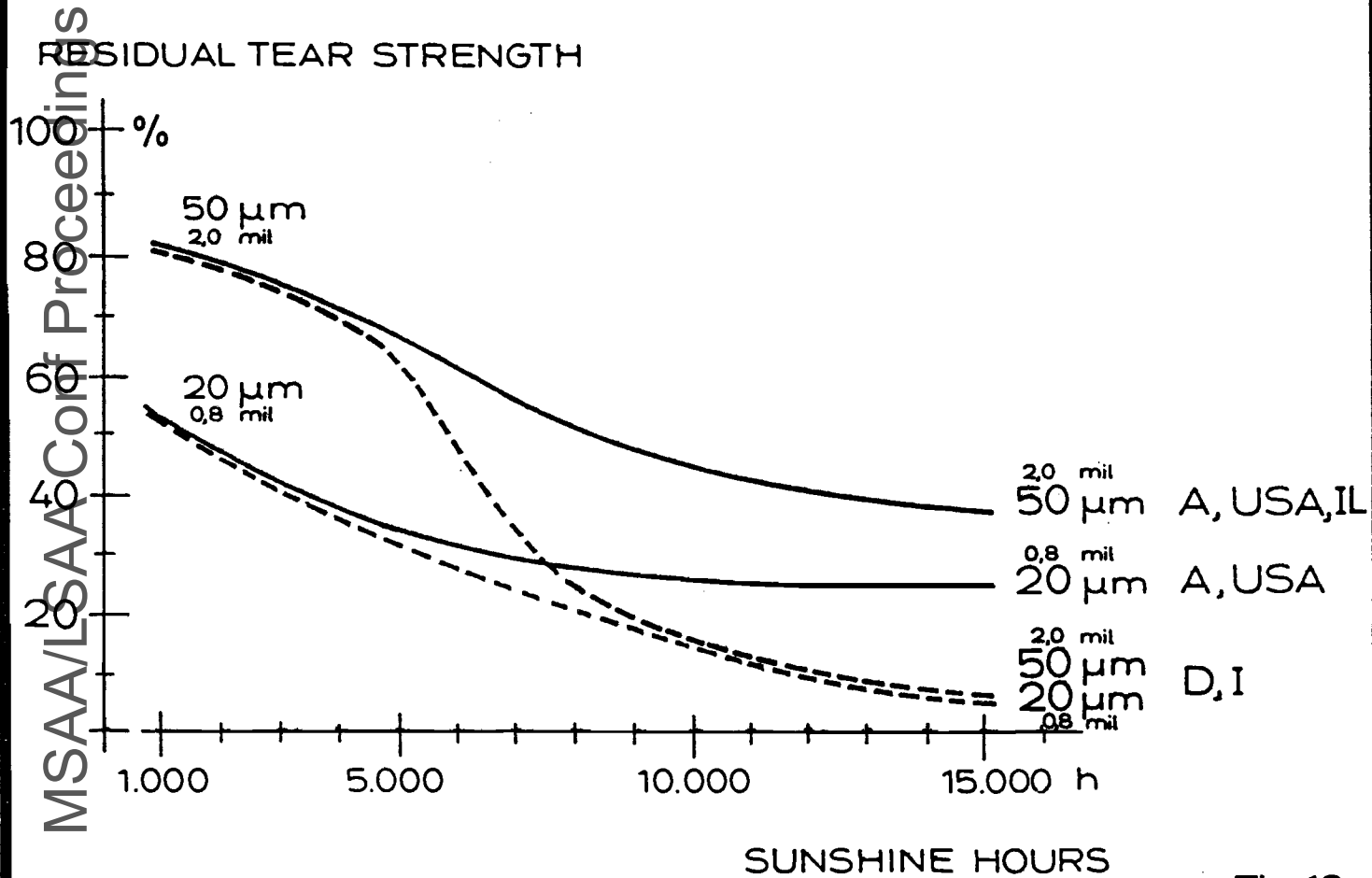


Fig. 12

Enka

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WEATHERING TESTS RESULTS XENOTEST (2000 h)

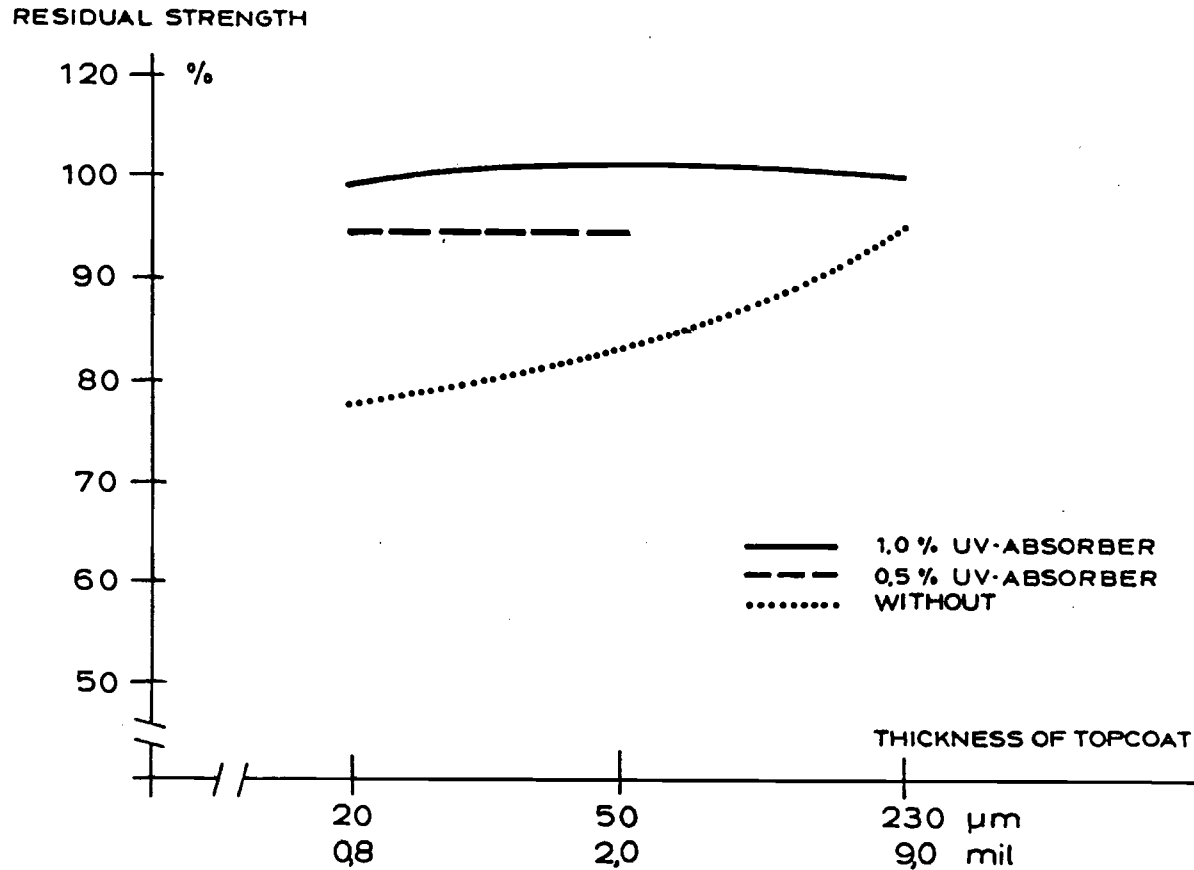


Fig. 13

Residual Strength (%) and Residual Tear Strength (%)
 after 1, 2 and 5 years weathering at different Locations

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 West District

1. Residual Strength (%)

| | Wuppertal | | | Ebnet | | | Dormeletto | | | Miami | | | Tel Aviv | |
|----------------|-----------|-----|-----|-------|-----|----|------------|-----|-----|-------|----|-----|----------|----|
| | 1 | 2 | 5 | 1 | 2 | 5 | 1 | 2 | 5 | 1 | 2 | 1 | 2 | |
| 20 μ | 62 | 50 | 33 | 65 | 58 | 48 | 67 | 45 | 23 | 52 | 35 | 26 | - | - |
| 0,5 % absorber | 80 | 64 | 37 | 83 | 72 | 53 | 80 | 51 | 21 | 61 | 49 | 35 | - | - |
| 1,0 % absorber | 92 | 81 | 31 | 92 | 81 | 59 | 90 | 58 | 18 | 75 | 60 | 43 | 62 | 37 |
| 50 μ | 98 | 88 | 47 | 96 | 92 | 86 | 100 | 80 | 32 | 82 | 70 | 55 | - | - |
| 0,5 % absorber | 98 | 92 | 37 | 95 | 87 | 72 | 99 | 83 | 21 | 86 | 76 | 51 | 86 | 70 |
| 2,0 mil | 106 | 97 | 42 | 100 | 99 | 86 | 100 | 83 | 25 | 97 | 83 | 57 | 90 | 72 |
| 230 μ | 100 | 99 | 100 | 100 | 99 | 96 | 100 | 90 | 93 | 100 | 98 | 92 | - | - |
| 0,5 % absorber | 100 | 100 | 113 | 100 | 95 | 87 | 100 | 99 | 109 | 100 | 97 | 97 | - | - |
| 9,0 mil | 100 | 99 | 96 | 100 | 100 | 75 | 100 | 100 | 107 | 100 | 98 | 112 | 96 | 94 |

2. Residual Tear Strength (%)

| | | | | | | | | | | | | | | |
|----------------|-----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|-----|-----|
| 20 μ | 35 | 30 | 23 | 30 | 30 | 20 | 38 | 22 | 14 | 23 | 19 | 18 | - | - |
| 0,5 % absorber | 45 | 40 | 22 | 43 | 40 | 31 | 50 | 35 | 14 | 29 | 27 | 21 | - | - |
| 1,0 % absorber | 75 | 69 | 29 | 60 | 63 | 48 | 68 | 61 | 12 | 47 | 44 | 34 | 43 | 21 |
| 50 μ | 76 | 84 | 40 | 72 | 74 | 57 | 80 | 112 | 18 | 52 | 50 | 33 | - | - |
| 0,5 % absorber | 81 | 77 | 28 | 72 | 70 | 52 | 80 | 68 | 17 | 53 | 54 | 36 | 64 | 52 |
| 2,0 mil | 98 | 104 | 25 | 86 | 98 | 63 | 94 | 99 | 22 | 75 | 75 | 48 | 77 | 63 |
| 230 μ | 96 | 94 | 86 | 96 | 107 | 84 | 94 | 122 | 100 | 85 | 109 | 127 | - | - |
| 0,5 % absorber | 90 | 105 | 87 | 100 | 110 | 94 | 92 | 133 | 101 | 88 | 122 | 139 | - | - |
| 9,0 mil | 100 | 105 | 100 | 96 | 108 | 96 | 99 | 128 | 102 | 100 | 130 | 132 | 100 | 100 |

Effective coating thickness ($\mu\text{m}/\text{mil}$) after 5 years weathering at different locations

| nominal | | Wuppertal | Ebnit | Dormeletto | Miami |
|----------------------------------|---------------------|-----------|----------|------------|---------|
| 20/0,8 $\mu\text{m}/\text{mil}$ | without UV-absorber | 0 | 24/0,9 | 0 | 18/0,7 |
| | 0,5 % absorber | 0 | 22/0,9 | 0 | 13/0,5 |
| | 1,0 % absorber | 0 | 23/0,9 | 0 | 15/0,6 |
| 50/2,0 $\mu\text{m}/\text{mil}$ | without UV-absorber | 0 | 51/2,0 | 0 | 41/1,6 |
| | 0,5 % absorber | 0 | 36/1,4 | 0 | 31/1,2 |
| | 1,0 % absorber | 0 | 42/1,7 | 0 | 34/1,3 |
| 230/9,0 $\mu\text{m}/\text{mil}$ | without UV-absorber | 247/9,7 | 261/10,3 | 187/7,4 | 234/9,2 |
| | 0,5 % absorber | 213/8,4 | 212/8,3 | 138/5,4 | 204/8,0 |
| | 1,0 % absorber | 215/8,5 | 217/8,5 | 133/5,2 | 216/8,5 |

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