FABRIC DURABILITY AND EXPOSURE TESTING

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The Need for Durability Testing

The Membrane Structures industry is one of many industries in which the preformance of the construction materials when exposed to the weather can be of the utmost importance. New designs, new ideas, new materials, new methods of fabrication are continually being developed. To ensure that each new development is in the right direction it is necessary that it is tried and tested before the construction stage is reached.

Proper evaluation of the weathering performance is important to the manufacturer of the material; he should know that he is producing good material. The manufacturer should be aware of the pitfalls that he might fall into which could reduce the performance of his product.

The selling agents should also be confident of the performance of products on weathering. With the introduction of new materials in place of the more conventional, materials engineers, architects, builders need some assurances that the materials they recommend and approve will last. Before they will recommend the new building material ABSAC (Australian Building Systems Apprasial Council Ltd, of CSIRO) now needs to know that exposure tests are progressing satisfactorily.

Also it is important that the customer is confident that he is using the material which will serve him best. Todays consumers are much more aware than ever before that durability testing is available and should have been done before a product is marketed.

Testing Locations

When it comes to testing products which may be used anywhere in the world, it is advisable to test in a location which is comparable in severity to anywhere in the world. This is one of the main reasons we originally chose Townsville as the most suitable location to establish Allunga Exposure Laboratory.

Apart from Townsville the other important testing centres are in Florida and Arizona USA. Results have shown that Townsville test results are slightly more severe (approx 20%) than Florida results. Townsville's solar radiation is 15-20% higher than Florida's while the moisture exposure characteristics are similar. Arizona has comparable radiation to Townsville but Arizona's climate is much drier.

Weathering Factors

The weathering factors which cause the most degradation to membrane fabrics are the same factors which we seek to maximize in choosing a test site for weathering tests. They are:

1. High incident solar radiation.
2. Low losses of components of solar radiation as it passes through the atmosphere, so that UV and other absorbed or scattered wavelengths are as high as possible.
3. Realistic moisture conditions from rainfall, humidity and dew.

Another important factor for testing is that these conditions continue throughout the year at a reasonably constant level andhigh severity. Sydney and Melbourne receive good testing radiation during the summer months but it drops off to much lower levels during the winter.

Outside the Earth's atmosphere the solar radiation is almost constant. On the earths surface we receive what the atmosphere lets through and this changes with the ozone layer, the lenght of the path through the atmosphere, cloud, dust, pollution, etc. These factors serve to cut out UV below 290nm wavelenght and to produce considerable variations in the UV we do receive between 290 and 320nm. (2)(3)

In general the more radiation received the greater the degradation.

Other factors also have a major influence on exposure results, the most important of these being the moisture exposure. Townsville has lower rainfall than other localities along the tropical east coast, but its wet time from rain and dew is excellent for exposure testing. Its rainfall of 1090mm (43 ins) is comparable to our southern cities, but it falls more in summer than in winter.

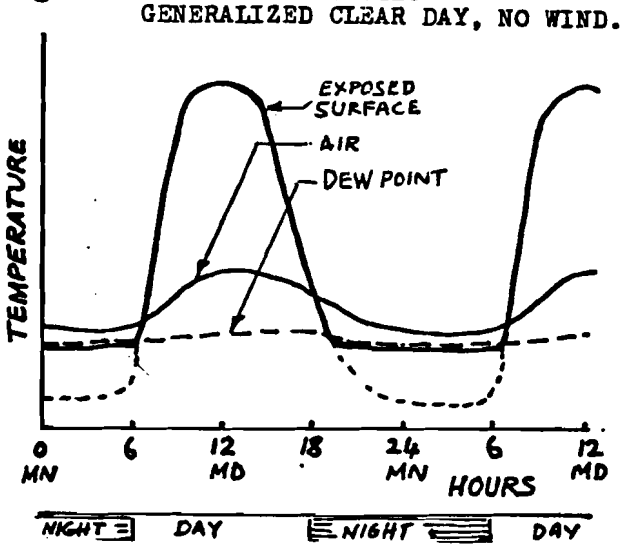
Wet time: It is easy to place too much emphasis on the total rainfall when the actual figure is of little importance; of much more importance is the time over which it falls. The most important moisture factor for weathering is the total time for which samples are wet from both rain and dew. In Townsville the wet time produced by dew is much longer and consequently more important than the wet time produced by rain.

For dew to form on a surface the surface temperature needs to fall to dew point. This will happen on still nights when the sky is clear and dew point is relatively close to air temperature. Dew formation prevents the surface temperature from falling below dew point, so the net result is that the surface is saturated with distilled water at dew point temperature for a considerable period of time, often approx 12 hours.

An alkyd film for example would absorb less than 1% moisture under these conditions (moisture absorption continues as the time increases (4)). During the subsequent dry period the moisture is removed by evaporation, often under the influence of sunlight. Repeated cycles cause slight changes in the finish which may be manifested as changes in gloss, chalking, checking, etc.

Figure 1 demonstrates in a generalized form the temperature changes of an exposed surface compared with air temperature and dew point when skies are clear and there is no wind. If the dew point drops as dry air moves in, the temperature of the exposed surface follows the dotted line during the night and dew does not form.

Fig. 1. TEMPERATURE CYCLES
GENERALIZED CLEAR DAY, NO WIND.



Types of Exposure

Almost all exposure tests can be classified into the following types:

1. Exposures conducted on a time basis.
2. Exposures conducted on an incident solar radiation basis.
3. Exposures conducted until a specified degradation condition is reached: this may be colour fade, loss of gloss, surface chalking, checking or crazing etc, or tensile properties.
4. Accelerated exposures.

Membrane fabrics would normally fall into the first as their exposures would proceed for a number of years. Over this length of time the radiation received and the other weather conditions tend to even out and thus a time basis is satisfactory.

Shorter term exposures are generally the ones specified on a radiation basis. The unit of radiation is the mega joule per square metre, MJm^{-2}. Until recently the units used were the langley (cal/sqcm)(America & Europe) or the mWhr/sqcm (British).

1 MJm^{-2} =23.9 langley (approx) =27.8 mWhr/sqcm.

Materials tested on a radiation received basis may be for example, upholstery fabrics, plastic components, facias, instrument dials, and many automobile interior items.

Both open exposures and under glass exposures are specified in this manner. The same level of radiation received takes place sooner on open exposure than under glass exposure; the difference being due to radiation losses in the glass and reflections from the glass surfaces.

Types of Racks

Exposure angles:

Traditionally samples were exposed at 45° facing south in the northern hemisphere and 45° facing north in the southern hemisphere. Then the automotive industry changed to 5° inclinations. More recently the tendency has been to expose at latitude angle inclined towards the equator. Our latitude at Allunga is 19°15'S so we have a number of exposure racks at 20° facing north. As well, to suit many practical applications we have other racks at horizontal and vertical facing both north and south.

In Townsville the 45° exposure angle suffers from low angle of incidence of direct solar radiation during the summer months. At 5° exposure angle summer exposure is very intense but winter exposure is less severe. At 20° exposure angle the midday sun is perpendicular to the surface at the equinoxes and at mid summer and mid winter is only approx 23½° from the perpendicular. (This represents approx 16% change of intensity). Surfaces inclined towards the equator at the latitude angle, are parallel to the earths surface at the equator. In general there is less dirt collection on 45° than on 5° but moisture exposure may not be quite as severe. 5° panels have higher dirt collection as they are not as self cleaning from rain and dew; they have slightly better moisture exposure as dew tends to deposit on the more horizontal surfaces first. At 20° moisture exposure is almost equivalent to 5° and dirt collection is less than for 5°.

Under-Glass Exposures:

'Under Glass' exposures are for materials which are intended for interior use. These racks are inclined mostly at 20° facing north. They are well vented to avoid excessive heat inside them as they have a backing sheet which acts as a sample mount and is 100mm below the glass.

Allunga Glass Fronted Black Box:

Some automobile manufacturers who have had troubles resulting from very high internal car temperatures in Australia, Saudi Arabia, and similar hot countries, have been in need of a suitable practical test. To meet this requirement we developed glass fronted black boxes which have been very effective in reproducing field failures in reasonably short periods. On sunny days the internal air temperature of the box will reach 80°C while the temperature of the exposed surface of a dark coloured vinyl dash pad for example will reach 120°C.

These tests have proved very successful and have enabled the materials engineers to adjust their specifications and so provide much improved field performance.

Evaluation

When the exposure termination point is reached samples or panels are normally returned to the originator. Sometimes clients request samples returned for inspection after set exposure times. Occasionally they may make the trip to Townsville to assess them themselves, but more frequently they request that we examine their samples on a regular basis and forward exposure reports to them.

For painted surfaces the Australian Standard AS1580 has proved a very good method of assessment. AS1580 together with specular gloss readings and often a few words of additional comment can be used to describe most painted surfaces. In many cases we find it also useful to apply AS1580 assessment ratings to other surfaces (plastics in particular).

For fabrics AS1177 or AS2001 may be used. For upholstery fabrics for example Standard Blue Scale woollen fabrics are exposed simultaneously under glass, and the fade of the fabric is rated according to the Blue Scale Standard of similar fade. Alternatively the fade of fabrics or the colour change of other materials can be described by instrumental colour readings specifying colour space coordinates.

Where microscopic surface changes have to be detected the scanning electron microscope has been very effective. It is excellent for viewing and recording pictorially the degradation of many surfaces and cracking of fibres of threads, carpets, etc.

In most cases where reports are required it is essential to have 'unexposed'material for comparison. Often it is quite adequate to mask a portion of the sample with Al-foil before exposure. All of our standard 300mm spaced racks cover 50mm at the top of the sample for before and after comparison. If neither of these masks will be satisfactory it is necessary to supply additional reference samples to be kept unexposed for reporting. Sometimes these must be kept in a deep freeze unit if changes may occur at room temperature storage.

Whether the exposure is time or radiation dependent it must be attended to immediately a report is due or the exposure is complete. Because there must be some leeway to suit work planning, intermediate reports may be written a day or two in advance or behind the due date. In this way the labour demand for reporting, which is a very time consuming operation, can be evened out.

When a client sends an exposure it is important for him to specify full detailsregarding exposure conditions and the frequency and type of testing required. Very often samples are received with no or very scanty details. Sometimes without any paperwork at all.

Accelerated Testing

By accelerated testing we usually mean evaluations which occur faster than the maximum attainable by fixed rack testing even in severe climates.

The first step toward faster testing can be made by rotating the test rack so that it always faces the sun through daylight hours and inclined to match the suns elevation with the seasons. By these means it is possible to increase the annual incident radiation by up to 40%. This method has the advantage that the radiation spectrum through the test is very close to that of fixed rack exposures; moisture conditions are also close.

Another means of speeding up the weathering is to increase the moisture conditions while keeping the radiation conditions constant. This is done by adding water sprays to fixed rack exposures. This is common practice and it appears most suitable where moisture resistance is critical such as testing the performance of some adhesives and sealing systems.

To achieve a significant increase in the rate of weathering we have developed our ALTRAC machines. The machine has ten mirrors each of which is focused onto the sample under test. The unit rotates so that it tracks the sun during the day. When the sun is shining the samples receive reflected solar radiation from the ten planar aluminium mirrors. With a

reflectivity of greater than 80%, the samples are receiving the direct radiation equivalent to eight suns. With this intensity, to prevent thermal degradations it is necessary to cool the sample, and this is done by forced air draught across its exposed surface.

To add the moisture so necessary for organic surface weathering reactions a water spray is added. The exposed surface is gently sprayed for three minutes each hour night and day, with rain water drawn from storage tanks.

The net result is that a sample exposed on ALTRAC will receive in twelve months the exposure it would receive in approx four years exterior 20° fixed rack exposure.

We believe that ALTRAC exposure will yield results that will give a good indication of the materials exterior durability. However, as with all other accelerated tests, we do not feel that it should be used as a substitute for actual exposure tests.

References

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