SINGLE-PLY: MASTERY AND REQUISITE PERFORMANCE

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The three principal factors influencing the development of reinforced asphalt single-ply membranes are:

a) obtaining modified bitumens with appropriate properties
b) developing reinforcement materials directed toward performance
c) concern for socio-economic aspects such as production cost, use of manpower, labor, etc.

From the European point of view, where the use of increased amounts of thermal insulation has become current practice, the use of single-ply waterproofing calls for specific precautions, rules and regulations, and the use of a design adapted to the structural deck (insulated or non-insulated).

DESIGN OF THE PRODUCT

The modern bituminous single-ply has a modified bitumen base. Two of the more popular modifiers are:

a) SBS modified bitumens (polystyrene-butadene-styrene) —thermoplastic rubber contributing to blendings with dominant elastic properties
b) APP modified bitumens (atactic polypropylene)—the APP bitumens offer dominant plastic properties.

These two modifiers are often used in combination with other polymers to create somewhat sophisticated combinations.

The modified single-ply bitumen product must meet many criteria:

- a large usage temperature range:
  - better cold temperature flexibility
  - higher softening point

A range of 120C (248F) between these two points is an accepted minimum.

- adequate aging resistance: artificial aging at 70C (158F) in a ventilated oven should display a retention of minimum properties for approximately 1 month for traditional bitumen, and from four to six months and longer for the various modified bitumens.
- good shear resistance: since it is modified, the polymeric bitumen offers better cohesion and increased shear resistance compared to traditional bitumens. This is a significant point when considering the adhesion properties required for single-ply joints.
- ease of installation: conventional methods of installation should be applied to the single-ply modified bitumen, whether this is to be by hot-mopping or torch-applying the membrane.

Torch-applied modified bitumen should further satisfy the following constraints:

1) simple fusion of the modified bitumen
2) low viscosity of the melted bitumen
3) non-deterioration of the polymer-bitumen
4) adhesion and cohesion to various decks

- in general, greater thickness than is needed for traditional hot-mopped modified bitumen membrane material.

When torch-applying modified bitumen membranes, fusion is rapid. The rolls of the melted bitumen attain a maximum temperature between 230 and 250C (446F and 482F).

At these temperatures, the SBS modified bitumen offer a viscosity of 800/900 mPa. The APP bitumens, with values of 500/700 mPa, offers a lower viscosity. At an equivalent viscosity, less energy is needed to melt the APP modified bitumen. However, it is not always possible to regulate the torch to a "soft flame."

GPC dosage (a method used in physics for separating molecular masses) of the SBS in the elastomeric bitumen before and after torching shows nothing to suggest that the polymer is significantly deteriorated. Other polymeric bitumens do not seem to show a significant deterioration either.

Torch-applying the membrane to insulated substrates requires specific surface preparation. Only mineral composition insulations, (perlite, mineral wool, etc.) seem adequate; insulation with bituminous facings permit excellent torching application. The minimal thickness for torch-applied modified bitumen material seems to standardize around 4mm (160mils). More substantial thicknesses are also utilized in Europe.

Single-ply modified bitumen is best installed by torch application. The previous facts testify that the modern modified bitumens are well adapted to this type of installation technique, since the viscosity of the bitumen depends on its temperature and the manner in which the bitumen was formulated.

At 230C (the temperature of the melted bitumen), the relationship between viscosity and shear is as follows:

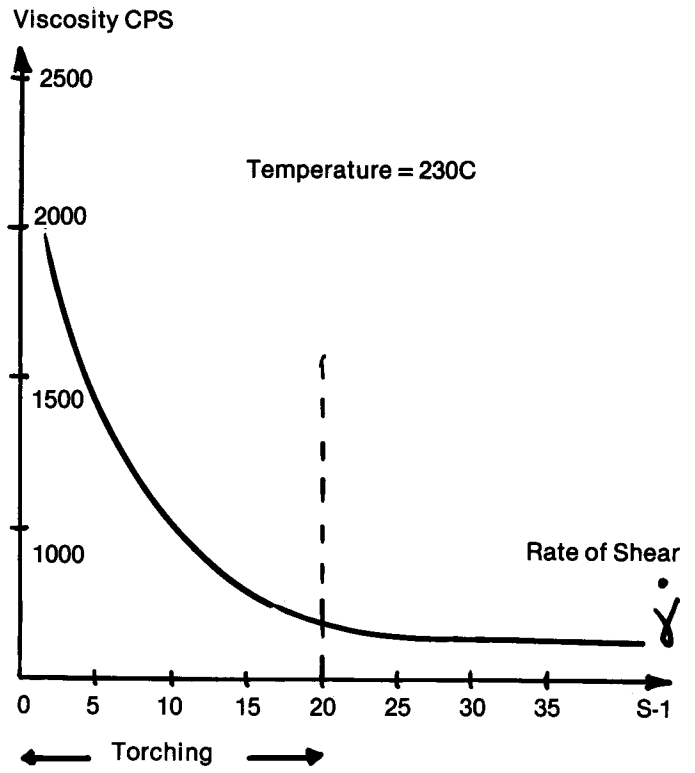


Figure 1

The viscosity of the modified bitumen is reduced as the amount of flame is increased, and is increased as the flame is reduced. This is important considering the difficulty of maintaining a regular rhythm in the application of the flame.

CONTRIBUTION OF THE UNDER FACING (LINING) FOR IMPLEMENTATION BY TORCHING

In addition to the significance of torching, the lining of the modified bitumen plays an important role. Laboratory and field tests show that for the same material, changing from a sand lining to a 7- or 20-micron thick polyethylene or polypropylene film results in a 30 to 50 percent gas consumption reduction and a 20 to 50 percent installation speed increase.

For aesthetics, ease of installation and cleanliness of the workplace, the modern modified bitumen single-ply membrane should be lined with plastic film.

PERFORMANCE OF THE REINFORCED FINISHED PRODUCT

The contribution of the reinforcement in a modified bitumen membrane is of prime importance. A high level of performance is assured through the following tests.

■ Dimensional Stability

The French limit elongation or shrinkage to ±3 percent after cycling the material first to 80C (176F) and then to 20C (68F). This 3 percent maximum value necessitates that special attention be given to impregnating (penetration) and coating of heavy reinforcements and non-woven polyester (200 to 350 g/m²).

■ Static Puncture

The standard UEATC test in France and in Europe measures puncture resistance of the product when resting upon polystyrene insulation density 25 kg/m³).

A 1cm (0.4-inch) diameter ball point of specified weight is rested on the membrane for 24 hours. Self-surfaced modified bitumen membrane material must achieve a resistance of 15 kg, while field surfaced membrane material must resist 25 kg.

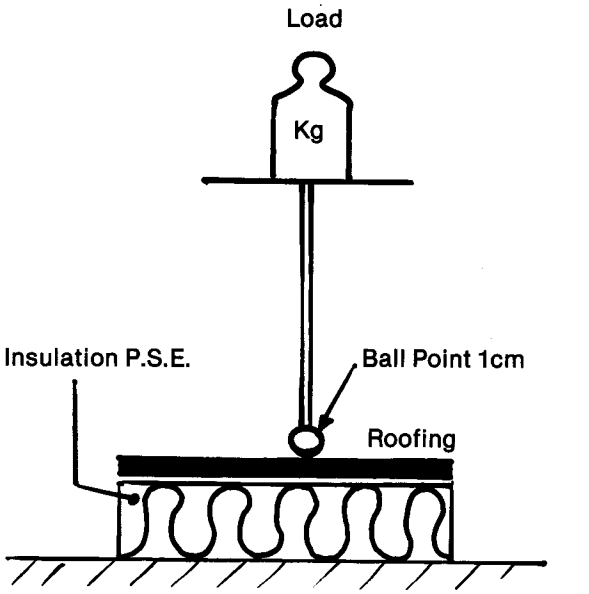


Figure 2

■ Dynamic Puncture

The French standardized test measures two parameters of dynamic puncture

- □ impact (shock) energy
- □ penetrating puncture

A U-shaped blade with the bottom of the blade measuring 2×50mm (1 cm²) impacts the test sample perpendicular to its surface. The test sample rests upon the same insulation substrate as was used for the static puncture test.

A shock energy between 5 and 50 Joules is obtained by increasing the weight of the blade from 1 to 8 kg. The height of fall permits a constant impact speed of 3.16 meters per second.

A resistance of 7.5 Joules is required for a self-surfaced modified bitumen material, whereas field-surfaced material required 15 Joules.

■ Control (behavior) of the joints

Tests are conducted at two temperatures: 20C (66F) and 50C (122F).

20C Test: In tension, a joint assembled according to the manufacturer's guidelines should rupture outside the area of joint or attain minimum resistance of 500N.

50C Test: At this temperature, the specimens shear within the modified bitumen in the joint. The resistance to the shearing (stress) should exceed 0.3 BAR.

These values should be retained after artificial aging for 28 days at 80C (176F).

■ **Resistance to Fatigue**

Various approaches are possible. The following measure of resistance to fatigue of a modified bitumen single-ply joint is proposed:

□ test temperature −10C (15F)

□ amount of movement = 2mm

□ speed of opening/closing = 16mm/hr.

The test sample should achieve the following:

a) Unaged (new) sample: the break should occur outside the joint area, or the sample should withstand 500 cycles.

b) Aged sample: the break should occur outside the joint or the sample should withstand 200 cycles (28 days at 80C)

DURABILITY OF SELF-SURFACING

For products which are self-surfaced (primarily by colored mineral granules) the durability of self-surfacing material is determined through a brush test according to the Underwriters Lab 55B Standard. The French practice is to express the loss as a percentage of granules lost per square meter.

■ For dry brushing:

□ 0 to 15 percent (approximately 0 to 1.25 g)—excellent

□ 15 to 30 percent (approximately 1.25 to 2.5 g)—satisfactory

□ more than 30 percent (more than 2.5 g)—poor, inadequate

■ For wet brushing (after 24 hours in water):

□ less than 50 percent (approximately 4 g)—satisfactory

□ greater than 50 percent (more than 4 g)—inadequate

For modified bitumen single-ply products, the French view the wet brushing more critically.

PERFORMANCE EXPERIENCE (from the point of view of the manufacturer:)

Modified bitumen: The first French usage of SBS modified bitumen has survived 15 years with excellent behavior.

The official standards (CSTB) for SBS bitumens date to 1978.

The experience already known with these materials is such that practical standards are already established.

For the APP modified bitumens, the knowledge and expertise acquired has permitted other countries to use the material. The suitability of APP bitumens depends upon:

■ high softening point

■ low (weak) ultraviolet sensitivity

■ good resistance to aging

■ very good soldering ability

This suitability and its ease of installation are counterbalanced by the cost and availability of APP, considering the large amount of APP necessary for the modification of the bitumen.

The reinforcement: Since it is the core of the modified bitumen single-ply product, reinforcement plays a key role for:

■ dimensional stability

■ mechanical characteristics

■ resistance to static and dynamic puncture

The most important new development in the past few years is the use of non-woven polyester as a reinforcement. Progress has been considerable for the majority of the points cited above. Progress for the resistance to dynamic punctures and dimensional stability is continuing.

Organic materials (iron, fabric) are more advantageous to achieve stronger values of resistance to dynamic puncture. This holds true for shrinkage as well.

A choice thus develops;

■ utilization of non-woven polyester reinforcement of significant weight, stabilized, and then impregnated using available technology.

■ blending of polyester/glass fibers or fiberglass. The polyester/glass fiber approach offers several advantages:

□ single reinforcement for single ply

□ dimensional stability (1 to 3 percent maximum shrinkage)

□ resistance to dynamic punctures (15 to 20 Joules)

Application: The manufacturer of modified bitumen single-ply material should furnish the contractor with as complete technical assistance as possible, including:

■ clear and concise information and documentation

■ full specification details related to each job.

The longevity of a modifed bitumen single-ply in the field depends upon the installation of a quality material by a competent and experienced contractor.

Techniques: Modifed bitumen single-ply may be used with a variety of roof decks and methods of attachment.

■ **Complete adhesion:** by heat-welding or hot-mopping to panelized insulation, to a nailed substrate, etc.

■ **Semi-adhesion:** by partial heat-welding, by heat-welding with perforated asbestos screen, by partial gluing, etc.

■ **Loose-laid:** the waterproofing sheet is separated (isolated) from the substrate and made waterproof by welding the joints. The difficulty lies with the reliability of the joints; a careful installation is necessary.

APPLICATIONS

As a conclusion to the development of reinforced bitumen single-ply membranes, I illustrate with some typical applications.

■ **Waterproofing with self-protected single-ply membranes.** This is the most frequent application particularly where reroofing is involved. This system not only renovates but also enhances the aesthetic effect. Some examples: school buildings—CAEN ACADEMY (France), 10,000 m^2; supermarket—22,00 m^2; rubber products factory—7,000 m^2.

■ **Waterproofing under ballast.** This application is more limited. In France the laying under ballasted protection enables the membrane to be loose-laid with only the joints sealed. In single-ply applications, the quality of workmanship must be 100 percent as the least error will result in a leak.

■ **Special cases.** Polymer-modified, reinforced bitumen single-ply membranes are excellent for waterproofing bridge decks, tanking and general civil engineering works. With the performance level described above, the protection layers can be laid with conventional equipment, without harming the waterproofing.

CONCLUSION

Today, as we have shown, the modern bituminous waterproofing industry can both manufacture and supply functional, single-ply high performance materials.

In any application it is important that the design is fully detailed and specified from the decking to the final protection. However, even with good products and detailed specifications, it is also important that the roofing contractors are well-trained and conversant with these modern membranes and technologies.

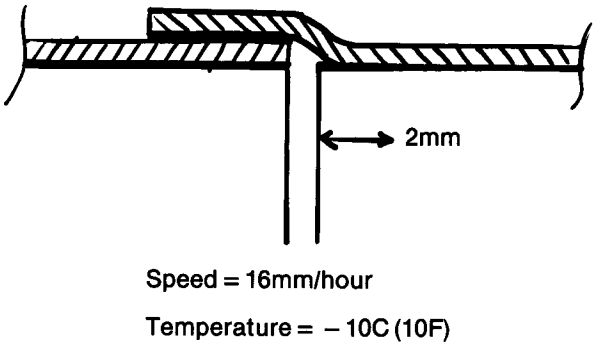
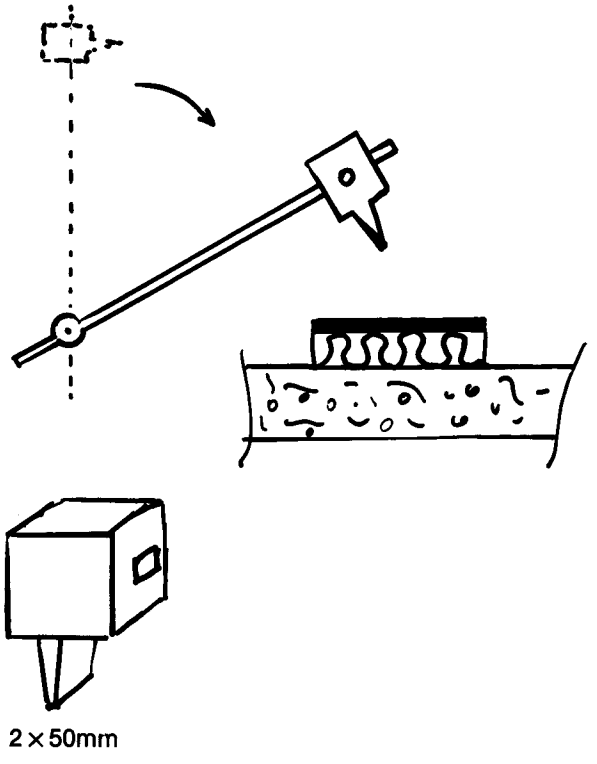


Figure 3



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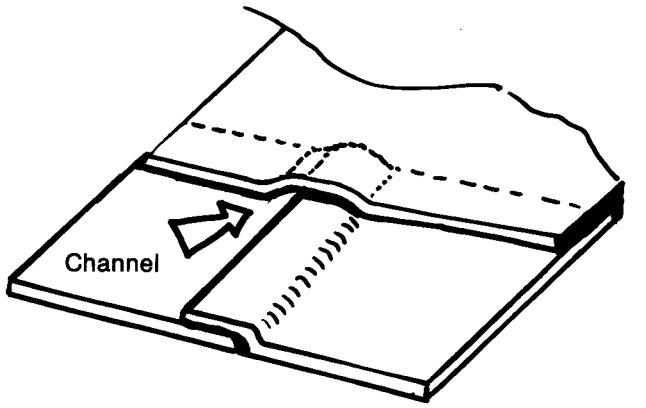

Figure 5

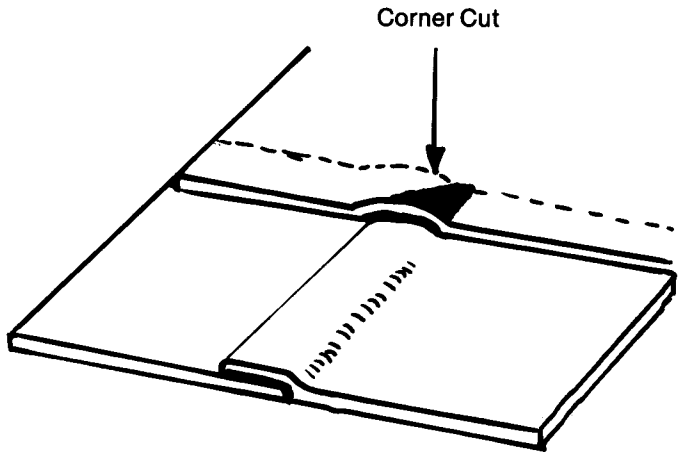

Figure 6