SPECIFICATIONS FOR QUALITY ASSURANCE OF SINGLE-PLY MEMBRANE MATERIAL

M. PUTERMAN
National Building Research Institute, Technion
Haifa, Israel

K.H. REINHORN
Civil Engineering and Construction Center, IDF
Tel Aviv, Israel

M. MARTON
Marton Roofing and Waterproofing Consulting
Tel Aviv, Israel

The use of single-ply roofing membranes is expanding all over the world, as it is in Israel. In spite of the increased popularity of these materials, there does not yet exist an efficient local standard to assure the quality of the various membranes. There was the need, therefore, to prepare appropriate specifications as a measure of quality assurance for the materials and seams (field and factory).

Israel has various climate zones; from high mountains covered with snow every winter, to the Dead Sea, the world's deepest valley. But, the most common phenomenon is the six-month hot and dry summer with absolutely no rain. In addition, there are places with great thermal fluctuations (desert type). As a result of these conditions, there have been many single-layer roofing failures due to high shrinkage.

The authors have seen many "trampoline" phenomena lead to quick tear and premature aging failure. Therefore, it is very important to use only first quality roofing sheets.

Even so, there is a need to find short and inexpensive aging tests. However, since most roofing materials in Israel are imported, it would be wise to specify according to existing standards. Because Israel's roofing industry is relatively young and somewhat inexperienced, the authors feel that the field seam test is extremely important.

INTRODUCTION

This paper presents the requirements recommended as a set of specifications for the following materials:

- PVC Membranes
  - Non-reinforced
  - Non-reinforced, on a nonwoven carrier
  - Non-reinforced, containing fibrous filler
  - Reinforced with woven or nonwoven fabrics
- EPDM Membranes
  - Non-reinforced, black
- Modified Bituminous Membranes
  - Modified with styrene-butadiene-styrene (SBS-modified bitumen), reinforced
  - Modified with atactic polypropylene (APP-modified bitumen), reinforced

The requirements are summarized in Tables I, II and III, respectively.

The specifications relate only to the quality assurance of the membrane, and not to the application practices or details of installments. Hence, any set of requirements is composed of three groups of tests:

- Physical properties of the new membrane.
- Physical properties of the membrane after exposure to accelerated weathering conditions.
- Properties of the seams (factory and field seams).

The tables also contain the suggested reference for the test methods.

The values were derived from a large number of tests, and producer's data sheets.

(The effect of accelerated weathering on the mechanical and physical properties of the membranes is still under study. The proposed requirements are, therefore, not yet final and will be reconsidered in due time.)

KEYWORDS

EPDM, modified bitumens, PVC, single-ply membranes, specifications.

SPECIFICATIONS FOR QUALITY ASSURANCE

PVC Membranes

Specifications were determined according to ASTM 4434 since it was the latest PVC standard available, but there are some differences.

- The maximum linear dimensional change (L.D.CH.) was limited to 0.7 percent. It is the authors' opinion that a material with 3 percent L.D.CH. cannot be used in roofing (at least in Israel). In the past, many failures occurred due to this phenomenon.
- The PVC roofing sheets, which the two Israeli manufacturers are producing, have much higher tensile strength than the minimum ASTM specifications.
- The Type I-B roofing sheet, the most popular PVC roofing sheet in Israel, is an unreinforced type with a nonwoven carrier. Although it can be identified with the ASTM Type II Grade 1, it was found that the carrier does affect the tensile and elongation properties. Therefore, a minimum breaking strength of 800 N/50mm (and not

tensile strength) was determined. The elongation is affected by the depth of the carrier's fibers in the mass of the PVC. Results of 120-250 percent were achieved. The two extremes are from different producers. The above explanation was arrived at after studying the results and optical investigations.

- Demand for maximum change in properties after aging still requires more investigation.
- The water pressure seam resistance is due to the German Din.

EPDM Membranes

It is only logical that the EPDM be specified according to ASTM No. 4637-87. Below are some differences:

- To the best of the authors' knowledge, no roofing with reinforced EPDM or neoprene sheets was done in Israel in the last five years. Thus, the specification relates only to non-reinforced EPDM. Refer directly to foreign standards including ASTM 4637-87 for other types.
- The thickness demands are significantly higher than ASTM's minimum. One of the reasons is the large number and depth of pinholes, which are sometimes found in the EPDM roofing sheets. As a matter of fact, the thickness requested was that used on roofs.
- The dimensional change demand will be reduced, due to a very bad experience. The 2 percent is much too high.
- In addition to the factory seam strength, we also specify field seam demands (Strength, at R.T., at 70°C, and after aging - 28 days at 115°C), peel strength and water pressure resistance were also specified. The field seam demands, which are not mentioned in ASTM 4637, are slightly higher than the later European Union of Agrement (UEAtc). It was observed that, in the last three or four years, significantly lower results were received than before. One producer indicated that the new glues are much weaker, but have better humidity and immersion performance (which were not checked).
- The dimensional change is tested after the 28-day heat aging.
- The water pressure resistance test was checked per the German Din.

Modified Bituminous Membranes

- The specification for the modified bitumen roofing sheets are based on nonwoven polyester reinforced modified bituminous sheets (in contrast to the UEAtc which suit all kinds of reinforcements). The Canadian standard was also considered, but the elongation/strength equations were too complicated.
- In a future revision, the high temperature resistivity of the APP-modified bitumen will be changed to about 145°C.
- Changing the low temperature flexibility to −25°C for SBS-modified, and −15°C for APP-modified sheets is being considered. This change is the result of a test on the number of relatively good roofing sheets which claimed for the UEAtc. The 20 percent change in properties after aging is still under investigation. The cause and the meaning of the various results found are being studied.
- The shear strength and water pressure resistance of the field seams are as tested in accordance with the German Din.

SUMMARY

In addition to the comparisons of standards previously discussed, following are others that should be mentioned:

- It was found that the SIA 281 (LBP) - modified bitumen is a very interesting analytic standard. Since these specifications deal only with roofs, just a part of that standard is relevant (part A). This part suits only cold countries as the high temperature resistivity demand is 80°C. The strength and elongation requirements are too low.
- SIA 280 (synthetic materials - polymers) gives the answer to many materials and applications.

It was found that, as is expected from a common denominator, the individual requirements were too low, except the 0.5 percent dimensional change which suits one kind of Swiss-made PVC. But most of the other polymeric single-ply roofing materials, which perform very well on roofs, will fail in this test. The 5000-hour artificial weathering test is too long and expensive.

The German 52123, 52132 and 52133 Dins are very accurate. They deal with reinforcements as Hessian, perhaps because of tradition or industry pressure. These materials are not used in Israel any longer.

The minimum thickness of the polyester fleece reinforced felt of 5mm is excellent, but still too expensive for our market.

The Canadian 37-GP-56M is a very interesting standard. The "load strain" product gives the answer to all types of reinforcement. Since the authors work only with the polyester reinforced sheet, they can specify with numbers without product. The low temperature flexibility of −30°C indicates that the Canadians deal mostly with SBS-modified bitumen. Much more APP is used in Israel than SBS, especially on exposed roofs.

The static and dynamic puncturing tests are very important. Since the authors deal only with the polyester reinforced sheets, they came to the conclusion that the roofing felt will stand up to all their requirements, and will also have a good puncturing resistance.

These were some of the authors' considerations. They have already received some remarks from the industry, from contractors and architects, and are waiting for the new European CEN norms, for more remarks. Together with their new experience and investigation, they will modify the specifications during the next year.

Properties	Units	Requirements				Test Method According to:
		Type I-A Unreinforced	Type I-B Unreinforced with a nonwoven carrier	Type II Unreinforced containing fibers	Type III Reinforced	
I. Physical properties of the new membrane						
1. Minimal thickness (excluding carrier layer)	mm	1.0	1.0	1.2	1.2	ASTM D 638 ASTM D 751
2. Tensile strength at break (MD/XD), min.	MPa	15/15	—	10/10	—	ASTM D 638
3. Breaking strength (MD/XD), min. (50mm width)	N	—	800	—	1200/1200	ASTM D 751,B
4. Elongation at break (MD/XD), min.	%	200/200	150/150	200/200	15/15	ASTM D 638 ASTM D 751,B
5. Tear resistance (MD/XD)	N/mm N	40/40 —	— 200/200	40/40 —	— 200/200	ASTM D 1004 ASTM D 751,B
6. Dimensional stability at high temperature, 6 hr. at 80°C						
Linear dimensional change (MD/XD), max.	%	0.7/0.7	0.7/0.7	0.1/0.1	0.7/0.7	ASTM D 1204
Textural change		Blisters or bubbles should not develop				
7. Low temperature flexibility, -20°C	°C	Cracks on the surface should not develop				DIN 52123
II. Physical properties after exposure to accelerated weathering						
1. UV resistance, 2000 hr. of exposure at 60°C (QUV, 8 hr. UV; 4 hr. cond.)						ASTM G 53
Tensile or breaking strength (MD/XD)		Change in properties - less than 20%				
Elongation at break (MD/XD)		Change in properties - less than 20%				
Surface texture		No cracks or other visible changes				
2. High temperature stability, 168 hr. at 90°C						ASTM D 1204
Tensile or breaking strength (MD/XD)		Change in properties - less than 20%				
Elongation at break (MD/XD)		Change in properties - less than 20%				
III. Properties of seams (by welding)						
1. Shear strength of seam	KN/m	If the separation occurs in the seam - at least 80% of the original strength, but not less than 12 KN/m.				ASTM D 638
2. Water pressure resistance, 1 bar for 24 hr.		No penetration of water				DIN 52123 II

Table 1 *Specifications for PVC membranes.*

Properties	Units	Requirements	Test Method According to:
I. Physical properties of the new membrane			
1. Minimal thickness	mm	1.3 - for partially adhered 1.5 - for fully adhered	ASTM D 412
2. Tensile strength, min.	MPa	9.0	ASTM D 412
3. Elongation at break, min.	%	350	ASTM D 412
4. Tear resistance, min.	N/mm	25	ASTM D 624
5. Tensile set, from 250% elongation, max.	%	10	ASTM D 214
6. Low temperature flexibility at −40°C		No cracks after bending	DIN 52123
II. Physical properties after exposure to accelerated weathering			
1. UV-resistance, 2000 hr. of exposure at 60°C (QUV, 8 hr. UV: 4 hr. cond.)			ASTM G 53
Strength and elongation at break		Change in properties - less than 10%	
Tear resistance		Change in properties - less than 10%	
2. High temperature stability, 28 days at 115°C			ASTM D 573
Tensile strength, min.	MPa	8.3	
Elongation at break, min.	%	250	
Tear resistance, min.	N/mm	22	
Dimensional change, max	%	±2 (MD/XD)	
3. Resistance to ozone 168 hr. in 100 PPHM at 50% elongation		No cracks seen at X 7-10	ASTM D 1149
III. Properties of seams			
Factory vulcanization (30mm overlap)			
1. Shear strength of seams, min.			ASTM D 816,B
New sample (at R.T.)	KN/m	If the separation in seam - 9	
After 28 days at 115°C (test at R.T.)	KN/m	If the separation in seam - 7.2	
2. Water pressure resistance, 1 bar for 24 hr.		No penetration of water	DIN 52123 II
On-site adhered (100mm overlap)			
3. Shear strength of seams, min.			ASTM D 816,B
New sample (at R.T.)	KN/m	If separation in seam - 6	
New sample at 70°C	KN/m	If separation in seam - 4	
After 28 days at 115°C (test at R.T.)	KN/m	If separation in seam - 5	
4. Peel strength	KN/m	0.8	ASTM D 816,C
5. Water pressure resistance, 1 bar for 24 hr.		No penetration of water	DIN 52123 II

Table 2 Specifications for EPDM membranes.

Properties	Units	Requirements		Test Method According to:
		MB/SBS	MB/APP	
I. Physical properties of the new membrane				
1. Minimal thickness (excluding protective layer)				ASTM D 751
Total	mm	4 ± 0.3	4 ± 0.3	
Above reinforcement	mm	1.0	1.0	
Below reinforcement	mm	1.2	1.2	
2. Breaking strength (MD/XD), min. (50mm width)	N	700/650	700/650	ASTM D 751
3. Elongation at break (MD/XD), min.	%	40/40	40/40	ASTM D 751
4. Tear resistance, min.	N	70	70	ASTM D 624
5. High temperature resistivity	°C	115	125	DIN 52123 I
6. Low temperature flexibility	°C	−20	−10	DIN 52123 I
7. Dimensional stability at high temperature, 6 hr. at 80°C				ASTM D 1204
Dimensional change not larger than . . .	%	0.5/0.5	0.5/0.5	
II. Physical properties after exposure to accelerated weathering				
1. UV resistance, 2000 hr. of exposure at 60°C (QUV, 8 hr. UV:4 hr. cond.)				ASTM G53
Strength and elongation at break		Change in properties - less than 20% of original.		
Upper surface texture		No cracks, detachment of stone flakes or other visible changes.		
2. High temperature stability, 30 days at 80°C				ASTM D 1204
Strength and elongation at break		Change in properties - less than 20% of original.		
Flexibility at low temperature	°C	−10	−5	DIN 52123 I
III. Properties of seams (welded)				
1. Water pressure resistance, 1 bar for 24 hr.		No penetration of water		DIN 52123 II
2. Shear strength of seam, min. (50mm width)	N	500	500	

Table 3 *Specifications for modified bituminous membranes.*