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PROJECT REPORT 38

Norwegian Building Research Institute

Einar M. Paulsen

Aging Tests for Bituminous Roofing Membranes

Oslo/Trondheim 1988

NORWEGIAN BUILDING RESEARCH INSTITUTE

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AGING TESTS FOR BITUMINOUS ROOFING MEMBRANES

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Contents

Preface

The Trondheim Division of the Norwegian Building Research Institute (NBI) has a specialised and experienced staff that often acts as advisers and consultants for manufacturers and users of building materials and components. A feature of the division is the development of test methods and laboratory testing equipment. Another important aspect is obtaining practical experience by investigating building faults and doing systematic field surveys.

This report summarises the laboratory testing and evaluation carried out at NBI as part of a Scandinavian project aimed at finding relevant methods of aging bituminous roll roofing materials.

The work, which involves testing, modification of apparatus and reporting, has been funded by:

- The participating roofing felt manufacturers
- Nordisk Industrifond
  (Nordic Fund for Technology and Industrial Development)
- Norges Teknisk- Naturvitenskapelige Forskningsråd (NTNF)
  (The Royal Norwegian Council for Scientific and Industrial Research)
- Takprodusentenes Forskningsgruppe (TPF)
  (Norwegian Roofing Research Group)

Because of wide international interest and focus on testing the durability of bituminous roofing membranes, the Institute has decided to print this report in English.

Arne Bakkejord is thanked for carrying out the testing of material properties.

Oslo/Trondheim, December 1988

Åge Hallquist

INTRODUCTION

The Norwegian Building Research Institute (NBI), Trondheim Division, has been engaged in roofing research from its establishment in the 1950's.

For flat roofs with flexible roofing, field investigation techniques were originally used as a basis for subsequent revision of recommended codes of practice.

At the beginning of the 1970's, the need for laboratory testing and evaluation became more evident. Backed by the industry, NBI set out to design and build a multifunction roof testing apparatus with test programmes for

- wind uplift strength (pressure and temperature)
- simulated aging (temperature and moisture)
- accelerated aging (IR lamps and UV tubes).

The apparatus and the results of the initial research were presented at ISRR, Brighton in 1974 (1).

During the 1970's the apparatus was extensively used for wind uplift strength research and commercial testing.

With the introduction of polymer-modified bitumen, work on the accelerated aging programme was resumed in the early 1980's, initially on a research contract for a Danish housing corporation, but also on a project for testing and evaluating liquid-applied roofing materials (6).

As part of a Scandinavian project coordinated by Statens Provningsanstalt, Borås, Sweden, NBI undertook in 1984 to test commercially-available products from the roofing felt manufacturers in Finland, Sweden, Denmark and Norway.

After the first aging run of 24 weeks in a ventialted oven at +70 °C and 24 weeks according to test method, NBI 142/84, the participants reached a general agreement that some changes in the visual appearance after aging did not occur in practice, and that an adjustment of the test conditions was necessary.

The modification consisted of doubling the number of UV tubes, reducing the distance of the UV tubes from the test specimen by 50 %, and lowering the maximum temperature from +70 °C to +60 °C.

A second aging run of 24 weeks, using the procedure described in NBI 142/86, was performed using a representative selection of previously tested products as well as additional ones.

This report is a summary based on individual test reports released by the participants for the benefit of evaluating the test methods.

PARTICIPANTS AND THEIR PRODUCTS

The following companies have participated in the project, both financially and by delivering products for testing:

- Jens Villadsens Fabriker A/S	Denmark
- Phønix A/S	Denmark
- Mataki AB	Sweden
- Trebolit AB	Sweden
- Roofsafe AB	Sweden
- Icopal AB	Sweden
- Derbit Belgium S.A.	Belgium
- Soprema S.A.	France
- Takfiltföreningen RF	Finland
- Isola Fabrikker A/S	Norway
- Fjeldhammer Brug A/S	Norway

The products subjected to aging have been grouped as follows to facilitate comparison.

a) Overlayer sheets containing SBS polymer-modified bitumen. The sheets may be used as a cap sheet in a multilayer system or, in some cases, as a single layer

b) Underlayer sheets containing SBS polymer-modified bitumen

c) Sheets containing APP polymer-modified bitumen

d) Overlayer sheets (cap sheets) containing oxidised bitumen

e) Underlayer sheets containing oxidised (OX) bitumen

f) Two ply membrane containing oxidised bitumen

Particulars about the products are given in Table 1, where the following abbreviations have been used:

Product No.

Four figures: First two = material no.

Last two = participant no.

Core material

PES = non-woven polyester

PES + Al = PES with laminated aluminium foil

GF + PE = Fibreglass laminated on both sides of polyethylene

PES/GF	=	one layer of PES and one layer of GF
ORG	=	organic felt
PES + ORG	=	PES with a portion of organic fibres

Surface colour

W	=	white
LG	=	light grey
G	=	grey
DG	=	dark grey
D	=	dark
B	=	black
RB	=	redish brown

Surface finish

M	=	mineralised
S	=	sand
T	=	talcum powder
F	=	film
GF	=	fibreglass
GV	=	fibreglass fabric

Table 1
Products subjected to aging

Product no.	Core material	Thickness	Mass	Surface finish		Surface colour
		mm	kg/m2	upper	lower	upper
a) Overlayer, SBS						
1004	PES	3.8	4.0	M	S	DG
1107	PES	3.5	4.0	M	S	DG
1208	PES	3.8	5.2	M	S	W
1309	PES	3.7	4.0	M	S	LG
1401	PES + Al	3.7	4.6	M	F	DG
1502	PES + Al	4.0	4.8	M	F	G
1602	PES	5.0	5.4	M	F	LG
1710	PES	4.2	5.0	M	F	RB
1810	PES	5.0	5.6	M	F	RB
1902	GF + PE	3.1	3.2	M	S	G
2002	GF + PE	3.2	3.2	M	S	G
2108	GF + PE	3.4	4.2	M	S	DG
b) Underlayer, SBS						
2207	PES	2.7	3.0	S	S	RB
2301	PES	2.8	3.0	S	S	D

Table 1, to be continued on page 10 and 11.

Table 1
Products subjected to aging

Product no.	Core material	Thickness	Mass	Surface finish		Surface colour
		mm	kg/m2	upper	lower	upper
c) Sheets, APP						
2411	PES and GF	4.2	4.7	GF	F	B
2505	PES	4.0	3.9	T	F	B
d) Overlayer, OX						
2607	Not specified	3.3	3.9	M	S	DG
2707	GF	3.5	4.1	M	S	DG
2808	GF + PE	3.5	4.2	M	S	DG
2902	ORG	3.2	3.8	M	S	G
3003	PES + ORG	3.2	4.0	M	S	DG

Table 1
Products subjected to aging

Product no.	Core material	Thick-ness	Mass	Surface finish		Surface colour
		mm	kg/m^2	upper	lower	upper
e) Underlayer, OX						
3107	GV	3.1	4.0	S	S	RB
3209	PES	1.7	2.0	S	S	D
3306	PES	2.1	2.3	S	S	D
3403	PES	2.1	2.5	S	S	D
3504	PES	2.3	2.3	S	S	D
f) Two layer, OX						
3609	PES/PES	5.5	4.9	M	S	DG
3706	PES/PES	5.6	7.4	M	S	DG
3803	PES/PES		7.3	M		DG
3904	PES/PES	6.4	7.1	M	S	DG

METHODS OF AGING

I Roof weathering test (RW) (Photo 1)

24 weeks aging with a 24-hour cycle as described in test method NBI 142/86 given in Appendix 1.

The maximum temperature in the heating period is 333 K (+60 °C) and the minimum temperature in the freezing period is 263 K (-10 °C).

The test specimen measuring 450 mm x 450 mm, is laid on a test rack of perforated steel plates and mounted in the aging apparatus at an angle of of 1:50 (Photos 2, 3 and 4). Three edges of the specimen are covered by a steel frame, the lowest edge being left exposed.

The test rack position in the RW is changed every four weeks to compensate for any differences in exposure.

II Ventilated oven (H)

24 weeks heat aging in air at 343 K (+70 °C).

The test specimen measuring 450 mm x 450 mm, is laid on a wire mesh and mounted horizontally in the apparatus as shown in Photo 6.

The oven is ventilated, and control measurements have shown that there is no need to change the position of the test specimens during the aging period.

III Wet base (WB)

8 weeks exposure in the RW with the test specimen lying on a wet base.

The test specimen, measuring 450 mm x 450 mm, is laid on 3 layers of blotting paper soaked with water in a tray made of aluminium plates, as shown in Photo 5.

Three edges of the test specimen are enclosed by bending down the edges of the metal plate, whereas the fourth edge remains exposed with the metal plate in a vertical position as shown in Fig. 1.

The specimen is mounted in the RW with the exposed edge at the lowest position. The blotting paper is kept wet by periodic spraying with water.

IV Natural weathering

Samples measuring 500 mm x 500 mm of all the materials tested are being subjected to natural weathering at the NBI experimental station at Tyholt, Trondheim, as shown in Photo 7.

The membrane is in principle placed loosely on 50 mm polystyrene (EPS) insulation and installed at an angle of of 1:16 facing south. Details of the mounting fixture are shown in Fig. 2.

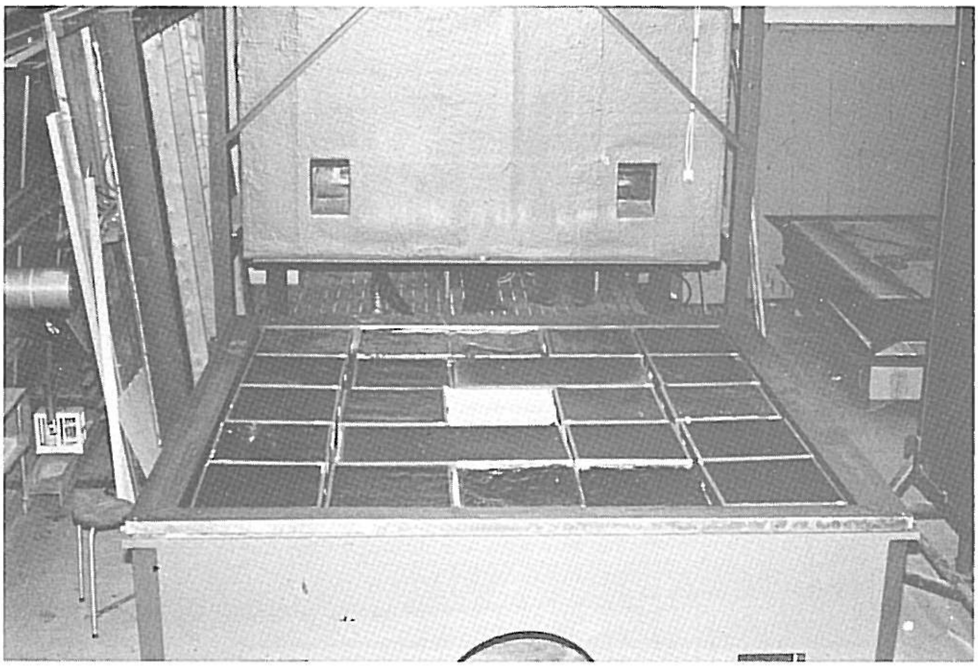


Photo 1
General view of roof testing apparatus

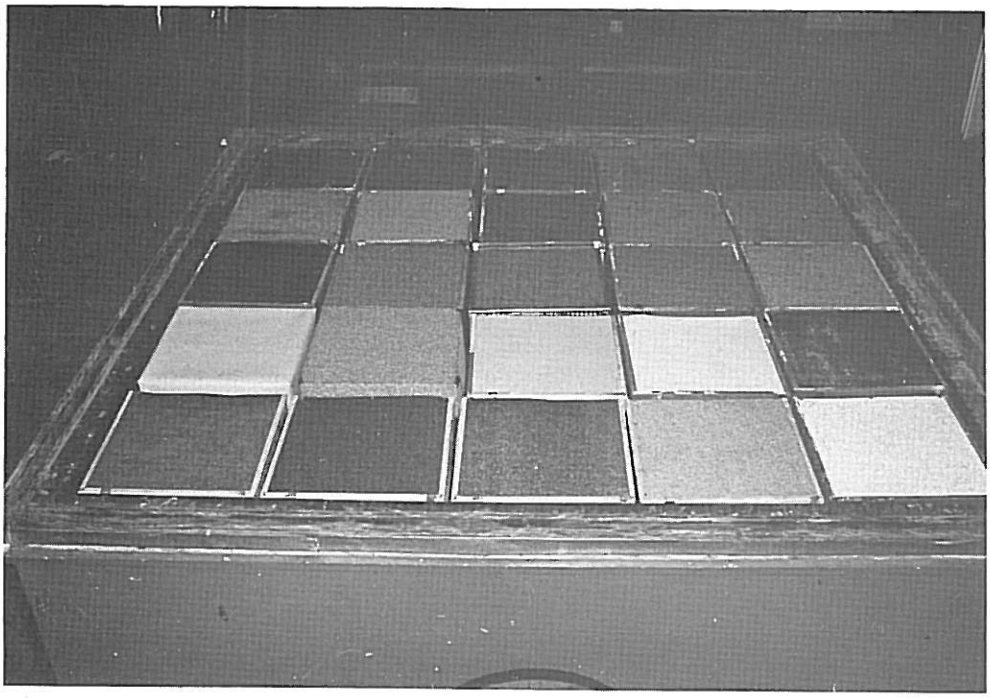


Photo 2
Samples installed for testing according to NBI 142/86

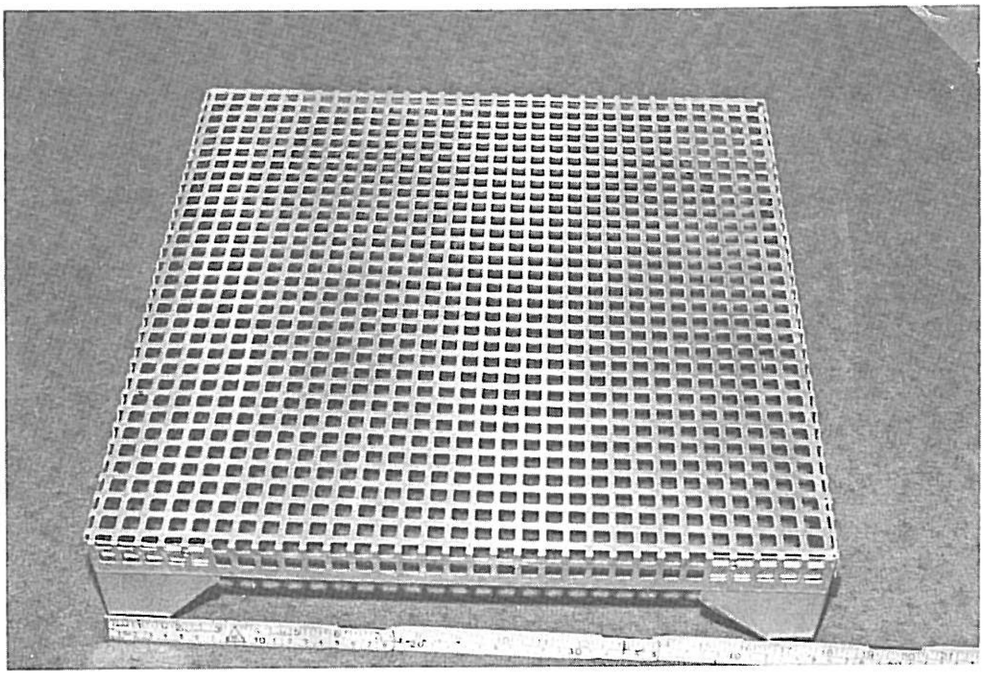


Photo 3
Test rack of perforated metal sheets

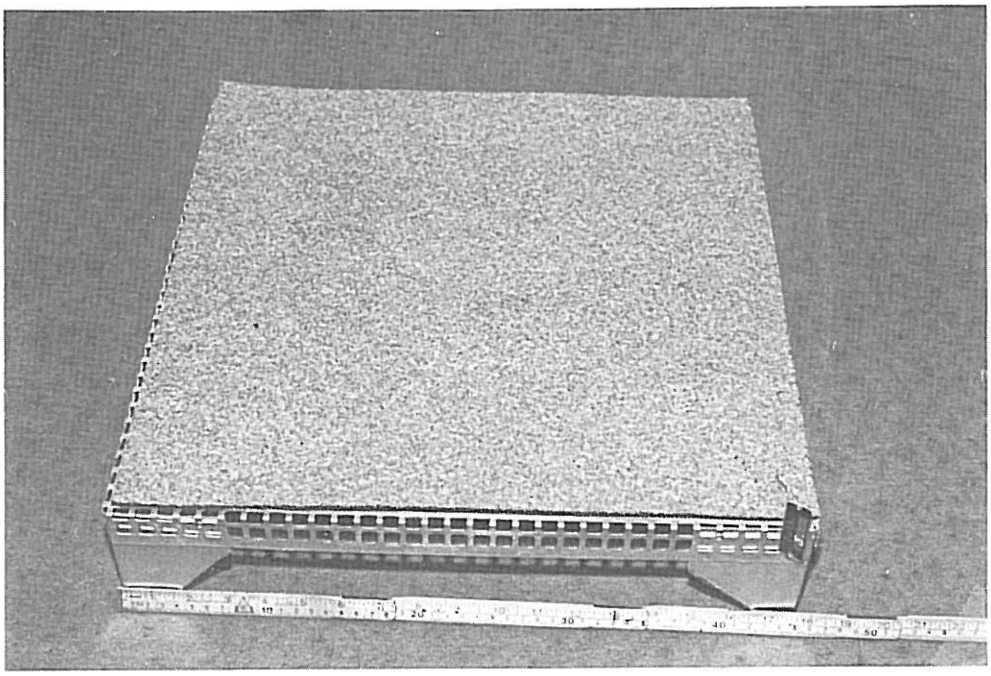


Photo 4
Samples laid on test rack

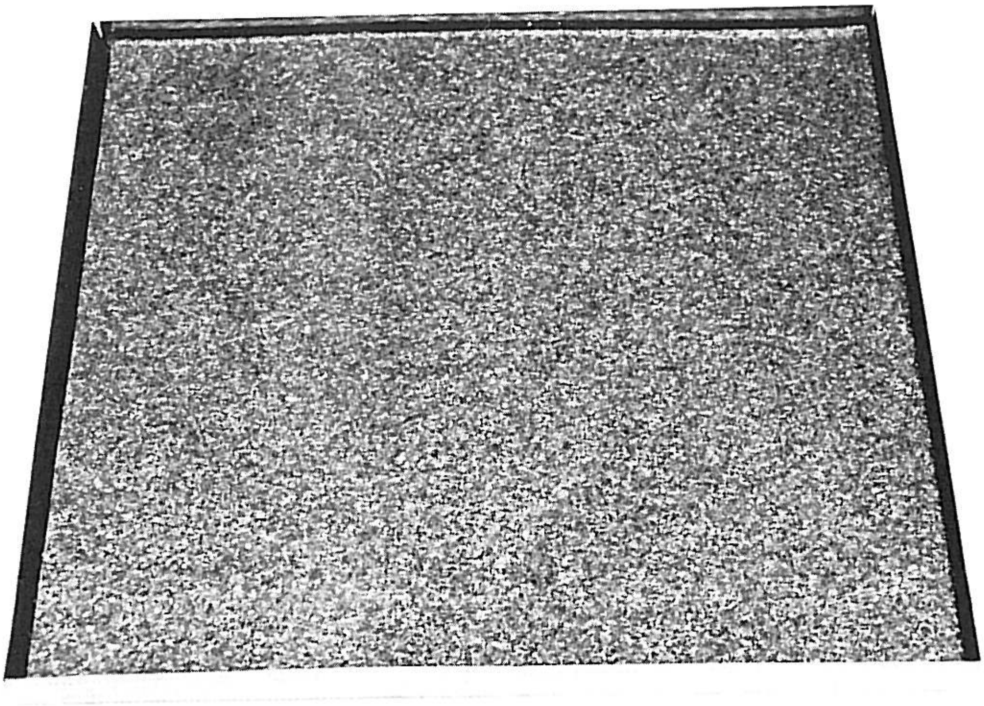


Photo 5
Sample laid on wet base in Al tray

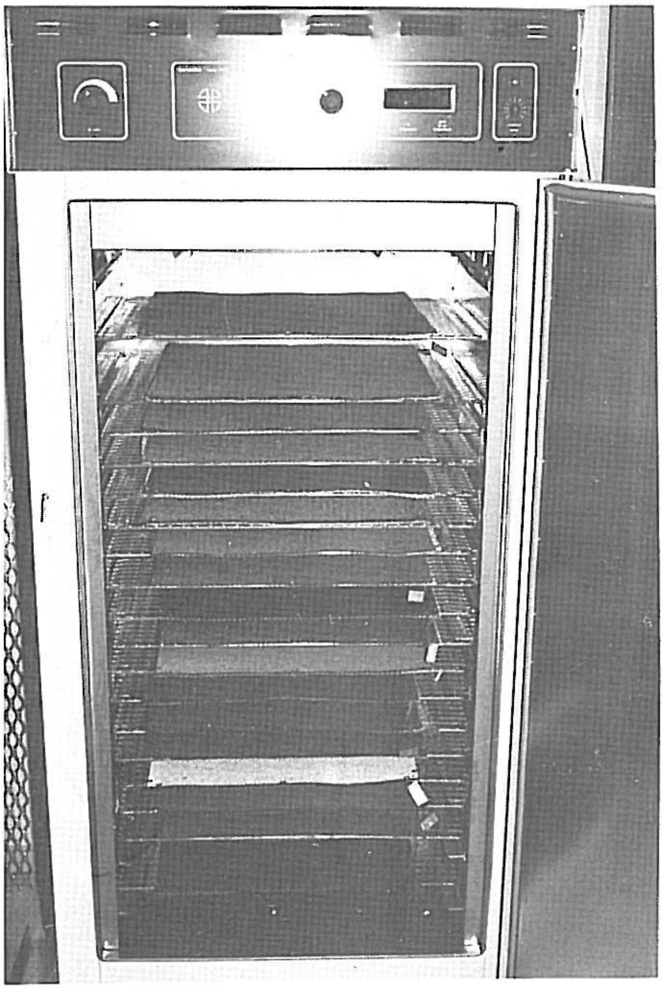


Photo 6
Samples mounted in ventilated oven

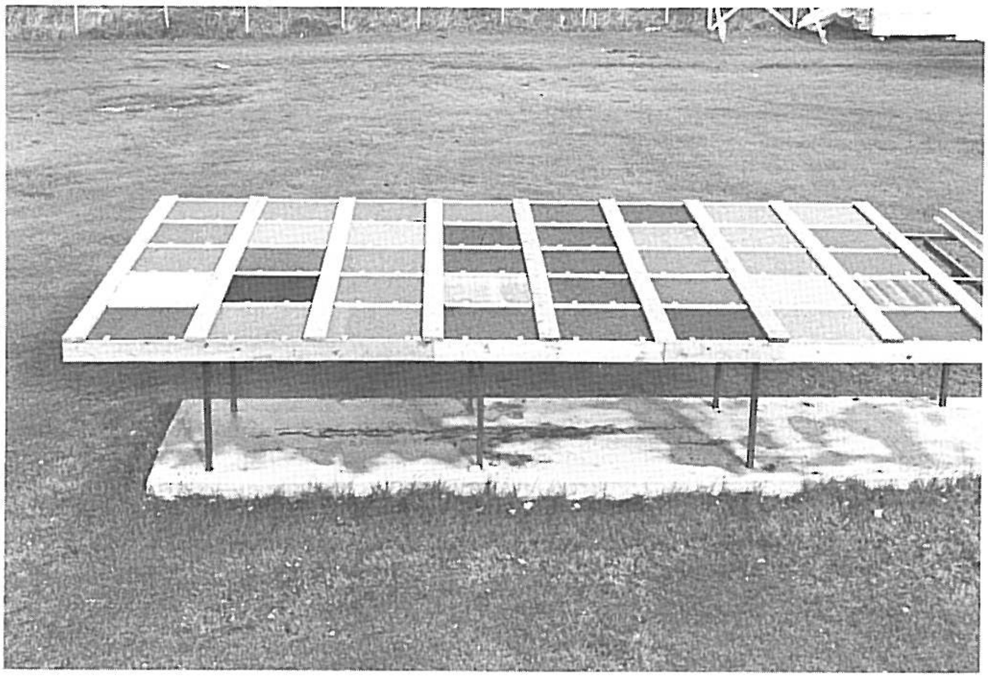
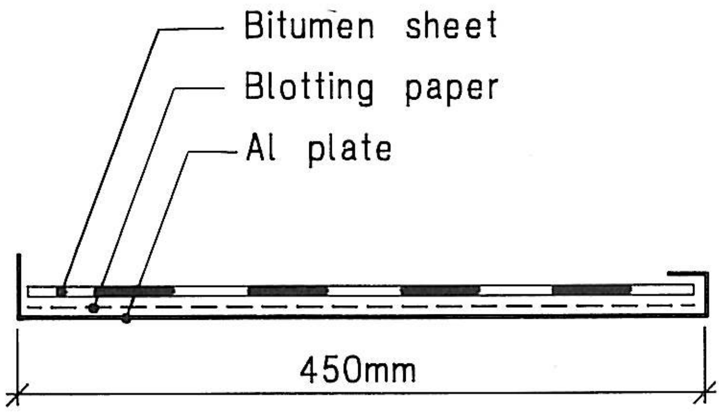
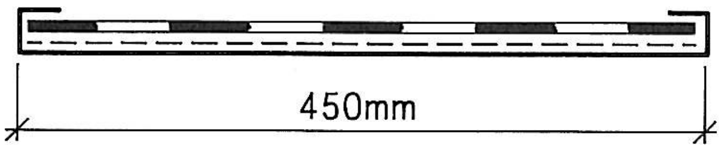


Photo 7
Samples mounted for natural weathering

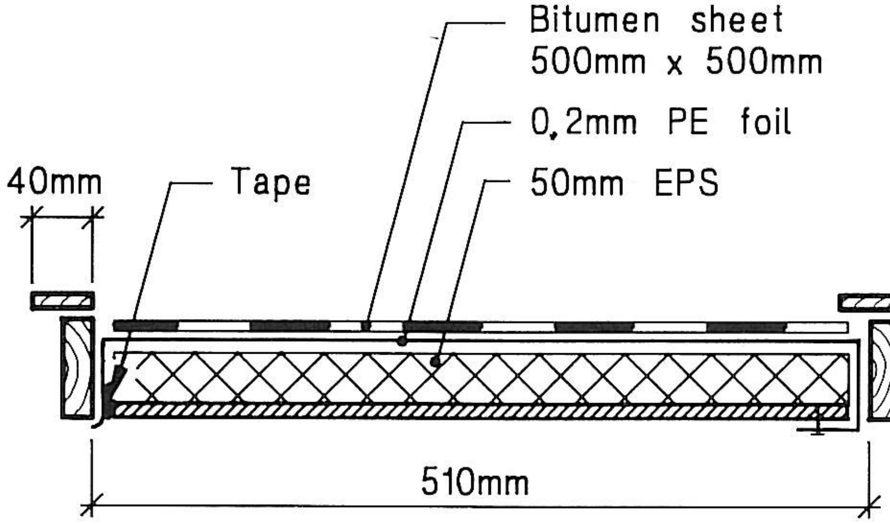


SECTION a - a

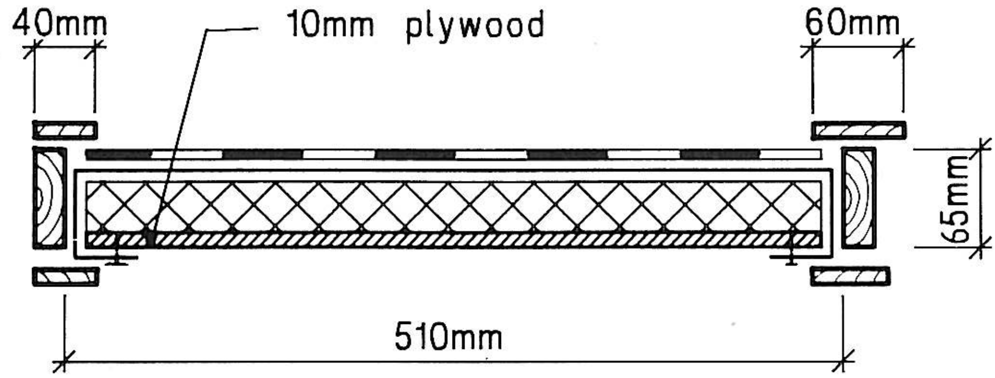


SECTION transverse of a - a

Fig. 1
Test arrangement for mineralised cap sheets with moisture from underside



SECTION a - a



SECTION transverse of a - a

Fig. 2
Method of mounting sheets for natural weathering

ATTRIBUTES EVALUATED

Tensile strength

Tensile strength is the greatest stress that the test specimen can stand without breaking the reinforcement or the membrane itself.

Method: DIN 52123, Norwegian Standard NS 3530

- 300 mm x 50 mm test specimen
- 200 mm effective length (distance between jaws)
- 40 mm/minute test speed
- 296 K (+23 °C) and 253 K (-20 °C) test temperatures

The results are based on the average of 3 tests in the machine direction, and are expressed as N/50 mm.

Elongation

a) At 296 K (+23 °C) test temperature

Elongation at break defines the value of greatest stress required to extend the test specimen.

Method: DIN 52123, NS 3530

- 300 mm x 50 mm test specimen
- 200 mm effective length (distance between jaws)
- 40 mm/minute test speed

The results are based on the average of 3 tests in the machine direction, and are expressed as percentage of original length.

b) At 253 K (-20 °C) test temperature

To measure the ability of the membrane material to elongate at low temperatures before cracks occur.

Method: NBI 143/84, NS 3530

- 300 mm x 50 mm test specimen
- 200 mm effective length (distance between jaws)
- 40 mm/minute test speed

The test is carried out with a special apparatus using 140 mm x 10 mm Cu electrodes on both sides of the test specimen. An electrical charge of 15 000 V is applied between the electrodes.

Elongation when sparks occur, indicating cracks in membrane material, is registered as the point of failure.

The results are based on the average of 3 tests in the machine direction and are expressed as percentage of original length.

Flexibility

The ability to resist bending without cracking.

Method: DIN 52123, NS 3530

- 200 mm x 50 mm test specimen
- 6, 10, 30, 50 or 100 mm bending plates with semicircular end

Test specimen is bent around the plate during a period of 5 seconds at intervals of 5 °C from 298 K (+25 °C) down to 253 K (-20 °C) or until cracks occur in the membrane.

Change in dimensions

The membrane is measured in both directions before and after aging. Changes in dimensions are expressed as percentages of original size.

Change in weight

The membrane is weighed before and after aging. Change in weight is expressed as percentage of original weight.

Visual inspection of surface

The test samples are inspected visually before and after aging. Specific aging phenomena are recorded.

RESULTS OF TESTING AND EVALUATION AFTER AGING

The attributes of the test materials have been evaluated at different stages during the course of the project.

The possibility of changes taking place in the material with time has been minimised by storing sufficient amounts of fresh material, along with the surplus material from the test specimens, in a dark room at a temperature of about 280 K (+7 °C).

Roof weathering test (RW) and ventilated oven (H)

The data derived from the testing and evaluation of fresh and aged material are given in the following tables:

Table 2. Tensile strength and elongation

Table 3. Changes in dimensions, weight and appearance

Abbreviations used for change in surface appearance of aged material relative to fresh material:

A = No significant change

B = Paler, otherwise no significant change

C = Darker

D = Darker and brownish

E = Black staining, "bleeding" and embedment of surface mineral matter

F = Dull black and formation of elephant skin

Table 4. Flexibility

Abbreviations:

O = fresh material

X = aged 24 weeks according to NBI 142/86

h = aged 24 weeks in ventilated oven at +70 °C

Wet base (WB)

Three types of material were subjected to exposure for 8 weeks in the RW according to method NBI 142/86 (Appendix 1).

After exposure the surface was examined visually with the following results:

Prod. no. 2902 Considerable raising or topping of slate minerals all over the surface

Prod. no. 3003 Slight tendency for raising of individual grains

Prod. no. 1902 No visual change.

Table 2
Tensile strength and elongation

Sample no.	Tensile strength (N/50 mm)				Elongation (%)			
	Fresh		142/86	Heat	Fresh		142/86	Heat
	+23 °C	-20 °C	-20 °C	-20 °C	+23 °C	-20 °C	-20 °C	-20 °C
a) Cap sheet, SBS					x)			
1004	744	1350	1150	1116	46	35	29	29
1107		1177	1266	1186		38	33	36
1208	1190	1554	1336	1400	63	47	35	13
1309	948	1238	786	870	49	5	3	3
1401	1098	1380	1300	1113	63	44	33	8
1502		1358	1076			30	17	
1602		1754	1700			19	19	
1701	956	1384	1236		42	23	21	
1810	1230	1556	1540		60	36	33	
1902	545	1092	1260	1176	3	6	3	4
2002		1164	1023			4	3	
2108	804	1386		1410	4	4		3
b) Underlayer, SBS								
2207		1356	1133	1316		43	31	33
2301	1082	1430		1370	54	32		8

x) The result is based on measuring the distance between the jaws which have sinusoidal grips. When measuring the deformation on the test specimen itself, the elongation will be in the order of 5 to 10 % lower for membranes with PES reinforcement.

Table 2
Tensile strength and elongation

Sample no.	Tensile strength (N/50 mm)				Elongation (%)			
	Fresh		142/86	Heat	Fresh		142/86	Heat
	+23 °C	-20 °C	-20 °C	-20 °C	+23 °C	-20 °C	-20 °C	-20 °C
c) Sheets, APP								
2411		1502	1623			27	15	
2505		1502	1253			29	3	
d) Cap sheet, OX								
2607		1070	1086	1003		2	3	2
2707		734	713	633		2	2	2
2808	712	1268		1260	4	4		4
2902	580	1352		1463	2	4		3
3003	429	730		1176	5	4		1

Table 2, to be continued on page 24.

Table 2
Tensile strength and elongation

Sample	Tensile strength (N/50 mm)				Elongation (%)			
	Fresh		142/86	Heat	Fresh		142/86	Heat
no.	+23 °C	-20 °C	-20 °C	-20 °C	+23 °C	-20 °C	-20 °C	-20 °C
e) Underlayer, OX								
3107		2386	2110	2123		1	2	5
3209	603	692		672	38	5		1
3306	572	755		630	42	2		1
3403	394	606		483	21	3		1
3504	387	624		638	19	1		1
f) Two layer, OX								
3609	1478	1824		1736	45	10		8
3706	1090	1586		1456	27	13		4
3803	1092	1368		1286	18	8		2
3904	1224	1818		1633	40	24		9

Table 3
Changes in dimensions, weight and appearance

Sample no.	Change in dimensions (%)				Change in weight (%)		Appearance	
	NBI 142/86		Heat					
	L	T	L	T	142/86	Heat	142/86	Heat
a) Overlayer, SBS								
1004	-0.4	+0.4	-0.3	+0.2	-4.4	-2.4	A	E
1107	-0.3	+0.4	-0.2	+0.2	0.0	+0.2	C	A
1208	-0.3	+0.2	-0.4	+0.2	-3.5	-2.4	A	C
1309	-0.6	+0.2	-0.5	+0.1	-4.0	+0.1	A	C
1401	-0.4	+0.3	-0.5	+0.2	-3.4	+0.7	B	E
1502	-0.2	+0.2			+0.2		A	
1602	+0.2	+0.3			+0.2		C	
1710	-0.3	+0.5			+0.1		A	
1810	-0.2	+0.2			+0.1		A	
1902	-0.1	+0.2	0.0	0.0	-0.1	+0.5	B	C
2002	0.0	+0.1			+0.2		B	
2108			0.0	0.0		-0.3		C
b) Underlayer, SBS								
2207	-0.3	+0.3	-0.2	+0.2	-0.3	+0.4	D	D
2301			-0.5	+0.2		-0.9		E

Table 3, to be continued on page 26 and 27.

Table 3
Changes in dimensions, weight and appearance

Sample no.	Change in dimensions (%)				Change in weight (%)		Appearance	
	NBI 142/86		Heat					
	L	T	L	T	142/86	Heat	142/86	Heat
c) Sheets, APP								
2411	-0.1	-0.4			-0.4		D	
2505	-0.5	+0.1			-0.2		F	
d) Overlayer, OX								
2607	+0.1	+0.2	+0.1	0.0	-0.4	-0.2	B	A
2707	+0.2	+0.1	0.0	0.0	-0.1	-0.1	B	A
2808			0.0	0.0		-0.8		A
2902			-0.2	-0.4		+0.1		A
3003			-0.3	-0.2		+0.2		A

Table 3
Changes in dimensions, weight and appearance

Sample no.	Change in dimensions (%)				Change in weight (%)		Appearance	
	NBI 142/86		Heat					
	L	T	L	T	142/86	Heat	142/86	Heat
e) Underlayer, OX								
3107	+0.5	+0.4	0.0	0.0	-1.9	-0.1	D	E
3209			-0.4	+0.1		-0.4		C
3306			-0.5	0.0		+0.4		A
3403			-0.3	0.0		0.0		A
3504			-0.4	-0.1		+0.5		A
f) Two layer, OX								
3609			-0.5	+0.2		+0.3		C
3706			-0.4	-0.1		+0.1		C
3803			-0.5	+0.3		-0.1		C
3904			-0.1	-0.1		+0.2		A

Table 4. Flexibility

Prod. no.	6 mm												10 mm										30 mm										50 mm									
	- °C +												- °C +										- °C +										- °C +									
	30	25	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25
a) Overlayer SBS																																										
1004		o					x		h																																	
1107							o													h	x																					
1208															o					x						xh																
1309														o														x		h												
1401													o											h	x																	
1502														o						x				x																		
1602														o					x							x																
1710															o					x					o										x							
1810															o				x						o	xh										x						
1902													o																													
2002															o										x																	
2108																											o										o					h
b) Underlayer SBS																																										
2207		o					h																									x										
2301													o												h																	

Table 4. Flexibility

Prod. no.	10 mm										30 mm										50 mm										100 mm									
	- °C +										- °C +										- °C +										- °C +									
	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25
c) Sheets, APP																																								
2411												o	x																											
2505													o						x							x														
d) Overlayer, OX																																								
2607																	o								o		h		x											
2707																o									o		h		x											
2808															o										o										o					h
2902																			o								o									o				h
3003																o									o							o							h	

Table 4, to be continued on page 30.

Table 4. Flexibility

Prod. no.	10 mm										30 mm										50 mm										100 mm									
	- °C +										- °C +										- °C +										- °C +									
	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25	20	15	10	5	0	5	10	15	20	25
e) Underlayer, OX																																								
3107																o														h									x	
3209					o												h																							
3306												o															h													
3403																o														h										
3504																o														h										
f) Two layer, OX																																								
3609																									o														h	
3706																									o															h
3803																								o								h								
3904																										o						h								

DISCUSSION OF RESULTS

Tensile strength

The test results have been included in the report without detailed systematic presentation and analysis.

The maximum force recorded when testing elongation may, however, be of help when explaining differences in behaviour of products which are similar but have different reinforcement strengths.

In all cases, the strength increases when the temperature is lowered from +23 °C to -20 °C.

The increase varies according to the type of reinforcement, the amount and type of asphalt and the relative amounts of each.

In most cases, the ultimate strength is reduced after aging when tested at -20 °C.

Because of the large variation in strength, a statement on requirement could be expressed as a maximum permissable percentage reduction.

Elongation

The basic test is elongation at -20 °C without impairing the ability of the membrane to resist water pressure over time. This ability is defined as being vitally reduced when cracks occur in the membrane material. In most cases this can be detected using an electrical charge of 15 000 V between both sides of the specimen.

When Al foil forms part of the reinforcement, the electrical charge cannot be applied because of short circuiting.

The cracks in the asphalt are also noticed on the graphs, and can be observed visually.

Membranes with GF reinforcement and membranes with OX asphalt have low elongation characteristics at -20 °C. The method of testing does not give sufficient accuracy to form a basis for further analysis.

Membranes with PES reinforcement and polymer-modified bitumen have sufficiently large elongation at -20 °C to be evaluated by this method.

Change in dimensions

Linear dimensions are measured at three places in each direction on the specimen subjected to aging. The average values longitudinal (L) and transverse (T) to the machine direction are given.

The basic tendency for membranes containing PES only, is to be vulnerable to shrinkage in the machine direction and to elongation in the transverse direction.

Membranes reinforced with fibreglass show very little change in dimensions or tendency to elongate.

Membranes containing ORG fibres show shrinkage in both directions.

Change in weight

Loss of weight is the most dominant feature. It may be caused by

- loss of volatile material
- loss of surface material
- loss of membrane material

For some of the cap sheets containing SBS the loss of weight is 3 to 4%. To minimize the loss of granules the specimens were handled very carefully after weighing. Some specimens, especially those with a sanded lower side, showed a tendency for the asphalt to stick to the wire mesh, and some asphalt may have been lost in that way.

Material 1401 has a film on the lower side, but still shows a weight loss of 3.4%.

Loss of volatile material gives reduced flexibility, or elongation. This is the case for 3 of the 5 materials showing excessive loss of weight. Materials 1309 and 1401 show more reduction of flexibility than the average of the groups. Material 1309 also shows unusual behaviour as regards elongation at -20 °C.

Change in appearance

Changes recorded on visual inspection of samples after aging are always related to fresh material.

With the exception of E all types of surface change may not be noticed in practice. Black staining or "bleeding" was not seen on any sample from RW. But the phenomenon was recorded on samples subjected to heat aging at +70 °C.

Flexibility

A basic requirement when selecting the method for testing flexibility was that it should be possible for manufacturers to do the test themselves. This eliminated sophisticated methods to some extent. Further limitations were that the testing should be done in air and that the temperature should range between -20 °C and +25 °C.

Mandrels of 10 and 30 mm diameter were commonly used, but to cover the whole span from the most flexible to two layers of OX asphalt, the range of mandrels was extended to 6, 10, 30, 50 and 100 mm. Even so, the temperature for the 6 mm mandrel had to be lowered to -30 °C to cover the whole range of products.

It proved difficult to find any relationship between the size of mandrel and the temperature, especially since two products, 1710 and 1810, were found to crack at the same temperature with 10 and 30 mm mandrels.

There may be many sources of error in this kind of testing, but they have been reduced by adopting the following measures:

- all testing has been done by the same person
- crack formation has been evaluated by the same person
- bending has been done in air at the specified temperature
- samples have been allowed ample time to condition at the specified temperature.

Overlayer sheets, SBS

Two categories of reinforcement are represented, PES and GF. All products have surface protection which years of experience have proved to be adequate. The UV exposure in the RW is not expected to have any influence. Six materials were subjected to both RW and H. The flexibility test shows that for two of these RW = H, for two other RW > H, and for the last two RW < H.

Underlayer sheets, SBS

Results only from two materials have been included in this report. Both were subjected to H and one to RW as well as part of a test to study the influence of UV on poorly protected SBS bitumen. The flexibility of the one material was quite different when the material was exposed to RW in contrast to H. The other material showed reduced flexibility and elongation after H.

Sheets, APP

This group is also represented by two materials, one with PES and APP bitumen on both sides, the other with a GF reinforcement in the upper surface and PES underneath. GF in the upper surface may give some protection against UV, as shown by the elongation and flexibility test, but when GF was present, it was very difficult to obtain a reliable result from the flexibility test.

Overlayer sheets, OX

Five materials with mineral protection, but with different types of reinforcement, were tested. The surface appearance was not much changed by either RW or H. The flexibility was clearly reduced for all the products. RW had the most severe effect on the two materials exposed to both methods.

Underlayer sheets, OX

Five materials were tested. One had GV reinforcement and four had PES. The strength of the GV reinforcement was about three times the value of the PES on the other materials.

Again one material was subjected to RW, which resulted in lower flexibility than for H.

Two play, OX

All four membranes had PES in both layers with mineral surface on top. The test results are consistent and give meaningful values for elongation and changes in dimensions as well as for flexibility using 50 and 100 mm mandrels.

Roof weathering test (RW)

The modification of the stresses in the apparatus have given the expected improvement. The surface phenomena observed are more in keeping with what was to be expected. No black bleeding or staining are observed on any of the samples tested. This corresponds to what has been experienced in practice in the case of a well designed compounds.

If there is any doubt about the quality of the surface protection, UV radiation should be included in the basic reference test.

The combination of IR and UV radiation seems to give realistic information about the UV resistance of the system as well as providing additional information about membranes that are vulnerable to dimensional instability, which is a very important aspect.

Ventilated oven (H)

The heat aging test is relevant for all underlayer felt. For exposed membranes it shows reasonable correlation with the accelerated weathering test provided surface protection is adequate, and it can be used to check the stability of the compound.

For membranes intended for use in the Nordic climate, 70 °C is too high to avoid black bleeding, even in the case of SBS compounds which have a satisfactory performance record.

Wet base (WB)

It is well known that ponding water on an OX bituminous membrane with organic felt reinforcement has a poor performance record. This test with the membrane on a wet base is an attempt to assess the ability of the roofing felt to resist moisture which has been taken up by the reinforcement.

The effect of ponding water as an agent accelerating the degeneration of the membrane could easily be added as an additional factor when evaluating the qualities of membranes intended for use on horizontal roofs.

Natural weathering

All the materials tested in the research program have been installed at the NBI outdoor experimental station at Tyholt, Trondheim.

Exposure started in the summer of 1986 and should last for at least five years (1991) before any attempt is made to assess the aging progress. To save material, more sophisticated methods of testing the effect of aging should be used. For that purpose, reference material and surplus pieces of the aged material are stored in a dark room at low temperature.

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Roof coverings: Accelerated aging test

1. SCOPE

This method has been specially designed to study the influence of the outdoor climate on the performance of materials and components used in flat roofs.

2. FIELD OF APPLICATION

The test method is basically an accelerated aging test for the roof covering alone lying on a neutral metal grid base sloping 1:50.

The test apparatus and test cycle used are always the same, but the duration of the test, the exposure used, and the design of test samples may vary.

3. REFERENCES

4. DEFINITIONS

The resistance of building materials and components to weathering has to be described in different ways according to the types of materials and components and their intended functions in the exterior envelope. Usually it is described as the changes or lack of changes occurring during exposure. Possible changes may be fissures, cracks or other types of visual damage, loss of gloss or colour, changes in weight, dimensions and physical properties, etc.

5. SAMPLING

Unless otherwise agreed upon, the manufacaturers of the mateirals or components have to supply the quantities necessary for the tests, together with a sufficiently detailed description of the products and their intended use. The samples must be sufficiently large to be representative for the products.

6. TEST METHOD

6.1 Principle

The samples to be tested are mounted in a special apparatus for accelerated weather resistance testing and exposed to an artificial weathering cycle for an agreed period of time. The weather resistance is found from the detectable changes in the visual characteristics and measurable properties.

6.2 Apparatus

The roof testing apparatus consists of three main parts, as shown in Fig. 1 and 2.

A) An upper box to simulate outdoor climatic effects

- IR heating with lamps positioned 0.4 m from the surface of the test specimen
- Convective heating from air heating elements
- Cooling with an ordinary air cooler
- UV light from tubes supplying radiation in the range of 2800-3500 Å (UV-B)
- Water spray from nozzles, and drainage at the lower end of the metal plate covered test rack assembly.

B) A test rack assembly on the lower box, which forms a watertight, insulated division between the two boxes. The test racks are mounted directly on the metal clad base which has a slope to water outlet of about 1:50.

C) A lower box to support and transport the test specimen. Temperature and humidity can be controlled if necessary.

The accelerated aging test is based on a 24-hour cycle during which the climatic strain factors are programmed and controlled automatically as follows:

- the temperataure curve shown in Fig. 3 is measured as black panel temperature at test specimen level. 333 K (+ 60 °C) is the temperature maintained most of the time, interrupted by three water sprays and one cooling phase to 263 K (- 10 °C) every cycle
- water spray for about 15 minutes three times every cycle with water temperature of about 283 K (+ 10 °C)
- UV light is engaged continuously, except during the 4 hrs. cooling phase.

The size of the test specimens is normally 450 mm x450 mm or 450 mm x 900 mm, but other sizes can be tested up to a maximum of about 2.4 m x 2.4 m.

In addition to the special apparatus for accelerated weathering it is necessary to have other types of equipment to investigate properties of materials and components being tested. These depend upon what is being tested and which properties are of interest.

6.3 Preparation of test samples

Preformed sheet-applied roofing materials are placed directly on the test rack shown in Photo 1. The edges are covered on three sides with a metal frame (Photo 2). The test specimen is conditioned at 296 K (23 ± 2 °C) and 50 % RH, and data such as weight, dimensions and appearance are recorded.

Liquid-applied membranes are prepared with a base material depending on their intended use, and allowed a minimum curing time before testing. Other materials are prepared as agreed.

6.4 Procedure

The test specimens are mounted in the test rack assembly as shown on Photo 3. The exposure time will depend upon the type of material or component to be tested. The time is recorded in days with recommended testing periods of 56, 112 or 168 days (8, 16 or 24 weeks).

The test specimens are inspected at regular intervals, and observations and measurements are carried out according to the programme.

6.5 Recording of results

Any visual or measurable changes resulting from the test are recorded. The changes may be recorded by visual observations, such as loss of gloss, colour changes, sweating and sagging, or by measuring of changes in weight, dimensions and physical properties.

6.6 Accuracy

All kinds of accelerated aging tests involve a certain degree of uncertainty. The results must therefore be considered in relation to relatively broad limits. Judgements based on long experience is an important factor when results are being analysed and actual field performance is being predicted.

6.7 Test report

The test report should, as far as possible, include the following information:

a) Name and address of the testing laboratory

b) Name and address of the person or organisation commissioning the test

c) Purpose of the test

d) Date and identification number of the report

e) Date of supply of the materials or components

f) Name and address of the manufacturer or supplier of the materials or components tested

g) Name or other identification marks of the materials or components tested

h) Designation of the materials or components according to criteria expressed in official standards or regulations

i) Description of the materials or components

j) Properties of the materials, such as performance data, model descriptions etc., should be given

k) Description of the test situation

l) Date of test

m) Test method

n) Deviations of test method, if any

o) Test results.

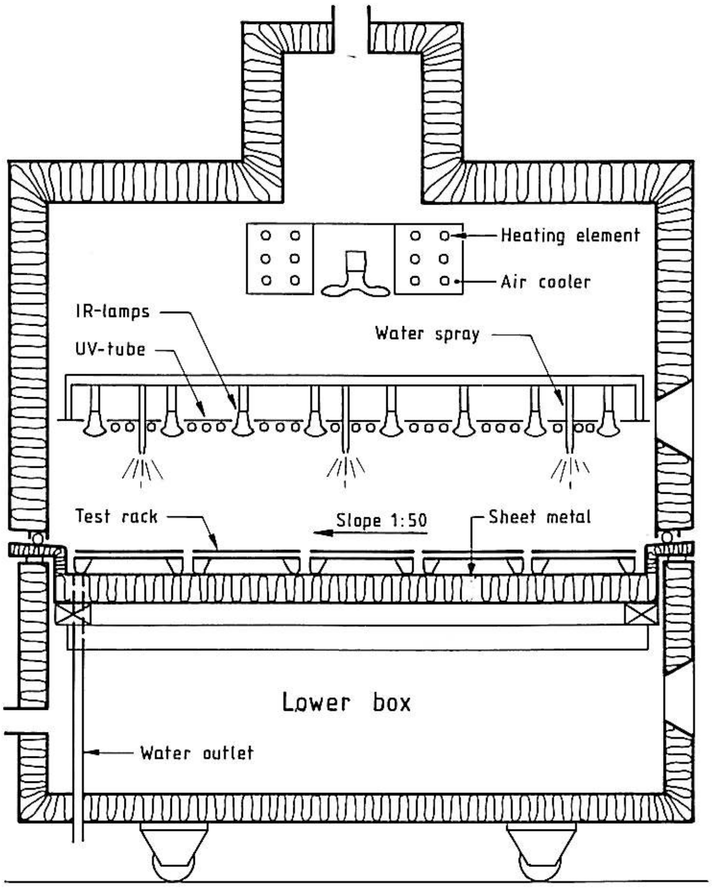

Fig. 1

Section of roof testing apparatus

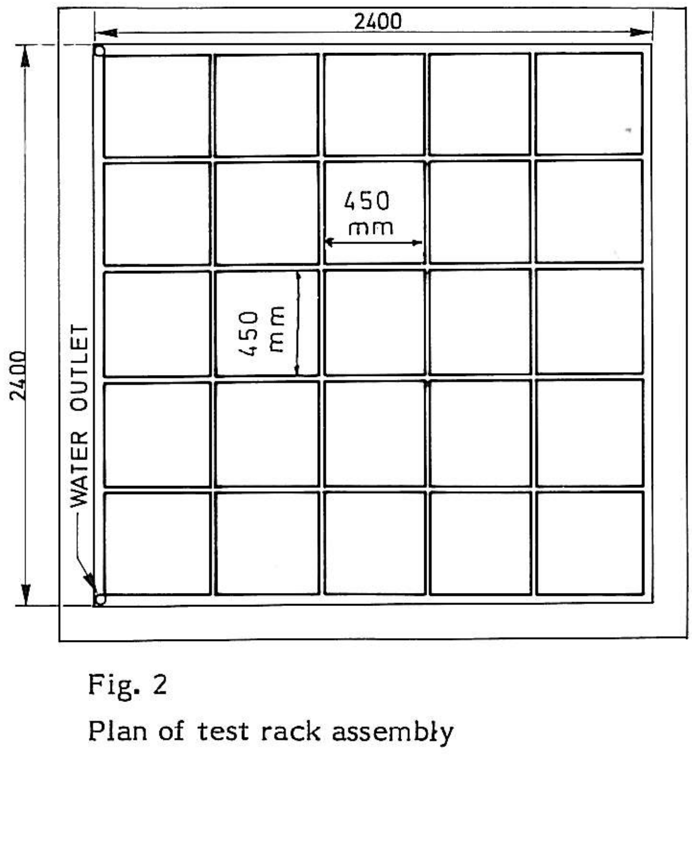

Fig. 2

Plan of test rack assembly

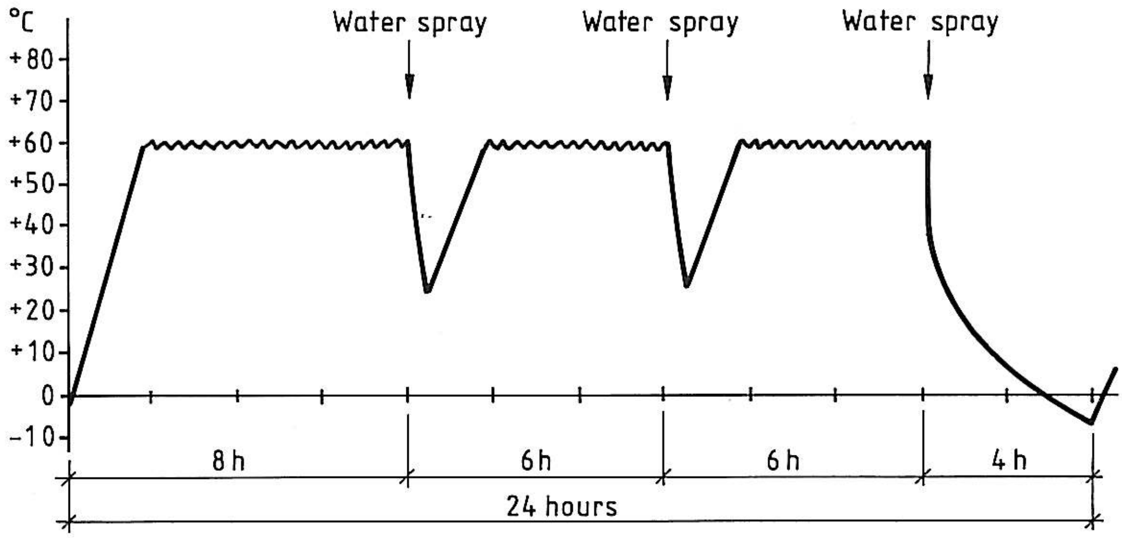

Fig. 3

Temperature (black panel) at test speciment level during one test cycle of 24 hours

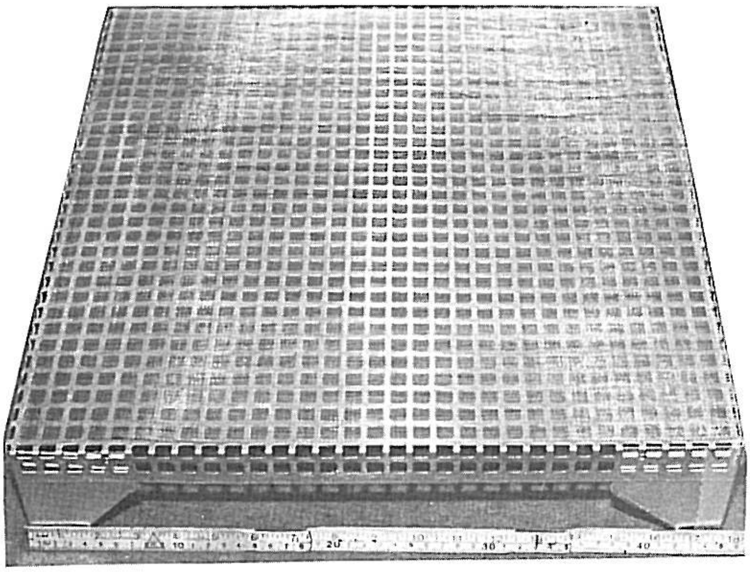

Photo 1

Test rack of perforated metal plates with wire mesh on top

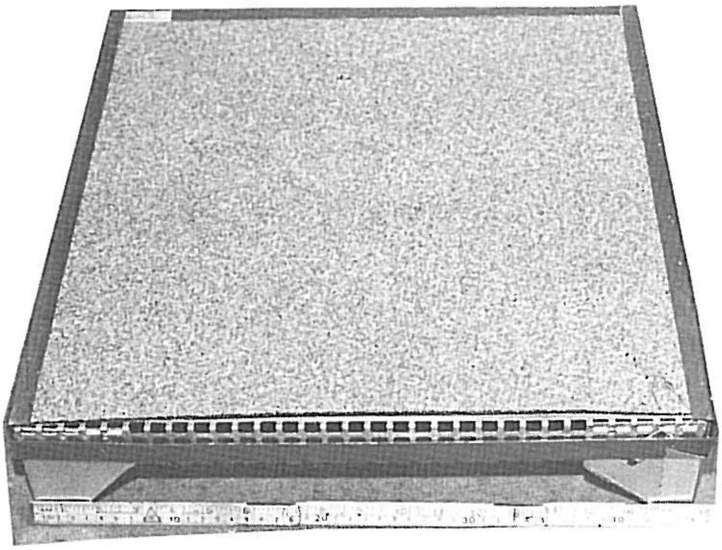

Photo 2

Membrane laid on test rack with metal frame to cover the edges on three sides

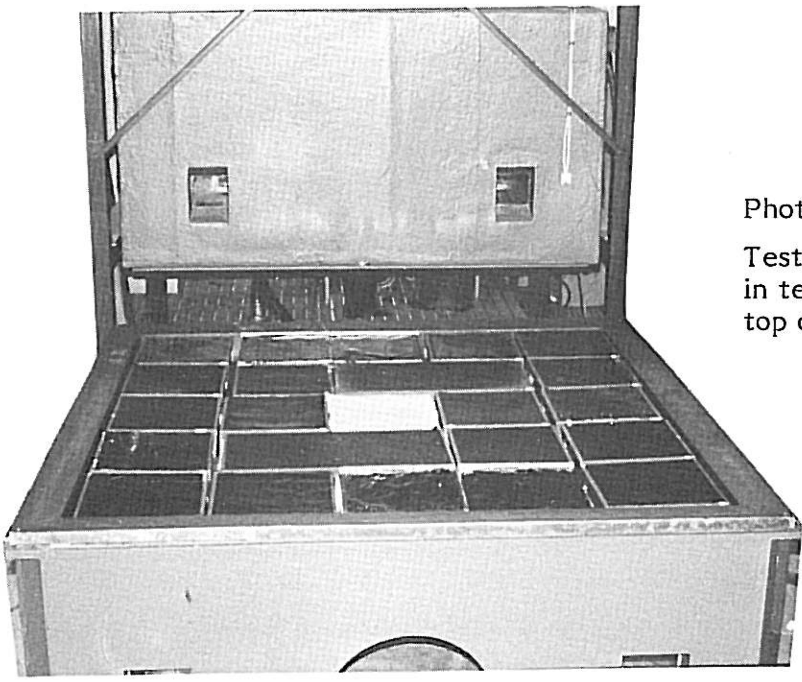

Photo 3

Test specimens mounted in test rack assembly on top of lower box