

## FIRE TEST OF BUILDING ELEMENTS

According to EN 13381-3

## ASSESSMENT REPORT 08 - U - 090

Reference test reports :

**08 - U - 090**

**08 - U - 086**

**08 - F - 103**

**08 - U - 071**

**08 - U - 082**

Scope

**Sprayed product MONOKOTE MK6-HY on concrete structures**

**Applied thicknesses : 10 to 55 mm**

Sponsor :

**GRACE PRODUITS DE CONSTRUCTION SAS**

**1001, RUE MAISON NEUVE**

**F - 71580 SAILLENARD**

*This assessment report consists 76 pages. Only a full copy of this assessment report permits a normal utilization of the results.*

## 1. SCOPE OF THIS TEST REPORT

Determination, according to the characterization methodology of protective materials as indicated by the european standard EN 13381-3 "TEST METHOD FOR DETERMINING THE CONTRIBUTION TO THE FIRE RESISTANCE OF STRUCTURAL MEMBERS : BY APPLIED PROTECTION TO CONCRETE MEMBERS", of the temperatures inside concrete structures exposed to the conventional fire in function of the type of structures, the depth inside the concrete, the thickness of protective material and the duration of the exposure.

## 2. TEST LABORATORY

Name : EFECTIS France  
Address : EFECTIS France  
Voie Romaine  
F - 57280 MAIZIERES-lès-METZ

## 3. SPONSOR OF THE FIRE TEST

Name : GRACE PRODUITS DE CONSTRUCTION SAS  
Address : 1001, rue MAISON NEUVE  
F - 71580 SAILLENARD

## 4. REFERENCE FIRE TEST REPORTS

Reference fire tests reports : 08-U-090 / 08-U-086 / 08-U-071 / 08-U-082 / 08-F-103

Date of tests : February and March, 2008

## 5. REFERENCE AND MANUFACTURER OF PROTECTIVE MATERIAL

References : MONOKOTE MK6-HY  
Manufacturer : GRACE  
DAMMAN (SAUDI ARABIA)

## 6. DESCRIPTION OF THE PROTECTIVE MATERIAL

### 6.1 GENERAL

The concrete structures are protected by a cementeous product sprayed directly on their apparent sides.

The protective material is sprayed on bare structures exclusively.

### 6.2 COMPONENTS LIST

Name	Trade reference	Characteristics	Supplier
Accelerator	MONOKOTE Accelerator	Aluminium sulphate	GRACE
Protective material	MONOKOTE MK6-HY	d = 258 ± 39 kg/m <sup>3</sup> th = 10 to 55 mm	GRACE
Bonding primer	FIREBOND		GRACE

*d = density / th = thickness*

### 6.3 APPLICATION OF THE PROTECTIVE MATERIAL

#### 6.3.1 Concrete members

MONOKOTE MK6-HY sprayed product can be applied directly on beams, slabs and walls exposed on one side only, in dense concrete.

#### 6.3.2 Preliminary surface preparation of concrete structures

No specific preliminary preparation of concrete structures to be protected by MONOKOTE MK6-HY is required.

However, they must be free of dust and bare.

The protective material MONOKOTE MK6-HY can be applied on concrete structures cast with one release agent applied in the mould and belonging to following families :

- Mineral oil type DEMOTEC 200 (TECHNIQUE BETON) or similar ;
- Emulsion type CHRYSO DEM AQUA 80 (CHRYSO) or similar.

#### 6.3.3 Application of protective material

MONOKOTE MK6-HY is intended to be applied directly on concrete structures.

However, the concrete structures can be eventually treated with bonding primer FIREBOND.

In this case, this one is applied with a roll and/or a brush on all parts to be protected with MONOKOTE MK6-HY spray material.

Then MONOKOTE MK6-HY spray material is applied some minutes after, once the bonding primer tacks.

It is applied with a spraying machine, in one layer for a goal thickness from 10 up to 25 mm and successive layers for a goal thickness between 25 and 55 mm with no stop/restart between each one.

During the application, the thickness of protective material is regularly controlled with a pin calibre.

Once the goal thickness is reached, a last finishing droplet spray can be applied.

MONOKOTE MK6-HY is sprayed by using accelerator referenced MONOKOTE Accelerator (Aluminium sulphate) diluted in potable water under the ratio of 1 bag (27.2 kg) / 10 US gallons (37.9 liters).

Each bag of MONOKOTE MK6-HY is mixed with potable water in the mixer tank of the spraying machine during 1 to 1 ½ minute.

The ratio between MONOKOTE MK6-HY and water is 1 bag (20.9 kg) / 23 to 32 liters.

Characteristics of the spray machine :

- Trade reference : S5
- Manufacturer : PUTZMEISTER.

### 6.3.4 Characteristics of the protective material MONOKOTE MK6-HY

#### 6.3.4.1 Average densities

- **Dry densities**

Type of application	Applied thickness (mm)	Average density (kg/m <sup>3</sup> )
Machine	11	266 ± 40
Machine	17	270 ± 40
Machine	42	237 ± 35
Machine	81	225 ± 34

#### 6.3.4.2 Average water content after drying at 105°C in a ventilated oven

Type of application	Applied thickness (mm)	Water content (% of dry weight)
Machine	11	18
Machine	17	18.2
Machine	42	18.4
Machine	81	

#### 6.3.4.3 Applicable thicknesses

Applicable thicknesses : 10 to 55 mm.

## 7. ASSESSMENT METHOD

The assessment method used to assess the protective material is the method described in paragraph 13 of standard EN 13381-3.

## 8. REFERENCE CONCRETE TEMPERATURES

### 8.1 CHARACTERISTIC TEMPERATURES OF SLABS

#### 8.1.1 Minimum thickness - Reference fire test 08-U-090

The experimental thickness taken into account for reference minimum thickness is 11 mm.

Time (min)	Characteristic temperatures (°C)							
	Interface	HA 10	Inside concrete					Upper side
			15 mm	30 mm	45 mm	60 mm	75 mm	
0	18	18	18	18	18	18	18	19
4	70	23	25	20	18	18	18	19
8	100	35	39	27	21	19	19	19
12	142	44	50	35	26	22	20	20
16	185	53	62	42	32	25	22	20
20	207	64	73	51	38	29	24	20
24	225	73	84	59	44	33	27	19
28	237	82	93	67	50	38	30	20
30	243	86	97	71	53	40	32	20
32	250	90	101	75	56	42	34	20
36	261	99	108	82	62	47	37	21
40	271	106	115	89	69	52	41	23
44	281	112	122	95	75	57	46	25
48	290	118	129	101	81	62	50	27
52	297	123	137	106	87	67	54	29
56	307	129	144	111	92	72	59	31
60	315	134	151	117	98	77	63	33
64	324	139	158	122	103	81	67	36
68	333	145	165	126	108	86	71	38
72	344	151	173	131	112	90	75	40
76	353	159	181	135	117	94	79	43
80	363	167	189	140	121	98	83	45
84	373	175	197	144	125	102	87	47
88	382	182	205	149	129	106	90	50
90	387	186	210	152	131	108	92	51
92	392	190	214	155	133	109	94	52
96	403	197	222	161	137	113	98	55
100	413	205	231	167	141	116	101	57
104	423	213	239	173	145	120	103	59
108	434	220	247	180	148	123	106	62
112	443	228	256	186	151	126	109	64
116	452	236	264	193	154	130	112	66

Time (min)	Characteristic temperatures (°C)							
	Interface	HA 10	Inside concrete					Upper side
			15 mm	30 mm	45 mm	60 mm	75 mm	
120	460	243	272	200	156	133	115	69
124	469	251	280	206	159	136	117	71
128	479	258	289	213	162	138	120	73
132	488	266	297	220	167	141	122	75
136	498	273	305	227	172	143	124	77
140	507	281	313	234	178	145	126	79
144	517	288	321	242	184	146	128	80
148	527	296	329	249	191	149	130	82
150	533	300	333	252	194	150	131	83
152	538	303	337	256	197	152	132	84
156	548	311	345	263	203	155	133	85
160	559	319	353	271	210	159	135	87
164	571	327	361	278	216	163	137	88
168	582	335	370	286	222	168	138	92
172	592	343	378	294	228	172	139	93
176	601	351	387	301	234	177	142	93
180	610	359	395	309	241	182	145	94
184	623	367	403	317	247	187	149	94
188	634	376	412	324	253	193	153	94
192	646	384	421	332	259	199	158	95
196	658	393	430	339	265	205	162	95
200	669	401	438	347	272	210	167	95
204	681	410	447	354	278	216	172	96
208	694	419	456	362	285	222	177	96
210	699	423	460	366	288	224	180	96
212	706	427	465	370	291	227	182	96
216	718	436	474	377	298	233	187	96
220	730	445	483	385	304	238	192	97
224	747	453	492	393	311	244	198	98
228	768	462	502	400	317	249	203	98
232	785	471	511	408	324	255	208	99
236	800	480	521	416	330	260	213	100
240	816	489	530	425	337	266	218	101
244	832	499	540	433	344	271	223	102
248	1085	508	550	441	351	277	229	103
252	857	517	560	449	357	283	234	105
256	863	526	570	457	364	288	239	106
260	874	536	580	465	371	294	245	108
264	886	546	590	474	378	300	250	109
268	823	556	601	482	385	306	255	112
270	829	561	606	486	388	309	258	113

See Annex I, plate 1.

### 8.1.2 Maximum thickness - Reference fire test 08-U-086

The experimental thickness taken into account for reference minimum thickness is 55 mm.

Time (min)	Characteristic temperatures (°C)							Upper side
	Interface	HA 10	Inside concrete					
			15 mm	30 mm	45 mm	60 mm	75 mm	
0	19	19	19	19	19	19	19	19
4	19	19	19	19	19	19	19	20
8	22	19	19	19	19	19	19	19
12	28	19	20	19	19	19	19	19
16	32	20	22	20	19	19	18	19
20	35	22	24	21	20	19	19	19
24	38	23	25	22	21	20	19	19
28	40	25	27	24	22	20	20	19
30	41	25	28	24	22	21	20	19
32	42	26	29	25	23	21	20	19
36	44	28	30	26	24	22	21	20
40	46	29	32	28	25	23	21	20
44	48	31	34	29	26	24	22	20
48	50	32	36	31	27	25	23	20
52	53	34	38	32	28	26	24	21
56	55	36	40	34	30	27	24	21
60	59	38	43	36	31	28	25	21
64	62	40	45	38	33	29	26	22
68	65	43	48	40	35	30	27	22
72	69	45	51	42	36	32	29	22
76	71	47	53	45	38	33	30	23
80	74	50	56	47	40	35	31	23
84	76	52	58	49	42	36	32	23
88	78	55	61	51	44	38	34	24
90	79	56	62	52	45	39	34	24
92	80	57	63	53	46	40	35	25
96	81	59	65	55	47	41	37	26
100	83	61	67	57	49	43	38	26
104	84	62	69	59	51	44	39	27
108	86	64	70	60	53	46	41	28
112	91	65	72	62	54	47	42	29
116	98	67	73	63	55	49	44	30
120	109	68	74	65	57	50	45	31
124	120	69	76	66	58	52	46	31
128	132	71	79	68	60	53	47	32
132	140	74	82	70	61	54	49	33
136	147	76	84	72	63	56	50	34
140	153	79	87	75	65	58	52	35
144	159	82	90	77	67	59	53	36
148	163	84	93	80	69	61	55	37
150	165	85	94	81	70	62	56	37
152	166	86	95	82	71	63	56	38
156	169	89	97	84	73	65	58	39

Time (min)	Characteristic temperatures (°C)							
	Interface	HA 10	Inside concrete					Upper side
			15 mm	30 mm	45 mm	60 mm	75 mm	
160	171	91	99	86	75	67	60	40
164	173	93	101	88	77	69	61	41
168	175	95	103	90	79	71	63	42
172	176	97	105	92	81	72	65	43
176	178	98	106	94	83	74	66	44
180	180	100	108	95	84	76	68	45
184	182	101	109	97	86	77	69	46
188	184	102	111	98	88	79	71	47
192	186	103	113	100	89	81	72	48
196	188	104	115	101	91	82	74	49
200	190	106	116	103	92	84	75	50
204	192	107	118	104	94	85	77	51
208	195	108	120	105	95	87	78	52
210	196	109	121	106	96	88	79	53
212	197	109	122	107	97	89	80	53
216	199	111	123	108	99	90	81	54
220	201	112	125	110	100	91	83	55
224	203	114	127	111	101	93	84	56
228	205	115	128	112	103	94	85	57
232	207	117	130	114	104	96	87	58
236	210	119	132	115	105	97	88	59
240	213	120	133	116	107	99	89	60
244	216	122	135	118	108	100	91	61
248	218	124	138	119	110	101	92	62
252	221	126	140	121	111	103	93	62
256	224	127	142	122	112	104	95	63
260	227	130	144	124	114	105	96	64
264	230	132	147	125	115	107	97	65
268	233	134	149	127	117	108	98	66
270	234	135	150	128	117	109	99	66
272	236	136	151	129	118	109	100	67
276	239	138	154	130	119	111	101	68
280	242	140	156	132	121	112	102	69
284	246	143	159	134	122	113	103	69
288	249	145	162	136	124	115	105	70
292	253	148	164	138	125	116	106	71
296	257	150	167	140	127	117	107	72
300	261	153	170	142	128	119	108	73
304	264	155	173	144	130	120	109	74
308	268	158	176	146	131	122	110	75
310	270	159	177	147	132	122	111	75
312	272	161	179	148	133	123	112	76
316	276	163	182	151	134	124	113	77
320	280	166	185	153	136	126	114	77
324	285	169	188	155	137	127	115	78
328	289	172	191	158	139	128	117	79

Time (min)	Characteristic temperatures (°C)							
	Interface	HA 10	Inside concrete					Upper side
			15 mm	30 mm	45 mm	60 mm	75 mm	
330	291	173	193	159	139	129	117	79
332	294	175	195	161	140	130	118	80
336	299	178	198	164	142	131	119	81
340	303	181	202	166	144	133	120	81
344	308	185	206	169	145	134	122	82
348	312	188	210	172	147	136	123	83
352	317	191	214	176	148	137	124	84
356	322	195	218	179	150	139	126	85
360	503	198	222	182	151	140	127	85

See Annex I, plate 2.

### 8.1.3 Intermediate thickness - Reference fire test 08-F-103

The experimental thickness taken into account for reference minimum thickness is 32 mm.

Time (min)	Characteristic temperatures (°C)						
	Interface	HA 8	Inside concrete				Upper side
			15 mm	30 mm	45 mm	60 mm	
0	19	19	19	19	19	19	19
4	21	19	19	19	19	19	19
8	31	20	23	20	20	19	19
12	36	23	26	22	21	20	19
16	41	26	30	25	22	21	19
20	46	29	34	27	24	22	20
24	52	32	38	30	26	23	21
28	59	36	42	33	28	25	22
32	65	40	47	37	30	27	23
36	70	45	51	40	33	29	24
40	74	49	56	44	36	32	26
44	78	53	60	47	40	34	28
48	82	56	63	51	43	37	30
52	88	60	66	54	46	40	32
56	95	63	70	57	48	43	35
60	101	67	74	60	51	45	37
64	108	71	79	64	54	48	40
68	114	75	84	68	58	51	42
72	119	80	88	72	61	54	45
76	124	84	92	75	65	57	47
80	128	88	96	79	68	60	50
84	133	91	99	83	71	63	53
88	137	94	102	86	75	66	56
92	142	97	105	89	78	69	58
96	146	100	108	93	81	72	61
100	151	103	112	96	84	75	64
104	155	106	115	99	88	78	66
108	159	108	118	102	92	81	69

Time (min)	Characteristic temperatures (°C)						Upper side
	Interface	HA 8	Inside concrete				
			15 mm	30 mm	45 mm	60 mm	
112	163	111	121	104	95	84	71
116	166	113	125	106	98	88	74
120	170	116	128	108	100	91	77
124	174	119	131	110	102	93	79
128	178	121	134	112	103	96	82
132	182	124	137	114	104	98	85
136	186	127	140	116	105	99	87
140	189	129	143	118	106	101	89
144	194	132	146	120	108	102	90
148	198	135	149	123	110	103	92
152	202	138	152	125	112	104	93
156	206	141	156	127	114	105	94
160	210	144	159	129	115	107	95
164	214	147	162	132	117	108	96
168	218	151	166	135	119	110	97
172	222	154	169	137	121	111	98
176	226	157	173	140	123	113	99
180	230	160	177	143	125	114	100
184	235	164	180	146	127	116	101
188	239	167	184	149	129	117	103
192	244	171	188	152	131	119	104
196	248	174	192	155	134	121	105
200	253	178	196	158	136	122	106
204	258	181	200	161	138	124	107
208	263	185	204	164	141	125	107
212	268	189	208	168	143	127	108
216	274	193	213	171	146	129	109
220	279	196	217	174	148	130	110
224	284	200	221	177	151	132	111
228	290	204	226	181	153	134	111
232	296	208	230	184	156	136	112
236	303	212	235	188	159	138	113
240	312	217	240	191	161	140	113
244	646	253	314	195	164	142	113
248	695	300	370	199	167	144	114
252	484	335	405	203	170	146	115
256	723	364	436	208	174	149	116
260	755	393	469	231	183	153	117

See Annex I, plate 3.

## 8.2 CHARACTERISTIC TEMPERATURES OF BEAMS

### 8.2.1 Minimum thickness - Reference fire test 08-U-071

The experimental thickness taken into account for reference minimum thickness is 10 mm.

#### 8.2.1.1 Along a vertical axis

Time (min)	Characteristic temperatures along a vertical axis (°C)				
	Interface	Stirrups Ø 8	Inside concrete		Upper side
			[75,75]	[75,150]	
0	12	12	12	12	13
2	51	12	12	12	13
4	60	17	12	12	13
6	67	22	12	12	13
8	83	28	12	12	13
10	101	35	14	13	13
12	119	41	16	15	14
14	144	47	18	16	15
16	159	54	21	19	15
18	171	61	25	21	17
20	183	68	28	24	18
22	192	75	32	27	20
24	199	82	37	30	22
26	206	89	41	33	23
28	213	92	46	36	25
30	219	97	50	40	28
32	226	101	56	44	30
34	233	105	63	47	32
36	239	108	73	51	35
38	245	112	83	55	37
40	251	116	93	59	40
42	256	120	100	63	42
44	259	125	106	66	44
46	263	129	110	70	47
48	267	134	112	74	50
50	271	139	114	79	52
52	277	144	116	84	55
54	282	149	117	90	57
56	288	155	118	98	60
58	294	161	119	101	63
60	302	167	120	104	65
62	309	174	120	106	68
64	316	180	121	109	71
66	322	187	121	112	74
68	329	194	122	115	77
70	336	201	122	118	80
72	343	208	123	120	83
74	350	215	124	123	85
76	357	222	127	124	88

Time (min)	Characteristic temperatures along a vertical axis (°C)				
	Interface	Stirrups Ø 8	Inside concrete		Upper side
			[75,75]	[75,150]	
78	365	229	130	125	91
80	372	236	134	126	95
82	379	242	137	127	98
84	386	249	140	128	99
86	393	256	144	129	100
88	399	262	147	129	101
90	407	269	150	130	102
92	414	276	154	131	103
94	421	282	157	132	104
96	428	289	161	133	105
98	435	296	165	135	107
100	442	302	168	137	108
102	449	309	172	139	109
104	458	315	176	141	110
106	466	322	180	143	111
108	473	329	185	145	113
110	481	336	189	147	114
112	491	343	193	150	116
114	499	350	198	152	117
116	507	359	202	155	119
118	515	375	207	157	121
120	524	393	212	160	123
122	531	409	217	162	125
124	540	423	222	165	127
126	707	436	229	168	129
128	740	449	235	170	131
130	913	461	242	174	132
132	830	473	249	177	134
134	834	485	256	181	136
136	838	496	263	186	138
138	843	506	270	190	140
140	651	515	277	195	141
142	590	519	284	200	140
144	552	514	292	206	140

See Annex I, plate 4.

8.2.1.2 Along an horizontal axis

Time (min)	Characteristic temperatures along an horizontal axis (°C)		
	Interface	Stirrups Ø 8	Inside concrete [75,150]
0	12	12	12
2	51	12	12
4	60	17	12
6	67	22	12
8	83	28	12
10	101	35	13
12	119	41	15
14	144	47	16
16	159	54	19
18	171	61	21
20	183	68	24
22	192	75	27
24	199	82	30
26	206	89	33
28	213	92	36
30	219	97	40
32	226	101	44
34	233	105	47
36	239	108	51
38	245	112	55
40	251	116	59
42	256	120	63
44	259	125	66
46	263	129	70
48	267	134	74
50	271	139	79
52	277	144	84
54	282	149	90
56	288	155	98
58	294	161	101
60	302	167	104
62	309	174	106
64	316	180	109
66	322	187	112
68	329	194	115
70	336	201	118
72	343	208	120
74	350	215	123
76	357	222	124
78	365	229	125
80	372	236	126
82	379	242	127
84	386	249	128
86	393	256	129
88	399	262	129

Time (min)	Characteristic temperatures along an horizontal axis (°C)		
	Interface	Stirrups Ø 8	Inside concrete [75,150]
90	407	269	130
92	414	276	131
94	421	282	132
96	428	289	133
98	435	296	135
100	442	302	137
102	449	309	139
104	458	315	141
106	466	322	143
108	473	329	145
110	481	336	147
112	491	343	150
114	499	350	152
116	507	359	155
118	515	375	157
120	524	393	160
122	531	409	162
124	540	423	165
126	707	436	168
128	740	449	170
130	913	461	174
132	830	473	177
134	834	485	181
136	838	496	186
138	843	506	190
140	651	515	195
142	590	519	200
144	552	514	206

See Annex I, plate 5.

8.2.1.3 Along a diagonal axis

Time (min)	Characteristic temperatures along a diagonal axis (°C)		
	HA 12	Inside concrete	
		[55,55]	[75,75]
0	12	12	12
2	12	12	12
4	14	12	12
6	20	13	12
8	27	15	12
10	34	18	14
12	41	22	16
14	48	26	18
16	56	31	21
18	64	35	25
20	72	40	28
22	80	46	32
24	89	51	37
26	96	57	41
28	101	63	46
30	105	70	50
32	109	77	56
34	113	84	63
36	118	91	73
38	122	97	83
40	128	101	93
42	133	106	100
44	139	109	106
46	145	112	110
48	151	115	112
50	158	118	114
52	165	120	116
54	172	121	117
56	179	122	118
58	186	124	119
60	194	126	120
62	201	129	120
64	209	131	121
66	216	135	121
68	224	138	122
70	231	141	122
72	239	145	123
74	246	150	124
76	254	154	127
78	262	159	130
80	269	164	134
82	277	169	137
84	284	175	140
86	292	180	144
88	299	186	147

Time (min)	Characteristic temperatures along a diagonal axis (°C)		
	HA 12	Inside concrete	
		[55,55]	[75,75]
90	306	191	150
92	314	197	154
94	321	202	157
96	329	208	161
98	336	214	165
100	343	220	168
102	351	226	172
104	358	232	176
106	365	238	180
108	372	244	185
110	380	251	189
112	387	257	193
114	394	263	198
116	402	269	202
118	410	275	207
120	420	281	212
122	430	287	217
124	440	294	222
126	451	300	229
128	461	306	235
130	471	313	242
132	482	320	249
134	493	327	256
136	504	334	263
138	515	342	270
140	525	350	277
142	536	358	284
144	543	366	292

See Annex I, plate 6.

## 8.2.2 Maximum thickness - Reference fire test 08-U-082

The experimental thickness taken into account for reference minimum thickness is 41 mm.

### 8.2.2.1 Along a vertical axis

Time (min)	Characteristic temperatures along a vertical axis (°C)				
	Interface	Stirrups Ø 8	Inside concrete		Upper side
			[75,75]	[75,150]	
0	20	20	19	20	20
4	21	20	19	20	20
8	32	20	19	19	20
12	37	23	19	19	20
16	41	25	20	20	20
20	44	28	21	21	20
24	47	31	23	22	20
28	51	35	24	23	21
30	53	37	25	24	22
32	56	38	27	24	22
36	61	43	29	26	23
40	66	47	32	28	24
44	71	52	35	31	26
48	75	57	38	33	28
52	78	61	42	36	29
56	82	65	46	39	31
60	92	69	50	42	33
64	103	73	53	45	35
68	114	77	57	48	38
72	129	82	60	52	40
76	139	87	64	55	43
80	145	91	68	57	45
84	149	94	72	60	48
88	152	97	76	63	51
90	154	99	78	65	52
92	155	100	80	67	54
96	158	103	85	70	56
100	161	107	89	73	59
104	164	110	93	76	62
108	167	114	98	80	64
112	171	117	101	83	67
116	175	121	103	86	70
120	179	125	105	89	72
124	182	129	107	93	75
128	186	134	108	97	78
132	190	139	110	101	80
136	195	144	112	103	83
140	200	149	114	105	85
144	206	154	117	106	88
148	212	159	119	108	90
150	215	162	121	109	91

Time (min)	Characteristic temperatures along a vertical axis (°C)				
	Interface	Stirrups Ø 8	Inside concrete		Upper side
			[75,75]	[75,150]	
152	218	164	122	110	92
156	225	170	126	112	94
160	232	176	129	114	95
164	239	181	132	116	97
168	246	187	135	118	98
172	253	193	139	120	98
176	260	199	142	122	99
180	267	206	146	124	100
184	274	212	149	127	100
188	280	218	152	129	101
192	287	224	156	132	101
196	294	231	159	134	101
200	301	237	162	137	102
204	308	244	166	139	102
208	315	250	169	142	103
210	319	254	171	143	104
212	322	257	173	144	104
216	330	264	177	147	105
220	337	270	182	149	107
224	344	277	187	152	109
228	352	284	192	154	112
232	359	291	197	156	115
236	366	298	202	158	118
240	373	305	208	160	120
244	380	312	213	162	122
248	388	319	219	164	124
252	397	327	225	167	125
256	405	335	232	169	127
260	414	343	239	173	129
264	424	351	246	176	131
268	434	359	253	180	132
270	439	364	257	183	133
272	444	368	261	185	134
276	455	378	268	190	136
280	465	387	276	195	138
284	475	397	284	200	140
288	485	408	291	206	141
292	496	428	299	211	143
296	507	449	306	217	145
300	519	469	314	223	147
304	528	487	322	230	150
308	545	504	330	236	152
312	561	519	337	243	155
316	579	533	345	249	157
320	827	549	354	256	160
324	655	530	362	262	159

See Annex I, plate 7.

8.2.2.2 Along an horizontal axis

Time (min)	Characteristic temperatures along an horizontal axis (°C)		
	Interface	Stirrups Ø 8	Inside concrete [75,150]
0	20	20	20
4	21	20	20
8	32	20	19
12	37	23	19
16	41	25	20
20	44	28	21
24	47	31	22
28	51	35	23
30	53	37	24
32	56	38	24
36	61	43	26
40	66	47	28
44	71	52	31
48	75	57	33
52	78	61	36
56	82	65	39
60	92	69	42
64	103	73	45
68	114	77	48
72	129	82	52
76	139	87	55
80	145	91	57
84	149	94	60
88	152	97	63
90	154	99	65
92	155	100	67
96	158	103	70
100	161	107	73
104	164	110	76
108	167	114	80
112	171	117	83
116	175	121	86
120	179	125	89
124	182	129	93
128	186	134	97
132	190	139	101
136	195	144	103
140	200	149	105
144	206	154	106
148	212	159	108
150	215	162	109
152	218	164	110
156	225	170	112
160	232	176	114
164	239	181	116

Time (min)	Characteristic temperatures along an horizontal axis (°C)		
	Interface	Stirrups Ø 8	Inside concrete [75,150]
168	246	187	118
172	253	193	120
176	260	199	122
180	267	206	124
184	274	212	127
188	280	218	129
192	287	224	132
196	294	231	134
200	301	237	137
204	308	244	139
208	315	250	142
210	319	254	143
212	322	257	144
216	330	264	147
220	337	270	149
224	344	277	152
228	352	284	154
232	359	291	156
236	366	298	158
240	373	305	160
244	380	312	162
248	388	319	164
252	397	327	167
256	405	335	169
260	414	343	173
264	424	351	176
268	434	359	180
270	439	364	183
272	444	368	185
276	455	378	190
280	465	387	195
284	475	397	200
288	485	408	206
292	496	428	211
296	507	449	217
300	519	469	223
304	528	487	230
308	545	504	236
312	561	519	243
316	579	533	249
320	827	549	256
324	655	530	262

See Annex I, plate 8.

8.2.2.3 Along a diagonal axis

Time (min)	Characteristic temperatures along a diagonal axis (°C)		
	HA 12	Inside concrete	
		[55,55]	[75,75]
0	20	20	19
4	20	20	19
8	20	20	19
12	23	20	19
16	26	21	20
20	30	23	21
24	33	26	23
28	37	28	24
30	39	29	25
32	41	31	27
36	45	34	29
40	50	38	32
44	55	41	35
48	60	46	38
52	64	50	42
56	69	54	46
60	73	58	50
64	78	61	53
68	84	65	57
72	90	69	60
76	95	74	64
80	99	78	68
84	103	83	72
88	106	87	76
90	108	90	78
92	110	92	80
96	113	96	85
100	116	99	89
104	120	103	93
108	123	106	98
112	127	108	101
116	131	109	103
120	136	112	105
124	141	114	107
128	146	117	108
132	152	120	110
136	157	123	112
140	163	126	114
144	168	130	117
148	174	133	119
150	178	134	121
152	181	136	122
156	187	140	126
160	193	144	129
164	200	148	132

Time (min)	Characteristic temperatures along a diagonal axis (°C)		
	HA 12	Inside concrete	
		[55,55]	[75,75]
168	206	152	135
172	213	156	139
176	220	161	142
180	227	165	146
184	234	170	149
188	241	175	152
192	248	180	156
196	255	185	159
200	263	190	162
204	270	196	166
208	278	202	169
210	281	205	171
212	285	208	173
216	293	214	177
220	300	220	182
224	308	227	187
228	316	233	192
232	324	239	197
236	332	246	202
240	340	252	208
244	348	259	213
248	356	265	219
252	364	272	225
256	373	279	232
260	382	287	239
264	391	294	246
268	400	302	253
270	404	306	257
272	409	309	261
276	418	317	268
280	428	325	276
284	437	333	284
288	447	342	291
292	457	350	299
296	468	358	306
300	479	366	314
304	493	375	322
308	507	383	330
312	521	392	337
316	535	401	345
320	550	410	354
324	566	420	362

See Annex I, plate 9.

## 9. ASSESSMENT RESULTS

### 9.1 SLABS

The insulation efficiency of the protective material when applied on slabs is determined in function of :

- the thickness of protective material applied (mm) ;
- the standard concrete temperature comprised between [300,650] (°C) ;
- the duration of the thermal exposure under the conventional thermal program.

#### 9.1.1 Minimum thickness (11 mm) - Reference fire test 08-U-090

Depth (mm)	Temperatures inside concrete (°C)								
	Duration of exposure under conventional thermal program								
	30 min	60 min	90 min	120 min	150 min	180 min	210 min	240 min	270 min
0	243	315	387	460	533	610	699	816	829
15	97	151	210	272	333	395	460	530	606
30	71	117	152	200	252	309	366	425	486
45	53	98	131	156	194	241	288	337	388
60	40	77	108	133	150	182	224	266	309
75	32	63	92	115	131	145	180	218	258
120	20	33	51	69	83	94	96	101	113

See Annex I, plate 10.

#### 9.1.2 Maximum thickness (55 mm) - Reference fire test 08-U-086

Depth (mm)	Temperatures inside concrete (°C)											
	Duration of exposure under conventional thermal program											
	30 min	60 min	90 min	120 min	150 min	180 min	210 min	240 min	270 min	300 min	330 min	360 min
0	41	59	79	109	165	180	196	213	234	261	291	503
15	28	43	62	74	94	108	121	133	150	170	193	222
30	24	36	52	65	81	95	106	116	128	142	159	182
45	22	31	45	57	70	84	96	107	117	128	139	151
60	21	28	39	50	62	76	88	99	109	119	129	140
75	20	25	34	45	56	68	79	89	99	108	117	127
120	19	21	24	31	37	45	53	60	66	73	79	85

See Annex I, plate 11.

### 9.1.3 Intermediate thickness (32 mm) - Reference fire test 08-F-103

Depth (mm)	Temperatures inside concrete (°C)							
	Duration of exposure under conventional thermal program							
	30 min	60 min	90 min	120 min	150 min	180 min	210 min	240 min
0	62	101	139	170	200	230	266	312
15	44	74	104	128	151	177	206	240
30	35	60	88	108	124	143	166	191
45	29	51	76	100	111	125	142	161
60	26	45	68	91	103	114	126	140
90	22	37	57	77	92	100	108	113

See Annex I, plate 12.

### 9.1.4 Standard temperatures inside concrete at standard durations under conventional thermal program

Standard temperature inside concrete (°C)	Thickness of MONOKOTE MK6-HY (mm)	Depth inside a concrete slab (mm)											
		Duration of exposure under the conventional thermal program (min)											
		30	60	90	120	150	180	210	240	270	300	330	360
300	11	0,0	1,4	7,4	12,8	21,1	32,0	42,7	52,8	62,6			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,5				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	10,8
350	11	0,0	0,0	3,1	8,8	13,7	22,8	33,1	42,8	52,2			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,2
400	11	0,0	0,0	0,0	4,8	10,0	14,7	24,6	34,3	43,2			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,5
450	11	0,0	0,0	0,0	0,8	6,2	11,2	16,6	26,4	35,5			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8
500	11	0,0	0,0	0,0	0,0	2,5	7,7	12,5	19,3	28,3			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2
550	11	0,0	0,0	0,0	0,0	0,0	4,2	9,4	14,0	22,0			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
600	11	0,0	0,0	0,0	0,0	0,0	0,7	6,2	11,3	15,8			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
650	11	0,0	0,0	0,0	0,0	0,0	0,0	3,1	8,7	12,0			
	32	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0				
	55	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

See Annex I, plates 13 to 20.

## 9.2 BEAMS

The insulation efficiency of the protective material when applied on beams is determined in function of :

- the thickness of protective material applied (mm) ;
- the standard concrete temperature comprised between [300,650] (°C) ;
- along a vertical, horizontal and diagonal axis ;
- the duration of the thermal exposure under the conventional thermal program.

### 9.2.1 Minimum thickness (10 mm) - Reference fire test 08-U-071

#### 9.2.1.1 Along a vertical axis

Depth (mm)	Temperatures inside concrete along vertical axis (°C)			
	Duration of exposure under conventional thermal program			
	30 min	60 min	90 min	120 min
0	219	302	407	524
17	97	167	269	393
75	50	120	150	212
150	40	104	130	160
450	28	65	102	123

See Annex I, plate 21.

#### 9.2.1.2 Along an horizontal axis

Depth (mm)	Temperatures inside concrete along horizontal axis (°C)			
	Duration of exposure under conventional thermal program			
	30 min	60 min	90 min	120 min
0	219	302	407	524
17	97	167	269	393
75	40	104	130	160

See Annex I, plate 22.

#### 9.2.1.3 Along a diagonal axis

Depth (mm)	Temperatures inside concrete along diagonal axis (°C)			
	Duration of exposure under conventional thermal program			
	30 min	60 min	90 min	120 min
44	105	194	306	420
78	70	126	191	281
106	50	120	150	212

See Annex I, plate 23.

## 9.2.2 Maximum thickness (41 mm) - Reference fire test 08-U-082

### 9.2.2.1 Along a vertical axis

Depth (mm)	Temperatures inside concrete along vertical axis (°C)									
	Duration of exposure under conventional thermal program									
	30 min	60 min	90 min	120 min	150 min	180 min	210 min	240 min	270 min	300 min
0	53	92	154	179	215	267	319	373	439	519
17	37	69	99	125	162	206	254	305	364	469
75	25	50	78	105	121	146	171	208	257	314
150	24	42	65	89	109	124	143	160	183	223
450	22	33	52	72	91	100	104	120	133	147

See Annex I, plate 24.

### 9.2.2.2 Along an horizontal axis

Depth (mm)	Temperatures inside concrete along horizontal axis (°C)									
	Duration of exposure under conventional thermal program									
	30 min	60 min	90 min	120 min	150 min	180 min	210 min	240 min	270 min	300 min
0	53	92	154	179	215	267	319	373	439	519
17	37	69	99	125	162	206	254	305	364	469
75	24	42	65	89	109	124	143	160	183	223

See Annex I, plate 25.

### 9.2.2.3 Along a diagonal axis

Depth (mm)	Temperatures inside concrete along diagonal axis (°C)									
	Duration of exposure under conventional thermal program									
	30 min	60 min	90 min	120 min	150 min	180 min	210 min	240 min	270 min	300 min
44	39	73	108	136	178	227	281	340	404	479
78	29	58	90	112	134	165	205	252	306	366
106	25	50	78	105	121	146	171	208	257	314

See Annex I, plate 26.

### 9.2.3 Standard temperatures inside concrete at standard durations under conventional thermal program

#### 9.2.3.1 Along a vertical axis

Standard temperature inside concrete (°C)	Thickness of MONOKOTE MK6-HY (mm)	Depth inside a concrete beam along a vertical axis (mm)									
		Duration of exposure under the conventional thermal program (min)									
		30	60	90	120	150	180	210	240	270	300
300	10	0,0	0,3	13,2	46,8						
	41	0,0	0,0	0,0	0,0	0,0	0,0	5,0	20,0	51,7	86,5
350	10	0,0	0,0	7,0	30,8						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,8	24,6	61,5
400	10	0,0	0,0	0,9	16,1						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,8	42,8
450	10	0,0	0,0	0,0	9,6						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	24,1
500	10	0,0	0,0	0,0	3,1						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	6,5
550	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
600	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
650	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

See Annex I, plates 27 to 31.

9.2.3.2 Along an horizontal axis

Standard temperature inside concrete (°C)	Thickness of MONOKOTE MK6-HY (mm)	Depth inside a concrete beam along an horizontal axis (mm)									
		Duration of exposure under the conventional thermal program (min)									
		30	60	90	120	150	180	210	240	270	300
300	10	0,0	0,3	13,2	40,2						
	41	0,0	0,0	0,0	0,0	0,0	0,0	5,0	19,0	37,5	56,8
350	10	0,0	0,0	7,0	27,7						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,8	21,5	45,1
400	10	0,0	0,0	0,9	16,1						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,8	33,3
450	10	0,0	0,0	0,0	9,6						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	21,5
500	10	0,0	0,0	0,0	3,1						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	6,5
550	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
600	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
650	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

See Annex I, plates 32 to 36.

9.2.3.3 Along a diagonal axis

Standard temperature inside concrete (°C)	Thickness of MONOKOTE MK6-HY (mm)	Depth inside a concrete beam along a diagonal axis (mm)									
		Duration of exposure under the conventional thermal program (min)									
		30	60	90	120	150	180	210	240	270	300
300	10	0,0	0,0	45,8	73,4						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	59,5	81,4	
350	10	0,0	0,0	0,0	61,1						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	62,7	86,6
400	10	0,0	0,0	0,0	48,9						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	45,4	67,8
450	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	52,7
500	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
550	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
600	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
650	10	0,0	0,0	0,0	0,0						
	41	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

See Annex I, plates 37 to 40.

### 9.3 STICKABILITY

The stickability of protective material MONOKOTE MK6-HY has been determined according to requirements of paragraph 13.5. of standard EN 13381-3, in function of :

- the thickness of protective material applied (mm) ;
- the concrete structure, beam or slab ;
- the type of release agent used to cast the concrete.

Type of concrete structure	Type of release agent	Thickness of MONOKOTE MK6-HY (mm)	Maximum interface temperature (°C)
Slab	Mineral oil	11	987
	Emulsion	11	882
	Mineral oil	55	321
	Emulsion	55	344
Beam	Mineral oil	10	576
	Emulsion	10	579
	Mineral oil	41	598
	Emulsion	41	771

### 9.4 EQUIVALENT THICKNESSES OF CONCRETE

The equivalent thicknesses of concrete induced by the protective material MONOKOTE MK6-HY has been determined according to requirements of Annex C of standard EN 13381-3 and according to requirements of Annex A of document NF EN 1992-1-2 : « Eurocode 2 : Design of concrete structures – Part 1-2 : General rules – Structural fire design» - October 2005.

Type of concrete structures	Thickness of MONOKOTE MK6-HY (mm)	Equivalent thickness of concrete (mm)					
		30 min	60 min	90 min	120 min	180 min	240 min
Slab	11	44	54	57	58	53	*
	32	85	85	>85	>85	>85	>85
	55	>85	>85	>85	>85	>85	>85
Beam	10	20	38	44	39	*	*
	41	25	82	81	99	109	98

See Annex I, plates 41 to 46.

## 10. CONDITIONS of ASSESSMENT RESULTS VALIDITY

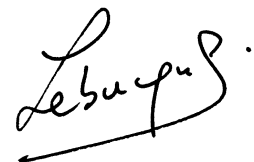
The results of the assessment are valid only according to the following conditions :

- ◆ Protective material MONOKOTE MK6-HY composition and application conditions identical as those noted during reference fire tests ;
- ◆ Density of protective material MONOKOTE MK6-HY included in [219,297] (kg/m<sup>3</sup>) range ;
- ◆ Applied thicknesses of protective material MONOKOTE MK6-HY included in [10, 55] (mm) range ;
- ◆ Protective material MONOKOTE MK6-HY applied on bare concrete structures cast with following release agents :
  - Mineral oil ;
  - Emulsion.
- ◆ Protective material MONOKOTE MK6-HY can be applied on bare concrete structures preliminary treated with bonding primer FIREBOND;
- ◆ Protective material MONOKOTE MK6-HY applied on :
  - Slabs ;
  - Beams ;
  - Walls exposed on one side only.
- ◆ Density of concrete equal to 2330 kg/m<sup>3</sup> ± 15%;
- ◆ Thickness of slabs or walls greater or equal to 120 mm ;
- ◆ Width of beams greater or equal to 150 mm ;
- ◆ Maximum duration of the exposure to the conventional thermal program as prescribed by EN 1363-1 equal to 5 hours at maximum for application on beams and to 6 hours for application on walls or slabs, depending on the type of concrete structures and the thickness of MONOKOTE MK6-HY applied.

Written at Maizières-lès-Metz, January, 29<sup>th</sup> 2007



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