

NEW RESEARCH, TESTS AND EXPERIENCE CONCERNING THE FIRE RESISTANCE OF BITUMINOUS ROOFING SYSTEMS IN THE FEDERAL REPUBLIC OF GERMANY

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The majority of flat roofs in West Germany are covered with two or three layers of bituminous roofing. Recent research has shown that about 80 percent of all flat roofing has been waterproofed this way.

During the summer of 1984 in West Germany much severe damage was caused to rigid, fire-resistant roof coverings such as tiles, asbestos, cement, slates, and metal cladding as well as to thin synthetic and plastic roofing sheet by a series of hail storms. Clearly the superiority of multilayered bitumen waterproofing was confirmed anew by withstanding weather of this type which can cause perforations. (Figures 1 and 2.)

As a result, a modified bitumen capsheet is being used more and more in West Germany. Ninety percent of elastomeric bitumen roofing is SBS modified. The change to this type of roofing sheet, which has taken place primarily for reasons of long-term durability, has additional positive advantages:

- the trend in energy saving has increased the thickness of insulation materials from 40 to 45mm to 120mm as per German Federal law and its supplement of January 1, 1984 (Wärmeschutzverordnung);
- roof areas are increasing in size. Shopping centers, large warehouses and exhibition halls often have roof areas of 20,000 to 40,000 square meters;
- the substructure which used to be heavy concrete has changed. Almost 10 million square meters per year now is steel deck. This produces higher stresses on the roof waterproofing layer.

Fire resistance is always a point of discussion with regard to steel deck roofs. It is recognized that after a fire, this type of construction offers significant advantages from the point of view of demolition and reconstruction. First and foremost, the fire resistance of the structure during the beginning and middle phases of a fire is crucial. Therefore, it is important to find the optimum balance between a satisfactory roofing system on one hand and sufficient fire resistance on the other.

DIN 4102, part 7, is the West German standard which sets the requirements of roof waterproofing and covers all materials which are laid in a bearing structure, including insulation and waterproofing products. Both are subject to the requirements of "hard" roofing which is tested with a fire basket for fire penetration and flame spread.

Roofs with bitumen felt pass this test regardless of the type of insulation used. All insulation materials of minimum B 2 (normal inflammable) are allowed.

Fire protection for buildings of a particular type and use

always is a point of discussion, especially buildings in which many people live, work or are gathered, such as shopping centers, assembly halls and hotels, should need higher fire standards.

About 65 percent of West German roofs are insulated with expanded polystyrene (EPS). This is not only for its advantages in relation to cost and efficiency, but also for its physical properties, such as very low moisture absorption, dimensional stability and suitability for structures providing flexibility and penetration resistance in inclement weather. Tests of the IFBS (Institut zur Förderung des Bauens mit Bauelementen aus Stahlblech e.V., Düsseldorf) make evident that mineral wool absorbs 760 grams of moisture whereas EPS absorbs only 263 grams. Moreover, laminated to other materials it offers simple and easy application. However, at high temperatures this material sinters and is regarded very critically in the test by NRW authorities reported here.

PRELIMINARY FIRE TESTS

A. W. Andernach KG first carried out investigations concerning insulation material with bituminous waterproofing laid on steel decks at the Institute Staatliche Brandverhütungstelle in Linz, Austria in 1972. These fire tests of laminated EPS insulation material on steel deck were comparative trials between EPS insulation and non-flammable mineral insulation. The tests showed that the time factor is critical. In the first phase of burning, sintering EPS performs considerably better. In the middle phase a non-sintering insulation material is better. In the final phase no difference could be established.

Tables 3 and 4 show the differences in temperature in the steel deck during the test.

On the basis of this knowledge, the IVH Association e.V., Heidelberg carried out fire tests in 1978 on roof structures and inner wall cladding to see how fires develop. For all intents and purposes the results were an extension of the knowledge obtained from the Austrian trials, but based on more detailed test programs carried out on special test structures.

Based on this knowledge the Federal NRW carried out official fire tests to examine the time factor more closely and to examine how minor changes in building technique might achieve a higher fire resistance.

The results confirmed that definite improvements could be made by better riveting and by cementing the flanges with perlite over fire walls.

The determination of the time factor shows that in ap-

proximately the first 15 minutes a sintering thermoplastic insulation material has clear advantages. After a short time the sintering effect reduces thermal stress considerably. This means that with steel deck construction, and a test temperature of 800 to 1,000 degrees C in the burning room underneath the deck, the temperature is reduced by 250 degrees C. This effectively counteracts opening up of the steel deck.

From the 15th to the 25th minute the non-sintering material is better as long as the structure has not yet opened. Then the temperature of the steel deck becomes so high as a result of direct heat on the roofing sheet that the self-igniting temperature of bitumen can be reached.

In the final phase of the burning, which with light structures usually occurs after 25 minutes, the steel deck will be failing and splitting open. It then is immaterial whether the insulation is fire resistant or not, as the whole surface area will be on fire.

Examples of such fires are those at General Motors in Livonia, Mich., Ford in Cologne and Elektrolux in Maristad, Sweden.

The tests have further shown that if a vapor barrier is installed it superimposes the burning process and whether or not the insulation is fire resistant is not important. Vapor barriers combined with thicker insulation material are being installed increasingly in West Germany. There also is a distinct trend towards partially or fully air conditioned buildings.

The result of the large scale NRW fire tests showed that it was essential to proceed with the development of a vapor barrier with the least fire risk and one having technical fire protection components which prevent burning through for as long as possible while the structure still stands. In addition, the vapor barrier must have satisfactory physical properties, such as corrosion resistance and mechanical strength to resist damage while being laid on the steel deck.

The object of a fire protection vapor barrier is to stay in position during the middle phase of a fire. Therefore, it must:

- prevent the burning through to the insulation above it;
- avoid burning drops falling inside of the building and;
- avoid, as far as possible, the formation of smoke inside the burning room.

Table 5 shows the specification of the numerous tests which have been executed.

OFFICIAL FIRE TEST AT KARLSRUHE IN 1984

To overcome these problems, a special fire protection vapor barrier was developed to meet these requirements. It consists of a double fire protection component which is non-corrosive.

Thin aluminum foil is coated with a thin film of polyester to prevent corrosion. The polyester does not affect the results of fire tests. A special glass fiber felt which contains fire protecting compounds is on the upper side of the aluminum foil.

The official NRW fire tests were based on a zero test in which the fire reached the roof surface after twelve minutes because the EPS insulation board sintered. Burning through followed as the 300 degrees C self ignition point of the bitumen waterproofing had been reached. The test then was terminated.

On July 26, 1984 the official test was carried out at Karlsruhe University on a similar structure to the NRW test. The only change was that a fire protection vapor barrier was laid over the steel deck under the EPS insulation.

This special fireproof vapor barrier has very high strength and resistance to foot traffic and corrosion. A special glass fiber base is embedded in thin polyethylene foil on the upper side. This is combined with a double fire protection medium of crystalline water and a foaming fire protection compound.

When the steel deck structure reaches 150C the crystalline water is set free and fills all apertures with cooling water vapour. This prevents burn through.

The fire test in Karlsruhe took place in the presence of leading German fire and insurance experts. The tests confirmed the function of the special vapor barrier. The surface temperature of the bitumen layer did not exceed 200C and did not approach the point of self ignition. Despite considerable deformation of the steel deck there was no burning through. The other requirements also were achieved. In no phase of the trial were there burning drops of molten material.

Subsequent inspection of the roofing showed that the fire protective vapor barrier was fully intact and that there had been no flow of burning beads of bitumen or EPS.

In no phase of the thirty-minute trial was there formation of smoke in the burning room as had been the case in the NRW tests where bituminous vapor barriers had been used.

The test program showed that it was possible to combine the physical properties of a building material with fire resistance properties in a vapor barrier. Fire protection of the EPS insulation was fully achieved. As the EPS melted, the hollow spaces were filled with cooling water vapour. See the comparative temperature curves.

As a result, EPS board can be used for flat roof insulation without risk of fire burning through. Moreover it is no longer necessary to lay gypsum, perlite or similar boards as a separating layer between the steel and insulation. The special vapor barrier has a similar effect and also is a vapor barrier.

PROTECTION OF ROOF SURFACE AGAINST FIRE

Many roof fires in West Germany occur through carelessness during the roofing work. In contrast to the United States where pump boilers generally are used, in West Germany the work frequently is done with small bitumen boilers placed in the roof. If these catch fire roof fires often result.

Another problem is that sometimes the carelessness in laying bitumen torching sheet, particularly during repair work, sets the surface of the bitumen roofing on fire, causing considerable damage. This also applies to poor workmanship around roof lights, expansion joints or details. Minor jobs such as these often can cause large fires.

Often greater fire resistance is required around roof openings such as roof lights, expansion joints or details to prevent burning through to the roof surface.

As a result the technical people concerned with fire protection have had the task of developing a coating material with double function of roof maintenance and fire protection.

The answer to this is an elastomer bitumen coating containing two fire protection components. The coating is sol-

vent based and applied cold on all types of normal bituminous roofing, polymeric bitumen roofing (APP) and elastomeric bitumen roofing (SBS).

A slate chipping finish is spread on the fresh coating. This tight mineral coating is weather-resistant and fire resistant. Weatherometer testing indicates that this coating retains these properties for at least 10 years.

Shopping centers, exhibition halls and similar buildings which are built of light weight construction will not be able to withstand the load of 5cm thick chippings, the best form of fire protection on roofs. This coating provides fire protection to the roof during maintenance work or other fire risks.

Fire tests carried out by the largest German insurance company Allianz AG, Munich, demonstrated that with this special coating the roofing did not catch fire even after days of exposure to a torching flame (Figures 6 and 7).

This coating should be applied using 800 g/m² with the

slate granules 3 to 4 kg/m². This provides good maintenance and effective fire protection with an additional roof load of only 5 kg/m².

SUMMARY

As a result of these developments two long sought functions have been achieved:

- protection for roof covering on light weight building structures against fire from below and;
- protection of bituminous roofing against external fire hazards.

Light weight roofs with steel deck construction have been successful in West Germany for many reasons. The most important being low cost construction and rapid installation. These product advances have made it possible to increase the safety of such structures with bitumen roofing.

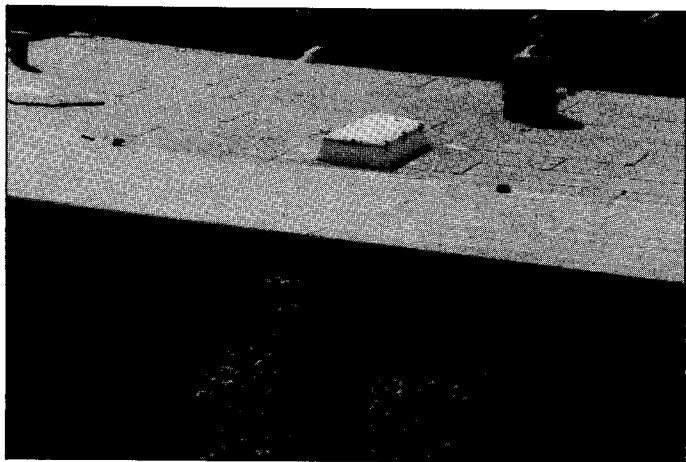


Figure 1

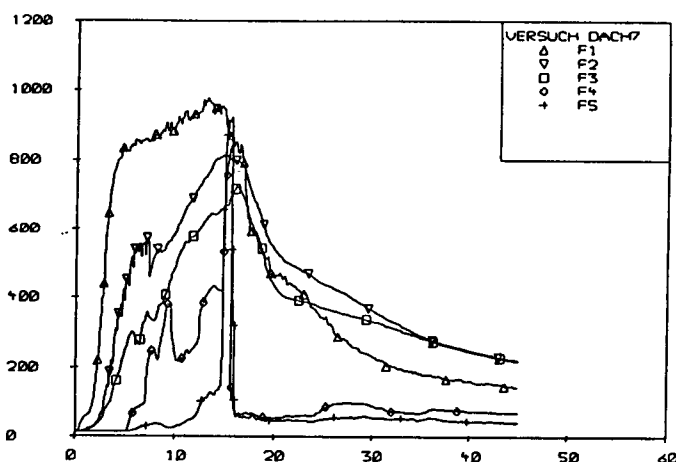


Figure 2

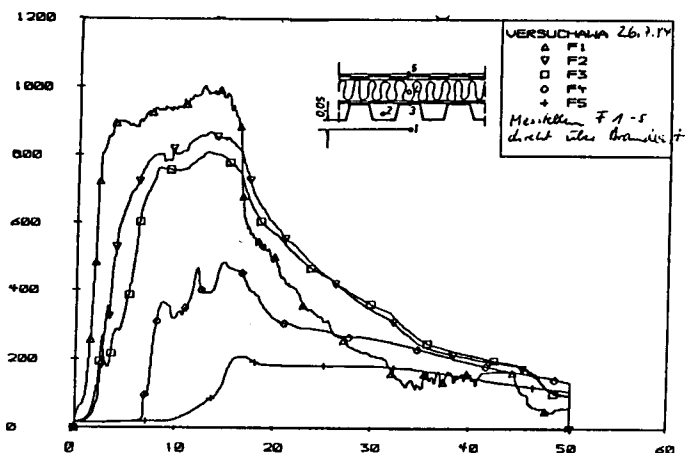
Figures 1 and 2 Hail storm in Munich, Summer 1984. Nonflammable roofing materials, such as tiles, sheet metal and asbestos cement slates have been damaged.

Flammable roofing coverings such as bitumen shingles or elastomeric bitumen layers withstand hail.

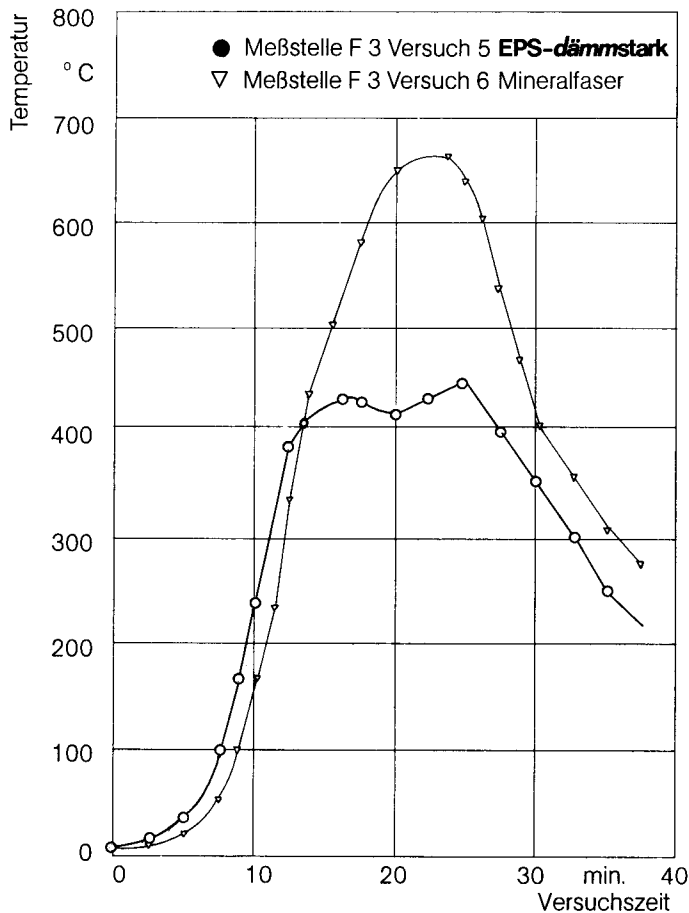
Comparative temperature curves.



Fire test without fire protection vapor barrier. Burn through occurs in about 12 minutes.



Fire test on July 26, 1984 with fire protection vapor barrier. Burn through is prevented.



Vergleich der Temperaturen am Obergurt des Trapezblechs über der Brandlast.

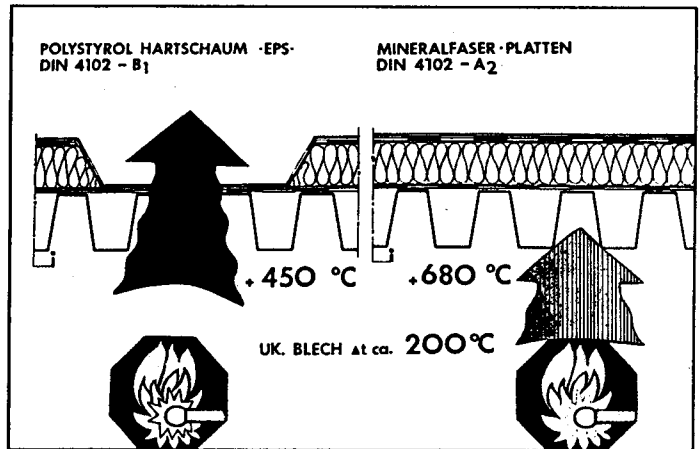


Table 4

Table 3

Prüfstatt f. Materialprüfung der Brandverhaltensstelle für Oberösterreich Brandversuche an einer Dachkonstruktion										Großbrandversuche der Forschungsstelle für Brandschutztechnik an der Universität Karlsruhe (TH) — Stahltrapezblechdächer mit jeweils unterschiedlichen Dämmstoffen —																			
Versuch awa		Auftraggeber: IVH Industrieverband Hartschaum e. V.		Auftraggeber: NRW Minister für Landes- und Stadtentwicklung des Landes Nordrhein-Westfalen		Versuch awa		Versuch awa		Versuch awa		Versuch awa		Versuch awa		Versuch awa		Versuch awa		Versuch awa		Versuch awa		Versuch awa					
awa/1	awa/2	Versuch IVH	MH/1	IVH/2	IVH/3	IVH/4	IVH/5	IVH/6	Versuch NRW	NRW/1	NRW/2	NRW/3	NRW/4	NRW/5	NRW/6	NRW/7	NRW/8	NRW/9	NRW/10	NRW/11	Dämmstoff	awa ISOLIT AL	NRW/7 Nullversuch						
18.07.73	25.10.73	Datum	11.02.77	25.02.77	4.03.77	25.03.77	14.04.77	29.04.77	Datum	18.10.79	4.12.79	7.03.80	28.03.80	27.06.80	1.08.80	26.09.80	14.11.80	15.12.80	20.02.81	20.03.81	Datum	26.07.84	26.09.80						
Styropor PS 20		Dämmstoff	EPS 20 SE Styropor					Mineralfaserplatte	Dämmstoff	EPS 20 Styropor	Mineralfaserplatte	PUR 30 WDS Polyurethan	Mineralfaserplatte	PUR 30 WDS	EPS 20	PUR 30 WDS	Bitumin. Holzfaser	EPS 20	Perliteplatte	Dämmstoff	EPS 20 SE Styropor								
B 3	B 3	Baustoffklasse nach DIN 4102	B 1	B 1	B 1	B 1	B 1	A 2	Baustoffklasse nach DIN 4102	B 1	B 1	A 1	B 1	A 2	B 1	B 1	B 2	B 2	B 1	B 2	Baustoffklasse nach DIN 4102	B 1							
40	40	Dämmstoffdicke (mm)	50	50	50	50	50	50	Dämmstoffdicke (mm)	50	50	50	40	50	40	50	40	70	50	70	Dämmstoffdicke (mm)	50							
nein	nein	Dampfsperre V 60 S 4	ja	ja	ja	ja	ja	ja	Dampfsperre V 60 S 4	ja	ja	ja	ja	nein	nein	nein	nein	nein	nein	nein	Dampfsperre	ISOLIT AL	nein						
geklebt	geklebt	Dämmstoffbefestigung	geklebt					geklebt	Dämmstoffbefestigung	geklebt	mechanisch mit Kunststoffdübeln					Auflast mech.					Dämmstoffbefestigung	geklebt	mech.						
ETK	ETK	Brandlast in kg Holz	25	50	100	100	200	200	Brandlast in kg Holz	400	200	200	200	400	400	400	400	400	400	400	400	400	400						
2	2	Anzahl der Holzstapel	2	4	4	4	4	4	Anzahl der Holzstapel	8	4	4	4	8	8	8	8	8	8	8	Anzahl der Holzstapel	8	8						
gezündet	gezündet	gezündet	2	4	4	4	4	4	gezündet	8	in der Längsachse m. 5 Weichfaserstreifen etwa 2/3 der Grundfläche					parallel zur Trennwand					gezündet	4	4						
	Zündung im Freigelände	Korrosionsschutz durch Bitumenanstrich der Dicke 200 µm im Profgrund gemäß Zulassung																				Korrosionsschutz durch Kunststoffbeschichtung							

Table 5

