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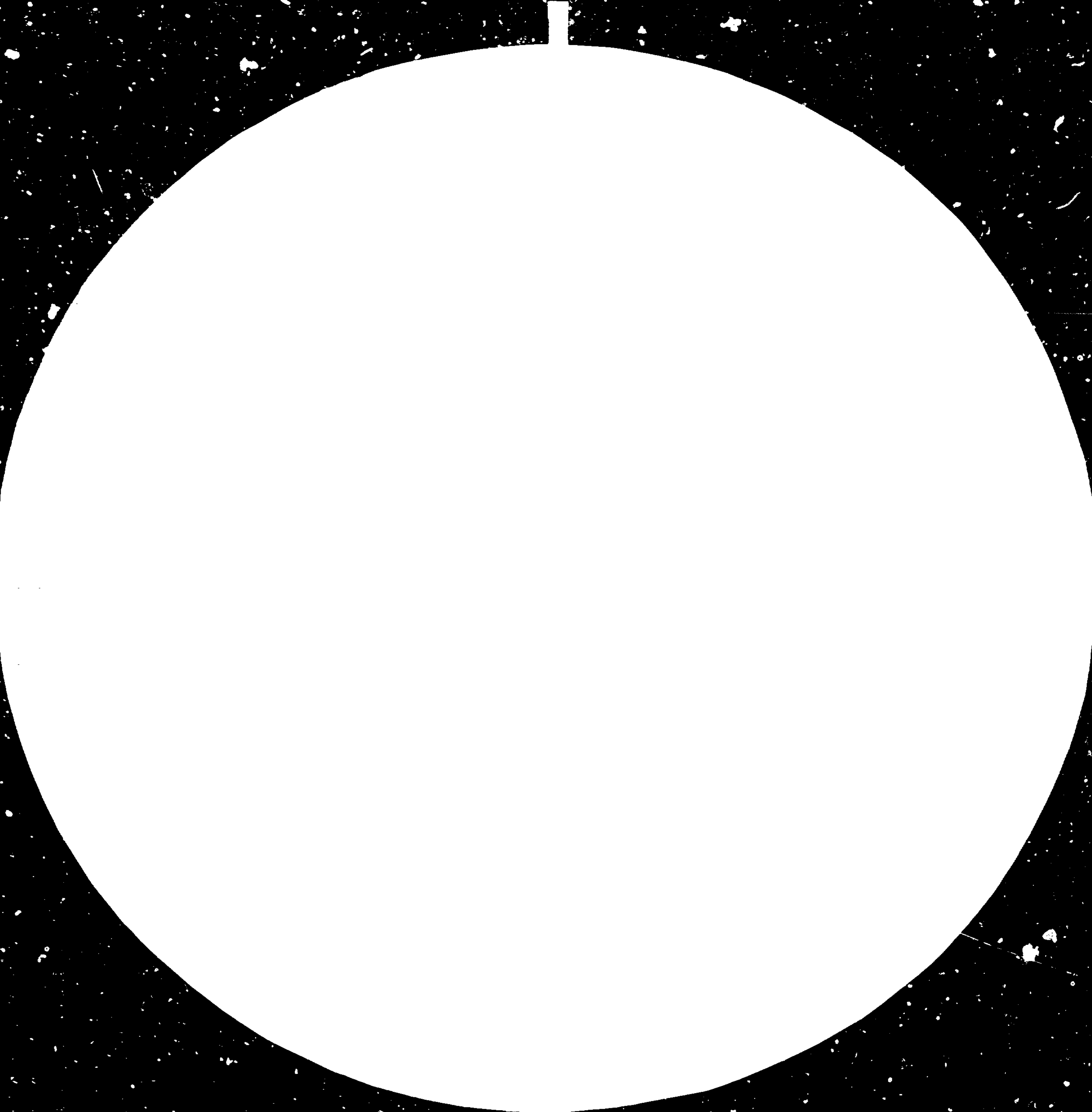

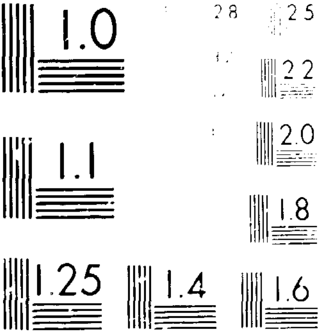

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POLYURETHANE IN THE FURNITURE INDUSTRY *

by

Raimo Väkevä **

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1. Flexible Polyurethane Foam Technology

The MAXFOAM technology is the first important development since the 1950's, when the production of flexible urethane foam began, using the "one-shot" method. To produce rectangular foam blocks in order to minimize the raw material waste has been a main objective for a long time. In this new production method, the sides need not be raised artificially; the foam block obtains its rectangular shape in a natural way. In the ordinary foaming process the foam rises like a dough. In the MAXFOAM process, the semi-foamed reaction mixture is allowed to expand "downwards" instead, whereby its upper surface remains in a relatively horizontal position. In using this new technology, the following advantages are achieved:

- the cross-section profile of the foam block is rectangular;
- thicker blocks can be produced;
- the bulk density differences between the upper and lower sections of the foam block are comparatively small;
- excellent physical properties;
- almost no formation of so-called "side skins";
- thin surface skin.

The first machines based on the MAXFOAM technology were brought into use in the summer of 1972. At the ESPE Oy Kouvola factory, the first test foaming based on this process was performed as early as the spring of 1974 and production began at the end of the same year. The use of this method has resulted in a great increase in production quality.

2. The properties of Flexible Urethane Foam

The consumer expects foam mattresses and upholstered furniture to be pleasantly comfortable and to retain its elasticity and firmness for a period of five to ten years or even more. These, like all other properties, are based on the structure of the smallest visible element in flexible urethane foam - the cell structure. A close study of the cell shows that it is a somewhat extended pentagonal dodecahedron.

To produce an ideal cell structure, an accurate formula must be developed. Special catalytic agents and other substances must be carefully chosen for this cell structure. These make it possible to give to the foam the desired optimal properties. Even though the formula is in every way complete, this is not enough to secure high quality, as other factors connected with the foaming process must also be mastered. These are for example the feed pressure of the raw materials, the rotation speed of the mixers, the volume and pressure of the mixing head, etc.

Although a great deal has been written about the correlation between the polymer structure and the physical properties, very little has been written about the cell structure of flexible urethane foam in correlation to its physical properties. As a result of many years of research and development work, ESPE Oy today has a new technique for controlling the foaming process in operation, by which it can be ensured that the physical properties of the final product come within certain tolerances (see table 1: The Properties of Normal Qualities; and table 2: The Properties of Soft Special Qualities on page 3).

The production of flexible urethane foams is at present subject to extremely strict controls, even from an international point of view. The finished product is carefully tested according to international standards, which means that the results obtained are internationally comparable. This procedure, to a certain extent, guarantees the high quality of the product. This continuous guarantee of quality also means that furniture manufacturers can produce high class furniture for the competitive export markets.

TABLE I: THE PROPERTIES OF NORMAL QUALITIES

a) Properties of standard Qualities	E-20	E-25	E-30	E-35	SUPERFLEX 33
Specific weight of the compound kg/m^3	19-21	24-26	29-31	34-36	32-24
Specific weight of the sheets kg/m^3	17.0-19.0	22.5-24.5	27.5-29.5	32.5-34.5	30.0-32.0
Hardness $N/323\ cm^2$ 25% Pressure	60-90	105-140	120-155	135-175	85-115
Deformation % max.	6	5	3	3	3
Loss of thickness under dynamic strain % max.	5	5	3	3	3
Tensile strength kN/m^2 Min.	60	80	100	100	50
Stretch % min.	220	220	220	200	150
Tear strength kN/m Min.	0.30 0.4	0.40	0.30	0.30	0.20
Cell strength pieces/cm	14-18	14-18	14-18	16-20	Hetero

b) Properties of special qualities	E-20EW	E-25HS	E-25EP	E-30EP	E-36P
Specific weight of the compound kg/m^3	19-21	24-26	24-26	29-31	34-36
Specific weight of the sheets kg/m^3	17.0-19.0	22.0-24.0	22.5-24.5	27.5-29.5	31.5-33.5
Hardness $N/323\ cm^2$ 25% pressure	30-60	10-30	45-75	45-75	70-100
Deformation % max.	6	6	5	4	3
Loss of thickness under dynamic strain % max.	4	4	4	3	3
Tensile strength KN/m^2 min.	50	80	50	50	50
Stretch % Min.	220	400	220	200	200
Tear strength kN/m Min.	0.25	0.40	0.20	0.20	0.20
Cell strength pieces/cm	14-18	14-18	14-18	14-18	16-20

Superflex is a high quality combination foam plastic.
Superflex 33 fills the requirements of ASTM D 1692 and MVSS-302 with respect to self-extinguishing properties.

ESPE foam plastic has been tested according to ASTM D1564 (In addition thickness loss is tested under dynamic strain according to DIN 53574). Hardness is tested on 5 cm thick sheets. Deformation at 70°C/22 hours, 50% pressure.

More than ten different tests are performed on each foaming batch to check the foam's properties. Parts of the research results pass directly to the customer in the form of various tables of properties and parts are used as feedback in process control.

2.1 Density

The basic condition for modern quality control is to know the density distribution for the whole area of the cross-section of the foam block. It must always be remembered that a change in the density also means a change in firmness. (See table 2)

TABLE 2: THE PROPERTIES OF UPHOLSTERY FOAMS USED IN DOMESTIC FURNITURE

a) Back Upholstery:

Foam grade (Density)	Indentation Hardness	Type of service
20 Kg/m3	normal	light
20 Kg/m3 (special formulation, low hardness loss after dynamic fatigue test)	super-soft	light/average
25 kg/m3	super-soft	average
30 kg/m3	super-soft	severe

b) Seating Upholstery:

Foam grade (Density)	Indentation	Type of service
25 kg/m3 1/	normal	light
27 kg/m3	normal	light
30 kg/m3	normal	average
35 kg/m3	normal	average
36 kg/m3	soft	average
40 kg/m3	soft	severe
Superflex-33 (Polystyrene-polyurethane composite foam)	initial softness high laod bearing	severe

1/ Hypersoft foam (density 25 kg/m3) should be used between the seating upholstery and the covering material. Instead of hypersoft foam polyester fiber batting can be used.

If the density varies considerably, for example 2 to 3 kilos/m^3, difficulties may arise in later stages of production in the form of fluctuations in quality.

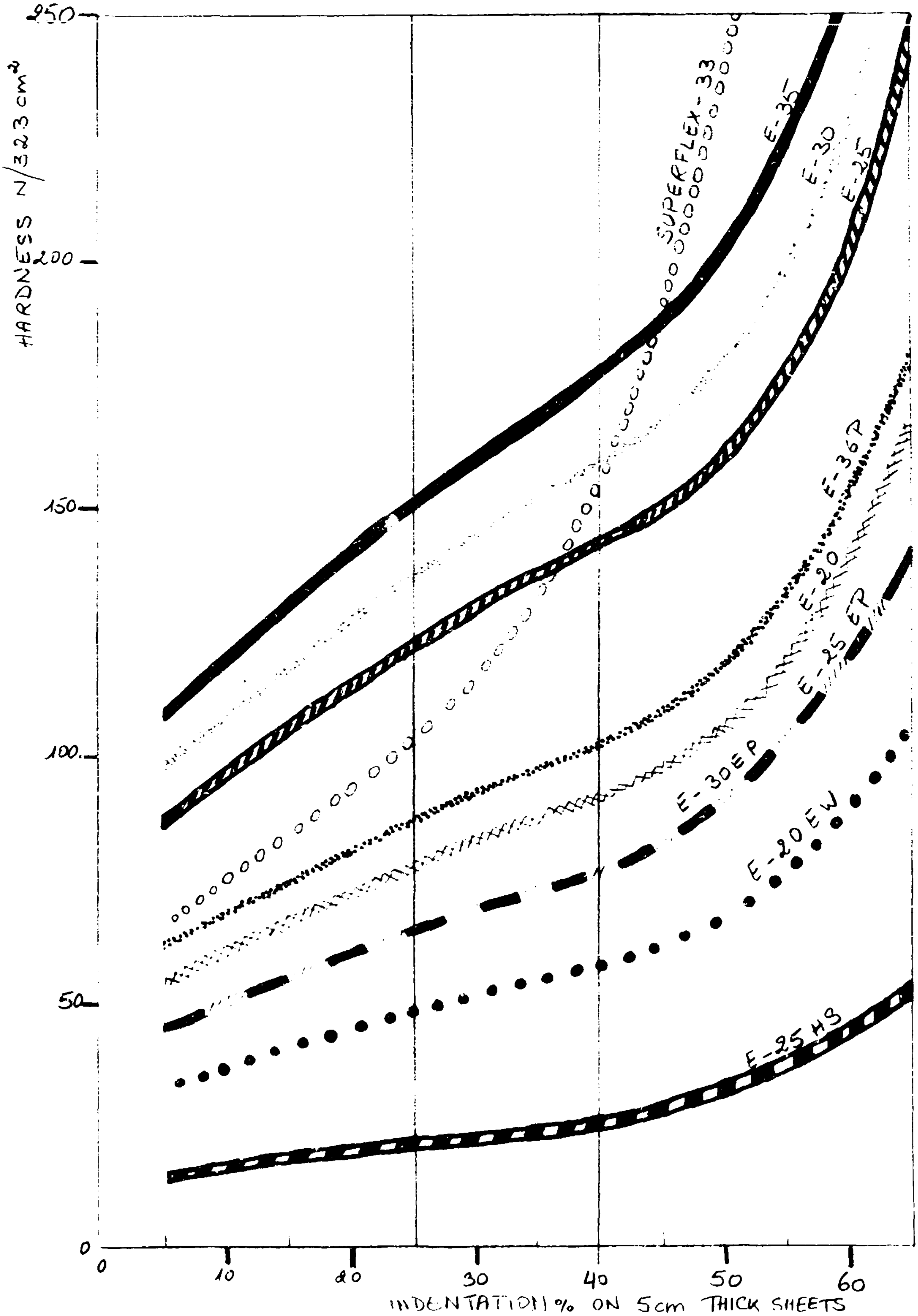
At present, using up-to-date production technology, density differences as small as 0.4 to 1.0 kilos / m^3 can be achieved. Heavier foam qualities have considerably better fatigue resistance. Thus foam qualities under 30 kilos/m^3 cannot be recommended for seat upholstery or mattresses subject to demanding conditions.

2.2 Indentation Load Deflection Hardness

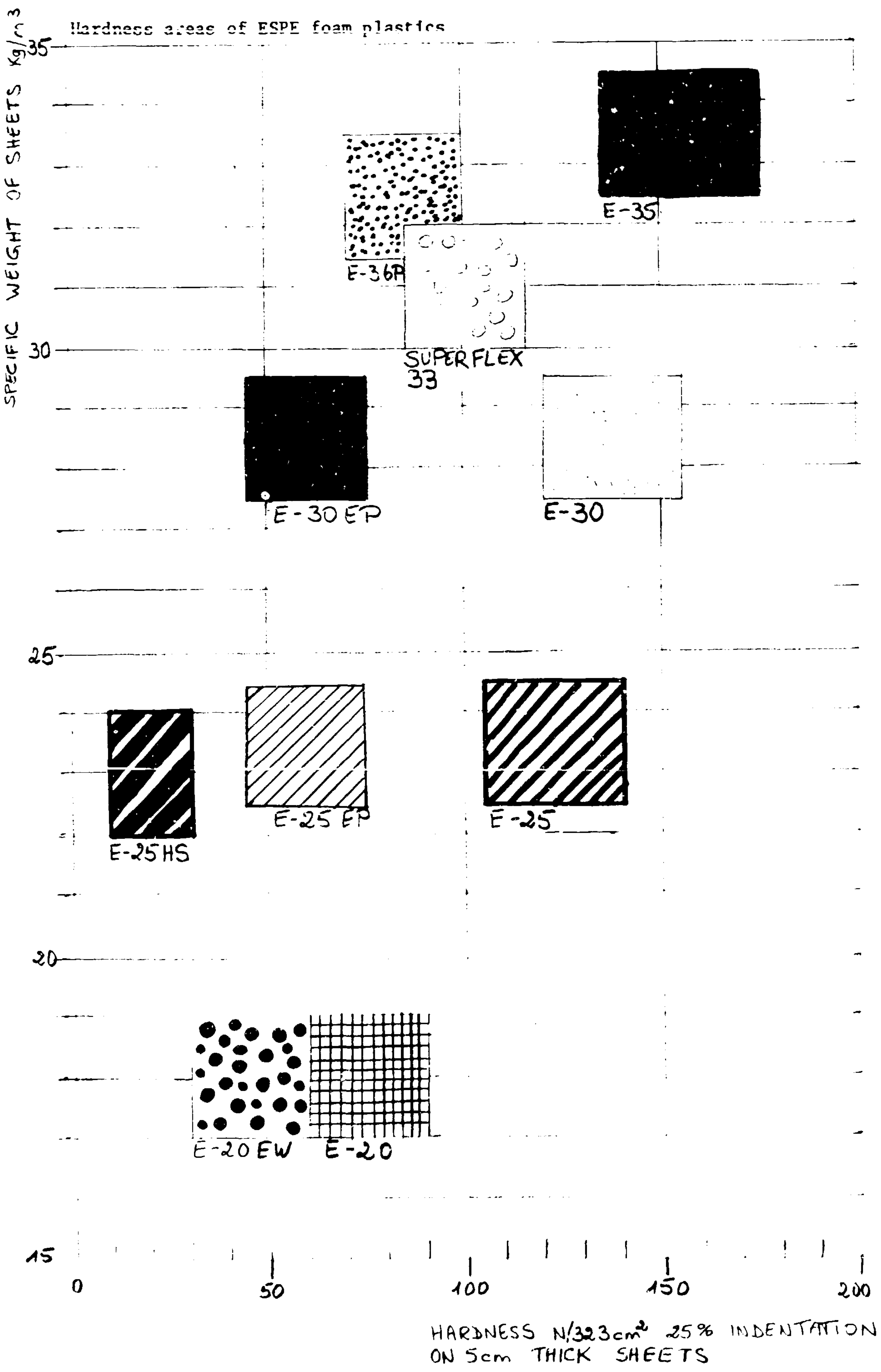
For furniture upholstery, Indentation Load Deflection (ILD) hardness in addition to bulk density is a very important factor, as for example the sitting comfort of the seat upholstery is evaluated on the basis of these two factors. (The value of ILD Hardness consists of measuing the load necessary to produce 25 percent, 40 percent, 50 percent and 65 percent indentation of the foam product.) A thorough knowledge of the properties of the raw material is needed, as well as the ability to apply this information to the formula, to prevent the quality of the foam from fluctuating from batch to batch. This knowledge also facilitates product development; prototype qualities can be screened in advance. (Foam plastic hardness curves are shown on page 6.)

The concepts of surface softness and of load bearing capacity are closely connected to that of ILD hardness (see Hardness areas of ESPE foam plastics on page 7). Generally, soft surface qualities lack load bearing capacity and qualities with good load bearing capacity lack surface softness. These factors must be taken into consideration in the upholstery design. In many cases, it is necessary to create a layer structure, two or three layers of different ILD hardness, to obtain the correct level of comfort in the upholstery. Exceptions from the aforementioned are the so-called HR foams (cold foams), as well as the

ESPE Foam plastics hardness curves



Hardness areas of ESPE foam plastics



polystyrene-urethane composite foam SUPERFLEX-33 which is the result of intense product development work and which combines pleasant surface softness with elasticity and an extremely good load bearing capacity. (See Hardness properties of various materials on page 9.)

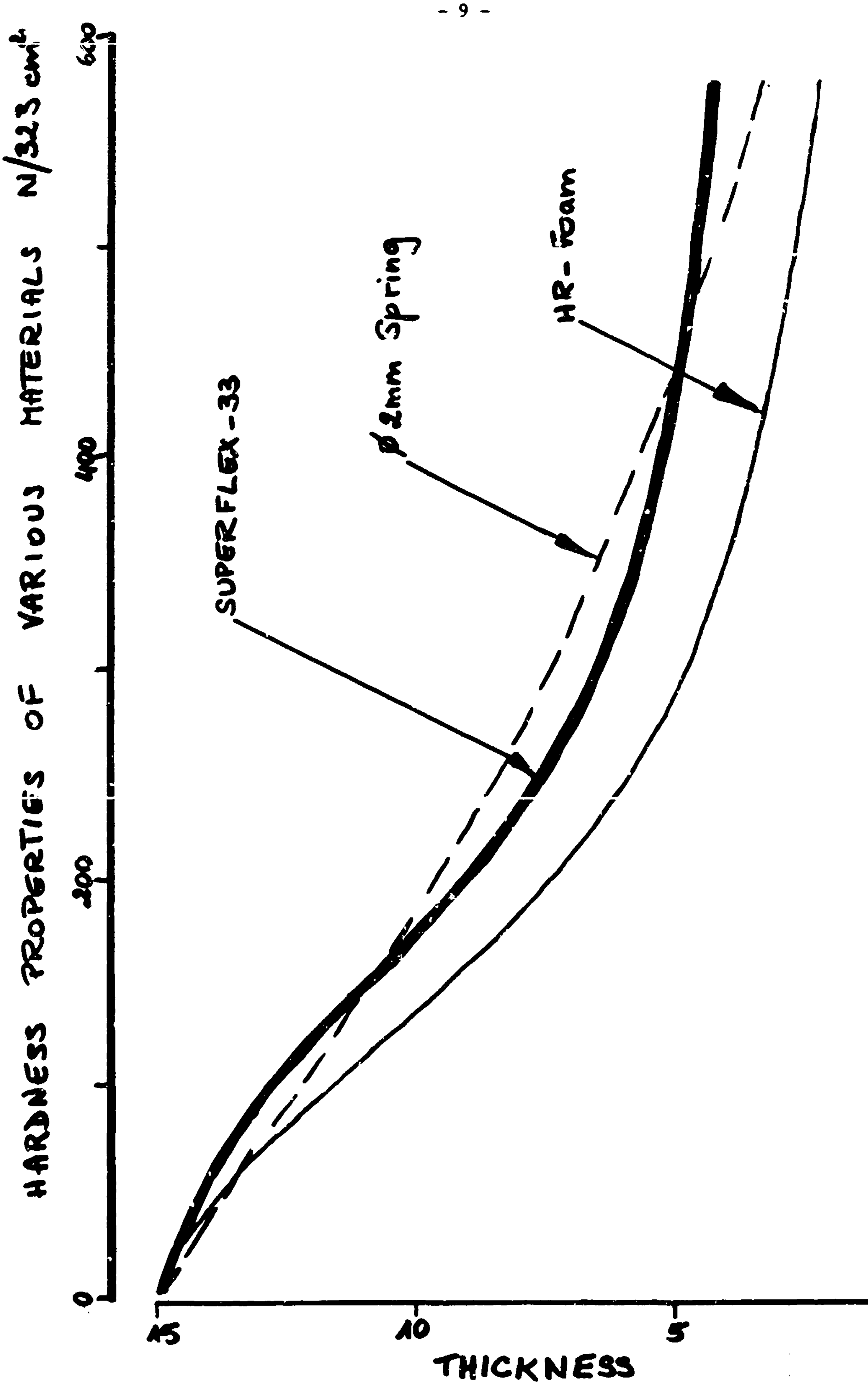
2.3 Compression set and fatigue resistance

Compression set is a factor which affects the service life. Knowing this compression set figure makes it easy to calculate the reaction of the upholstery under static fatigue. For example: Under 90 percent pressure the compression set of the upholstery is three percent, which gives a service life of nearly ten years, whereas with a compression set of five percent service life is only about four years. If all factors in the foam production process are known, it is possible to produce elastic and fatigue resistant material. In practice, this can be easily seen from the fact that the air permeability of the material is good.

In addition to static fatigue, upholstered furniture and mattresses are also subject to dynamic fatigue in normal use. In order to find out the total fatigue reaction of flexible urethane foam, its dynamic fatigue is tested according to the DIN 53574 standard. In this test, the foam specimen is charged with a pulsating load of 75 kilos (diameter of fatigue area 250 mm) 80.000 times. Testing time is about 19 hours, after which the thickness and hardness loss percentage is determined.

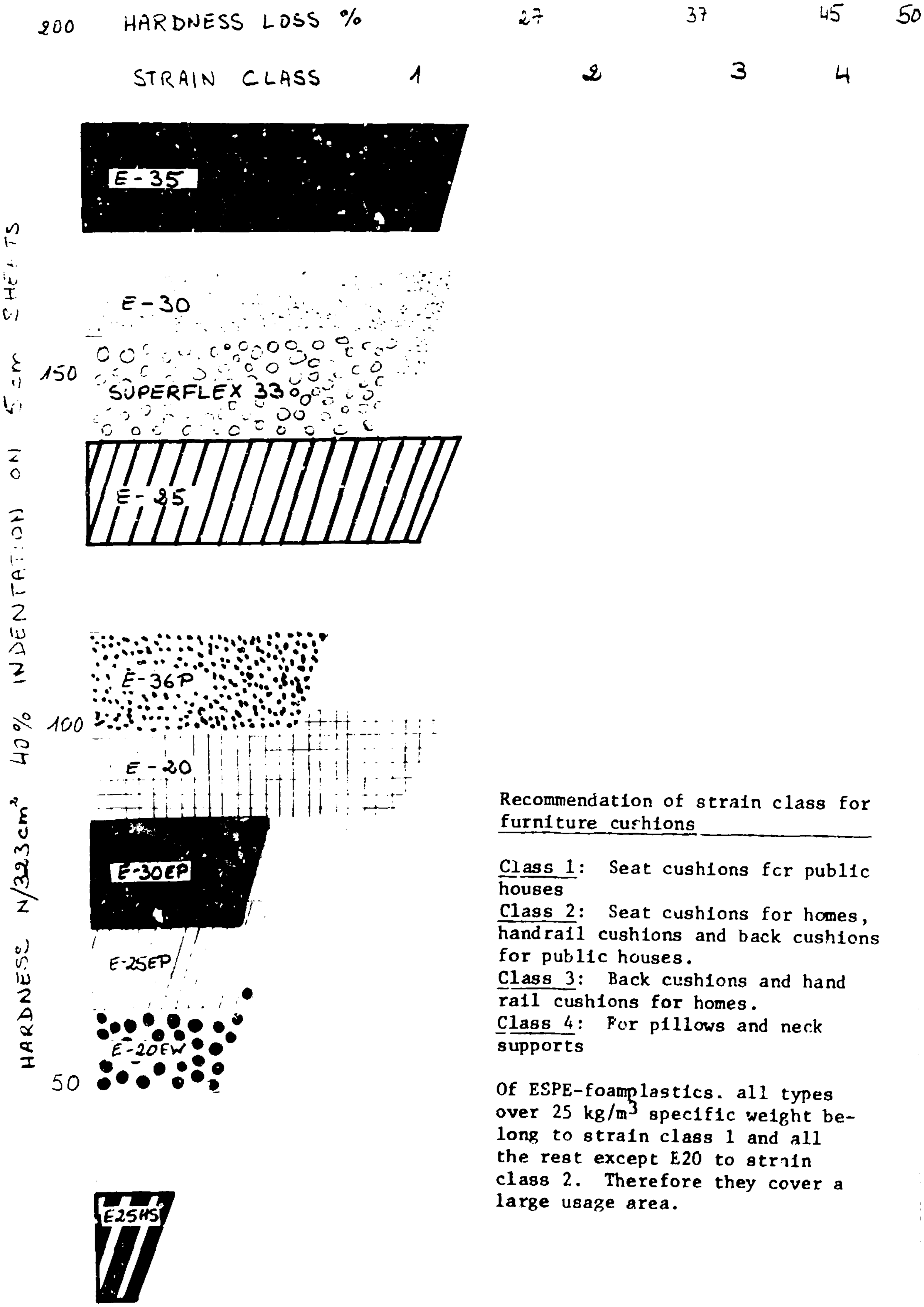
2.4 Fatigue resistance class recommendation for upholstery

According to British standards flexible polyurethane foams are divided into four different fatigue resistance classes (see Foam plastics strain on page 10 and Foam plastic cushions' thickness on page 11). Class 1: seat upholstery for use in public places; class 2: seat upholstery for use in domestic furniture, back and arm support upholstery in public places; class 3: back and arm support upholstery for domestic furniture and class 4: neck support upholstery, cushions.



ILD HARDNESS

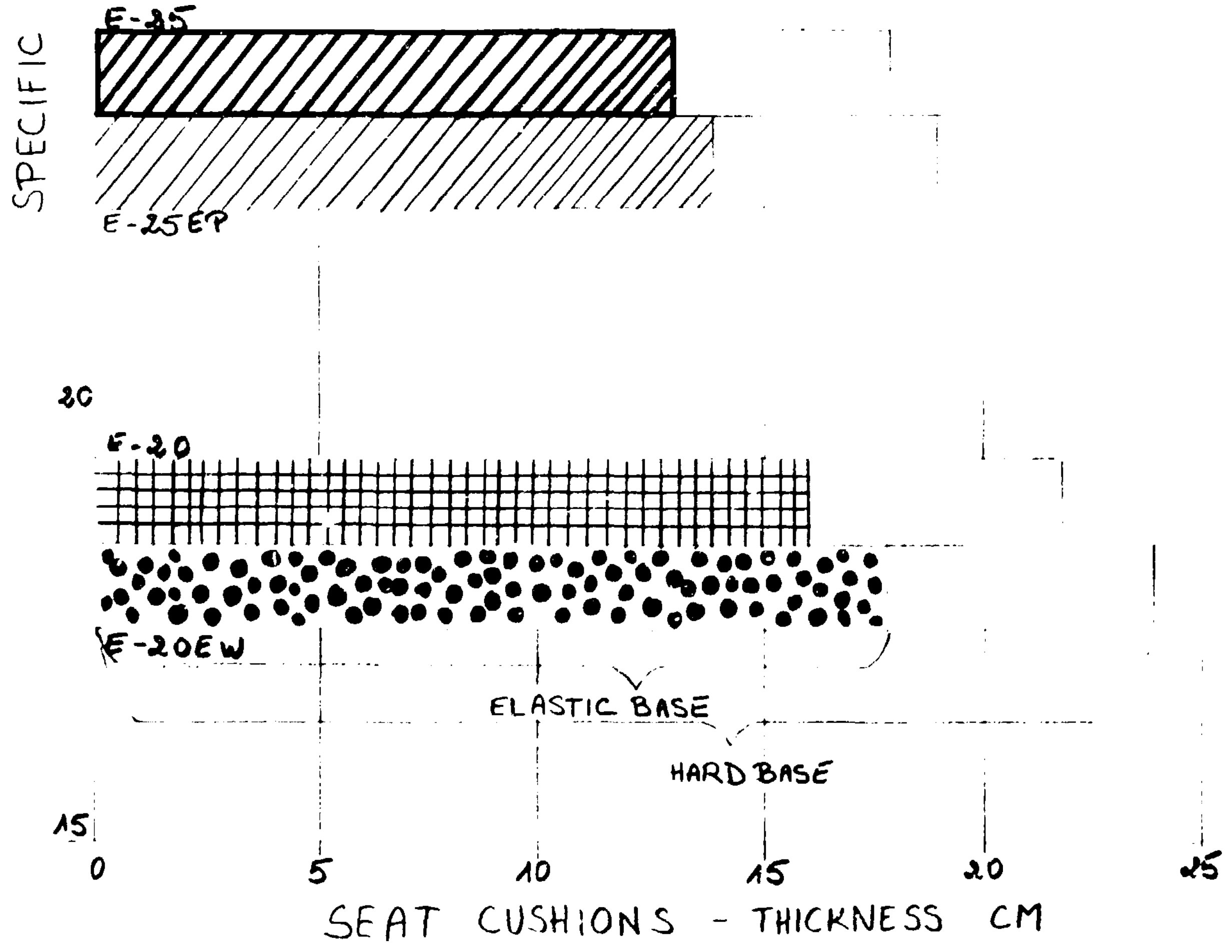
ESPE Foam plastics strain



Recommendation of strain class for furniture cushions

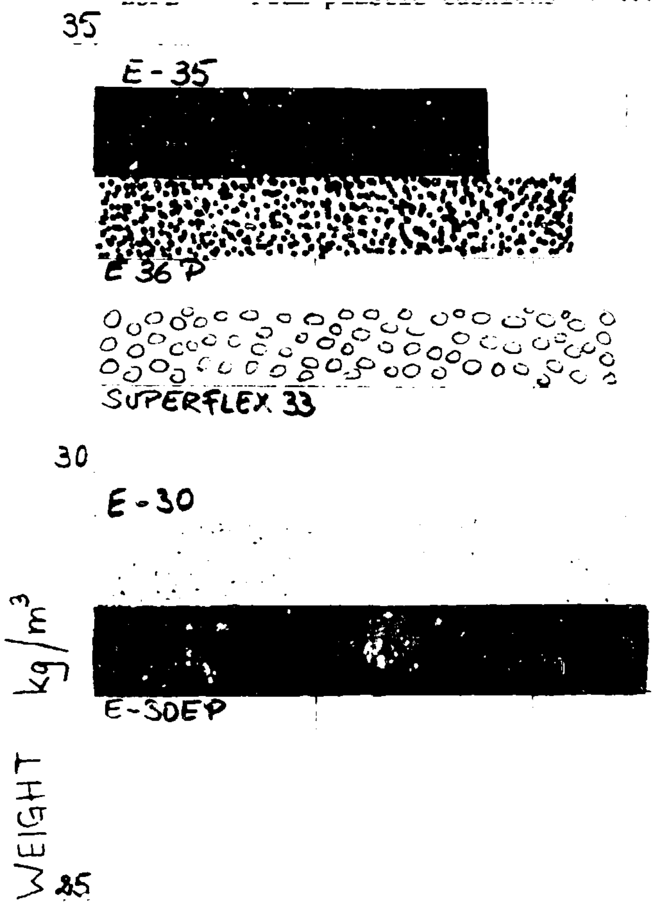
Class 1: Seat cushions for public houses
Class 2: Seat cushions for homes, handrail cushions and back cushions for public houses.
Class 3: Back cushions and hand rail cushions for homes.
Class 4: For pillows and neck supports

Of ESPE-foamplastics. all types over 25 kg/m^3 specific weight belong to strain class 1 and all the rest except E20 to strain class 2. Therefore they cover a large usage area.



SPECIFIC
E-25
E-25EP
20
E-20
E-20EW
ELASTIC BASE
HARD BASE
15
0
5
10
15
20
25
SEAT CUSHIONS - THICKNESS CM

ESPE Foam plastic cushions' thickness



In ESPE's range of products, all types above 25 kilos/m^3 belong to class 1 and the rest, except for the E-20, to class 2. Thus they cover a wide range of uses.

2.5 Cutting tolerances for foam upholstery

In addition to the correct physical properties, it is important to achieve the dimensions designed for it. Technically developed and highly automatized cutting machines in combination with highly skilled personnel have led to cutting tolerances that not only meet international requirements, but are even better. Strict cutting tolerances are of importance not only qualitatively, but also economically in the form of savings in raw material. (See table hereunder)

TABLE 3: Cutting tolerances of plastic foam cushions

Measurement of cushion (mm)	Tolerance in mm according to BS 3379:1978	
5 - 25	+ 3	- 0
26 - 100	+ 4	- 0
101 - 250	+ 6	- 0
251 - 500	+10	- 0
501 - 1000	+20	- 0
1001 - 1500	+30	- 0
1501 - 2000	+40	- 0
YLI 2000	+50	- 0

3. Polystyrene-urethane Composite Foam

Polystyrene-urethane composite foam, SUPERFLEX-33, is a combination of polyether and expanded polystyrene beads. It should be mentioned at this stage that it is not a normal polystyrene but a special type which has been specially developed for this purpose and which withstands the reaction heat. The beads expand during the foaming reaction. The result is a compound where the expanded beads are in exactly determined positions with regard to the elasticity and the desired load bearing capacity. The composite foam thus developed has proven to be extremely durable when tested. Due to its structure, it has a pleasant soft surface and elasticity and an extremely high load bearing capacity. Of the foam qualities produced, it is best suited for seat upholstery and mattresses. Also its bulk density is sufficient (33 kilos / m^3).

The composite foams can also be made fireproof, whereby the fire retarding substances are added in connection with the production reaction. This product meets the requirements of the ASTM 1692 and FMVSS-302 standards.

4. Flame Laminated Foams for the Textile Industry

It has always been possible to use polyesther-based foams for flame laminating, where the textile and foam are joined by means of a flame. Normal polyether-based foam used for upholstery lacks this property.

Only recently has a polyether foam for flame laminating been developed with a very good adhesive capacity and a short drying time. The latest product is a fire-proof flame laminated polyether which meets the fire protection requirements of the automobile industry and passes the so-called "fogging" test.

5. Fire-resistant Foams

It is possible to make flexible polyurethane foam fire-resistant by adding certain fire-retarding substances during the production process. Generally, these substances have a deteriorating effect on the physical durability properties. This is why extensive research work is often needed in order to develop a suitable formula. The production of fire-proof foam is still today comparatively insignificant. The reason for this is its high price and the fact that fire protection regulations vary from country to country. The following fire-proof foam qualities are available:

- automobile industry quality E-27PS (ASTM and MVSS standards);
- construction industry quality E-33PS (NT:FIRE002), fullfills the class 1 flammability requirements according to the Finnish construction regulations; structural fire protection;
- fire-proof mattress quality E-35PS (ASTM,FMVSS).

In 1977, there were 93,360 fires in Britain, out of which 2,618 originated from upholstery and 1,085 of these were caused by careless smoking.

Of all the European countries, Britain has carried out most the research on fires and their causes. During the last decade, this subject has been of particular interest to the labour unions as well as the Government.

In 1978, the British Consumer Safety Act laid down regulations concerning fire safety for upholstered furniture. According to these regulations, the upholstery material must be of such quality that it cannot be ignited by anyone who is negligent while smoking. The British Parliament passed the Upholstered Furniture (Safety) Regulation Act 1980, on 22 May 1980.

In cases where a piece of furniture does not fullfill these regulations, it must be provided with a sign warning against inflammability.

The Act is to come into effect in two phases:

1) From 1 October 1980, if a piece of upholstered furniture can be ignited by a burning cigarette or by a butane flame, it must be provided with a warning sign.
2) From 31 October 1982, all furniture must be fire resistant with respect to cigarettes, gas flames and matches. In this case no warning sign is needed.

If the furniture is fire resistant only with respect to cigarettes, a warning sign is obligatory.

The protection against fire prescribed by law is to be measured according to BS 5852: Part 1: 1979.

Nearly 50 percent of all fires begin in beds, while furniture is responsible for a little less than 25 percent.

Although the use of plastics has increased, their share as the cause of fires has not increased to a corresponding degree, whereas the share of other causes of fire is steadily increasing.

Natural materials and plastics develop toxic gases when burning. The greatest risk is constituted by carbon monoxide; other gases are generally present to a lower extent. Still these gases have an irritating effect. The spontaneous ignition temperature of polyurethane foam is 415°C. Most plastics and natural materials have a spontaneous ignition temperature of 350° - 600°C. Table 4 below shows the amount of heat produced by the combustion of different materials.

TABLE 4: Calorific Value of Certain Foams and Wood Species

	Megajoules per kg.	Megajoules per m^3
Polystyrene	41	--
Polyurethane	28	--
Urea Formaldehyde Foam	20	--
Birch	19	--
Flexible Polyurethane Foam (25 kg/m^3)	--	620
Oak	--	12800
White Birch	--	13400

The combustion of birch wood produces 19 Megajoules per kilo and the combustion of the same quantity of polyurethane produces 28 Megajoules or 46 percent more heat.

Those materials in which the molecules contain nitrogen atoms, produce under combustion the following quantities of hydrogen cyanide as can be seen below:

Polyurethane	41 microgrammes/g
Nylon	116 microgrammes/g
Wool	124 microgrammes/g
Acryl	260 microgrammes/g

The combustion temperature must always be known before the amount of gases produced can be measured. Generally, no fixed standard temperature occurs in fires.

Tests have been performed on rats, in which three different materials: polyurethane, cork and pine wood were used. Equal quantities of these materials were burned and the combustion gases directed into their cages. On the basis of these tests, no relationship was observed between hydrogen cyanide and the death of rats. On the other hand, there is a clear connection between the development of carbon monoxide and the death of the rats. The larger the quantity of carbon monoxide produced, the more rats died. Blood tests proved that carbon monoxide was the reason for the death of the rats. Thus, the most dangerous gas developed in fires is in fact carbon monoxide.

Furniture design also plays a significant role in fire security. It must always be remembered that vertical surfaces burn three times faster than horizontal surfaces. Fire security is improved by leaving sufficient space between the seat and the back support. If the upholstery material is wrongly applied, the chances of the object catching fire are greatly increased. Fire security can be improved by using an intermediate layer of cloth.

Fire protection methods for plastic foam are:

1. Additive fire retarders;
2. Reactive fire retarders;
3. Synergetic fire retarders;
4. Fire protection based on a reaction mechanism.

In the ESPE fire-protected polyether foams, a combination of methods 1 and 3 is used and in the HR foams a combination of methods 1 and 4 is used. The best results are achieved when all the materials utilized are fire-protected, in which case no risk occurs even if the upholstery cloth is damaged. In this connection, it should be remembered that total fire protection presupposes that carpets, curtains, wall papers, etc. are also fire-proof. When ignition is prevented, a fire is prevented.

One method of increasing product fire safety is to add a layer of fire-proof foam between the upholstery and the cover. A foam with a very effective fire resistance should be used. The working mechanism of this inserted layer is as following:

- At the first stage, water is released, which has a cooling effect;
- At the second stage, a fire-protective substance having an extinguishing effect is released;
- Finally, an isolating layer of carbon is formed.

Currently, the most general standards are:

- FMVSS-302 (used by the car industry)
- ASTM D 1692 (used by shipyards and the bedclothes industry).

All the eight fire-proof foam qualities produced by ESPE fullfill the requirements of these standards.

All upholstery materials used by the aircraft industry are subjected to a vertical fire test.

The Nord NT 002 Fire test is an extremely demanding test, in which a strong draught of "chimney effect" is created. Foam plastic can only pass this test if the B layer does not catch fire. Annex I shows two fire test reports on foams from ESPE Oy.

6. Factors to be Observed when Choosing a Foam Mattress

Your mattress is of great improtance for your sleep and rest. It is even reflected in your alertness and your daily work performance. When choosing a mattress, the general rule is that it must allow your spine to take a position of rest. When you are sleeping on your back, the discs between your spinal vertebrae should not be under stress but should take their natural positions. As you turn on your side, your spine should form a horizontal line. If you have chosen the wrong bed, a hammock effect is the result and you end-up with a sore back.

According to anatomic-physiological research on this subject, the mattress must have a minimum flexible depth of 6 to 7 cm. This ensures that your spine remains in a horizontal position even though you lie on your side. The thinnest foam mattresses are a minimum of 7 cm thick, and naturally the load bearing capacity of a mattres of this thickness is not very durable and the mattress softens after three to four weeks' use. When a person weighing 80 kilos sleeps on a 7 to 10 cm mattress with a bulk density of less than 30 kilos/m^3 on a bed with a hard base, the hard base is felt in the form of an increased surface pressure in the hip and shoulder regions within the above-mentioned period of time. Thin foam mattresses can thus be recommended only for persons who want to sleep on a hard bed. Such foam mattresses just give surface softness, they do not have any load bearing capacity. When buying a high quality foam mattress, attention must be paid to its surface softness, flexible depth and load bearing capacity. The surface softness is especially important for sleeping in comfort.

According to the Swedish publication Möbelfakta, the flexible depth of a foam mattress on a non-flexible base must be 9 to 14 cm and on a flexible base, 6 to 9 cm. If the flexible depth of your foam mattress is correctly dimensioned, your spine always takes a position of rest, which gives you a peaceful night's sleep. The load bearing capacity of the foam ensures that you cannot feel the base of the bed through your mattress. All these three properties - surface softness, flexible depth and load bearing capacity - form a harmonic whole, and the circulation of the blood remains undistrubed. Also R. Coerman[1/] has pointed out the significance of skin surface pressure. If the surface pressure rises above 0.07 kg/cm^2, the result is always an inhibition of the blood circulation. The use of a thin extra mattress adds to sleeping comfort by increasing the surface softness and makes it easier to make up your bed.

Tables 5 and 6 hereunder facilitate the choice of a foam mattress:

TABLE 5: Specifications of Foam Mattresses by End Use.

TYPE	Recommended Thickness	Bulk density
Children's mattresses	5 -- 7 cm	20 - 25 kilos/m^3
Youth mattresses	7 - 10 cm	25 - 30 kilos/m^3
Adults' mattresses	10 - 15 cm	30 - 35 kilos/m^3

TABLE 6: Recommended Choice for a Person Weighing 80 Kilos:

Density of Foam	Thickness of Mattress	
	Hard base	Flexible base
30 kilos/m^3	15 cm	12 cm
35 kilos/m^3	12 cm	9 cm

The body weight of the prospective user of the mattress must always be taken into consideration. If the weight is considerably less than 80 kilos, the above figures can be adjusted to suit personal requirements. Overweight persons are advised always to pay attention to

1/ R. Coerman, Arbeitsphysiologische Gesichtspunkte bei der menschengerechten Gestaltung von Fahrzeigen, 11. Internationaler automobiltechnischer Kongress in München, June 1966 thickness and bulk density when choosing their mattress.

7. Rigid Foams

Rigid polyurethane foams are used for thermal insulation, for structures and for packaging. Those used for insulation and packaging have densities of 8 to 40 kg/m^3; structural foams are used in densities of 40 kg/m^3 upwards.

All rigid foams have closed cells. Rigid polyurethane foam is used in furniture in densities from 40 to 80 kg/m^3. Owing to the low density of these materials, realtively thick walls as well as inserts for bolts, screws and nails are needed. Rigid integral skin foams are used for decorative details and structural purposes. They have a tight skin and a cellular core. The overall density of these foams is 200 to 600 kg/m^3.

8. Handling Equipment:

The number of mixtures (batcher) are determined as follows:

- required production rate	75 per hour
- mould time	5 minutes
- load time	0,5 minutes
- unload time	0,5 minutes
Total mixture time	6 minutes.

Units per mixture per hour 60 : 6 = 10 units

Number of mixtures required 75 : 10 = 7,5 = 8

Polyurethane foams are made by continuous methods as well as by batchwise moulding. Continuously foamed polyurethane must be cut to size; items produced by batch foaming are generally produced in their final shape through use of a mould. Polyurethanes are produced by blending two or more components in a mixer.

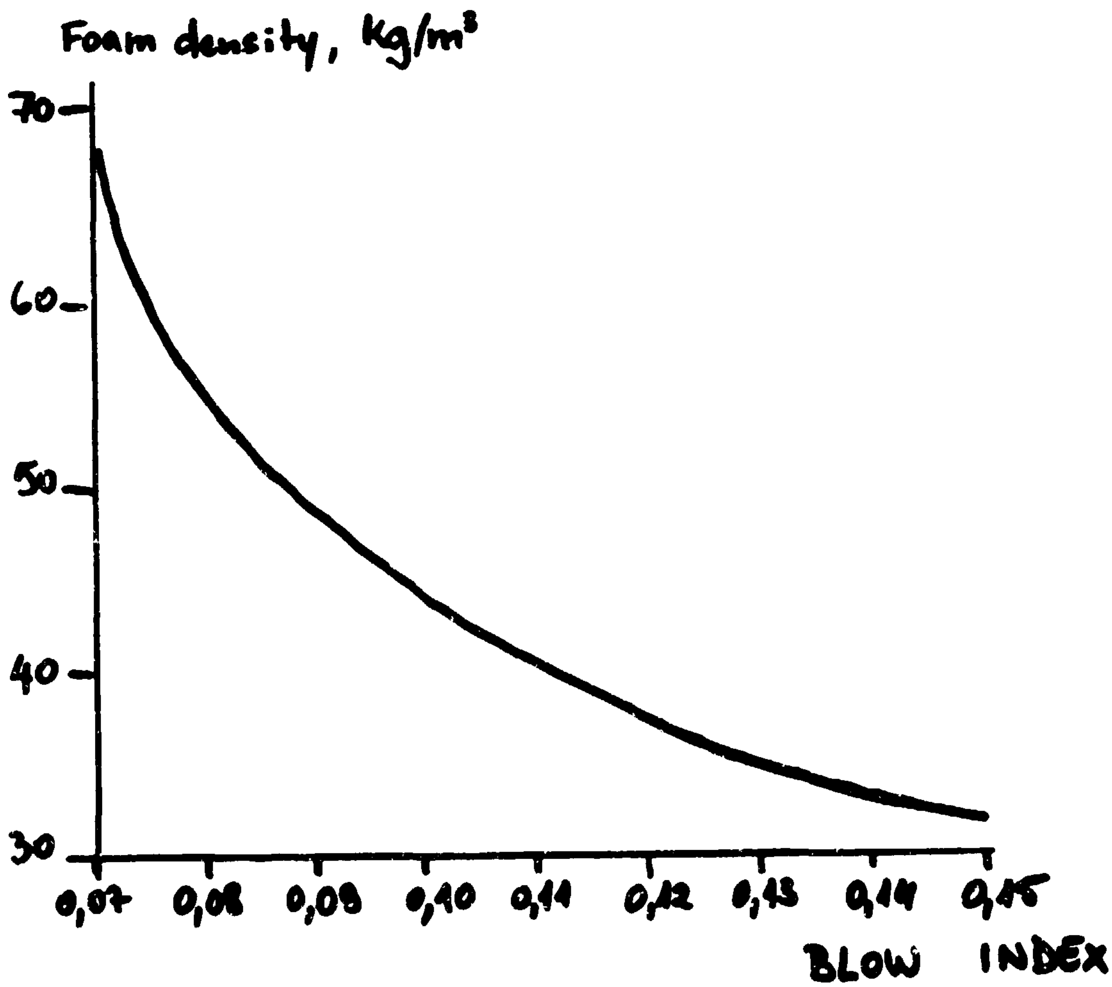
9. Blow Index

This is a quotient which enables an estimation of the approximate foam density that a specific formulation will give:

$$\text{Blow index (rigid foams)} = \frac{(\text{Trichloromonofluoromethane - 11}) + (10 \times \text{water})}{\text{polyol + flame retardant + silicone oil + catalyst + isocyanate}}$$

$$\text{Blow index (flexible foams)} = \text{water} + \frac{(\text{Trichloromonofluoromethane - 11})}{10}$$

All units above are in parts by weight. The figure hereunder illustrates the relation between foam density and blow index.



10. Quality Control:

The following test should be carried out on every day of production:

Density: The weight of a unit volume of a material.

Cream time: The time interval between mixing the foam and the visible start of the foaming reaction. start of the reaction is denoted by the mixture ng a creamy colour or by it just beginning to

Gel time: The time from the mixing of foam components to the time it is possible to draw a 10 to 25 cm long string or whisker when the surface of the foam is touched with a wooden spatula.

Tack free time: The time from mixing the foam components to the time a wooden spatula touched to the foam surface just ceases to stick to it.

Rise time: The time from mixing the foam components to the time the foam stops rising in an open container.

11. Safe Handling of Isocyanates

All persons concerned with the handling of isocyanates and isocyanate containing products must be conversant with the hazards and trained in the recommended handling procedures.

All isocyanates are potentially hazardous materials.

Recommendations for the handling of aromatic isocyanates are described in a document prepared by the Safety Committee of the International Isocyanate Institute:

1. Technical Information 4 compiled by the III, Inc.: Recommendations for the handling of 4, 4' Diphenylmethane Di-isocyanate MDI Monomeric and polymeric (August 1981).

2. Technical Information 1 compiled by the III, Inc.: Recommendations for the Handling of Tolvene Diisocyanate (TDI) (November 1980).

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TECHNICAL RESEARCH CENTRE OF FINLAND

Fire-technical Laboratory

TEST REPORT No. A 487/78

Annex 1
FIRE TEST REPORTS

Ordered by: Espe Oy, Kouvola Factory, Nevatie 2, 45101 Kouvola.

Order: Letter of December 27, 1977/Raimo Väkevä/Mii

Purpose of test: The determination of ignitability of foamed plastic E - 33PS.

Test Specimens: On December 28, 1977, the customer sent 10 pcs. of E-33PS foamed plastic sheets, sized 300 mm x 800 mm, thickness 50 mm, dencity appr. 35 kilos/ Sq.metre, to the Fire-technical Laboratory.

Tests: The determination of ignitability was made on December 29, 1977, using the 31 Nordtest NT FIRE 002, materials - coverings and linings: ignitability method. In the five tests performed the flame did not penetrate at all to the other sheet during the 30 minutes test period. During the test molten plastic was dropping from the sheet on to which the flame had been directed showing a 200 mm diameter hole.

Summary: On the basis of the tests performed it can be concluded that the surface of the E-33PS foamed plastic fulfilled the Class 1 ignitability requirements according to the Finnish building regulations collection (part E1, Structural Fire Safety), providing that these requirements conform to the fire classification report No. 310/1972.

Espoo, January 9, 1978

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TECHNICAL RESEARCH
CENTRE OF FINLAND
(stamp)

Claes Holm
Claes Holm
Laboratory Chief

Henry Weckman
Henry Weckman
Tester

5-PAL/EN,PE

Fire Technology Laboratory

Requested by: Espe Oy, Kouvolan tehtaat, PL 64. 45101 Kouvola 10.

Order: Despatch notes 19.1.1981/Raimo Väkevä and 30.1.1981/Ritva Heikkilä.

Object: Fire test according to ISO 3795.

Samples: On 3 February the customer provided the Fire Technology Laboratory with seven different foam plastic samples of which each comprised five 355 x 100 mm x 13 mm large specimens. The numbers of the samples were HR-25, HR-35, HR-50, E-27PS, E-33PS, SF-45PS and LIMI 130PS.

Test and results: The specimens according to ISO 3795 were marked with a 279 mm long measurement area at a distance of 38 mm from both ends. The specimens were conditioned in standardized conditions (50±5 % RH 23±2° C) at least for 24 h. The tests were made immediately after the conditioning.

Each specimen in turn was placed in a metal frame in horizontal position. The grips of the metal frame kept the specimen in place in three edges. A 38 mm high gas flame was applied from below at the open end edge. The distance of the gas orifice was 19 mm from the lower surface of the material. The ignition time was 15 s. The time of burning in the measurement area was measured. When the fire died out in the measurement area also the length of the damaged area was measured. The rate of burning was calculated on the basis of the damage in the measurement area and the time of burning. Also the length of the total damage was measured, or the damaged area in the specimen from the edge.

The following results were obtained:

Sample		Rate of burning mm/min	Total damage mm
HR-25	1	0	34
	2	0	28
	3	0	30
	4	0	30
	5	0	28
Mean		0	30
HR-35	1	0	22
	2	0	17
	3	0	23
	4	0	22
	5	0	33
Mean		0	23

Espoo, January 1978

Technical Research Centre of Finland

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Sample		Rate of burning mm/min	Total damage mm
HR-50	1	0	23
	2	0	28
	3	0	30
	4	0	28
	5	0	26
Mean		0	27
E-27PS	1	0	17
	2	0	29
	3	0	24
	4	0	21
	5	0	23
Mean		0	23
E-33PS	1	0	14
	2	0	25
	3	0	23
	4	0	28
	5	0	28
Mean		0	24
SF-45PS	1	0	26
	2	0	24
	3	0	26
	4	0	27
	5	0	23
Mean		0	25
LIMI 130PS	1	0	38
	2	0	32
	3	0	34
	4	0	33
	5	0	35
Mean		0	34

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In all the tests the plastics was extinguished by itself when the ignition flame had been removed.

Espoo 17.2.1981

TECHNICAL RESEARCH CENTRE OF FINLAND
Fire Technology Laboratory

Special Research Officer Liisa Pakkala

Research Offiser Brita-Lisa Irjala

For a true and correct translation
Technical Research Centre of Finland

1981-05-29 Marjatta Tommila

Marjatta Tommila, M.A