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NOVEL FOAM SHEET FOR IMPACT SOUND INSULATION WITH EXCELLENT CREEP PERFORMANCE

C.V. Vo, M. Reimers, C.P. Park, J.-F. Koenig

DOW DEUTSCHLAND INC., Industriestrasse 1, D-77836, Rheinmuenster, Germany

Tel.: (49) 7227 91 4293 / Fax: (49) 7227 91 4209 / Email: cvo@dow.com

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ABSTRACT
A new recyclable thermoplastic foam sheet product that improves on the limitations inherent to conventional materials, like mineral fibers, elastified EPS, extruded polyethylene foams, in particular for space constraint application, such as in the renovation market. The foam product is manufactured with a mixture of polystyrene, polyethylene and INDEX* ethylene/styrene interpolymer resin. The impact sound insulation performance, dynamic stiffness, short term creep recovery and long term creep resistance were discussed as a function of the resin characteristics and the foam structure. The novel foam sheet products of thickness of 3, 5 and 10 mm offer a ΔL_w of 18, 21 and 24dB respectively, while long term creep at 2.5 kPa load is less than 10%. The novel foam product is targeted for commercialization during this year.

1 - INTRODUCTION
For impact sound insulation in building construction, mineral fibers, elastified EPS and thin polyethylene foams are primarily used currently. However, for space constraint applications, such as renovation of old construction, these products present one or more drawbacks. Mineral fibers usually offer excellent impact sound performance [1], but the products are too thick, occupy precious space and suffer strong deformation under load. Elastified EPS products present good impact sound performance, but share some drawbacks of mineral fiber products, and are too friable if made thin. Thin polyethylene foam sheet products suffer from long term creep under high loads although their acoustical performance is satisfactory.

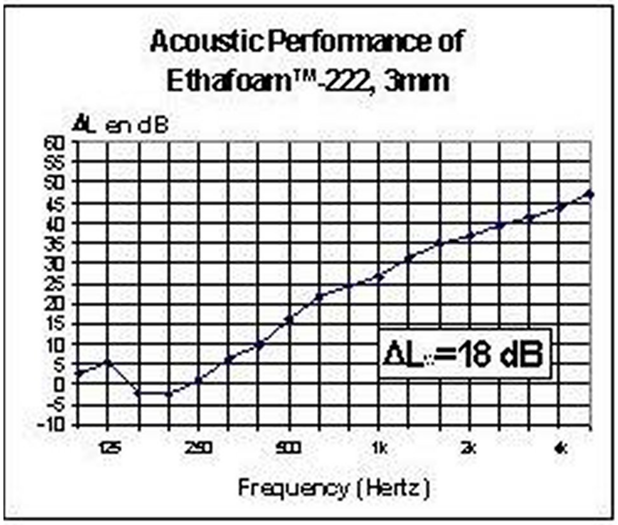
The objective of this work is to develop a product suitable for impact sound insulation in space constraint applications. The product should meet the impact sound performance, while its long term creep performance, compressibility and recovery from high deformation should be superior to polyethylene foams.

2 - PRODUCT DEVELOPMENT
The impact sound insulation in the renovation market find applications mainly in floating floors such as screed-floating floor or parquet floating floor. Because of room height, and door height restrictions, the desired thickness requirement is usually equal or less than 10 mm.

Mineral fibers and EPS usually offer products thicker than 20 mm [1]. Therefore, in many cases, thin extruded polyethylene foam sheets are often proposed. In some cases, cross-linked polyethylene foam sheet is also offered, however the material is rather expensive, and the acoustic improvement is relatively low to meet acoustic requirements.

The extruded polyethylene foams, particularly the ones produced by The Dow Chemical Company under trademark ETHAFOAM*-222 or ETHAFOAM*-SD offer sufficient acoustic performance, as demonstrated by the test conducted at CSTB institute [2].

ETHAFOAM* extruded polyethylene foam sheet, when initially installed offers sufficient acoustic performance, but under a very high load application and at a longer term, it may be subject to creep. This can become dramatic for other lower density and lower quality products of thin polyethylene foamed sheet



Frequency (Hz)	ΔL (dB)
100	2.5
125	5.3
160	-2.2
200	-2.6
250	0.7
315	6.3
400	9.5
500	15.9
630	21.7
800	24.2
1000	26.7
1250	31.5
1600	34.7
2000	36.7
2500	39.2
3150	41.4
4000	43.8
5000	47.1

Figure 1: Acoustic performance of ETHAFOAM*-222, 3 mm.

on the market. The creep will result in a reduction of thickness, leading to a higher dynamic stiffness, thus reducing impact sound performance.

On the other hand, we know that STYROFOAM* extruded polystyrene foam; trademark of The Dow Chemical Company offers excellent thermal insulation and outstanding long term creep performance. The FLOORMATE*-A-500 material for example, creeps less than 2% under a load of 210 kPa (210 tons/m^2) during a period of 50 years [3]. However, the material does not provide the desired impact sound performance, due to its too high rigidity.

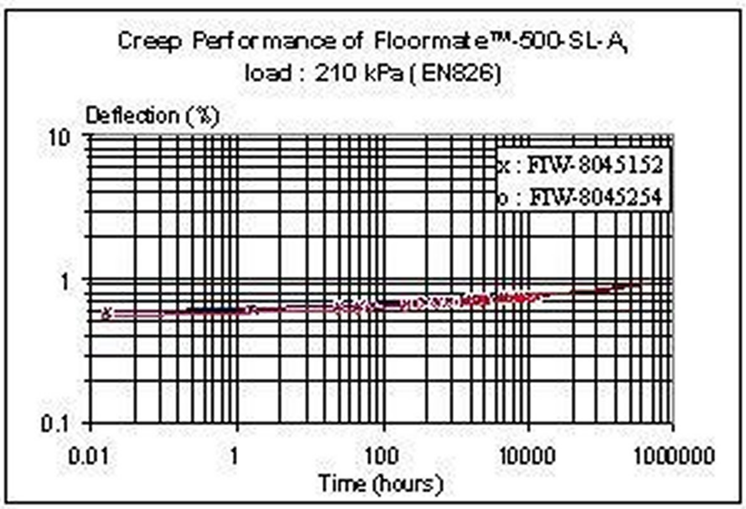


Figure 2: Creep performance of STYROFOAM*-500-A [3].

The major challenge in impact sound insulation is that a soft material is needed to provide the desired acoustic properties. On the other hand, the softer a material is, the worse its creep performance has been.

Therefore, one can think that blending a polystyrene with a polyethylene would be suitable to provide such a compromise between acoustic performance and stiffness. However, these two thermoplastic polymers are not compatible. Mixing them results in a less than desirable mechanical property blend, and is difficult to foam. To remedy the incompatibility, we found that a third component may be used to enhance the mixing between polyethylene and polystyrene. The third component used in the blend reported here was made possible thanks to the recent development of the new metallocene technology, allowing the production of INDEX* ethylene/styrene interpolymer. This product helped to enhance the dispersion between polyethylene and polystyrene, and further to its intrinsic property, possesses a high damping ratio, that neither of these two initial resins has.

3 - EXPERIMENTS: RESULTS AND DISCUSSIONS

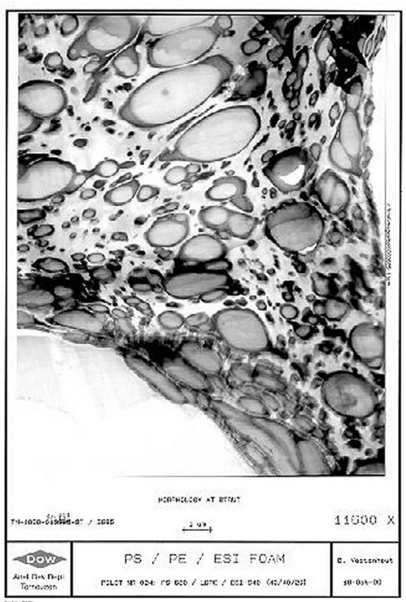
A novel foam sheet has been developed, using the foaming extrusion process. The polymer feedstock is composed of three components: STYRON* polystyrene (general purpose or high impact polystyrene), a low density polyethylene and INDEX* as a compatibiliser.

The mixture is melted in the extruder, and the blowing agent is injected into the mixing zone. The resulting gel is then cooled down through secondary extruder and/or several heat exchangers before expanding through a die at atmospheric pressure.

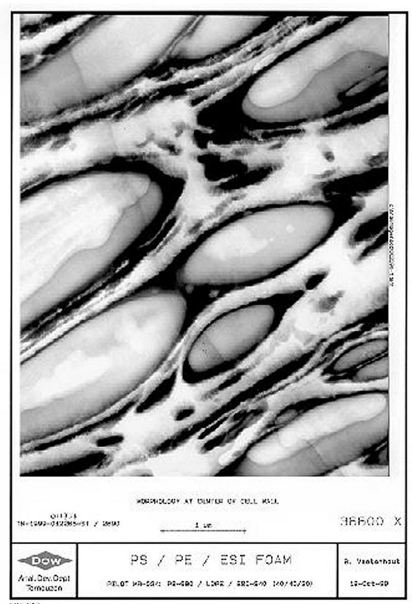
The acoustic performance, and particularly the impact sound insulation is further enhanced by the presence of open cell structure, specifically designed and achieved through foaming processing operation.

As it can be seen, the three resin components should be judiciously adjusted, to achieve optimum overall performance. For example, a high concentration of polystyrene would improve the mechanical properties, but the softness tends to suffer. On the other hand, a high concentration of polyethylene would improve the softness, but it may result in a less than desired recovery and creep. The INDEX* polymer offers excellent damping properties, but a high concentration may adversely affect the strength and mechanical properties.

Most importantly, the dispersion of material should be uniform. As can be seen on Graph 3a, in the strut of the cell structure, the dispersion of polyethylene is quite uniform in the matrix of polystyrene, and the nodules are well enrobed by the INDEX* ethylene/styrene interpolymer to ensure the compatibility between these two polymer phases.



(a)



(b)

Figure 3: Cell morphology in the strut and cell wall of the novel foam.

Such a structure seems to allow the foam product to meet the acoustic performance while still achieving suitable creep resistance, as well as thickness recovery after a high load, like the test specified in prEN12431, well known as dL-dB test.

Concerning creep performance, the novel experimental foam sheet (EF-J) exhibited excellent performance. At equivalent dynamic modulus, the new product is twice as resistant to creep than the reference ETHAFOAM*-SD, well known as a good product for impact sound and creep resistance.

The novel foam EF-J sheet, further tested at 3 ranges of thickness, 3, 5 and 10 mm presented following acoustic and mechanical properties:

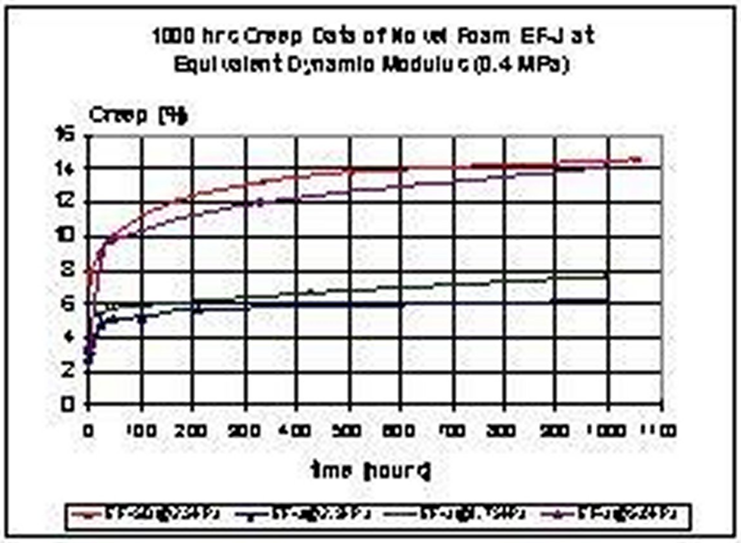


Figure 4: Creep performance of novel foam EF-J at various creep load.

	Unit	EF-J-3	EF-J-5	EF-J-10
Thickness	[mm]	3	5	10
Dynamic Stiffness [1]	[MN/m^3]	105	65	40
Dynamic Modulus [2]	MPa	0.315	0.325	0.4
Impact Sound Improvement ΔLw [3]	[dB]	18	21	24
Thickness recovery dL-dB [4]	%	10%	10%	10%
Creep, @3.5 kPa [5]	%	7.3%	7.3%	7.3%

Table 1: Acoustic and mechanical performance of novel impact sound insulation sheet.

- [1] Dynamic Stiffness according EN29052
- [2] Dynamic Modulus = Dynamic stiffness * Thickness
- [3] ΔL_w calculated according prEN 12354-2 with screed of 100 kg/m^2 surface weight
- [4] dL-dB according prEN 12431, calculated back as % of original thickness
- [5] 1000 hour creep test based on EN 1606

As can be seen on the above Table, the novel foam sheet, for which there is a patent pending, exhibited superior performance when compared to most of the products known today in the renovation market. It is being validated on a commercial scale.

4 - CONCLUSION

Through judicious selection of polystyrene, polyethylene and INDEX* ethylene/styrene interpolymer resins, a specific resin blend composition has been developed in order to produce a foam sheet, suitable for excellent impact sound insulation while maintaining its creep resistance, as well as good recovery from high load compressive test.

The new foam sheet is produced at three thicknesses, namely 3, 5 and 10 mm, and offers impact sound insulation performance of 18, 21 and 24 dB, while the long term creep under a load of 2.5 kPa is less than 10%.

The product is targeted for commercialization by The Dow Chemical Company during this year.

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