FACTSHEET

EUROPEAN DIISOCYANATE & POLYOL PRODUCERS ASSOCIATION

ISOPA

The Benefits of Polyurethanes in Transportation

INTRODUCTION

This factsheet describes the important and growing role of polyurethanes (PU) in a very wide range of applications in vehicles and transportation. The main benefits which polyurethanes bring are comfort, safety, weight saving and longevity coupled with design freedom. PU is used in every form of transportation throughout the world and brings several additional benefits to the transportation manufacturing and using industries in the European Union through employment and wealth creation.

This factsheet is the third in a series published by ISOPA (see www.isopa.org) on the sustainable development factors for PU applications. The other factsheets cover the roles of PU in building energy efficiency and in the cold food chain.

SUSTAINABLE DEVELOPMENT FACTORS

Transportation is synonymous with energy use and could be considered as contrary to sustainable development principles. However, given the societal need for mobility and independence, particularly in developed countries, it is part of a responsible industry's role to reduce the impact of transportation on society and the planet. PU is also widely used in public transportation for exactly the same reasons as it is used in the various modes of private transport, such as cars.

Environmental Protection

In the EU the transport sector is responsible for one third of the total emissions of CO_2 and this proportion is growing. The reduction of weight of vehicles resulting in less energy use makes a critical contribution to reducing emissions. Better fuel efficiency also gives less pollution by particulate matter from burning the fossil fuels for this energy. PU also contributes by reducing the material intensity through high performance coatings improving material durability, weather and corrosion resistance. Water, rather than solvent-based, coatings give environmental benefits.

Social Responsibility

PU materials contribute by providing improvements in the passenger safety (passive and active) of vehicles. They also provide superior comfort in seating and through the reduction of noise or of annoyance from fogging and smelling by using advanced polyurethane systems.

The automotive manufacturing industry based on PU in the EU employs a total of about 450,000 from chemicals manufacture up to the end use industry and including the contribution from indirectly involved industries.

Economic Development

The versatility of PU reduces production costs and makes the vehicles produced competitive in the global market. The EU industry based on polyurethanes includes over 10,000 companies and a high proportion (>85%) are SMEs, the engines of growth. In the EU the value of transportation components based on PU is about €40 billion.

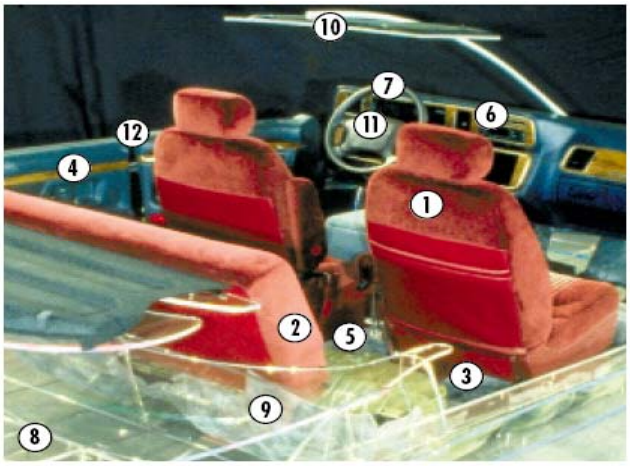
POLYURETHANE TRANSPORTATION APPLICATIONS

Polyurethanes in Passenger Cars

Passenger cars are the fastest growing sector and it is very important that the benefits of polyurethanes are used to their full extent in this sector. Today's key objective for the automotive industry is to develop cars which are clean, safe, energy efficient and affordable. PU combines lightweight and flexibility with great strength and durability. Its versatility is instrumental in achieving the precise mechanical properties required for specific applications.

A typical medium sized car of 1,000 kg total weight contains 100 kg of plastics, of which about 15 kg are PU. Car manufacturers recognise that, by choosing PU, they can significantly improve the quality, safety and cost-effectiveness of modern cars, and increase their technical, environmental and economic performance at the same time.

1 Seat foam
2 Cushion overlay (fabric backing)
3 Carpet backing
4 Door panels
5 Sound absorption and vibration dampening
6 Dashboards
7 Steering wheels
8 Bumpers
9 Energy absorbers
10 Headliners
11 Airbag covers
12 Window encapsulation



Polyurethanes in Public Transportation

PU plays an increasing role in buses, trains and trams and in rail tracks and systems. In public transportation PU-based seating is used as well as moulded parts in safety applications, just as in passenger cars. For trains and trams, pre-coated PU encapsulated rails provide high electrical insulation, vibration resistance, noise reduction, anti-skid and anti-corrosion properties. In addition, PU in this application substantially reduces installation time and civil engineering long-term risk and increases service life.

The uses of PU coatings for large vehicles (buses, trucks, rail carriages and aircraft) are similar to those for automotive coatings and save energy during application because they cure at low temperatures and provide excellent protection which ensures a long life in these demanding applications with minimum maintenance reducing overall reliance on virgin materials.

Polyurethanes in Freight Transportation

The PU industry's products and systems for the commercial transportation market help decrease both weight and cost by enabling thinner vehicle wall construction, reduced steel support structures and fewer mechanical fasteners. PU is used in the commercial transportation industry for body panel, front & rear systems, surrounds, wheel covers, grilles, moulding and trim to improve impact resistance, corrosion resistance, energy management and vehicle aesthetics.

A major application of PU rigid foam is in the production of systems for the transportation of food in refrigerated ships and by road and rail in refrigerated containers (reefers) and trucks. These applications are fully described in the accompanying factsheet The Role of Polyurethanes in the Cold Food Chain which is available on www.isopa.org .

VEHICLE ENERGY EFFICIENCY WITH POLYURETHANE COMPONENTS

This section of the factsheet describes how the various polyurethane applications lower environmental impact by reducing vehicle weight. This improves fuel efficiency and lowers emission levels.

Vehicle Seats

In the last five years the density of polyurethane for major applications has been reduced by 30 to 40 per cent while still maintaining the same mechanical properties. Seating foam, for instance, has one of the lowest densities of any plastic material used in a car: 0.03 to 0.05 g/cm3. Polyurethane foam in headliners is another good example with a density of 0.02 to 0.04 g/cm3.

Truck Bed Liners

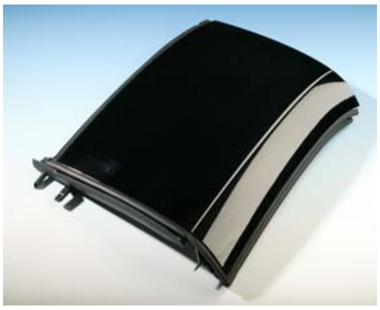
Truck bed liner made from compact PU-system, with 50% by weight glass content, displays

- High stiffness at only three mm thickness
- No corrosion, no buckling
- Freedom in design

Introducing this material allowed significant weight reduction compared with steel.

Polyurethane Composites

PU enables light weight composites based on paper honeycombs. These parts are very rigid, offer high heat resistance and dimensional stability, allow in-place moulding of inserts and give high freedom of design and tailored property profiles.

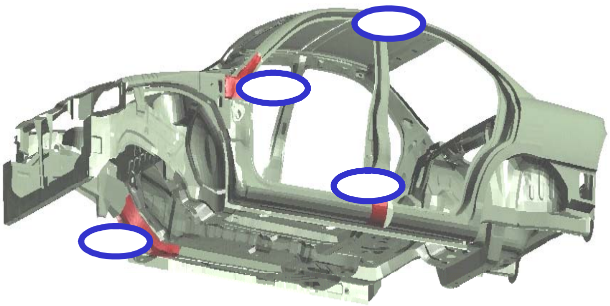


Composite Door Panels

In automotive engineering, natural fibre mats combined with PU systems have opened up new possibilities for the production of door trim. They have the particular advantages of being extremely thin and light. A composite containing up to 65% of flax or sisal fibres and

and PU as the binder has exceptionally high mechanical strength. Wall thicknesses of only 1.5 to 2.0 mm can be achieved. The weights of the end products are also extremely low at 1,250 to 1,600 g/m^2. Weight reductions of up to 2.5 kg per vehicle can be achieved in comparison with traditional materials. The use of large proportions of renewable raw materials further reduces the CO2 in-balance.

Structural Bonding



The bonding of glass windscreens to the metal body using PU seals and adhesives is very widely used. Glass bonding reduces weight, improves dynamic stiffness and strength, ensures cavity sealing and lowers cost.

Newly developed structural bonding applications can save up to 5 kg metal /1 kg of PU structural foam used. A large number of car manufacturers have published information on structural bonding weight saving aspects.

New vehicle bonding types	Adhesive material	Amount*/car
Plastic/Glass: tail gate	PU	0.3 kg
Plastic/Metal/Glass	PU, acrylics	1 kg
Plastic/Plastic	PU, acrylics	0.5
Pre coated metals	PU	small
Structural Bonding	PU	very small
Total		max. 3 kg

* for those OEM's widely using bonding technologies

Weight Savings

The weight reduction coefficient (WRC) depends very much on the car design, the application and manufacturing process. Examples of WRC are 3.5 kg for the Renault E84 through 0.035 kg of structural adhesive and Daimler-Chrysler with a WRC of 17 to 20 kg material/kg of structural bonding materials. The new E Class uses 65 m of bonding material giving a weight saving of >10 kg. The new BMW 7 series similarly has a total bonding length of 150 m weighing only 1.5 kg applied to steel/steel construction. High modulus glass bonding systems compared to standard modulus systems increase the body stiffness by 25 % to 35 %, which is equivalent to a weight reduction coefficient of 20.

CO_2 – Energy savings

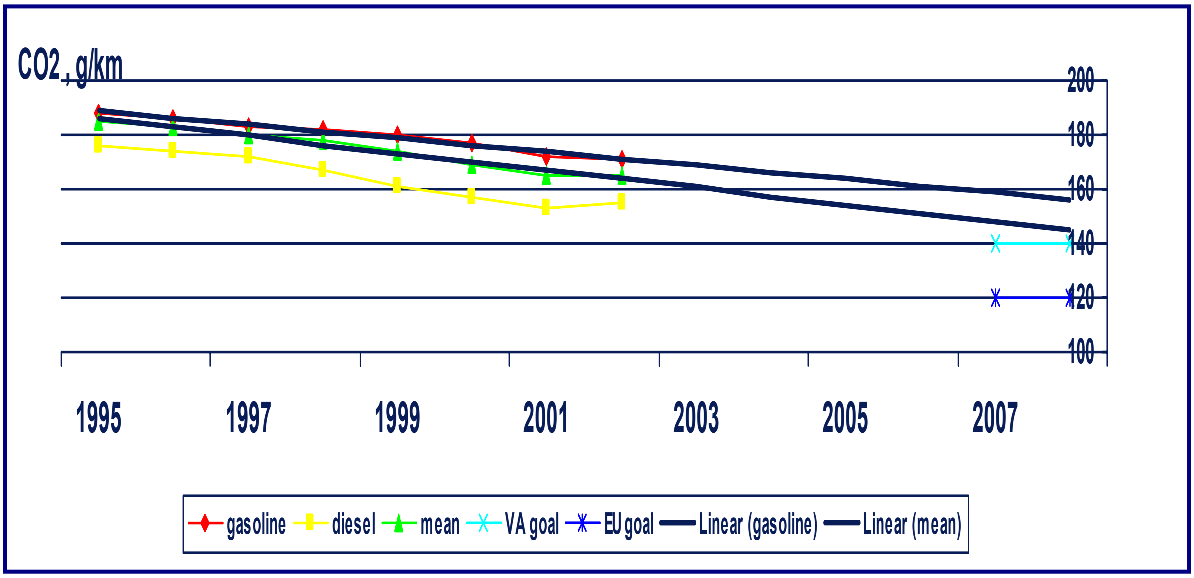
The effectiveness of bonding materials can be expressed with the help of the fuel reduction coefficient (FRC) with the values based on actual experiences from manufacturers for large volume vehicle production experience. The WRC values taken for the calculation here were 10 and 20 kg of material savings per kg of bonding material expressed as bonding material effectiveness (BME). The calculation assumes an average driving distance of 150,000 km.

Material efficiency of bonding applications						
Vehicles types	**Large**		**Medium**		**Small**	
FRC, Litre/100 kg*100 km	0.5		0.4		0.3	
WRC, kg weight /kg bm	10	20	10	20	10	20
FRC * WRC, Litre fuel/ kg bm	75	150	60	120	45	90
FRC/WRC, kg fuel /kg bm	60	120	48	96	36	72
Bonding material Efficiency * MJ fuel /MJ bm	**20**	40	16	32	12	**24**

**For BME calculation use average fuel density = 0.8 kg/litre, average fuel energy value 42 MJ/kg using litre of fuel/litre of oil conversion*

The results can be seen as conservative estimates, but demonstrate the high power of mass reduction through bonding applications. The calculations assume an average energy content for the fuel of about 40 MJ/litre and for the bonding raw materials such as PU or epoxy, which have gross energy contents of about 104 and 141 MJ/kg, respectively. For the average bonding material efficiency, an energy content of 125 MJ/kg bonding material is used. The bonding material efficiency (BME) is calculated to range from 25 to 121 on a unit to unit basis. The BME calculated as above is a true ratio of material substitution and the high number of 100 to 1 shows the incredible performance to reduce material and save 100 times the energy put into the chemical process used in producing the bonding materials. The environmental savings can also expressed in savings in tons of CO_2 but the BME ratio gives a much clearer appreciation of the power using bonding methods to save weight.

EU Fuel Consumption Targets and Data



This figure shows the progress being made in the EU towards the voluntary agreement set by the European automotive manufacturers (ACEA) and the goal set by the EU. PU has contributed towards these achievements.

Durability

Automotive finishing is one of the most technologically demanding coatings applications requiring protection against all kinds of environmental influences plus an attractive gloss finish. Coatings for aircraft must also be able to withstand intense UV radiation and temperature extremes. Coatings for high-speed trains must have very good resistance to stone chipping. The large size of those vehicles precludes the use of baking coatings. Two-component polyurethane coatings have become the industry standard in this segment because they can be cured at low temperatures and have excellent resistance properties.

COMFORT AND SAFETY WITH POLYURETHANE COMPONENTS

This section of the factsheet describes how PU adds to safety and comfort in transportation applications. These important benefits are brought about through the use of components which also contribute to weight saving.

Seating and Car Interior Components

High resilient foams in seats provide comfort under static and dynamic conditions. The design freedom of PU allows shaping to support the body to enhance comfort in ergonomic driving positions. Head rests are also based on PU and are important safety elements in the event of an impact.

Steering wheels and other interior components are based on integral skin PU which combine aesthetic appearance and functionality. They are also designed to minimise injuries in the event of a collision.

Noise and Vibration Reduction

PU vehicle acoustic systems reduce interior noise by isolating and absorbing noise and vibrations generated by the engine, suspension and tyres - the principle sources of in-car noise. Excessive noise has both comfort and safety implications, particularly for the driver of a vehicle. Effects range from simple interference with speech to the more serious onset of fatigue and loss of concentration. PU, which is combining sound insulation, sound absorption and vibration attenuation in a single carpet composite, reduces assembly cost; increases design freedom and give access to lower cost cars ranges.

PU acoustic systems also offer significant weight savings over conventional under-carpet systems such as bitumen sheet or fibre felt.

Shock Absorbers

Nearly all car makers fit shock absorbers equipped with spring aids made from a special cellular polyurethane elastomer. This type of wear resistant polyurethane withstands all the mechanical and dynamic loads to which such spring aids are subjected, and is the only material capable of satisfying all the requirements of the space- and weight-saving component design.

Bumpers

The excellent shock absorption properties of polyurethane in, for example, bumpers and dashboards ensure the safety of drivers, passengers and pedestrians.

RECOVERY AND MATERIAL CONSERVATION

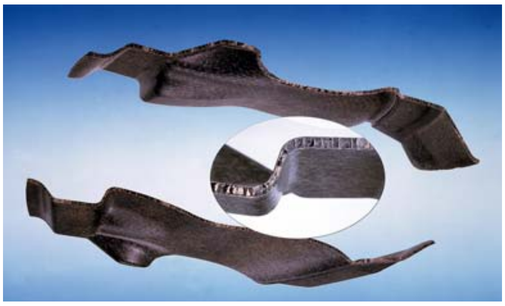
An important aspect of sustainable development applied to transportation is to optimise the use of materials and resources. PU contributes by being used at low densities in many applications and is a durable material resulting in components which have a long life. Fuel economy has been significantly improved. During manufacturing, good process control and the wide processing window result in low wastage by reducing the percentage of sub-standard components to very low levels.

In addition to these characteristics, the recovery aspects at the end of life of the vehicle/component, both energy recovery and recycling, have been thoroughly investigated. In the EU there are various legislative drivers such as the Directive on End of Life Vehicles (ELV – Directive 2000/53/EC) and horizontal measures such as the Landfill Waste Directive (1999/31/EC). The former requires the reuse and recycling of 80% by weight of a car by 2006 and this increases to 85% by 2016. For end-of-life materials and automotive applications energy recovery is the best option in eco-efficiency terms. If the infrastructure and number of incinerators is not sufficient then alternative routes such as feedstock, mechanical and chemical recycling will also have to play their roles.

There are a number of factsheets available from www.isopa.org which describe energy recovery and recycling options for PU.

IMPACT ON ECONOMICS

PU Optimises Processing Costs



PU offers engineers a wide choice of performance and processing characteristics, allowing applications to be tailor-made into advanced shapes and forms using the same basic chemicals. This contributes to lower vehicle costs and reduces the generation of scrap material.

Short production cycles as well as part integration and many other innovations made possible by PU help in cutting production cost and making cars competitive in the global market place.

Polyurethane Added Value

The annual value of vehicle components based on PU produced in the EU is about €40 billion. The value of the vehicles using these components is clearly several times this. These are produced by about 70 manufacturers but more than 10,000 other companies are involved in activities such as distribution. The total number employed in the value chain adds up to as many as 450 000 - from chemicals manufacture up to the end-use industry and including the contribution from indirectly involved industries.

CONCLUSIONS

This factsheet illustrates the large contribution that a very wide range of PU-based products make to lessening the environmental impact brought about by society's desire and necessity for mobility. The versatility of polyurethane chemistry is fully utilised in a growing range of applications and these applications result in less energy being used, comfort is enhanced and the safety of operators and passengers is addressed.

As transportation needs will continue to grow in private and public sectors and in distribution of goods polyurethane will play an increasing role across the world.

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