



Innovative solutions made of aluminum foam for lightweight construction



strong lightweight

- Founded in 2013 at the industrial site of Kirchmöser (Brandenburg an der Havel)

- Specialization in the industrial manufacturing of aluminum foam products

- Own series of Havel Lite® products

- Combination of many years of know-how's from science and industry

- Highly innovative lightweight materials for new industry solutions

Unique features



Unique

World's single manufacturer of four different aluminum foam series production technologies

Competent

Unique manufacturing technology for metallic bonded materials and components

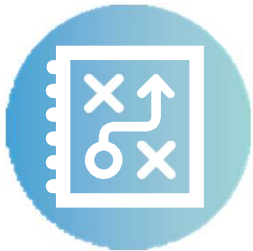
Versatile

Versatile product range and new cost-effective industry solutions that revolutionize lightweight construction

Innovative

Inhouse R & D department for new projects and prototype development

Services



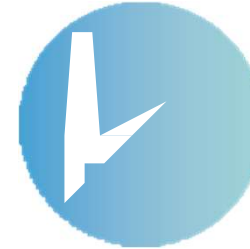
Research & Development



FEM calculations



Product solutions



Series production



Processing

Technology



Series production of aluminum foam products

- Sandwiches
- Panels
- Foam-filled profiles
- 3D formed parts



Processing technologies

- Bending
- Welding
- Milling
- Drilling
- Mechanical processing



Technical equipment

- Infrared furnaces
- Electrically heated continuous furnace
- Portal milling machine
- Rolling plant



Havel metal foam

Aluminum foam



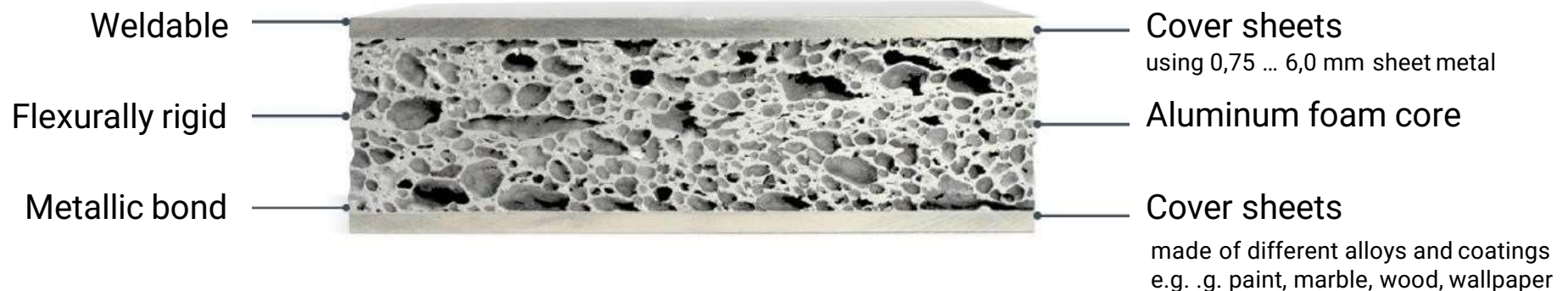
Aluminum foam



An innovative material with unique properties

- Extremely light and yet strong
- Cellular structure of the foam ensures that the material withstands extreme loads e.g. in energy absorption
- Trendsetting alternative to fiber composite materials, pure aluminum, steel and other conventional building materials.

Sandwich application example:



Advantages of aluminum foam

The 2+1 product advantages



Lightweight



High
Mechanical
strength

at least one of the following
product advantages:

- Simple mechanical processing possible (drilling, sawing, milling, welding)
- Good electromagnetic shielding
- Energy absorption / good crash behavior
- Foamability of inserts, threads, bolts (SAS)
- Repairable
- Strong vibration damping
- 100% recyclable
- Very good thermal conductivity
- Sound insulation
- Weldable
- Non-flammable (HL3 approval according to EN 45545)



New and cost-effective solutions for lightweight construction with aluminum foam

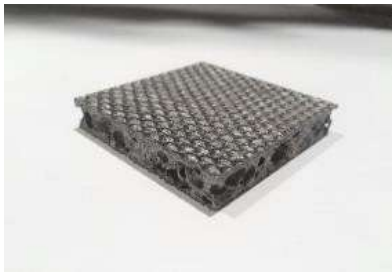
Product solutions



Havel Lite® AFP



Pure aluminum foam panel with cast skin as outer layer



Steel wire mesh improves the tensile strength of the foam



Very high Aluminum foam panel



Coated Aluminum foam panel

Pure Aluminum Foam Panels

- Manufacturing from a height of a few millimeters up to a thickness of 75 mm possible
- Aluminum foam panels with steel mesh inserts are very tensile and less brittle
- Lighter than sandwiches and far more favorable than e.g. carbon

Havel Lite® Sandwiches



*Verschweißte
Aluminiumschaum-
Sandwiches*

Aluminum-Aluminum foam-Sandwiches

AAS

Havel Lite® Aluminum foam
with aluminum sheet cover layers

Steel-Aluminum foam-Sandwiches

SAS

Havel Lite® Aluminum foam
with steel sheet cover layers



Production technology:
directly embedded fasteners



Processing options:
Drilling, Welding, Milling



Production possibility:
Laminated sandwich

- Metallic bond
- Non-flammable
- 100% recyclable
- Repairable
- Strong vibration damping
- Different alloys / coatings possible (e.g. paint, high-pressure laminate, wood)
- Embedding of fasteners, rails or threaded inserts (only with SAS)
- Copper sheet cover layers are also possible

Havel Lite® Foam-filled profiles



Foam-filled steel profiles

- Excellent damping properties, while reducing weight
- Filling of profiles and cavities with metal foam
- Improved vibration damping properties for fast moving components
- Higher accuracy and speed during further processing



*Foam-filled profiles
Bending test*



Foam-filled aluminum profiles



Foam-filled steel profiles

Havel Lite® 3D formed parts



- Almost every geometric shape possible
- Non-flammable, no smoke
- Long lifetime
- 100% recyclable
- High energy absorption
- Good crash behavior
- Noise and vibration damping
- Extremely light
with densities of approx. 0.7 g / cm^3



Shock absorber element



Drink holder

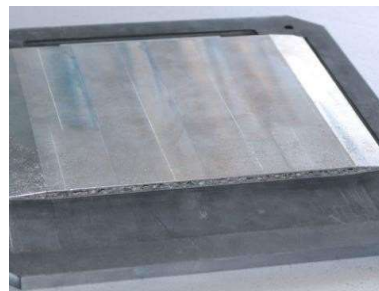


3D element

Havel Lite® 3D formed parts



Custom drawing parts



Connection without
weld seam



Fastener

- Almost every geometric shape possible
- Non-flammable, no smoke
- Long lifetime
- 100% recyclable
- High energy absorption
- Good crash behavior
- Noise and vibration damping
- Extremely light
with densities of approx. 0.7 g / cm^3

Suitable for use in water, air and land



Automotive



Safety & Protection



Railway industry

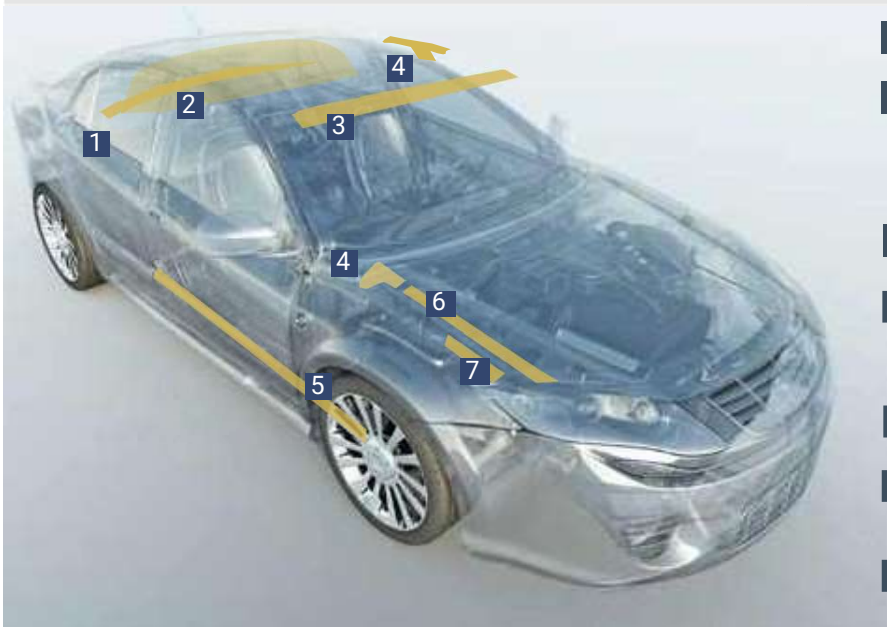
- Aerospace engineering
- Shipbuilding
- Wind energy
- Mechanical engineering
- Offshore
- Construction industry
- Energy technologies

Automotive

Areas of application

Stiffening elements in the body area, for example:

- Foamed bumpers
- Node areas, joints
- Side impact protection
- Doorsill
- Roof rack, side member, cross member
- Surface elements, e.g. roof bow



- 1 Crossbeam
- 2 Aluminum foam crash absorber in the luggage net of an Audi Q7
- 3 Roof rack
- 4 Stiffening elements in nodal areas
- 5 Doorsill
- 6 Longitudinal beams
- 7 3D molded part of a shock absorber



*3D molded part
Shock absorber*



*3D molded part
Window frame*



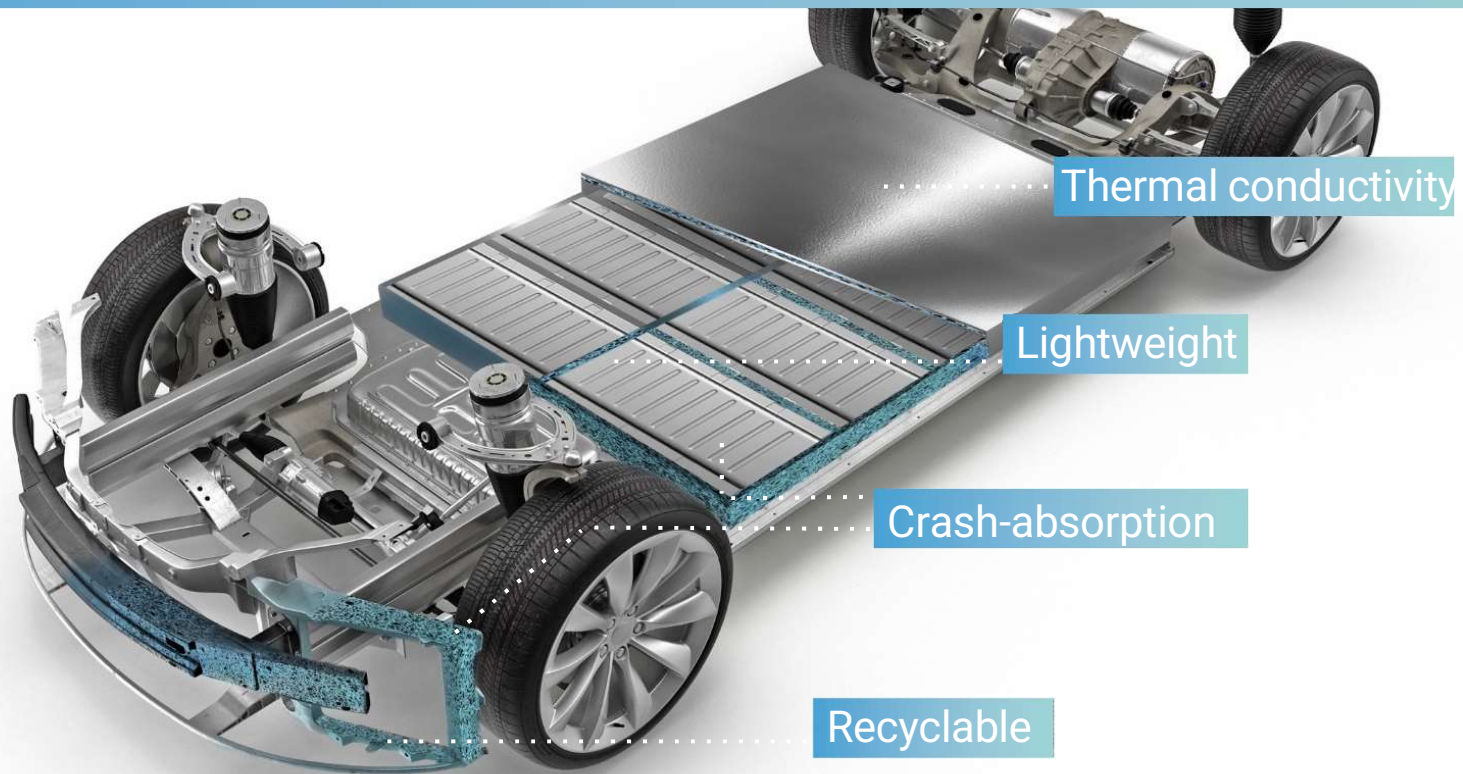
*3D prototype
Vehicle roof bow*

Advantages

- High energy absorption in the event of a crash due to plastic deformation
- The buckling and compression behavior of steel profiles is greatly improved
- Weight savings
- Excellent vibration damping, e.g. engine vibration
- Increasing the torsional rigidity of the overall body by approx. 10%
- Recyclability

Battery box of the future

made of aluminum foam for the automobile industry



Sandwiches · Panels · Foam filled profiles · 3D shaped elements

Possible applications

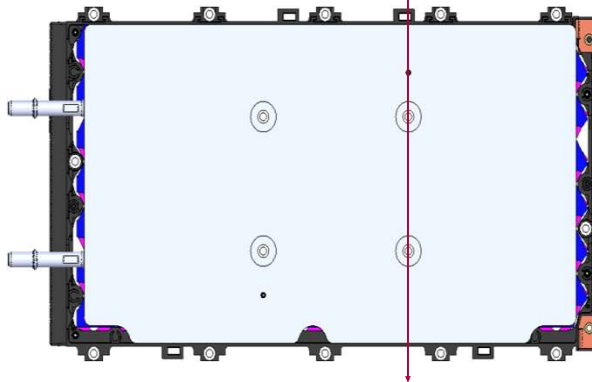
Complete battery box



Underbody protection



Cooling plate



Battery partitions

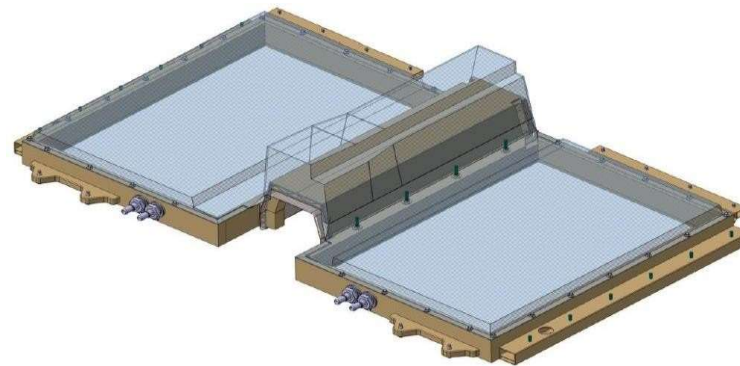


Possible applications

Side crash element



Battery systems for hybrid vehicles



Complex structures



Battery cover



5 Header goes here

Date

Thermal propagation test

New fire safety homologation

Battery homologation 'Fuel tank simulated fire test'



Battery is positioned in the fire
Performed on battery or battery with
some components that could influence
flame behavior

Duration: 130 s

2016

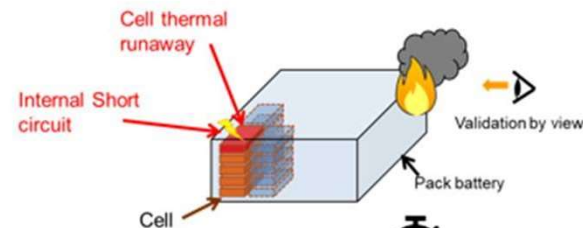
+3 hours after
removed from fire

Europe/Japan: GTR EVS

Newness = 'Thermal Propagation test'

Simulation of a short circuit leading to a thermal runaway in a cell
=> vh test or battery test

CONFIDENTIAL C



Battery test

Duration: 5 min after detection
of the thermal incident.



Vh test

Specs: 5 min after detection of
the thermal incident.



2023

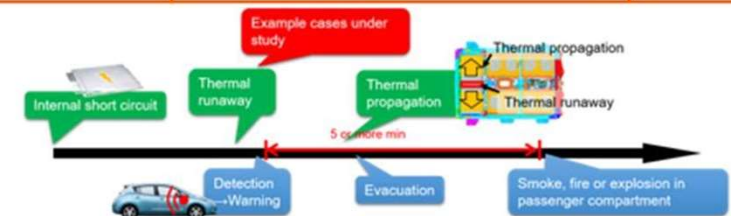
New type
battery

2025

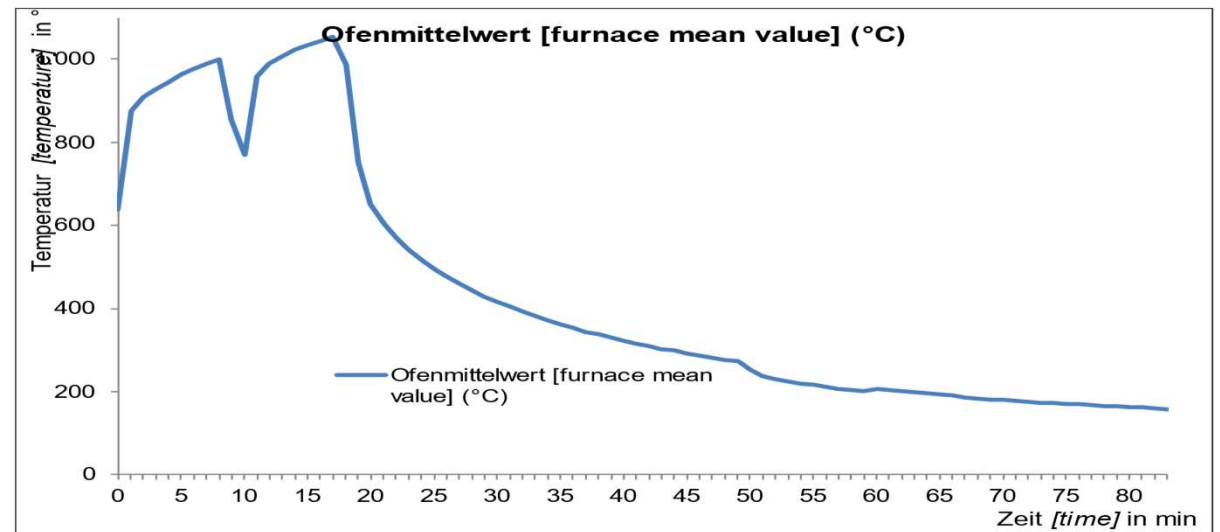
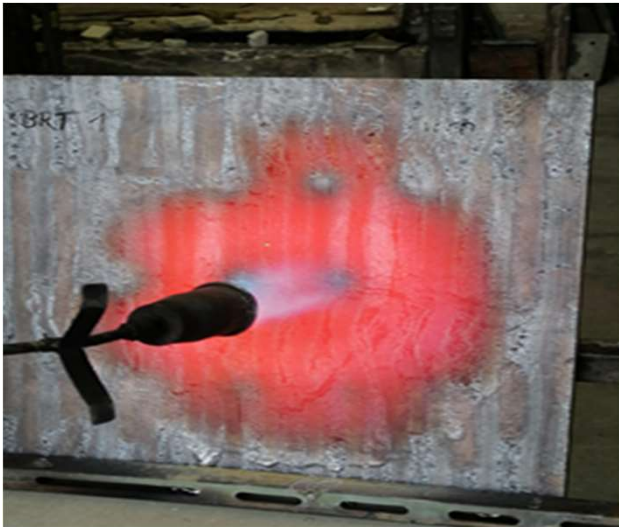
All type
battery

Chine
GB 38031

Jan 2021



Tests



Protection of hydrogen tanks according to UNECE standard R134 made with aluminium foam for the automotive industry





Protection of hydrogen containers against:

- fire
- explosion
- vibration
- energy absorption /
good crash behavior

Protection against explosions, fire and ballistics

Aluminum foam systems are suitable for the protection of persons and buildings

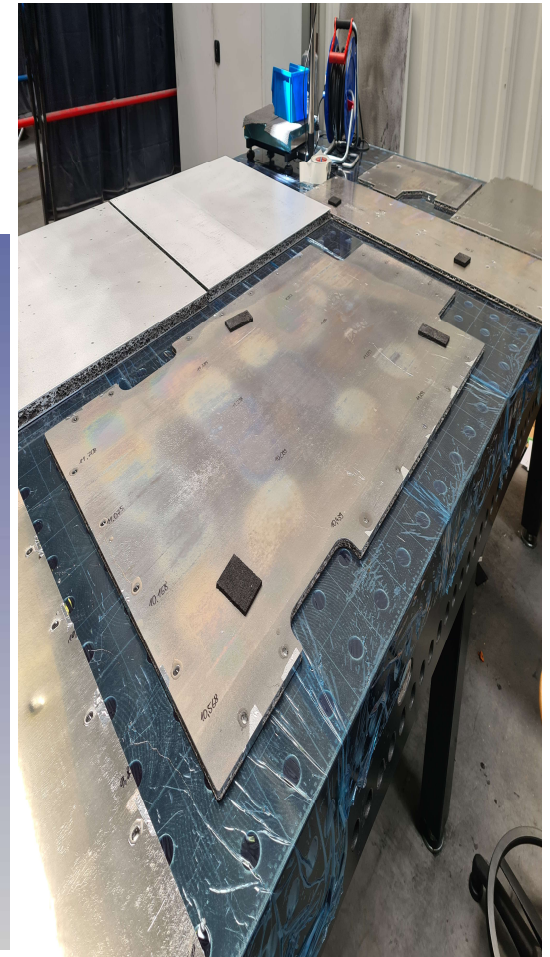
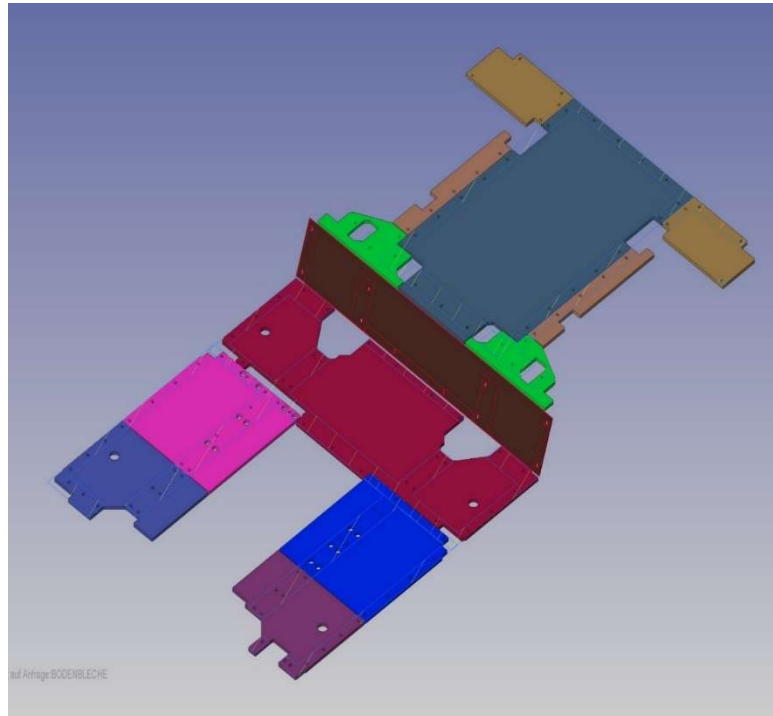
Aluminum foam systems are suitable for protecting cars and buildings, particularly through being used as explosion protection, as well as being fire resistant because of the cellular structure of aluminum foam, it can convert large amounts of kinetic energy into deformation energy. During this process, the cell walls break down and the foam is compressed. This is why aluminum foam is able to protect underlying load-bearing walls from damage



Protection against explosions, fire and ballistics

Armored Car System: underbody protection

- Strong and lightweight
- Product solutions for armored cars

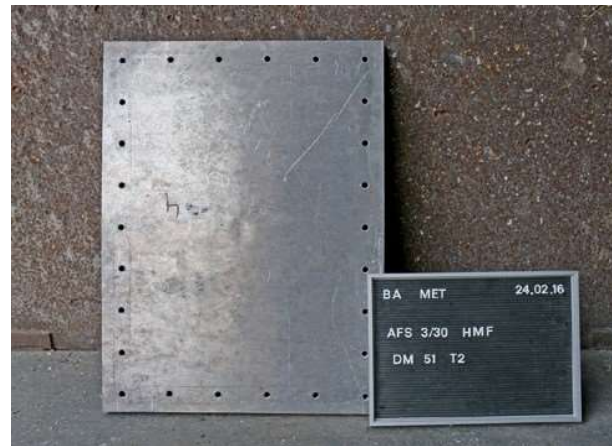


Protection against explosions, fire and ballistics

Protection - Explosion tests with aluminum foam sandwiches

Examination of the ability to resist blasts

2.



Used material: AAS 33-3-3

(33 mm composite plate made of 3 mm aluminum sheet, 27 mm aluminum foam, 3 mm aluminum sheet)

Explosive: Hand grenade DM51

(59 g PETN)

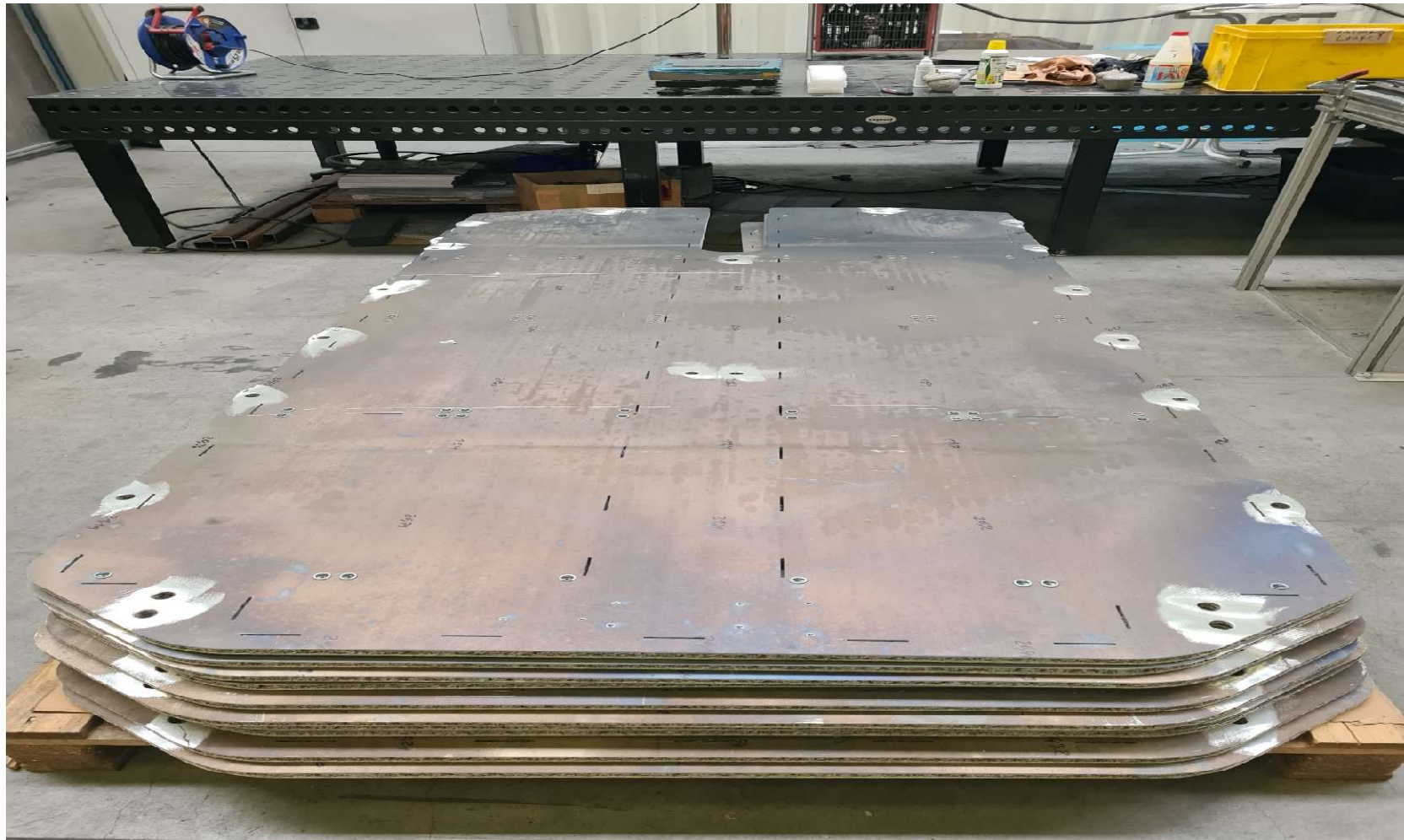
Result:

The dynamic deformation of the test object was max. 15 mm.

The side facing away from the explosive had no splayings of splinters.

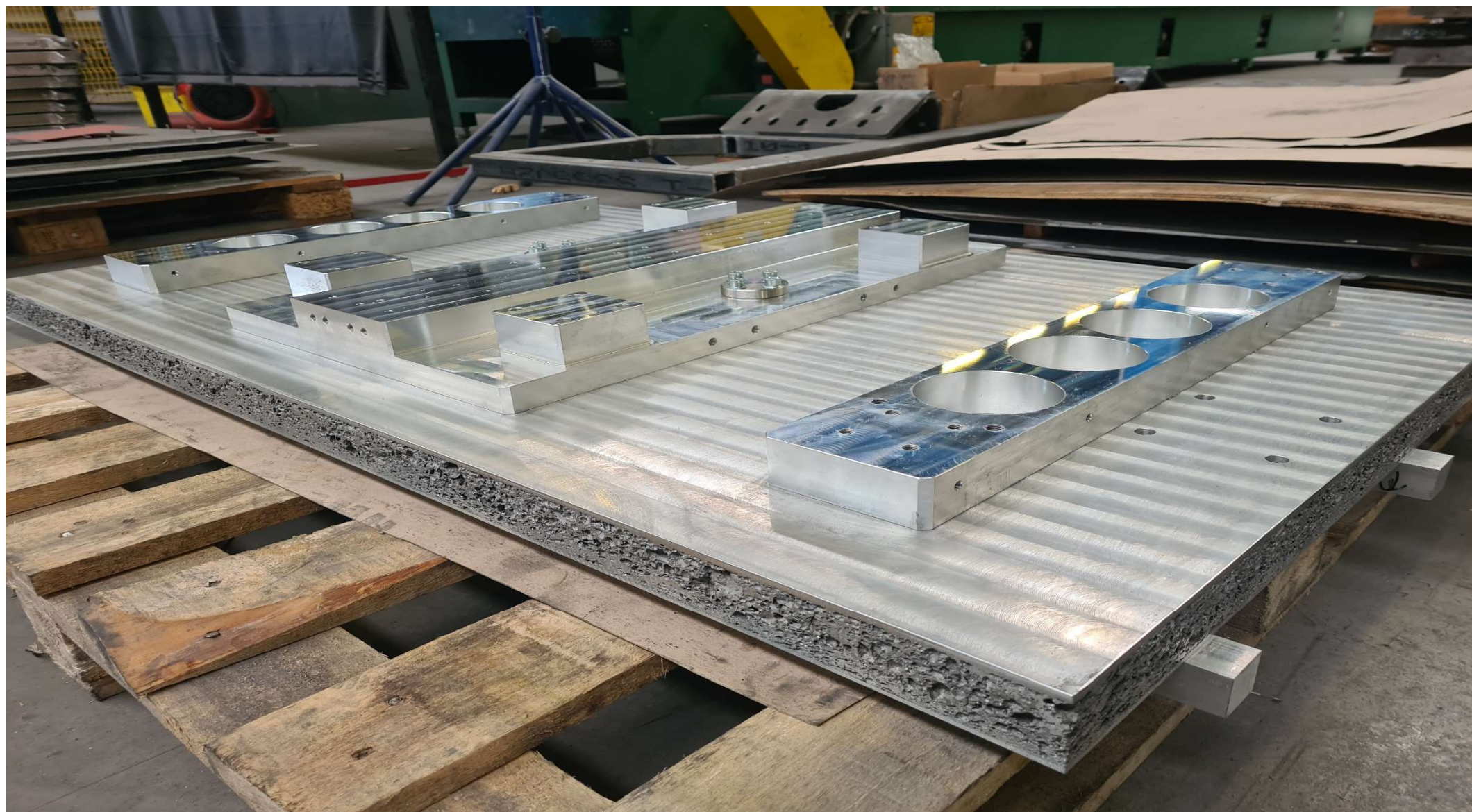
The splinter indicator was undamaged.













Protection against explosions, fire and ballistics

Blast results								
discription	Construction	Thickness (mm)	weight (kg)	Resulting surface area (kg/m ²)	Disintegrants	Distance (mm)	Medium dyn deformation (mm)	max. dyn. deformation (mm)
AFS 3_30	3mm Al-plate 25mm Al-foam 3mm Al-plate	33	ca. 9,5	ca. 19,95	1 x DM51	300,0	No splinters passage	15mm
SAS 3_30	3mm Steel 24mm Al-foam 3mm Steel	30,0	ca. 27,6	ca. 57,96	1 x HG85	300,0	No splinters passage	23
Test sample P5	Steel	42,50	29,30	61,04	PETN NSP711	700,0	Not measurable, < 25mm	Not measurable, < 25mm
	AL-foam							
	Fibre material							
	Organo steel plate							
Test sample P6	Organoblech	45,2	17,45	36,85	PETN NSP711	700,0	39,4	42,0
	AL-foam							
	Fibre material							
	Organo steel plate							
Test sample P7	Organo steel plate	34,0	18,74	38,98	PETN NSP711	700,0	33,4	38,0
	AL-foam							
	Organo steel plate							
Test sample P8	Organo steel plate	44,1	19,34	40,23	PETN NSP711	700,0	37,8	40,0
	AL-foam							
	Hybrid-fibe material mat							
	Organo steel plate							

In the explosive tests P5 to P8, a scale of the mass of the explosive charge and the distance between the explosive charge and the test sample was used for the detonation structure. The values of the scaling were determined after pressure, impulse and time course values from a blast test with 15 kg TNT at a distance of 2 meters from the object. PETN NSP711 was used as the disintegrant. The distance between the explosive charge and the test sample was determined in such a way that the comparability of the pressure-pulse-time curve with the 15 kg blast is ensured. Further tests with hand grenades HG85, as well as AP mines DM31 and further tests according to Stanag 4569 AEP Volume 2 are planned.

Protection against explosions, fire and ballistics

Analysis

sample	top layer	thickness	surface area weight	dyn. deformation
P5	steel plate Armox440, 4mm fibre mat below al-foam	42,8mm	61,04 Kg/m ² (to little)	not measurable
P6	Organo steel plate 7,6mm fibre mat below al-foam	45,2mm	36,45 Kg/m ²	39,4mm
P7	Organo steel plate 7,6mm without fibre mat	34,0mm	38,98 Kg/m ²	33,4mm
P8	Organoblech 7,6mm fibre mat below al-foam	44,1mm	40,23 Kg/m ²	37,8mm

Noticable features:

P7 is 11 mm thinner than P6 and has no fibre (material) mat, but ist 2,5kg/m² heavier.

P8 is almost as thick as P6 (1,1mm) and has the same structure, though 3,78 kg/m² heavier. The reason for this can be seen in the varying al-foam thickness on weights.

In the four aluminum-foam plates of identical sizes there are differences in weight to up to 2kg. Hence, this means that the acquired thickness differs a lot in the foaming process. This in turn may mean that the foam structure of the plates is not equally given.

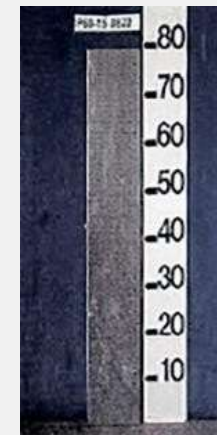
Characteristics & Properties



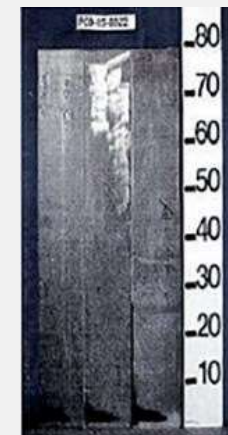
Metal Foam Sandwich is Non-Flammable



After 10 minutes 50 W/m² heat flow



*Before
the test*



*After
the test*

Due to the purely metallic aluminum foam structure (no use of adhesives or plastics), the material is not flammable.

Depending on the alloy, aluminum foam has a temperature resistance of up to 500 °C.

High Impact Energy Absorption

Aluminum foam is able to absorb pressure and impact effects and to prevent material destruction (cracks, fractures).

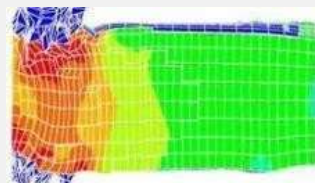
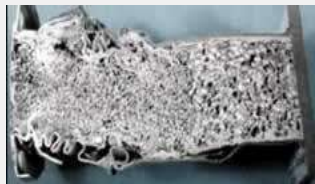
This increases both the safety and the reparability of the components.



Aluminum foam is predestined for use in areas where stiffness and good crash behavior are required.

It performs a higher deformation work compared to other building materials, so that a deterioration of the material takes place only after a very high degree of deformation.

FEM-Simulation



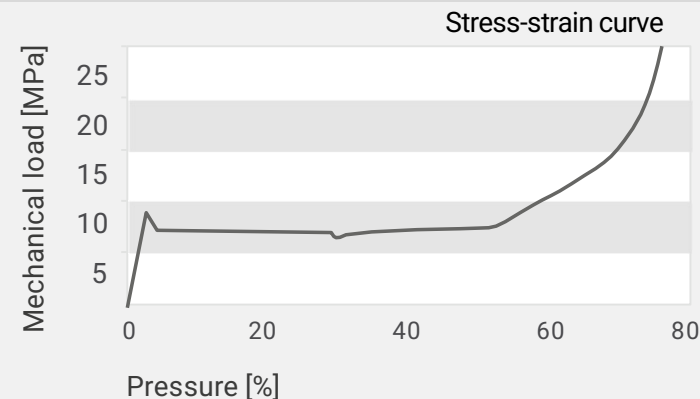
Compressive strength

Compressive stress at which the plateau is reached.

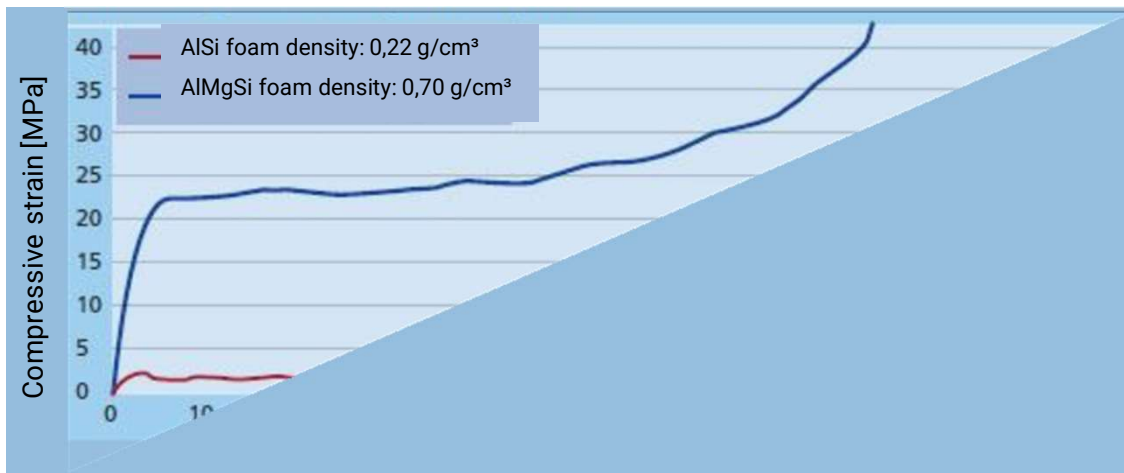
Plateau stress

Mean value of compressive stress at 20% and 40% elongation (compression)

Young's modulus / Elastic modulus



High Impact Energy Absorption



Measurement of energy absorption

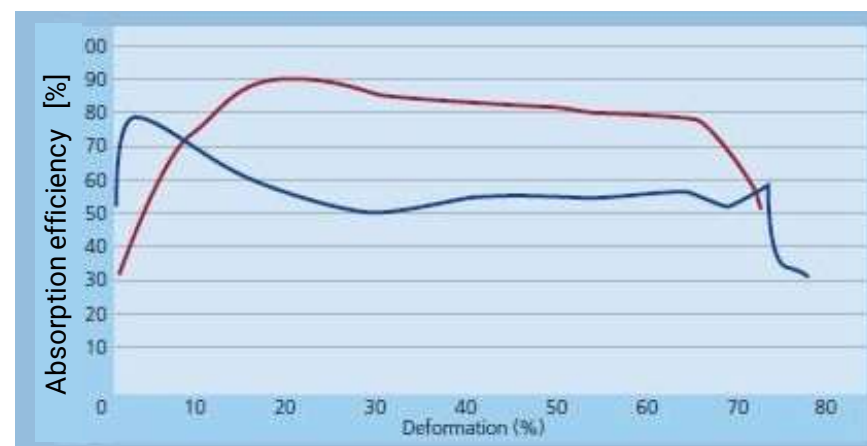
The two curves describe the minimum and the maximum possible energy absorption depending on density, alloy and heat treatment.

The energy absorption properties can be adjusted by foam density or pore size.

Comparison between aluminum profiles and aluminum foam as crash absorber



Stress-strain diagram



Absorption efficiency-strain diagram

High Sound/Noise absorption

When penetrating the aluminum foam, the sound/noise waves are effectively damped.

The density and thickness of the aluminum foam influence the results.

In addition, rattle properties of components in acoustic/automotive systems can be significantly improved.

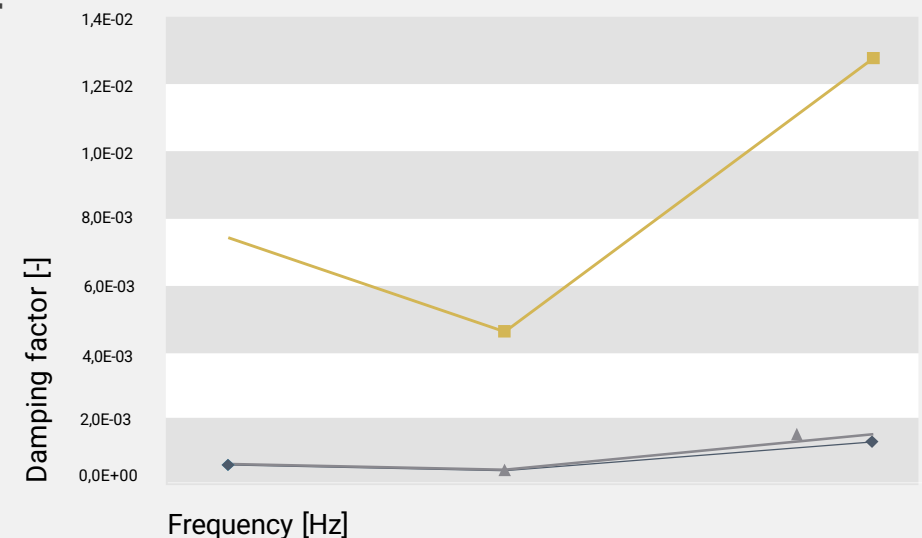


Damping factor

25 mm
Aluminum foam

5 mm
Aluminum sheet

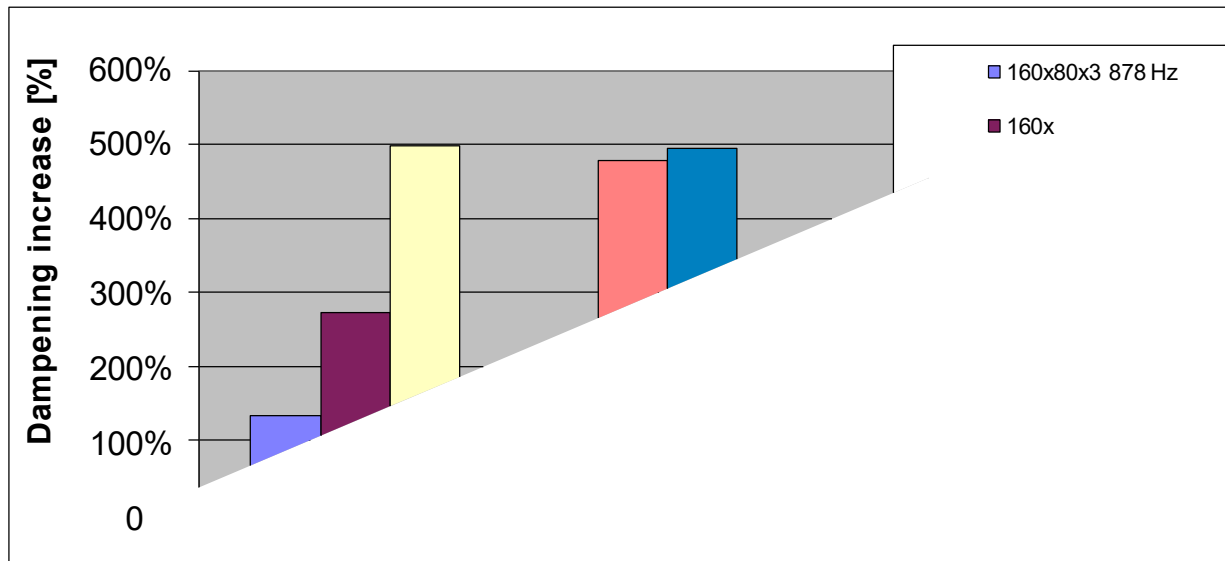
3 mm
Aluminum sheet



Vibration absorption

Tested material:

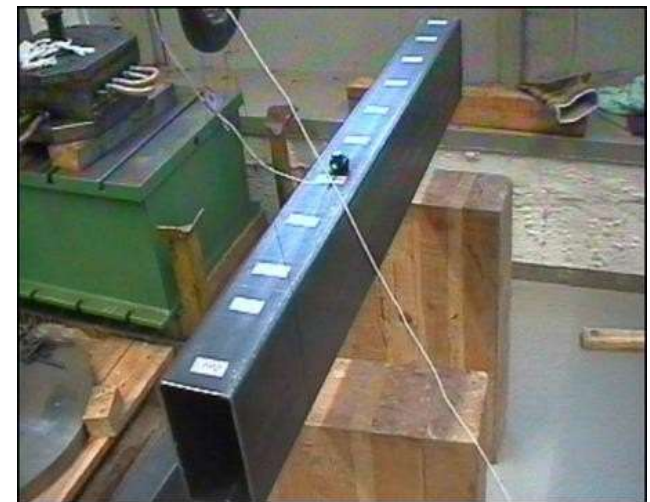
Aluminium foam-filled steel profiles



Measurements by Fraunhofer IWU

Test setup:

Steel profiles supported by 2 wires and worked with a hammer



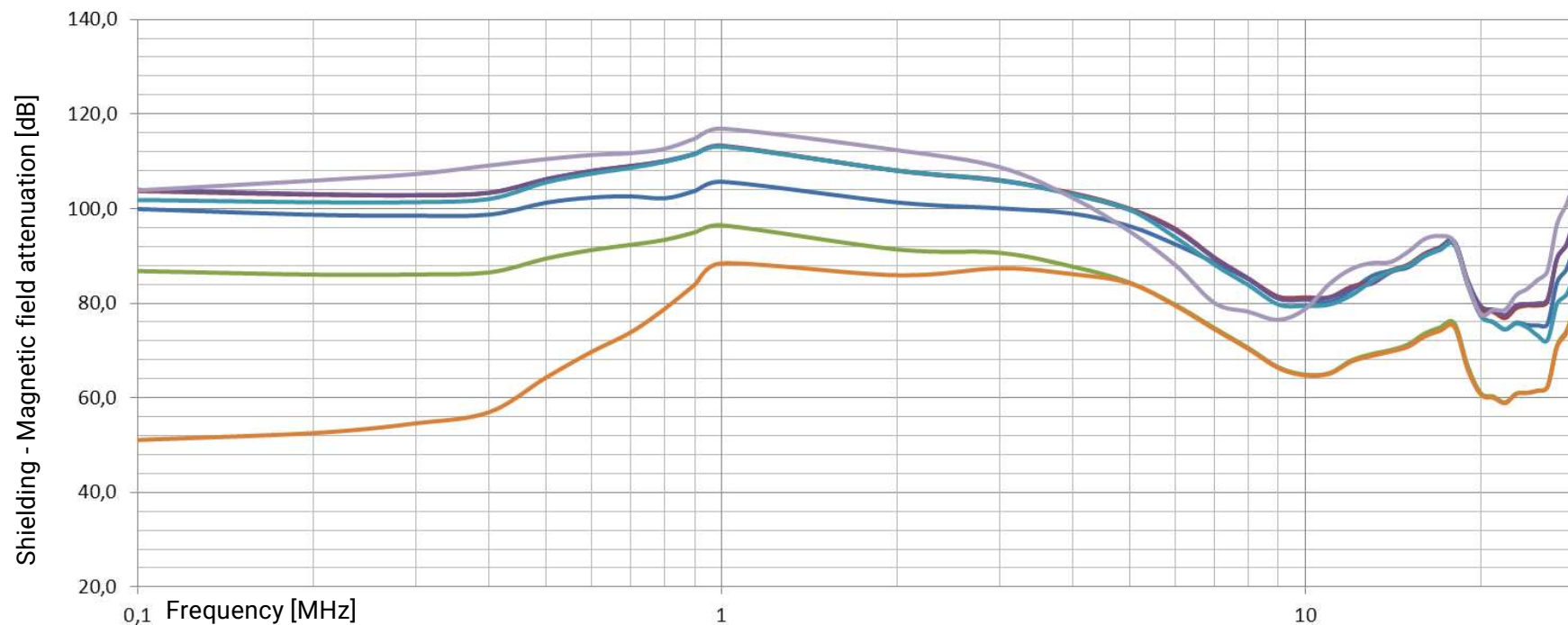
Conclusion:

A significant increase in vibration damping is observed with the use of aluminum foam.

Significant less risk of material or structures entering its own frequencies and get damaged.

Electromagnetic compatibility (EMC)

Shielding effect (magnetic field) depending on the frequency for semi-finished products according to EN 50147-1 (100 kHz - 1 GHz)



Measurements by Fraunhofer IWU

Steel-Aluminum foam-Sandwich (SAS) with 2 mm cover sheets, foam thickness 32 – 35 mm, weight: 7,5 kg

Steel-Aluminum foam-Sandwich (SAS) with 2 mm cover sheets, foam thickness 34 – 35 mm, weight: 7,9 kg

Aluminum foam with cast skin / closed surfaces, foam thickness 20 mm, weight: 2,5 kg

Aluminum foam without cast skin / open-porous surfaces, foam thickness 30 mm, weight: 1,0 kg

Metallic fiber sheet, thickness: 5 mm

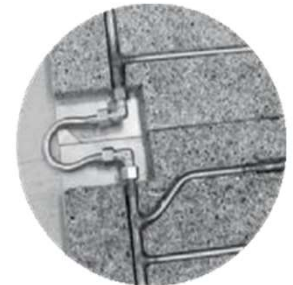
Maximum for semi-finished products

Thermal conductivity

Aluminum is one of the best metallic heat conductors. This property also makes aluminum foam a good heat conductor, which is used in both cooling systems and heating systems.



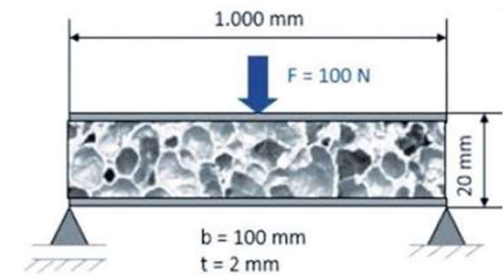
Steel-Aluminum foam-Sandwich (SAS)
with integrated steel tubing



Aluminum foam panel (milled)
with integrated tubing

Material specifications - Sandwiches

		Steel S235JR	Aluminum EN-AW 5754 AlMg3	AAS Aluminum- Aluminum foam- Sandwich	SAS Steel-Aluminum foam-Sandwich	Havel Lite Aluminum foam
	UOM					
Configuration				AAS 10-1-1	SAS 10-1-1 0,7 g/cm³ (*)	AlSi10
Density (Foam core / Cover sheet)	g/cm³	7,85	2,7	0,3-0,9 / 2,7	0,7 / 7,85	0,5-0,9
Elastic modulus (Foam core / Cover sheet)	GPa	210	70	5 / 70	6 / 210	6
Poisson ratio		0,3	0,34	0,3–0,34	0,31–0,34	0,31-0,34
Compressive strength	N/mm²			4-8 (Core)*	13 (Core)	7-13*
Yield strength	N/mm²	235	100			
Tensile strenght	N/mm²	340	180	120-200	235 (Cover)	4-6,3**
Bending stiffness	kN/mm	1,2	3,6	6,8**	2,4	22-41**
Thermal conductivity (Foam core / Cover sheet)	W/m·K	48–58	170–220	10-15 / 170-220	25 / 48–58	12-36
Weight 1.000 x 1.000 x 10 mm	kg	78,5	27	7,8*	21,3	5-9*



$$u_{\max} = \frac{1}{48} \cdot \frac{F \cdot l^3}{\sum (E_i \cdot I_i)}$$

Currently only densities between 0,5 and 0,9 g/cm³ are offered.

* Material properties of sandwiches and aluminum foam are highly dependent on the material density.

** Material properties of sandwiches and aluminum foam are very dependent on the respective geometry.

All values were determined analytically and serve only as a guideline.

For specific applications, the values must be determined specifically.

Sources for the calculations:
Tabellenbuch Metall, 43. Edition 2005, Fraunhofer IWU

Certificato Certificat Certificate Certificado Certificat

Zertifikat


TAW Cert

Die Zertifizierungsstelle TAW Cert
Zertifizierungsgesellschaft mbH für Management-Systeme und Personal
bescheinigt hiermit, dass die Organisation

Havel metal foam GmbH
Am Gleisdreieck 10
14774 Brandenburg a.d. Havel


Havel metal foam

für den Anwendungsbereich
Entwicklung, Herstellung und Vertrieb von innovativen Leichtbauprodukten aus Metallschaum

ein Umweltmanagementsystem eingeführt hat und anwendet.

Durch ein Audit vom 24.11.2020 bis 26.11.2020 wurde der Nachweis erbracht,
dass die Anforderungen der

DIN EN ISO 14001:2015

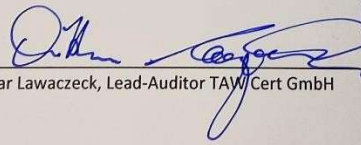
erfüllt sind.

Erstzertifizierung: 15.01.2021

Dieses Zertifikat ist gültig vom 15.01.2021 bis 14.01.2024

Zertifikat-Registrier-Nr.: UM-060614-DE

Altdorf, den 15.01.2021


Dittmar Lawaczek, Lead-Auditor TAW Cert GmbH


DAKKS
Deutsche
Akkreditierungsstelle
D-ZM-16100-01-00


TAW Cert

TAW Cert GmbH • Fritz-Bauer-Str. 13 • 90518 Altdorf
Dieses Zertifikat ist Eigentum der TAW Cert GmbH

Seite 1 von 1

Certificato Certificat Certificate Certificado Certificat

Zertifikat


TAW Cert

Die Zertifizierungsstelle TAW Cert
Zertifizierungsgesellschaft mbH für Management-Systeme und Personal
bescheinigt hiermit, dass die Organisation

Havel metal foam GmbH
Am Gleisdreieck 10
14774 Brandenburg a.d. Havel


Havel metal foam

für den Anwendungsbereich:
Entwicklung, Herstellung und Vertrieb von innovativen Leichtbauprodukten aus Metallschaum

ein Qualitätsmanagementsystem eingeführt hat und anwendet.

Durch ein Audit am 17.08.2020 wurde der Nachweis erbracht,
dass die Anforderungen der

DIN EN ISO 9001:2015

erfüllt sind.

Erstzertifizierung: 27.08.2014

Dieses Zertifikat ist gültig vom 27.08.2020 bis 26.08.2023

Zertifikat-Registrier-Nr.: QM-060614-DE

Altdorf, den 15.01.2021


Dittmar Lawaczek, Lead-Auditor TAW Cert GmbH


DAKKS
Deutsche
Akkreditierungsstelle
D-ZM-16100-01-00

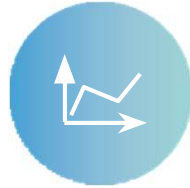

TAW Cert

TAW Cert GmbH • Fritz-Bauer-Str. 13 • 90518 Altdorf
Dieses Zertifikat ist Eigentum der TAW Cert GmbH

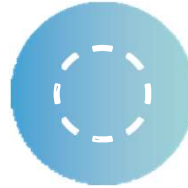
Seite 1 von 1



Development



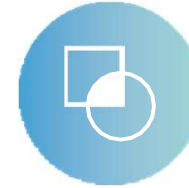
FEM calculations



Product solutions



Series production



Processing



Havel metal foam GmbH
Am Gleisdreieck 10 · 14774 Brandenburg an der Havel

Telefon +49 33 81.80 43 88 20 · Fax +49 33 81.80 43 88 40
info@havel-mf.de · www.havel-mf.de