ELASTOMER SOLUTIONS
COMPACT CATALOGUE

"Because the quality is the best."

David, 50, Buyer

OPTIBELT ELASTOMER SOLUTIONS – THE SOPHISTICATED SOLUTION FOR EXACTING REQUIREMENTS

Developing, manufacturing and sales of high-quality elastomer sheeting are all in one hand at Optibelt. Products made from all types rubber are distinguished by their excellent properties, such as close thickness tolerances.

Made in Germany
Quality since 1872

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deuser band original

ELASTOMER SHEETING TAKES CENTRE STAGE – UNUSUAL MATERIALS IN UNUSUAL PLACES!

In the scene pictured above, an Optibelt rubber membrane forms an effective backdrop for the unique "Tristan and Isolde" stage set at the State Opera House in Berlin. Vacuum technology made it possible for the elastomer sheet that was spanned across the stage to take on an ever-changing, constantly flowing "living" form.

ELASTOMER SOLUTIONS

TECHNICAL ELASTOMER SHEETING

optibelt ELASTOMIT TECHNICAL ELASTOMER SHEETING

These foils are used in applications such as the automotive industry, household appliances, the electrical industry, general machine engineering, and workplace and personal protection.

The portfolio of technical elastomer sheeting products comprises a variety of grades in the 0.25 to 2.00 mm thickness range. The materials are also available with different surface finishes and textures and are optionally available with fabric on one side, two sides, or in the centre. They can also be supplied in strips or rolls, optionally including a special surface finish.

USES

Automotive • Household appliances • General machine engineering
Workplace safety and personal protection • Membrane technology • Medical technology

Schlösser Dichtungen und Stanzteile

SPÄH DICHTUNGEN UND MEHR

SCHIPPL DICHTUNGEN UND MEHR

KARL POPP DICHTUNGEN UND MEHR

QUADRIGA POLYURETHANE UND MEHR

optibelt ELASTOMIT ELASTOMER SHEETING IS NOTED FOR ITS CLOSE THICKNESS TOLERANCES IN THE FINISHED PRODUCT.

CONVERSION EXAMPLES FOR QUANTITIES AND PRICES

$m^2 \rightarrow kg$ | $kg \rightarrow m^2$ | €/m^2 → €/kg | €/kg → €/m^2

FORMULAS

QUANTITIES

$m^2 \rightarrow kg$

m^2 × specific gravity × thickness = kg	×	100 m^2 × 1.08 × 0.4 = 43.2 kg

$kg \rightarrow m^2$

kg ÷ specific gravity ÷ thickness = m^2	÷	43.2 kg ÷ 1.08 ÷ 0.4 = 100 m^2

PRICES

€/m^2 → €/kg

€/m^2 ÷ specific gravity ÷ thickness = €/kg	÷	6,66 €/m^2 ÷ 1.08 ÷ 0.4 = 15.42 €/kg

€/kg → €/m^2

€/kg × specific gravity × thickness = €/m^2	×	15.42/kg × 1.08 × 0.4 = 6.66 €/m^2

CALCULATION EXAMPLE EPDM 750 K

Quantity	100 m^2
Thickness	0.4 mm
Specific gravity	1.08 / cm^3
Price	6.66 € / m^2

IDLER FORMATS

Standard width: 1200 mm
Strip width: from 40 mm
Minimum production quantity: 1000 kg

STANDARD LENGTHS

approx. 30 rm (1.0 - 2.0 mm thickness)
approx. 40 rm (0.5 - 0.9 mm thickness)
approx. 60 rm (0.3 - 0.4 mm thickness)

QUALITY DESCRIPTION	DESIGN	COLOUR	HARDNESS	TENSILE STRENGTH	ELONGATION	SPECIFIC GRAVITY
Dimension			Shore A	N/mm² (MPa)	%	g/cm³
Tolerance			± 5	Minimum	Values	± 0.02
to DIN			53505	53504	53504	53479
NATURAL RUBBER (NR)						
NR/IR 402	A	transparent	40	13	750	0.97
NR/IR 409	A	black	40	13	750	0.97
NR 340	A	black	40	17	550	1.08
NR 810	A	white	40	12	650	1.14
NR 829	A	black	40	14	600	1.10
NR 320	A	grey	45	16	600	1.11
NR 325	A	red-brown	45	16	600	1.11
NR 330	A	transparent	45	16	600	1.08
NR 395	A	black	45	20	600	1.05
NR 826	A	red	45	> 15	600	1.04
NR/IR 404	A	transparent	50	17	600	1.08
NR 828	K	grey	65	7	400	1.36
NR 890	K	black	65	10	400	1.26
NR 909	A	black	65	13	400	1.17
NITRILE BUTADIENE (NBR)						
NBR 1807	A	black	55	10	600	1.18
NBR 2055	A	black	55	14	550	1.13
NBR 2056	A	black	55	8	650	1.13
NBR 2056	K	black	55	8	650	1.13
NBR 2070	K	black	60	8	500	1.34
NBR 1534	A	black	65	9	400	1.40
NBR 1534	K	black	65	9	400	1.40
NBR 1570	A	black	75	9	300	1.42
NBR 1570/2	A	black	75	10	150	1.20
NBR 1580	A	black	80	8	180	1.42
NBR 1906	A	bright/white	60	14	600	1.25

TEMPERATURE RESISTANCE °Celsius Min. and max. values Continuous temperature	THICKNESS RANGE (mm) from - to	APPLICATION EXAMPLES, PARTICULAR CHARACTERISTICS
–40 - +70	0.4 - 2.0	Cable ties, deep-drawing process
–40 - +70	0.4 - 2.0	In version "C" for clothing
–40 - +90	0.3 - 2.0	Sulphur-free, heat-resistant
–40 - +70	0.4 - 2.0	Seals in the field of incontinence
–40 - +70	0.3 - 2.0	Seals
–40 - +70	0.3 - 2.0	Insulators, seals, compression bandages
–40 - +70	0.3 - 2.0	Vacuum plates
–40 - +70	0.3 - 2.0	Membranes for dust masks, vacuum plates
–40 - +70	0.3 - 2.0	High tensile strengths, good rebound resilience
–40 - +70	1.0 - 5.0	Belt support, good abrasion resistance
–40 - +70	0.4 - 2.0	Membranes for dust masks, vacuum plates
–40 - +60	0.3 - 0.8	Dust bag seals
–40 - +60	0.3 - 0.8	NR standard grade
–40 - +70	0.3 - 2.0	Seals
–35 - +120	0.3 - 2.0	According to VW 2.8.1. A,T; low sulphur content
–25 - +100	0.3 - 2.0	DVGW-tested in accordance with DIN EN 549 for gas seals
–35 - +120	0.3 - 2.0	High grade NBR grade, low sulphur
–35 - +120	0.3 - 0.8	High grade NBR grade, low sulphur, low shrink
–35 - +90	0.3 - 0.8	According to VW 2.8.1. G 60, 50180 4.1 + 4.2.1 + 4.3
–35 - +100	0.3 - 2.0	NBR standard grade, DBL 5563.32, VW 2.8.1. A; low sulphur
–35 - +100	0.3 - 0.8	DBL 5563.32 low sulphur
–25 - +100	0.3 - 2.0	Tank seals, GME 60258, GME 60255, BMW N 60200.05513
–25 - +100	0.3 - 2.0	DVGW-tested in accordance with the DIN 3535/1 Regulation for gas seals
–25 - +100	0.3 - 2.0	Seals
–25 - +100	0.3 - 2.0	Not electrically conductive, continuity resistance < 10^9 Ohm

QUALITY DESCRIPTION	DESIGN	COLOUR	HARDNESS	TENSILE STRENGTH	ELONGATION	SPECIFIC GRAVITY
Dimension			Shore A	N/mm² (MPa)	%	g/cm³
Tolerance			± 5	Minimum	Values	± 0.02
to DIN			53505	53504	53504	53479
POLYCHLOROPRENE (CR)						
CR 435	A	black	35	7	500	1.40
CR 450	K	black	50	5	250	1.30
CR 470	A	black	60	12	300	1.34
CR 475	A	black	65	9	350	1.55
CR 475	K	black	65	12	400	1.43
ETHYLENE PROPYLENE DIENE (EPDM)						
EPDM 740	A	black	40	5	400	1.06
EPDM 750	A	black	50	8	400	1.08
EPDM 750	K	black	50	8	400	1.08
EPDM 760	A	black	60	8	350	1.12
EPDM 760	K	black	60	8	350	1.12
EPDM 797	A	black	65	10	200	1.07
EPDM 770	A	black	70	9	250	1.12
EPDM 780	A	black	80	11	400	1.15
EPDM 775	A	black	75	10	350	1.24
STYRENE BUTADIENE RUBBER						
SBR/EPDM	370A	black	65	8	400	1.1

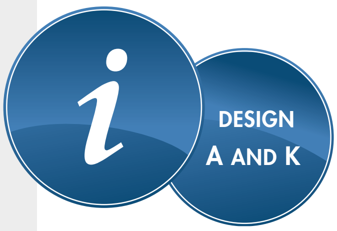
Design "A"
This design is manufactured from high-grade Auma goods that have a glassy surface on one side and a matt surface on the other, which are vulcanised in an **optibelt ELASTOMIT** rotational process.

Design "K"
The surface of this design is flat on both sides. The vulcanisation process is carried out in autoclaves (tanks). Through this special vulcanisation process, we are able to obtain a **"low-shrink"** grade (in both lengthwise and traverse directions) during the die-cutting process. The values measured on the manufactured product – the ultimate tensile strength and tear strength as well as the ultimate elongation – are reduced by approx. 1/3, depending on the process, compared to the "A" design.

TEMPERATURE RESISTANCE °Celsius Min. and max. values Continuous temperature	THICKNESS RANGE (mm) from - to	APPLICATION EXAMPLES, PARTICULAR CHARACTERISTICS
–30 - +100	0.5 - 2.0	Fire retardant according to UL 94 V-O
–30 - +90	0.3 - 0.8	Low shrink according to VW 2.8.1. G 50, no permanent deformation fuel splashes after 24-hour evaporation
–30 - +100	0.3 - 2.0	Talcum-free design electrically conductive (contact resistance ≤ 8000 Ohm)
–30 - +90	0.3 - 2.0	High grade CR grade
–30 - +90	0.3 - 0.8	CR standard grade
–40 - +110	0.3 - 2.0	Soft EPDM grade
–40 - +110	0.3 - 2.0	DBL 5571.10, DBL 5571.20, DBL 5571.30, VW 2.8.1. G 50, ASTM D 2000
–40 - +110	0.3 - 0.8	Special automotive grade VW 2.8.1. G 50, specification 2011-02 DBL 5571.10, DBL 5571.20, DBL 5571.30, ASTM D 2000 SAE J 200 M3BA 510 A14, B13, C12, F17 and Z1, Toyota (TSM) 1500 G - N 506
–40 - +110	0.3 - 2.0	GME 60258, DBL 5557.30, DBL 5571.10, DBL 5571.20, DBL 5571.30
–40 - +110	0.3 - 0.8	GME 60258, DBL 5557.30, DBL 5571.10, DBL 5571.20, DBL 5571.30
–40 - +125	0.3 - 2.0	High level of temperature resistance, peroxide cured, excellent compression set level (based on DIN 53517 [22 hours, +150 °C, deformation 25 %]) 20.8 % residual compression set value, resistant to hot air up to +150 °C
–40 - +110	0.3 - 2.0	Seals
–40 - +110	0.3 - 2.0	Seals
–40 - +110	0.3 - 2.0	Electrically non-conductive, UV, ozone and weather-resistant
–40 - +110	0.3 - 2.0	Continuity resistance max. 1000 Ohm acc. to DIN 53482, specific surface resistance on the material-structured side < 10 Ohm acc. to DIN 53582

Information on the degree of hardness

The physical values that are itemised above for both the **"A"** and **"K" designs** were established on DIN-compliant test specimens. The values measured on the manufactured product could vary from the details that were measured by us in the laboratory according to DIN. The DIN test specimens for ultimate tensile strength and ultimate elongation are 2 mm thick, while 6 mm is required for testing the Shore A hardness and compression set.



SPECIAL VERSIONS

“Auma” goods (design “A”) are available with a fabric lining (starting from a thickness of 0.8 mm). Available with one-sided fabric or double-sided fabric, as well as one-sided or double-sided fabric texture. All “Auma” grades are NR/NBR based and are available with a surface finish (design “C”). This special grade is powder free and also very low-friction. It is also possible to affix different release agents to the surface.

We would be pleased to develop further special grades and new applications jointly with you at any time upon request. The standard effective width of our elastomer sheeting is 1.200 mm. Our elastomer sheeting can also be delivered on request in strips with widths starting from 40 mm.

DIMENSION TOLERANCES

Our standard tolerances for vulcanised rubber foils (flat on both sides and without inlay) deviate from the dimension tolerances according to DIN 7715, Part 5.

THICKNESS RANGE	STANDARD TOLERANCES
from 0.30 mm - 0.60 mm	± 0.10 mm
from 0.60 mm - 1.00 mm	± 0.15 mm
from 1.00 mm - 1.50 mm	± 0.20 mm
from 1.50 mm - 2.00 mm	± 0.25 mm

Depending on the material thickness and grade, restricted special tolerances and colours may also be possible in consultation with us.
optibelt ELASTOMIT elastomer sheeting is characterised by close thickness tolerances on the finished product. It is used in applications such as the automotive industry, household appliances, and also in the electrical industry and general machine construction, as well as in workplace protection.

Optibelt is certified according to DIN EN ISO 9001-2015, and a quality audit has shown that our quality assurance system meets all requirements.
Our standards conform to the EU Guidelines for Prohibited and Declarable Substances according to RoHS 2002/95 EC, 2002/96 EC, 2003/11 EC, 2003/53 EC, 76/769 EEC, 1907/2006 EC (REACH).

In addition to this, we conform to the requirements of environmental management according to DIN EN ISO 14001:2005.

ELASTOMER SELECTION AID

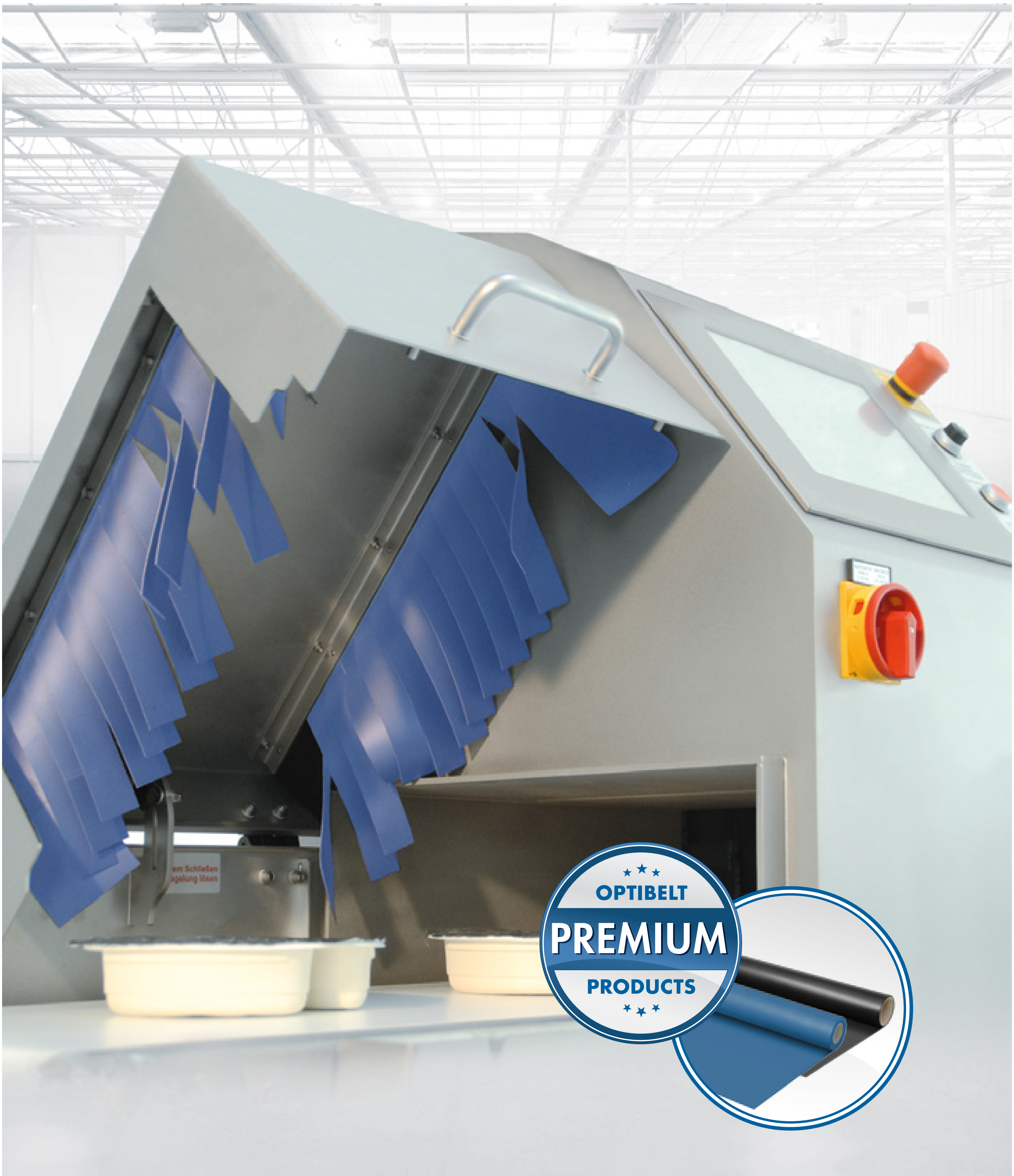
	Material abbreviation	Hardness range (Shore A)	RESISTANCE TO (MEDIA)							Temperature resistance	MECHANICAL PROPERTIES (AT ROOM TEMPERATURE)					COM-PRES-SION SET*		Gas impermeability
			Petrol / gasoline	Mineral oil	Water	Lyes	Acids	Light	Weathering and ozone		Tensile strength	Breaking strain	Tear strength	Rebound elasticity	Abrasion resistance	at high temperatures	at low temperatures	
Natural rubber/ polyisoprenes	NR / IR	30-90	6	6	3	2	4	4	4	– 60 + 80	1	1	2	1	2	5	2	5
Styrene butadiene rubber	SBR	30-90	5	5	3	2	4	4	4	– 50 + 100	2	2	3	3	2	4	3	4
Chloroprene rubber	CR	30-90	2	2	3	2	2	3	2	– 40 + 100	2	2	2	3	2	4	4	3
Nitrile butadiene rubber	NBR	30-90	1	1	3	6	4	2	5	– 30 + 100	2	2	3	4	2	3	4	2
Butyl rubber	IIR	30-80	5	6	2	1	1	3	2	– 40 + 120	3	2	3	6	4	2	4	1
Hydrogenated nitrile butadiene rubber	HNBR	40-90	1	1	3	6	4	2	1	– 30 + 160	1	2	3	4	1	1	4	2
Ethylene propyl-ene diene monomer rubber	EPDM	20-90	6	6	1	1	1	2	1	– 50 + 130	3	3	3	3	3	3	3	4
Chlorsulphonated polyethylene	CSM	40-90	2	2	3	2	2	1	1	– 20 + 120	3	3	3	5	3	5	5	3
Polyacrylate and ethyl acrylate rubber	ACM / AEM	50-90	2	1	5	5	3	4	2	– 25 + 150	3	3	4	5	4	3	4	3
Epichlorhydrine rubber	CO / ECO	40-90	2	1	4	2	5	4	1	– 40 + 140	3	3	4	4	3	3	4	2

*Compression set (CS)

1 = Excellent 2 = Very good 3 = Good 4 = Moderate 5 = Low 6 = Unfavourable

ELASTOMER SOLUTIONS

X-RAY PROTECTION – FOOD



optibelt ELASTOMIT X-RAY PROTECTION FOOD

Safety plays a special role in the food industry. In order to meet the high demands of the food industry, Optibelt offers lead-free protective curtain materials for X-ray systems which are used, among other things, in the detection of foreign bodies in food. Some qualities are also especially suitable for contact with unpackaged goods. Our material is therefore the ideal solution to combine protection against rodents and the high demands on food safety.

optibelt ELASTOMIT-R FDA 116A

LEAD-FREE

PRODUCT SPECIFICATION	
Matrix	Rubber
Colour	Blue
Surface finish	Highly abrasion resistant top surface on both sides
Lead equivalent (standard)	0.125 mm Pb and 0.25 mm Pb
Mass per unit area	On request
Tensile strength (min.), longitudinal	8 N/mm²
Temperature resistance	–40 °C up to +70 °C

APPLICATIONS

This product is specially designed for curtain material for X-ray inspection systems which are used in food production (packaged and unpackaged goods).

ADVANTAGES AND CHARACTERISTICS

- FDA compliance test according to 21 CFR 177.2600 (e) and 177.26000 (f)
- Highly abrasion resistant top surface on both sides
- Good temperature resistance
- High flexibility
- Unrivalled abrasion resistance due to extremely smooth surface
- Chemically treated for enhanced slippage/powder-free
- The lead equivalent is measured in accordance with DIN 61331-1 (2014) (60-100 kV)

optibelt ELASTOMIT-R FDA 115A

Worldwide unique FDA proofed curtain material for X-ray inspection systems

PRODUCT SPECIFICATION

Matrix	Rubber
Colour	Black and blue
Surface finish	Lacquered
Pb lead equivalent	From 0.125 mm Pb
Mass per unit area	min. 2000 g/m²
Tensile strength (min.), longitudinal	60 daN / 25 mm
Temperature resistance	–40 °C up to +70 °C

APPLICATIONS

This product is specially designed for curtain material for X-ray inspection systems which are used in food production (packed goods only).
Useable in direct contact with food.

ADVANTAGES AND CHARACTERISTICS

- FDA compliance test according to 21 CFR 177.2600 (e) and 177.2600 (f)
- Good temperature resistance
- High flexibility
- High abrasion resistance through extremely smooth surface
- Synthetic fabric layer in the middle of the sheet

optibelt ELASTOMIT-R BFR 121A

The first curtain material in accordance to regulation (EC) 1935/2004

PRODUCT SPECIFICATION

Matrix	Rubber
Colour	Black
Surface finish	Lacquered
Pb lead equivalent	From 0.125 mm Pb
Mass per unit area	On request
Tensile strength (min.), longitudinal	60 daN / 25 mm
Temperature resistance	–40 °C up to +70 °C

APPLICATIONS

This product is specially designed for curtain material for X-ray inspection systems which are used in food production (packed and unpacked goods).
Useable in direct contact with food.

ADVANTAGES AND CHARACTERISTICS

- EU compliance in accordance with regulation (EC) 1935/2004
- High flexibility
- High abrasion resistance through extremely smooth surface
- Good temperature resistance
- Painted on both sides
- Synthetic fabric layer in the middle of the sheet

optibelt ELASTOMIT-R BFR 122A

COMING SOON

LEAD-FREE

PRODUCT SPECIFICATION

Matrix	Rubber
Colour	Blue
Surface finish	Highly abrasion resistant top surface on both sides
Lead equivalent (standard)	0.125 mm Pb and 0.25 mm Pb
Mass per unit area	0.125 mm Pb: min. 2500 g/m^2 0.25 mm Pb: min. 4200 g/m^2
Tensile strength (min.), longitudinal	8 N/mm^2
Temperature resistance	–40 °C to +70 °C

APPLICATIONS

This product is specially designed for curtain material for X-ray inspection systems which are used in food production (unpackaged goods). Through the use of high-purity raw materials, the **optibelt ELASTOMIT-R BFR 122A** meets the stringent requirements of EU regulation (EC) 1935/2004. Accordingly, this product is suitable for direct contact with food.

ADVANTAGES AND CHARACTERISTICS

- EU compliance in accordance with regulation (EC) 1935/2004
- FDA compliance test according to 21 CFR 177.2600 (e) and 177.26000 (f)
- High abrasion resistance through a rubber top surface on both sides
- High flexibility
- Good temperature resistance
- The lead equivalent is measured in accordance with DIN 61331-1 (2014) (60-150 kV)

optibelt ELASTOMIT-R 1432170

COMING SOON

LEADED

PRODUCT SPECIFICATION

Matrix	Rubber
Colour	Black
Surface finish	Lead-free rubber top surface
Lead equivalent (standard)	0.125 mm Pb und 0.25 mm Pb
Mass per unit area	On request
Tensile strength (min.), longitudinal	8 N/mm^2
Temperature resistance	–40 °C up to +70 °C

APPLICATIONS

This product is specially designed for curtain material for X-ray inspection systems which are used in food production (packaged goods).

ADVANTAGES AND CHARACTERISTICS

- Excellent flexibility
- Good dynamic load in combination with a remarkable tensile strength
- High abrasion resistance
- Good slippage
- Lead rubber core with lead-free rubber top surface on both sides

TOP QUALITY FOR MAXIMUM SAFETY

optibelt ELASTOMIT-R products for X-ray protection in the food industry are distinguished by their excellent flexibility, abrasion resistance and slippage.

Thanks to our **BFR and FDA certification**, our curtain material is suitable for contact with both packaged and unpackaged food. Our products have also been tested for resistance to various cleaning agents and chemicals in a variety of tests.

ELASTOMER SOLUTIONS

X-RAY PROTECTION – BAGGAGE & CARGO

optibelt ELASTOMIT X-RAY PROTECTION BAGGAGE & CARGO

Thousands of pieces of luggage are handled at airports every day. This places special demands on the materials used in baggage handling. Our products serve as protective curtain material in X-ray inspection systems for the detection of cargo and baggage at airports.

Our particularly robust products are characterised by their extraordinary gliding properties and flexibility and are therefore tailor-made for the high demands of baggage and cargo handling. Optibelt quality thus contributes to smooth operations at airports.

optibelt ELASTOMIT-R 1403038A

WITH FABRIC LAYER IN THE MIDDLE OF THE SHEET

PRODUCT SPECIFICATION	
Matrix	NR / BR (natural rubber/ butadiene rubber)
Colour	Black
Surface finish	Lead-free, abrasion resistant rubber surface on both sides
Lead equivalent	From 0.25 mm Pb
Mass per unit area	Min. 4280 g/m²
Tensile strength (min.), longitudinal	75 daN / 50 mm
Temperature resistance	–40 °C up to +70 °C

APPLICATIONS

This X-ray protection sheet is specially designed for the shielding of X-rays in X-ray inspection systems which are used for freight goods and luggage.

ADVANTAGES AND CHARACTERISTICS

- Excellent flexibility
- Good dynamic load in combination with a remarkable tensile strength
- High abrasion resistance
- Good slippage
- Lead rubber core with fabric layer in the middle of the sheet and rubber top surface on both sides
- On customer request, a special surface treatment (version C) can be used to achieve increased slippage

STANDARD X-RAY PROTECTION

optibelt **ELASTOMIT** standard X-ray protection grades are made from a rubber-based lead rubber compound. The protective lead is added to a special form of rubber matrix.
They are also available as a single-layer material and in various equivalent Pb values ranging from 0.125 mm – 1.00 mm Pb (according to national and international X-ray standards). The films can be produced to customers' requirements with fabric inserts and covers as well as different finishing layers.

LEAD-FREE X-RAY PROTECTION

In lead-free rubber-based grades, lead is replaced entirely by other suitable metals with a similar specific weight.
An identical shielding effect is obtained.

ELASTOMER SOLUTIONS

X-RAY PROTECTION – PERSONS

optibelt ELASTOMIT X-RAY PROTECTION PERSONS

Our **optibelt ELASTOMIT-R** X-ray protection material shields X-rays in a variety of applications. Excellent shielding capacities are achieved through the use of different metals. The rubber used ensures outstanding flexibility in combination with low weight. In addition to versions containing lead, our product range also comprises lead-reduced and lead-free versions.

HAS PROVED ITSELF ON THE MARKET AS RELIABLE RADIATION PROTECTION UP TO 150 KV

Customers can choose from standard lead, ultra-light lead and lead-free grades.
The materials are based on a vulcanised rubber matrix which provides excellent flexibility and minimal residual deformation under mechanical stress.

The cross-linking principle that takes place during the vulcanisation process reduces the plasticiser content and minimises odour.
Wide-ranging uses are found in the medical sector and veterinary medicine as well as in X-ray equipment engineering.

Our safety consciousness means that 100 % of all X-ray protection films – **with a Pb equivalent value of up to 0.35 mm Pb** – are additionally tested for flaws by means of a hi-scan X-ray tunnel machine.

ULTRA-LIGHT LEAD X-RAY PROTECTION

In **optibelt ELASTOMIT** ultra-light rubber-based lead grades, the lead content is reduced and replaced by other suitable materials with a low specific gravity. Remarkably, the same shielding effect is achieved even though the weight has been reduced.

INTERESTING FACTS ABOUT X-RAYS

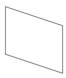
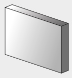
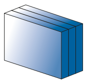
IONISING RADIATION

We speak of ionising radiation if ions are generated by passing through matter. To do so, however, the photons or particles that penetrate matter must have sufficiently high energy.

The following list includes some of the different types of radiation (see figure 1):

X-rays (generated by an X-ray tube)
- are undulatory radiation
- are a high-energy type of electromagnetic radiation and belong to the ionising types of radiation due to their high energy
- are generated by changes in the energy states of electrons in the atomic shell
- energy range approx. 100 eV – approx. 250 keV

Radioactivity / radioactive isotopes
- **a**-rays (particle radiation)
- **b**-rays (particle radiation)
- **g**-rays (undulatory radiation, electromagnetic radiation)

TYPE OF RADIATION		IN MATERIALS	IN FABRIC
α radiation		1 sheet of paper does not penetrate paper	hardly penetrates the skin
β radiation		4 mm aluminium or 15 sheets of paper is absorbed by the materials	is absorbed by the fabric
γ radiation and X-ray radiation		thicker layers of lead weakened by passing through the material	penetrates the fabric; partially absorbed

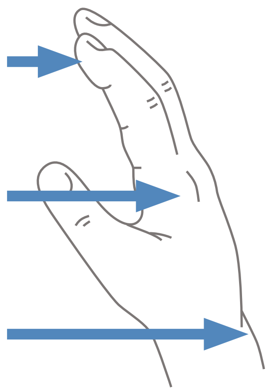


Figure 1: Types of radiation and range

X-RAYS – A GROUND-BREAKING DISCOVERY

In the year 1895, Wilhelm Conrad Röntgen (see figure 2) discovered the rays (known as X-rays) associated with his name at the institute of physics in the university of Würzburg. This ground-breaking discovery opened up the possibility for the first time of "seeing" into the human body without an operation – this represented a tremendous advance in diagnostic medicine! A revolutionary development followed.

The film / image plate technology, or X-ray film, was developed, followed by contrast media for imaging hollow organs and blood vessels, and computer tomography, enabling the human body to be depicted without overlap in cross-section images.

Figure 2:
Wilhelm Conrad Röntgen

PRINCIPLE OF X-RAY TUBES AND PRODUCTION OF X-RAYS

The structure of an X-ray tube is outlined in figure 3. It consists of an evacuated glass cylinder containing a cathode with a heating element and an anode.

The heating voltage applied to the cathode results in a thermal emission, i. e. an emission of electrons. These electrons are accelerated through the potential (high voltage U_R, ~30 kV – 150 kV) applied, i.e. an electrical field, and strike the rotating anode with an energy of $E_{kin} = e \cdot U_R$ (kinetic energy, unit [eV], e: elementary charge).

A continuous wavelength spectrum (or braking radiation) is produced on the one hand, while on the other hand a few clear lines (line spectrum) appear, these being dependent on the anode material and therefore described as characteristic spectrum or radiation.

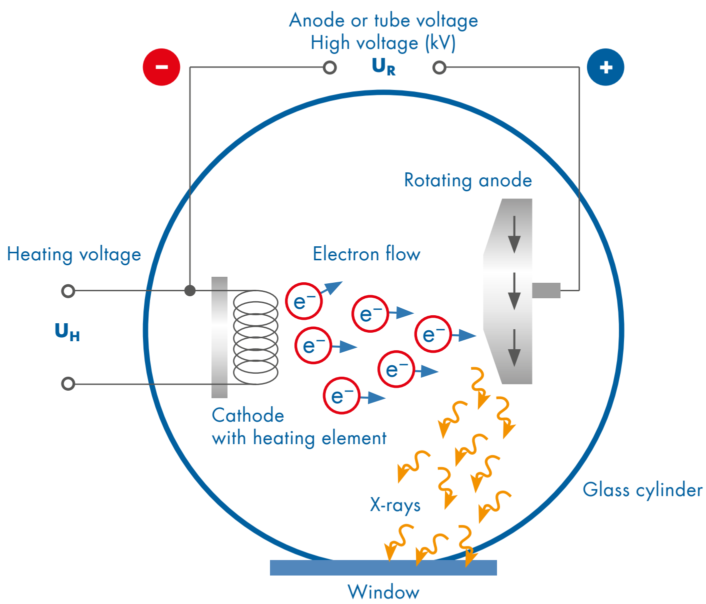


Figure 3:
Schematic structure of an X-ray tube

Since the electrons react with the anode material, the majority of kinetic energy in the process (99 %) is converted to heat. For this reason, tungsten anodes are used (with a melting point of ~3350 °C). In addition, rotating anodes are used in order to distribute the heat that is generated. The heat produced is of no use, however, for diagnostic purposes. Only ~1 % of the energy generated by the electrons is converted to X-rays.

X-RAYS AND INTERACTION WITH MATTER (ATTENUATION)

Outside the X-ray tube, X-rays are attenuated through interaction of the X-ray quanta with the atoms or molecules of the materials (attenuation = absorption + scattering). A transfer (scattering), absorption and conversion (pair production) of energy therefore takes place. During this process, absorption predominates at a low X-ray tube voltage, and scattering occurs in all directions. In the case of higher tube voltages, an increase in absorption and in scatter radiation towards primary radiation can be observed.

Ionising radiation can cause biological effects and result in radiation damage. This is the reason why measures such as radiation shielding are used in practice. Shielding means that a suitable absorbent material is inserted between the source of radiation and the body (see figure on page 14, German Federal Office for Radiation Protection), in particular to protect parts of the body that are not to be X-rayed. The differences in the shielding effect for various types of radiation are shown in figure 1.

In radiological examinations requiring X-rays with a high radiation dose, several measures are taken to reduce the dosage. These include measures such as lead rubber sheets (placed under the patient), which protect parts of the body not being examined from radiation (in this case from below) (see figure on page 14, German Federal Office for Radiation Protection). During the examination, the doctor is protected through lead glasses, a thyroid collar, an all-round protective lead rubber apron plus an additional lead rubber blanket which is placed on the examination table between him, or her, and the X-ray tube (see figure on page 14, German Federal Office for Radiation Protection).

Interactions and shielding, of course, weaken the intensity of the radiation. If the radiation intensity is measured before entering the matter (see I_0 in figure 5) and after passing through (see I(x) in figure 5), then this can be described with the so-called law of attenuation or law of absorption.

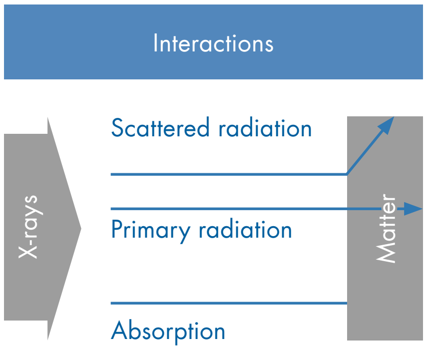
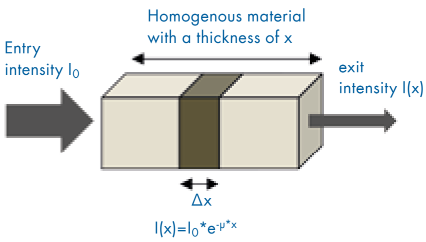


Figure 4: X-ray interactions



I_0 = Intensity of radiation as it hits the object
I(x) = Intensity of radiation as it leaves the object
Δx = Thickness of matter
μ(x) = coefficient of attenuation [1/cm]; sum of all partial attenuations; alternatively, mass absorption coefficient μ/p [cm^2/g]

Figure 5: Quantitative assessment of the attenuation: the law of absorption

The exit intensity decreases exponentially with the thickness of the irradiated material.

The absorption (attenuation, coefficient of attenuation **m**) of radiation is dependent on four factors, which are shown in the diagram in figure 6.

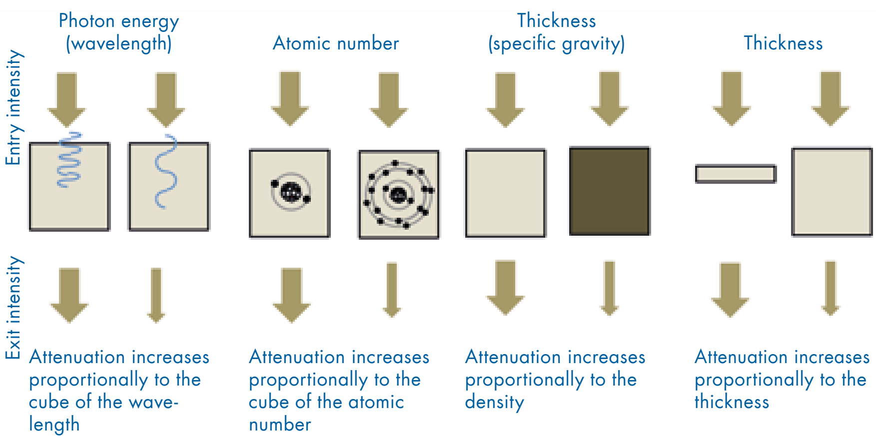


Figure 6: Schematic model of the attenuation factors

NORMATIVE REGULATIONS AND STANDARDS AND THEIR PARAMETERS

Radiation protective clothing constitutes personal protective equipment (EU directive 89/686/EEC) for the purpose of reducing the exposure of the examiner or assisting staff to radiation. Radiation protective accessories include other aids such as protective equipment and lead rubber curtains as found in X-ray inspection systems.

The **DIN EN 61331-3 standard (protective clothing, eyewear and protective patient shields)** [8] deals with protective devices such as protective clothing and eyewear for the protection of persons against X-radiation with X-ray tube voltages up to 150 kV during radiological examinations and interventional procedures. It contains general requirements concerning the accompanying documents, and the design of the protective devices and the materials used. This concerns the dimensioning, particular design features, minimum attenuation properties of materials, marking, and standardised forms of statements of compliance with this standard. It covers protective clothing mainly for protecting the user, such as X-ray protective aprons including thyroid collars, radiation protective gloves, surgical radiation protective gloves, eyewear and radiation protective devices for protecting the patient's gonads, such as gonad aprons, testes protection, ovary shields, indirect gonad protection, and dental aprons.

An important requirement concerns the attenuation properties of the materials used, which are indicated as attenuation equivalent for lead (lead equivalent, Pb equivalent) in [mm] Pb.

For the **determination of attenuation properties of materials** (including **optibelt ELASTOMIT** X-ray grades), the standard **DIN EN 61331-1** [9] applies. This standard describes the procedures for determining and characterisation of the attenuation properties (see figure 8; figure 7) of materials in sheet form that are used for manufacturing protective devices (material for X-ray aprons and radiation inspection systems) against X-rays with radiation qualities generated with X-ray tube voltages up to 400 kV.

The attenuation equivalent according to DIN EN 61331-1 is determined by comparing the measurement of the air kerma rate $\dot{K}_e$ of the sample with the thickness of the reference material, which produces the same value for $\dot{K}_e$.

According to DIN EN 61331-1, the following definition is to be used for determining the degree of attenuation S (including also with F; see figure 8):

$$S = F = \frac{\dot{K}_O}{\dot{K}_e} = \frac{\text{(measurement without test sample)}}{\text{(measurement with test sample)}}$$

with $\dot{K}_O$ = air kerma rate in unattenuated broad beam geometry,

$\dot{K}_{(X)}$ = air kerma rate in attenuated wide beam geometry

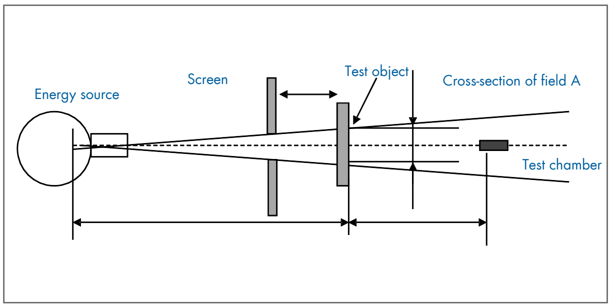


Figure 7: Test setup with narrow beam geometry for attenuation equivalence / lead equivalence according to DIN EN 61331-1

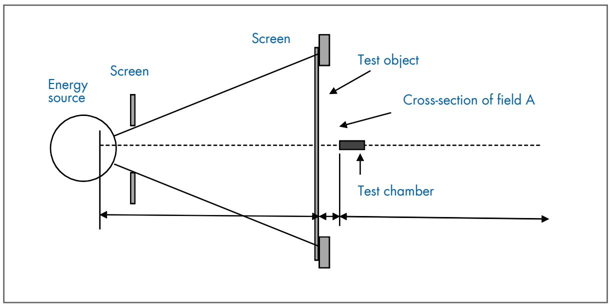


Figure 8: Test setup with broad beam geometry for attenuation factor F according to DIN EN 61331-1

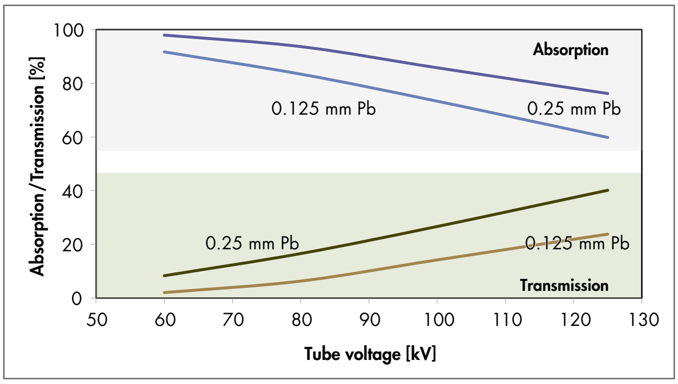
The percentage absorption values (A) and transmission values (T) can be determined according to laws of physics with the following equations:

$$A(\%) = \left(1 - \frac{\dot{K}_{(X)}}{\dot{K}_O}\right) \cdot 100\% = \left(1 - \frac{1}{F}\right) \cdot 100\% \qquad T(\%) = \frac{\dot{K}_{(X)}}{\dot{K}_O} \cdot 100\% = \frac{1}{F} \cdot 100\%$$

Definitions of the properties of radiation protective clothing and procedures for determining these were already contained in the standards DIN EN 61331-1 and DIN EN 61331-3.
These standards have their origin in international standards IEC 61331-1 and IEC 61331-3. The requirements contained in these standards concerning the attenuation properties of protective materials refer only to the lead equivalence value. Lead used to be the only material used as shielding material for protective clothing. For some time now, other materials containing little or no lead have also been used. Investigations have shown that the lead equivalence value does not adequately describe the protective properties of this material for radiation in the X-ray tube voltage range up to 150 kV. For this reason, the draft standard **DIN 6857-1 (Determination of shielding properties of unleaded or lead-reduced protective clothing)** [10] was generated. Materials for protective clothing classified according to this standard achieve the same protective effect as purely lead. This standard therefore applies for testing lead-free or lead-reduced radiation protective clothing for protecting persons against X-radiation from X-ray tube voltages up to 150 kV. This applies particularly if lead-free or lead-reduced protective materials are compared with lead-containing materials. This standard therefore deals with general requirements for measuring procedures, test equipment and measuring devices and the way of indicating the shielding properties on the protective clothing and in the accompanying documents.
A classification of protective classes (I to IV) and the nominal lead equivalent values of lead rubber clothing is given for 0.25 mm Pb, 0.35 mm Pb, 0.5 mm Pb and 1.0 mm Pb.

EXAMPLES OF USE FOR ANALYSIS AND OPTIMISATION

Generation of product-specific data from test results in accordance with DIN EN 61331-1
X-rays are a mixture of hard and soft rays. If we pick out just one bundle of X-rays of a precisely determined wavelength (monochromatic radiation) and pass these rays through an object, the X-rays become weakened. This is more pronounced in thick layers, and less pronounced in the case of thin layers. The attenuation of X-rays is not in straightforward proportionality to the thickness of the object, as can be seen from figure 5. According to DIN 6813, radiation protective clothing must however be marked with the lead equivalence. This makes sense, since attention must be paid to selecting the right apron.



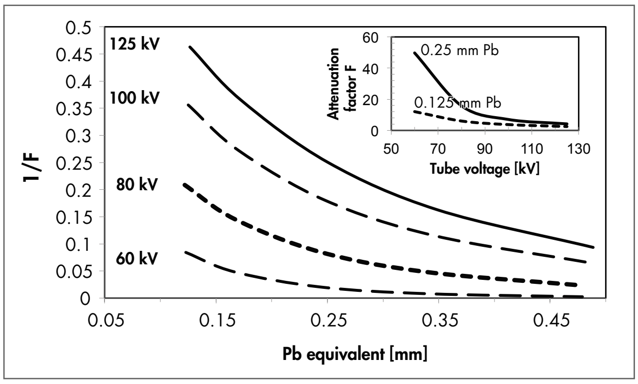


Figure 9: Absorption, transmission (left) and attenuation factors (right, 1/F) for lead equivalence values 0.125 / 0.25 mm and for four different X-ray tube operating voltages

A front apron, for example, protects about 6 %, while an all-round apron protects ~83 % of the bone marrow [11]. The attenuation in relation to the energy (kV) is a further point that needs to be taken into account.
The attenuation properties and lead equivalence of **optibelt ELASTOMIT** radiation protective grade are therefore determined in independent tests, and then evaluated and indicated in a customer-friendly way.
In figure 9 (left) and figure 10, for example, the absorption and transmission values are measured from the attenuation grades and factors and shown graphically for different lead equivalence values (mm Pb).

Figure 9 (right), shows the attenuation factors (F or 1/F) for X-radiation which were generated with voltages of 60 kV, 80 kV, 100 kV and 125 kV and "filtered" through an **optibelt ELASTOMIT** X-ray protection grade with 0.125 / 0.175 / 0.25 / 0.35 / 0.5 mm Pb. It is clear that as the Pb equivalence increases, the reciprocal value (1/F) of the attenuation factor F decreases and reduced radiation (intensity 1(x), see figure 5 and attenuation grade equation) is registered according to the corresponding **optibelt ELASTOMIT** X-radiation protection grade. With an identical Pb equivalence, 1/F increases analogously to the energy (voltage, kV), which also fits in with the theory.

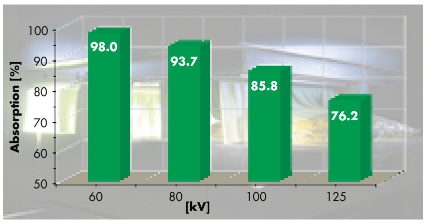


Figure 10: Schematic representation of absorption values of an optibelt ELASTOMIT X-radiation protection grade with 0.25 mm Pb (use in X-ray inspection systems)

Product/Process optimisation using product-specific data from test results in accordance with DIN EN 61331-1

If, for instance, samples from manufacture according to DIN EN 61331-1 are subjected to measurement-based analysis, the Pb equivalence values recorded can be graphically represented with standard deviances in relation to the tube voltage (kV). This is demonstrated schematically in figure 11, for example. Looking at the yellow curve progression of "0.175 mm Pb" it will quickly be seen that the product-specific Pb equivalence up to ~130 kV far exceeds +10 % tolerance, and therefore points to higher material usage. In this case, at a maximum voltage of 150 kV, material savings of ~ –10 % of the Pb equivalence could be made. Radiation protection would not be endangered as a result, as the specified tolerance range is not exceeded. A further advantage of this type of analysis also applies when newly developing an X-ray protection grade. If the attenuation properties of a new product are determined, for example, only at maximum voltage (in this case 150 kV), the results, in relation to the tolerance range, can be used accordingly for production purposes. The final measurements according to DIN EN 61331-1 do not therefore have to be carried out several times at all voltages.

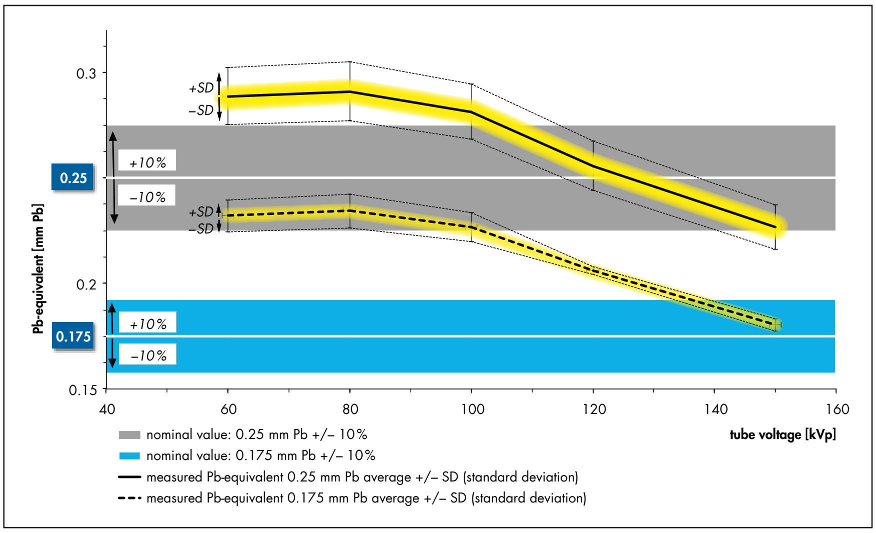


Figure 11: Graphic representation of Pb equivalence values determined on two optibelt ELASTOMIT X-ray protection grades (according to DIN EN 61331-1) with SD and in relation to the tube voltage

Radiological analysis of radiation-relevant properties of X-ray protective products

To investigate X-ray protective products to ascertain some of their radiation-relevant properties, microscopic testing including to determine their homogeneous particle distribution (for example, lead particles), particle size, and uniform structures is carried out (see figure 12).

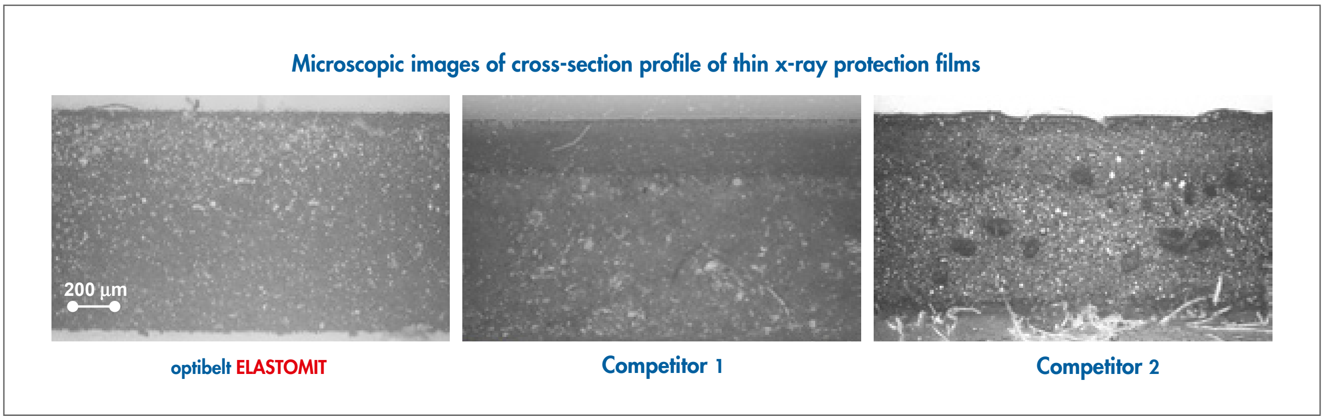


Figure 12: Cross-section profiles of the products: optibelt ELASTOMIT, competitor 1, competitor 2

During an X-radiation analysis, the protective clothing products to be investigated are then bombarded with X-rays. The X-rays penetrate the samples and produce a transparent silhouette on a photographic film. The more beams hit the film, the blacker it becomes. It therefore follows that:

- Pb equivalence / attenuation factor ↑ → X-radiation intensity behind the "sample" ↓ → blackening of X-ray film ↓
- Pb equivalence / attenuation factor ↓ → X-radiation intensity behind the "sample" ↑ → blackening of X-ray film ↑

The X-ray analysis of the samples shown in figure 11, for example, indicate corresponding problems, such as non-homogeneous particle distribution / inclusions (see figure 12, competitor 2) or a non-homogeneous structure (see figure 12, competitor 1).

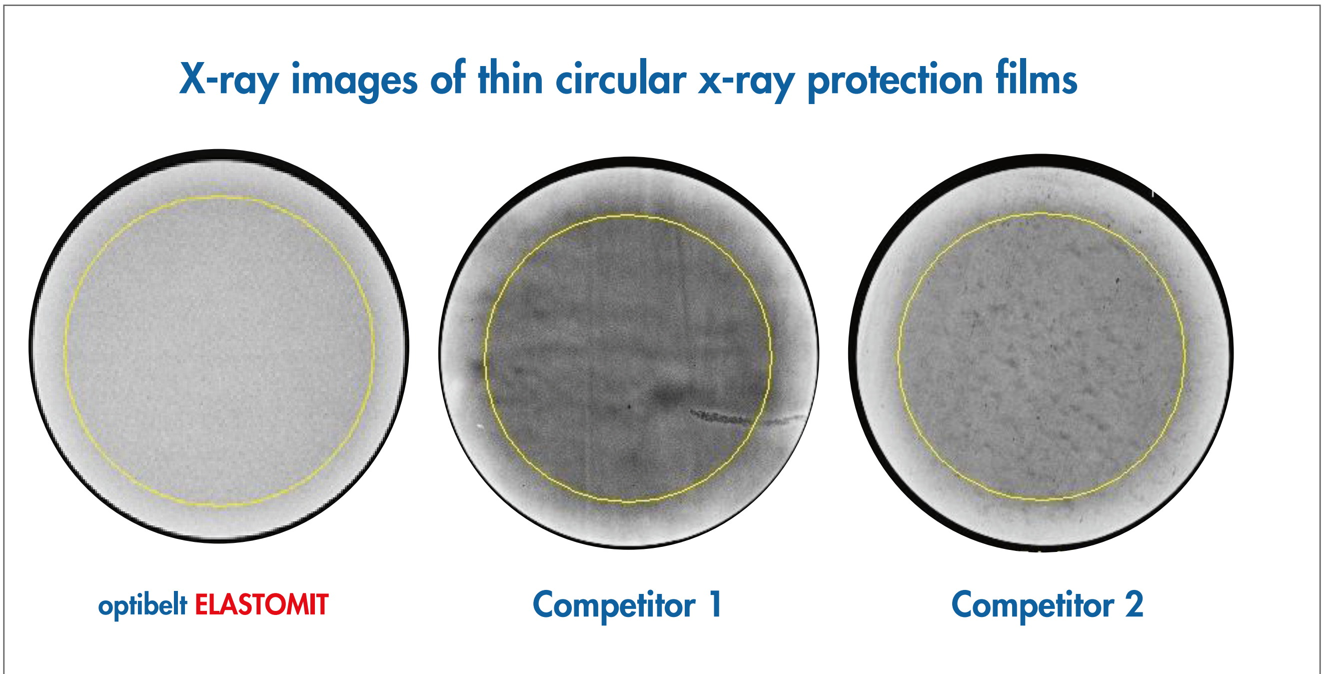


Figure 13: X-ray images of the products: optibelt ELASTOMIT, competitor 1, competitor 2

Using mathematical models, line profiles / grey scale analyses (see figure 14) and scientific analysis software, it is possible to show deviations in relation to prescribed tolerance ranges in the masses per unit area, the Pb equivalence values and the degrees of attenuation. Using analysed differences in the grey tones of the X-ray images (figure 13), corresponding differences in the Pb equivalence values, for example, can be displayed graphically (figure 14). It can therefore be ascertained that competitor 2's product should no longer be used as an X-ray apron with 0.25 mm Pb, as the Pb equivalence is outside the admissible tolerance.

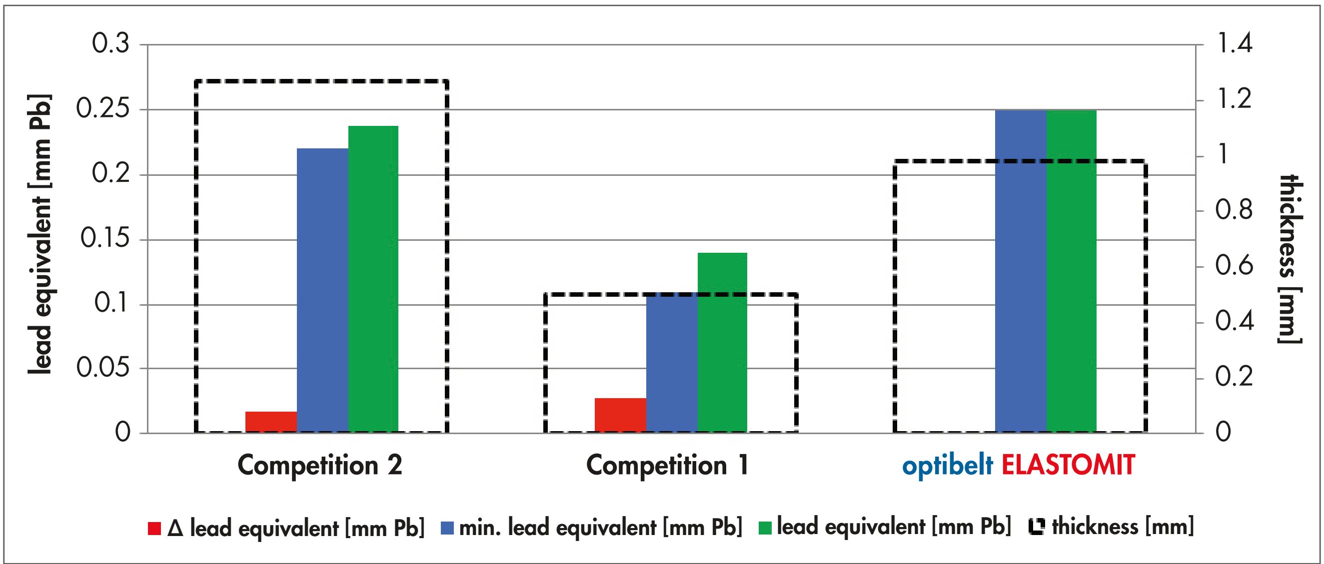


Figure 14: Analysis results for the products: optibelt ELASTOMIT, competitor 1, competitor 2

For a line profile, too, X-rays of the products are made to begin with, as shown in figure 15 for an **optibelt ELASTOMIT** product and a rival product.

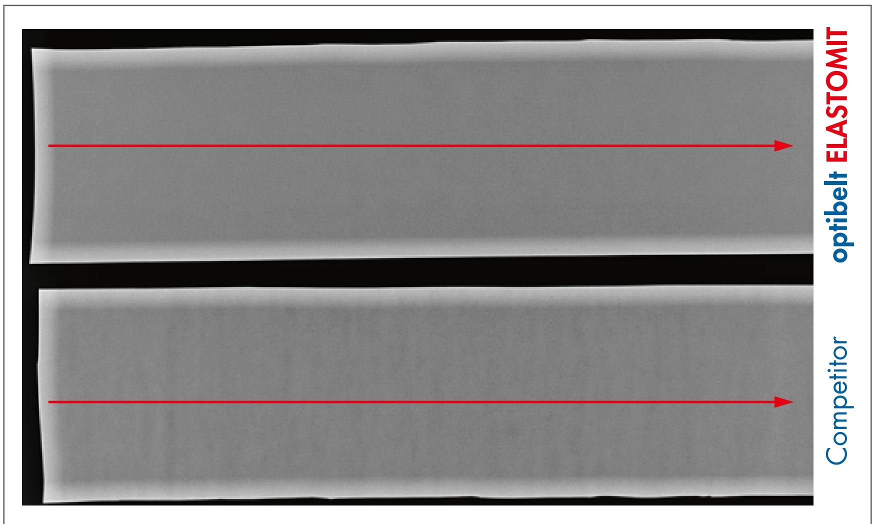


Figure 15: X-rays of longitudinal strips of the optibelt ELASTOMIT product and a rival product

The red arrows in figure 15 indicate the local position of the grey scale analysis of the line profile. Using scientific analysis software, the grey scale line profile can be created (figure 16). The "trend line" in figure 16 represents the background grey scale determined; the orange-coloured image "noise" corresponds to the grey scale fluctuations along the length of the X-ray image.

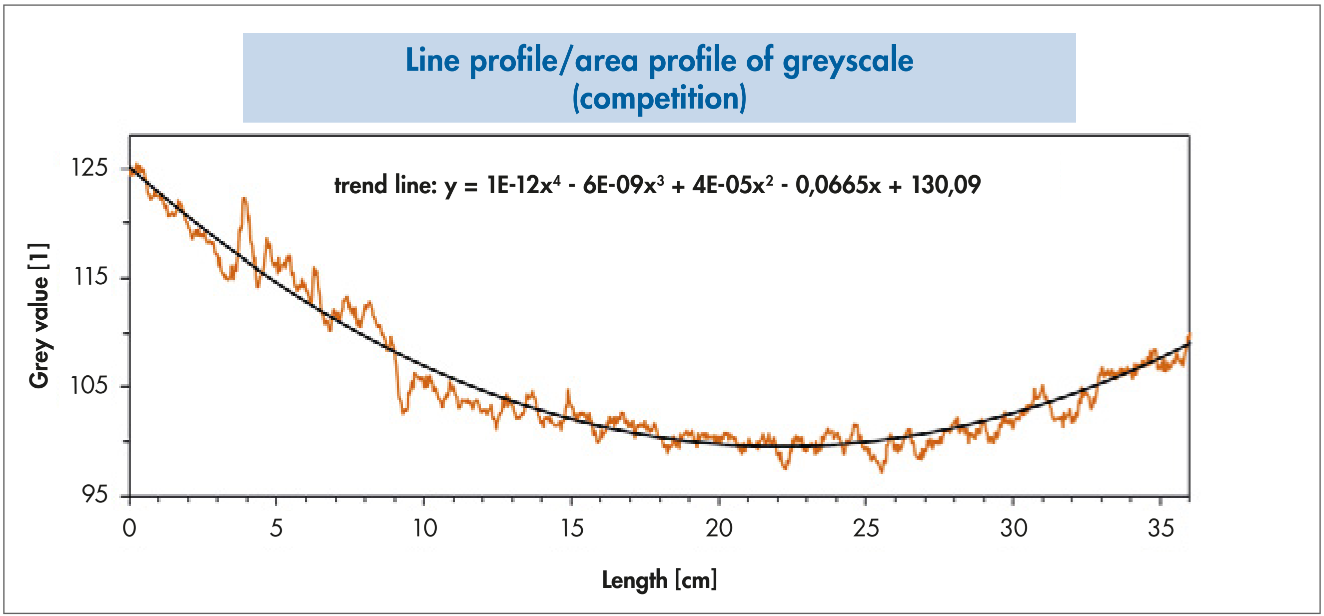


Figure 16: Grey scale analysis of X-ray images along the length of the rival product

If we then subtract the background grey scale values from the actual grey scale signal, we obtain the grey scale fluctuations for the product concerned. The percentage of grey scale fluctuations can then be referred to the mass per unit area and allow a graphic comparison of the homogeneity of the grey values of a rival product and an **optibelt ELASTOMIT** grade (figure 17).

In the rival product in question, it was possible in this way to determine not only the ~8 % deviation in the mass per unit area compared to the **optibelt ELASTOMIT** product but also that the additional 5 % fluctuation in the mass per unit area resulted in the product falling below the tolerance range.

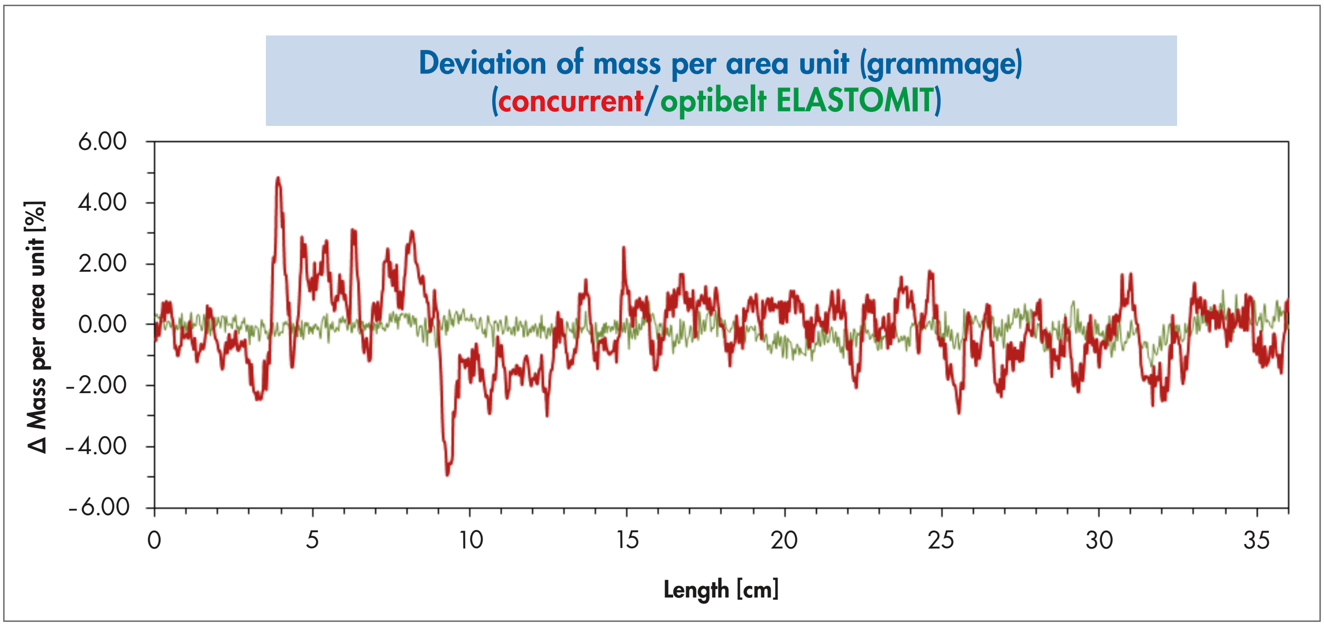


Figure 17: X-rays of longitudinal strips of the products from optibelt ELASTOMIT and a rival product

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The Arntz Optibelt Group takes a responsible approach to the environment, as a matter of course.

The quality and continuous further development of the company's processes and products are of central importance to the Arntz Optibelt Group, as is the assurance of the quality and environmental management standards, which are certified according to DIN EN ISO 9001 and 14001.

The Arntz Optibelt Group is committed to complying with existing environmental laws and regulations as well as official regulations.

Above and beyond the requirements of existing environmental laws and regulations, we also work continuously on reducing any negative environmental influences caused by our products or business activities.

The continuing improvement of our environmental footprint and our efficient use of resources is a result of our responsible use and careful conservation of energy, water and other resources.

High-quality products, technologically advanced solutions and close personal ties between our company and our business partners help to improve the level of satisfaction of all parties involved.

REACH, RoHS AND CONFLICT MINERALS[1]

The Arntz Optibelt Group attaches particular importance to compliance with the legal regulations, guidelines and standards applicable to its products.

For the Arntz Optibelt Group, it is therefore essential that its suppliers are aware of and ensure compliance with the applicable legal requirements, such as REACH, RoHS and "Conflict Minerals – the Dodd-Frank Act".

OPTIBELT RESPONSIBILITY DESIGNS FUTURE

blue VISION

[1]Extract from the Code of Conduct of the Arntz Optibelt Group

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certifies that the company

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for the societies

Arntz Beteiligungs GmbH & Co. KG, Optibelt GmbH, Optibelt Elastomer Solutions GmbH, Deutsche Keilriemen GmbH, Arntz Optibelt GmbH, Optiservice GmbH, Optibelt Produktions GmbH, Optibelt Material Handling GmbH

at the sites

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according to

DIN EN ISO 14001:2015

Scope:
development, production and sales of power transmission systems
and technical rubber products

Number of certificate: 1802001
Validity until: 13.11.2020

Coesfeld, 10.01.2018

CERTIFICATE

TÜV NORD

Management system as per
DIN EN ISO 9001 : 2015

In accordance with TÜV NORD CERT procedures, it is hereby certified that

Arntz OPTIBELT Group
Corveyer Allee 15
37671 Höxter
Germany

with the locations / sites according to the annex

applies a management system in line with the above standard for the following scope

Development, production and sales of power transmission systems and rubber sheets

Certificate Registration No. 44 100 061953
Audit Report No. 3522 1268

Valid from 2017-08-21
Valid until 2020-08-20
Initial certification 2001

Certification Body
at TÜV NORD CERT GmbH

Essen, 2018-09-11

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

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