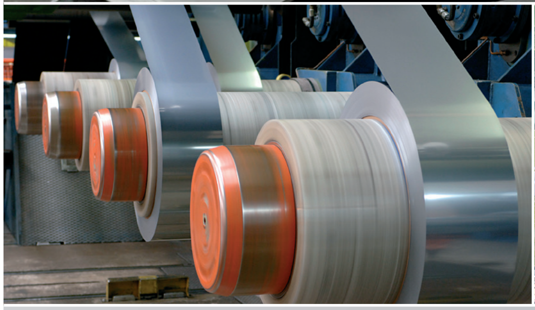


Environmental product declaration for tin coated steel (tinplate)

Based on ISO 14025
Life cycle assessment according to ISO 14040/44
Modular structure based on EN 15804

ThyssenKrupp Rasselstein

ThyssenKrupp

Contents

1. Product

1.1 Product description

Tinplate is sheet steel cold rolled to a thickness of 0.100 to 0.499 mm and subsequently electrolytically coated with tin. ThyssenKrupp Rasselstein GmbH offers this product under the brand names **ANDRALYT**® (electrolytic tin coated steel) and **Thinplate**®. **Thinplate**® indicates ThyssenKrupp Rasselstein's claim to be a leader in resource efficiency (for example, "0.100" and thickness reduction for crown corks and drawn and wall-ironed material (D&I).

1.2. Delivery condition, dimensions, and packagings

1.2.1 Delivery condition

The product is available in various formats, for example, as coils, sheets (straight or scroll cut), or slit strips.

1.2.2 Dimensions

Product dimensions vary according to application and customer requirements. Unless otherwise stated by the customer in enquiries and orders, products are dimensioned and delivered according to EN 10202.

Coils

Thickness mm	SR BA Width mm	SR CA Width mm	DR BA Width mm	DR CA Width mm
0.100 – 0.119	600 – 950*	–	600 – 1,000*	*
0.120 – 0.129	600 – 1,000*	–	600 – 1,090	*
0.130 – 0.139	600 – 1,000*	–	600 – 1,090	600 – 1,090
0.140 – 0.149	600 – 1,050	–	600 – 1,090	600 – 1,090
0.150 – 0.179	600 – 1,090	600 – 1,090	600 – 1,220[1)]	600 – 1,090
0.180 – 0.199	600 – 1,090	600 – 1,090	600 – 1,220[1)]	600 – 1,220[1)]
0.200 – 0.499	600 – 1,220[1)]	600 – 1,220[1]	600 – 1,220[1)]	600 – 1,220[1)]
≥ 0.50*				

Other dimensions on inquiry.
1) Up to 1,230 mm by arrangement
* On inquiry

Sheets

Thickness mm	SR BA Width mm	SR CA Width mm	DR BA Width mm	DR CA Width mm
0.100 – 0.119	600 – 950*	–	600 – 1,000*	*
0.120 – 0.129	600 – 1,000*	–	600 – 1,090	*
0.130 – 0.139	600 – 1,000	–	600 – 1,090	600 – 1,090
0.140 – 0.149	600 – 1,050	–	600 – 1,090	600 – 1,090
0.150 – 0.179	600 – 1,090	600 – 1,090	600 – 1,120	600 – 1,090
0.180 – 0.199	600 – 1,090	600 – 1,090	600 – 1,120	600 – 1,120
0.200 – 0.499	600 – 1,120	600 – 1,120	600 – 1,120	600 – 1,120
≥ 0.50*				

Sheet length:
Straight-cut: 450 – 1,200 mm
Scroll-cut: 560 – 1,150 mm

Lacquered sheets:
min. 660 x 510 mm
max. 1,120 x 980 mm

* On inquiry

Sheets and Coils

	Orientation	Max. packing unit weight	Max. outside diameter	Inside diameter	Inside diameter on inquiry
Coils	Vertical axis	3.0 – 12.7 t	1,630 mm	420 mm	450/508 mm
	Horizontal axis	3.0 – 18.0 t	1,850 mm	508 mm	420/450 mm
Sheets	–	2.5 t	–	–	–

1. Product

1.2.3 Packaging

The choice of packaging type depends upon product dimensions, destination (domestic or international), and specific requirements of individual customers. The following types of packaging materials are used by ThyssenKrupp Rasselstein GmbH.

- Corrugated paper board (disk, strip), cored paper disk, gray board (non-coated)
- Container sleeves, container lids
- PE film (flat film, stretch wrap, shrink film, tubular film)
- A4 transparent labeling pockets made from PE
- Paper tube, slotted
- Fiberboard (disk, tube)
- Steel disk, tube, lid
- Edge protection (steel, paper)
- Corner brackets and corner protection
- Gray board corner protection
- Lamiflex corner protection
- Strapping tape, 2 types, made from steel
- Cross buckles
- Pallets (steel, wood)
- Tape (steel, plastic)
- Anti-corrosion paper
- Crepe paper

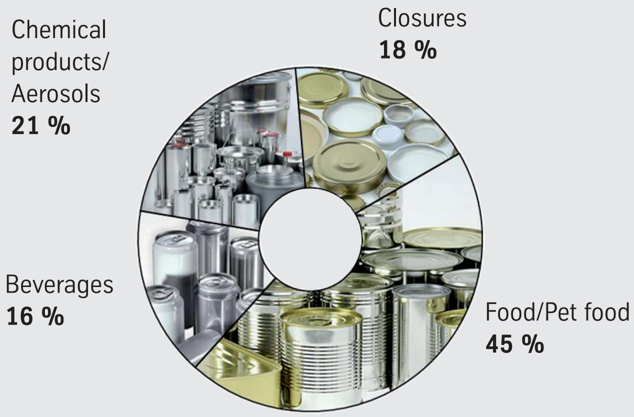
The steel pallets and some wooden pallets, fiberboard disks and fiberboard tubes are taken back and reused (loop system) by ThyssenKrupp Rasselstein GmbH. The conducted life cycle assessment only considers the tinplate but not the packagings.

1.3 Product application and product processing

Almost all the material ThyssenKrupp Rasselstein GmbH produces is used in the packaging industry. Applications include cans for food and pet food, packagings for chemical products, aerosol cans, closures and beverage cans.

Products made from tinned steel are also found in non-packaging applications, such as in the automotive, electronics, construction and garment industries, in household goods, schools, offices, and in recreational and leisure equipment.

Distribution by market segment for products in the packaging industry in the fiscal year 2011/12:



1. Product

Through further development of material properties in conjunction with optimized manufacturing processes, ThyssenKrupp Rasselstein GmbH ensures that the applications and processability of tinplate are continuously improved and expanded. Examples include:

- Optimization of material properties: Improved steel grades with even better and more economical formability, enabling a large variety of shapes and designs. Shaped cans can be manufactured in very different geometries.
- Material savings through reduced thickness of steel sheet (up to one third of the original thickness) making the material suitable for the direct wall ironing process in beverage can production. Material thickness reductions also help to decrease transport costs and CO_2 emissions.
- Weight reduction while still maintaining high rigidity, enabling packagings made of tinplate to be suitable for transport and storage and thus capable of being used in many different ways.
- Closures with optimized reliability and user-friendliness, such as Easy Open Ends, and further improvement of opening behavior.

1.4 Use of product

The most important requirement for tinplate packagings is protection of their contents. Tinplate is used as packaging material when packaging must remain intact under high stresses and strains. This means break-proof, shock-proof, and puncture-proof. While protecting contents (food, beverages, paints, chemicals, and other goods) from external influences, tinplate cans offer benefits for transport and storage because of their stackability and stability. The material properties span a large performance profile: light-weight, high-rigidity, gas-tight, liquid-tight, opaque, heat-resistant, and heat-sterilizable.

Tinplate packagings keep their contents fresh and maintain taste, vitamins, and minerals in a safe, protective, hygienic, and practical pack. One of the most important functions of the packaging is to increase shelf life of food. Because tinplate assures a long shelf life, this substantially contributes to the avoidance of food waste. A threepiece can may enable a shelf life of 3 years.

Tinplate packagings also fulfill consumer requirements, such as product variety, convenience, user-friendliness, attractive packaging designs, and environmental sustainability. The material can be used in many ways: for two-piece cans, aerosol cans and beverage cans with widget or Easy Open Ends. Tinplate packagings enable easy handling, easy opening and reclosing, the possibility to completely empty the contents, and offer a wide range of choices for new lid and cap solutions.

Novel, highly formable tinplate grades enable manufacturing of low-profile cans with bigger openings, suitable for microwave ovens, allowing the contents to be warmed up inside the packaging. Such bowls or trays that are tapered and stackable can also be fitted with convenient peel-off lids.

Tinplate is suitable for the manufacturing of products that require a high degree of material deformation, such as D&I (drawn and wall-ironed) and DRD (drawn and redrawn) cans, valve disks, and vacuum twist-off closures (also known as FLIP caps). Moreover it allows functional coatings to be applied, such as rubber coatings for seals.

Tinplate packagings enable optimal modification of the packaging to accommodate different portion sizes. The shape of the steel container can be adjusted to suit the intended portion size (minimizing food waste).

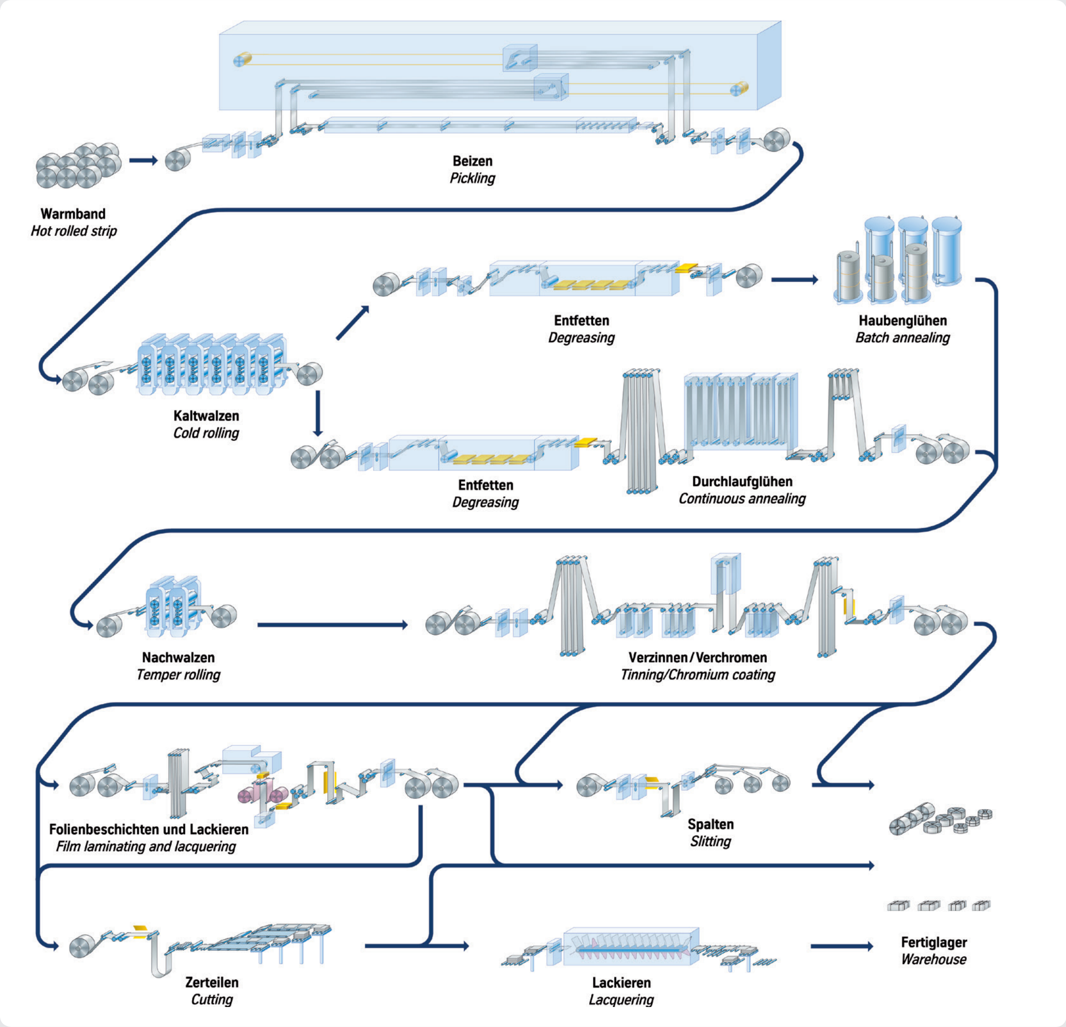
In the retail business, steel cans also fulfill logistic requirements. In addition to the essential attributes of being rigid, unbreakable and leakproof, tinplate packagings meet expectations regarding good storability and stackability, hence saving space. Moreover, food stored in cans does not need to be refrigerated.

1. Product

Tinplate packagings have superior printing and coating properties. Very often, tinplate used for packaging also has an additional coat of corrosion protection material besides its metallic finishing. Common applications are in food cans, beverage cans, crown corks, and vacuum twist-off closures. The coating gives full-surface protection against corrosion with a uniform layer thickness and homogenous surface that is highly scratch- and wear-resistant, pore-free, and provides an optimal substrate for coloring and decorative designs. By using modern coating technologies, cans can be given individual customized finishes with brand-specific details.

1.5 Production of tinned steel sheet

The base material for producing tinplate is hot-rolled sheet steel (hot rolled strip) that has a thickness of 1.8 mm to 3.9 mm and comes from ThyssenKrupp Steel Europe AG in coils weighing 6 to 28 metric tons. The steps involved in tinplate production are described in detail below:



Pickling:
Pickling serves to remove layers of iron oxide (scale) which may have developed on the surface during the hot-rolling process. This is done in a continuous pickling plant in baths of dilute hydrochloric or sulfuric acid.

Cold-rolling/Degreasing/Annealing:
The strip is oiled to protect it from corrosion and provide lubrication while the thickness of the steel sheet is being reduced through cold-rolling. Any strain hardening (reduction of forming capability) is eliminated later by annealing. Depending on the intended use or the required material properties, tinplate may be produced using a batch or a continuous annealing process.

1. Product

Temper rolling:
In order to give the steel sheet the required properties for the intended purpose (achieving the desired surface finish and processing properties), temper-rolling is performed after annealing. Temper-rolling is dry “post-rolling” without lubrication or cooling and is also referred to as dressing. The deformation (degree of reduction) varies from 0.4% to 2.0%, depending on application purposes. Two of the three temper rolling mills at ThyssenKrupp Rasselstein GmbH can also perform wet temper-rolling and are capable of reducing the thickness by up to 43%. The double-reduced (DR) strip produced in this way saves material for customers but requires the use of lubricants and coolants.

Tinning:
After pre-treatment (degreasing, pickling) the steel strip is passed through a continuous electrolytic tinning line until the specified coating thickness is reached. To achieve the typical tinplate look, the material is then heated briefly to above the melting point of tin (232° C). Another chemical post-treatment, passivation, minimizes build-up of tin oxide on the surface and optimizes the anticorrosion protection. Oiling with oil approved as safe for food packaging concludes the process.

Slitting and cutting:
Finally tinplate is tailored (cut to size) to meet customers’ requirements before delivery.

1.6 Special material properties

Compliance with the European standard EN 10202, which defines the requirement parameters for tinplate ensures that the products will be fit for the ultimate use intended by customers. The different parameters are complied with as appropriate for the intended use. These parameters relate to:

- Material characteristics determining strength and deformability (yield strength and tensile strength)
- Surface condition (surface finish, roughness, tin coating, oiling)
- Material thickness

According to the product range, tinplate is offered in the following material grades (steel grades depending on application purpose):

EN 10202 – 2001

Grade	Yield strength
TS 230	230 +/- 50
TS 245	245 +/- 50
TS 260	260 +/- 50
TS 275	275 +/- 50
TS 290	290 +/- 50
TS 340	340 +/- 50
TS 480	480 +/- 50
TS 520	520 +/- 50
TS 550	550 +/- 50
TH 330	330 +/- 50
TH 340	on inquiry
TH 415	415 +/- 50
TH 435	435 +/- 50
TH 450	450 +/- 50
TH 480	480 +/- 50
TH 520	520 +/- 50
TH 550	550 +/- 50
TH 580	580 +/- 50
TH 620	620 +/- 50
TH 650	650 +/- 50

AISI/ASTM 623

Code
T 1
T 2
T 3
T 4
T 5
DR 7
DR 7.5
DR 8
DR 8.5
DR 9
DR 9.5

1. Product

Tinplate is supplied in different tin coat thicknesses. Depending on customers' requirements, the tin layer can be applied to one or both sides. A subsequent passivation for tinned grades is also offered under Code 300, Code 311, and Code 314.

Coating weights for tin

EN g/m² one side	Corresponds to lbs/bb two sides
1.00	0.089
1.40	0.125
2.00	0.179
2.80	0.250
4.00	0.357
5.00	0.446
5.60	0.500
8.40	0.750
11.20	1.000

AISI/ASTM lbs/bb two sides	Corresponds to g/m² one side
0.05	0.60
0.10	1.10
0.15	1.70
0.20	2.20
0.25	2.80
0.35	3.90
0.50	5.60
0.75	8.40
1.00	11.20

Coating weights shown at left are possible for equal and differential coating.

Deviations in coating weights from 1.00 to 11.20 g/m² or 0.100 to 1.000 lbs/bb are possible.

Other tin coating weights on inquiry.

One-side tin coatings possible in the range 0.50 to 5.60 g/m².

Marking of differential coatings in accordance with Euronorm/SEFEL, alternative markings by arrangement.

Oiling

To assure processability at high speed in canning lines in customer plants, a thin film of oil is applied to the tinplate to assure adequate sliding properties. For tinplate, an oil film of 4 – 7 mg/m² per side is necessary. This has to be applied evenly without forming droplets. Any greater film weights can disturb processing and cause spreading problems at the lacquering stage. DOS has proven itself as the main oiling method. ATBC and alternative oiling types are of secondary importance.

DOS	4 +/- 2 mg/m² per side
ATBC	7 +/- 3 mg/m² per side
Alternative oiling	4 +/- 2 mg/m² per side

Finishes

During the dressing process, the surface finish is generated with a roughness as required for the intended use while the flatness is improved at the same time. The following surface finishes are offered:

Finish	Melted	Roughness (Ra) µm
Bright	Yes	≤ 0.30
Fine stone	Yes	0.25 – 0.45
Stone	Yes	0.30 – 0.75
Silver matt	Yes	0.40 – 2.25
Matt	No	0.40 – 2.25

Closer tolerances within the roughness ranges in accordance with the standards or on inquiry.

Different roughness values per side on inquiry

1.7 Base materials, operating materials and consumables

All the base materials, operating materials and consumables used meet the requirements of ThyssenKrupp Rasselstein GmbH's quality, environmental, and occupational health and safety management systems. In conformity with the REACH regulation, all the materials have been registered with the European Chemicals Agency (ECHA).

1.7.1 Base materials (pre-products)

The starting material for the production of tinplate is **hot-rolled steel strip** from ThyssenKrupp Steel Europe AG, that is reduced to the required thickness through cold rolling and then coated with tin. To manufacture the pre-material "steel" (hot-rolled steel strip), the following materials are used for production:

1. Product

Primary metallurgy: Hot metal is produced in the blast furnace (BF) through the reduction of iron ore with the help of reducing agents (coke and coal) and other additives (such as slag formers and lime). It takes about 1.5 metric tons of iron ore to produce 1 metric ton of tin coated steel. The carbon contained in the reducing agents reacts with oxygen (in the hot air blasted into the furnace) to form carbon monoxide. The carbon monoxide gas reacts with the oxygen contained in the iron oxide. The products of this reaction are hot metal (raw iron) and slag. Hot metal still contains 4 – 5% carbon, which is then removed in the steel mill. During further processing in a basic oxygen furnace (BOF), the carbon in the hot metal is oxidized by injecting oxygen into the hot metal (technically known as refining) to produce crude steel. In this process, the energy released is utilized to melt down up to 25% iron and steel scrap. This means that even the "primary production" of steel uses recycled materials. The residues of the ore, also called gangue, react with the slag formers to form slag which is entirely utilized, for example in the construction industry.

Secondary metallurgy: To produce the type of steel used for tinplate – with special requirements regarding processing and properties in use – secondary metallurgy treatment is essential in addition to modern steel production processes. Depending on the desired quality, this can, among other things, involve the addition of alloying elements.

After secondary metallurgy treatment, the molten crude steel is continuously cast to form steel slabs. Afterwards, in the hot-rolling process that follows, the thickness of the slab is reduced to 1.8 – 3.9 mm and the resulting strip is coiled.

1.7.2 Operating materials and consumables

In the tinplate production process, the following operating materials and consumables are used:

- **Pickling:** sulfuric or hydrochloric acid, oils
- **Cold rolling:** water-rolling oil emulsion
- **Degreasing:** degreasing agent, caustic soda (sodium hydroxide)
- **Batch and continuous annealing:** oxygen-free inert gas, nitrogen or hydrogen
- **Temper-rolling:** rolling oil
- **Finishing:** pickling and degreasing agents, electrolyte, tin (1.0 – 11.20 g Sn/m^2 per side)
- **Passivation:** detergent, electrolyte
- **Oiling:** DOS (4 +/- 2 mg/m^2 per side), ATBC (7 +/- 3 mg/m^2 per side), alternative oiling (4 +/- 2 mg/m^2 per side)

1.7.3 Raw material extraction and materials origins

Iron ore, coal, alloying elements and lime are extracted from natural deposits. The processing methods are designed to take account of natural variations in quality. Coal is the starting material for producing the reducing agent coke and is also used directly as a reducing agent. Lime and the required alloying elements for tinned steel grades are input in the appropriate form. Alloying agents are used in secondary metallurgy (post-treatment of steel after refining) in the form of ferroalloys (ferrosilicon, ferromanganese) and microalloys (ferrotitanium, ferroniobium).

Iron is a chemical element that does not exist in pure form in nature; it is mainly found in oxidized form. Iron ores are mixtures of iron oxides (chemical compounds of iron and oxygen) deposited in non-ferrous rock.

Steel is an iron-based alloy containing less than 2% carbon that can be forged and shaped. At the end of its service life, a steel product can be returned to the material loop without any loss in quality.

1.7.4 Availability of raw materials

Iron is the second most common metal (after aluminum) and the fourth most common element in the Earth's crust, accounting for a share of 3.38%. The deposits of iron ore around the planet are an almost unlimited resource because iron is one of the most frequently found elements on Earth. The iron ore deposits that are known today will last for several hundred years.

1. Product

Coal is used as reducing agent either directly or after it has been converted into coke. The earth has vast coal deposits. The availability of today's known resources will last for several hundred years.

Depending on the type of the element, the availability of **alloying elements** varies. However, this is of minor importance because tinplate is produced using low-alloyed steel.

Iron and steel scrap are steel products which, at the end of their service life, are processed into appropriate forms that can be utilized as secondary input materials. The recycling rate[1] of packaging steel is at a record level of 93.6% (GVM 2011). For the primary production of steel, up to 25% iron and steel scrap is required. This saves the use of primary resources: every metric ton of steel or packaging steel that is recycled saves 1.5 metric tons of iron ore, 0.65 metric tons of coal, and 0.3 metric tons of lime.

Products made from tinplate can be recycled almost completely without any loss of quality. Tinplate consumer packagings collected through the German "Green Dot" system (Der Grüne Punkt) are gathered nationwide by DWR "Deutsche Gesellschaft für Weißblechrecycling GmbH" (a subsidiary of ThyssenKrupp Rasselstein GmbH) and delivered to ThyssenKrupp Steel Europe AG and melted down to make new steel at the Duisburg steel mill. There is also a return and recycling system for industrial and commercial enterprises: the company KBS Kreislaufsystem Blechverpackungen Stahl GmbH (another subsidiary of ThyssenKrupp Rasselstein GmbH).

1.8 Environmental protection and occupational health during production (rules for quality assurance, placing the product on the market, and product use)

1.8.1 Quality management system

The following quality management systems and certifications are currently in place:

- Quality management DIN EN ISO 9001:2008
- Quality management ISO/TS 16949:2009 certified by Lloyd's Register
- Declaration of conformity according to ISO/IEC Guide 22
- Declaration of conformity according to ISO/IEC Guide 22 regarding radioactivity of tinplate
- Conformity with good manufacturing practice (GMP) and hazard analysis critical control point (HACCP), (the quality and hygiene guidelines of the food industry) certified by Lloyd's Register
- BME code of conduct

Declaration of conformity according to ISO/IEC Guide 22:
For the products that fall into the category of "cold-rolled sheet metal packaging products -electrolytically tin coated steel" in the application area of packaging (food and non-food), the following types of conformity according to ISO/EC Guide 22 are confirmed:

DIN EN 10202 Tinplate	Product/delivery standard	Cold-rolled sheet metal packaging products – electrolytically tin coated steel
DIN EN 610	Production standard	Tin and tin alloys – tin in ingots Tin quality 99.90% Sn, less than 100 ppm Pb
DIN EN 10333 Tinplate	Application standard	Steel for packaging – Flat steel products intended for use in contact with foodstuffs, products and beverages for human and animal consumption – Tin coated steel (tinplate)
EC 1935/2004		Materials and items intended for contact with food.
94/62/EC Art. 11		Heavy metals Cd, Pb, Hg, Cr6+ less than 100 ppm in total

General product requirements for coils, sheets, and slit strip (please refer to product range at: http://www.thyssenkrupp-rasselstein.com/fileadmin/pdf/publikationen/ThyssenKrupp_Rasselstein_Product_Range.pdf) are described in the standard EN 10202 (cold-rolled sheet metal packaging products – electrolytically tin coated steel) and in EN 10140 (for slit strip with a width less than 600 mm; dimension limits and shape tolerances) or can be specified by customers.

[1] According to GVM, the recycling rate is defined as the collection and sorting of scrap, which corresponds to the starting volume obtained from the sorting plants.

1. Product

1.8.2 Environmental management system

Since 2001, ThyssenKrupp Rasselstein GmbH has had an environmental management system in place that is certified according to DIN EN ISO 14001:2004.

1.8.3 Energy management system

The energy management system in accordance with DIN ISO 50001:2011 has the goal of reducing specific energy consumption in the long term and increasing energy efficiency in a continuous improvement process. Because of the close relationship between environmental and energy management, the energy management system is integrated, as much as possible, into the existing environmental management system.

1.8.4 Health and safety management in accordance with OHSAS 18001

ThyssenKrupp Rasselstein GmbH works in line with the occupational health and safety management system (OHSM) of OHSAS 18001. Preparations are being made for certification in 2013, scheduled for November.

1.8.5 REACH

With respect to the REACH regulation (regulation for registration, evaluation, authorization, and restriction of chemicals), ThyssenKrupp Rasselstein GmbH has fulfilled its obligations as a manufacturer and importer of substances, preparations, and products. For all substances that are produced or imported by ThyssenKrupp Rasselstein GmbH, registration with the European Chemicals Agency (ECHA) has been completed and the registration numbers are available.

1.9 Product, environment, and health during product use

1.9.1 Product impact in relation to environmental and health factors

In the use phase of the product, the impacts in relation to environmental and health factors are as given below:

In general:

- Danger to water, air/atmosphere, and soil does not arise when tinplate is used for the intended purpose.
- Tinplate is stable and does not emit toxic substances into water.
- The product does not contain hazardous materials.
- During mechanical processing (welding, cutting, grinding), dust and vapors may occur; these are, however, process-specific and not product-specific.
- With normal use of tinplate, according to the intended purpose, adverse health effects are not known.
- It is possible that corrosion will appear, this depends on O_2 level, temperature level, pH, mechanical stressing, and the duration of the exposure to these factors. To avoid corrosion and reaction of tinplate with food during the use phase, a homogeneous tin coating can be applied.
- Tinplate is a quality-controlled material which is developed specifically for each application purpose and fulfills the high safety standards demanded for the specific filled goods involved.

Processed product:

- When processed into cans, tinplate has a barrier function with a dual effect that protects the environment from hazardous contents and protects the filled goods from external influences while maintaining the formulation.
- Tinplate is not permeable to light, oxygen, gases, fragrances and flavors, oils, fats, fluids, and pests.
- Metal packagings made from tinplate (cans and containers) are suitable for the safe transport of chemical products and hazardous materials in particular. They fulfill:
    - Regulations for design type testing
    - Regulations for UN or ADR/RID (Agreement on dangerous goods transport by road/ Regulations concerning the international transport of dangerous goods by rail)
    - Stringent quality requirements in production, assured through internal and external inspection and monitoring

  With its monitoring organization for metal packagings (“Überwachungsgesellschaft Metallverpackungen”), the metal industry in Germany has its own quality management scheme; this is accredited by the state authority “BAM” (Federal Institute for Materials Research and Testing).

1. Product

- Metal packagings are absolutely solvent-proof and gas-tight:
  - The packagings thus reliably prevent permeation of flammable liquids
  - In contrast to other packaging materials, metal is exempt from additional permeability tests when it comes to obtaining approvals for hazardous goods

Transport and storage:
- Metal packagings made from tinplate are durable and easy to store. The physical properties of tinplate ensure long life of the packaging and an extremely long shelf life of its contents.
- Metal packagings made from tinplate resist compression. Because of the material's strength, they can withstand high axial loading: a 1-liter can bears a load of about 3.2 kN or 20 beer crates. This results in significant advantages for storage and transport:
  - No problem stacking in several layers
  - Will remain in a stable position even in high temperatures
  - Requires very little secondary packaging
  - Allows optimal space utilization in warehouses, trucks, and containers
- During transport or storage of solvents in metal packagings made of tinplate, an explosive atmosphere cannot develop because tinplate packagings are solvent-proof and gas-tight.
- Cans with lacquered and film-coated interiors can be used for very aggressive contents. An organic coating (lacquer or film) applied before can manufacturing reduces the formation of cracks during shaping and deep drawing, which could potentially be points of attack for oxidation.
- Liquid and acidic foods result in harmless and permissible attacks on the tin layer. This interaction is reduced by avoiding air contact (for example, by reducing the head space volume and filling the goods under inert gas).
- The use of tinplate as a basis for food packagings results in energy savings and hence a reduction of environmental impacts throughout the life cycle of the packaged goods because the foodstuff or beverage requires no refrigeration during transport and storage. In a household, food that has been packaged in cans only requires brief (re)heating but not cooking. Handling of cans in the consumer goods industries, in retail stores, and by consumers uses less energy than required by refrigerated products and thus also saves resources.

Consumers:
- For chemical and technical filled goods, cans and containers made of tinplate offer a high measure of safety (see above).
- For food, tinplate cans offer broad protection from contamination, bacteria, humidity, light, and odor, resulting in a longer shelf life and the avoidance of food waste.

1.9.2 Extraordinary effects

Fire/Fire protection:
Tinplate is extremely heat-resistant. The critical temperature, the melting point of tinplate, is approximately 1,532 °C. There is no official flammability classification in European standards concerning tinplate to be used as a packaging material. In our own assessment, the material has a flammability of less than 1%.

Water:
When exposed to weathering in the presence of oxygen and water, steel corrodes (slow oxidation).

Resilience:
Tinplate has a very high mechanical resilience and stays intact under high load. It is unbreakable, shock-resistant and puncture-resistant. Even under harsh conditions such as heat, cold, and solar radiation, tinplate protects its contents reliably during transport, storage, and during use.

1. Product

1.10 After-use phase/disposal

Steel scrap is fed back into the material loop through long-established recycling systems. Tin coated steel (tinplate) is almost 100% recyclable. Besides this, tinplate can be recycled as often as desired, any number of times, and with no loss in quality.

Because of its magnetic properties, packaging steel is a material that can be collected and recycled easily and economically. After being separated out of collected waste with magnets, cans made of tin coated steel are pressed into scrap bales for remelting in steel mills. The steel scrap is used as input together with primary resources such as iron ore, coking coal and lime to make new steel, thus closing the material loop. The recycling of one metric ton of packaging steel saves two metric tons of raw materials (coal and iron ore). Worldwide, the recycling of steel scrap is estimated to avoid the extraction of 850 million metric tons of iron ore and the use of 370 million metric tons of coal each year.

Through their outstanding recyclable properties (recycling rate of 93.6% (GVM 2011)), metal packagings that are made from tinplate help to mitigate environmental impacts by reducing material input and providing efficient product protection (reduction of CO_2 emissions and saving of energy). ThyssenKrupp Rasselstein GmbH works together with DWR Deutsche Gesellschaft für Weißblechrecycling mbH and KBS Kreislaufsystem Blechverpackungen Stahl GmbH in order to optimize recycling streams (through quality assurance of tinplate recycling, finding solutions to recycling problems at customers).

2. Life cycle model information

2.1 Functional unit

This study refers to 1 kg of tin coated steel (tinplate). The reference service life (RSL) of tin coated steel is not declared because the material being considered is an intermediate product for which there are multiple possible uses and applications.

2.2 System boundary

The life cycle assessment of the manufacturing phase of the considered tinplate encompasses the life cycle path from cradle to gate. This begins with consideration of ore mining and its processing into steel, and ends with cutting the tinplate to size for delivery. Production of other raw materials, operating materials, and any necessary energy carriers and electric power supply are also considered as they relate to the life cycle assessment. The study covers the following life cycle phases (the packaging of the product was not considered in view of the large variety of packaging options):

- Raw materials purchased upstream, including iron ore, alloying elements and pellets
- Transport from ThyssenKrupp Steel Europe AG to ThyssenKrupp Rasselstein GmbH
- Complete process chain (from sintering to the tin coated steel) of ThyssenKrupp Steel Europe AG and ThyssenKrupp Rasselstein GmbH, including operating materials and consumables (such as thermal and electrical energy, lubricants, and so forth)
- End-of-life (recycling potential of tin coated steel)

The system boundary for the end-of-life phase takes into account the recovery, that means the treatment of tin coated steel for recycling.

2.3 Assumptions and estimations

No assumptions or estimations were necessary for this life cycle assessment.

2.4 Background data

For life cycle modeling of the production and recycling of tin coated steel, the GaBi 6 Software System for Life Cycle Engineering, developed by PE INTERNATIONAL AG, was used /GABI 2013/. All relevant background datasets were taken from GaBi 6 software database.

2.5 Cut-off rules

All data from operational data collection, the thermal energy used, as well as power consumption and diesel consumption were considered in the analysis. For transport of the hot rolled strip from ThyssenKrupp Steel Europe AG to ThyssenKrupp Rasselstein GmbH, a transport distance of 150 km was used. All data from the data collection that account for more than 1% of total mass and total energy of the system have been included.

It can be assumed that neglected processes account for less than 5% of the considered impact categories.

The manufacture of the items that are necessary for production such as machinery, equipment, and other infrastructure are not considered in the life cycle assessment.

2.6 Period of consideration

This life cycle study is based on data from the production year 2008. All the foreground data on production were made available by ThyssenKrupp Steel Europe AG (up to the hot rolled strip) or ThyssenKrupp Rasselstein GmbH (from the hot rolled strip to the tin coated steel). The last update of the used background data sets from the GaBi system took place less than 5 years ago.

2. Life cycle model information

2.7 Data quality

The data quality is deemed to be high. Datasets for all the relevant pre-products and operating materials are available in the GaBi database and are consistent. The production data are primary data from 2008, supplied by ThyssenKrupp Steel Europe AG and ThyssenKrupp Rasselstein GmbH.

2.8 Allocation

At the Andernach production site of ThyssenKrupp Rasselstein GmbH, there are no co-products. No allocation was conducted in this respect within the life cycle assessment framework.

3. LCA: scenarios and further technical information

3.1 End-of-life scenario

The end-of-life scenario covers the recovery and recycling of tinplate. The recovery rate in the end-of-life phase is 93.6% (GMV). This means that, after use by consumers or industrial end users, 93.6% of the tinplate packagings are recovered and fed back into the steel production route, thus closing the material loop. As can be seen from the data cited above, a certain amount of iron and steel scrap is already used as input during the primary production of tinplate. This proportion must be taken into account when computing the life cycle assessment data. The exact approach to be followed derives from the World Steel Association's methodology for conducting life cycle inventory analysis of steel scrap.

4. Life cycle assessment results

ENVIRONMENTAL IMPACT:
1 kg tin coated steel

		Production	Credit
Indicator	**Unit**	**Modules A1 – A3**	**Module D**
GWP	[kg CO_2-Eq.]	2.64	-1.41
ODP	[kg CFC11-Eq.]	1.23E-10	1.06E-10
AP	[kg SO_2-Eq.]	9.43E-03	-5.38E-03
EP	[kg PO_4^{3-}- Eq.]	8.27E-04	-4.50E-04
POCP	[kg Ethen Eq.]	1.22E-03	-8.06E-04
ADPE	[kg Sb Eq.]	2.98E-08	-3.80E-08
ADPF	[MJ]	29.0	-13.2

GWP = Global warming potential; ODP = Ozone layer depletion potential; AP = Acidification potential; EP = Eutrophication potential; POCP = Photochemical ozone creation potential; ADPE = Abiotic depletion (elements); ADPF = Abiotic depletion (fossil)

RESOURCE DEPLETION:
1 kg tin coated steel

		Production	Credit
Indicator	**Unit**	**Modules A1 – A3**	**Module D**
PED (reg)	[MJ]	0.99	0.22
PED (nreg)	[MJ]	29.5	-12.4
Secondary materials	[kg]	0.12	0
Freshwater consumption	[kg]	10.6	-0.56

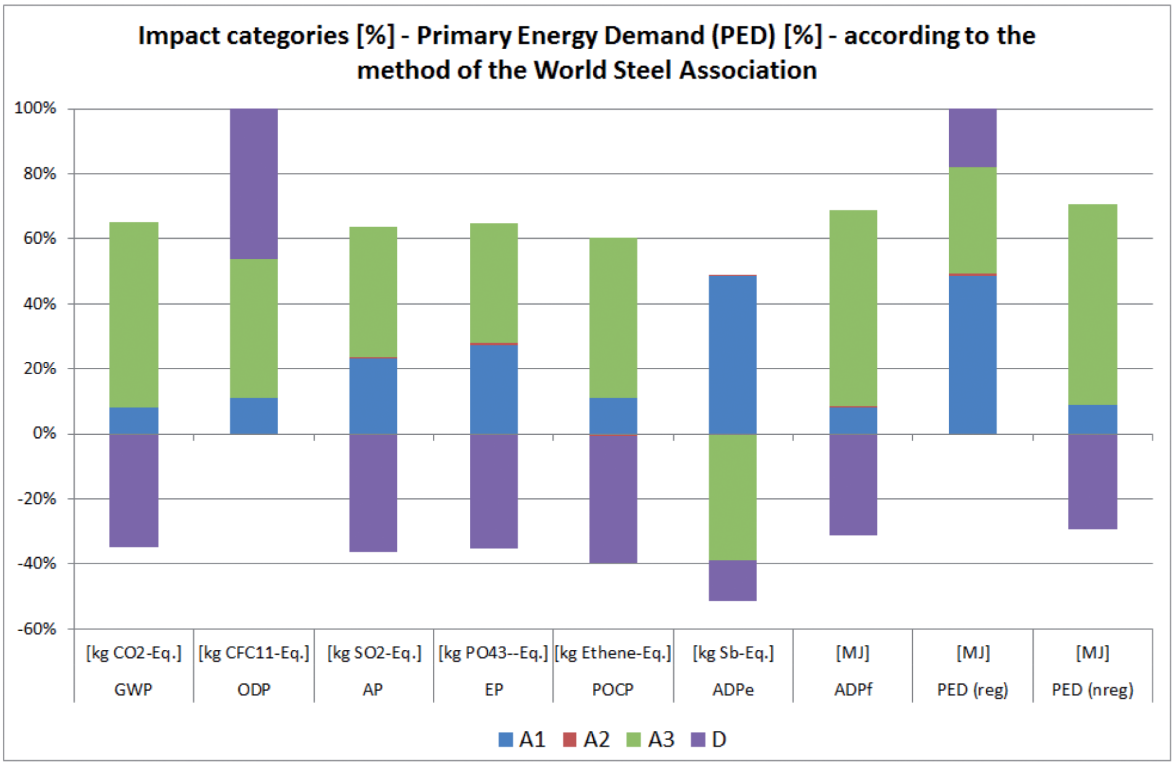
PED (reg) = Primary energy demand from renewable resources, PED (nreg) = Primary energy demand from non-renewable resources

OUTPUT FLOW AND WASTE:
1 kg tin coated steel

		Production	Credit
Indicator	**Unit**	**Modules A1 – A3**	**Module D**
Hazardous waste	[kg]	8.84E-04	-7.66E-04
Non hazardous waste	[kg]	3.05E-02	4.79E-02

5. Interpretation

The charts below show the impact categories and the primary energy according to the World Steel Association method. The modular structure is based on that of EN 15804. A description of the modules is provided with the table below.



Module	Description
Module A1	Raw materials purchased (“upstream”), including iron ore, alloying elements and pellets
Module A2	Transport of hot rolled strip from ThyssenKrupp Steel Europe AG to ThyssenKrupp Rasselstein GmbH
Module A3	Complete process chain (from sintering to the tin coated steel) of ThyssenKrupp Steel Europe AG and ThyssenKrupp Rasselstein GmbH, including operating materials and consumables (such as thermal and electrical energy, lubricants and so forth)
Module D	Credits (according to the World Steel Association methodology) for the net scrap amount referred to the recycling potential.

In the production of tin coated steel, the production of the hot-rolled steel strip (pre-product) dominates in all the impact categories especially for renewable and non-renewable primary energy demand.

The **global warming potential** (GWP) is influenced to a major extent by the production of the hot-rolled steel strip. Within the pre-product production chain, GWP is dominated (45%) by emissions from internal thermal and electrical power generation (boiler). Another significant emission source, amounting to 23%, is the blast furnace.

The **ozone depletion potential** (ODP) is dominated by the production of the pre-product, especially by the supply of iron ore (and the power required to do this) and electrical power used in the process chain. The recycling potential has a positive value. This is due to the fact that the main impact on ODP comes from the emissions, namely R11 and R114, from the upstream supply of electricity (particularly that generated in nuclear power plants).

5. Interpretation

The credit assigned according to the “value of scrap” methodology, makes a positive contribution: Contrary to expectations, the credit represents an additional environmental impact. This can be explained as follows: The “value of scrap” according to the methodology of the World Steel Association represents the theoretical environmental profile of steel scrap. This results from the difference between primary steel production (theoretical value on the basis of the blast furnace route, no scrap input) and secondary steel production (100% scrap input in an electrical arc furnace, EAF). The ODP value is dependent on power consumption and is in this case mostly determined by the share of nuclear power in the power mix. In the EAF route, electricity is mostly used as energy carrier, whereas fossil fuels (such as coal) are used in the blast furnace. The power mix also has a regional specificity. As a result, the German power mix is used for the electrical power drawn from the grid for primary production, while the power mix typical of the respective production country is used for secondary production in the EAF. The country-specific power mixes generally have a higher share of nuclear power, so that the proportion of nuclear power in the mix is higher overall for the EAF route. The use of the scrap value dataset results in negative value in the ODP category, which in the case of scrap credits (inversed “value of scrap” dataset) will lead to additional environmental impact.

The **eutrophication potential (EP)** is mainly influenced by sulfur dioxide emissions. In the upstream process chains for tin coated steel production, the supply of thermal energy from hard coal at ThyssenKrupp Steel Europe AG dominates in this category.

For the **photochemical ozone creation potential (POCP)**, the biggest share is contributed by nitrogen oxides. Within the scope of life cycle inventory, the production of hot-rolled steel strip at ThyssenKrupp Steel Europe AG dominates in this category. Within the steel strip production itself, the sintering process dominates with a share of 57% of the impact.

The **abiotic depletion (elements) (ADPe)** is almost completely influenced by the iron ore input. Credits for the blast furnace and converter slag are offset against cement. According to the CML, the characterization factor of the gypsum contained in cement is 1,000 times higher than that of iron ore, which results in a relatively high share of credits.

Regarding the **abiotic depletion (fossil) (ADPf)**, it is the hard coal used in steel production that dominates, similar to the situation for non-renewable primary energy demand (PED (nreg)) described below. The differences between ADPf and PED (nreg) can be attributed to the nuclear power in the power mix. Unlike PED (nreg), the resources used for the generation of nuclear power are not considered in the ADPf. There is therefore only a small difference, as the primary steelmaking route is dominated by the use of fossil energy carriers.

The **renewable primary energy demand (PED (reg))** is dominated, at approximately 18%, by the recycling potential. Similar to the ozone depletion potential, the PED (reg) reflects an additional environmental impact due to the ‘value of scrap’ methodology of the World Steel Association. This is attributable to the difference between the upstream energy supply chains for steel from a primary or a secondary production route. The electricity used for the production of secondary steel in an EAF contains a share of renewable energy, depending on the type of power mix. Since the primary production route uses fossil energy carriers, the scrap value – as the difference between the two routes – is considered as a negative value for the renewable primary energy demand. The credit (inverse scrap value) thus returns a positive value.

The **non-renewable primary energy demand (PED (nreg))** is dominated, at about 77%, by the use of hard coal in steel production.

Further results of the life cycle assessment mentioned in chapter 4 – namely the resources used, output streams, and waste categories – are explained below.

In steel production, **secondary materials** (recycled materials) are utilized. Internal scrap is fed back into the material flow in the steel mill. For 1 kg tin coated steel produced, about 0.12 kg of post-consumer steel scrap is used.

Water is evaluated according to the “Blue water consumption” measures. “Blue water” considers surface and ground water (that is water, that is used for cooling), while rainwater is not considered. The figure given is the amount of water that is lost from the system (evaporation).

Non-hazardous wastes are mainly generated by aggregated losses of 6.1% at the end of the life cycle.

6. Literature

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