Flat Carbon Europe

ArcelorMittal

Steel for packaging
Product catalogue

Product catalogue
Steel for packaging

1 Editorial

Steels for packaging are thin gauge flat carbon steels, tin or chromium coated on both sides. This particular combination gives the tinplate an interesting set of properties: strength and stiffness, formability, welding ability, lacquer ability and printability, good cosmetic appearance and corrosion resistance. These properties bring appropriate response to all the necessary requirements: content protection during stocking and transportation, safe food preservation, printed information for the final user, ease of use, sustainability and environmental friendliness.

Mass production of tinplate for canning human food started in year 1810, when Nicolas Appert wrote a famous book describing the technique of sterilization (also called "appertization") to preserve the food and when Peter Durand patented the same year the use of metal cans for the foodstuffs.
Since then, tinplate has constantly taken advantage of dramatic improvements, especially over the past decades: improvements of the steel production processes (lower melting residuals and better inclusion cleanliness, switch from ingots to continuous casting, better temperature controls during hot rolling, high precision cold rolling), improvements of the coating process (hot dip tinning replaced by electro tinning to reduce the thickness of the tin layer), improvements of lacquers to increase the corrosion resistance, switch from soldering to electric welding for the can bodies.

Unlike any other packaging material, steel is 100% infinitely recyclable and recycled.
Thanks to its magnetic properties, steel packaging is the easiest and most economical type of packaging to sort and recover for recycling. Regardless of how many times it is recycled, steel loses none of its strength or inherent properties. The reuse and recycling cycle of steel is a never-ending process. Its unlimited lifespan and the potential for perpetual recyclability without detriment to its mechanical properties place the sustainability advantage firmly in the hands of steel.
With steel, natural resources are saved for future generations and total energy use and CO_2 emissions are significantly reduced. In fact, each item of recycled steel packaging saves one and a half times its weight in CO_2. In other words, the more steel is recycled, the greater the reduction in CO_2 emissions.
Recycling of steel packaging in Europe has reached a new all-time high of 76% as announced by APEAL, the Association of European Producers of

Steel for Packaging, in June 2016. This record rate confirms steel as Europe's most recycled packaging material for the 10th consecutive year and sees the recycling rate of steel packaging way above any other packaging materials.

At ArcelorMittal, thanks to our R&D capabilities, we offer the most advanced steel solutions for packaging applications such as easy open ends, ultra thin gauges for bodies, crown corks or caps, weld-free DWI cans (drawn and wall ironed) or steel can compatibility with microwave food heating. We support can weight lightening trends. We promote ecodesign and resource efficiency.

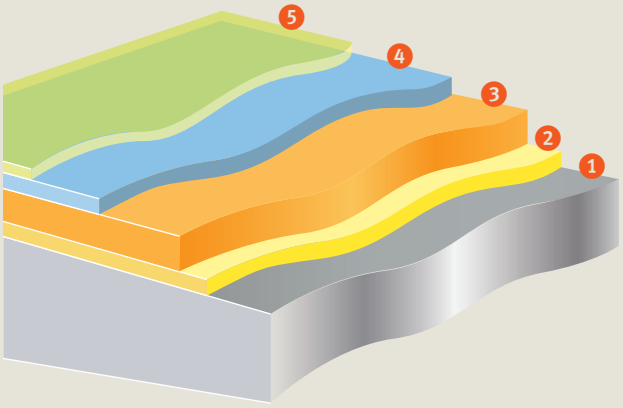
Our aim is to constantly improve our environmental performance while managing the impact induced by our activities, products and services on the environment. All our steel for packaging production plants are certified ISO 14001 and complying with the Environmental Policy of ArcelorMittal. Continuous improvements of processes - growing material efficiency, energy consumption reduction, and increased steel recycling – have resulted in a significant decrease in the CO_2 impact of our steel products.
Over the past 30 years we have reduced our carbon footprint in Europe by more than 50%.

Steel for packaging is the solution for a sustainable future.
Enjoy discovering the ArcelorMittal offer in this catalogue.

2 Steel for packaging production processes

Structure of the coated steel strip

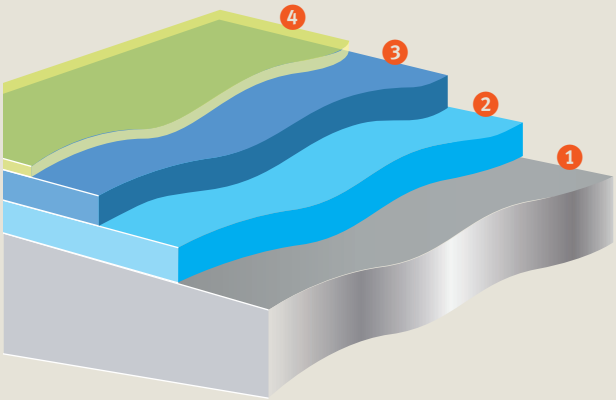
Packaging steel sheet is a composite multilayer product:



Example of tinplate

tin coating E2.8/2.8 + passivation 311

1. steel substrate
2. iron-tin alloy layer $FeSn_2$ (thickness 0.1 µm)
3. tin layer Sn (thickness 0.4 µm)
4. passivation 311: Cr + Cr_2O_3 (thickness 0.002 µm)
5. oil film (thickness 0.005 µm).



Example of electrolytic chromium coated steel

Chromium coating

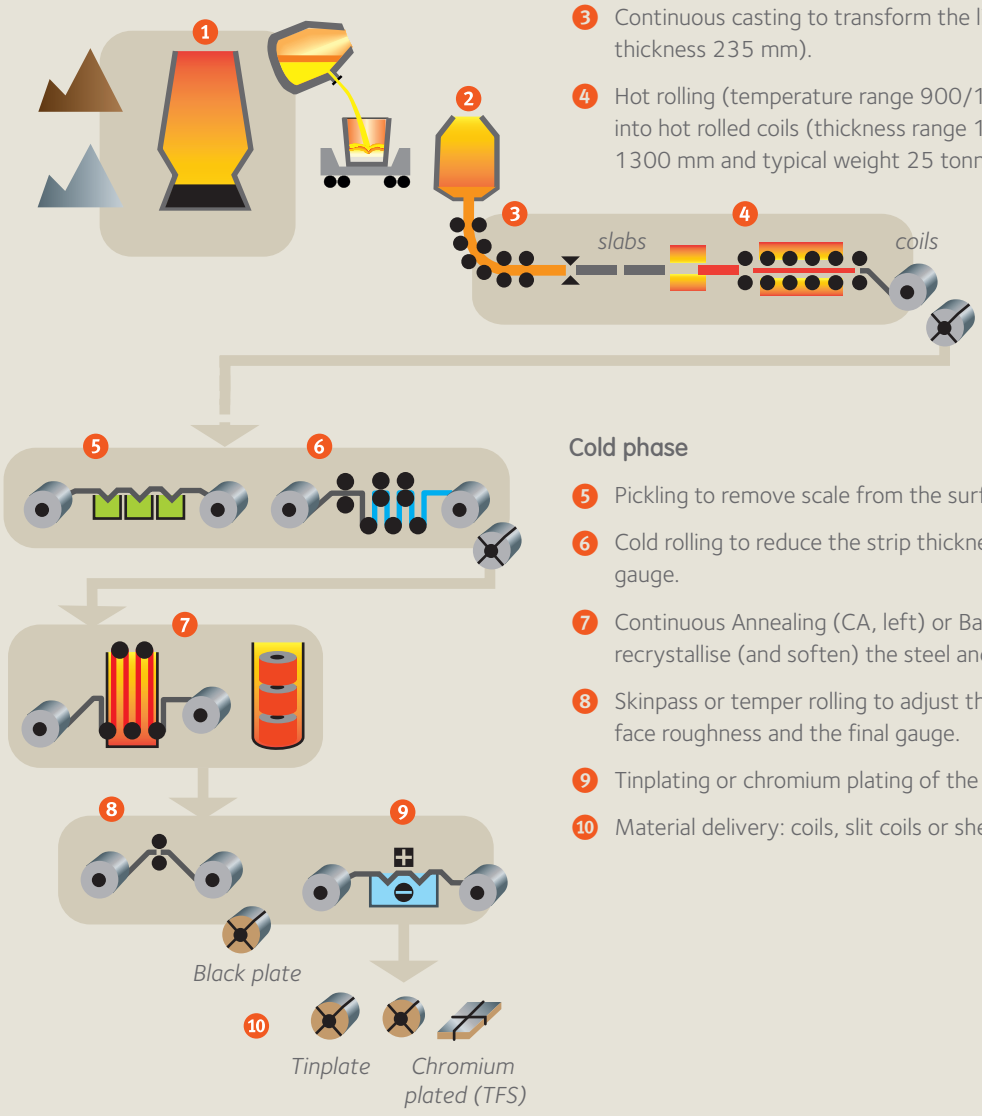
1. steel substrate
2. 3 chromium layer Cr + Cr_2O_3 (thickness 0.02 µm)
4. oil film (thickness 0.005 µm)

Overview of the packaging steel process

Making a tinplate can is a complex multi-stage process:

Hot phase

1. Blast furnace to produce pig iron from iron ore and coal coke.
2. Oxygen steel furnace to transform the pig iron into low carbon steel with the correct chemical composition and specifications.
3. Continuous casting to transform the liquid steel into solid slabs (typical thickness 235 mm).
4. Hot rolling (temperature range 900/1200°C) to transform the slabs into hot rolled coils (thickness range 1.5 to 3.5 mm, typical width 800-1300 mm and typical weight 25 tonnes or more).



Cold phase

5. Pickling to remove scale from the surface.
6. Cold rolling to reduce the strip thickness close to the requested final gauge.
7. Continuous Annealing (CA, left) or Batch Annealing (BA, right) to recrystallise (and soften) the steel and restore its ductility.
8. Skinpass or temper rolling to adjust the mechanical properties, the surface roughness and the final gauge.
9. Tinplating or chromium plating of the black plate.
10. Material delivery: coils, slit coils or sheets.

Steel grades and steel processes

The yield stress of steel grades ranges from 200 MPa to 750 MPa. The process parameters required to achieve these different grades and combine good strength and good ductility are chemical composition, cold reduction, annealing and steel ageing.

Chemical composition

Packaging steels are basically low carbon steels or sometimes ultra-low carbon steels, but it is possible to obtain a large variety of products by combining chemical elements like carbon, nitrogen, manganese, aluminium, etc. This is why it is advisable for tinplate consumers to provide information about the end use (can processing and can filling) to enable the steel supplier to offer the most appropriate steel metallurgy. Approval trials are strongly recommended.

Steel ageing

Before being formed into can parts, tinplate sheets are often lacquered and are susceptible to ageing, as the lacquering process includes a polymerisation baking treatment at around 200 °C. When the steel is sensitive to ageing, the shape of the stress-strain curve is modified (yield stress elongation). This means that plastic deformation is not uniform, resulting in so-called Lüders bands (or stretcher-strain marks).

Ageing in packaging steels is sometimes desirable (increased mechanical resistance by bake hardening) and sometimes detrimental (reduced ductility and formability). This is why several steel metallurgies are offered to tinplate users:

- non-ageing grades: currently BA grades
- ageing grades: currently CA grades
  (although additional overageing treatment can reduce the sensitivity of CA grades to ageing)
- interstitial-free (IF) steels (= Creasteel® grades)
  IF steels are free from ageing, whatever the annealing process (CA or BA)

Tempering line in Aviles, Spain

Cold metallurgical process

The cold metallurgical process includes three successive steps:

1. Cold Rolling to reduce the band thickness close to the requested value
2. Annealing to recrystallise the microstructure and restore the ductility of the cold rolled strip
3. Temper Rolling to achieve final thickness and mechanical properties

Cold Rolling

The only role of that step is to reduce the thickness close to the final value. The typical reduction rates are between 85% and 95% (to pass from 2 mm to 0.2 mm for example). The cold rolling rate is adapted to ensure low planar anisotropy *(see § 'Requested information for orders or enquiries')* when needed.

Continuous Annealing (CA) or Batch Annealing (BA)

After cold rolling, a high temperature treatment (around 600 °C – 800 °C) is necessary to recrystallise the strip and restore its ductility and make possible the forming of the strip into can parts. The usual grain size range is around 5-10 µm (= ASTM grain size 10-12).

There are two types of annealing: Batch Annealing - BA (coil is put for several hours in the furnace) or Continuous Annealing - CA (strip is passed through a heating section for a few minutes at higher temperature). CA is the most popular nowadays for its highly homogeneous properties and high yield strength. BA is still preferred for low tempers and its non-ageing properties.

Euronorm steel grade names provide information on the annealing process:

- Continuous Annealing: THxxx for CA (example: TH550)
- Batch Annealing: TSxxx for BA (example: TS550)

Temper Rolling

That step plays three different roles:

- It prevents the occurrence of Lüders bands during metal forming,
- It gives the good roughness to the band *(see 'Product Offer' – table 'Surface Finish')*,
- It allows to achieve the ordered thickness and steel grade *(see 'Product Offer' – table 'Mechanical Properties')*

The temper mill looks like a cold rolling mill (with only one or two stands). Higher is the temper mill reduction rate, harder is the steel grade. In ASTM, two ranges of grade are mentioned: SR (Single Reduced) grades and DR (Double Reduced) grades. SR grades roughly correspond to low temper mill reduction rate (typically < 5%) and DR grades to higher temper mill reduction rate (typically > 5%). DR grades are generally stronger and less ductile than SR grades.

Metallic coating

As mentioned earlier, there are two types of Steel for Packaging, depending on the metallic coating:

- Tinplate with a tin coating and, in most of the cases, a passivation layer made of Chromium compounds
- Electro Chromium Coated Steel (ECCS) or Tin-Free Steel (TFS) with a coating made of Chromium compounds

The choice between these two products is sometimes imposed by the type of packaging or guided by the aimed aspect or by the contents to be packed.

REACh, the new European regulation for chemicals, aims to improve the protection of human health and environment. In that objective, REACh will impose the ban of chromates by 2017, September 21st.
In the Packaging industry, chromates are used for the current passivation of the Tinplate and for the manufacturing of ECCS.
The four main European Tinplate producers have applied for an authorisation of four years to implement the Cr Free alternatives.
The Cr Free passivation (jointly developed by the European Tinplate industry) and a substitute to ECCS are proposed by ArcelorMittal.

Tin coating

Tin coating is usually a three-stage process:

1. electro tinning
2. tin flow-melting (optional)
3. chromium passivation (optional)

The tin coating is measured by the tin weight per surface unit (grams per square metre per side). Several tin weights are available *(see 'Product Offer' – table 'Tinplate')* depending on the aimed visual aspect (external) and the product to be packed (internal). If the coating is differential (one side with heavier tin coating) it is usual to have a marking (spaced lines) on one side of the strip

The tin coating is often flow melted. It gives the Steel for Packaging its attractive brightness. Moreover it makes an alloying layer $FeSn_2$ at the interface between iron substrate and tin, which improves the corrosion resistance of the tinplate.

Passivation – current and future

The tinplate surface is in most cases passivated to stabilize the surface, typically by preventing the growth of tin oxides.

- The most common is passivation 311. It is an electrochemical treatment in a bath of sodium dichromate to deposit both metallic chromium and chromium oxide on the tin surface. ArcelorMittal is also proposing passivation 310, a lighter version of passivation 311, when a better lacquer adhesion is required.
- Another possibility is passivation 300, a plain (non electrolytic) dip treatment and the resulting deposit is chromium oxide only. Passivation 300 is not advised if the stocking of tin plate before use is excessive (more than several months).
- For a few applications like DWI beverage or DWI Food, non passivated tinplate can be delivered.

A Titanium/Zirconium passivation has been developed by the European Tinplate industry to replace the current chromium passivation and be compliant with REACh regulation. ArcelorMittal can provide any specification with that passivation on request. That new passivation will be the only passivation available at European Tinplate suppliers after the definitive ban of chromates.

Chromium coating – current and future

Chromium coating was primarily developed as an economic alternative to tin coating. It is an electrolytic treatment in a bath of chromic acid to deposit metallic chromium and chromium oxide on the blackplate. The usual name is Electro Chromium Coated Steel (ECCS) or Tin-Free Steel (TFS).

TFS is excellent for lacquer adhesion and must always be lacquered both faces before use.

TFS is not suitable for welding or soldering. Its appearance is less attractive (lower brightness) than tinplate. The absence of tin makes TFS non appropriate for acidic food (pH < 4) because of lower corrosion resistance

To be compliant with REACh regulation, the European Tinplate producers are developing alternatives to the current ECCS. ArcelorMittal proposes a Low Tin Steel (LTS) with Titanium / Zirconium passivation and can provide any specification on request.

Oiling

Oiling is necessary to reduce friction and scratches while handling the sheets. The three most common oil types are:

- DOS = dioctyl sebacate
- BSO = butyl stearate
- ATBC = acetyl tributyl citrate

Organic coating

For specific applications like tabs and aerosols mounting cups, can-making lines are fed with lacquered coils or lacquered slit coils; ArcelorMittal is able to deliver such product ranges. For customers facing a lack of lacquering capacities, ArcelorMittal can also propose coated products
ArcelorMittal can offer varnished products in coils, sheets or slit coils :

- ECCS/TP varnished in coil or sheets for any application except welded bodies
- TP varnished in slit coils for aerosol mounting cups
- ECCS/TP/Zinc coated steel varnished in slit coils for Tabs.

Depending on the application requirements, different varnishes' formulas are proposed. BPA-NIA substitutes are already available on request.

3 Product offer

Available standards

	Tinplate and ECCS	Blackplate
Coils and sheets	EN 10202 ASTM 623 (on request)	EN 10205
Slit coils	Dimension: EN 10140	

Mechanical properties

AMFCE	EN10202	Old EN	ASTM	Annealing	Reduction	Yield stress (MPa)	Thickness range	Main end use
TS230	TS230	T50	T1	BA	SR	230	0.16 - 0.49	Bakeware
TS245	TS245	T52	T2	BA	SR	245	0.16 - 0.49	General line
TS260	TS260	T55		BA	SR	260	0.16 - 0.49	Expanded cans
TS275	TS275	T57	T3	BA	SR	275	0.16 - 0.49	General purpose
TS290	TS290	T59	T4	BA	SR	290	0.16 - 0.49	Aerosol tops
TS340				BA	SR	340	0.14 - 0.49	Can bodies, can ends
TS480				BA	DR	480	0.14 - 0.34	3P can bodies
TS500				BA	DR	500	0.14 - 0.30	3P can bodies
TS520		DR520	DR7.5	BA	DR	520	0.12 - 0.30	3P can bodies
TS550	TS550	DR550	DR8	BA	DR	550	0.12 - 0.30	3P can bodies
TH330				CA	SR	330	0.16 - 0.49	Drawn can bodies
TH360				CA	SR	360	0.16 - 0.49	Drawn can bodies
TH415	TH415	T61	T4	CA	SR	415	0.16 - 0.49	3P can bodies, crown corks
TH435	TH435	T65	T5	CA	SR	435	0.16 - 0.49	3P can bodies, can ends
TH460				CA	DR	460	0.14 - 0.49	Can ends, easy-open ends
TH480				CA	DR	480	0.13 - 0.40	3P can bodies
TH520	TH520	DR520	DR7.5	CA	DR	520	0.13 - 0.40	3P can bodies, tabstocks
TH550	TH550	DR550	DR8	CA	DR	550	0.13 - 0.38	3P can bodies, tabstocks, aerosol tops and bottoms
TH580	TH580	DR580	DR8.5	CA	DR	580	0.13 - 0.38	Twist-off caps, drawn cans
TH620	TH620	DR620	DR9	CA	DR	620	0.13 - 0.34	Twist-off caps, can ends
TH650			DR9.5	CA	DR	650	0.13 - 0.34	can ends

Tolerances on yield stress comply with Euronorm, i.e. +/- 50 MPa, after ageing

Maleïs®,
our special range for easy-open ends

Designation	Yield stress (MPa)	Thickness (mm)	Typical elongation
ML460	460	0.17 - 0.30	12%
ML550	550	0.16 - 0.30	8%
ML600	600	0.16 - 0.25	5%
ML650	650	0.16 - 0.25	5%
MP700	700	0.15 - 0.21	3%
MP750	750	0.15 - 0.21	3%

For more information about Maleïs®, see Steel for easy-open ends.
Tolerances yield stress +/-30 MPa

DR-Advanced,
high grade - advanced for can ends and tabs

Designation	Yield stress (MPa)	Thickness (mm)	Typical elongation
TH650-A	650	0.15 - 0.21	3%
TH700-A	700	0.14 - 0.20	3%
TH750-A	750	0.14 - 0.20	3%

Tolerances yield stress according EN 10202 +/-50 MPa after aging

Creasteel®,
our special range for shaped cans and bakeware

Designation	Yield stress (MPa)	Thickness (mm)	Typical elongation
CS210	210	0.17 - 0.40	35%
CS230	230	0.17 - 0.40	32%
CS300	300	0.17 - 0.20	25%

For more information about Creasteel®, see Steel for drawn cans.
Tolerances Yield Stress +/-40 MPa

Low-earing material for deep drawing:
two-piece (2P) can, twist-off cap, aerosol top

Designation	Yield stress (MPa)	Thickness (mm)	Main end uses
TS230 to TS275	230 to 275	0.16 - 0.49	2P cans, drawn ends
TH330 to TH435	330 to 435	0.16 - 0.49	2P cans, aerosol tops
TH550 to TH620	550 to 620	0.13 - 0.40	2P cans, twist-off caps

Tolerances yield stress according EN 10202 +/-50 MPa after aging

Material for expanded cans and aerosols body

Designation	Yield stress (MPa)	Thickness (mm)	Typical elongation
TS245	245	0.17 - 0.49	28%
TS260	260	0.17 - 0.49	25%
TS275	275	0.17 - 0.49	22%

Tolerances yield stress according EN 10202 +/-50 MPa after aging

Material for DWI cans (beverage and food)

Designation	Yield stress (MPa)	Thickness (mm)	Width (mm)
TH330	330	≥ 0.205	≤ 1230
TH360*	360	≥ 0.195	≤ 1230
TH390*	390	≥ 0.195	≤ 1205
TH410	410	≥ 0.190	≤ 1205
TH430*	430	≥ 0.180	≤ 1205
TH500	500	≥ 0.160	≤ 1205

All these grades have low earing.
** Main tempers for DWI food*
Tolerances Yield Stress +/-30 MPa

Tinplate (TP)

Tin coating (g/m²)	Min (g/m²)	Max (g/m²)*	ASTM
1	0.75	1.80	
1.4	1.10	2.30	
2	1.60	3.00	
2.8	2.30	3.90	25
4	3.35	5.30	
5	4.20	6.50	
5.6	4.70	7.20	50
8.4	7.15	Not defined	75
11.2	9.55		100
14	11.95		
15.1	12.90		

** Maximum tin coating defined for welded application only.*

Other tin coatings available on request.
Marking of differential coatings in accordance with Euronorm. Alternative marking available on request.

Chromium passivation

Passivation code	Min (mg/m²)	Max (mg/m²)
No passivation		
300	1	3
310	3.5	7
311	3.5	9

Titanium/Zirconium passivation

Passivation code	Retorted food	Other market segments
505	Possible (only with non sulphuring media)	Recommended
555	Recommended	Possible

DOS oiling

Oiling	Typical weight (mg/m²)
Light	1 to 4
Standard	3 to 7
Abundant	8 to 12

ATBC oiling is also available on request.

Electrolytic Chromium Coated Steel (ECCS)

ECCS	Min (mg/m²)	Max (mg/m²)
Cr total	50	140
Cr ox	7	35

Total Chromium is the sum of metallic chromium and chromium oxide.

BSO or DOS oiling

Oiling	Typical weight (mg/m²)
Standard	3 to 7

Electro zinc coated (EZ) – only for tabstock

Zinc 1.5µm/side, i.e. 11g/m²/side.

Surface finish

Name	Code	Steel substrate	TP	ECCS	EZ	Flow melted	Roughness Ra (µm)
Fine Stone	FS	Fine stone	■	■	■	Yes	0.25 - 0.45
Stone	ST	Stone	■	■	■	Yes	0.35 - 0.60
Silver	SG	Shot Blast	■			Yes	0.80 - 1.20
Mat	MM	Shot Blast	■	■		No	0.80 - 1.20

Lacquering

Colours

Organic coating \ Final use	Tabstocks	Can ends	Aerosol mounting cups
Gold	Possible on TP, ECS, Zinc substrates	Recommended on TP, ECS substrates	–
Clear			Recommended on TP substrates
Gold Alu pigmented	Recommended on Zinc substrates	–	–
Clear Alu pigmented			
Typical organic coating weight (g/m²/side)	5*	6*	8*

** Typical range: ± 1 g/m²*

Food contact ability to be confirmed.
BPA-NIA version on request.

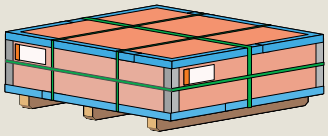
Dimensions

Format	Dimension	Min	Max
Coil	Weight	6 tonnes	20 tonnes
	Width	680 mm	1250 mm
Lacquered coil	Width		980 mm
Slit coil	Width	22 mm	
	External diameter		1600 mm
Straight sheets	Length	510 mm	1150 mm
Scrolled sheets	Length	559 mm	1150 mm

Some restrictions may exist, depending on the product.
Tolerances and specific dimensions to be confirmed on request.

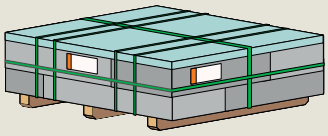
Packing

Products are delivered in standardized packaging, adapted to destination and mode of transport. Here follow some example:



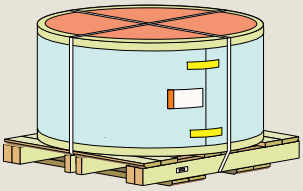
Sheet packing for road or rail transportation

- Paper or plastic wrap
- Hardboard top protection
- Steel edge protections
- 4 straps



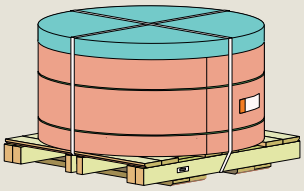
Sheet packing for sea transportation

- Top and bottom hardboard protections
- Paper or plastic wrap
- Steel circumferential and top sleeve
- 6 straps



Coil packing for road or rail transportation

- Cardboard outer edge protection rings
- Plastic wrap
- Hardboard top and bottom protection
- 2 straps



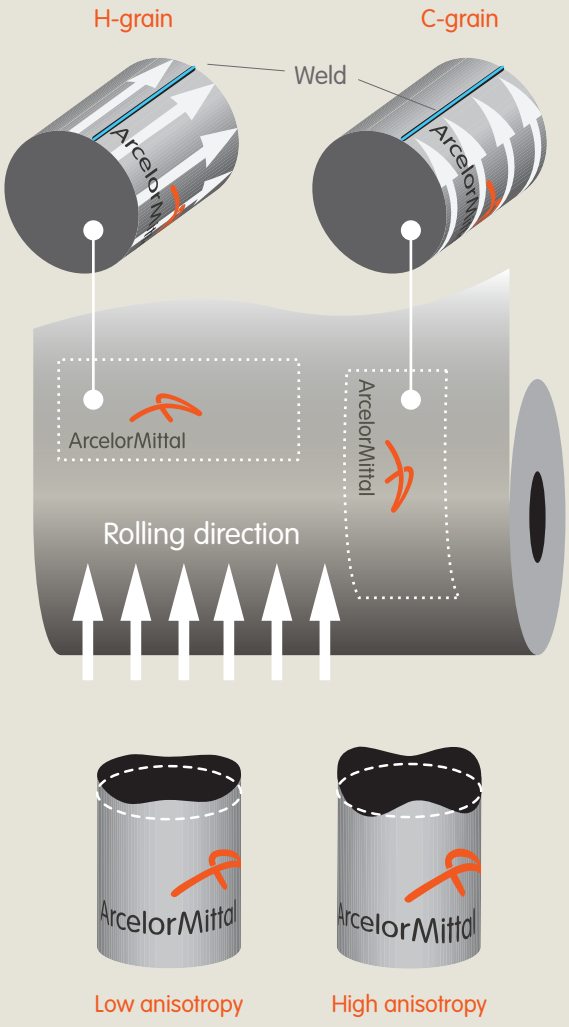
Coil packing for sea transportation

- Cardboard outer edge protection rings
- Sealed plastic wrap
- Hardboard circumferential protection
- Steel top protection
- 2 straps

These images do not imply any contractual commitment on the part of ArcelorMittal.

- E2.8/2.8 means tin weight of 2.8 g/m² on each side of the strip
- 2.8/8.4D means 2.8 g/m² outside coil (or side up if sheets stacked) and 8.4g/m² inside coil, and marking (continuous lines) on heavier side 8.4
- D8.4/2.8 means 8.4 g/m² outside coil (or side up if sheets stacked) and 2.8 inside coil, and marking (continuous lines) on heavier side 8.4
- D2.8/8.4 means 2.8 g/m² outside coil (or side up if sheets stacked) and 8.4 g/m² inside coil, and marking (dotted lines) on lighter side 2.8
- 8.4/2.8D means 8.4 outside coil (or side up if sheets stacked) and 2.8 inside coil, and marking (dotted lines) on lighter side 2.8.

Examples of coating descriptions according to EN10202



Requested technical information for orders or enquiries

Temper and annealing type: *(see 'Product Offer' – table 'Mechanical Properties')* TS272 (EN10202) or T3 BA (ASTM), TH415 or T4 CA.

Surface finish: Fine Stone, Stone, etc.

Metallic coating: tinplate (TP) or chromium plate (ECCS/TFS)

If **tin coating**: specify coating masses on each side (E for equally coated, D for differential coated, D shall be adjacent to the surface to be marked) and passivation P311, P300 or alternative.

Dimension in mm:

- for **coils**: thickness x width
- for **sheets**: thickness x rolling width x cut length
  Cut length is parallel to ArcelorMittal lamination direction, but lamination direction can be indifferent for the customer (e.g. for twist-off caps)

Customer application

Part type: can end or easy-open end, can lid, welded can body, expanded can body, deep drawn can body, twist-off caps, crown cork, aerosol top or end or body, etc.

Can/end form, size and volume: round can D73 mm H110 mm, can D99 mm size 4/4, beverage can 33 cL, oval end 178x126 mm, end 104x59 mm (1/4club).

For welded can body: specify "C grain" or "H grain" (see illustration). "C grain" version is generally preferred for thin strip gauge or expanded (shaped) can bodies to avoid the risks of thickness mismatch between both sides of the weld and to make the weld more consistent.

For drawn parts:
specify with or without controlled anisotropy (see illustration)

For twist-off caps, drawn part:
diameter and height or dimension of drawn can

For expanded part: diameter initial and after expansion, type of expansion: mechanical blow forming e.g. 20L conic pail D275/292 mm H364 mm.

Can end use and content: sterilised food (meat, fish, tomatoes, white fruits, vegetables, etc), non-sterilised food (powdered milk, oil, peanuts, etc), general line (paint, motor oil, etc)

Packing

Coils:

- inner diameter (max/min)
- outer diameter (max)
- maximum weight (gross or net)
- number of welds (normally: max 3 accepted)
- vertical axis (eye to sky)
- winding (clockwise or anticlockwise)

Sheet bundle:

- maximum weight (gross or net)
- maximum height if appropriate
- runner length (direction) of the wooden pallets (parallel to short side unless otherwise requested)
- runner height (100 mm unless otherwise requested)

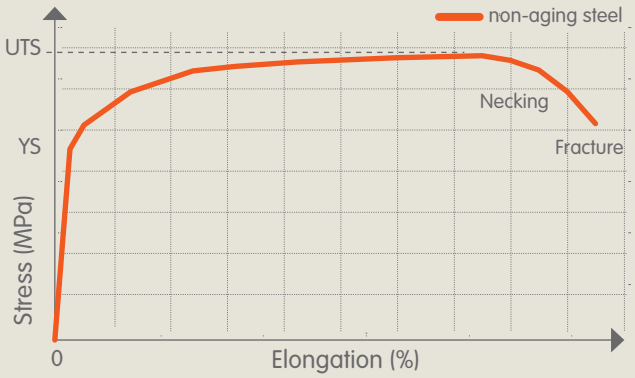
Appendix: Theoretical weight

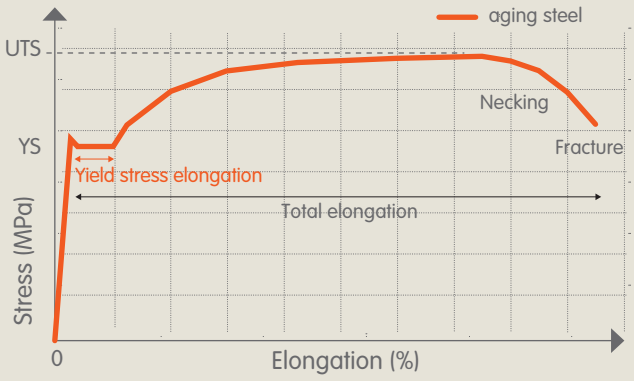
For a given coil weight measured with a weighing machine, the strip surface (and the number of can parts produced) may vary significantly, due to the thickness tolerances (+ 5%). This is why the invoiced tinplate quantity (coils or sheets) is usually the theoretical weight calculated from the rated ordered strip thickness and width and from the measured coil length or sheet length, taking into account the fact that the low carbon steel density is exactly 7.85 g/cm^3.

Example:

Ordered strip size: 0.18x950 mm
Measured coil length: 7,209 m
Theoretical coil weight = 0.18x950x7,209x7.85x10^{-3} = 9,677 kg

Tensile graph





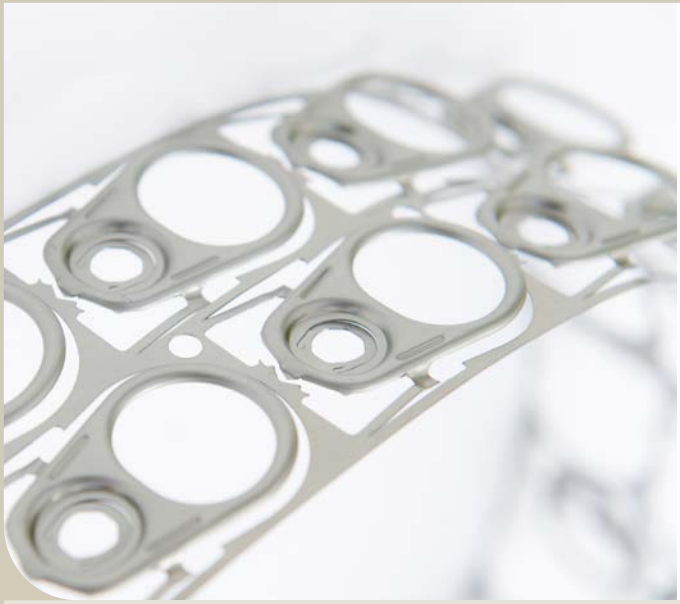
Appendix: Measurements of mechanical properties (tensile properties, hardness)

The test samples must be artificially aged at 200°C for 20 minutes to obtain standardised measurements of the mechanical properties.

The tensile test is performed according to Euronorm and gives a precise characterisation through the stress-strain curve. It is more elaborate than the hardness test.

Yield stress (YS) and ultimate tensile strength (UTS) give information on mechanical resistance. Elongation (and necking) provides information on ductility. The presence (or absence) of the yield point elongation shows whether the material is sensitive to ageing. The strain hardening exponent (n-value, also called the Hollomon coefficient) expresses the capability of plastic deformation by expansion. The tensile test (uniaxial) can be conducted in the three directions 0°, 45°, 90° in relation to the rolling direction 0°. The strain normal plastic anisotropy (average r-value, also called the Lankford coefficient) expresses the strip resistance to thinning during a tensile or drawing operation.

The relevant hardness measurement for tinplate is Rockwell hardness HR30T when the thickness is more than 0.20 mm, and HR15T when the thickness is less than 0.20 mm, as described in the usual standards. The measured HR15T can be converted to HR30T using conversion tables.



4 Steel solutions for packaging

	Gauge	Elongation	Yield stress	Microstructure	Cleanliness
Opening force (pop/tear)	■		■	■	
Shelf life				■	
Pressure resistance (burst)	■		■		
Double seam reliability	■		■		
Rivet forming - efficiency	■	■			■
Score forming - efficiency	■			■	■

Steel for easy-open ends

Manufacturing of easy-open ends (EOEs) is a very demanding process, combining high production output, complex rivet-forming operations and very low spoilage rate.

Expected key properties are high pressure resistance during retorting, low opening forces for the final consumer and safe seaming ability.

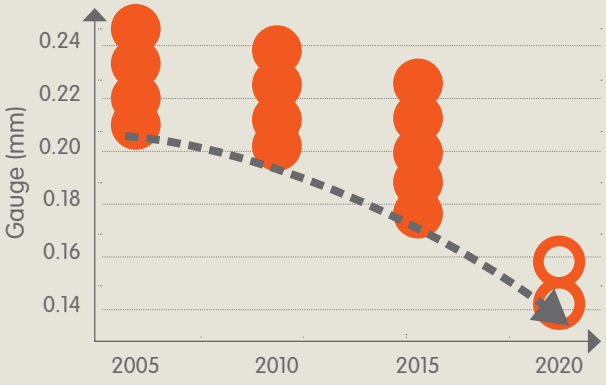
All these requirements must be guaranteed with the objective of cost reduction and lightweighting via thickness reduction.

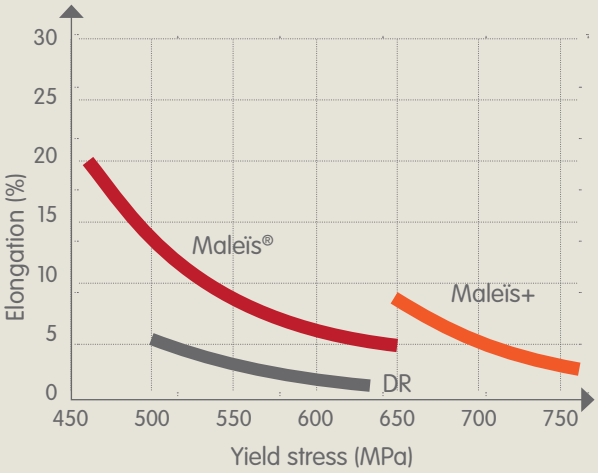
For a reliable rivet-forming process, packaging steels for EOEs must have excellent cleanliness and high ductility in all directions.

Thickness reduction is ensured thanks to high temper steel grades, minimum elongation and tight tolerances on mechanical properties.

These high temper grades also improve opening ability (pop and tear forces) for the final consumer.

More than fifteen years of lightweighting





To meet the EOE manufacturing requirements, excellent cleanliness and minimum elongation in all directions is guaranteed in the ArcelorMittal product range for EOEs.

The ArcelorMittal range is suitable for the EOE manufacturing process (three or four steps for rivet forming), end shape (round or rectangular) and can retorting process (with or without counter-pressure):

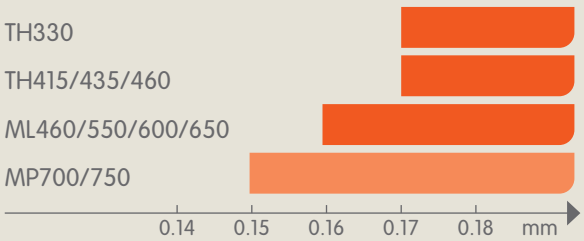
Maleïs® (MLxxx) and Maleïs+ (MPxxx) are the ideal candidates for round EOEs retorted without counter-pressure.

TH330 is recommended for retorting with counter-pressure.

Standard SR grades (TH415/435/460) are available for smaller diameters and demanding processes.

Tight tolerances on mechanical properties (+/- 30 MPa) are guaranteed for the highest temper grades (Maleïs® and Maleïs+).

Product offer for easy-open ends



	Gauge	Elongation	Yield stress	Microstructure
Shelf life				■
Pressure resistance (NRP)	■	□	■	
Double seam reliability	■		■	

Steel for standard ends

Standard ends are highly standardised products able to satisfy numerous markets: round or irregular shapes (mostly rectangular), demanding retort conditions if required. Proper seaming of these components onto the can bodies guarantees leak-proof packaging.

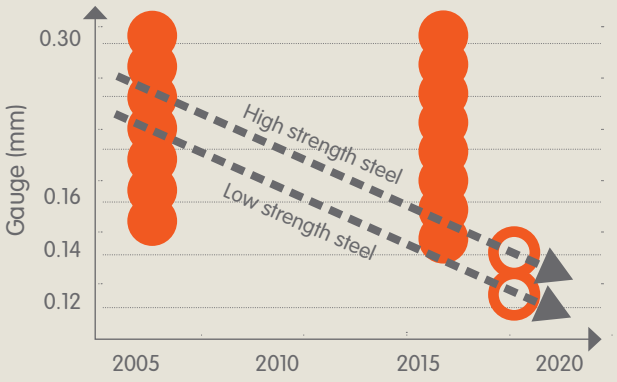
Pressure resistance and seaming ability determine the correct steel specification. For the most demanding cases, minimum metal elongation could be required to avoid excessive metal thinning during manufacturing, which might adversely affect the pressure resistance of the finished end.

ArcelorMittal offers a broad product range: the yield stress can be chosen from 275 MPa up to 750 MPa. Bestsellers so far are TH415/435/460/520/580/620.

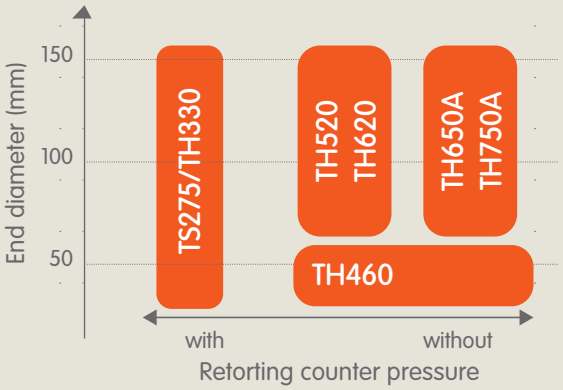
The future lightweighted trend can be divided into:

- Very high strength steel grades TH650A to TH750A with residual elongation >1%, for round standard ends retorted without counter-pressure and gauges down to 0.14 mm..
- Medium strength steel grades TH330/TS340-400 with gauges down to 0.130 mm are the best alternative for standard ends to be retorted with counter-pressure whilst maintaining excellent seaming ability.

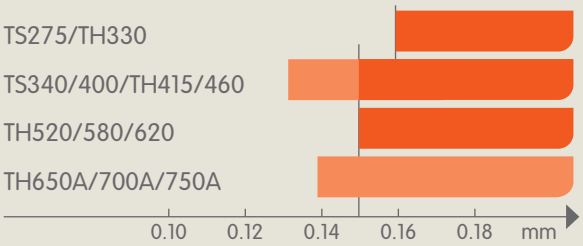
One light weighting path



Steel grade is driven by final use



Product offer for standard ends



	Gauge	Elongation	Yield stress	Metallic coating	H grain/C grain cut
Axial resistance	■		■		■
Panelling resistance	■				
Denting resistance	■		■		
High speed welding		■		■	
Flanging	■	■	■		■

Steel for three-piece bodies

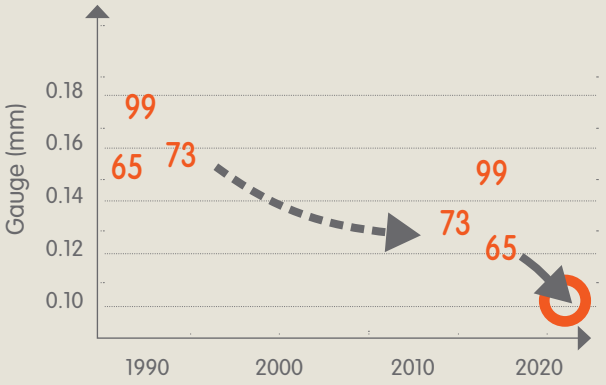
Three-piece (3P) bodies made by electrical welding have experienced outstanding lightweighting in the past. Critical end-use properties are axial resistance for safe palletising, panelling resistance to withstand retorting pressure constraints, and denting resistance. The capacity to ensure efficient production is related to high-speed welding and flanging performance. The next frontier is 0.100 mm: the new proposal for metal cost-saving dedicated to small diameter cans or to any cans being processed in mild conditions.

Some examples of key factors to be considered are:

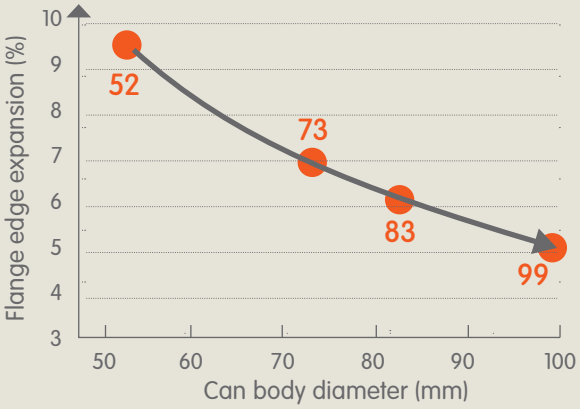
- Diameter of the can and flanging technique (die/spin). Minimum metal elongation is required.
- Slitting of the metal blank along or transversely to the metal rolling direction, so-called H grain or C grain. This choice determines the metal properties at the edges of the strip.
- The metal surface properties, for example the free-tin quantity, to ensure a safe welding window whatever the welding speed (> 100 m/min).
- The expected panelling performance and axial resistance of the finished can, which are influenced by the metal yield stress.

To meet the requirements of various can sizes and can-making processes, ArcelorMittal offers a range of products with gauges down to 0.100 mm. Bestsellers are TH480/520/550 for classic formats, 73-83-99 mm. The most demanding cases, such as cans made from thin gauges down to 0.120 mm, are preferably made from TS480/520/550. The thinnest product (0.100 mm) is made using an innovative TS520 solution.

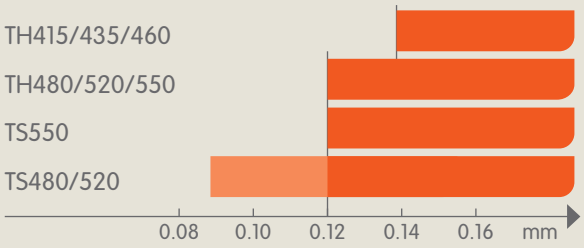
One can size, one path for lightweighting



Flanging strain is related to can diameter



Product offer for three-piece cans



	Gauge	Yield stress	r-Lankford n-Hollomon	Earing ΔC	Elongation	Microstructure
Denting resistance	■	■				
Appearance (smooth surface)		□			□	■
Printing quality				■		■
Shelf life						■
Pressure resistance (peaking)	■	■				
Single operation drawing			■		■	
Manufacturing - Efficiency			■			
Manufacturing - Trimming			■			

Steel for drawn cans

The drawn can is a unique way to demonstrate the outstanding forming ability of steel. The challenge can be assessed based on the height/diameter ratio: up to 0.8 in the case of a single draw using high performance steel, and much higher when a draw-redraw technique is used. Market is expecting an attractive appearance (smooth surface, good print quality) and the ablility to withstand seaming, retorting and palletisation constraints, without damage. Strong with eye-catching appeal.

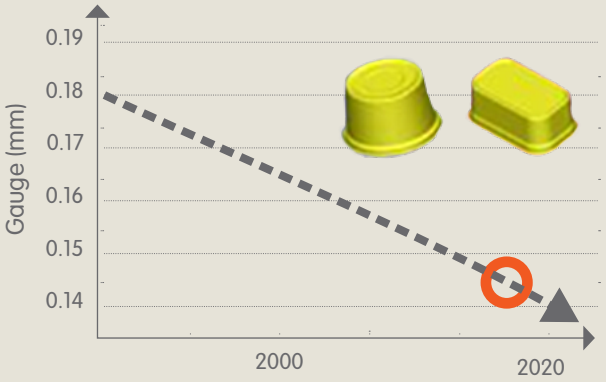
For successful production by drawing, the steel material has to combine quite specific properties:

- High r-Lankford value to make the manufacturing process much easier and minimise trim.
- Low earing, a true requirement for round cans, again to minimise trim.
- Very high values for elongation, r-Lankford and n-Hollomon if the designers are looking for very complex shapes: conical wall, non-linear contour, etc.
- A controlled microstructure and consistency of metal properties to enhance printing quality.

Any drawn metal packaging will find an optimised solution in the ArcelorMittal catalogue:

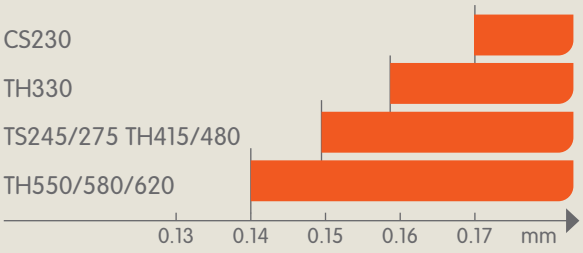
- Creasteel® CS230 is the ultra high performance grade for very demanding shapes. It is the best choice to compete with aluminium.
- TH330 is specifically intended for round or rectangular cans, preferably those to be retorted with counter-pressure.
- TH550/580/620 is the cost-effective solution preferred for standardised formats, for example the famous tuna can. The gauge can be as low as 0.130 mm. High strength is required for retorting without counter-pressure or harsh conveying-palletisation conditions.

More than fifteen years of lightweighting



CS230 *Aluminium 5000 series*

Product offer for drawn cans



	Gauge	Elongation, n-value	r-value	Yield stress	YPE% - Lüders effect	Microstructure	H Grain / C Grain cut
Shape complexity	■	■	■				■
Denting resistance	■			■			
Resistance (axial…)				■			
Aesthetic - Surface					■	■	
High speed welding		■				■	
Shaping technique		■	■				■
Height variation			■				

Market segments

- Shaped aerosols
- Syrup cans
- Party kegs
- Three pieces bottles
- Miscellaneous

Steel for 3P Shaped Bodies

To create complex 3D surfaces, three-piece bodies are shaped using fluid or solid pressure. Whatever the technique, the metal is strained in a uniaxial mode (equivalent to the uniaxial tensile test), although the manufacturing process is commonly described as "expansion". The expansion rate is typically up to 15% for mechanical forming, and up to 30% for pressurised fluid forming. Issues to overcome are the risk of the metal body bursting, and excessive variation in the body height.

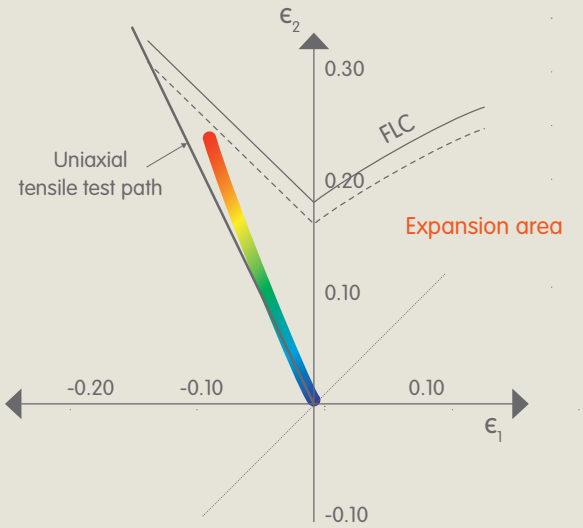
The key metal features to ensure excellent forming performance at the can-making plant are:

- Guaranteed minimum metal elongation in order to be able to produce the most complex shapes (with an expansion rate of up to about 30% or non-axisymmetric shape)
- Guaranteed r-Lankford value (high average value and low industrial dispersion - Cpk) to minimise variation in the finished body height.

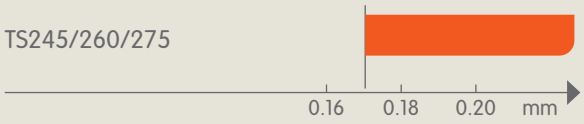
ArcelorMittal best performers are TS245/TS260. For the most demanding manufacturing processes, tight tolerances on rheological properties are available.

When developing a new shape, the metal specifications have to be considered at an early stage. Moreover, the maximum "expansion" rate of a given shape does not totally represent the severity of the strain. Geometry is key (for example, unstrained areas at mid-height of the welded body are more demanding). ArcelorMittal has developed some Finite Element Modelling (FEM) tools to support its customers in this kind of development work.

Strain is not pure expansion strain



Product offer for shaped cans



	Thickness	Cleanliness	Yield strength	Tin coating	Roughness
Line efficiency	■	■		■	■
Seam reliability		■			
Pressure resistance	■		■		
Axial load resistance	■		■		
Can aspect				■	■

Steel for DWI Beverage

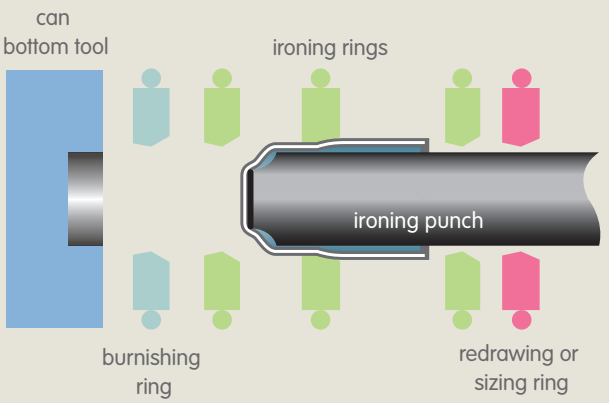
The cost-advantage of 2P beverage cans lies in their high-speed production (approx. 2,000 cans/min). Production line stoppages must therefore be kept to a minimum. In use, the can must be able to withstand internal pressure (6.2 bars with beer and soft drinks) and axial load for stacking. All cans must be free from any forming defects and have a bright and perfect surface. This is certainly a challenge!

The highly demanding DWI can-making process requires perfect steel:

- Steel must be free from any detrimental inclusions (to avoid short cans and split flanges)
- The steel manufacturing process must be robust to guarantee consistent mechanical properties, especially drawability (yield stress, r-Lankford coefficient) and low earing (anisotropy)
- Steel strip thickness must be tightly controlled to ensure a smooth and efficient manufacturing process and the expected can performance

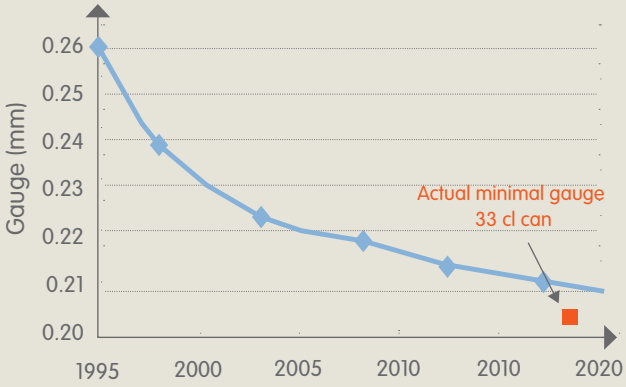
ArcelorMittal supplies its customers with the most advanced DWI metallurgies - low carbon and ultra-low carbon - on a wide range of grades, thicknesses and widths (up to 1,230 mm) to satisfy all requirements. The steelmaking process is fully optimised to increase product cleanliness. Any combination of upper and lower side tin coatings is available to allow the tin to act as lubricant during the ironing process.

ArcelorMittal supports its customers' development work and downgauging projects – such as the latest 0.18 mm thick TH500 development.

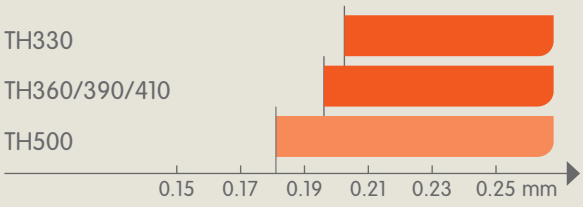


Tool Pack

Gauge evolution since 1995



Product offer for DWI beverage



Steel for DWI food cans

The DWI food can is an attractive alternative to welded 3P cans for sterilised food. Several processes co-exist, but the most current one nowadays is still:

- stamping (cupper)
- drawing (bodymaker) and trimming
- outer protection (cleaning + washcoat)
- flanging + beading
- inside lacquering (sprayers)
- Inside Bake Oven

Current can size is D73 mm H110 mm.

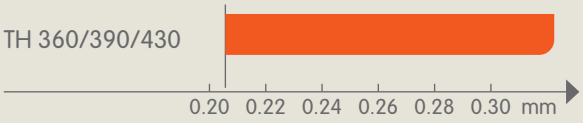
The requirements for DWI food cans are a high-speed process, low earing, no split flange, good surface properties (appearance and lacquerability) and good mechanical properties of the cans (axial and radial load).
To meet the requirements, ArcelorMittal offers steel strip with very tight thickness tolerances, good inclusion cleanliness, low anisotropy, and baking hardenability.

Special surface passivations are also available to improve the surface wettability and washcoat adhesion if need be.

Typical tinplate strip is:

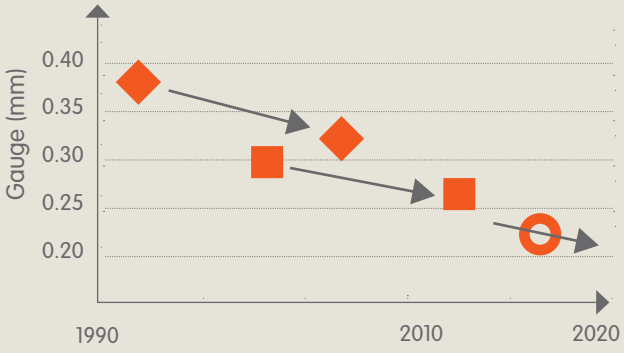
- thickness range 0.20-0.35 mm
- width around 1,200 mm (up to 1,230 mm)
- temper TH360, TH390, TH430
- tincoating generally unmelted
- special passivation

Product offer for DWI food cans

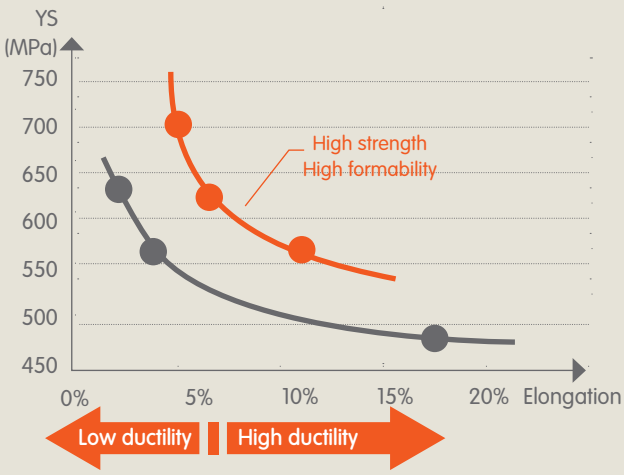


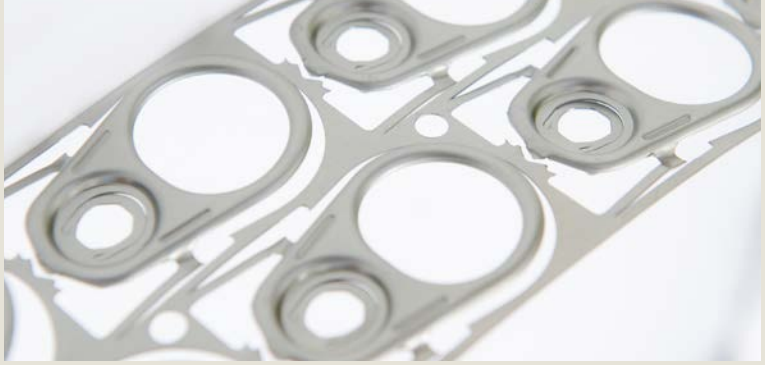
	Gauge	Yield stress	Elongation	Microstructure	Cleanliness	Earing ΔC	r-Lankford / n-Hollomon	Ageing properties (YPE%)
Tab strength (bending resistance)	■	■						
Tab strength (tear at horseshoe)	■							
Rivet loosening (tab detachment)	■	■						
Metal forming (crack risk)			■					

The way down to 0,23 mm and below



New grades for new lightweighted tab designs





Steel for tabs

A tab for an easy-open end is manufactured and riveted onto the end panel by high-speed conversion presses that require consistent metal properties to run efficiently. Subsequently, the tab is seen by consumers as a smart tool to open the can, a tool that is strong enough to maintain its integrity during the opening action: no bending, no tearing and no rivet loosening.
Based on Finite Element Modelling (FEM), a tab can be produced from a metal gauge as thin as 0.20 mm as soon as:

- Bending rigidity is achieved. This comes from the shape and the metal yield stress. The most resistant shapes are usually made with sharp radii, which are quite demanding for tab forming if metal elongation is too low. Elongation of about 5% or more allows complex forming without detrimental thinning.
- The tab horseshoe area withstands severe strain in the shear mode during opening.

The tabstock yield stress is sufficiently high to ensure rivet stability.

Products with medium yield stress (TH435/460) or high yield stress (TH520/550/620) are the best options for standard tab geometries.

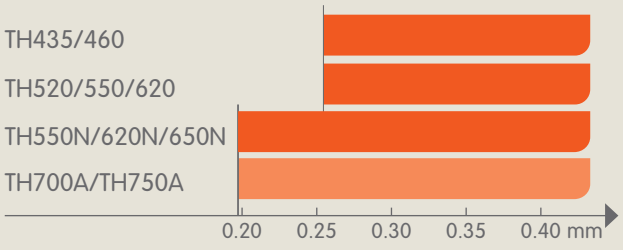
ArcelorMittal recently introduced a new range of products for lightweighted tabs, with the key features of very high strength and high formability: TH550N/620N/650N and TH700A/750A.

A high-performance tab also requires adequate surface coating. ArcelorMittal can supply all surface coatings:

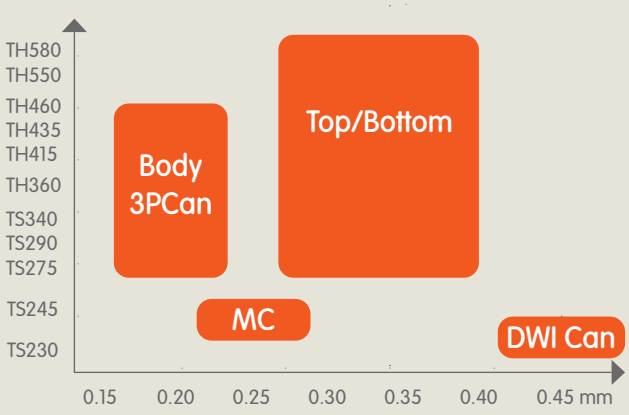
- Metallic coating: zinc, tin or chromium. Zinc is the preferred option to eliminate the rust risk, especially for demanding filling or retorting.
- Organic coating: clear, gold, mostly alu-pigmented.

The size of the tabstock coils also affects the productivity of the conversion press; ArcelorMittal offers coil diameters up to 1,600 mm to minimise production losses caused by coil changeovers.

Product offer for tab stock



	Gauge	Yield stress	Elongation	Metallic coating	Roughness	Earing ΔC	r-Lankford / n-Hollomon	Ageing properties (YPE%)
Puncture resistance	■	■						
Appearance - printing quality					■			■
Vacuum resistance	■							
Pressure resistance (burst)	■	■						
Drawing (bottom - top - m.cup)			■			■		
Body forming (small diameter)								■



Steel for aerosols

Steel is the ideal material for aerosol. Puncture resistance, strength to support high pressure (12-18 bars) and exciting shiny appearance are natural characteristics of steel. This packaging is made of four components: mounting cup, top, body and bottom, each of them satisfying different end-use properties or manufacturing constraints. The future evolution towards high pressure systems (pressurization 20+ bars) will impact most of these components.
To define the relevant steel offers for the four parts, the following key factors have to be considered:

- Welded bodies: nice surface after printing and body forming (no Lüders Bands for smaller diameters) and vacuum resistance at the filling line
- Bottom: pressure resistance and seaming ability
- Top: pressure resistance, high formability and controlled anisotropy and earing.
- Mounting cup: (MC) very low earing (ΔC- value) and excellent coil coated surface

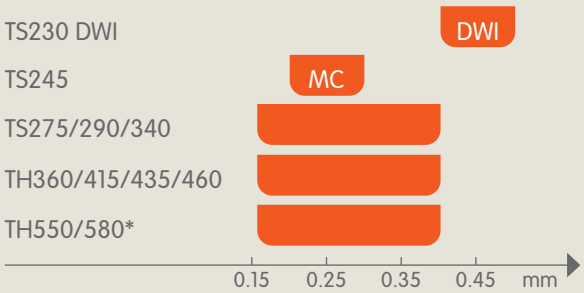
For each component, ArcelorMittal proposes tailor-made steel ranges.
The outstanding characteristics are:

- Welded bodies: non ageing steel grades, tight flatness control for an excellent printing quality and tight thickness control (transverse direction) for the welding process in the typical H-Grain mode
- Mounting cups: grades with high formability, controlled anisotropy and deliveries in lacquered slit coils
- Bottoms and tops: yield stress from 280MPa to 580MPa with controlling anisotropy for tops.

Aerosol DWI: to compete with aluminium ArcelorMittal has developed a specific steel grade TS230 DWI for aerosol monobloc bodies. Low anisotropy and great homogeneity of mechanical properties are aimed to support ironing and necking steps.

For any light-weighting purpose or to satisfy new regulations, ArcelorMittal is ready to offer a technical support through Finite Element Modelling (FEM) to optimize the steel specifications of any component.

Product offer for aerosols



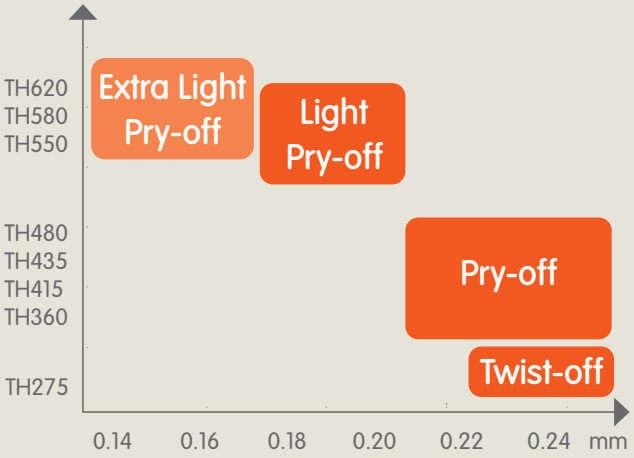
* High-Nitrogen steel available on request

Steel for crown corks

Crown corks (pry-off or twist-off) for the closure of beverage glass bottles are made of chromium-plated or tin-plated steel, on which high-precision printing is required.

Downgauging is becoming a major challenge in this competitive market. Some light solutions for pry-off are today typical, and future will be much lighter downwards 0,15mm or below. Part of this successful trend comes from the use of high strength steel grades.

Good flatness, very good lacquer adhesion and tight tolerances on strip width and sheet squareness are necessary for high-quality printing. ArcelorMittal offers a wide range of tempers and thicknesses to enable downgauging and cost reduction:
TS275; TH360; TH415; TH435; TH480
TH550; TH580; TH620

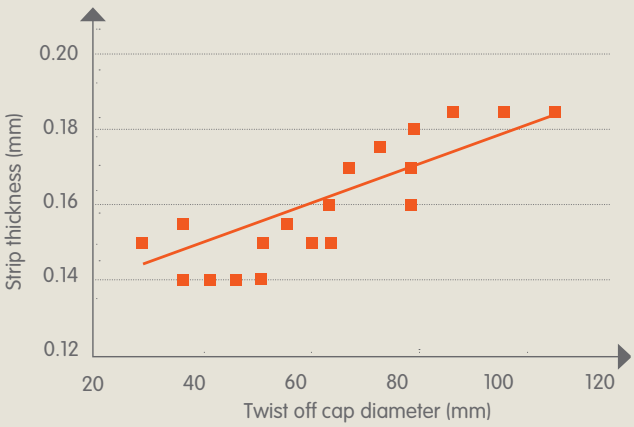


Steel for caps

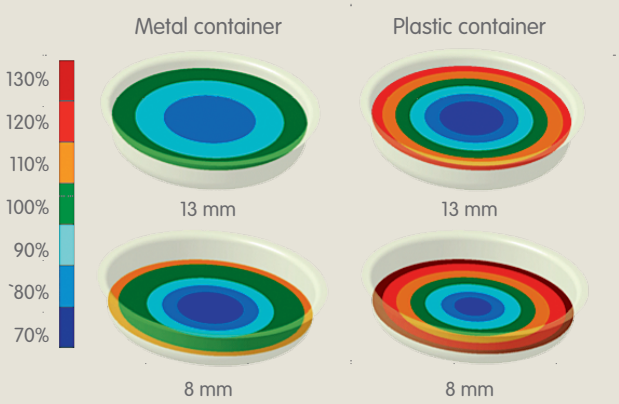
Twist-off caps for hermetic closure of glass containers for sterilised food have a safety button (flip panel) with a snap action to produce a characteristic noise when opening the jar, reassuring the consumer that the food is safe. As the forming process does not involve a trimming step, earing after drawing must be very low, especially for small-diameter caps.

The tinplate requirements are good flatness for good printing, tight tolerances on thickness and yield stress to make the forming of the flip panel consistent, and low anisotropy material to avoid earing during drawing.

ArcelorMittal offers TH620 or TH580 with controlled anisotropy in a wide range of thicknesses to cover all cap dimensions.



More uniformed heating



Temperature dispersion in metal and plastic containers at 8 mm and 13 mm height

Steel for microwaveable cans

With more and more people spending less and less time cooking and eating at home, the ready-meals market is very dynamic and is steadily growing worldwide (by around 10% per year for chilled ready meals). The consumer only needs to put the meal in the microwave oven for a few minutes and can then eat directly from the container. Most of these products today are packed in unattractive plastic trays that lose their rigidity when heated. This is not an environmentally friendly option either, since plastic trays are not recyclable and need secondary cardboard packaging. Thanks to its unique properties, steel packaging can offer added value to this market.

The Fraunhofer Institute in Freising, Germany, has demonstrated that the use of steel packaging in microwave ovens is totally safe, as long as a few basic guidelines are followed. The Institute also concluded that heating is more homogeneous in steel trays than in plastic trays, avoiding the formation of hot spots in the food. It recommends the use of wide, shallow containers (plate or bowl shape) for improved heating efficiency.

ArcelorMittal's special Creasteel® grade is perfectly suitable for drawing cans with low height and large diameter (90 mm and above). Creasteel® also makes it possible to draw attractive shapes in order to offer high-quality containers, thanks to its soft mechanical properties, high formability and high elongation (more than 35%). These trays can be drawn in just one operation, without any wrinkles, reducing the investment needed to develop a new shape. With Creasteel®, you can offer your customers premium decorated packaging for the ready-meals market!

	Yield stress (MPa)	Elongation (%)	Drawability properties
Steel 0.160 TH620	620	< 3	Standard
Aluminium 0.190-0.240	~ 200	~ 8	Standard
Creasteel® 0,170 CS230	230	> 35	High

Steel for speciality packaging

Speciality packaging includes:

- Industrial cans used, for instance, for paints, chemicals (including those classified as hazardous) or shoe polish
- Cans for non-processed food such as baby powder milk or edible oil
- Decorative cans for alcohol or biscuits

Speciality packs are often printed with high-quality design or sometimes take advantage of the shiny finish of tinplate with very light lacquering.

To ensure high precision in the printing process, can-makers need to start with high-quality tinplate, with a perfect aesthetic appearance. Very good flatness is also necessary for precise printing.

In non-processed food applications, tinplate is often used in direct contact with food and therefore needs to be perfectly safe and impeccably clean.

In promotional packaging, due to the large diversity of cans, can-makers need to be offered a wide variety of tinplate.

ArcelorMittal offers a very large range of products to meet every customer requirement: batch annealing or continuous annealing, from 0.16 mm to 0.49 mm, from 230 MPa to 550 MPa. When necessary, ArcelorMittal guarantees tighter tolerances on thickness, for hazardous product packaging for instance. ArcelorMittal also offers lighter customised passivation, called 310, which offers better adhesion properties than passivation 311. From this large product range, we will most certainly find the perfect solution for every project!

5 Global presence

We are here to help you

ArcelorMittal's expert engineers and researchers are here to help. Let our experts find a solution for all of your packaging design questions by contacting us at *www.arcelormittal.com/packaging*

Credits

Photography:
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PR-UM-MCO-EN – 04/2017