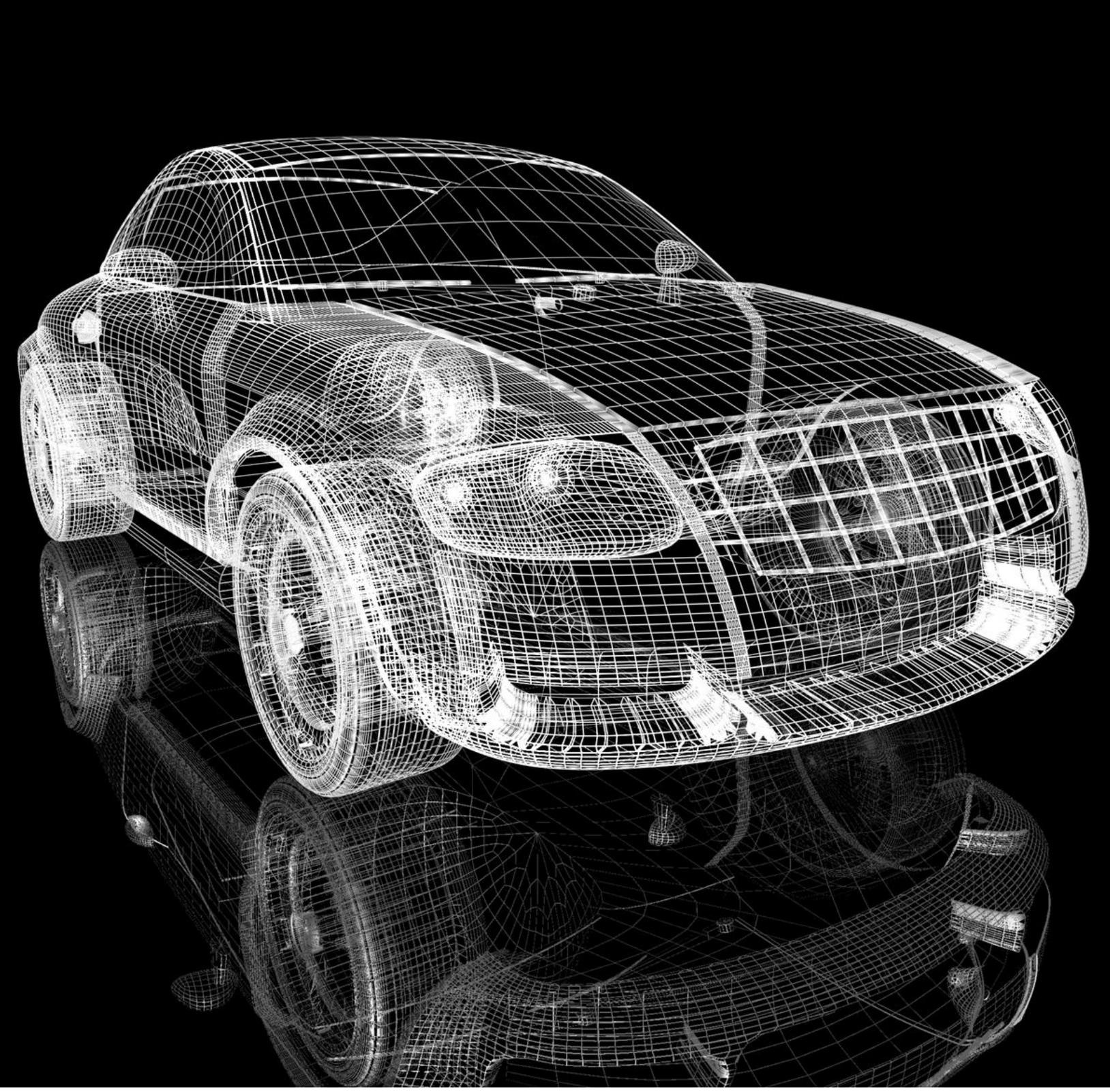


aperam
made for life

Our stainless steel automotive structural components offer

performan

Aperam is a global stainless steel player offering a multitude of effective, innovative and environmentally friendly stainless steel solutions, tailored to meet our customer expectations.

Aperam stainless: your key partner.

We **anticipate** end-users' new requirements and we **support** every customer, from technical assistance to product co-development, thanks to our global presence.
Flat products by Aperam Stainless Europe and Aperam Stainless South America, welded tubes by Automotive Tube Europe, are **your partners of choice**.

Aperam Stainless Europe, supplying stainless steel solutions for the automotive

Innovation

Developing new products and markets is fundamental to assuring our joint future. With an expertise of over 20 years in automotive exhaust system and fully supported by the Aperam R&D platform, we are offering innovating solutions for new car models.

Competitiveness

Conception and construction with stainless steel guarantees excellent cost effectiveness. Price stability, notably ferritic grades, as well as comparable transformation costs with other metals traditionally used for facades, give stainless steel its competitiveness.

Proximity

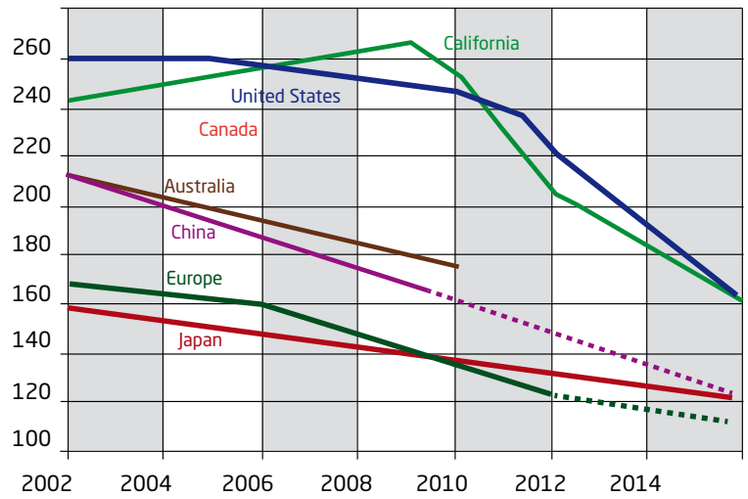
With 16 European service centres (flat products, tubes and precision flat products) carrying out finishing operations on our stainless products, cutting and slitting to required dimensions, surface finishing and packing, we are committed to answering your individual needs and responding to your expectations. You thus benefit from the strength of a large organisation and the responsiveness of a human-scale operation

Context

Environmental trends

Faced with growing concerns about the impact that cars have on our environment, Governments have imposed more and more stringent environmental regulations on the automotive industry for emissions control and fuel economy.

On the following chart we represent the global fuel economy versus the vehicle emission regulations in CO_2 equivalent g/Km converted to NEDC test cycle.



Source: FSV Phase 1 Report

As a result, global OEMs and suppliers are being challenged to constantly update their product portfolios to meet these new regulatory requirements.

While alternative fuels (hybrids and electrical vehicle...) are in the development phase, the automotive industry must look to other solutions which aid in the effort of dramatically reduce fuel consumption and carbon dioxide (CO_2) emissions.

One of their main targets is therefore to design components of the body in white that gives both reduced weight and sufficient crash safety and stiffness.
These conflicting aims can be achieved with lightweight constructions and well-chosen materials.

These would include the use of:

> High strength steels
> Modern manufacturing methods
> Optimization of design

S -in motion

S-in motion is a new concept developed by ArcelorMittal for car makers who wish to create lighter, safer and more environmentally friendly vehicles for the 21st Century.

Steel
Saving weight
Saving costs
Sustainability
Safety
Service
Strength
Solutions

The project objective is a technico-economic challenge aiming to:

> Ensure that replacement components meets all functional performance requirements.
> Avoid and minimize weight increase.
> Make components manufacturable with available production processes.

Here below is an example proposed by Aperam Stainless Europe of a stainless steel part that can be used to lighten production vehicles

Source: S-in motion

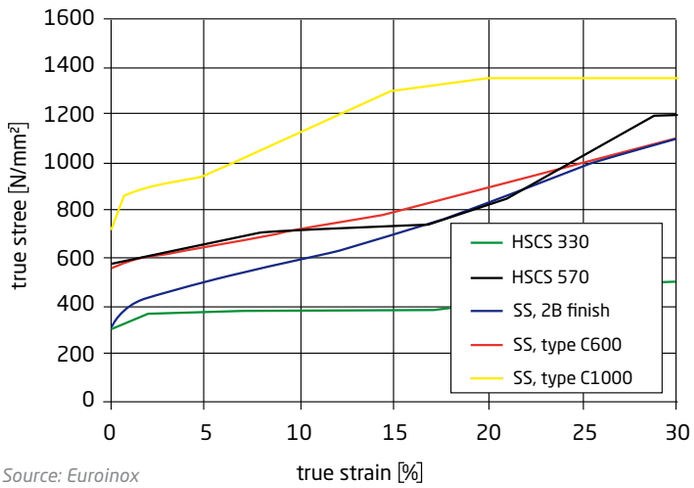
A pillar:
Stainless steel grade 301M, 1.1 mm thick has been selected to replace a DP 600, 1.4 mm carbon steel outer A pillar part with around 24% mass gain. High level of formability allow parts integration and shape optimization. A possible further decrease down to 1 mm (- 29%) has been demonstrated by crash simulation taken into account strain hardening effect of austenitic grades.

What characterizes stainless steel as candidates for automotive applications ?

Corrosion resistance is the most important property of stainless steels.
However, they have other qualities that make them interesting for automotive applications.

The most interesting properties of austenitic stainless steels for automotive parts are the following ones.

› Their strain hardening and outstanding mechanical properties at high strain rates as shown below in the stress-strain curves of different steel grades: High Strength Carbon Steel (330 & 570) and Stainless Steel 1.4310 type.



Source: Euroinox

› The ability to reach high strengths by cold working.

› Stainless steels (cold worked) exhibit generally a better combination of strength and formability than high strength carbon steels.

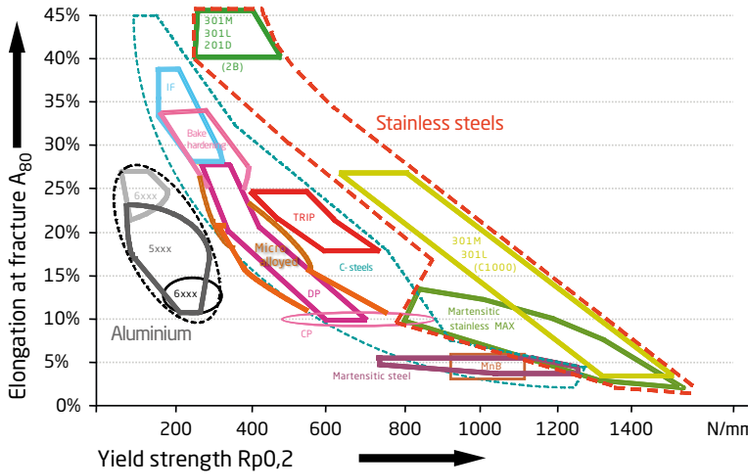
› Similarly, the fatigue strength of stainless steels is better.

› The strain hardening and the behaviour at high strain rates of both austenitic and duplex stainless steels make them especially suitable in components for energy absorption in crashes.

Crash performance in compression:
1.4310/ 301M grade

Our offer completes that of the carbon steels.

The graph below compares stainless steel yield strength Rp0,2 versus elongation of grade used for automotive application.

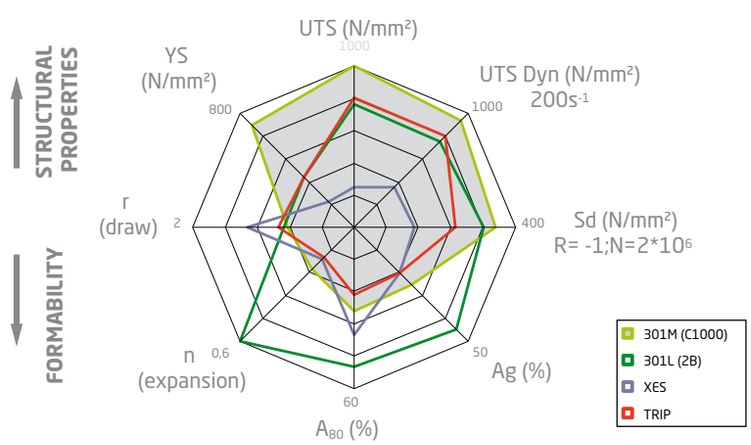


Austenitic stainless steels offer a high forming potential.

› **1.4310; 1.4318 series:** Our 301L and 301M C1000 with 30% in elongation provides a good forming capacity.

› **1.4618 serie:** Our 201D with 50% elongation allow the deep drawing of very difficult parts with interesting Rp0,2 and Rm.

› **Martensitics 1.4006 & 1.4028: MAX and MA3** are delivered as annealed; 27 - 30% elongation is sufficient to deep draw parts. However direct hot stamping after an austenization heating above 900°C concerns the major application. Martensite formation during cooling provides very high strength steel above 800 MPa YS which is necessary for structural parts like side frame, crash box and door reinforcement. Hot stamping favours a very good control of the geometry.



The radar below shows the excellent behaviour of 301 series compared to TRIP and low carbon steels XES.

Workability of stainless steel with tools of the automotive industry

This chapter aims to demonstrate potential users of stainless steels, by illustrating their remarkable ease of fabrication, in different manufacturing techniques.

Convinced of the importance of promoting the use of stainless steels in automotive industry, **Aperam Stainless Europe** has worked for years in collaboration with car manufacturers, OEM and much intensive research and development to demonstrate that stainless steel can be formed into complex shapes and joined using most conventional joining methods, including welding.

Fine for forming

Given correct adaptation of tooling, good lubrication of the blank and choice of grade, countless shapes may be formed using stainless steel.

Drawability of a side pavilion panel:
304D 2B
0.7 x 1250 x 3200 mm
On the right side of the photo is the finished component in XES carbon steel.

The engine cradle (10 kg) here below made of 304D 2B, 0.8 mm thick exhibits a weight saving of around 25% compared to galvanised HE320D carbon steel (12.5 kg).

Stamping at 50 strokes/min: the objective was to achieve a stainless component using existing tools and industrial conditions. The chosen part for these tests is a reinforcement of car hood hinge originally manufactured in aluminum 2 mm thick at a rate of 30 strokes/min.

Car hood hinge:
301L C850
1.5 x 270 mm:
3500 pieces at
40 to 50 cps/mn

Drawing tests have shown the good behavior of the grade 301L C850 at rates between 40 and 50 strokes/min. These trials had the same time aim to evaluate the behavior of the tooling surface and the influence of lubrication when using stainless. The test achieved successfully 3500 stamped parts in total with a geometry which fits to the reference.

A few achievements

Suspension arms

301L C850
Thick 3.2 mm / 2,4 kg
-25% compared to 3.2 kg in HE400M - thick 4 mm

301L 2B - thick 1.8 mm
The carbon steel reference part weight is 2.730 kg.
1- Two plain stamped parts, MIG welding assembled Weight =2.180 Kg (weight reduction of **20%** (550g))
2- Special design with windows, weight =1.740 kg (weight reduction of **36%** (990g)), welding of fastener is saved.

301L 2B
Thick 1.6 mm
= -1kg / arm

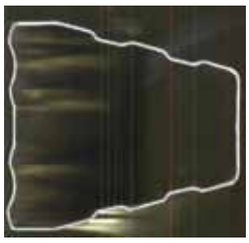
Profiling

Continuous or spot welded profiles are extensively used to manufacture vehicle structures. Thanks to impressive elongation parameters, austenitic stainless steels are suitable for profiling.

Door frame:
304D 2B
Thick 1.16 mm

Moreover the ability of some austenitic grades to be work hardened during deformation leads to high tensile strength.

Closed profiles made of 301M grade



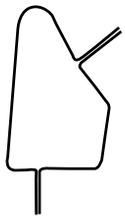
387 x 1.5 mm
UTS = 1349 MPa
YS = 1228 MPa
E% = 20%

360.30 x 0.6 mm
UTS = 1267 MPa
YS = 960 MPa
E% = 27 %

Bumper
301M grade

Stretch-bending

Aluminium extrusions can be turned into a limitless number of shapes for the automotive industry. Using the technology of stretch bending on two stainless steel profiles joined by seam or spot welding, Aperam Stainless Europe wants to demonstrate that other alternative solutions exist.



Pavilion beam 304D 2B
Thick 0.8 mm
Length: 3800 mm

A few achievements

Two prototypes side member of a body in white were carried out to examine the ease of formability in the delivery conditions of stainless steels and to show the high mechanical properties the designers were able to obtain after forming .

Side members
301L - 2B
Thick 1.8 mm - 2 mm

Hydroforming

One of the largest applications of hydroforming is the car industry, which makes the use of complex shapes possible by hydroforming to produce stronger, lighter and more rigid structural part for vehicles. Stainless steel can be formed by the hydroforming technology and the following demonstrators testify.

Rear axle made of hydroformed welded tube
304D grade.
dia. 114.3 mm - thick 2 mm

Bumper made of hydroformed welded tube
301L grade.
dia. 60 mm – thick 1.8 mm

Rectangular
welded tube
301L grade.
2B
40 x 40 mm
thick 2 mm

This hydroformed connecting node for an A-Pillar illustrates the high formability of stainless steels. (The original tube was rounded and straight). C700 - 800 strength class grades with about 45 to 50% elongation is well adapted for complex geometry and hydroformed.
The use of an adapted cost model, taking into account some of the specifications in the manufacturing, also including new forming technologies like hydroforming and 3-D profiling, is now very common.

Connecting node made of hydroformed welded tube
304D grade 2B
Thick 3 mm
80 x 40 mm (original dia. 70 mm)

Painting

Assuming a structural component of the body in white may be made of stainless steel, the question often asked by designers is how stainless steel behaves with cataphoresis ? To answer this question we carried out different tests here below in cataphoresis coatings, DuPont type, test VDA621 415 (9 weeks).

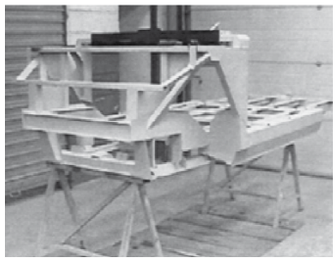
Scratch (sample not rinsed)

After gravelling

Spot welds

MIG welds

Another example is the frame of a prototype chassis made from folded stainless steel sheet, 304D 2B grade, thicknesses from 1 to 2.5 mm and 304D welded tubes, 40 x 20 x 1.2 mm - 20 x 10 x 1.5 mm.



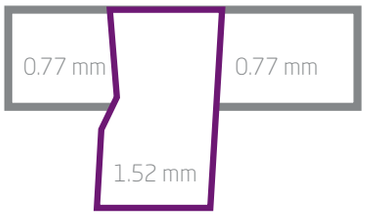
The frame was then entirely painted using conventional paints and primers (epoxy type) after a simple cleaning and degreasing of the surface.

Joining

Stainless steels are well suited to all the numerous methods of joining.

Welding

Many of the welding processes developed for carbon steels can be used with stainless steels: arc, resistance and laser welding. Here below is an example of a B-pillar made of stainless steel grade 304D using the laser welded tailored blanks technique.



Mechanical joining

Mechanical joining techniques used for carbon steels can be equally successfully used with stainless steels.

Riveting

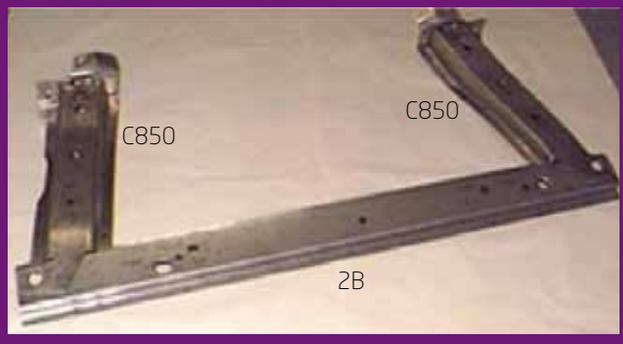
An example using self-piercing rivets of 5 mm diameter and 6 mm length (hardness type 4 ~ 480 HV) on 301L 2B finish 1.5 mm thick.

Screwing and bolting

Stainless steel screws and bolts are available in all the principal grades.

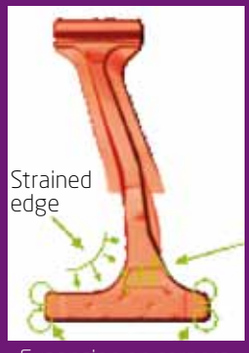
A few achievements

Add-on of an engine cradle
301L C850



Weight = 5.2 kg (weight reduction of 26 % (1.8 kg))
The carbon steel - XES + Galva - reference weight is 7 kg.

B-pillar
301M C1000
Feasibility study of a shape relatively complex made of DP600, iso-thickness of 1.5 mm.



Expansion on corners

NEXT GENERATION VEHICLE

Next Generation Vehicle project

An alliance of leading stainless steel producers and automotive OEMs, was launched few years ago with the aim of identifying potential for the use of stainless steel in auto construction.
The automotive OEMs participating in the project were Audi, BMW, DaimlerChrysler, Fiat, General Motors & Saab and Ford & Volvo, while the stainless steel producers involved were ThyssenKrupp Nirosta, Outokumpu and **Aperam Stainless Europe**.

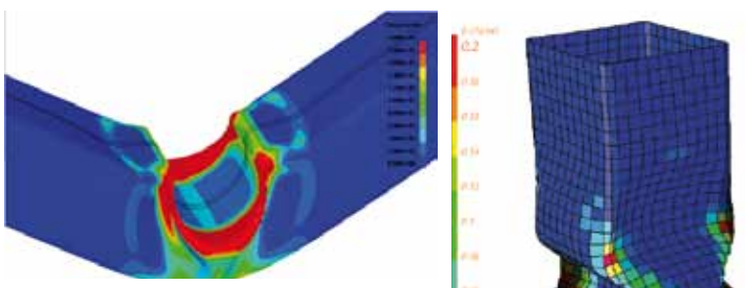
Engineering guidelines

The aim of the Next Generation Vehicle project was to draw up processing guidelines for stainless steels as a prerequisite for their use. The study, drawn up by development and applications engineers from the companies involved shows that the use of stainless steel in vehicle construction can be especially beneficial in crash relevant structural parts.
The project's findings have been summarized in design and processing guidelines.

Modelling of transformation induced by plastic deformation in commercial mechanical design software

The new software programs, which will also be available commercially in the future, meet the further requirement for the broader use of stainless steel. They open up new possibilities for automotive developers.

Crash simulations



SIM1, BEND SPEC1
Time = 0,03402
Contours of Effective Plastic Strain
Max ipt.value
Min = 0, at elem#1
Max = 1.03686, at elem#2021

Plastic Strain

A Dedicated cost model

The Next Generation Vehicle project also developed a cost model in collaboration with the Boston Massachusetts Institute of Technology, which allows the use of different production methods and materials to be compared directly and the optimum stainless steel solution determined. Next Generation Vehicle will continue its work in the coming months.

Crash validation on real B-pillar

A complete B-pillar demonstrator was manufactured and crashed in order to evaluate the proposed approach.

After crash test:

Front view

Side view

Other developments in the automotive industry

In addition to the high strength stainless steels offer on the previous pages for automotive structural components, Aperam Stainless Europe develops the use of stainless steels for many other applications.

Other achievements

Hydraulic pressure bowls
304M / 1.4307 / 18-9L
thick 3.2 mm / 1.368 kg
-12% compared to
1.545 kg in carbon steel
3CTi - 3.6 mm.
Bursting pressure is 760 bars
for 304M (490 bars for 3CTi)

LPG tanks
301L / 1.4318 / 18-7L
2B, thick 2.5 mm
-30% compared to
P355N/1.0557 carbon steel.
Bursting pressure > 100 bars
Crash resistance > 50 Kph

Air bag (driver)
301L / 1.4318 / 18-7L
Combustion cup: 2 mm - C850
Housing: 3.1 mm - 2B
304 / 1.4301 / 18-9E
Diffuser: 2.6 mm - 2B

Motorcycle brake discs
MA3 - 2B
thick 3 – 6 mm
The 2B condition leads to a UTS of ~600 MPa very useful for material processing. After heat treatment at 1000°C and quenching, a UTS of 1700 MPa can be reached. Hardness is needed for brake discs.

Fuel tank fill tube
304L / 1.4301/ 18-9L 2B
th. 0.8 -0.9 mm, dia. 30 to 50 mm
More than 15 years of experience supplying stainless steel to various rolling stock projects.

Rolling stock
301L / 1.4318 / 18-7L
More than 15 years of experience supplying stainless steel to various rolling stock projects.

Internal roof profiles: 2 mm,
Profiled roof sheet: 1 mm,
Side beam: 5 mm, Outside panels: 1.20 mm,
Cross beam: 4 mm, Long beam 5 mm,
Floor board: 0.70 mm

Aperam Stainless Europe also supplies its customers with a varied portfolio of services for the automotive industry market:

> Technical Partnership

We put our network of engineers and technicians at your disposal. Whether it's theoretical or practical training, we are recognised for our know-how. Aperam Stainless Europe can also assist you through co-development programmes.

> Product Innovation

Developing new products and markets is fundamental to assuring our joint future. At Isbergues, we have a highly competent research centre dedicated to stainless steels, that can also call upon the entire research resource of the ArcelorMittal Group. This potential allows us to develop innovative stainless steel solutions for both new and existing applications.

> Logistics Offer

At our mills, the logistics chain is a priority, including our just in time delivery for exhaust systems products.

> Close to the customer

With 16 European service centres (flat products, tubes and precision flat products) you thus benefit from the strength of a large organisation and the responsiveness of a human-scale operation.

In conclusion

A push is under way to move stainless steel into more vehicle applications than just exhaust systems- notably structural parts.
This brochure demonstrates Aperam Stainless Europe's ongoing commitment to the automotive sector with a long and permanent effort to develop stainless steel solutions that can be used to lighten production vehicles today.

Appendices

The following tables show the chemical analysis according to standards EN and ASTM and the mechanical properties of stainless steels grades used in this document.

Chemical analysis (typical values)

Commercial designation	EN	ASTM	C	N	Cr	Ni	Mn	Si
301M	1.4310	301	0.10	0.07	17.30	7.30	0.90	0.60
301L	1.4318	301LN	0.025	0.11	17.50	6.60	1.70	0.50
304D	1.4301	304	0.04	0.55	18.20	8.10	1.20	0.40
MAX	1.4006	410	0.11	0.03	12.30	-	0.30	0.35

Mechanical properties (typical values)

Commercial designation	Delivery condition	UTS (MPa)	YS (MPa)	A80 (%)
301M	C1000	1000	740	30
301L	2B	760	350	52
301L	C850	850	500	40
304D	2B	630	300	55
MAX	2B	530	310	29

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for life

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