Stainless Steel and Alloys in Transport

Recent developments and Aperam's vision on tomorrow

Stainless Steel and Alloys in transport

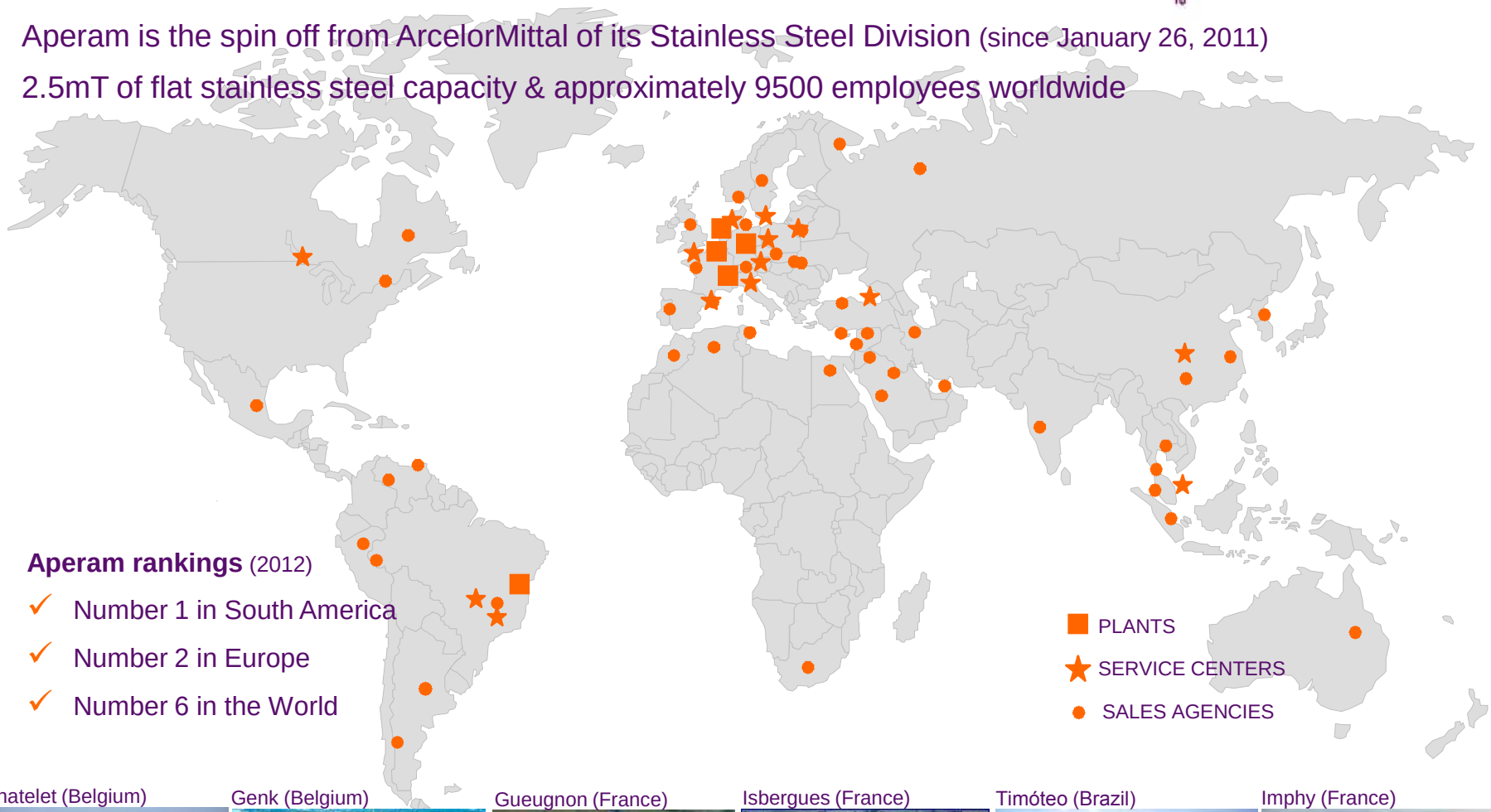
Topics

- Introduction of Aperam
- Stainless steel in transport
- Examples (grade selection)
- Trends and solutions for the future

Aperam is a global player

Aperam is the spin off from ArcelorMittal of its Stainless Steel Division (since January 26, 2011)

2.5mT of flat stainless steel capacity & approximately 9500 employees worldwide



Aperam rankings (2012)

- ✓ Number 1 in South America
- ✓ Number 2 in Europe
- ✓ Number 6 in the World

Chatelet (Belgium)

Genk (Belgium)

Gueugnon (France)

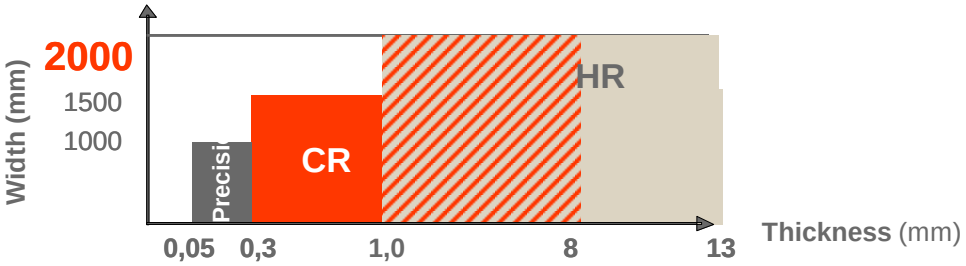
Isbergues (France)

Timóteo (Brazil)

Imphy (France)

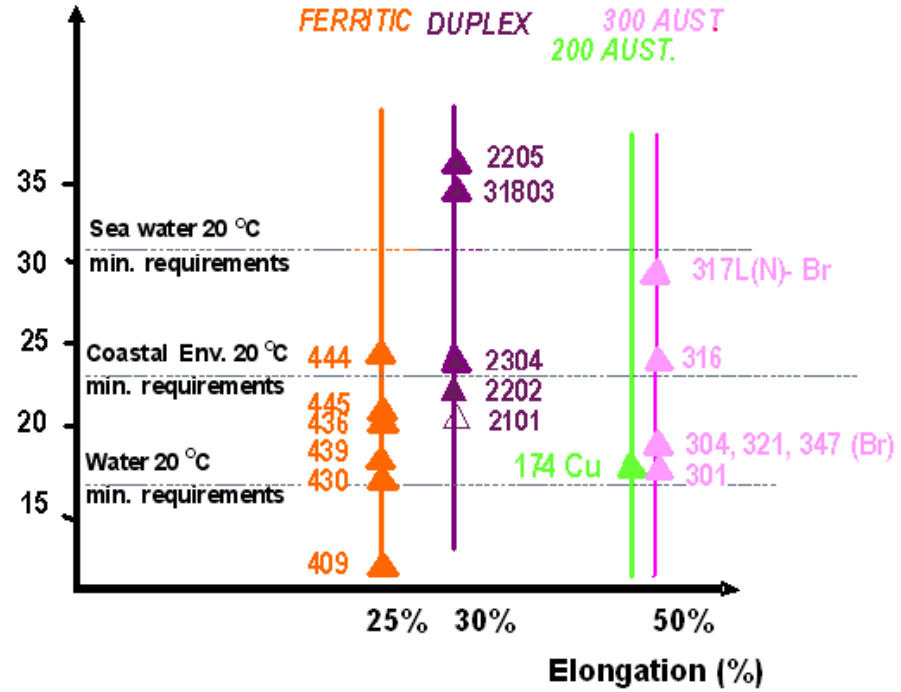
Unique strengths

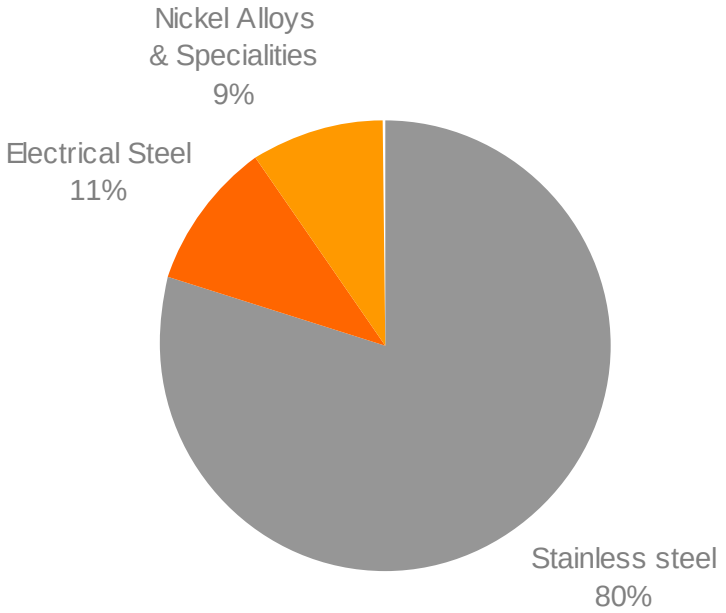
A large product range of specialties supported by strong R&D



115 employees in R&D
Isbergues (France) : Stainless Steel
Timoteo (Brazil) : Electrical and Stainless Steel
Imphy (France) : Ni Alloys and Specialties

Corrosion resistance
(PREN = %Cr+3.3%Mo+16%N)





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Importance of stainless steel in transport

Growth of stainless steel in transport

- Aesthetical appearance (growing wealth)
- Economics
  - Growing emphasis on total life cycle cost
  - But… fear to leave comfort zone well-known materials
  - Move from short-term to long-term based decision making
- Increasing safety regulations
  - Crash & fire resistance
- More stringent emission regulations
  - Lower fuel consumption
  - Improve passenger capacity (increase payload)

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Some examples (grade selection)

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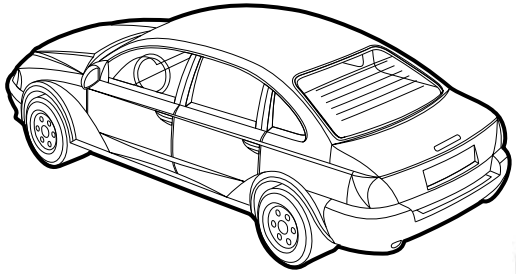
Passenger transport: car, bus, railway

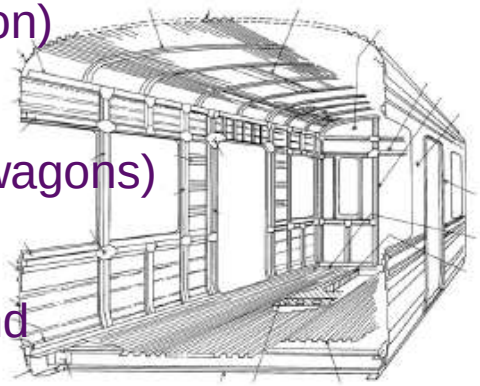


Usage

- Decorative parts & trimming
- Structural & body parts
- Exhaust systems

Advantages

- Aesthetics
- Corrosion resistance (longer lifespan, less maintenance, …)
- Mechanical properties (crash resistance, lower weight, fuel consumption, …)
- Production cost (no need to paint all parts, only for decoration)



Grades used (typically)

- Ferritics (1.4003, …) as C-steel replacement (also for bulk wagons)
- Standard 304 (1.4301/1.4307), well known
- 301LN (1.4318) and 201LN (1.4371) for weight reduction and improved crash resistance (work hardened)

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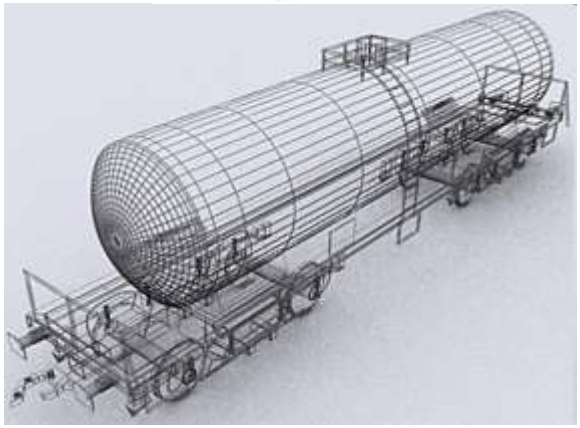
Tank containers, trailers and wagons

Usage

- Inner shells and dished ends
- Outer cladding (2B or 2R-BA finish)
- Structural parts

Requirements transport of (dangerous chemical) products

- High corrosion resistance
- High surface quality (also colour)
- Dimensional tolerances for weight reduction (improved payload)
- Strict international regulations & standards



Grades used (typically)

- 1.4301/1.4307 (304/304L)
- 1.4404/1.4402 (316/316L), 1.4571 (316Ti)
- 1.4318 (301LN)
- New developments: duplex, 200-series, …

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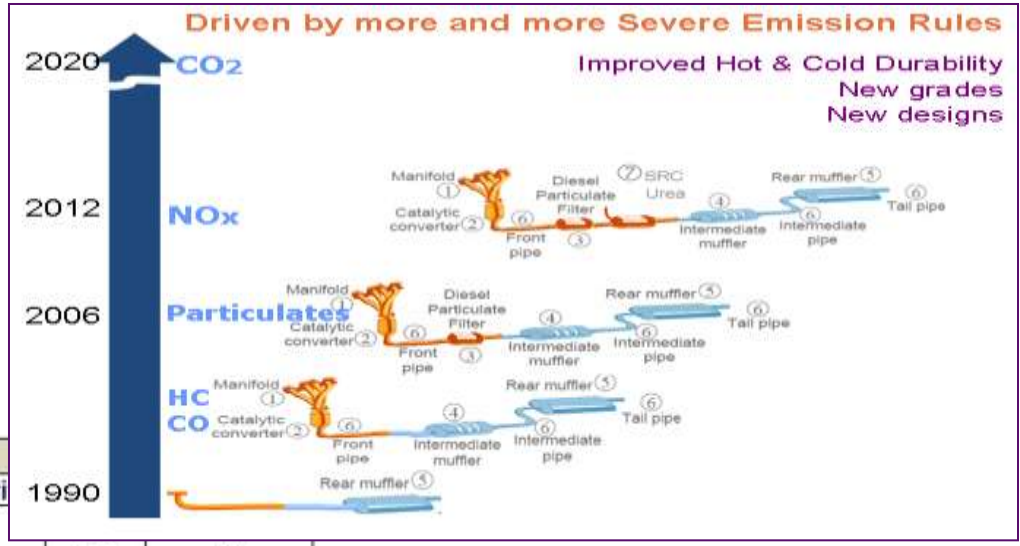
Trends and solutions for the future

Important trends (in transport)

- Economics → cost reductions
- Environmental regulations



Marine Emission Regulations					
In force	Regulation	Description	Authori		
1 Jan 2010	2005/33/EC	Fuel Sulphur content < 0.1% in EU ports & waterways	EU		
1 Jul 2010	IMO Annex VI	Fuel Sulphur content < 1.0% in SECAs	IMO	SECA [1]	All
1 Jan 2011	IMO Annex VI	NO_x emissions reduced to Tier II limits, approx. 20% below Tier I limits	IMO	Global	Newbuildings
1 Jan 2012	IMO Annex VI	Fuel Sulphur content < 3.5%	IMO	Global	All
1 Jan 2015	IMO Annex VI	Fuel Sulphur content < 0.1% in SECAs	IMO	SECA	All
1 Jan 2016	IMO Annex VI	NO_x emissions reduced to Tier III limits, approx. 75% below Tier II limits	IMO	ECA [2]	Newbuildings
1 Jan 2020 [3]	IMO Annex VI	Fuel Sulphur content < 0.5%	IMO	Global	All

[1] – SECA is Sulphur Emission Control Area
[2] – ECA is Emission Control Area
[3] – Subject to a technical review to be concluded 2013 this date could be delayed

Stainless Steel and Alloys in Transport

Lower cost alternative grades

Cost reductions

- Grades 304 and 316 are the most popular stainless steel grades
- But the price is volatile due to Nickel and Molybdenum price variations

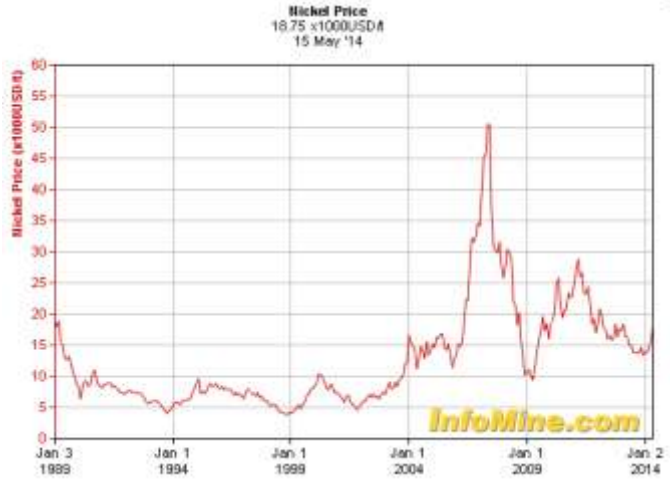
304 / 316

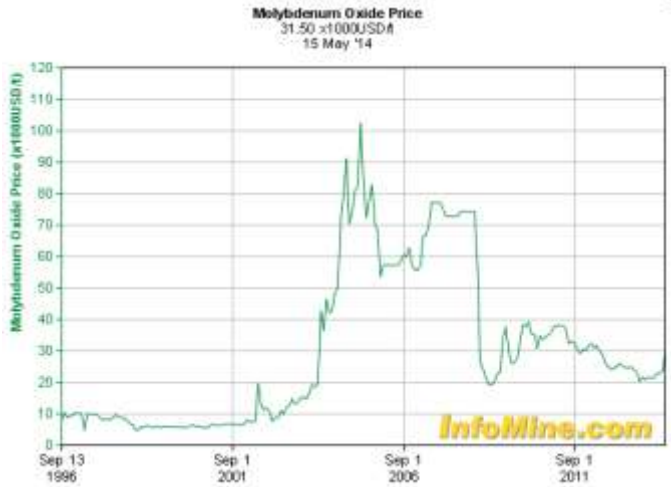
Reduction Ni, Mo

400-Series (ferritic)
Fe-Cr-Mo, **Ni free**

Duplex
austeno-ferritics

200-Series
Austenitics with Mn
Fe-Cr-Mn-Ni-Mo





When nickel price increases excessively, alternative grades become more attractive.
Aperam is prepared

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Containerized LNG

LNG as marine fuel (and road)

- Driven by environmental restrictions for marine transport
- Storage infrastructure and containerized distribution for LNG (as marine fuel)
- Cryogenic environments (vacuum insulation)
  … and thus only austenitics into play.
- Weight reductions possible by improved mechanical properties

304 → Increase C to increase mechanical properties (incl. cold working) 1.4310 *301* → Substitute C by N to increase weldability, ductility and corrosion resistance 1.4318 *301LN* = 301LN (1.4318)

→ Nickel substituted by Manganese = 201LN (1.4371)

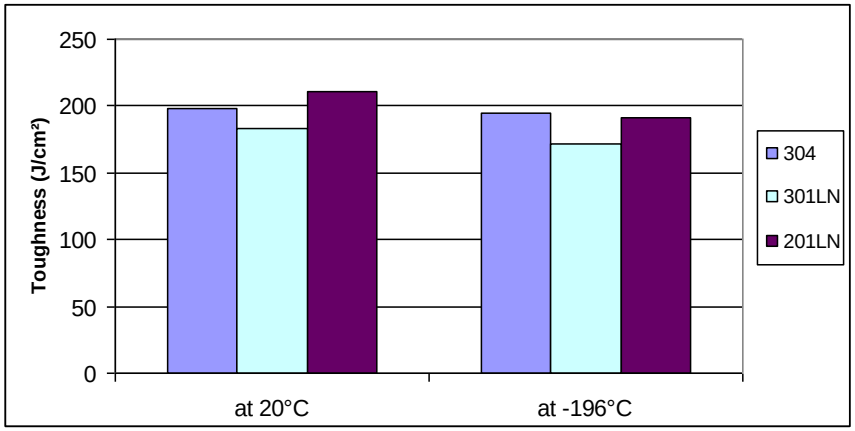
Properties 301LN & 201LN vs 304(L)

- Corrosion resistance comparable to 304(L) (1.4301/1.4307)
  Reduced risk of intergranular corrosion due to low C → good weldability
- Improved strength to ductility ratio compared to 304(L)

Grade			$R_{p0.2}$			R_m			A		
Aperam	ASTM	EN	Aperam	ASTM	EN	Aperam	ASTM	EN	Aperam	ASTM	EN
				(MPa)			*(MPa)*			*(%)*	
18-9L	304L	1.4307	300	≥ 170	≥ 220	630	≥ 485	≥ 520	54	≥ 40	≥ 45
18-7L	301LN	1.4318	360	≥ 240	≥ 350	765	≥ 550	≥ 650	50	≥ 45	≥ 40
16-5Mn	201LN	1.4371	360	≥ 310	≥ 330	720	≥ 655	≥ 650	55	≥ 45	≥ 45

(*) Values for cold rolled (2B) finish

- Higher work hardening rate allowing improved mechanical properties (finish 2H)
- Good toughness at low temperatures



301LN & 201LN for LNG tank containers

- Available as continuous rolled 2m wide at Aperam
- Pressure vessel standardization is important
- Proposal submitted to fully specify 301LN & 201LN (including toughness at -196° C)

European standard

NF EN 10028-7

Table 9 — Mechanical properties at room temperature and impact energy at –196 °C of austenitic steels in the solution annealed condition [a] and resistance to intergranular corrosion

Steel grade		Product form [b]	Thickness	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V) KV			Resistance to intergranular corrosion [c]	
Steel name	Steel number		mm max.	MPa min. (tr.) [c d]		MPa	< 3 mm thick % min. (tr.) [c]	≥ 3 mm thick % min. (tr.) [c]	J min. at 20 °C (long.)	at 20 °C (tr.)	at –196°C (tr.)	in the delivery condition	in the sensitized condition
Aus													
301LN													
X2CrNiN18-7	1.4318	C	8	350	380	650 to 850	35	40	90	60	60	yes	yes
		H	13,5	330	370								
		P	75	330	370								
201LN													
X2CrMnNiN17-7-5	1.4371	C	8,0	330	380	650 to 850	40	45	100	60	60	yes	yes
		H	13,5	300	370								
		P	75,0	300	370								

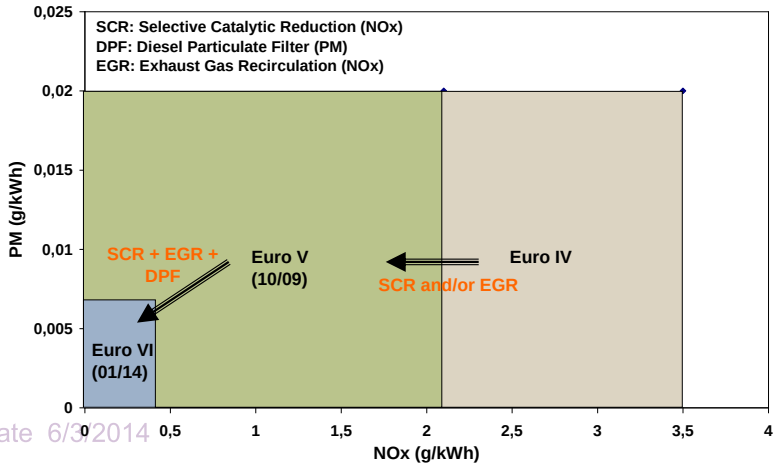
Proposed updates new version (2014)

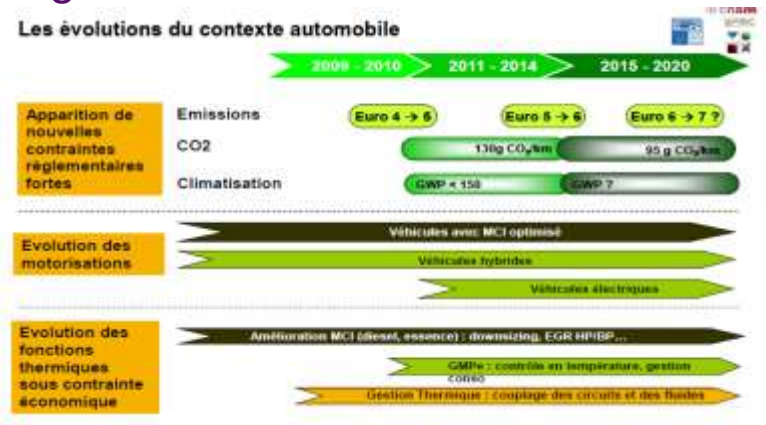
Stainless Steel and Alloys in Transport

Exhaust Systems

Improved exhaust systems

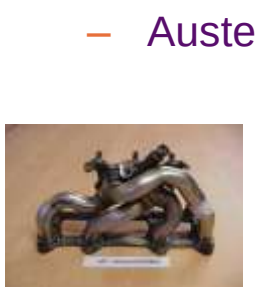
- Evolution of stringent emission standards.
- Large fraction of energy lost as heat in exhaust system → energy recovery!
- Stainless steel volumes per exhaust system will increase (no. of components), and all components will be in stainless steel.
- New corrosion conditions at cold parts, higher temperatures at hot end.
- New grades are being developed to resist up to 1000° C to offer products as an answer to anti-pollution norms and technologies.

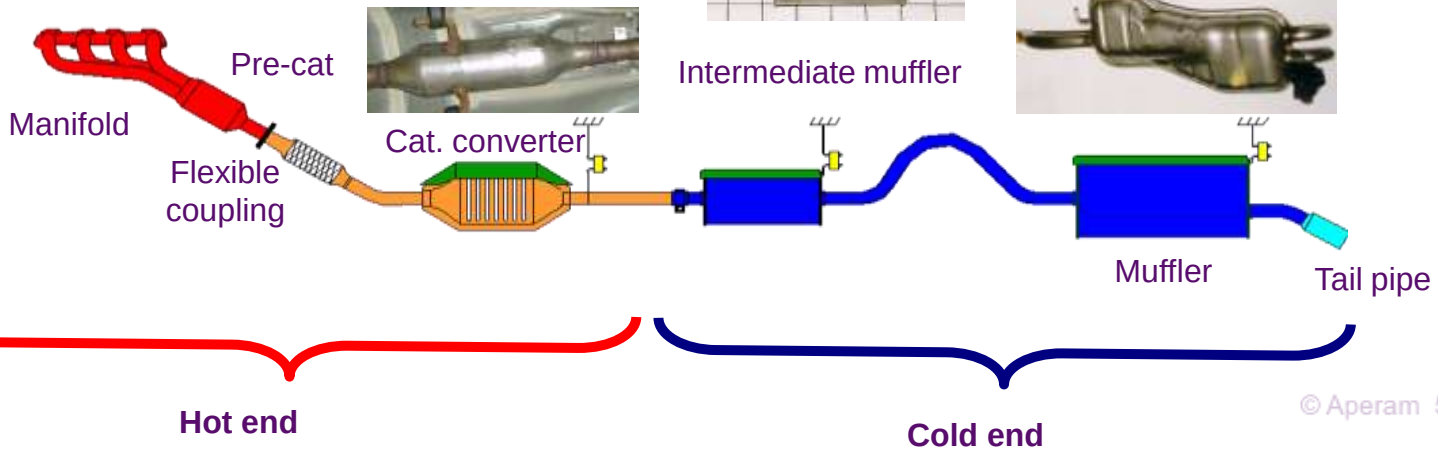




Improved exhaust systems

- Aperam offers a wide range of grades dedicated to exhaust market.
- Hot End
  - Ferritic: K41X (1.4509), **K44X (1.4521)** for high temperature application
  - Austenitic: 1.4828
- Cold End:
  - Ferritic: **K33X (1.4513) -** (17% of Cr, stabilized Ti, with 0,9% of Mo)
  - Austenitic: 1.4301





Stainless Steel and Alloys for Transport

Summary & conclusions

Stainless Steel and Alloys for Transport

Summary & conclusions

- Economics focus more and more on life cycle cost
  - Lower production cost
  - Lower maintenance over (longer) lifespan
  - Fuel economy (energy recuperation)
  - Lower weight
- Environmental regulations
  - Lower emission standards and fuel consumption drives technology
- Safety standards
  - Improved crash resistance

… all favor using stainless steel solutions.

… Aperam is ready!

The End