

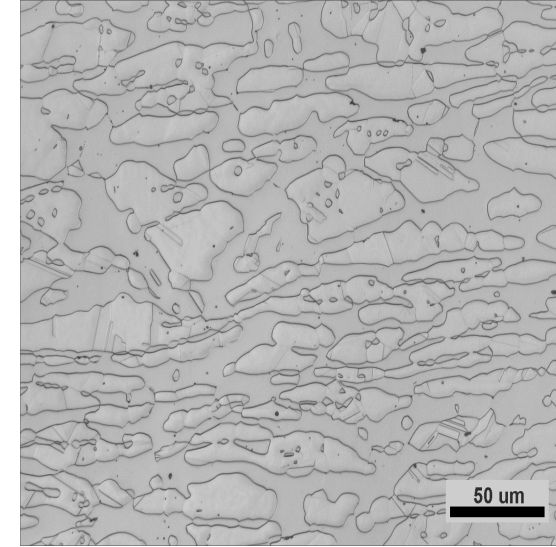
Duplex stainless steels

History, properties and applications

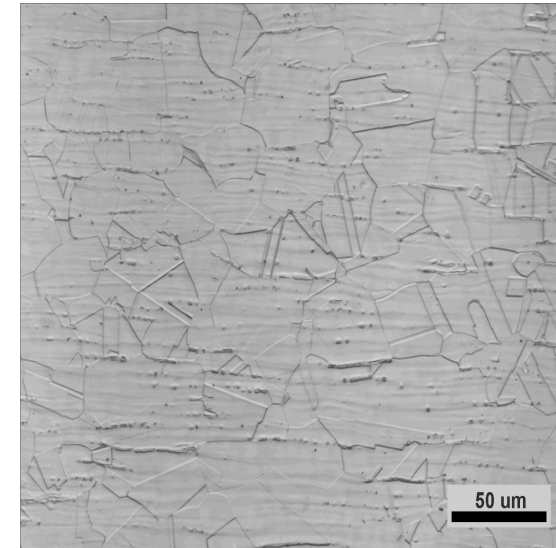
Seminar Duweltool & SuperAVON
Paul Janiak, 2020-02-20

What is duplex stainless steels?

- Duplex stainless steel has a ferritic-austenitic microstructure
- The phase balance is approximately 50% ferrite and 50% austenite
- Duplex stainless steel combines most of the beneficial properties of ferritic and austenitic steels
- The duplex microstructure contributes to high strength and high resistance to stress corrosion cracking



Duplex microstructure



Austenitic microstructure

Duplex stainless steel benefits

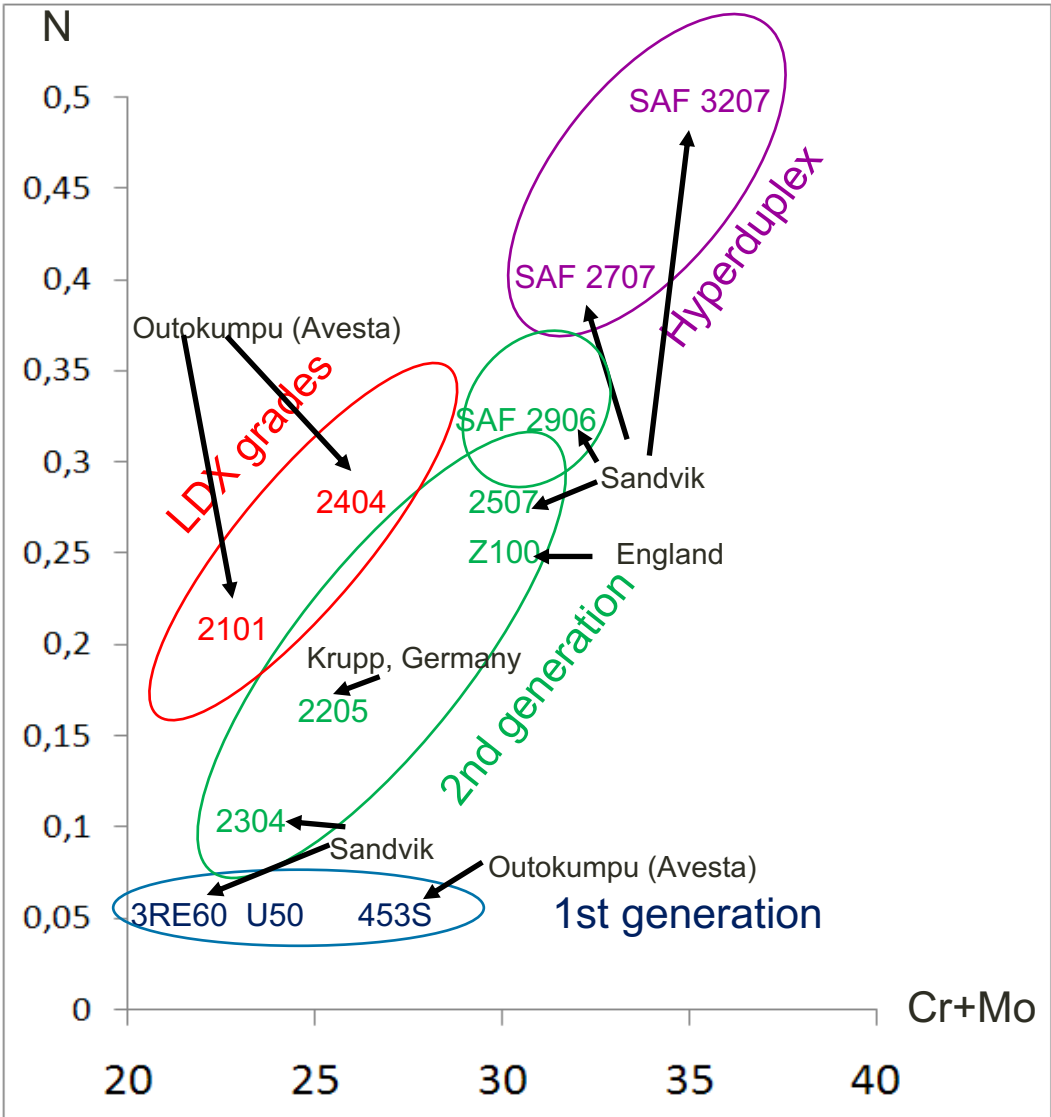


Courtesy of Outotec.

- High mechanical strength ($R_{p0,2} \min > 400 \text{ MPa}$)
- High resistance to localized corrosion (PRE 26 to 45) and stress corrosion cracking
- High wear resistance
- Low thermal expansion
- High energy absorption
- Good fabricability

→ Cost effective and sustainable solutions

History of duplex stainless steels



- The first duplex grades were originally developed to reduce the intergranular corrosion problems in the early high-carbon austenitic stainless steels.
- Later the 3RE60 was also developed specifically for increased SCC resistance.
- Introduction of the AOD process in the 70's greatly improved the properties of duplexes as C-content could be reduced and controlled Nitrogen additions became possible.

Year	Grade	C	Cr	Ni	Mo	Cu	N	Other
1930	453S	0,09	26	6	1,5	-	-	Avesta
1935	URANUS 50	0,09	21	6,5	2,5	1,5	-	France
1960	3RE60	0,03	18,5	5	2,7	-	-	Sandvik
1970-s	2205	0,02	22	5,7	3,1		0,17	Krupp
1980-s	2304	0,02	23	4,8	0,3		0,11	Sandvik
~1985	2507	0,02	25	7	4		0,27	Sandvik
2005	LDX 2101®	0.03	21,5	1,5	0,3		0,22	Mn=5 Avesta

Duplex families

(Standard) duplex (PREN 28-38)

- 22Cr is the duplex workhorse
- High strength alternative to 317L, 904L
- 25Cr are general purpose grades with even better corrosion resistance than 22Cr (lower Mo and N compared to super duplexes)

Super duplex (PREN 38-44)

- High pitting corrosion resistance competing with 6Mo superaustenitics (several grades with equal properties)
- High Cr grades tailor-made for urea industry

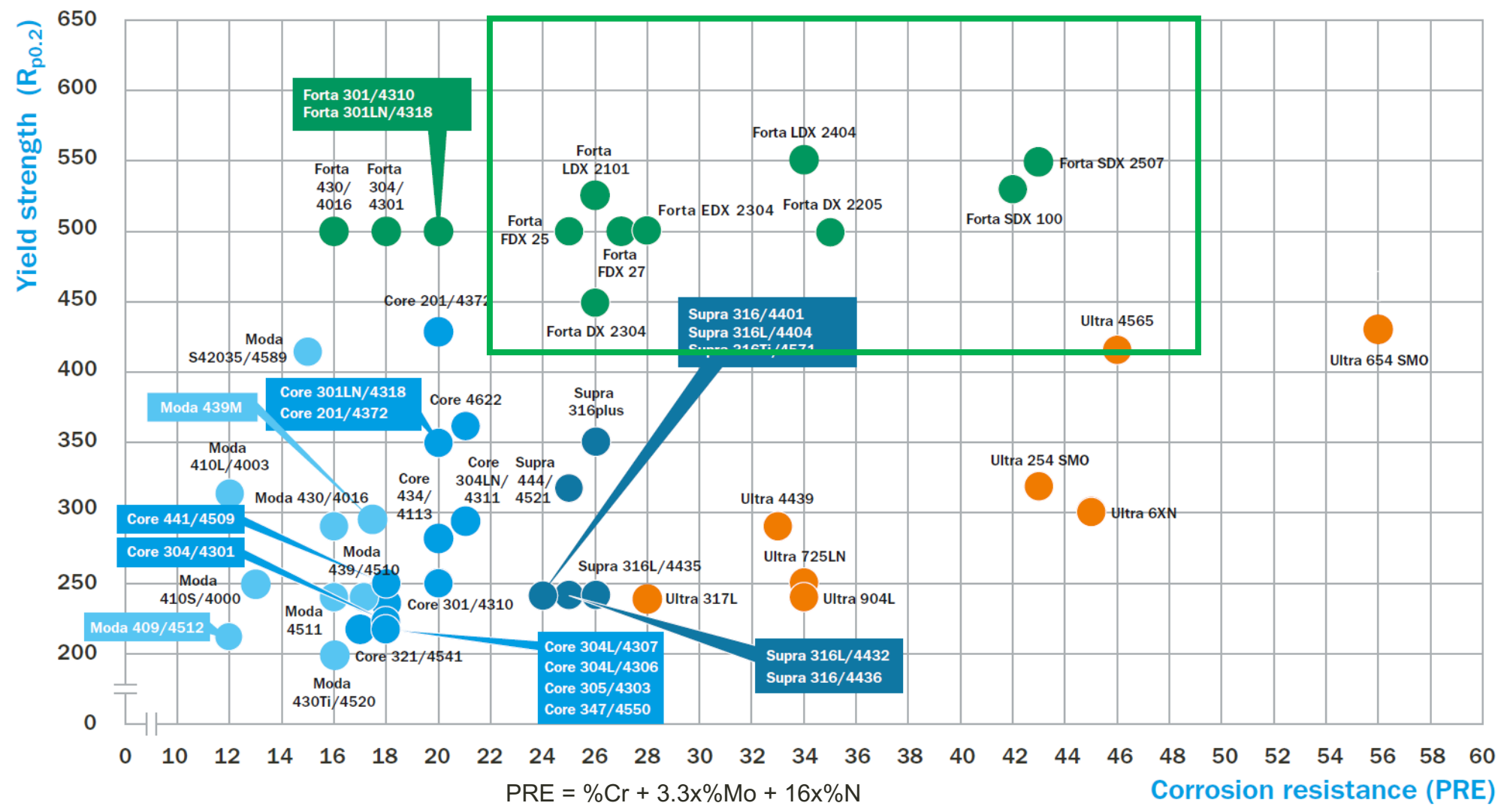
Lean duplex (PREN 22-28)

- Low cost alternatives to 304 & 316 and also competitors to carbon steel in selected applications.

Hyper duplex (PREN > 45)

- Superior pitting resistance, better than 6Mo, superior strength

Product performance comparison

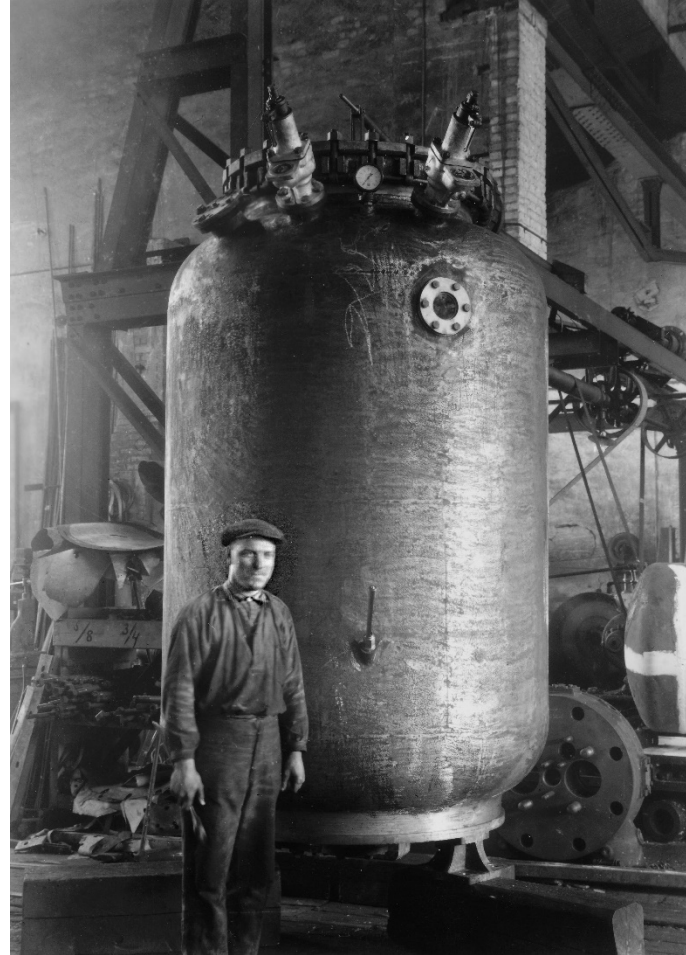


Examples of early applications

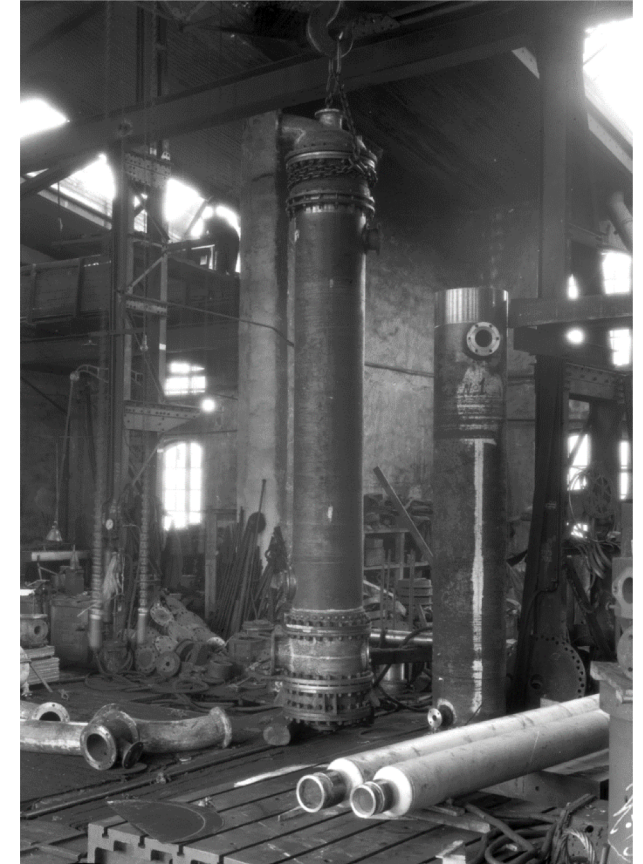
Cast valve bodies of 453S for sulfite industry



Autoclave made of 453S for the production of gun powder, delivered in August 1933



Brobeck cooler fabricated of 453S for sulfite mill



Later (modern) applications

- Pressure vessels
- Pulp and paper
- Storage and process tanks
- Heat exchangers
- Oil & Gas
 - Pipes, pipelines
 - Secondary structural steel
 - Pipe support
 - Umbilicals
- Cargo tanks in chemical tankers
- Flanges, tubes, and pipes
- Structural components in bridges
- Flood gates
- Valves



Thank you!

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