

*Spoilt for choice: what grade selection means for
fabrication parameters*

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Brussels, Belgium

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Scope of the presentation

- About Euro Inox
- Grade selection process – when and why
- Heat treatment in fabrication
 - Solution annealing
 - Annealing
 - Quench hardening
 - Stress relieving
- Pickling and passivation

Euro Inox

Members:

- Integrated European producers of stainless steel flat products
- National associations
- Alloying element organisations

Euro Inox

Focus on online communication:

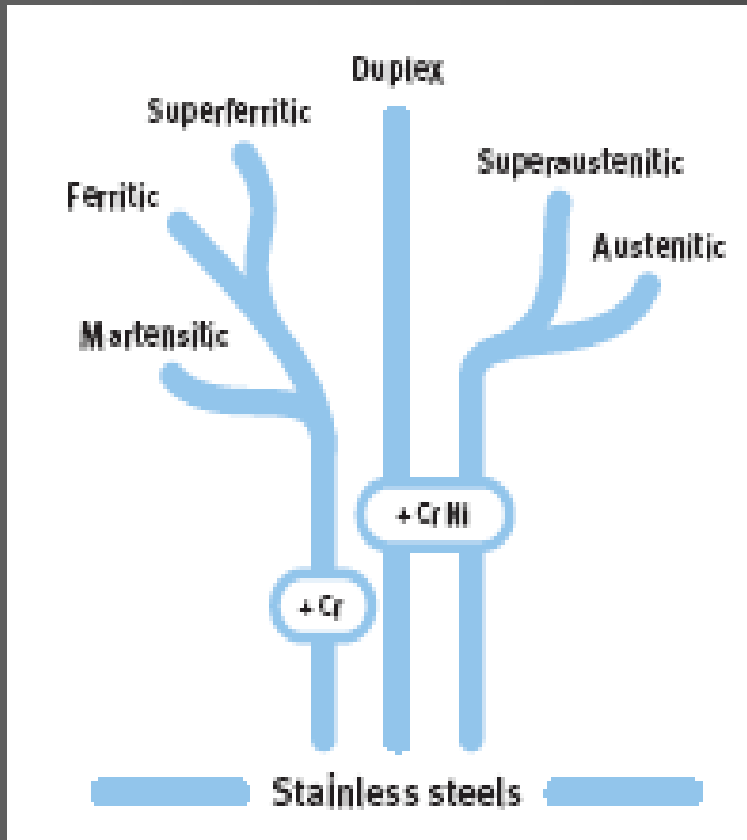
- about 140 documents available on the websites www.euro-inox.org and <http://mobile.euro-inox.org>

Other lines of activity:

- events
- helpdesk
- support of research
- image-building activities

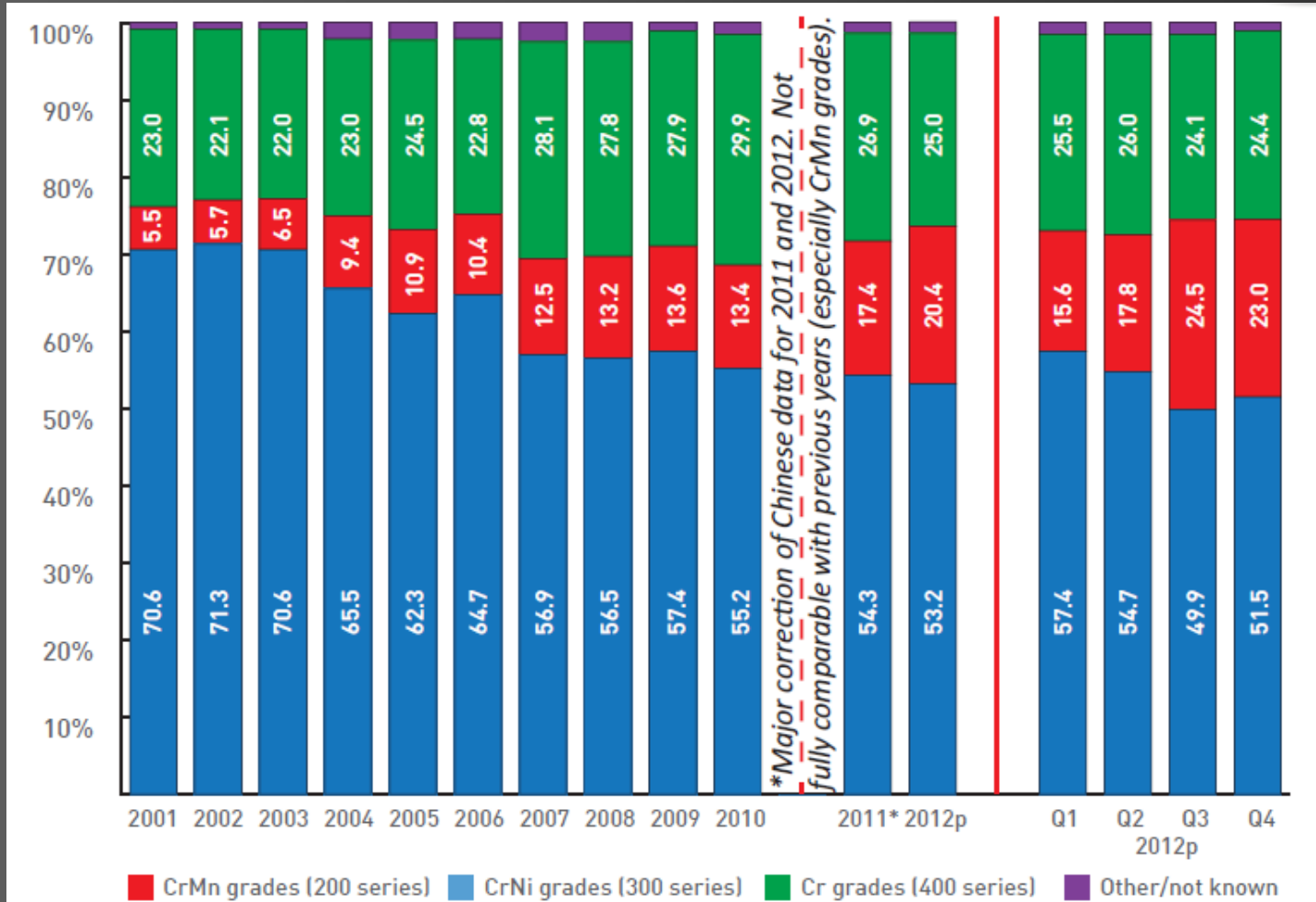
The screenshot displays the Euro Inox website interface. At the top, the logo 'euro inox' is accompanied by the text 'The European Stainless Steel Development Association'. A language selection menu includes options for English, Česky, Deutsch, Español, Français, Italiano, Nederlands, Polski, Suomi, Svenska, and Türkçe. The main navigation menu on the left lists categories such as 'Materials and Applications', 'Architecture, building and construction', 'Transport', 'Stainless steel in the home', 'Environment and human health', and 'Search'. The 'Materials and applications' section is expanded, showing a list of documents including 'The Euro Inox Materials and Application Series', 'New: Colouring Stainless Steel', and 'Austenitic Chromium-Manganese Stainless Steels - A Eu Electropolishing Stainless Steels'. The right-hand side of the page features a 'Welcome to the Euro Inox website, the' message, an online library, and a 'Euro Inox Mobile' section with a smartphone image and a link to 'The pocket guide to stainless steel'. Below this is a 'Videos/Animations/Interactive content' section with thumbnails for 'Self-Repairing', 'Alloyed', 'Recycled', and 'Corrosion'. The footer contains links for 'Updates', 'Events', 'Press', 'Members only', 'About Euro Inox', 'Disclaimer', 'List of Members', 'Other organisations', and a 'Follow us on twitter' button.

Grade selection process – when and why



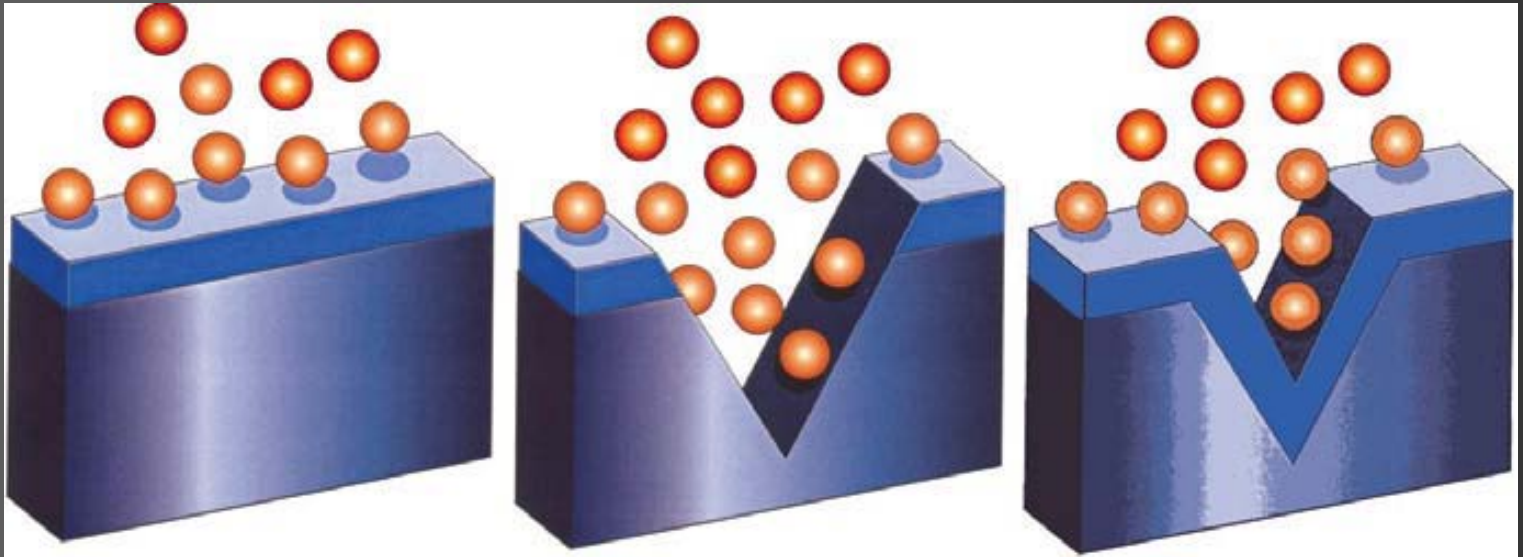
- Austenitic
- Ferritic
- Martensitic and precipitation hardening
- Duplex

Grade selection process – when and why



Grade selection process – when and why

- Stainless steels exhibit excellent resistance to corrosion due to a passive film or passive layer
- Passive film is affected by any heat treatment



Heat treatment in fabrication

In the delivery condition mostly no need for heat treatment:

- Austenitic : in solution annealed condition for highest corrosion resistance and ductility
- Duplex: in solution annealed condition for highest corrosion resistance and mechanical properties
- Ferritic: in annealed condition
- Martensitic: in annealed condition; hardening to follow

When and why to heat treat?



Solution annealing

Austenitic stainless steels

- Heat treatment often required in fabrication after welding or thermal processing for optimum corrosion resistance, softness and ductility
- Cannot be hardened by heat treatment (but only as a result of cold working)



Solution annealing

Austenitic stainless steels

- Solution annealing in the range of 1040–1150 °C
- Cooling must be rapid (but it must be consistent with distortion limits)
- Avoid 500–900 °C temperature range

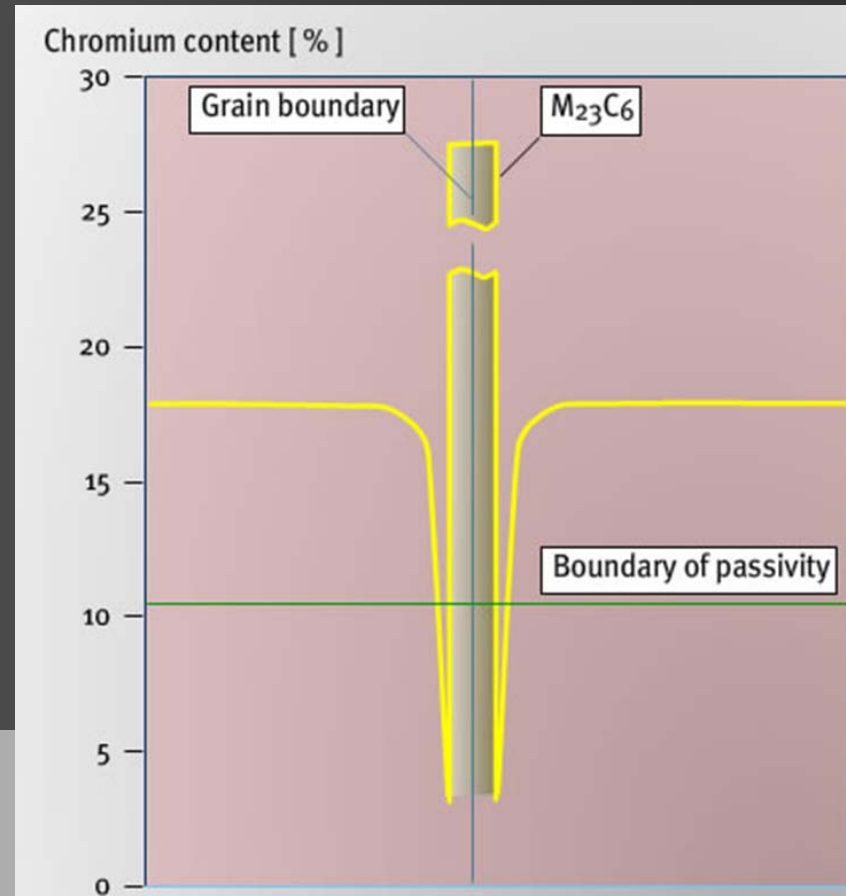


Solution annealing

Austenitic stainless steels

Sensitisation

- Risk of chromium carbide precipitation at grain boundaries and reduced corrosion resistance
- Forming of chromium carbide (Cr_{23}C_6)
- High carbon steels



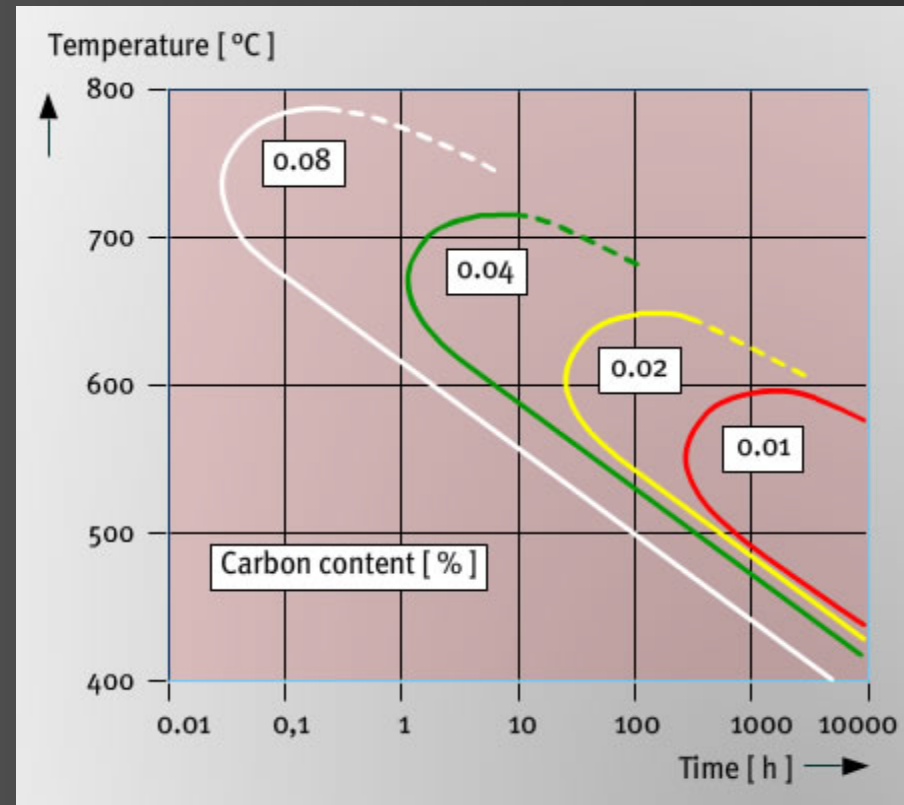
Solution annealing

Austenitic stainless steels

Chromium carbide formation is delayed with lower carbon content

Avoiding sensitisation:

- Solution annealing
- Stabilisation with Ti or Nb
- Reducing the carbon content



Solution annealing

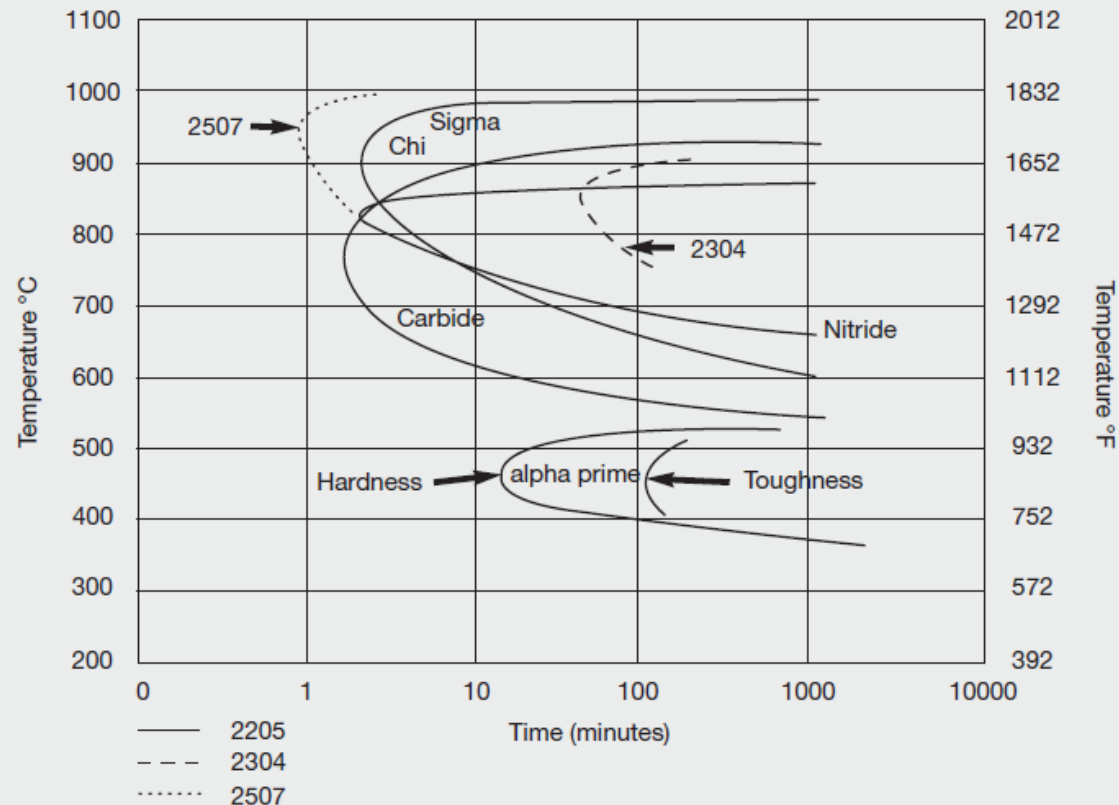
Duplex stainless steels

- Full solution annealing followed by rapid cooling for restoring mechanical properties and corrosion resistance

Grade	EN Number	UNS Number	Minimum annealing T (°C)
2101	1.4162	S32101	950
2202	1.4062	S32202	980
2304	1.4362	S32304	950
2205	1.4462	S32205	1020
2507	1.4410	S32750	1040

Solution annealing Duplex stainless steels

- With the welding the time at temperature before precipitation of intermetallic phases is being used



Solution annealing

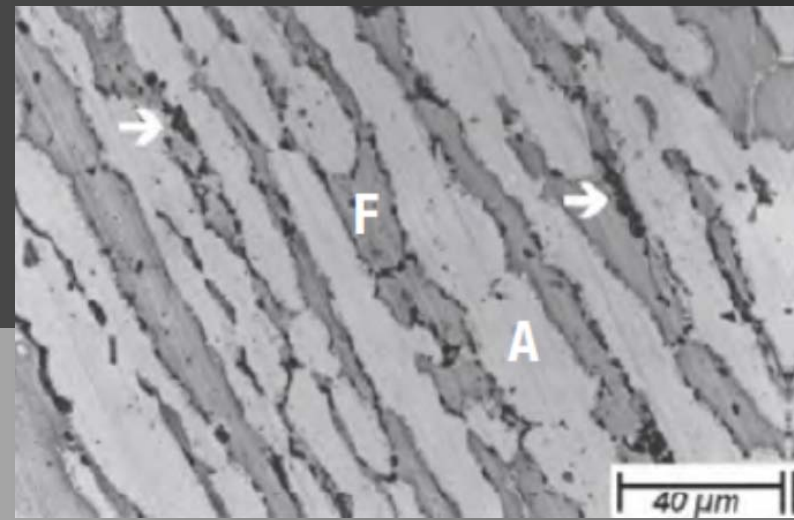
Duplex stainless steels

Intermetallic phases

- Sigma, chi phase, alpha prime, carbides, nitrides, Laves

Approximate temperature ranges to avoid

- Sigma phase formation 700–950 °C
- Carbide precipitation 450–800 °C
- 475 °C embrittlement 300–525 °C



Solution annealing

Duplex stainless steels

Time

- Conservative: comparable to the the total time in 650–980 °C range subsequent to the previous full annealing

Additional measures

- Warping and distortions are likely, because soft at annealing temperatures (support!)

Cooling

- Water



Solution annealing

Duplex stainless steels

Testing for absence of detrimental phases as to ASTM A 923

- Metallographic examination
- Charpy impact testing
- Corrosion testing
- Many fabricators have adopted this test as a part of their qualification for welding procedures

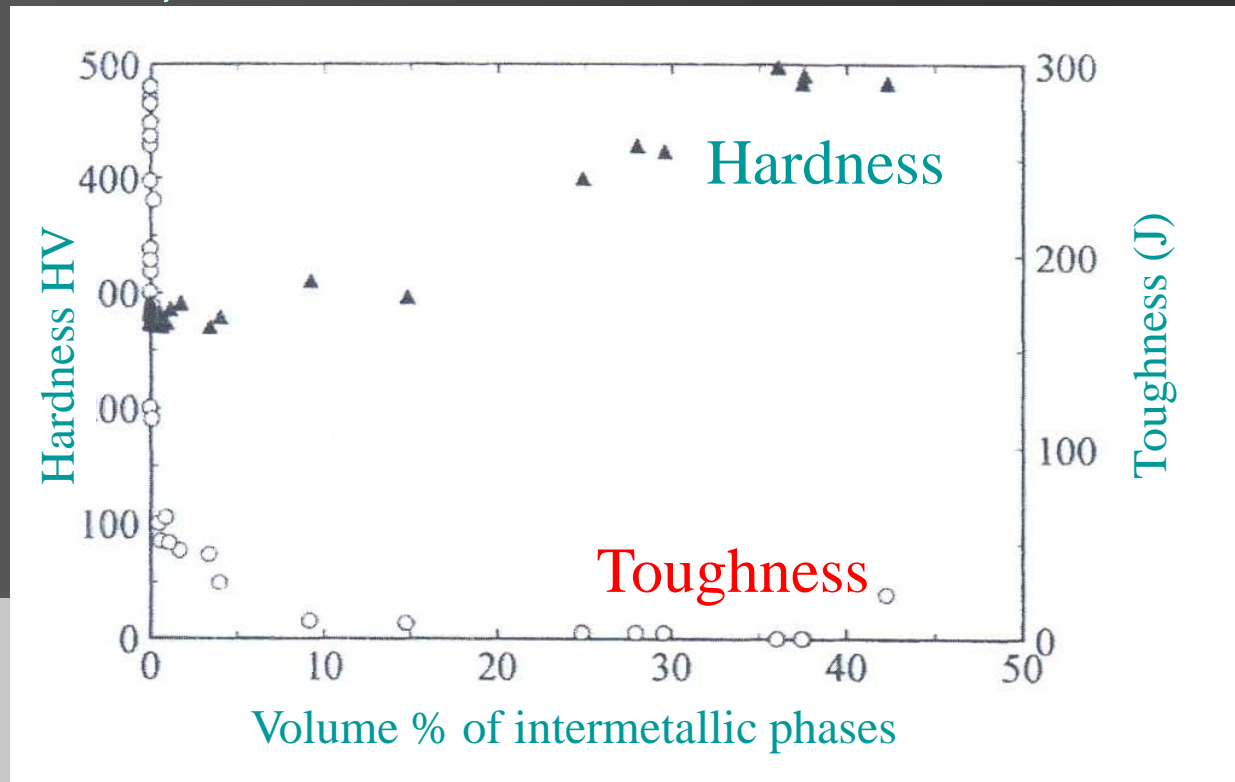
No similar EN standard!



Solution annealing Duplex stainless steels

ASTM A 923, Method B - Charpy impact testing

- For 2205
- min. 54 J for base metal, HAZ and weld metal



Annealing

Ferritic stainless steels

- Supply condition annealed
- Not hardened by quenching
- The only heat treatment is annealing
 - Relieved stresses developed during welding or cold working
 - Subcritical annealing (process)
 - Full annealing



Annealing

Ferritic stainless steels

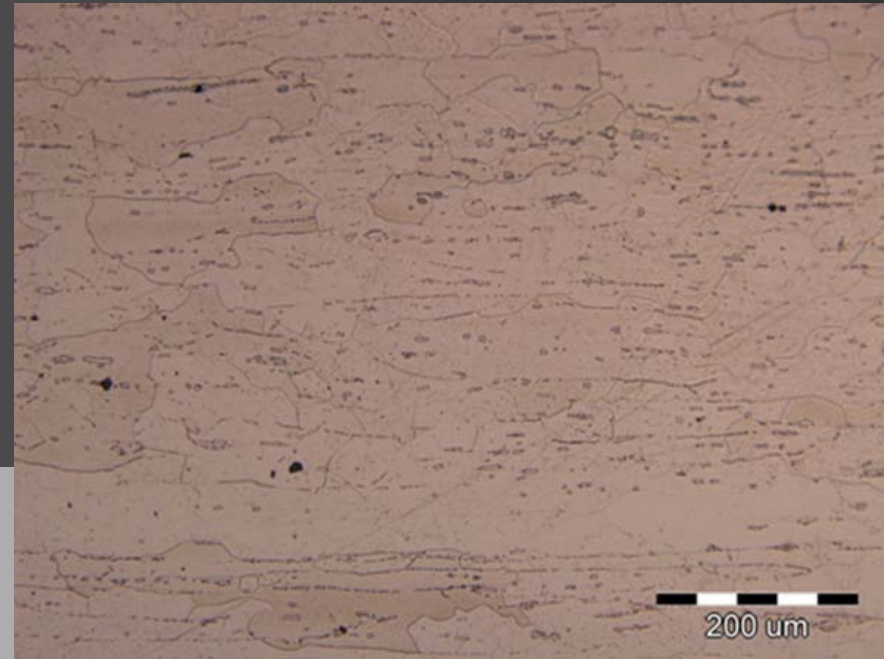
The ferritic stainless can be divided into two groups:

- Conventional ferritics, such as types 405, 409, 430 and 446
 - Low-interstitial ferritics, such as types 444, superferritics
-
- Annealing – for more homogenous structure by dissolving transformation products formed during welding.
 - Post heat treatment of the low-interstitial ferritics is generally unnecessary and is frequently undesired

Annealing

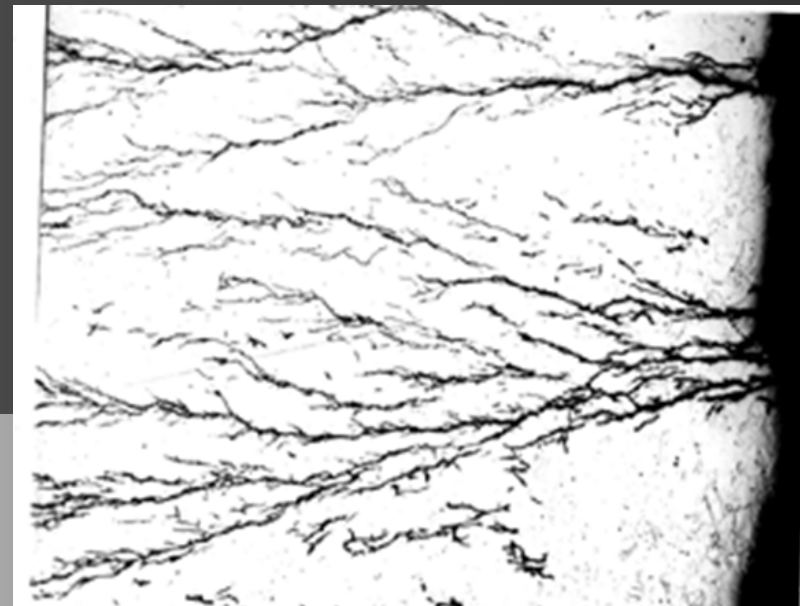
Ferritic stainless steels

- 475 °C embrittlement – common to the ferritic grades; can be developed from prolonged exposure to, or slow cooling within, the temperature range from about 370–525 °C
- The effects of embrittlement increase rapidly with chromium content



Stress relieving

- Cold worked austenitic stainless \Rightarrow strain induced martensite
- Stress corrosion cracking (SCC), which relies on tensile stresses as part of the failure mechanism
- Reduced risk of distortion during forming or machining



Stress relieving

- Below 400 °C is acceptable practice, but results in only modest stress relief
- Full solution annealing removes all residual stresses in austenitics, but is not practical
- Stress relieving of duplex is not recommendable
- Stress relieving of martensitics and ferritics weldments will temper weld and HAZ



Pickling and passivation

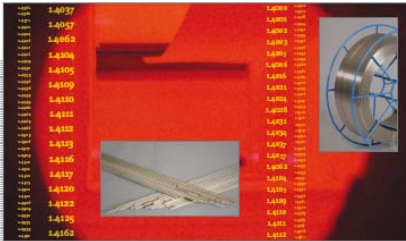
- After heat treatment surfaces must be metallurgically clean no matter how
 - Mechanical (grinding, polishing, bead blasting)
 - Chemical (pickling, passivating)
 - Mechanical + chemical (electropolishing)



Support available from Euro Inox

euro/inox
The European
Stainless Steel
Development Association


**Stainless Steels:
Tables of Fabrication Parameters**
welding processes and filler materials – heat treatments – typical end uses



Materials and Applications Series, Volume 17

euro/inox
The European
Stainless Steel
Development Association


Wytrawianie i pasywacja stali nierdzewnej



Seria Materiały i Zastosowanie, zeszyt 4

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Stainless Steel
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Barwienie stali nierdzewnej



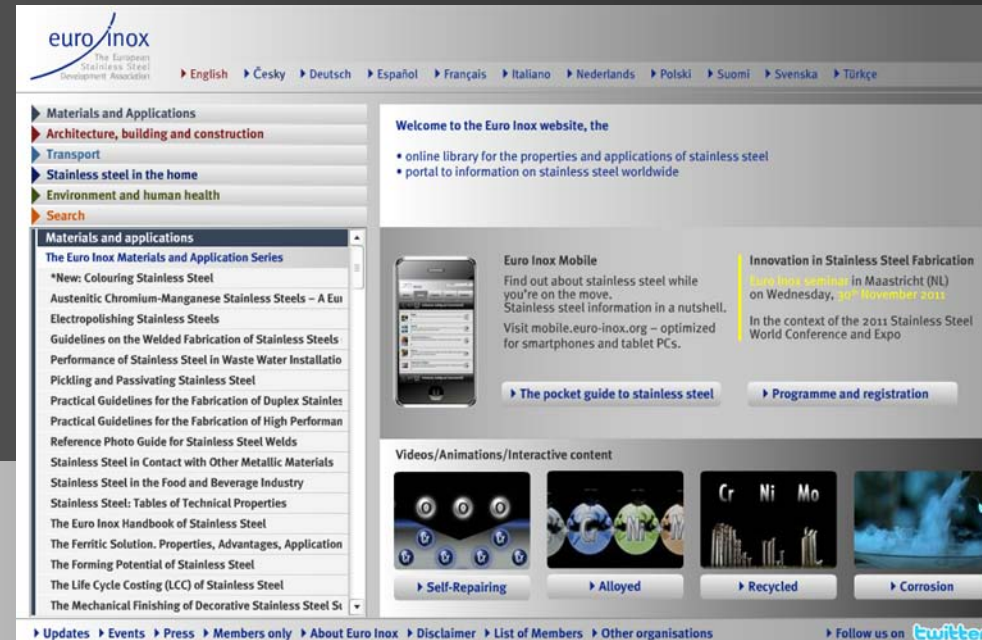
Seria materiały i zastosowania, księga 16

Support available from Euro Inox

Euro Inox provides a wide range of advisory publications in up to 14 languages

<http://www.euro-inox.org>

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On the right side, a "Welcome to the Euro Inox website, the" message is followed by two bullet points: "online library for the properties and applications of stainless steel" and "portal to information on stainless steel worldwide". Below this, there are two promotional boxes. The first, "Euro Inox Mobile", features a smartphone image and text: "Find out about stainless steel while you're on the move. Stainless steel information in a nutshell. Visit mobile.euro-inox.org – optimized for smartphones and tablet PCs." It includes buttons for "The pocket guide to stainless steel" and "Programme and registration". The second box, "Innovation in Stainless Steel Fabrication", mentions a "Euro Inox seminar in Maastricht (NL) on Wednesday, 30th November 2011" and notes it is "In the context of the 2011 Stainless Steel World Conference and Expo".

At the bottom, a "Videos/Animations/Interactive content" section displays four categories: "Self-Repairing", "Alloyed", "Recycled", and "Corrosion", each with a representative image and a button.

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