Outokumpu Mexinox
1. Why tolerate the volatility of nickel?
2. Common myths of stainless steel
3. Supporting the industry in the search for technical alternatives
4. Meeting customer requirements
5. Essential role of parameters related to surface finishes
6. Successful business cases
Stainless Steel Environment

VOLATILITY OF NICKEL
DEMAND UNCERTAINTY
TRADITIONAL PLANNING
INVENTORY VALUATION

outokumpu
Impact of metal prices on stainless steel
Surcharges from January 2007 - August 2015

Nickel-bearing alloys are volatile to the fluctuations of nickel pricing.
Ferritic stainless steels

Today’s ferritic stainless steels, properly specified, can often substitute 304 to excellent effect.
Why tolerate the volatility of nickel when there are alternatives just as usable as 301 and 304 stainless steel?

Specify stainless with lower or even no nickel content without sacrificing the quality and usability of your products.

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outokumpu Core 304/4301</td>
<td>Higher nickel content, more expensive surcharges</td>
</tr>
<tr>
<td>Outokumpu Core 301/4310</td>
<td></td>
</tr>
<tr>
<td>Outokumpu Core 201/4372</td>
<td>No nickel content, lower surcharges</td>
</tr>
<tr>
<td>Outokumpu Moda 430/4016</td>
<td></td>
</tr>
</tbody>
</table>
Corrosion resistance of stainless steel

The most important property of these steels is their corrosion resistance, because their mechanical properties can be offered or surpassed by other types of steels at a lower cost.

What provides the corrosion resistance?

A passive layer of chromium oxide

This passive layer is formed when a minimum of **10.5 % of chromium** is added to the steel.
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Common myths of stainless steel

First myth: Stainless steel must have Ni to be stainless

WRONG

The element that confers corrosion resistance is Chromium
Common myths of stainless steel

**Second myth:** Stainless showing magnetism is of inferior quality

WRONG

Magnetism depends on the crystallographic array of the atoms.
Common myths of stainless steel

**Third myth:** Stainless never corrodes

WRONG

If not properly specified, ALL stainless steel grades are subject to corrosion under certain environments - specially by chlorine containing substances.
Common myths of stainless steel

**Fourth myth:** Ferritic stainless cannot be welded

**WRONG**

Today, ferritic alloys have been designed to endure the difficult designs of the Automotive Industry.
Ferritic special trump cards

- Ferritics are **magnetic**.
- Ferritics have **low thermal expansion** (they expand less than austenitics when heated).
- Ferritics have **excellent high-temperature oxidation resistance** (they are less prone to scaling than austenitics).
- Ferritics have **high thermal conductivity** (they conduct heat more evenly than austenitics).
- Ferritics stabilised with niobium have **excellent creep resistance** (they deform less than austenitics in response to long-term stresses).
- Ferritics are **easier to cut and work** than austenitics (which require special tools and more powerful machines and generate greater tooling wear).
- Ferritics are significantly **less prone to springback** than austenitics, during cold forming.
- Ferritics have **higher yield strength** (similar to that of popular carbon steels) than type 304 austenitics.
- Ferritics, unlike austenitics, are **not prone to stress corrosion cracking**.

Source: “The Ferritic solution” by ISSF, April 2007
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Comparison of chemical composition
What makes stainless steel corrosion resistant?

<table>
<thead>
<tr>
<th>ASTM UNS</th>
<th>C Wt%</th>
<th>Mn Wt%</th>
<th>Cr Wt%</th>
<th>Ni Wt%</th>
<th>Mo Wt%</th>
<th>N Wt%</th>
<th>Cu Wt%</th>
<th>Ti Wt%</th>
<th>Nb Wt%</th>
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<td>316L/4404</td>
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<td>1.15</td>
<td>17.0</td>
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<td>304/4301</td>
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<td>1.3</td>
<td>18.0</td>
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<td>0.06</td>
<td>-</td>
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<tr>
<td>301/4310 6.7%</td>
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<td>1.8</td>
<td>17.0</td>
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<td>0.65</td>
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</tr>
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<td>17.0</td>
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<tr>
<td>430/4016</td>
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<td></td>
<td></td>
<td>0.96</td>
<td>0.04</td>
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<td>434/4113</td>
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<td>16.6</td>
<td>16.6</td>
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<tr>
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<tr>
<td>460</td>
<td>&lt;0.03</td>
<td>1.0</td>
<td>16.6</td>
<td>16.6</td>
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<tr>
<td>470</td>
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<td>16.6</td>
<td>0.96</td>
<td>0.04</td>
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</tbody>
</table>
Outokumpu Mexinox

Why pay for nickel if you don’t have to?

Surcharge cost reduction vs. performance

Outokumpu Core
304 /4301

Outokumpu Core
201 /4372

Outokumpu Moda
439 /4510

Outokumpu Moda
430 /4016

KEY
1 poor 2 sufficient 3 satisfactory 4 good 5 excellent

Corrosion resistance
Forming
Welding
Polishing
Brightness

Corrosion resistance
Forming
Welding
Polishing
Brightness

Corrosion resistance
Forming
Welding
Polishing
Brightness

Corrosion resistance
Forming
Welding
Polishing
Brightness

10/30/2015
Performance comparison 304 vs 441

Outokumpu Core 304 / 4301

Outokumpu Core 441 / 4509

KEY
1 poor
2 sufficient
3 satisfactory
4 good
5 excellent
The PRE factor

The “PRE” or Pitting Resistance Equivalent number is a theoretical measure of the relative pitting corrosion resistance of a stainless steel grade in a chloride-containing environment. The higher a grade’s PRE value, the more corrosion resistant the grade will be.

\[ \text{PRE} = \%\text{Cr} + 3.3 \times \%\text{Mo} + 16 \times \%\text{N} \]

Nickel content is not considered in the formula, since in most applications it plays no role in resistance to pitting corrosion.

The PRE comparison chart shows at a glance that for every austenitic grade there is a ferritic grade with comparable corrosion resistance.

Source: “The Ferritic solution” by ISSF, April 2007
### Moda range

#### Steel designations

<table>
<thead>
<tr>
<th>Outokumpu name</th>
<th>EN</th>
<th>ASTM Type</th>
<th>UNS</th>
<th>Performance</th>
<th>Typical chemical composition, % by mass</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PRE</td>
<td>%</td>
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<tr>
<td>Moda 430/4016</td>
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<td>S42035</td>
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#### Alternatives

<table>
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<tr>
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<th>EN</th>
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<th>UNS</th>
<th>Performance</th>
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<td></td>
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<td></td>
<td></td>
<td>PRE</td>
<td>%</td>
</tr>
<tr>
<td>Moda 410L/4003</td>
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<td>410L</td>
<td>S40977</td>
<td>12</td>
<td>20</td>
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<tr>
<td>Moda 409/4512</td>
<td>1.4512</td>
<td>409</td>
<td>–</td>
<td>12</td>
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<tr>
<td>Moda 410S/4000</td>
<td>1.4000</td>
<td>410S</td>
<td>S41008</td>
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<td>19</td>
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#### Low-Cr alternatives

<table>
<thead>
<tr>
<th>Outokumpu name</th>
<th>EN</th>
<th>ASTM Type</th>
<th>UNS</th>
<th>Performance</th>
<th>Typical chemical composition, % by mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PRE</td>
<td>%</td>
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<td>409</td>
<td>–</td>
<td>12</td>
<td>25</td>
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<tr>
<td>Moda 410S/4000</td>
<td>1.4000</td>
<td>410S</td>
<td>S41008</td>
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<td>19</td>
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</tbody>
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**PRE = %Cr + 3.3 x %Mo + 16 x %N**
## Core range

### Corrosive environments (PRE 17 to 22)

<table>
<thead>
<tr>
<th>Steel designations</th>
<th>Performance</th>
<th>Typical chemical composition, % by mass</th>
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<tbody>
<tr>
<td>Outokumpu name</td>
<td>PRE</td>
<td>(A_{80})</td>
</tr>
<tr>
<td>Core 304/4301</td>
<td>18</td>
<td>45</td>
</tr>
<tr>
<td>Core 304L/4307</td>
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<td>45</td>
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<td><strong>Alternatives</strong></td>
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<td></td>
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<td>Core 304LN/4311</td>
<td>21</td>
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<tr>
<td>Core 304L/4306</td>
<td>18</td>
<td>45</td>
</tr>
<tr>
<td>Core 305/4303</td>
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<td>Core 321/4541</td>
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<td>Core 301LN/4318</td>
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<tr>
<td>Core 301/4310</td>
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<td><strong>Low-Ni alternatives</strong></td>
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<td>Core 201/4372</td>
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<td>45</td>
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<tr>
<td>Core 201LN/4372</td>
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<td><strong>Ni-free alternatives</strong></td>
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<td>Core 441/4509</td>
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<td>18</td>
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<tr>
<td>Core 4622</td>
<td>21</td>
<td>30</td>
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<tr>
<td>Core 434/4113</td>
<td>20</td>
<td>18</td>
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</table>

PRE = \(\%Cr + 3.3 \times \%Mo + 16 \times \%N\)

10/30/2015
## Supra range

<table>
<thead>
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<th>Supra name</th>
<th>EN</th>
<th>ASTM Type</th>
<th>UNS</th>
<th>Performance</th>
<th>Grade family</th>
<th>Typical chemical composition, % by mass</th>
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<tbody>
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<td>PRE</td>
<td>A$_{80}$</td>
<td>$R_{0.2}$</td>
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$^{a}$ Mechanical values acc. to SANS S0028 T.

**PRE** = %Cr + 3.3 x %Mo + 16 x %N

Values for $R_{0.2}$ yield strength and the $A_{80}$ for elongation are according to EN 10088-2 min. values for cold rolled strip.

Chemical compositions and PRE calculations are based on Outokumpu typical values.

Grade families:

- **A** = Austenitic
- **F** = Ferritic
- **D** = Duplex
- **M** = Martensitic
- **PH** = Precipitation hardening
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Mexinox seeks new ways to meet the changing needs of our customers and to help to adapt to the changing market conditions.

Mexinox collaborates with its customers through joint research projects.

Mexinox collaborates with its customers through joint grade substitution projects.
Outokumpu Mexinox provides its customers the technical know-how they need in terms of presentations, conferences and training.

Moda range ferritic grades gives the customer benefits in terms of quality and design.

Mexinox co-funds and supports the efforts of IMINOX in educating the market in the use of ferritic grades.
Establish customer proximity to understand their needs and requirements.

Provide service and quality beyond their expectations in all products that Outokumpu Mexinox provides.

Outokumpu Mexinox creates pools of knowledge to respond when opportunity knocks. This is a competitive edge.
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Mexinox experience in surface polished finishes has been well established during decades

Attractive appearance and consistency, make a popular choice for appliances

Mexinox is renowned for its tailored solutions, maintaining a strict plan for consistency.
Polished surface roughness may produce surfaces with some microscopic defects.

Polishing abrades the stainless surface, and may introduce corrosion vulnerabilities preventing a continuous chromium oxide layer from re-forming (P4 with microscopic Silicon Carbide embedded particle).

Rolled-On is achieved by embossing the polish pattern on the surface but without scratching and contaminating the chromium oxide layer.
Rolled-On is a linear pattern embossed into the stainless steel. The finish is prepared by skin passing a coil through specially prepared rolls, simulating the appearance of the more traditional abrasive polished finish.

Acceptable roughness range on rolls: 75 – 120 micro inches. Final roughness on the product: 25 to 50 micro inches. Improved corrosion resistance on a BA substrate. Uniformity of finish on both top and bottom sides.

Preparation of the skin pass roll is in the transverse direction to the abrasive line with multiple verification points.
Salt spray fog testing has shown that Deco range 430 Rolled-On finish has similar corrosion resistance to 304 abrasively polished finish.

A continuous analysis of the produced surface in terms of aspect, glossiness and roughness is made as a routine.


Mechanical, chemical and formability properties remain unaltered with respect to Mexinox standards.
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Summary

• For every austenitic grade there is a ferritic grade with comparable corrosion resistance
• Ferritic grades prices are less volatile than Austenitic grades because they do not contain Nickel
• New users have to be trained in forming and joining technics
• User should consult his stainless steel producer regarding correct grade selection
• The user shall acquire his material from a reliable source, able to obtain proven guarantees as to the grade, quality and origin of the material supplied