

Alloying Elements and Properties of Steel

Here is a comprehensive list of are a few major alloying elements for steel, what they do, and what they are used for.

For clarity, there are no links. Look up these modules for explanations:

- [Science of Alloying](#)
- [Alloying Elements in Detail](#)
- [Properties of Steel](#)

Illustration

Element	Stabilizes....	Hardness Increase Mechanism	Tendency to form hard Carbides	Major / Minor Functions
Manganese Mn	Austenite Open γ -field	Moderate increase Powerful solution strengthener	Middle	<ol style="list-style-type: none"> 1. Takes care of Sulphur (S). 2. Makes special steels in high concentrations 3. <i>Cheap</i> increase of hardenability.
Silicon Si	Ferrite Closed γ -field	Hardens, but <i>reduces ductility</i> Moderate increase	None	<ol style="list-style-type: none"> 1. Deoxidation ("killing") of <i>liquid steel</i>. 2. Increases <i>electrical resistivity</i> (important for transformer cores). 3. Improves oxidation resistance.
Aluminum Al	Ferrite Closed γ -field	Small Grain size hardening	No carbides but nitride.	<ol style="list-style-type: none"> 1. Deoxidation ("killing") of <i>liquid steel</i>. 2. Improves oxidation resistance.
Chromium Cr	Ferrite Closed γ -field	Moderate increase (Secondary) prec. hardening	Strong	<ol style="list-style-type: none"> 1. Corrosion resistance. 2. Strength + oxidation resistance at <i>high T</i>. 3. <i>Abrasion resistance</i> (needs high C, too).
Titanium Ti	Ferrite Closed γ -field	Strong increase; Prec. hardening Grain size hardening	Extremely strong	<ol style="list-style-type: none"> 1. Oxygen, nitrogen and sulphur scavenger. Forms hard carbides. prevents grain growth. 2. Prevents <i>local depletion</i> of carbon in stainless steels due to Cr-carbide formation
Vanadium V	Ferrite Closed γ -field	Very strong increase Prec. hardening Grain size hardening Moderate solid solution hardening	Very strong	<ol style="list-style-type: none"> 1. <i>Restricts grain coarsening</i> of austenite. 2. Increases hardenability. 3. Delays softening during tempering.
Nickel Ni	Austenite Open γ -field	Mild increase	None	<ol style="list-style-type: none"> 1. Enables austenitic steels. 2. Enables Invar steel

<p>Molybdenum Mo</p>	<p>Austenite Open γ-field</p>	<p>Strong increase Prec. hardening Grain size hardening</p>	<p>Very strong</p>	<p>1. Improves <i>corrosion resistance of stainless steels</i>. 2. Prevents <i>embrittlement</i> of certain Ni/Cr steels. 3. Keeps strength at higher T. 4. Provides high <i>abrasion resistance</i>.</p>
<p>Boron B</p>	<p>? Major changes i at very small concentrations</p>	<p>Strong increase Prec. hardening Grain size hardening</p>	<p>Very strong</p>	<p>1. High strength steel 2. Nitrogen scavenger 3. Replacement for expensive elements without compromising properties</p>