

## Commercial Grade Steels vs Custom Grade Steel

### The Element and its Metallurgical Effects

**Carbon (C)** Carbon is an essential element in steel, it is added in specific amounts to control the hardness and strength of the material. In general, increased carbon content reduces ductility but increases tensile strength and the ability of the steel to harden when cooled rapidly from elevated temperatures. With an increase in the amount of carbon, the hardness and tensile strength of the steel also increase (which slows as the level of carbon rises). An increase in carbon thusly causes a decrease in both ductility and weldability.

**Chromium (Cr)** Increases the steel's hardenability, corrosion resistance, and provides wear and abrasion resistance in the presence of carbon. It is largely present in stainless steels, usually ranging from 12 to 20%.

**Molybdenum (Mo)** Its use as an alloying element in steel increases hardenability and in low alloy steels reduces the risk of temper brittleness. When added to stainless steels it increases their resistance to corrosion. It is also used in high-speed steels.

**Manganese (Mn)** Fulfilling a number of important functions, Manganese is one of the most important constituents of alloy steel. It acts as a mild de-oxidizing agent. It combines with the sulfur present to form globular inclusions of Manganese sulfides that are beneficial to machining. It increases tensile strength and the hardenability of steel. Will also increase hardness, but not to the same degree as carbon. Ductility and weldability are decreased but, again, to a lesser degree than caused by carbon.

**Nickel (Ni)** One of the most widely used alloying elements in steel. In amounts up to 5.00% its use in alloy steels increases the toughness and tensile strength without detrimental effect on the ductility. Nickel also increases the hardenability, thus permitting the steel to be oil-hardened instead of water quenched. In larger quantities, 8.00% and upwards, nickel is the constituent, together with chromium, of many corrosion resistant and stainless austenitic steels.

**Vanadium (V)** Steels containing vanadium have a much finer grain structure than steels of similar composition without vanadium. It raises the temperature at which grain coarsening sets in and increases hardenability where it is in solution in the austenite prior to quenching. It also lessens softening on tempering and confers secondary hardness on high speed steels. Vanadium is used in nitriding, heat resisting, tool and spring steels in conjunction with other alloying elements.

**Silicon (Si)** Silicon serves as a principal deoxidizer in steel. Its content in the steel is dependent upon the steel type. Killed steel has the highest percentage of silicon, upwards of 0.60 percent.

**Phosphorus (P)** Its presence in steel is usually regarded as an undesirable impurity due to its embrittling effect, for this reason its content in most steels is limited to a maximum of 0.050%. Benefits machinability and resistance to atmospheric corrosion. It increases strength and hardness, much akin to carbon, but it decreases ductility and impact strength (toughness).

**Sulfur (S)** Generally regarded as an impurity in steel because of its detrimental effects on strength, ductility and weldability, and the causation of hot and cold shortness. Its content in most steels is limited to a maximum of 0.050%. Sulfur is beneficial to machining and is added to freecutting steels in amounts up to 0.35% with the manganese content increased to overcome any detrimental effects. Like phosphorus, sulfur is generally undesired, except where machinability is an important goal for the steel. Ductility, impact strength or toughness, weldability, and surface quality are all adversely affected by sulfur content.

Accurloy / Nichroloy	4140	4150	4340
<b>.48-.50</b>	<b>.38-.43</b>	<b>.48-.53</b>	<b>.38-.43</b>
<b>The carbon content of Accurloy/Nichroloy combines the hardness of 4150 with the ductility and weldability of the 4140/4340 grades.</b>			
<b>1.00-1.10</b>	<b>.80-1.10</b>	<b>.80-1.10</b>	<b>.60-.80</b>
<b>Higher average levels of Chromium in Acc/Nich increase benefits relative to the 4XXX grades.</b>			
<b>.20-.30</b>	<b>.15-.25</b>	<b>.15-.25</b>	<b>.20-.30</b>
<b>High end levels of Moly promote hardness while reducing brittleness over the 41XX grades.</b>			
<b>.85-1.00</b>	<b>.75-1.00</b>	<b>.75-1.00</b>	<b>.60-.80</b>
<b>Higher average levels of Manganese in Acc/Nich increase machinability, hardness and cleanliness relative to the 4XXX grades.</b>			
<b>.20-.30</b>	<b>Nil</b>	<b>Nil</b>	<b>1.65-1.95</b>
<b>Accurloy and Nichroloy contain beneficial amounts of Nickel, an addition offering increased toughness compared to the 41XX steels.</b>			
<b>.15-.20</b>	<b>Nil</b>	<b>Nil</b>	<b>Nil</b>
<b>Key to Accurloy and Nichroloy in that Vanadium provides a cleaner grain structure, lending to a purer shaft with fewer hard and soft spots than the commercial grades.</b>			
<b>.15-.30</b>	<b>.15-.35</b>	<b>.15-.35</b>	<b>.15-.35</b>
<b>Approximately equivalent amounts of Silicon.</b>			
<b>.015 max</b>	<b>.035 max</b>	<b>.035 max</b>	<b>.035 max</b>
<b>The Acc/Nich group exhibits far less negative effects (increased brittleness, decreased ductility and toughness) through decreased Phosphorus levels relative to the generic grades.</b>			
<b>.015 max</b>	<b>.040 max</b>	<b>.040 max</b>	<b>.040 max</b>
<b>Sulfur, an undesirable element in this type of shafting, is minimized in Accurloy and Nichroloy, muting the loss of strength, ductility and weldability as compared to the 4XXX grades.</b>			



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