Proximate Chemical Composition [in %- wt] & Mechanical Properties

<table>
<thead>
<tr>
<th>Element</th>
<th>%C</th>
<th>%Si</th>
<th>%Mn</th>
<th>%P</th>
<th>%S</th>
<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>%V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>2.3</td>
<td>0.4</td>
<td>0.70</td>
<td>0.06</td>
<td>0.04</td>
<td>13</td>
<td>0.80</td>
<td>0.90</td>
<td>0.00</td>
</tr>
<tr>
<td>Max</td>
<td>3.0</td>
<td>0.8</td>
<td>1.20</td>
<td>max</td>
<td>max</td>
<td>19</td>
<td>1.50</td>
<td>1.6</td>
<td>0.30</td>
</tr>
</tbody>
</table>

1 MPa = 1 N/mm² (=0.1 kgf / mm²)

Hardness in Depth [SH C]

GONTERMANN-PEIPERS (INDIA) LIMITED
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P.O. Pailan, Diamond Harbour Road, 24 Parganas(S), West Bengal, India, Pin: 743512
Phone: 91 33 2453-2455 / 56, 2497-8684-86 / 8294,
Fax: 91-33-2497-8547 / 8686, Website: www.gontermann-peipers.com/
Centrifugally Cast Composite High Chromium Iron Rolls

Composite High Chromium Iron rolls are normally used in the initial stands (F1 to F3 and at times F4) of Hot Strip Mills where the stock undergoes the maximum reduction. These centrifugally cast rolls have a high chromium content shell with a nodular iron core. Though there are a few other areas of application for these rolls like skin pass rolls in Cold Rolling Mills and initial stands of tandem mill these applications are very limited in nature.

High Chrome Iron rolls are normally designed to have the following properties -

- High compressive strength – To increase the load bearing capacity.
- High thermal fatigue strength – To reduce crack initiation
- Higher peeling resistance of the oxide layer - To reduce rolled in scale and other such rolling defects
- High wear resistance - To get a higher campaign life

Though rolls are generally customized as per the specific rolling mill conditions of the user, High Chromium rolls are characterized by the presence of well distributed ternary carbides of M$_7$C$_3$ type in the shell area which remain well distributed in a tempered upper Bainitic and Martensitic matrix.

The high hardness and morphology of these carbides provide the desired wear resistance properties. This feature coupled with the high strength matrix provided by the Cr in solid solution, ensures that these rolls have a higher impact & fatigue resistance along with improved wear resistance and resistance to oxidation that is necessary for good performance under the higher temperature conditions that these rolls encounter. The relatively lower difference between these special carbides & the matrix ensures an even wear pattern during actual use.
Anti Peeling  Hi-Cr Iron Roll

Proximate Chemical Composition [in %-wt] & Mechanical Properties  
\[ 1 \text{ MPa} = 1 \text{ N/mm}^2 (=0.1 \text{ kgf/mm}^2) \]

<table>
<thead>
<tr>
<th>Element</th>
<th>%C</th>
<th>%Si</th>
<th>%Mn</th>
<th>%P</th>
<th>%S</th>
<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>%V</th>
<th>Tensile Strength of Journal (MPa)</th>
<th>Bending Strength of Journal (MPa)</th>
<th>Barrel Hardness in ShC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>2.2</td>
<td>0.4</td>
<td>0.70</td>
<td>0.06</td>
<td>0.04</td>
<td>13</td>
<td>0.80</td>
<td>0.90</td>
<td>0.00</td>
<td>300</td>
<td>450</td>
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</tr>
<tr>
<td>Max</td>
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<td>max</td>
<td>max</td>
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<td>1.6</td>
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<td>500</td>
<td>750</td>
<td>85</td>
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Hardness in Depth [SH C]
Centrifugally Cast Composite Anti Peeling High Chromium Iron Rolls

**Composite Anti Peeling Hi-Cr Iron** Work Rolls are generally used for the early stands of Hot Strip Mills. **Anti Peeling** High Chromium Iron rolls are used in the initial stands (F1 to F3 and at times F4) of Hot Strip Mills where the stock undergoes the maximum reduction replacing conventional Hi-Cr Iron rolls.

- These centrifugally cast rolls are have a high Chromium content shell with a nodular iron core like a conventional Hi-Cr Iron roll but the Carbon content & Cr to C ratio are precisely controlled to get a balanced microstructure in between a conventional Hi-Cr (I) & Hi-Cr Steel rolls.

**High Chrome Iron rolls are normally designed to have the following properties**

- Higher Resistant to Oxidative wear as well as Abrasive wear
- Higher Resistance to "Banding" hence better surface quality
- Improve gripping thereby reducing roll bite related problems
- Improved Resistance fire cracking resulting lesser stock removal per campaign.
- Higher campaign life and lesser grinding due to improved peeling resistance.

Though rolls are customized as per the specific rolling mill conditions of the user, Anti Peeling High Chromium Iron rolls are characterized by the presence of well distributed ternary carbides of \( M_7C_3 \) type in the shell area which remain well distributed in a tempered upper Bainitic and Martensitic matrix with relatively lesser eutectic carbides coupled with higher matrix hardness than conventional Hi-Cr Iron roll.

- In conventional Hi-Cr Iron rolls the peeling problem is more due to its inherent micro structural characteristics. On the other hand the Hi-Cr steel offers excellent resistance to oxide layer peeling & is resistant to oxidative wear while having poor resistance towards abrasive wear required in later stand of early finishing stand of HSM.

- The optimization of these properties have led to the development of the Anti Peeling Hi-Cr Iron rolls variety which are resistant to both ‘Thermo-Mechanical’ as well as abrasive wear conditions. To obtain these properties Anti Peeling Hi-Cr Iron roll have a microstructure that contains appreciable amounts of finer eutectic carbides to improve the load bearing capacity and abrasive wear resistance at the same time the high Chromium content in the matrix ensures resistance to oxidation and a higher matrix hardness.

- In addition the relative wear properties are further enhanced by the presence of well dispersed secondary globular carbides throughout the matrix by a series of Heat-treatment process.
Proximate Chemical Composition [in %- wt] & Mechanical Properties

<table>
<thead>
<tr>
<th>Element</th>
<th>%C</th>
<th>%Si</th>
<th>%Mn</th>
<th>%P</th>
<th>%S</th>
<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>%V</th>
<th>Tensile Strength of Journal (MPa)</th>
<th>Bending Strength of Journal (MPa)</th>
<th>Barrel Hardness in ShC</th>
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</thead>
<tbody>
<tr>
<td>Min</td>
<td>1.0</td>
<td>0.4</td>
<td>0.70</td>
<td>0.06</td>
<td>0.03</td>
<td>8.0</td>
<td>0.80</td>
<td>1.00</td>
<td>0.00</td>
<td>300</td>
<td>450</td>
<td>65</td>
</tr>
<tr>
<td>Max</td>
<td>2.3</td>
<td>0.8</td>
<td>1.20</td>
<td>max</td>
<td>max</td>
<td>15.0</td>
<td>1.50</td>
<td>2.5</td>
<td>0.30</td>
<td>500</td>
<td>750</td>
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</table>

Hardness in Depth [SH C]
Hi-Cr Steel Rolls are used as Work Rolls for Roughing Stands of Hot Strip Tandem Mill & Reversing Mill where the strip temperature is the highest. New generation Hi-Cr Steel Rolls are also used as Work Rolls for early finishing stands (F1 and F2) of Hot Strip Mills.

These centrifugally cast rolls have a high chromium low carbon shell with a nodular Iron core. High Chrome Steel rolls are normally designed to have the following properties.

- Excellent resistance to peeling of oxide layer -- To get resistant to sticking.
- Better Thermal conductivity (due to lower Chromium content than Hi-Cr Iron rolls) --To give resistance to thermo-mechanical cracking. Lesser slippage problem due to lower carbide content.
- Excellent resistance to oxidative wear due to higher Chromium partitioning towards matrix -- To give lesser wear resulting higher campaign life.
- Excellent toughness due to lower carbon content - To resist crack initiation under fatigue loading conditions.

- In conventional High Chromium roll the Chromium Carbide eutectic give rise to cracking particularly in the roughing stand where thermal load is more & speed of the stand is less. Due to this the peeling of oxide layer also takes place particularly in F1 & F2 stand (second stand of finishing train) of continuous strip mill causing poor surface strip. In roughing stand of HSM the conventional rolls are having poor performance due to cracking, excessive oxidative wear with poor strip quality & mill productivity.

- To overcome the above problem Hi-Cr Steel roll was developed for roughing stand & early finishing stand where the wear is basically ‘Thermo-Mechanical’ rather than abrasive in nature. The most important prevailing factor in Hi-Cr steel shell is the micro-hardness of the matrix which is governed by Chromium content of the matrix (Cr\text{Matrix}) or intern by (Cr/C) ratio with %Carbon content, ultimately result in increase in hardness, hardenability & oxidation resistance of matrix.

- Finally, the micro hardness will further increase in the range of 600 to 650 hv by special heat-treatment cycle to minimize difference of Hardness between matrix & carbide. This gives the mechanical stability of matrix / carbide interface, leading to decrease in delamination wear.
Indefinite Chill Double Pour Roll

Hardness in Depth | [SH C]

<table>
<thead>
<tr>
<th>Element</th>
<th>%C</th>
<th>%Si</th>
<th>%Mn</th>
<th>%P</th>
<th>%S</th>
<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>%V</th>
<th>Tensile Strength of Journal (MPa)</th>
<th>Bending Strength of Journal (MPa)</th>
<th>Barrel Hardness in ShC</th>
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<tbody>
<tr>
<td>Min</td>
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<tr>
<td>Max</td>
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<td>0.5</td>
<td>0.02</td>
<td>450</td>
<td>700</td>
<td>85</td>
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Centrifugally Cast Indefinite Chilled Composite Iron Rolls

Indefinite Chilled Iron Rolls are generally used in the last two to three stands (F4, F5 and F6 Stands) in the Finishing Stands of Hot Strip Mills as well as in Roughing & Finishing Stands of Four High Plate Mills and Finishing Stands of Rod & Narrow Strip Mills

To enable Hot Strip Mills to meet stringent dimensional tolerances and strip surface finish standards along with increasing mill productivity, the Indefinite Chilled Iron Rolls both Regular and Enhanced Carbide varieties are characterized by the following properties –

· Good thermal and impact fatigue resistance – to provide resistance to crack initiation and spalling
· Good anti-sticking properties – to provide a good surface finish & reduce mill incidents.
· Good wear resistance – to ensure good productivity per campaign
· Vibration damping capabilities – to provide a good surface finish
· High Rigidity- to maintain the strip thickness and contour
· Good thermal conductivity – to reduce fire cracking during use

The combination of above properties are achieved by careful selection and adjustment of the alloying elements and subsequent heat treatment cycles to control to distribution and morphology of the graphite and the basic matrix of the roll to obtain a range of microstructures varying from a Bainitic-Martensitic matrix to a Martensitic-Bainitic matrix depending on the end use conditions in order to get the best performance. The presence of ternary and complex primary carbides in the working layers ensuring a good and uniform roll wear property.
Proximate Chemical Composition [in %- wt] & Mechanical Properties

<table>
<thead>
<tr>
<th>Grade</th>
<th>%C</th>
<th>%Si</th>
<th>%Mn</th>
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<th>%S</th>
<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>Tensile Strength of Journal (MPa)</th>
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<th>Barrel Hardness in ShC</th>
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<tr>
<td></td>
<td>Max</td>
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<td>4.20</td>
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Hardness in Depth [SH C]
Spheroidal Graphite Iron Rolls

Spheroidal Graphite or Ductile Iron Rolls (SG Iron Rolls) are generally used in Roughing and Intermediate Stands of Structural and Section mills as well as Finishing Mill of wire rod & light structural mills where the toughness and wear resistance of the rolls are critical for getting a good performance during use.

Traditionally SG Iron Rolls have the following properties –

- High Strength and Toughness
- High Wear Resistance
- Higher gripping properties for better roll bite
- Resistance to firecrack propagation

The graphite in the form of nodules significantly reduces the notch effect thereby improving upon the mechanical properties – one of the reasons they are considered one of the most versatile roll materials being the strongest among cast irons and having a strength comparable to steel.

The SG Iron rolls are generally chill cast with the working surface having eutectic Cementite and free graphite in Spheroidal morphology. The addition of appropriate alloying elements in carefully adjusted combinations are practiced to get a wide range of matrix microstructure varying from fine Pearlite to Bainite or Acicular Martensite depending on the area of application of the roll. Precise inoculation & control of the rate of cooling during solidification allows the proportion of Cementite to be reduced at the same time allowing an increase in the proportion of graphite nodules.
Nominal Chemical Composition [in %- wt] & Mechanical Properties

\[1 \text{ MPa} = 1 \text{ N/mm}^2 (=0.1 \text{ kgf} / \text{ mm}^2)\]

<table>
<thead>
<tr>
<th>Element</th>
<th>%C</th>
<th>%Si</th>
<th>%Mn</th>
<th>%P</th>
<th>%S</th>
<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>Tensile Strength of Journal (MPa)</th>
<th>Bending Strength of Journal (MPa)</th>
<th>Barrel Hardness in ShC</th>
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<tr>
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<td>0.70</td>
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<td>0.04</td>
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Hardness in Depth [SH C]
Centrifugally Cast High Speed Steel Roll

Proximate Chemical Composition [in % weight] & Mechanical Properties

<table>
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<tr>
<th>Element</th>
<th>%C</th>
<th>%Si</th>
<th>%Mn</th>
<th>%P</th>
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<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>%W</th>
<th>%W</th>
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<tbody>
<tr>
<td>Min</td>
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<td>0.4</td>
<td>0.30</td>
<td>0.04</td>
<td>0.03</td>
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<td>3.00</td>
<td>2.00</td>
<td>0.02</td>
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<tr>
<td>Max</td>
<td>2.20</td>
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<td>8.0</td>
<td>1.50</td>
<td>6.00</td>
<td>6.00</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Tensile Strength of Journal (MPa) | Bending Strength of Journal (MPa) | Barrel Hardness in Sh C

- 350 | 525 | 85
- 550 | 825 | 85

Hardness in Depth [Sh C]

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Email: gontermann@vsnl.net, Website: www.gontermann-peipers.com
Centrifugally Cast Composite High Speed Steel Rolls

Spin cast High Speed Steel & Semi High Speed Steel Rolls with a SG Iron core are one of the latest generation rolls used in Roughing & Initial Finishing Stands of Hot Strip Mills, finishing stands of Narrow Strip Mills, finishing stands of Wire Rod Mills, small Angle & Channel Mills.

The materials of these rolls belong to the generic tool steel family and are generally alloyed with Cr, Mo, V & W. The presence of finely dispersed MC type primarily carbides along with $M_6C$, $M_2C$ & $M_7C_3$ type carbides in a tempered martensitic matrix provides the working layer with a highly wear resistant surface. The presence of finely distributed MC type globular carbides reduce the crack propagation to a very large degree.

These rolls are characterized by the following properties:

- Extremely wear resistant – To provide better strip shape and surface quality features as well as higher campaign life
- Better wear resistance also enables Schedule Free Rolling campaigns
- High Thermal Fatigue Resistance - For improved resistance to fire cracking
- Very high Peeling resistance – To get improved strip surface finish
- Allows higher mill productivity and higher availability of grinding facilities

Though HSS rolls are gaining popularity at leading steel plants the following mill pre-requisites are necessary for obtaining an optimum performance –

- Suitable crown in the roll to prevent buckling
- Improved roll lubrication
- Increased roll cooling efficiency
- Proper inter-stand cooling to ensure strip temperatures below 950°C
- Installation of proper crack detection equipment on grinding machines

<table>
<thead>
<tr>
<th>Heat Treatment Capability</th>
<th>Drop in Hardness</th>
<th>Radial Depth</th>
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</thead>
<tbody>
<tr>
<td>Hardening Method</td>
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<td>Tempering</td>
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Micro Structure Analysis – HSS

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<tr>
<th>Matrix</th>
<th>Carbide % (Eutectic)</th>
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<td>Tempered martensitic</td>
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<tr>
<td>Matrix with secondary carbides</td>
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</table>
Nominal Chemical Composition [in %-wt] & Mechanical Properties

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<th>%C</th>
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<th>%Mn</th>
<th>%P</th>
<th>%S</th>
<th>%Cr</th>
<th>%Ni</th>
<th>%Mo</th>
<th>Tensile Strength of Journal (MPa)</th>
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<td>1.40</td>
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<td>1600</td>
<td>2400</td>
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Hardness in Depth [SH C]

GONTERMANN-PEIPERS (INDIA) LIMITED
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Phone : 91 33 2453-2455 / 56, 2497-8684-86 / 8294,
Fax: 91-33-2497-8547 / 8686, Website : www.gontermann-peipers.com/
Medium carbon alloyed steel is statically cast & then series of special heat treatment cycles undertaken like dehydrogenation treatment, Homogenizing, Normalizing to improve the overall structural soundness, stress distribution uniformity & toughness. As the roll well conditioned with the above treatment it undergoes differential hardening process followed by mist quenching or compressed air quenching depending on the hardness requirement. The tempered roll exhibits a uniform bainitic microstructure at the shell & pearlitic structure at the core/neck.

Due to the differential hardening the barrel/working area up to a critical depth only reaches to critical temperature & hence hardened. The rest core & neck remains unaffected resulting higher impact strength as well as strength against overload during the rolling.

The above rolls are of following applications-
• Hot & cold mills Back-Up rolls
• Continuous & Semi-Continuous hot strip mills Back-Up rolls
• Roughing 4-High stands Back-Up rolls
• Cold tandem mills Back-Up rolls
• Cold temper mills Back-Up rolls
• Thick plate mill Back-Up rolls

These rolls are characterized by the following properties:

• Wear Resistant - To provide higher campaign life
• Resistance to mechanical fatigue - For improved resistance to spalling