High strength steels
for cold rolled and
cold rolled clad applications
Product Portfolio

Nickel Bars and wire
Thermo Bi-metal
Clad material
Cold rolled strip

Ni-specialities World wide
Bimetal World wide
Clad Material World wide
Quality leader TOP 5 in Europe
Organization of Wickeder-Group

Wickeder Westfalenstahl GmbH
Based in: Wickede (Ruhr)

100% 100% 100%

micrometal GmbH Müllheim Baden
Wickeder Steel Company Pleasant Prairie, WI, USA
Engineered Materials Solutions Attleboro, MA, USA, China

Strategic investment
Product Range of Cold Rolled Strip

Wickeder Westfalenstahl produces cold rolled strip as unalloyed and micro-alloyed soft forming steels, micro-alloyed solid forming steels, soft magnetic steels, unalloyed and micro-alloyed case-hardening, heat treatable and spring steels - The classical product programme of medium sized cold rolling mills

- Unalloyed and micro-alloyed soft forming steels (DIN EN 10139)
  DC01 – DC06
  Low-earing steel (DC03)
  Non-earing steel (DC01)
  ULCN 140

- Micro-alloyed solid forming steels (DIN EN 10268)
  HC 260 LA – HC 460 LA

- Soft magnetic steels (DIN EN 17405)
  RFe 40 – RFe 160

- Unalloyed case-hardening steels
  C10 – C15
  16 MnCr 5

- Unalloyed and low alloyed heat treatable steels
  C22 E – C60 E
  25 CrMo 4
  42 CrMo 4

- Unalloyed and low alloyed spring steels
  C55 S – C100 S
  51 CrV 4

... and further specialized steel grades
Product Range of Clad Materials

Wickeder Westfalenstahl offers a wide spectrum of standard clad combinations as well as customized clad combinations

- **Carbon steel as core strip** (e.g. DD11, DD14)

  - Aluminium-cladding
  - Copper- and Nickel-cladding
  - Other copper alloys/non-ferrous metal cladding
  - Stainless steel-cladding

- **Stainless steel as core strip** (e.g. 1.4512, 1.4016, 1.4301/7, 1.4404)

  - Cladding on stainless steel

- **Non-ferrous-metal as core strip** (e.g. Cu-DHP)

  - Special claddings
Advanced High Strength Steel Concept

WiWe’s advanced high strength steel development is based on the well-known Multi Phase Steel concepts mainly developed during the last 15 years. The original main application focus has always been on weight reduction and improvement of crash behaviour of cars.

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**Multi phase steel product family:**

- **Dual Phase Steel** (DP)
- **Residual Austenite Steel** (TRIP)
- **Complex Phase Steel** (CP)
- **Partial Martensite Steel** (PM)
- **Martensite Steel** (MS)

**Wide range of tensile strength:**

- 500 – 1.300 MPa

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Source: ThyssenKrupp Steel

European standard for cold rolled steel: DIN EN 10346

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Steigende Festigkeit

<table>
<thead>
<tr>
<th>Material</th>
<th>Rm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Phase Steel</td>
<td>500-600</td>
</tr>
<tr>
<td>Residual Austenite Steel</td>
<td>600-800</td>
</tr>
<tr>
<td>Complex Phase Steel</td>
<td>&gt; 800</td>
</tr>
<tr>
<td>Partial Martensite Steel</td>
<td>&gt; 1,000 MPa</td>
</tr>
</tbody>
</table>

Source: ThyssenKrupp Steel
Material properties of classical Cold Rolled Steel (CRS)

There is a quite a wide range of material concepts available, produced from medium sized cold rolling mills up to very high strength levels of about 2,600 Mpa. But formability deteriorates considerably above a tensile strength of 600 MPa.
WiWe‘s High Strength Steel Concept targets

The main target of WiWe´s development activities has been to reach maximum elongation and formability at a tensile strength range of 600 – 1.100 MPa.
Heat Treatment

Besides special chemical analysis a continuous annealing process with defined temperatures, material speed and cooling conditions is implicitly necessary to reach the desired properties of the described High Strength Steels.

Forming of a mixture of a austenitic and ferritic crystal structure during heating phase and a defined temperature-time curve during rapid cooling are the relevant parameters to achieve the material properties.
Tested Property range of WW-HS

The expected material properties for 3 Multi Phase Steel types have been achieved during several trial series down to very thin thicknesses.

![Graph showing the properties of WW-HS600 (DP), WW-HS800 (CP), and WW-HS1000 (CP) with Bruchdehnung (A80) and Zugfestigkeit (Rm) values. Thickness range: 0.10-1.50mm.]
Comparison WW-HS with HSS steels according to DIN EN 10346

Because of certain differences in continuous annealing technology the material properties of DIN EN 10346 grades and WW-HS are not directly comparable. But WW-HS properties are in the range of HCT types. Especially the formability exceed the value of the DIN EN 10346 and is thus more than competitive.

<table>
<thead>
<tr>
<th>WW-HS</th>
<th>EN 10346</th>
<th>Rp0,2 (MPa)</th>
<th>Rm (MPa)</th>
<th>A80 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW-HS 600 (DP)</td>
<td>HCT 600X</td>
<td>250-450</td>
<td>340-420</td>
<td>&gt;=600</td>
</tr>
<tr>
<td>WW-HS 800 (CP)</td>
<td>HCT 780C</td>
<td>350-500</td>
<td>500-700</td>
<td>&gt;=780</td>
</tr>
<tr>
<td>WW-HS 1000 (CP)</td>
<td>HCT 980C</td>
<td>500-700</td>
<td>700-900</td>
<td>&gt;=980</td>
</tr>
</tbody>
</table>
WS-HS within the property spectrum of CRS

WW-HS 600/800/1000 covers a relevant part of the targeted property window.
Application Concepts

Wickeder Westfalenstahl offers its High strength steel concept WW-HS customized for specialized applications and niche markets:

**Cold Rolled Strip**
Substitution of piece hardend and tempered stampings, with focus on thinner gauges

**Clad Materials**
Combination of the strength and formability potential of High Strength Steel and the electrical conductivity of Copper for plug-in connectors with spring properties and similar electrical properties
Tested application examples (1)

WW-HS 1000 substitutes C60S or C75S, soft annealed, stamped and piece hardened parts for Length connector of window inner frames

Requirement:
The original bending radius had to be enlarged from 0,2mm to 0,5mm

Thickness: 0,50mm
Tested application samples (2)

WW-HS 800 for Turning lever of an overhead panel mechanism in kitchen cabinets. Even critical areas for forming and embossing worked satisfactorily with small adaptations.
Tested application sample (3)

The „Bandarm“ demonstrates a further sucessfully approved application for furniture hinges. Because of the substantially higher forming requirements **WW-HS 600** was selected for testing.

The general forming operation worked very well, but the rim hole for the later screw thread needs adaptation.
Economic reflection

A comparison of the economical, technical and logistical advantages in the use of WW-HS shows that initially higher material and possibly tooling cost are overcompensated by savings through the avoidance of the heat treatment process.

+ Avoidance of component heat treatment
+ Less quality problems because of avoidance of quench distortion
+ Lower processing stock, i.e. smaller capital commitment
+ Relevant shortened through-put time
+ When indicated, surface coating on strip possible

- Higher specific material price
- Design changes may be required (tooling cost)
- Possibly sourcing of new stamping tools based on higher value materials
- Possibly higher value tool coating
- Possibly decreased stamping through-put and tool durability

Improved total energy balance based on lower heat treatment expense
Application concepts

Medium sized cold rolling mills as Wickeder Westfalenstahl have to look for specialized applications and niche markets for the usage of the High Strength Steels

Cold Rolled Strip
Substitution of component hardenend and tempered stamping and bending pieces, especially in the thinner gauge ranges

Clad Materials
Combination of the strength, formability and light weight potential of High Strength Steel and the electrical conductivity of Copper for plug-in connectors with spring properties and similar electrical properties
General understanding of cold rolled cladding

Through a cold roll cladding process a metallic core strip is clad in a continuous process with a different metallic strip to form a composite metal. A new material is created combining the properties of the cladded metallic partners.
Application-specific target characteristics of a material can be reached by intelligent combination of the required positive properties of the individual materials.

Example of cladding Cu on Steel - WiWe-product: **CUFER**

- **Copper**
  - very high electrical conductivity
  - very good formability

- **Steel**
  - low strength of basic metal
  - higher specific weight
  - high metal price

  - high basic strength
  - good formability
  - lower specific weight
  - comparable low price level

- **Copper + Steel**
  - medium electrical conductivity

- **Result**
  - good electrical conductivity
  - high (adjustable) strength
  - reduced specific weight
  - reasonable price level
Material Price development

Copper prices increase much faster than steel. Substitution is required and make it more and more interesting to find a Cu-Steel-compound material to save costs.
Realized LC Steel based CU clad products

Solid Copper applications can be substituted by CUFER with a Cu layer ratio from 6-60% leading to sufficient electrical conductivity, higher strength and lower material price.

Electrical contact parts in Mini Circuit Breakers (MCB)

CUFER Connector in Motor Contactors

BRAFER carbon brush holder

Wrapped lugs in current counters or motor contactors
The cladding idea

Combination of High Strength Steel and Copper
spring properties versus electrical conductivity

- Wide range of Strength and Conductivity
- Property control by annealing and temper rolling conditions
- Cost saving by steel usage
- Improved formability based on higher elongation level
- Higher heat resistance due to steel usage expected
## Future product family of CU clad on steel

<table>
<thead>
<tr>
<th>Cladding Type</th>
<th>Rm (MPa)</th>
<th>A80 (%)</th>
<th>μ (MS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CUFER</strong> (10% - 30% Cu)</td>
<td>300 – 400</td>
<td>10 – 40</td>
<td>16 – 40</td>
</tr>
<tr>
<td><strong>Cu–Carbon Steel–Cu</strong> (10% Cu)</td>
<td>530 – 650</td>
<td>8 – 25</td>
<td>10 – 15</td>
</tr>
<tr>
<td><strong>Cu–WW-HSxxx–Cu</strong> (10% , 20% Cu)</td>
<td>500 – 1000</td>
<td>8 – 25</td>
<td>10 – 16</td>
</tr>
<tr>
<td>five-layer-clad:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cu–WW-HSxxx–Cu–WW-HSxxx–Cu</strong></td>
<td>450 – 770</td>
<td>10 – 30</td>
<td>40</td>
</tr>
<tr>
<td><strong>(Cu)–1.4310–Cu–1.4310–(Cu)</strong></td>
<td>950 – 1100</td>
<td>2 – 8</td>
<td>27</td>
</tr>
</tbody>
</table>

**WW-HS 600:** Rm = 580 – 700 MPa  
**WW-HS 700:** Rm = 750 – 950 MPa  
**WW-HS 800:** Rm = 800 – 900 MPa  
**WW-HS 1000:** Rm = 950 – 1050 MPa
HS-CUFER within property spectrum of HS-CU alloys (1)
HS-CUFER within property spectrum of HS-CU alloys (2)
Bending behaviour of HS-Cufer

Cu-WW-HS700-Cu-WW-HS700-Cu with slight temper-rolling reduction and CuSn6 with high reduction degree show similar strength and bending properties, but different bending behaviour caused by homogenous versus compound material system and different E-modulus.
Summary

Based on long-term experience and a wide range of technological capabilities Wickeder Westfalenstahl is focused on a permanent innovation process and working on several and different product developments combining both cold rolled strip and cladding expertise:

www.wickeder.de
Thanks for your attention.