Areas of application

Complex-phase steels CP-W® and CP-K® by thyssenkrupp offer very high strengths and yield points. They are particularly suitable for weight-saving production of cold-formed, crash-relevant automotive components such as side impact intrusion beams, B-pillar reinforcements, profiles, cross members, body reinforcements, bumper bars and chassis parts. The use of complex-phase steels in B-pillar reinforcements can double the strength, for example, compared to with conventional micro-alloyed steels. The hot-rolled and cold-rolled grades which are currently available are characterized by strong strain hardening even with only minor deformation forces.
Available steel grades

thyssenkrupp supplies the following steel grades as per the product information or the reference steel grades in accordance with the respective standards.

<table>
<thead>
<tr>
<th>Steel grade designation and surface refinements</th>
<th>Surface refinements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel grade</td>
<td>UC</td>
</tr>
<tr>
<td>CP-W® 660Y760T</td>
<td>●</td>
</tr>
<tr>
<td>CP-W® 800</td>
<td>●</td>
</tr>
<tr>
<td>CP-W® 1000</td>
<td>●</td>
</tr>
<tr>
<td>CP-K® 570Y780T</td>
<td>●</td>
</tr>
<tr>
<td>CP-K® 900Y1180T</td>
<td>●</td>
</tr>
</tbody>
</table>

- UC  Uncoated
- EG  Electro-galvanized zinc coating
- GI  Hot-dip zinc coating
- GA  Galvannealed
- ZM  ZM Ecoprotect®
- AS  Aluminum-silicon coating

Material characteristics

Due to its selected chemical composition and special hot-rolling process, complex-phase steel has an extremely fine microstructure. In the complex interaction of matching microstructure components and precipitation hardening, this results in a particularly attractive combination of properties: high strength and wear resistance with good cold formability and weldability.

Micrograph of CP-W® 660Y760T and CP-K® 570Y780T

Microstructure of complex-phase steel CP-W® 660Y760T.
Microstructural contrasting with color etching according to Klemm.

Microstructure of complex-phase steel CP-K® 570Y780T.
Microstructural contrasting with color etching according to Klemm.
## Technical features

### Chemical composition

|---------------------------------|------------|------------|------------|-----------|-----------|-------------|-----------------|-----------------|-----------|-----------|

**Steel grade**

- **CP-W® 660Y760T**
  - C: 0.14
  - Si: 1.00
  - Mn: 2.20
  - P: 0.080
  - S: 0.015
  - Ti + Nb: 0.015–2.0
  - Cr + Mo: 0.015–2.0
  - V: 0.015
  - B: 0.005

- **CP-W® 800**
  - C: 0.14
  - Si: 1.00
  - Mn: 2.20
  - P: 0.080
  - S: 0.015
  - Ti + Nb: 0.015–2.0
  - Cr + Mo: 0.015–2.0
  - V: 0.015
  - B: 0.005

- **CP-W® 1000**
  - C: 0.19
  - Si: 1.00
  - Mn: 2.20
  - P: 0.080
  - S: 0.015
  - Ti + Nb: 0.015–2.0
  - Cr + Mo: 0.015–2.0
  - V: 0.015
  - B: 0.005

- **CP-K® 570Y780T**
  - C: 0.14
  - Si: 1.00
  - Mn: 2.20
  - P: 0.080
  - S: 0.015
  - Ti + Nb: 0.015–2.0
  - Cr + Mo: 0.015–2.0
  - V: 0.015
  - B: 0.005

- **CP-K® 900X1180T**
  - C: 0.20
  - Si: 0.80
  - Mn: 2.60
  - P: 0.080
  - S: 0.015
  - Ti + Nb: 0.015–2.0
  - Cr + Mo: 0.015–2.0
  - V: 0.015
  - B: 0.005

### Mechanical properties

#### Test direction in rolling direction

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Yield strength</th>
<th>Tensile strength</th>
<th>Elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_{e5},[\text{MPa}]$</td>
<td>$R_{m},[\text{MPa}]$</td>
<td>$A,[%]$</td>
</tr>
</tbody>
</table>

- **CP-W® 660Y760T**
  - $R_{e5}$: 660–830
  - $R_{m}$: 760
  - $A$: 12
  - $A_{80}$: 10

- **CP-K® 570Y780T**
  - $R_{e5}$: 570–720
  - $R_{m}$: 780
  - $A$: –
  - $A_{80}$: 10

- **CP-K® 900Y1180T**
  - $R_{e5}$: 900–1,070
  - $R_{m}$: 1,180
  - $A$: –
  - $A_{80}$: 6

#### Test direction transverse to rolling direction

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Yield strength</th>
<th>Tensile strength</th>
<th>Elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_{e5},[\text{MPa}]$</td>
<td>$R_{m},[\text{MPa}]$</td>
<td>$A,[%]$</td>
</tr>
</tbody>
</table>

- **CP-W® 800**
  - $R_{e5}$: 680–830
  - $R_{m}$: 780
  - $A$: 12
  - $A_{80}$: 10

- **CP-W® 1000**
  - $R_{e5}$: 720–920
  - $R_{m}$: 950
  - $A$: 12
  - $A_{80}$: 9

- **Hot-rolled flat products**
- **Cold-rolled/hot-dip coated flat products**

$R_{e5}$: Proof strength at 0.2% plastic elongation

$R_{m}$: Tensile strength

$A$: Percentage elongation after fracture using a proportional specimen with $L_0 = 5.65 \sqrt{S}$, for sheet thicknesses $\geq 3.0\,\text{mm}$

$A_{80}$: Percentage elongation after fracture using a specimen with gauge length $L_0 = 80\,\text{mm}$, for sheet thicknesses $< 3.0\,\text{mm}$
Heat treatment of hot-rolled complex-phase steels at temperatures from 500 to 700°C can be used to increase the yield strength by up to 100 MPa (e.g., 680°C, dwell time 0.7 min/mm sheet thickness in saline bath). In addition, forming in the temperature range from 550°C to 650°C enables complex parts to be produced without compromising the component properties.

Surfaces

Surface refinements, electrogalvanized zinc coating

<table>
<thead>
<tr>
<th>Specification</th>
<th>Nominal coating on each side of single spot sample</th>
<th>Coating on each side of single spot sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mass [g/m²]</td>
<td>Thickness [μm]</td>
</tr>
<tr>
<td>EG25/25</td>
<td>DIN EN</td>
<td>18</td>
</tr>
<tr>
<td>EG18</td>
<td>VDA 239 - 100</td>
<td>–</td>
</tr>
<tr>
<td>EG50/50</td>
<td>DIN EN</td>
<td>36</td>
</tr>
<tr>
<td>EG29</td>
<td>VDA 239 - 100</td>
<td>–</td>
</tr>
<tr>
<td>EG75/75</td>
<td>DIN EN</td>
<td>54</td>
</tr>
<tr>
<td>EG53</td>
<td>VDA 239 - 100</td>
<td>–</td>
</tr>
<tr>
<td>EG100/100</td>
<td>DIN EN</td>
<td>72</td>
</tr>
<tr>
<td>EG70</td>
<td>VDA 239 - 100</td>
<td>–</td>
</tr>
</tbody>
</table>

Surface refinements, hot-dip galvanized

<table>
<thead>
<tr>
<th>Specification</th>
<th>Minimum coating mass on both sides [g/m²]</th>
<th>Coating on each side of single spot sample</th>
<th>Informative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Triple spot sample</td>
<td>Single spot sample</td>
<td>Mass [g/m²]</td>
</tr>
<tr>
<td>GI100</td>
<td>DIN EN</td>
<td>100</td>
<td>85</td>
</tr>
<tr>
<td>GI40</td>
<td>VDA 239 - 100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>GI140</td>
<td>DIN EN</td>
<td>140</td>
<td>120</td>
</tr>
<tr>
<td>GI60</td>
<td>VDA 239 - 100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>GI200</td>
<td>DIN EN</td>
<td>200</td>
<td>170</td>
</tr>
<tr>
<td>GI85</td>
<td>VDA 239 - 100</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Further coatings on request.
### Surface finishes and surface qualities

<table>
<thead>
<tr>
<th>Products</th>
<th>Finish type</th>
<th>Surface quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold-rolled flat products</td>
<td>Uncoated</td>
<td>A  Normal surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U  Unexposed (interior parts)</td>
</tr>
<tr>
<td>Electrolytically zinc coated flat products</td>
<td>Electrogalvanized zinc coating</td>
<td>A  Normal surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U  Unexposed (interior parts)</td>
</tr>
<tr>
<td>Hot-dip coated flat products</td>
<td>Hot-dip zinc coating</td>
<td>B  Improved surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U  Unexposed (interior parts)</td>
</tr>
</tbody>
</table>

A/B as per DIN EN  
U as per VDA 239-100

### Surface treatments

<table>
<thead>
<tr>
<th>Type of surface treatment</th>
<th>UC</th>
<th>EG</th>
<th>GI</th>
<th>GA</th>
<th>ZM</th>
<th>AS</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

● Serial production  
UC Uncoated  
EG Electrogalvanized zinc coating  
GA Galvannealed  
GI Hot-dip zinc coating  
ZM ZM Ecoprotect®  
AS Aluminum-silicon coating
Notes on applications and processing

Forming
Complex-phase steels are particularly suitable for crash-relevant parts such as pillars, side impact intrusion beams and bumper bars. Hot-rolled complex-phase steels are also used in the vehicle chassis area. Cold-rolled complex-phase steels have a higher minimum yield strength in comparison with dual-phase steels of identical tensile strength. Complex-phase steels can be worked in crash forming operations, that is, without a blank holder in a single forming step. Calibration should be integrated to enable specific, localized plasticization, in order to improve the dimensional accuracy of the worked components. Folding or bending operations are also customary, as are deep-drawing and stretch-forming operations up to the B-pillar geometry. Suitability for roll forming is guaranteed. This is where cold-rolled complex-phase steels offer an interesting alternative to equal-strength dual-phase steels on account of their strain-hardening characteristics and bending ability. Due to their extremely fine microstructure, complex-phase steels also exhibit good hole expansion properties.

Particular attention must be paid to the design of the cutting and forming tools. Tool requirements are exacting, especially in cutting. In addition to a sufficient hardness of $> 60$ HRC, it is important to select suitable tool materials to simultaneously ensure high ductility, thus preventing premature breaking of the cutting edges. Specific rounding of the cutting edge in the dimension of about 50 microns helps to optimize the edge stability of the tools. The cutting gap must be designed to taking the material thickness into account and should be taking $\geq 10\%$ of the sheet thickness.

A sufficient supporting hardness must be achieved for the forming tools. A segmented structure of the forming tools is common today. In highly stressed areas, the use of high speed steels may be necessary. These include 1,3343 or corresponding sintered tool materials. In addition, tool coatings such as CVD (TiC-TiN coating) can minimize tool wear.

The presses should have high pressing and hold-down force potentials. As a guideline, the tensile strength level should be considered here, compared with known materials.

Processing instructions for joining
Complex-phase steels are suitable for welding both same-grade joints and hybrid joints with other common steel grades. The precondition is welding parameters matched to the material.

Resistance spot welding
For spot welding complex-phase steels, the same equipment can basically be used as for welding unalloyed deep-drawing steels. However, the electrode forces should be increased compared to these steel grades in order to achieve a large welding zone. Stable and rigid welding rods with large power reserves are therefore recommended for spot welding of complex-phase steels; this may also offer advantages in case of engineering fit issues. Extending the welding time has a positive effect on the welding zone; for this reason, medium to long welding times are recommended for spot welding.
Typical properties of a resistance spot weld

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Sheet thickness [mm]</th>
<th>Welding zone ΔI [kA]</th>
<th>Cross tensile strength $d_{\text{w,10}}$ [kN]</th>
<th>Shear tensile strength $d_{\text{w,20}}$ [kN]</th>
<th>Mean hardness HV 0.1</th>
<th>Base material</th>
<th>Weld nugget</th>
</tr>
</thead>
<tbody>
<tr>
<td>HX340LAD+Z</td>
<td>1.5</td>
<td>2.0</td>
<td>9.9</td>
<td>13.7</td>
<td>165</td>
<td>330</td>
<td></td>
</tr>
<tr>
<td>CP-W® 660Y760T</td>
<td>1.5</td>
<td>1.4</td>
<td>6.7</td>
<td>17.3</td>
<td>280</td>
<td>390</td>
<td></td>
</tr>
<tr>
<td>CP-W® 1000</td>
<td>1.5</td>
<td>1.5</td>
<td>6.2</td>
<td>18.9</td>
<td>330</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td>CP-K® 570Y780T</td>
<td>1.5</td>
<td>1.6</td>
<td>8.1</td>
<td>17.2</td>
<td>290</td>
<td>395</td>
<td></td>
</tr>
</tbody>
</table>

1) Test results as per SEP 1220-2.

- Hot-rolled flat products
- Cold-rolled/hot-dip coated flat products
- Sheet thickness of test specimens $d_{\text{w,20}}$, Welding spot diameter of 4 $\sqrt{t}$

Compared to lower-strength steels, complex-phase steels have a lower electrical conductivity; lower welding currents are thus required for in spot welding electrodes with the same force. In resistance spot welding of galvanized sheets, the welding currents must be increased due to the higher conductivity of the coating compared with the base material (substrate). In addition to the sheet type, surface and thickness combination, other factors e.g., the type of electrode used, play an important role in determining optimum joining parameters.

Good weld nugget formation.

Relatively low hardening compared to the base material.
MIG arc brazing
Information sheet DVS 0938-2 “Arc brazing” describes brazing of steels up to a tensile strength of approximately 500 MPa. As the material described here is above this tensile strength, it is advisable to check the component-specific suitability for brazing.

Fatigue strength and crash performance
Complex-phase steels exhibit high structural durability. In terms of stress-strain curve characteristics the steels are superior to dual-phase and retained-austenite steels. However, in case of excessive elongation, that is, in case of misuse load, their behavior is more sensitive.

High resistance to crash deformation is assured due to the high yield point, without compromising elongation at break values. This group of materials is thus suitable, for example, for A-pillar and B-pillar reinforcement parts, which are designed in particular to prevent a component group buckling under crash load.
Available dimensions

CP-W® 660Y760T, CP-W® 800

EG  Electrogalvanized zinc coating
GI  Hot-dip zinc coating
GI trimmed
EG trimmed
Uncoated with mill edge

For interior parts
Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100.

Further dimensions on request.
CP-W® 1000

For interior parts
Typical dimensions for automotive customers.
Further dimensions on request.
EG   Electrogalvanized zinc coating
EG trimmed
Uncoated with mill edge
For interior parts
Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100.
Further dimensions on request.
For interior parts. Typical dimensions for automotive customers. Restrictions may apply to steel grades as per VDA 239-100.

Further dimensions on request.
Sample applications

B-pillar made of CP-W® 660Y760T. Rear axle torsion tube made of CP-W® 660Y760T.