Installation of Contact Wire (CW) for High Speed Lines - Recommendations

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Product Development Metal and Railways

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Content

1. Material properties
2. Tension
3. Levelling Device
4. Examples for installation with levelling device
5. Quality check
6. Different Contact Wires in Europe
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Examples – High speed

Cologne- Frankfurt

Spain
The high-speed train TGV V150 reached with a speed of 574.8 km/h the world land speed record for conventional railed trains on 3 April 2007.

The train was built in France and tested between Strasbourg and Paris.

The trials were conducted jointly by SNCF, Alstom and Réseau Ferré de France.

The catenary wire was made of bronze, with a circular cross-section of 116 mm$^2$ and delivered by nkt cables.

Catenary voltage was increased from 25 kV to 31 kV for the record attempt. The mechanical tension in the wire was increased to 40 kN from the standard 25 kN. The contact wire was made of copper tin by nkt cables and has a cross-section of 150 mm$^2$.

The track super elevation was increased to support higher speeds. The speed of the transverse wave induced in the overhead wire by the train's pantograph was thus increased to 610 km/h, providing a margin of safety beyond the train's maximum speed.
1. Material Properties - 1

Contact wire drawing:
1. Material Properties - 2

Tensile test:

Grooved Contact Wire RIM 120

Parameter table:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Wire type</td>
<td>CuAl</td>
</tr>
<tr>
<td>Drum No.</td>
<td>EN 10223-3 (ISO 624)</td>
</tr>
<tr>
<td>Test standard</td>
<td>EN 10223-3 (ISO 624)</td>
</tr>
<tr>
<td>Test speed</td>
<td>0.0015 m/s</td>
</tr>
<tr>
<td>Test speed range</td>
<td>0.0015 m/s</td>
</tr>
<tr>
<td>Speed in the yield range</td>
<td>0.0015 m/s</td>
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</tbody>
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Results:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cross-section area</th>
<th>Area</th>
<th>Tensile area</th>
<th>Stress</th>
<th>Yield strength</th>
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<tbody>
<tr>
<td>1</td>
<td>119.2</td>
<td>67</td>
<td>460</td>
<td>97</td>
<td>593</td>
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<td>2</td>
<td>119.3</td>
<td>67</td>
<td>460</td>
<td>97</td>
<td>593</td>
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<td>3</td>
<td>119.3</td>
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<td>460</td>
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<td>593</td>
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<tr>
<td>5</td>
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<td>97</td>
<td>593</td>
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<tr>
<td>6</td>
<td>119.3</td>
<td>67</td>
<td>460</td>
<td>97</td>
<td>593</td>
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<tr>
<td>7</td>
<td>119.3</td>
<td>67</td>
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<td>97</td>
<td>593</td>
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<td>8</td>
<td>119.3</td>
<td>67</td>
<td>460</td>
<td>97</td>
<td>593</td>
</tr>
<tr>
<td>9</td>
<td>119.3</td>
<td>67</td>
<td>460</td>
<td>97</td>
<td>593</td>
</tr>
<tr>
<td>10</td>
<td>119.3</td>
<td>67</td>
<td>460</td>
<td>97</td>
<td>593</td>
</tr>
</tbody>
</table>

Series graphics:
1. Material Properties – 3.1

Bending and plastic deformation:

\[ D_{\text{min}} = d \times \frac{E}{R_p} \]

- \( D_{\text{min}} \): Elastic bending diameter
- \( d \): Contact wire diameter
- \( E \): Elastic (Young’s) modulus
- \( R_p \): Yield point (elastic limit)

Examples with calculation basis \( R_{p0.2} \):

- RiM 120 (CuMg0,5): \( D_{\text{min}} = 3.0 \) m
- RiM 150 (CuMg0,5): \( D_{\text{min}} = 3.4 \) m
- RiZ 120 (CuSn0,4): \( D_{\text{min}} = 3.2 \) m
- RiZ 150 (CuSn0,4): \( D_{\text{min}} = 3.6 \) m
1. Material Properties – 3.2

Torsion and plastic deformation:

\[ M_t = 0.58 \pi \times d^3 \times \frac{R_p}{16} \] (round wire)

- \( M_t \): Elastic torque
- \( d \): Contact wire diameter
- \( R_p \): Yield point (elastic limit)

Examples with calculation basis \( R_{p0,2} \):

- RiM 120 (CuMg0.5): \( M_t = 100 \text{ Nm} \)
- RiM 150 (CuMg0.5): \( M_t = 136 \text{ Nm} \)
- RiZ 120 (CuSn0.4): \( M_t = 85 \text{ Nm} \)
- RiZ 150 (CuSn0.4): \( M_t = 119 \text{ Nm} \)
Contact Wire is sensitive for plastic deformation by bending and torsion!

- Bending can result in torque and plastic torsion (profile geometry)

- Even low torque by twisting the CW (>50 Nm depending on material and cross section) results in plastic torsion!

- Winding and unwinding of contact wire is a plastic deformation, therefore it has to be done under constant and controlled conditions – laser control during production (ensure, wave amplitude has to be below 0,1 mm)

- Waves and kinks can result from uncontrolled and inhomogenous guidance of the CW during installation
1. Material Properties - 5

Influence of Mg-content on material and installation properties:

- Mg – atoms are solved within the copper matrix and increase the strain hardening properties of the material.

- Increasing Mg-content decreases the electrical conductivity.

- Homogenous distribution of Mg and constant content throughout the CW-length are a pre-condition for homogenous bending properties during installation. Tight control of casting: tolerance of Mg-content <0.05 % Mg.

- The actual level of Mg-content between 0.2...0.7 % has no significant influence on the wave amplitude of the installed CW.

- Tight control of all involved processes like casting, drawing, winding, unwinding and installation can be regarded as fundamentals for homogenous mechanical behaviour and a low level of wave amplitude of the CW.
2. Tension

Calculation of max. tension according to EN 50119 (example):

\[ \sigma_{zul} = \sigma_{\text{min}} \times 0.65 \times k_{\text{temp}} \times k_{\text{wear}} \times k_{\text{load}} \times k_{\text{eff}} \times k_{\text{clamp}} \times k_{\text{joint}} \]
\[ = \sigma_{\text{min}} \times 0.65 \times 1 \times 0.8 \times 0.95 \times 0.95 \times 1 \times 1 \]
\[ = \sigma_{\text{min}} \times 0.4693 \]

Tension during installation:

Table 1: Tension Forces
3. Levelling Device - 1

Leveling Device for installation of High Speed Contact Wires

Comleting the picture
When installing cable systems, the installation and installation method is of utmost importance. To avoid setting due to loss of contact in the couplings, the cable surface in the horizontal have to be kept extremely even. This is extremely important for high-speed trains and speeds above 200 km/h. In these applications, the required adherence for deviations from the horizontal are normally ±0.3 mm. One of the methods to meet these requirements is the use of exactly positioned rollers for the drums to ensure the installation tension is regulated and thus ensuring the correct wire leads to a higher service life.

When using contact wires with very high tensile strength, such as copper-nickel or copper wires, the exact matching of the bending tension of the drums becomes even more important for the quality of the safety systems. For these contact wires, the mean to move the tension is to use the contact wire drum and the tension drum that leads to the elongation of the contact wire or the bending drawing of the contact wire into the lower layer of the drums is very small.
4. Examples for installation with levelling device -1

4. Examples for installation with levelling device -2

4. Examples for installation with levelling device -2.1

- On construction site consultancy
- Leveling device for contact wire with onside training
4. Examples for installation with levelling device -3

China- projects:

- Beijing – Tianjin
- Hefei – Nanjing
- Wuhan – Hefei
- Wuhan - Guangzhou
4. Examples for installation with levelling device -4
5. Quality Check

Cable rewinding unit:
Measurement of microwaves
Effect of levelling device

Test field
Re 330 – CuMg0,5 - 120 mm²
6. Different Contact Wires in Europe

- EN 50149
- Changes to EN 50149
- Examples
- Comparison ASTM B9
Train speed face to face with material

Maximum train speed for different materials of contact wire

Wave propagation speed:

\[ c = 3.6 \times \sqrt{\frac{\sigma}{\rho}} \]

\( \sigma \) – tension in N/m²

\( \rho \) - density in 1000 kg/m³

\( c \) – wave propagation speed in Km/h

\[ v_{\text{max}} \leq 0.7 \times c \]

The maximum train speed should be lower / equal to 70 % of the wave propagation speed.

<table>
<thead>
<tr>
<th>Material</th>
<th>Contact Wire</th>
<th>Tension (kN)</th>
<th>Wave Propagation Speed (km/h)</th>
<th>Maximum Train Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re 200</td>
<td>Cu</td>
<td>100</td>
<td>c = 376</td>
<td>( v_{\text{max}} = 263 )</td>
</tr>
<tr>
<td>Re 250</td>
<td>CuAg</td>
<td>120</td>
<td>c = 427</td>
<td>( v_{\text{max}} = 299 )</td>
</tr>
<tr>
<td>Re 330</td>
<td>CuMg</td>
<td>120</td>
<td>c = 572</td>
<td>( v_{\text{max}} = 400 )</td>
</tr>
<tr>
<td>EAC-350</td>
<td>CuMg</td>
<td>150</td>
<td>c = 553</td>
<td>( v_{\text{max}} = 387 )</td>
</tr>
<tr>
<td>SNCF</td>
<td>CuSn</td>
<td>150</td>
<td>c = 517</td>
<td>( v_{\text{max}} = 362 )</td>
</tr>
</tbody>
</table>
6. Different Contact Wires in Europe
Contact Wires for all Speeds and Applications

All values for cross section 120 mm² acc. to EN 50149:2001 and CuMg0.5 Valcond® with increased electrical conductivity.
nkt cables manufactures all cross section according to customers needs.
# 6. Different Contact Wires in Europe

## Properties of different Contact Wire Materials

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Maximum speed</th>
<th>Minimum conductivity</th>
<th>Minimum conductivity</th>
<th>Minimum tensile strength</th>
<th>half hard point</th>
<th>density</th>
<th>coefficient of thermal expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kmph</td>
<td>m/(Ω*mm²)</td>
<td>% IACS</td>
<td>N/mm²</td>
<td>°C</td>
<td>10³ kg / m³</td>
<td></td>
</tr>
<tr>
<td>E-Cu (bare copper)</td>
<td>160</td>
<td>56,27</td>
<td>97,00</td>
<td>375,00</td>
<td>360</td>
<td>180</td>
<td>8,89 1,7 x 10⁻⁵</td>
</tr>
<tr>
<td>CuAg0,1</td>
<td>250</td>
<td>56,27</td>
<td>97,00</td>
<td>375,00</td>
<td>360</td>
<td>320</td>
<td>8,89 1,7 x 10⁻⁵</td>
</tr>
<tr>
<td>CuSn0,2</td>
<td>360</td>
<td>41,75</td>
<td>72,00</td>
<td>450,00</td>
<td>420</td>
<td>344</td>
<td>8,92 1,7 x 10⁻⁵</td>
</tr>
<tr>
<td>CuSn 0,4</td>
<td>360</td>
<td>46,40</td>
<td>80,00</td>
<td>450,00</td>
<td>430</td>
<td>344</td>
<td>8,92 1,7 x 10⁻⁵</td>
</tr>
<tr>
<td>Cu Mg0,2</td>
<td>360</td>
<td>44,60</td>
<td>77,00</td>
<td>450,00</td>
<td>430</td>
<td>370</td>
<td>8,89 1,7 x 10⁻⁵</td>
</tr>
<tr>
<td>CuMg0,5</td>
<td>400+</td>
<td>36,00</td>
<td>62,00</td>
<td>510,00</td>
<td>490</td>
<td>375</td>
<td>8,89 1,7 x 10⁻⁵</td>
</tr>
<tr>
<td>CuMg0,2Valcond®</td>
<td>360</td>
<td>46,40</td>
<td>80,00</td>
<td>450,00</td>
<td>430</td>
<td>370</td>
<td>8,89 1,7 x 10⁻⁵</td>
</tr>
<tr>
<td>CuMg0,5 Valcond®</td>
<td>400+</td>
<td>40,60</td>
<td>70,00</td>
<td>510,00</td>
<td>490</td>
<td>375</td>
<td>8,89 1,7 x 10⁻⁵</td>
</tr>
</tbody>
</table>

(according to EN 50149:2001)

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Frank Pupke 2010-01-25
6. Different Contact Wires in Europe

Change of EN 50149:
Definition of mechanical 'microwaves'

\[ W \text{ Wire} \]
\[ R \text{ remaining bending Radius under lower tension (up to 10 kN)} \]
\[ h_{\text{max}} \text{ maximum variation of longitudinal axis in mm} \]
6. Different Contact Wires in Europe

Change of EN 50149:

Other new copper alloys will be allowed

4.3 Identification

All alloys shall be clearly identified. For normal and high strength copper and copper-silver, copper-cadmium, copper-magnesium and copper-tin alloys the method of identification shall be as shown below. For other alloys the identification method (whether grooves or other method) shall be agreed between purchaser and manufacturer. 

NOTE it is recommended that this method of identification be by hardmarking on the top of the contact wire the material designation, configuration and cross section at a maximum spacing of 1 m between marks.
6. Different Contact Wires in Europe

Change of EN 50149:

Other new copper alloys will be allowed

Figure 1 – Two identification grooves
Figure 2 – One identification groove
Figure 3 – Three identification grooves
Figure 4 – One offset identification groove
Example: Overhead Catenary Systems of Deutsche Bahn

<table>
<thead>
<tr>
<th>construction</th>
<th>Re 100</th>
<th>Re 200</th>
<th>Re 200 mod</th>
<th>Re 250</th>
<th>Re 330</th>
</tr>
</thead>
<tbody>
<tr>
<td>load (kN) - Charge</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>contact wire - Fil de Contac</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>messenger wire - Porteur</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
</tr>
<tr>
<td>mm²</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>contact wire - Fil de Contac</td>
<td>Cu</td>
<td>Cu</td>
<td>CuAg0,1</td>
<td>CuAg0,1</td>
<td>CuMg 0,5</td>
</tr>
<tr>
<td>(mm²)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>dropper wire - Pendule</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
</tr>
<tr>
<td>(mm²)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>stitch wire</td>
<td>no</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
<td>Bz II</td>
</tr>
<tr>
<td>(mm²)</td>
<td>25</td>
<td>25</td>
<td>35</td>
<td>35</td>
<td>35</td>
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<tr>
<td>length (m) - Longeur</td>
<td>14 / 18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
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<tr>
<td>max. distance</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>65</td>
<td>65</td>
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</tbody>
</table>
### Examples:

**Comparison of different standards/materials of contact wire**

<table>
<thead>
<tr>
<th>Material</th>
<th>Mg/Ag/Cd/ Sn</th>
<th>km/h</th>
<th>Ω/km at 20°C</th>
<th>% IACS</th>
<th>mm²</th>
<th>KN</th>
<th>N/mm²</th>
<th>Standard/DB</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuMg 0,2</td>
<td>0,1 - 0,3</td>
<td>350</td>
<td>0,154</td>
<td>80</td>
<td>150</td>
<td>62,6</td>
<td>430</td>
<td>SNCF</td>
<td></td>
</tr>
<tr>
<td>CuMg 0,5</td>
<td>0,4 – 0,7</td>
<td>350</td>
<td>0,191</td>
<td>62</td>
<td>150</td>
<td>68,4</td>
<td>470</td>
<td>EN 50149</td>
<td>Japan</td>
</tr>
<tr>
<td>CuMg 0,5</td>
<td>0,4 – 0,7</td>
<td>350</td>
<td>0,239</td>
<td>62</td>
<td>120</td>
<td>60,0</td>
<td>490</td>
<td>DB/Re 330</td>
<td></td>
</tr>
<tr>
<td>GT-CS</td>
<td>Copper-clad steel</td>
<td>350</td>
<td>&lt; 0,239</td>
<td>60</td>
<td>110</td>
<td>67,0</td>
<td>587</td>
<td>Japan No DB appr</td>
<td></td>
</tr>
<tr>
<td>GT-CSD</td>
<td>Copper-clad steel</td>
<td>&lt; 350</td>
<td>&gt; 0,239</td>
<td>80</td>
<td>110</td>
<td>50,0</td>
<td>441</td>
<td>Japan No DB appr</td>
<td></td>
</tr>
<tr>
<td>Cu-Cd 0,7</td>
<td>0,5 – 0,8</td>
<td>350</td>
<td>0,138</td>
<td>&gt;80</td>
<td>150</td>
<td>62,6</td>
<td>430</td>
<td>SNCF(past)</td>
<td></td>
</tr>
<tr>
<td>Cu-SN 0,2</td>
<td>0,15 – 0,55</td>
<td>300</td>
<td>0,206</td>
<td>72</td>
<td>120</td>
<td>48,9</td>
<td>420</td>
<td>EN 50149</td>
<td></td>
</tr>
<tr>
<td>Cu-Sn 0,4</td>
<td>0,3 – 0,5</td>
<td>300</td>
<td>&lt;0,165</td>
<td>80</td>
<td>150</td>
<td>61,1</td>
<td>430</td>
<td>SNCF</td>
<td></td>
</tr>
<tr>
<td>CuAg 0,1</td>
<td>0,08 - 0,12</td>
<td>250</td>
<td>0,153</td>
<td>100</td>
<td>120</td>
<td>40,7</td>
<td>350</td>
<td>DB/Re 250</td>
<td></td>
</tr>
</tbody>
</table>
6. Different Contact Wires in Europe

Comparison to ASTM B9:

Alloy 55

Alloy 80
Comparison of CuCd1.0 and CuMg0.2 — Mechanical

Prüfzeugnis / Test report
EN 10204/3.1

<table>
<thead>
<tr>
<th>Bestellung Nr./ Order No.:</th>
<th>TEST</th>
<th>Unsere Auftrags-Nr./ Our Order-No.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erzeugnis / Product:</td>
<td>Grooved contact wire 107mm²</td>
<td>Lieferbedingungen / Terms of Delivery:</td>
</tr>
<tr>
<td>Werkstoff / Material:</td>
<td>CuMg0.2 and CuCd1.0</td>
<td>Lieferbedingungen / Terms of Delivery:</td>
</tr>
<tr>
<td>Stück / Pieces:</td>
<td>2</td>
<td>Gewicht / Brutto Weight / gross:</td>
</tr>
</tbody>
</table>

Results:

<table>
<thead>
<tr>
<th>Contact wires</th>
<th>Cross-section in mm²</th>
<th>Break strength in kN</th>
<th>Stress in N/mm²</th>
<th>Strain L₀=200mm in %</th>
<th>Number of bendings until break R₉₀</th>
<th>Number of Torsion until break L₀=250mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuMg 0.2</td>
<td>106.5</td>
<td>48.35</td>
<td>454</td>
<td>3.2</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>CuCd 1.0</td>
<td>106.9</td>
<td>47.51</td>
<td>444</td>
<td>3.9</td>
<td>13</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contact wires</th>
<th>Hardness HB (Brinell) with 31.25kg</th>
<th>Hardness HV (Vickers) with 30kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuMg 0.2</td>
<td>139</td>
<td>148</td>
</tr>
<tr>
<td>CuCd 1.0</td>
<td>131</td>
<td>146</td>
</tr>
</tbody>
</table>
7. Recommendations - 1

- Upright stationary standing drums (not laying on flange)
- Keep the CW under tension when drum is opened
- Avoid uncontrolled bending
- Avoid plastic torsion – torque below 50 Nm
- Constant tension force on CW during tensioning in the given range (see instruction manual). Continuous and controlled braking of the drum during installation. Tolerance of tensioning force < 0.5 kN
- Avoid oscillation of the unwound CW
- No walking of installation personnel on the installed CW – creates kinks!
- No safety belt on CW
- Pulling CW according to the picture 1 in order to keep the original bend direction of the CW. A bending of the CW in the opposite direction is not permitted and leads to waviness and kinks
7. Recommendations - 2

1. Coverage
   - Contact Wires acc. to DIN EN 50149:
     - Copper Magnesium Contact Wires, Rm AC-120, Rm AC-150, Alloy CuMg 0.5
     - Copper Tin Contact Wires, RZ AC-120, RZ AC-150, Alloy CuSn 0.4

2. Recommendations for Installation
   - Upright stationary standing drums (not laying on range)
   - Keep the CW under tension when drum is opened
   - Avoid uncontrolled bending
   - Avoid plastic torsion - torque below 50 Nm
   - Constant tension force on CW during tensioning in the given range (see table 1).
   - Continuous and controlled braking of the drum during installation. Tolerance of tensioning force < 0.5 kN
   - Use guide pulleys for the unwound CW with a minimum diameter of 0.8 m or several smaller guiding rolls in a bow with a bending diameter of minimum 0.8 m
   - Divert the CW not more than 20° by a guiding pulley
   - Avoid oscillation of the unwound CW
   - No walking of installation personnel on the installed CW - creates kinks!
   - No safety belt on CW

3. Pulling CW according to the picture 1 in order to keep the original bend direction of the CW on the drum. A bending of the CW in the opposite direction is not permitted and leads to waves and kinks

   - Picture 1
   - Picture 2
   - Picture 3

   - Cautious starting and braking of the installation train and the drums in order to avoid:
     - Idling of the CW - drum causing waves on the installed CW
     - High accelerations (bends on the CW)

   - Applicable tension forces during installation depend on material, drum stability and installation equipment. General recommendation for tension directly on the drum:
     - Wooden drums: 1 kN < F < 5 kN
     - Steel drums: 1 kN < F < 8 kN
     - The use of higher tension in the allowed range is preferred
     - Check with CW supplier before contracting in any case
7. Recommendations - 3

- Cautious starting and braking of the installation train and the drums in order to avoid:
  - High accelerations (bends on the CW)
  - Idling of the CW-drum causing waves on the laid CW
- Applicable tension forces during installation depend on material, drum-stability and installation equipment. General recommendation for tension directly on the drum:
  - Wooden drums: 1 kN < F < 5 kN
  - Steel drums: 1 kN < F < 8 kN
  - Check with CW-supplier before contracting in either case
- By the use of a capstan the tension force into the overhead catenary system (OCS) can be increased to the final working tension, because this force is decoupled from the drum. Tolerance of 0,5 kN for tension force on drum and into OCS to be kept.
7. Recommendations - 4

• Each metal product shows the effect of 'creeping' under tension
• Most plastic elongation of the CW by creeping occurs within the first 6...10 weeks after tensioning
• CuMg and CuSn – Contact wire have relatively low creeping rates compared with pure copper
• If possible in a project, it is recommended to have a 'maturing' of the CW under tension for 10 weeks before fixing the droppers. This is reducing the regulatory work.
• Acceleration of creeping by limited overload
7. Recommendations - 5

- Use of the Levelling Device (developed by nkt and Siemens) during installation of CW´s with higher tensile strength:
  - CuMg 0,2
  - CuMg 0,5
  - CuSn 0,4

- By the use of the Levelling Device it is possible to 'overcome' a lot of more difficult situations during the installation, when it is impossible to have constant tension on the unwound CW
Thank you for your attention!