# 20 KV OVERHEAD LINES WITH COVERED CONDUCTORS

W. Panosch[1], K. Schöngrundner[2], K. Kominek[3]

EVN AG, Austria

The experiences of an Austrian utility, an over-head-line fittings producer and a conductor company are reported in this paper.

Aerial bundled conductor systems for 400 V are in use with good results by the Lower Austrian Utility EVN and the next step was the introduction of covered conductors for 20 kV. Despite of the extreme winter conditions in year 95/96 and in subsequent years breakdowns occurred to a less degree. Faults by snow, hoarfrost, by wind and storm or by iceshedding were minimal.

Following permission from the relevant Government ministry a test line was erected with reduced distances phase to phase. In this project called Hackbichl smaller lanes through the forests were permitted. Experiences with regard to protection against over voltage and partial discharges shall be discussed.

[1] Ing. Walter Panosch; EVN AG, EVN Platz, A-2344 Maria Enzersdorf

[2] Dipl.-Ing. Karl Schöngrundner; Mosdorfer Ges.m.b.H., Mosdorfergasse 1, A-8160 Weiz

[3] Ing. Kurt Kominek; SCHWECHATER KABELWERKE GmbH, Himberger Straße 50, A-2320 Schwechat; Chairman of the working group COHL in CENELEC-TC20

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## 1. KUF Covered conductors

These conductors are covered with XLPE for protection against accidental touching.
This means, there is no breakdown if the conductor touches earthing parts or other phase conductors. Covered conductors are not safe against touching and you have to treat them as a bare conductor.

## 2. Project Hackbichl

The former 20kV line was erected in 1953 and is located in the south east of Lower Austria. It is a hilly area 700 m above sea level. The line passes through forests and across a hill to open country. This line is exposed to extreme weather conditions like ice, snow hoarfrost and wind. Falling branches and trees that have fallen down and made some short interruptions to supply and caused short circuits. Big branches that have broken under heavy snow were also a reason for faults.
Short circuits occurred by contact between phase conductors after ice shedding made an interruption of the energy transmission on a regular basis.

**Objective:**

The target was to determine an economic way of improving this existing line.
The most important points were:

- the safety of power supply in the future
- the wattage of transmission should be increased
- the existing lanes through the forest together with the trees at the edge of the wood should not be changed.
- the countryside should be unchanged

Good experiences in ten different projects with covered conductors but with the distances for bare conductors according the Austrian regulations were the reason for EVN to build this pilot project.
The line was now erected by reduced distances between the phase conductors and smaller lanes through the wood.

**Regulations:**

The existing regulations did not allow the reduction of the distance between the conductors. Therefore, the authority has given an exception for this line.
The regulations on behalf of covered conductors were adjusted in the meantime.

**Technical and structural data for this project:**

Year of erection: 1998

Length of the line: 4.130 m

Distance of phases: 0,5 m

Crossarms: hot dip galvanized horizontal steel construction

**Picture 1.** Location of the line

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Insulators:
Suspension pole: Porcelain pin insulator VHD 20G
Tension pole: Porcelain longrod insulator L60/5

Material of the conductor: E-AlMgSi, crossection 95 mm², compacted thickness of the sheath (XLPE) 2,3mm

initial tension stress:
$s_o$= 7 daN/mm²

**Picture 2.** construction of the conductor KUF 50mm²

Fittings for the conductor:
Suspension pole: Oscillating groove clamps and side ties. The sheath of the conductor is not removed at the clamps.
Tension pole: Double wedge clamps on bare conductor (insulation removed).

Poles: Existing wooden poles

Number of poles: 71

Average span lenght: 59m

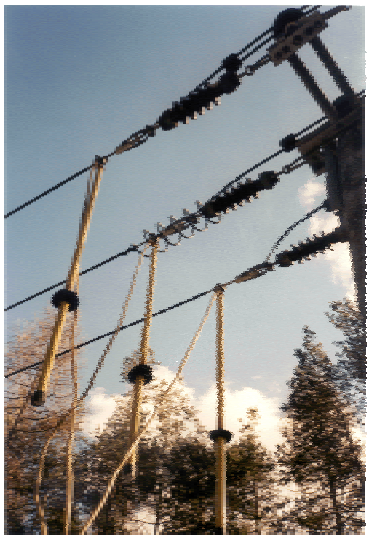
Parallel groove clamps: Piercing clamps. The sheath of the conductor was not removed. In the middle phase the aluminium clamps were covered with a plastic cap in the open country and through the forest all three phases were covered.

Over voltage protection:
Arcing horn on each 4$^{th}$ pole. At the existing tranformer stations surge arresters are used.

**Picture 3.** Suspension pole with oscillating clamps and lightning protection.

Earthing point:
Earthing stirrup on each 3$^{rd}$ suspension pole or angle pole (pict. 4). At the tension pole the earthing point is the area of removed conductor area near to the wedgeclamp (pict. 5).

**Picture 4.** suspension pole with earthing stirrups.



**Picture 5.**
Tension pole with bird protection (helicoil fitting) and connected earthing equipment.

Bird protection spiral fittings: They are made of black carbon polyamid, outer diameter 18 cm. They are mounted at the middle phase conductor upon the metallic wedge clamps, they prevent contact by birds. (danger of a short circuit due to contact by the wings of the birds).

**Picture 6.** Difference single poles old - new

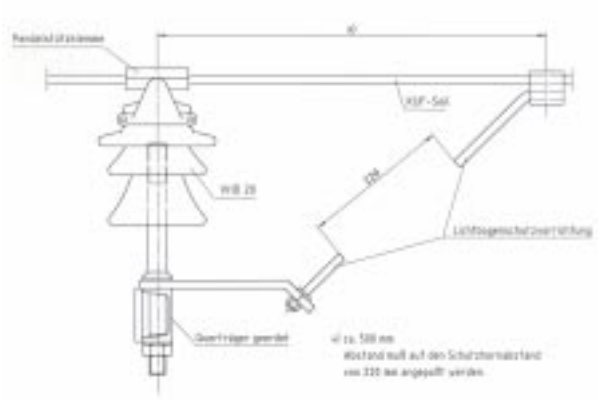
## 3. Over voltage protection:

On covered conductors an arc caused by overvoltage is not able to move along the conductor and it is burning on one point. The high induced energy and the duration of burning can destroy the conductor.
The protection against overvoltage is possible by arcing horns or surge arresters.
Protection is to the the conductors, insulators and transformers.
The installation depends of the economic attitude of the utility.
Arc protecting devices allow two different arcs.
- Arc between the phases( short circuit arc)
- Arc between phase and earth ( earth circuit arc)

In the last case the over voltage protection will be arranged between arcing horn clamp and counter horn. The distance between the arcing horn clamp and counter horn is smaller than the distance between the arcing horns of the phase conductors. Therefore an arcing horn and counter horn is more effective.

Many tests were done to find the best arrangements for the over voltage system.
The result was that arcing horns between the phases need higher currents (> 5kA) to move the arc from the insulator area.
Special installation instructions for the arcing horns avoid contact between the horn and counter horn when fallen trees are pressing down on the conductors.
In hilly areas it is easy to adjust the horns regarding the gradient of the land.

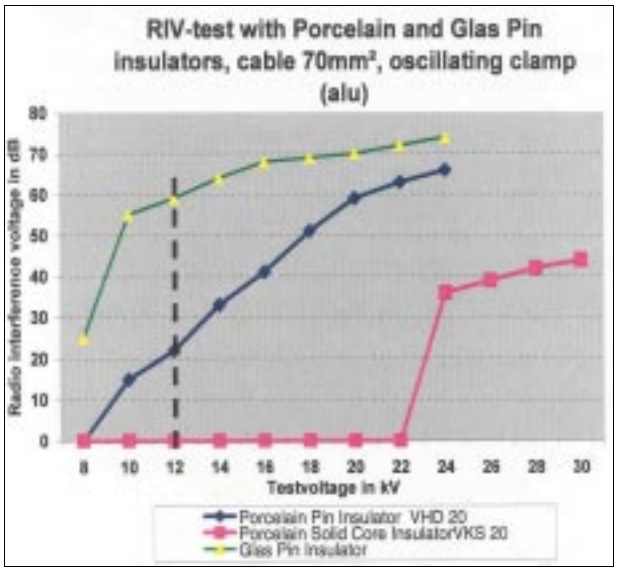
Burnt horns are easy to change without opening the piercing clamp.



**Picture 7**. Mounting instruction of the arcing horn system.

## 4. Partial discharges on covered conductor lines.

Real life has shown us that strong electrical fields caused by unsuitable insulators can produce radio interference voltage (RIV) which destroy the plastic sheath of the conductor and make noise and disturbances for TV. The RI voltage was 60 dB.
at the nominal voltage of $U_0$/U 12/20 kV.




**Picture 8.** RIV-test

Pict. 8 tests with different fittings, design of crossarms, insulators at the University of Graz have given us an idea how to avoid this problem. Past experiences have shown that an interference level under 30 dB does not create any damage to the sheath of conductor.
The kind of fitting ( helicoil or clamp) together with the standard material did not affect the radio interference voltage. A suitable insulator is the most important thing.

## 5. Comparison of the costs between bare and covered conductor systems.

The comparison of the costs in detail and the comments are:

- poles, pulling of the line, crop damages: sundry cost decrease with covered conductors.
- Crossarms and fittings: the crossarms are cheaper because of the conductor distance; insignificant additional costs for arcing horns, earthing stirrups, piercing connectors
- Reimbursement for owners of the land. Because of the smaller distances between the conductors and between trees and the line the width of the lane is smaller. The saving is between 3 and 3,5 m² of the running meter of the line.

## 6. Changes in the Austrian and international regulations and standards.

On the basis of these good experiences, the distances in the Austrian regulations between the phase conductor were reduced to 0,5 m and the distances to trees and branches from 3m to 1,5 m.
A new standard ÖVE/ÖNORM E 8227 (Covered conductor) was drawn up.
This document is the reason for establishing a CENELEC working group to prepare a European Standard for covered conductors up to 36 kV.

## 7. Report of experiences

In the meantime EVN has built more than 40 km of covered conductor lines. The positive experiences even in extreme winter conditions has convinced sceptical people.

These main points for using covered conductors are:

- No faults or troubles with snow or hoarfrost.
- No interruptions by dropping branches
- Branches or trees were moved away under normal working conditions.
- No faults with touching conductors by ice-shedding.
- No additional costs after changing the conductors.

Further advantages of covered conductors:

- smaller lanes through forests, reimbursement for owners is smaller.
- The clearing of the lane from growing trees is more seldom. The big trees at the border to the forest can remain in their place. Therefore, a lot of savings are possible.
- Covered conductors are a cheaper alternative to underground cable, especially in difficult terrain.
- Lines near to areas where the public visit are not so dangerous because of accidental touching as it is possible to touch the conductor without any electrical shock.

**Picture 9:** Safe supply during extreme weather situations in winter 95/96 in the area of EVN.

## 8. Conclusion and outlook

Since 1994 covered conductor lines were used by EVN. In conclusion from this 6-years term experiences covered conductors are a cost-effective and a safe solution for over head lines. In areas with strong hoarfrost, in forests and in areas with heavy snow the operation of a covered conductor line is optimal.
The good experiences in northern Europe and the endeavour to prepare a European standard give a good background for covered conductors in the future.

**Literature**

Pict. 2: Horst Faber GmbH; A-2560 Berndorf
Pict. 8: Mosdorfer Ges.m.b.H., A-8160 Weiz