LONG TERM OPERATIONAL EXPERIENCES WITH FLUID-FILLED AND POLYMERISED POLYETHYLENE 110 KV CABLES IN VIENNA

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ABSTRACT

Wien Energie Stromnetz GmbH and Wien Energie Wienstrom GmbH are the unbundled network operator (management and service) for Vienna and its surroundings [3]. It operates a distribution network at 380 kV, 110 kV, 20 kV, 10 kV, and 400 V, with cables in any of this voltage levels, especially also in densely populated areas of Austria’s capital.

110 kV cables are being used since 1960, in the beginning for transport, later, as 1979 the first fluid-filled 380 kV cables were put into operation, more and more for distribution purposes. This paper deals with our experiences in 110 kV cable operation.

INTRODUCTION

Our 110 kV network is being operated in 7 groups with earth-fault neutralizing.

In 3 of the 7 110 kV groups there are only cables, 2 are half overhead line/half cable and 2 overhead line dominated. Every group is supplied by at least two connection points to the transmission network. Group size is limited by the feeding transformer (n-1) and by earth-fault current (figure 1).

For the purpose of comparison see e.g. [1].

THE 110 KV GRID

At the moment around 380 km of 110 kV cables are in operation, with the following age structure (see figure 2).

Figure 2: 110 kV cables in Vienna, age structure

Since 1974 also polyethylene insulated cables are being used, since 1990 exclusively polymerised polyethylene insulated (except for fault repair). About 80 km of non-fluid-filled cables are in operation so far.

As the practical long-term experience shows, in many ways the operation and the applicability of these two main technologies differ.

The main point in the exit of fluid-filled cables is the liquid itself.

On the one hand this type of insulation is very reliable and brings long component life. In the case of 110 kV cables we expect 50 years of operation and even more. No significant problems were noticed so far. However, life expectancy depends upon operation parameters. Even small damages to the cable (e.g. third party construction) can be noticed shortly observing the liquid pressure, if not leading to insulation fault and protection activation.

On the other hand, besides from environmental issues, the
liquid pressure results in more complexity. The route is divided into pressure sections with manometers on both sides, also at joints to other components as e.g. switchgear or other cable type, needing additional maintenance, and eventually communication systems. 
If the damage or failure in led-structure on the cable is very small, it may be a problem to find the location where it appears. With experienced specialists from the cable supplier you have to freeze the cable in 50% sections for localisation. In theory you can find the leak, where the cable is dropping that way. If the leak is too small, you will find out and stop searching after some tries.

Finally, it becomes also more and more difficult to buy fluid-filled cable since factories are being shut down.

Maintenance of polymerised polyethylene insulated cables limits to sheath insulation measurements. In times of much third party construction a problem is often damage, not seen at first glance (leads to unplanned fault instead of planned disconnection). Years later, when treeing leads to fault and the construction company no longer exists, there is no one to blame. However, we experienced some faults after around 10 years of operation of the component, without apparent reason so far.

At last, lower costs (installation and maintenance) are the main factor in the choice of our today’s standard cable, which is 2XHM2Y, 500mm² copper.

WIENSTROM has established an own quality standard for cables and accessories many years ago. This standard has been worked out by our quality management department, in accordance to the IEC-cable testing standards, but more intensive. Every cable and accessories which are in use now had to pass this type test which is coupled to the manufacturer and the production site.

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The protection of the cables is a major point you have to look for at all the time. WIENSTROM puts the cables in concrete troughs in fine sand. Joints and turns are fully protected with concrete bricks and slabs, also filled with fine sand.

**FAILURES**

**Statistics**

You know what Churchill said about statistics. The failure and switch-off rates and durations depend strongly on the included events, which makes literature comparisons difficult. A recent study estimates a combined failure rate of 0.015 per km and year with a duration of 179 hours (mean values, no supply interruptions).

**Recent failures (examples)**

**Event 1**

A contractor had to cross a road to lay fiberoptic cables. To drill and lay pipes was the solution. They had knowledge of the 110 kV cable but a missinterpreted the depth. 110 kV cables are normally laid in a depth of 1.5 m. The concrete trough stops you excavation in 1.3m. When you are drilling and you meet the cable first you get a one-phase short-to ground and the cable will be switched off within some minutes by the load dispatching centre. It may happen that this short-circuit is not being noticed, which can get dangerous for the involved workers.

In the last case, we had to exchange all three phases and open part of a bridge, because there was no place for joints. Repair costs are in the majority of cases covered by insurance, which, of high enough coverage, we encourage the construction companies working near our fixtures to have.

**Event 2**

There was a company in Vienna which asked a lightning-arrester specialist to inspect and improve an arrester
system. All of the earth connections had to be renewed. With a basic machine the new metal stacks were simple to strike in. This was seventeen years ago.
Fifteen years ago we detected some falling pressure on a fluid filled cable which means a small leak. Only one phase was involved. One month of searching, excavation and freezing brought no result. Before we increased the pressure in the cable for investigations. Thereafter the leak seems to be closed and we stopped searching.
Two years ago, a property was sold and the building was to be removed. Also they had to remove and move the lightning arresters which were put out of the property in the paved way. That time the pressure loss in the cable system appeared again. This time we found the damage within two weeks and some freezing works. We are still on a trial to get the cost paid back and it will be a long way. Three phases were touched, one had a cut in the lead shed for many years. There was no electrical breakdown all the years.

Event 3
In Vienna there was a private waste canal to be connected to the road canal system. The road was very new and there was no permission to make an open trench for the connection. An experienced excavation company got a special permission to proceed. It destroyed all three phases of the 110 kV cable. Further they did not call for assistance and left the site as usual. Six joints had to be installed.

Event 4
For many years it is common to use so called air pressure rockets, mostly to connect small pipes or cables direct from the road to the house or near the house. With this method you can avoid to open a big part of the trench. This is not the best method for roads with 110 kV cable installations. In the last years we had some damages of cables as a consequence.

Event 5
A young family rented a little property from the town authorities. On this property, which is near a power station, five 110 kV systems are installed. By the contract it was not allowed to dig. When they used it as a garden they wanted to cultivate some vegetables. Solar energy was used for light, water was brought in by hand, which is trying. The idea was to dig a well. They tried to drill the well by hand with a rented striking tool. The result was all three phases damaged, six joints to be installed, luckily nobody was injured.

MAINTENANCE

MAINTOS
For maintenance purposes MAINTOS (Maintenance and operation system), a further development of MABIPLUS [4], is used. It consists of multiple software modules concerning the areas master data, technology, maintenance, evaluation, faults, and history.
I.a. the maintenance module schedules tasks and offers protocols, especially for mobile usage. 110 kV cable protocols are e.g. inspection (at different levels) of stop joint bunker, manometer box, oil tank bay, cable bay, earthing separation, cross-bonding box, culvert and bridge construction. The MMI is organized mostly in checkboxes and choice boxes, with minimal and one-handed input, and a traffic-light system for relevance.
The entries are passed on to an intelligent condition-centered evaluation module based on operation experiences and influence future maintenance.

Reinvestition
Reinvestition in power transmission systems at the end of their life-cycle depends upon many parameters [2]. Today’s trend are cables, based i.a. on optical, urbanistic and electromagnetic reasons.
Cables have many benefits, if their application is economically justifiable and technically reasonable.

SUMMARY AND OUTLOOK
The age pattern of our cable systems, as for most 110 kV cable network operators, will soon enforce high expenses for reinvestition. At this point it is crucial to take all available knowledge about component behaviour into account to recreate a reliable and economically reasonable network for the next generation (maybe 40 years or more of use).

REFERENCES