

# New catenary renewal technology introduced on Polish State Railways

Within the framework of the AGC agreement (Accord Européen sur les Grandes Lignes Internationales des Chemins de Fer), a number of main lines of Polish State Railways (PKP) are currently undergoing large-scale upgrading to allow operation at speeds of up to 160 km/h. In order to increase the productivity of the modernisation projects, PKP ordered a new catenary renewal train - the MTW 100.051, built by Plasser & Theurer, Austria. The train, which was delivered in March 1999, has been in operation since August 1999. Operating experience gained to date has proven its many advantages in comparison with conventional catenary renewal methods.

In the 1920s, the 3 kV DC power supply system was selected to electrify short commuter lines in Poland, with 1936 seeing the start of electric suburban train operation on the sections Warsaw - Otwock and Warsaw - Pruszków of PKP's network. After World War II, reconstruction and expansion of electrification of PKP's main lines were carried out, also using the 3 kV DC power supply system. Between 1960 and 1988 - in response to the very high transport demands from the Polish industry, a very extensive electrification programme was conducted, aimed at allowing mixed traffic operation (passenger and freight) to be carried out at speeds of up to 120 km/h. Currently, approx. 11,600 km of PKP's network (i.e. about 50 %) is electrified; with electric trains carrying more than 92 % of the total passenger and freight traffic volume. In view of the fact that electric traction is used on nearly all main lines of PKP's network, it was assumed that the electrification process in Poland would be complete.



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However, during the 1990s, after big political and economic changes in Poland, certain main lines of PKP's network became designated as important European transport corridors which, in accordance with the AGC agreement, require upgrading in order to allow passenger train operation at speeds of up to 160 km/h. In 1993, the modernisation of the western section of the E-20 line (Warsaw - Poznan - Kunowice (German border)) began, and in 1999 that of the eastern section (Warsaw - Minsk Mazowiecki). In 2000, work will start on the E-30 line (section Wroclaw - Opole). The modernisation projects are carried out with considerable support from European financial institutions such as the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD), and the PHARE Fund.

The upgrading tasks embrace:

- track renewal, often with a new layout;
- replacement of bridges;
- conversion of stations, halts, and signalling equipment;
- renewal of catenary systems.

## *Catenary renewal work*

The renewal of catenary systems aims at increasing the mechanical wire tension forces: in copper contact wires with a cross-section of 100 mm<sup>2</sup> to between 950 and 1,000 daN, and in copper carrying cables with a cross-section of 120 mm<sup>2</sup> to between 1,500 and 1,600 daN.

In most cases (on the majority of sections under reconstruction), there is also a need to replace worn-out equipment (droppers, insulators, cantilevers). On the lines electrified in the early days, renewal work very often also includes the exchange of catenary wires (both contact wires and carrying cable) and the installation of new masts.

Initially, the renewal projects were carried out using conventional assembly trains, which consisted of two or three old passenger coaches withdrawn from normal commercial service, hauled by diesel locomotives. These coaches featured long, roof-mounted bridges which were used as work platforms from which catenary work was carried out.

However, this method required quite large physical efforts from the crew, and did not offer a high rate of productivity. For instance, using this conventional method, a full catenary renewal (i.e. removal of the old system including all the equipment mounted on the masts, the masts themselves and the contact wires with carrying cables, and installation of the new system) of a 1,300 m section required five track possessions, each lasting about eight hours.

## **The imminent need for a more efficient catenary renewal method**

In order to increase the productivity of the catenary renewal work, PKP management took the decision to introduce some new technologies. Thus, a new and efficient technology to exchange catenary components was sought. In order to select a proper solution, experts from PKP acquired information on the most modern catenary renewal technologies in use in Sweden, Austria, France, Switzerland, Norway, Morocco, China and Germany. The method introduced in Sweden in 1990 by Banverket (Swedish National Rail Administration) was considered the most efficient (see [Reference]).

The technology used in Sweden - which produces the final wire tension during installation - enables Banverket to carry out a full catenary renewal of a 1,300 m section during a single track possession of only five hours. Such a high output was what PKP needed for upgrading its main lines.

Subsequently, PKP set out to make a list of requirements which had to be met by the application of a catenary renewal train on its network. The main criteria being:

- the exchange of catenary equipment of a full 1,300 m section - embracing the exchange of one carrying cable and two contact wires (characteristic of the DC system used in Poland), all cantilevers with insulators, tensioning devices, continuity jumpers, stitch wires, etc. - was to be carried out in a single operation, lasting no more than one track possession of eight hours;
- the catenary renewal train was to consist of two independent parts (one for dismantling and the other for assembly work);
- the installation of the new wires was to be carried out with constant pre-determined cable tension forces (with the same also applicable for winding up the old wires with lower tension forces);
- the train was to be self-propelled (both during work and transfer travel).

The respective tender procedure was started in 1997. The financial source was the loan granted by the EIB for the modernisation of the E-20 line. The rules concerning the tender procedure and the contract itself were established in conformity with provisions of the EIB and the World Bank. In the same year, the contract for procurement of a catenary renewal train - the MTW 100.051 - was signed with Plasser & Theurer, Austria, which submitted the most satisfactory offer taking into account the specified evaluation criteria.

In March 1999, the catenary renewal train was delivered and, since August 1999, has been operated by PKP's Mechanised Catenary Renewal Division in Słotwiny (located near Koluński junction, about 100 km south of Warsaw), which is responsible for catenary renewal work on the entire network of PKP.

### The MTW 100.051 catenary renewal train

PKP's MTW 100.051 catenary renewal train is designed to perform continuous renewal of direct-current overhead wires, i.e. the removal of droppers, two contact wires, one carrying cable and cantilevers, and the simultaneous assembly of new cantilevers, one carrying cable, two contact wires and the mounting of droppers. It can also be used to remove and install line feeders, as well as return current conductors.

The MTW 100.051 catenary renewal train consists of:

- units to dismantle the old catenary system (see Diagram):
  - a *catenary removal machine FUM 100.051/3FWW*, which consists of two parts:
    - a two-axle crane car - designed as a standard railway vehicle with buffer and draw hooks, but no driver's cab - which features a loading crane with two roller heads to deflect the old carrying cable and contact wires. The elevating work platform located behind it, which

features a maximum working height of around 15 metres, is used for dismantling the cantilevers. During transfer travel, it is lowered onto the vehicle platform and locked.

Further, it features an air-cooled 12-cylinder Deutz diesel engine and power-shift transmission with which, when coupled to the workshop & crew car FUM 100.D.1.WP (which features a driver's control desk), it can achieve a self-propelled speed of 80 km/h. The work drive is hydrostatic (0-7 km/h);

- a two-axle cable drum car, which is also designed as a standard railway vehicle, featuring buffer and draw gear, but no self-propulsion. It features three laterally displaceable frictional cable winch units, which are used to wind up the old cables. The cable winch units are mounted on laterally displaceable guide rails to enable a uniform winding of contact wire and carrying cable onto the storage drums. The cable winch units are powered by an on-board air-cooled four-cylinder Deutz diesel engine;

- a *four-axle workshop & crew car FUM 100.D.1.WP for dismantling the droppers*: the car is fitted with two running bogies, and buffer and draw gear. The end-to-end cabin features a driver's control desk, a crew room, a washroom with shower and WC, a material room and a workshop area. A 5-metre loading platform with crane is provided at the rear. The crane is used to lay the old cantilevers onto the loading platform. The roof-mounted self-propelled scissor-type elevating work platform, which can ride across the whole length of the car, is used for dismantling the droppers. The roof can be reached by ladder from the loading platform.

The car also features a diesel generator, which is mounted underfloor, for powering lighting, heating and other electrical appliances, as well as a compressor for pneumatic tools;

- units to assemble the new catenary system (see Diagram):
  - a *catenary assembly machine FUM 100-V*: the FUM 100-V is the centrepiece of the catenary renewal train. It is used for continuous installation of contact wires and carrying cable (and/or line feeders and return current conductors). The machine is equipped with a running bogie and a powered bogie, an air-cooled 12-cylinder Deutz diesel engine, a secondary power-shift distributor and a gearbox, which enables a self-propelled speed of 80 km/h.

The work drive is equipped with a special drive control which ensures that no jolting or over-proportional tension peaks occur during cable installation when starting off.

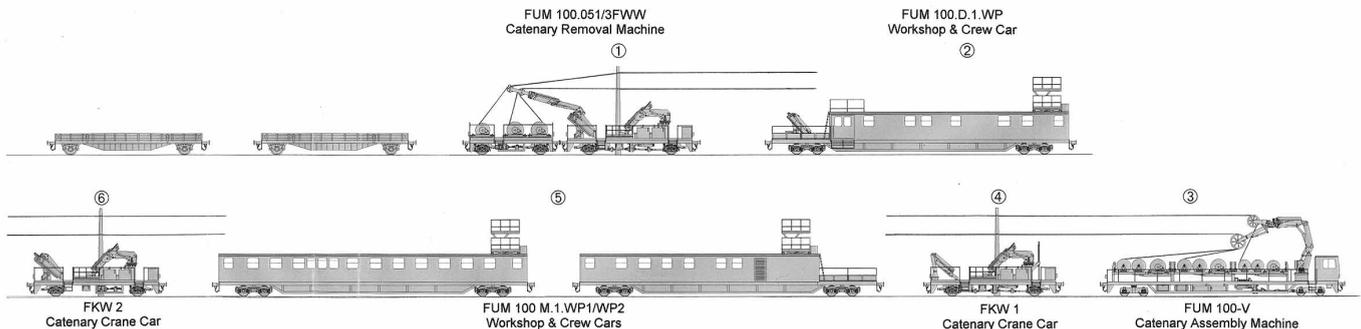
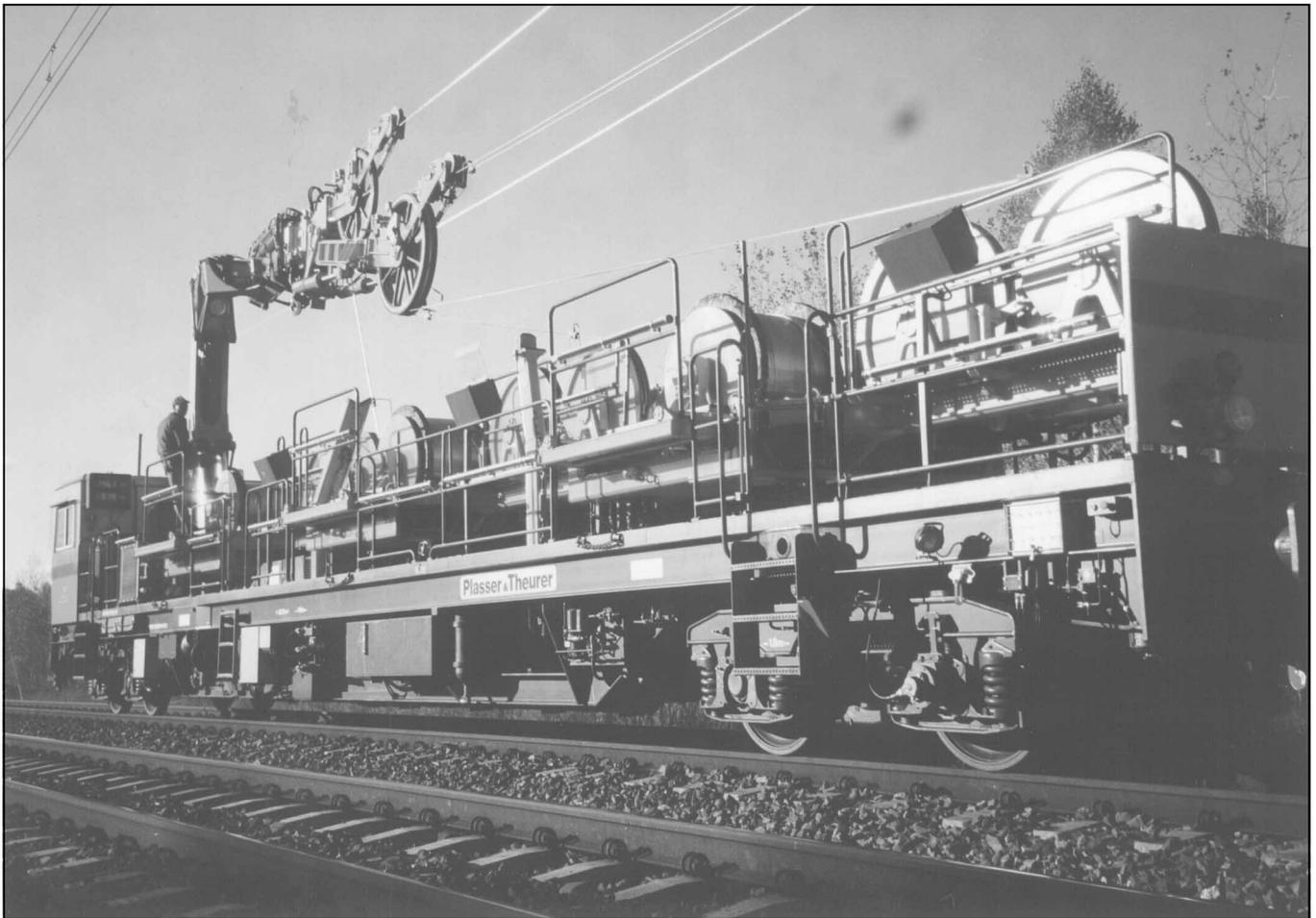
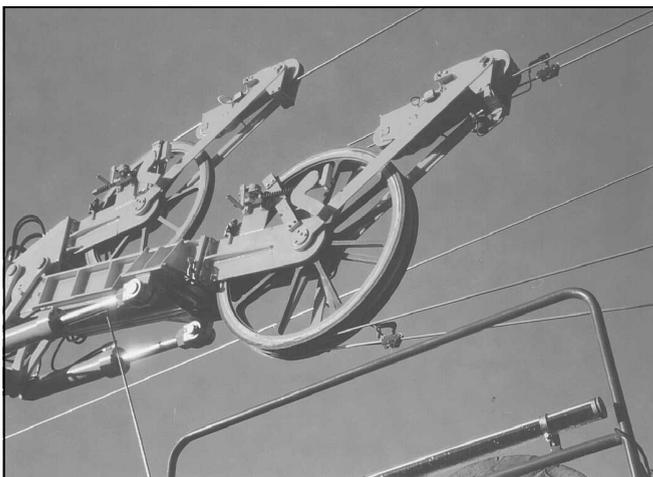


Diagram presenting the various machines of the Plasser & Theurer MTW 100.051 Catenary Renewal Train, in their sequence of operation



*Catenary Assembly Machine FUM 100-V*

The overhead wires are drawn up over the adjustable cable deflection units by the loading crane. Three tiltable frictional cable winch units are mounted on the machine, each consisting of a storage drum holder, a hydraulically driven winch wheel on a second, synchronised winch wheel. One cable winch unit serves to install the new carrying cable, whereas the other two units are used to install the two new contact wires. The units are in both tiltable and laterally displaceable design, which enables the wires to enter the deflection wheels of the crane, or the frictional cable winch wheels, in a straight line;



*Deflection wheels for contact wire installation*

- *a catenary crane car FKW 1*: this vehicle features a freely-movable elevating work platform with radio remote control to operate the catenary assembly machine FUM 100-V. The new cantilevers are mounted from the elevating work platform. At the end of the machine, there is a small loading crane which is used to pick up the new cantilevers stored on the work platform. An air-cooled 12-cylinder Deutz diesel engine provides the power for transfer and work travel. The FKW 1 also features a contact wire height-measuring system. During work, the FKW 1 is decoupled from the FUM 100-V and powered separately;
- *two workshop & crew cars FUM 100 M.1.WP1/WP2*: the two cars are each provided with washrooms with shower and WC, a crew room, an office, a workshop compartment and seven sleeping compartments with bunk beds. The car at the rear is also fitted with a driver's control desk for transfer travel. A diesel generator provides power for lighting, heating, electrical appliances and operation of the scissor-type elevating work platforms. The two scissor-type elevating work platforms, which can be displaced lengthways over the roof of the car, are used to mount the new droppers;
- *a catenary crane car FKW 2*: the two-axle catenary crane car FKW 2 features a hydrostatic work drive which is fed from an air-cooled four-cylinder Deutz diesel engine. The FKW 2 is used to carry out auxiliary work after the catenary renewal work has been performed, and to check the actual height of the overhead wires. For this purpose, it is equipped with a freely-movable elevating work platform, a loading crane with hydraulically extendible supports and a contact wire height measuring system.

The removal and assembly units can be operated separately.

During renewal work, there are no restrictions to traffic on the adjacent track. In one eight-hour track possession, the MTW 100.051 catenary renewal train achieves an output of 1,300 m. As the contact wires are installed with the final cable tension, no post-adjustments need to be carried out. Thus, after renewal work, the line can immediately be re-opened for train operation at full line speed.

### **Initial operating experience gained on PKP with the MTW 100.051 catenary renewal train**

In August 1999, after the setting into operation phase, the MTW 100.051 catenary renewal train started work on the Warsaw Rembertów - Minsk Mazowiecki (located about 48 km east of Warsaw) section of the E-20 line. Under the supervision of specialists from Plasser & Theurer, the machines of the catenary renewal train were used to remove the old catenary system and to install a new one suitable for train operation at speeds of up to 160 km/h. It embraced the following tasks:

- the removal of the old masts, including their foundations;
- the installation of new masts;
- the exchange of catenary wires (i.e. two contact wires and one carrying cable);
- the exchange of suspension equipment;
- the installation of overhead tensioning systems; and
- some auxiliary work.

During this work, practical training for staff was conducted under normal operating conditions. Taking this into consideration, a very satisfactory output of about 55 km in 65 working days with 24-hour track possessions was achieved.

In December 1999, whilst working on the Koluszki - Rogów section of the Warsaw - Katowice line, the MTW 100.051 catenary renewal train performed a productivity test (one of the most important contractual obligations), which it passed with positive results.

Up to the end of January 2000, about 75 km of overhead catenary systems had been renewed using the new train. In 2000, the most important task for the new catenary renewal train will be the modernisation of the E-30 line (section Wrocław - Opole).

The crew of the train is very positive about working with the new equipment - the possibility to install catenary wires with constant mechanical tension and the use of efficient, modern work platforms and cranes are regarded as very welcome, as they significantly reduce the degree of physical effort involved, whilst offering a safe working environment.



*Catenary Crane Car FKW 1*

### **Conclusions**

The new MTW 100.051 catenary renewal train has proven its many advantages in comparison with the old technologies previously used by PKP. It is believed that after some alterations in catenary equipment design will have been made, and some minor teething troubles will have been overcome, an even higher output will be obtained than has been achieved so far. Thus, the efficiency of modernisation work on PKP is expected to see a significant increase.

### **Reference**

Thylén S., Lundin L.: 'New method of installation and renewal of overhead catenary systems in operation in Sweden', Rail Engineering International, Edition 1991, Number 1, pp.17-20.

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