ADVANCEMENT IN THE POWER SUPPLY SYSTEM OF THE 760 MM GAUGED SINGLE-PHASE 25 HZ MARIAZELLERBAHN 1908 – 2015

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Topics

- About Mariazellerbahn
- Need for electrification
- Power plants, substations and original power supply system
- Original rolling stock
- Improvements over the years
- New trainsets
- Present-day power supply system





Mariazellerbahn







Mariazellerbahn

- Mariazellerbahn is a narrow gauge line (760 mm), 84 km long.
- The track runs from St. Pölten, capital of the province of Lower Austria, situated 60 km westbound of Vienna on the Rhine – Danube Corridor (TEN 17), to Mariazell in Styria.
- Mariazell is famous for its Saint Mary pilgrim site.
- The single-track line was opened in several stages between 1898 and 1907.
- She climbs from St. Pölten (267 m above sea-level) with a gradient of max. 2.8%, passing many tunnels and viaducts and turning in spectacular loops to an altitude of 892 m, reaching the summit in km 65.5 in the Gösingtunnel (2368 m long). Eventually, she runs down to Mariazell (km 84, 849 m).





Longitudinal Profile







Operation today







Today's Operation

- Today, after heavy investments in the past five years (altogether 115 Mio. €), Mariazellerbahn appears as a modern, stateof-the art railway.
- She is the last remaning Railway in Europe using the 25 Hz single phase system.
- Since 2013 new Stadler trainsets bear the brunt of transport
- For touristic purposes the original trainsets, dating from 1910 1914, are still on duty.





1908 Need for Electrification







1908 Need for Electrification, Power Houses

- Originally, the line was built and steam-operated by the federal State of Lower Austria.
- She reached its limit of performance in the first operational year, 1907, already.
- Therefore it was decided to electrify the line as soon as possible.
- To generate electrical power for traction needs the water powers of Erlauf and Lassing rivers in that area were used by erecting a hydro-power plant at Wienerbruck.
- This power station is situated nearby the end of the line.
- For reserve purposes as well as for times when water was scarce, the provision of large diesel engines at the other end of the line, St. Pölten, was suggested.
- To use surplus energy, it was envisaged to feed industry and households along the railway line.





Wienerbruck Hydropower Station







Diesel Auxiliary St. Pölten







Turbine-Alternator-Sets







Turbine-Alternator sets

- The Wienerbruck power house has been equipped with four turbinealternator-sets.
- Every alternator was designed to generate three-phase current as well as single phase current with a voltage of 6.5 kV. Due to special switching arrangements, either one or three phases could be used.
- Two transmission lines were fed by means of transformers 6.5/27 kV :
- The one, single-phase, ran to the two railway substations, situated in km 12 and km 31, as well as to the auxiliary Diesel power house.
- The other, with three phases, fed several transformers in the villages, as well as the local grid in St. Pölten together with the other power plants there.
- That way it was possible to feed the railway demand as well as the industrial demand and the demand for private settlements, farms etc. along the line.





Power Supply arrangement

- Why using the alternating current system 25 Hz?
- A considerable reason was the fact, that at that time several smaller hydro-power and steam-power stations were using the 25 Hz system in the St. Pölten area already.
- It was foreseen to interconnect all these power plants to provide electrical energy in the whole region along the Mariazellerbahn line, in a service area of more than 100 km in length.
- Furthermore, Siemens-Schuckert as the electrical supplier already had expertise in that field, since they supplied, among others, the Wien – Baden interurban railway, which had been operated in their core section with AC 500 V 25 Hz since 1906.





Power Supply Arrangement







Substation 27/6.5 kV



Abb. 16. Schaltbild eines Umformerwerkes

т	Transformator	В	Blitzableiter
D	Drosselspule	ow	Ölwiderstand
OA	Ölausschalter	W	Wasserstrahlerde
R	Zeit-Relais	Tm	Thermometer
S	Spannwerk	ĸ	Klappenschrank
Sp	Sperrung	L	Läutewerk
M	Flektromagnet	F	Fada

- A Abschalter







Substations, Erlaufboden Plant

- The railway contact line has been fed on the one hand directly from the power houses with 6.5 kV current, coming directly from the alternators; On the other hand she was supplied from the single phase transmission line via two substations, situated in km 12 and km 31.
- All railway feeding points were operated in parallel mode.
- In 1924 a second hydropower station was erected, now equipped with three turbine-alternator sets for 50 Hz current.
- One set was carried out with two directly coupled alternators, the one for 50 Hz current, the other for 25 cycles. That way a rotary converter has been formed and it was possible to exchange energy between both grids.
- The Diesel power house served only ever as a reserve capacity. His main purpose was to distribute the energy in the local grid of St. Pölten.
- Thus, six different power stations worked together, partially waterpropulsed, steam-operated and diesel-powered. Far apart from each other, they fed an early common distribution grid.





Erlaufboden Hydropower Station







Turbine-Converter Set







Power Plant Interconnection







Overhead and Transmission Lines

- The three different wirings in particular the 6.5 kV 25 Hz single phase contact line, the 27 kV single-phase feeder line and the 27 kV 25 Hz-three phase system were carried jointly on the railway's overhead poles.
- These five leads were fixed laterally, alternately on the left and on the right side on the top end of the masts.
- The catenary consisted originally of a contact wire of copper with a section of 80 mm², suspended from an auxiliary wire made on steel, whilst the catenary cable was a steel cable with a total section of 35 mm². The span from mast to mast amounted to 50 m.
- The catenary cable and the auxiliary wire were anchored inflexibly, whilst the contact wire was tension-regulated by means of rollers and weights. Originally, the length of all overhead sections amounted to 115.5 km.





Overhead and Transmission Lines







Overhead Wiring System



Abb. 17. Anordnung der Fahrleitung mit Vielfachaufhängung

(Bauart SSW)

a Fahrdraht

- b Fahrdrahtklemme c Hilfstragdraht
- d Tragseil e Hängedraht f Hängedrahtklemme
- g Tragseilbock
- h Tragseilisolator
- i Isolator für seitliche Festlegung
- k Isolatorstrebe

1 Klemme für seitliche Festlegung





Original Rolling Stock

- From 1911 until 2013 traction of all Mariazellerbahn passengers and goods trains was performed almost entirely - by 16 six-axle locomotives of class 1099, built between 1910 and 1914 (Krauss/Siemens-Schuckert).
- They had two series-wound single-phase collector motors, each rated at 220 kW, fed from two main transformers, controlled by tapping contactors.
- After WW I, operations and energy supply of the Mariazellerbahn has been divided: Train operation was done since 1922 by ÖBB, energy supply and maintenance of the different wiring systems was performed by EVN, the energy supplier of Lower Austria Country.





Passenger Trains







Goods Trains







Single Phase 25 Hz Motor







Partial renovations

- In the 1960s a new contract between the energy supplier EVN and ÖBB allowed to modernise parts of the electrical equipment by maintaining the 25 Hz system.
- The reason for that was the fact that it was impossible to finance a new rolling stock at that time.
- By using ÖBB standard parts, the overhead wiring and feeding system was partially renewed, but carried out by EVN-employees.
- Two new substations, situated at km 25 and km 67, has been built, now supplied by an improved converter set at Erlaufboden hydropower station.
- The two substations and the hydropower stations at Wienerbruck and Erlaufboden were operated now remotecontrolled as well as the switches for the connection of diffrent overhead line sections.



New Body, old Motor Bogies







Trainsets working since 1910







Partially renewed Overhead







Substation from 1969







New Trainsets

- Despite everything, about 2007 the 25 Hz energy generation by EVN represented an unique and isolated application for an energy supplier in a competitive market.
- The aim of EVN was to separate the 25 Hz-part of the railway's energy supply from the normal 50 Hz-EVN-grid.
- At the other hand, comprehensive studies proved that it would be highly recommended to keep the 25 Hz supply level to guarantee a transition without interruption between the old and a new generation of trainsets.
- Nevertheless, the new trainsets should be prepared for a later conversion onto 50 Hz supply.



New Trainsets since 2013







New Depot and Workshop







New Trainsets – new energy requirements

- After a strong tendering, Stadler won 2012 the contract to deliver nine inverter-driven EMUs for general purposes
- Furthermore four panorama-trailers for touristic services has been built.
- The 8-axle EMUs are rated for 1200 kW. Each of them is capable to pull four trailers over the 2.8%-ramps with an average speed of 45 km/h. The maximum speed is 80 km/h.
- The trainsets are fully air-conditioned, they offer enough space for bikes, buggies and wheelchairs.
- Additionally, a new depot, combined with modern workshops, was erected in the middle of the line at Laubenbachmühle.





Rising of Energy Consumption







Improvement of Catenaries





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Separation of grids

- After deep considerations the most suitable solution appeared to separate the feeding grid from the railway's level by a new, combined transformer- and substation at Klangen (km 16), consisting of three rotating frequency converters 50/25 Hz.
- This new converter plant was erected in 2014.
- It is fed from the EVN-grid with 20 kV three-phase current. It forms the interface between the power grids of EVN and the new railway operator NÖVOG.
- The continuous performance of altogether is at least 3.7 MW, the peak performance for 2 minutes is 5 MW.
- The 25 Hz energy produced there is high-strung to 30 kV and is led to the other substations via a high-voltage cable.
- Furthermore, the station is designed to feed the 6.5 kV overhead line directly.





Converter-Substation







New Converter Station Klangen

- Three rotating converter sets, delivered by the Austrian supplier Hitzinger, run with a machine voltage of 690 V. Following different load curves, each converter can be engaged and disengaged individually.
- The converter station Klangen feeds via a 30 kV cable the substations Rabenstein and Gösing. Additionally, a new substation at Laubenbachmühle was considered necessary.
- The need for that 2 MVA substation derived on the one hand from the high standby power consumption of the new train sets, domiciled in the newly built operational center right there. On the other hand, that site enables the best voltage spreading all over the line.
- Finally, the modernization of the substations at Rabenstein and Gösing was carried out with new transformers, rated for 30/7 kV and 2 MVA.





Converter-Substation Scheme



zu den anderen

Unterwerken

und erschütterungsisoliert aufgestellt. Weiters ist hier umfangreiche Sicherheits-, Steuerund Überwachungstechnik eingebaut, um den Betrieb der Umformer zu regeln.

Outgoing Circuits





Hitzinger Rotary Converters







Remote Control





Substation at the new Depot







Line Voltage and Current







Power Supply Scheme 2015







AC/DC at Mariazell Station







Intrested in more Details? See you at St. Pölten UAS!





