Zeitschrift: Swiss express : the Swiss Railways Society journal
Herausgeber: Swiss Railways Society
Band: 3 (1991-1993)
Heft: 9

Artikel: The road to the converter locomotive. Part 2, The new locomotives
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DOI: https://doi.org/10.5169/seals-855232

Re4/4^{IV} No.10101 in original livery at Brig. *Photo John Jesson*

The Road to the Converter Locomotive Part 2

The New Locomotives

By A.E.Hauser-Gubser

Continued from Page 22 December 1992 Swiss Express

A solution to the thyristor problem was not in sight, so the SBB reluctantly ordered four trial locomotives Re4/4^{IV} with phase angle control. The high cost of reducing the idle power consumption and the investment necessary to prevent interference with signal circuits due to harmonic waves made it clear that this could not be a wholly satisfactory solution, despite the higher tractive effort and speed produced (see Figure 5).

Fortunately a significant breakthrough had been achieved just before the introduction of the Re4/4^{IV} locomotives; the invention of the gate-turn off thyristor (GTO thyristor), with which infinitely variable switching was now possible. Furthermore, this new type of thyristor

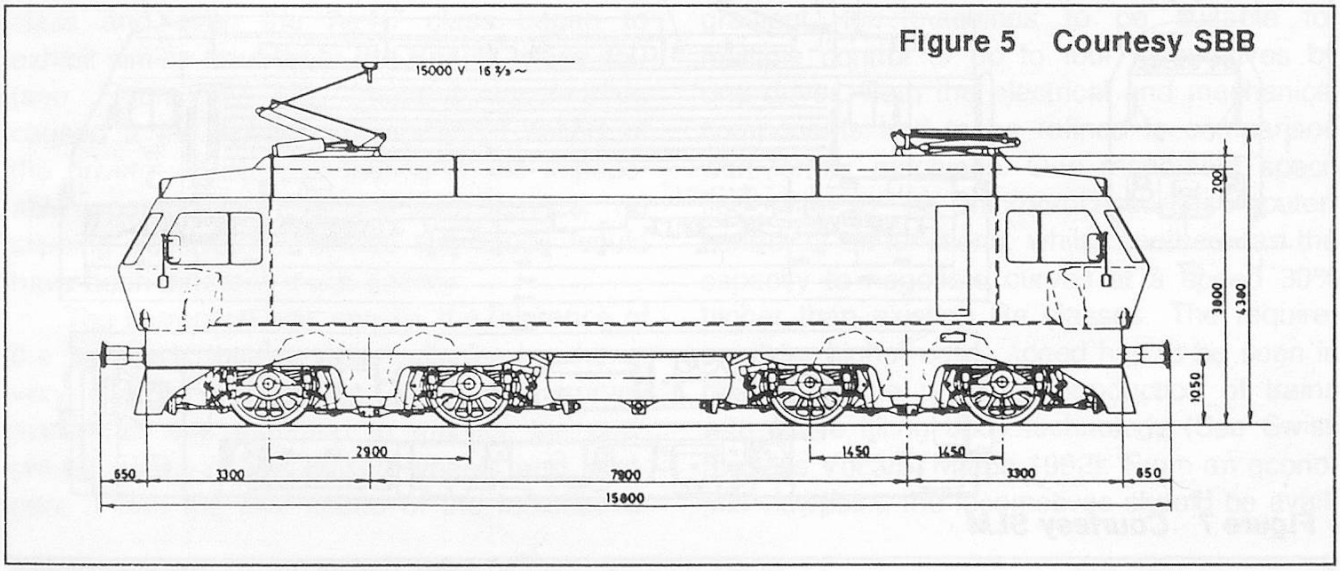


Figure 5 Courtesy SBB

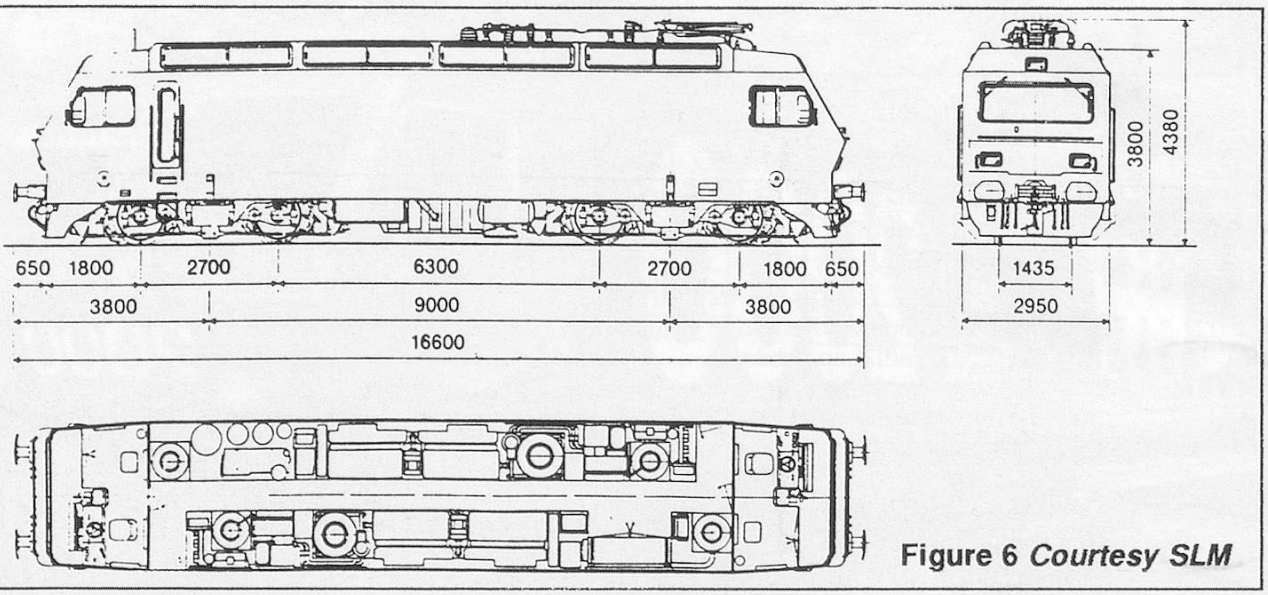


Figure 6 ***Courtesy SLM***

was capable of handling far higher currents and voltages than hitherto, thus increasing the possible power range.

At the beginning of the eighties, both the Bodensee-Toggenberg and Sihlthal-Zürich-Uetliberg were faced with the problem of replacing their older electric locomotives. A careful estimate of the situation carried out by BBC and SLM was responsible for the decision to buy six converter locomotives for the BT and two of the same type for the SZU. These engines of 3200 Kw, 240 kN tractive force and a top speed of 140 km/h were an immediate success (see Figure 6). They were the first locomotives with GTO thyristor technology using the new self-steering shifting axle drive bogie. With an adhesion coefficient of 0.35, an excellent value was attained if one considers that the weight is only 69 tonnes. The regenerative brake is highly regarded because the savings in energy consumption are welcomed by smaller companies not owning hydro-electric plants. The maintenance cost of the engines is extremely low due to the suppression of tap changers, commutators and brushes together with much lower wear to wheel tyres and rails. In fact, the latest information speaks of an engine mileage of 600000 or more before it becomes necessary to reprofile the tyres and about 6 million miles between major overhauls.

These excellent results induced the SBB to purchase the same type, with only one driving cab, for the Zürich S-Bahn (RTR) for its opening in 1990. Apart for a few minor details, the locomotives are virtually the same. It was therefore a complete surprise when, from the start of services, certain components of the suspension had to be replaced, this fault

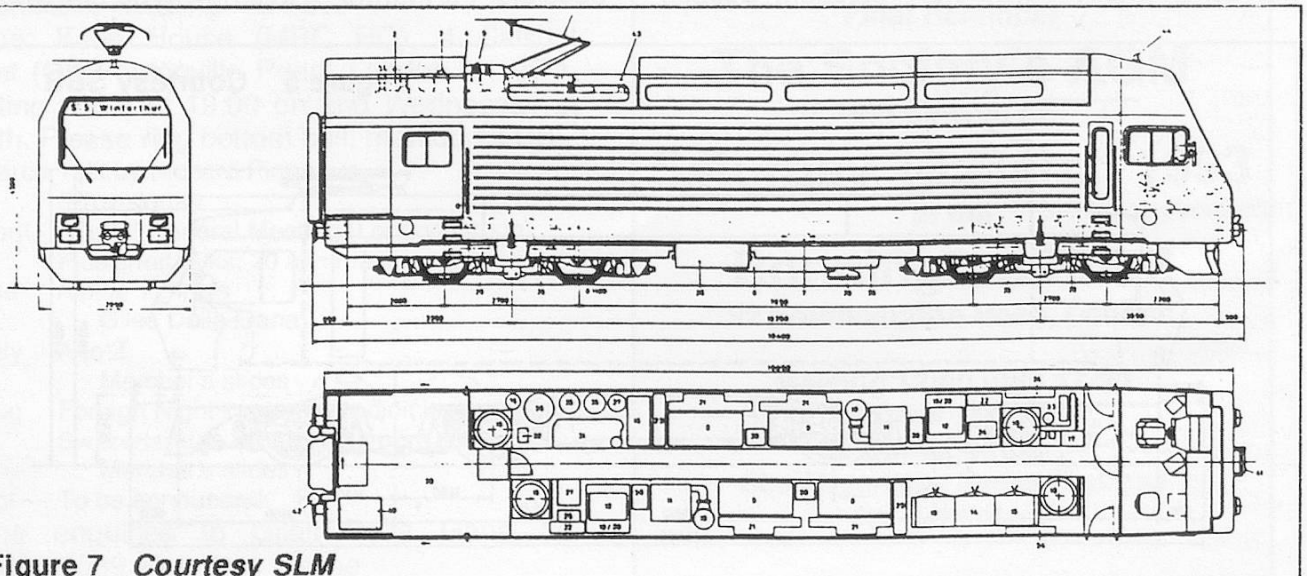


Figure 7 ***Courtesy SLM***

Bodensee Toggenberg Re4/4 No.91 *Romanshorn* at Herisau, 19 June 1992. *Photo C.J.Freezer*

caused considerable headaches. Several theories involving body frequencies or the influence of thyristor switching cycles proved to be unfounded. The cause was finally traced to the residue from the plastic brake shoes of the RABDe12/12 shuttle trains which made the rails extremely slippery. (A case of the wrong sort of brakes? Editor). Due to the shortage of S-Bahn rolling stock during its first year of operation, the service area of these trains had been considerably extended from their traditional Zürich-Rapperswil routes, causing the same trouble on almost all S-Bahn services. Conventional locomotives, such as the Re4/4 class and even the Ae4/7 class began to exhibit similar troubles to the Re4/4^{V}, class 450 (see Figure 7). The frequent acceleration caused a far higher circumferential speed of the driving wheels, but thanks to the impeccable operation of the anti-skid devices, no slipping occurred, otherwise the cause would have been detected much sooner.

The correction was simple; the tolerance of the anti-skid devices were optimised within a very narrow margin. In addition a survey apparatus was mounted to monitor the peripheral speed of the driving wheels and compare it with the true speed of the locomotive. As soon as the peripheral speed exceeds the locomotive speed, the motor voltage is reduced accordingly to obtain the correct wheel revolutions. At present, the locomotives now give complete satisfaction in service; 95 units will be delivered and further machines are likely to be ordered.

In 1985 the SBB had required BBC and SLM to undertake research and produce proposals by 1987 for a converter locomotive of 6100 kW and 275 kN tractive force at a speed of 80 km/h, with a top speed of 230 km/h, with BoBo axle configuration, capable of hauling at least 650 tonnes at 80 km/h on a 2.7% gradient, the machines to be suitable for multiple control of up to four locomotives by one driver. Both the electrical and mechanical components had to be refined in comparison with former machines. One refinement specified was to be microprocessor (computer) control of all functions, whilst another was the capacity to negotiate curves at a speed 30% higher than existing Re classes. The requirement for higher curve speed has to be seen in relation to the possible introduction of trains with active tilting body technology (See Swiss Express Vol.3/5, March 1992). From an economic viewpoint, the locomotives should be avail-

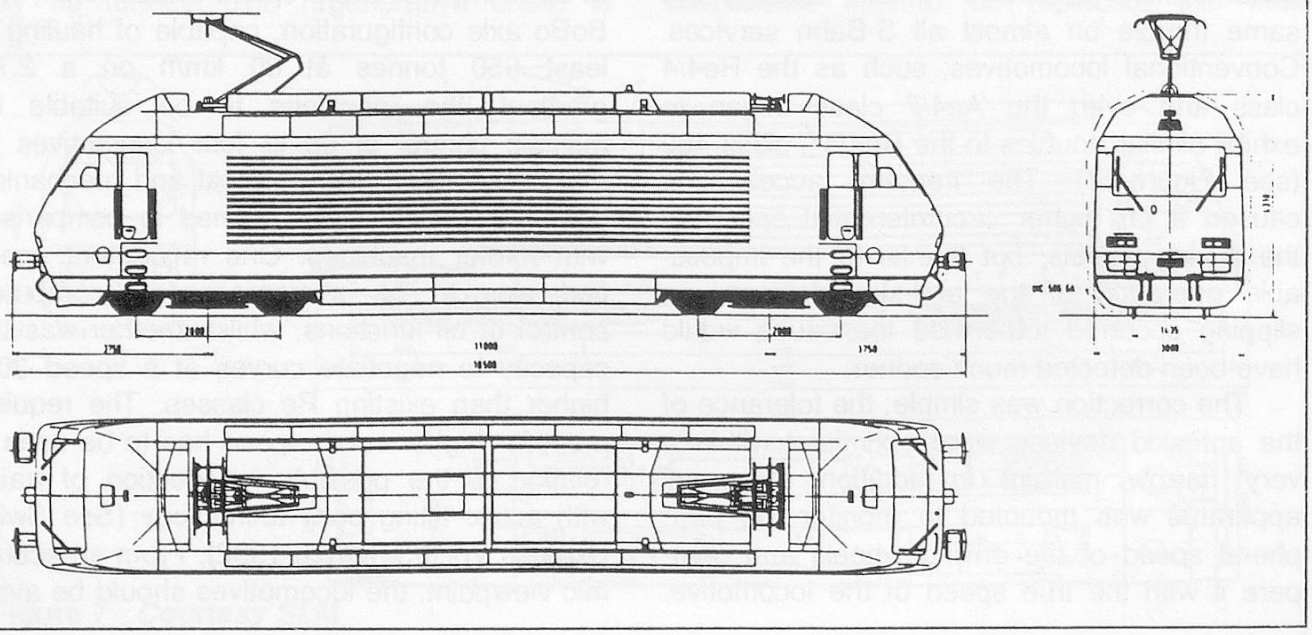
SBB Re4/4[450] No.450.006-2 at Zürich Hbf, 10 September 1989. *Photo Gary Olson*

able for passenger or freight service. A completely new bogie design was the consequence of this last requirement.

In December 1987, a new batch of twelve locomotives Re4/4[VI], class 460 were ordered, based on an offer submitted by the industry. This was later increased to 24 engines. In 1989, the Federal Council, then under heavy pressure from the EC to open corridors for 40 tonne lorries through Switzerland, took the decision to invest one and a half billion Swiss Francs in a modernisation of the Gotthard route, aiming at an overall capacity of 50,000 road consignments to be carried by rail from 1992 onwards. A further 75 class Re4/4[460] locomotives were therefore needed.

Six of Europe's most reputable locomotive builders were invited to tender for these on the basis of the SBB's 1985 specifications. To the surprise of all concerned, only two offers were

Figure 8 ***Courtesy SLM***



Re4/4^{460} No.460.024-3 at Göschenen, August 1992. *Photo Les Heath*

received, despite the fact that the order was worth upward of 500 million Swiss Francs. Whilst the unit price of each of the two offers was slightly below that of the BBC/SLM consortium (about SFr.10,000 per locomotive), various vital requirements were either not met or not even offered. The order therefore went to SLM/BBC and delivery of the 90 locomotives is now under way (see Figure 8).

A detailed description of the new Re4/4^{460} class will be the subject of a later article, but I can confirm that all the original specifications have been met. The trials currently in progress are to optimise the performance of the machines, each group of components being tested to see whether any improvement beyond the original specification is possible (see Swiss Express Vol.3/4, December 1992), whilst a cost/profit analysis is made. For example, if the motor cooling can be substantially improved then the maximum power possible within the thermal limits of the traction motors can be sustained for a longer period, this is clearly of considerable importance on mountain routes.

Over the next few years locomotives ordered by other companies, BLS, EBT, RhB, AB and MOB will profit from the experience gained. In my humble opinion, the refinement of this technology will be significant during the next few years. Later it is possible that even more powerful Re6/6 locomotives, with BoBoBo wheel arrangements producing 8000 kW or even 12000 kW will appear on Swiss rails.

Table 1 Notable Converter Locomotives

Type	Railway	Axle config	Power kW	Tract. eff.kN	kg/kw	Overall weight	Year in service
Be4/4	SBB	BoBo	950	75	67	64 T	1972
Am6/6	SBB	CoCo	1840	240	60	111 T	1976
Em6/6^{II}	SBB	CoCo	1500	355	70	105 T	1979
Re4/4	BT/SZU	BoBo	3200	240	21	68 T	1987
Re4/4^{V}	SBB	BoBo	3200	240	22	74 T	1990
Re4/4^{VI}	SBB	BoBo	6100	275	13.2	81 T	1990
Re4/4	BLS	BoBo	7000	300	11.5	81 T	1992
Ge4/4^{III}*	RhB	BoBo	3500	250	18	64 T	1993

* Metre gauge