# Locomotive BLS Ae 8/8 275


**Dossier de recherches lié au cours de conservation restauration**
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**HEAA Arc / Filière Conservation-Restauration**
**Orientation OSTH 1ère année**
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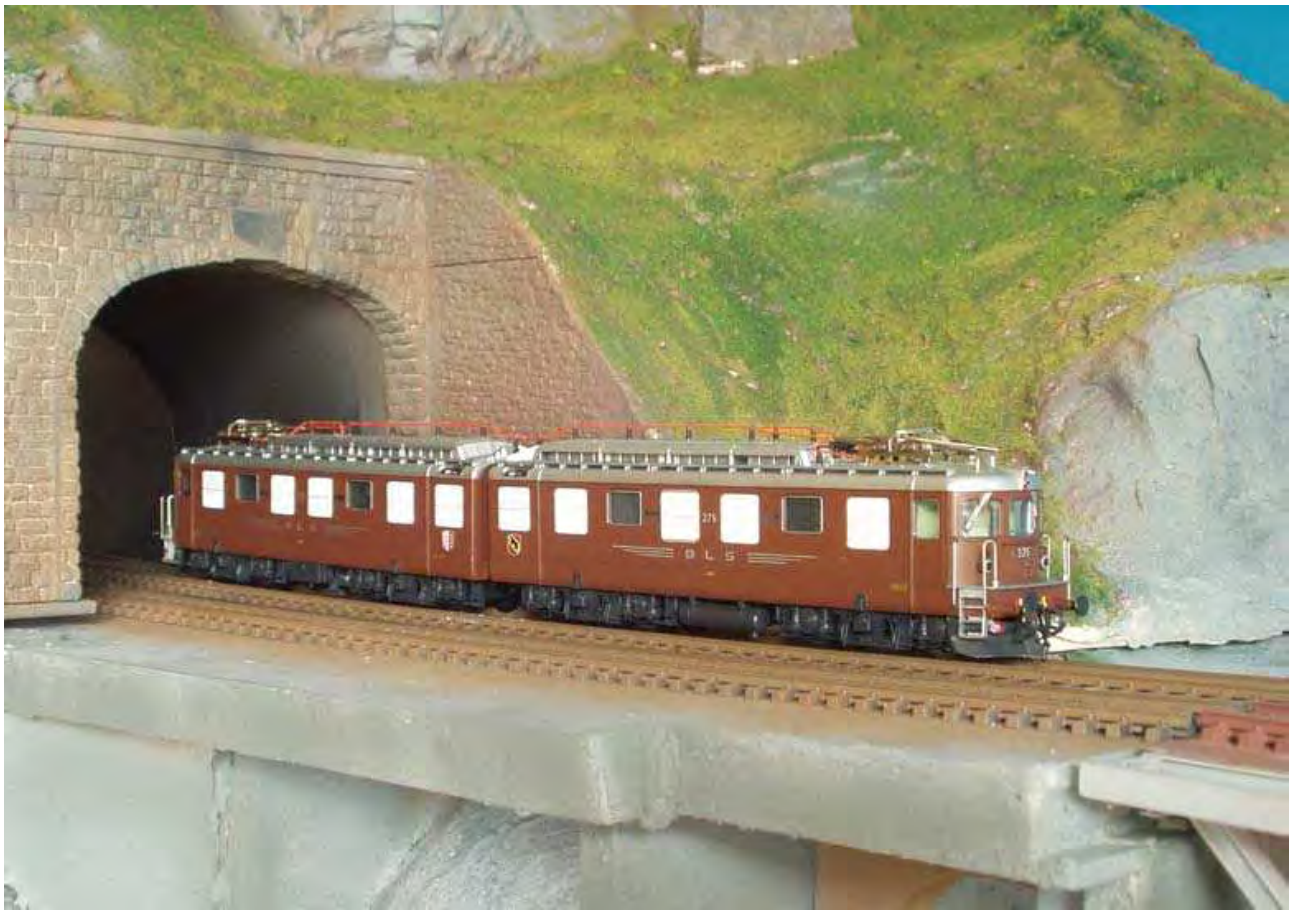

Illustration René Wolf

First page illustration “bls-info.ch”

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# 1. Introduction

The five engines Ae 8/8 271-275 of the BLS have furrowed the slopes of the Alps for soon 50 years.

Which motivations the engineers did they find to build steel monsters of more than 8000 HP?

The reader will find in the first part the historical evocation of company BLS, the large engines which preceded famous Ae 8/8, a detailed description of this engine and the technological innovations that it brings.

The second part is devoted to the report of current state like to the diagnosis of “the” Ae 8/8 275 preserved at the Verkerhshaus at Luzern.
A proposal of treatment and a development is also outlined.

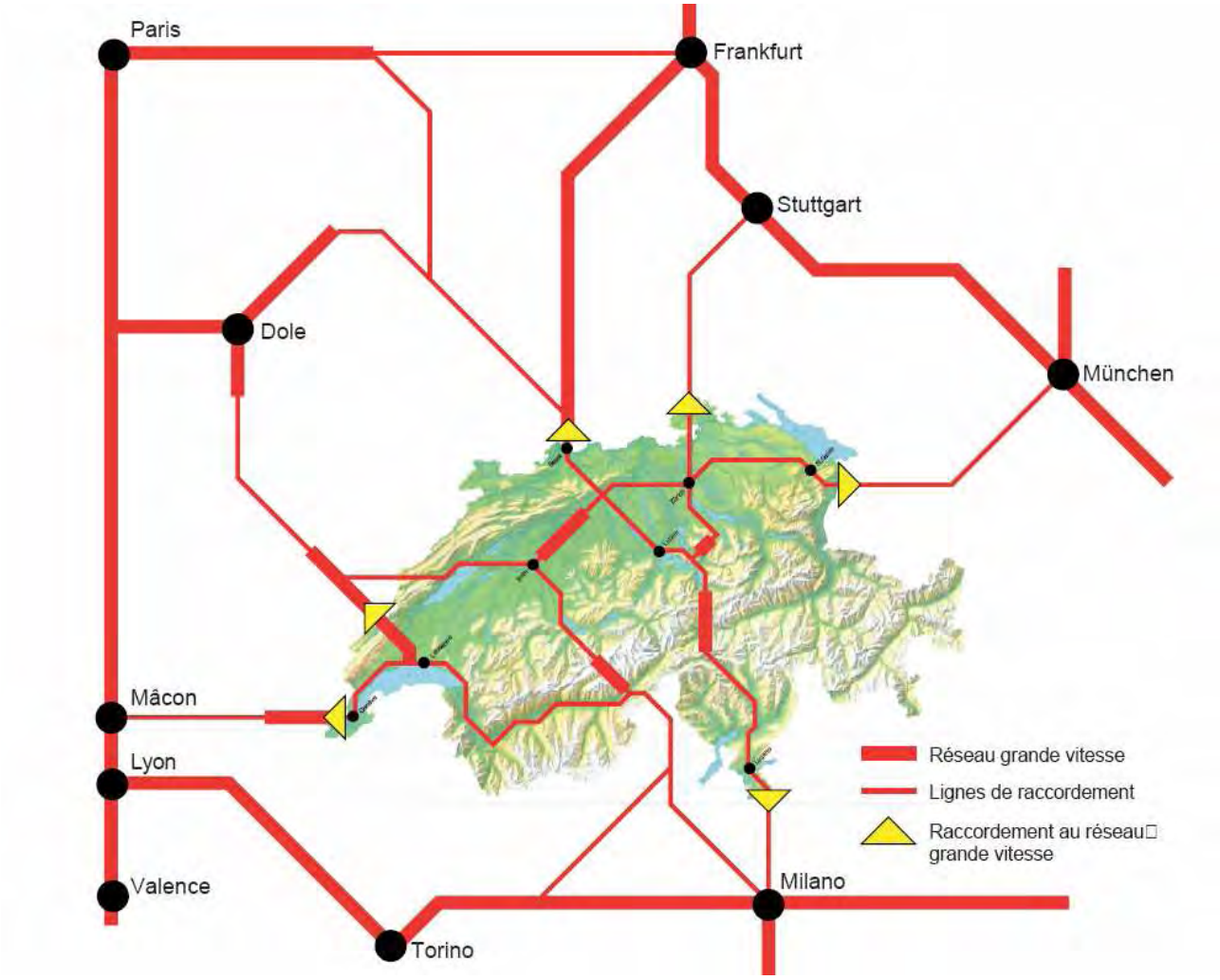
Lastly, the reader will find in the appendices a lexicon, a plan of the layout of mountain and the charts of the offered products.

# 2. History

## 2.1. The Bern - Lötschberg - Simplon Company

The opening of the Gothard's line in 1882 which connected up Basle to Chiasso excludes the canton of Bern in its race with a North-South rail link. The annexation of Alsace-Lorraine by the German Empire in 1870 allowed the canton of Bern to finance a crossing through the Alps in its canton. Indeed, a Parisian financial group provides its assistance to this new route.

A groupe of personalities of Bernese Oberland plained to build a short railway section of Spiez to Frutigen to join the Simplon's tunnel. The Lötschberg has been selected, and on July 27, 1906 the "railway company of the Bernese Alps" has been constituted under initials BLS (Bern - Lötschberg - Simplon).



The boring of the Lötschberg's tunnel (14.6 kilometres) began on October 15, 1906, the inauguration's year of the Simplon's tunnel. It was built with double track from the beginning and it was completed on March 11, 1911. The line of Lötschberg was immediately electrified whith single-phase current of 15'000 volts 16.7 Hertz. It was inaugurated on July 15, 1913.

In 1919, the Alsace and Lorraine became a part of French territory again. The point border of Delle lost its importance. The Lötschberg's line was developed in the international traffic of goods between Germany and the industrial centers of Piedmont. The national traffic had a great importance between Wallis and central Switzerland.
In 1913, the BLS operate Thunerseebahn (TSB: Thoune - Interlaken - Böningen). It exploited also the railroad Bern - Neuchâtel (BN), Gürbetalbahn (GTB), Bern - Schwarzenburg - Bahn (BSB), Spiez - Erlenbach - Bahn (SEB) and Erlenbach - Zweisimmen - Bahn (EZB). By this fusion, the BLS also became owner of the navigation's service over the Thoune and Brienz's Lakes.
A second fusion appeared in 1944. Thus, the GTB and BSB became the GBS (Gürbetal - Bern - Schwarzenburg - Bahn) and the SEB and EZB became the SEZ (Spiez - Erlenbach - Zweisimmen - Bahn).
A few other works have taken place in 1976 (doubling of the way on the Lötschberg's line) and in 1993 (corridor of piggyback allowing the passage of the 4 height meters trucks). In 1992, after votation, the Swiss accepted the project NLFA (Nouvelle Liaison Ferroviaire Alpine), and a tunnel was dug on 34.6 kilometres between Frutingen and the Rhone's valley.
Lastly, a last fusion has take place on January 1, 1997. The SEZ, GBS and BN will amalgamate with the BLS to become the new company BLS (Lötschbergbahn AG).

## *2.2. Some famous locomotives from the origins to Ae 8/8*

Among the many engines that company BLS had in its travelling vehicle fleet, here is the description of the most famous than we selected. With these engines we will recall quickly the great technological developments.

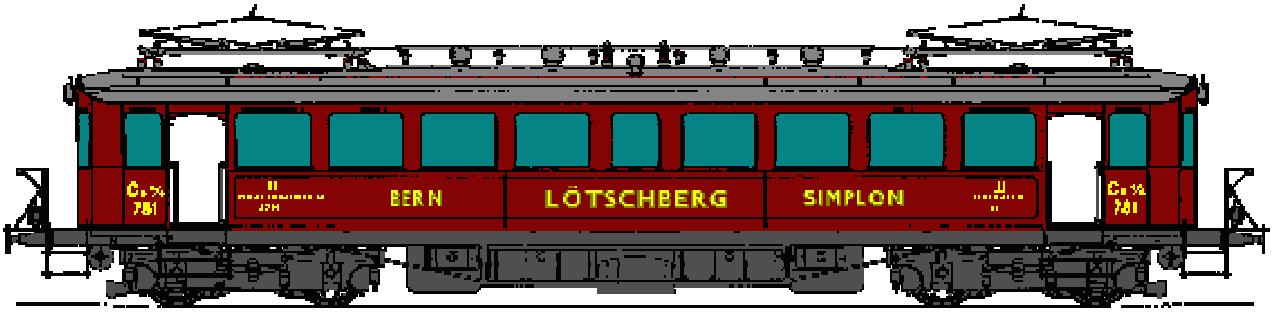



Illustration Bruno Laemmli

The first railcars chosen for the Spiez-Frutigen line were the Ce 2/4 781 and 783. They carried out the experimental voyages in July 1910. These first railcars replaced the steam traction for the transport of the passengers. They had Westinghouse type's brakes and automatic air compressed brake. Each engine had 225 HP and could transport a train of 120 tons on slopes from 15‰ to 45 km/h.

They were transformed into Ce 4/4 in 1935 and their power passed from 450 to 800 HP. The transformer gave a continuous power of 490 kVA and had an air cooling. Eleven positions of walk were laid out laterally. The same year, cradles were installed in the bogies. These railcars were removed into 1953/54 and were replaced by ABDe 4/8 746-748.

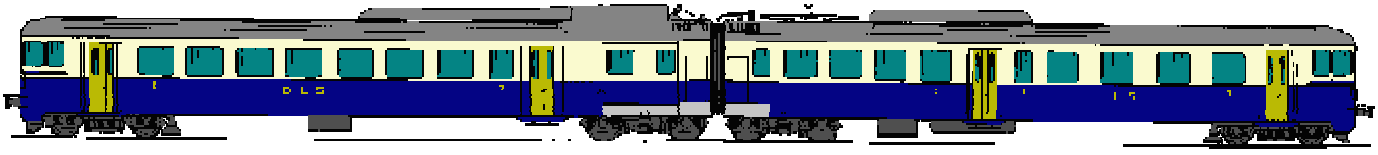


Illustration Bruno Laemmli

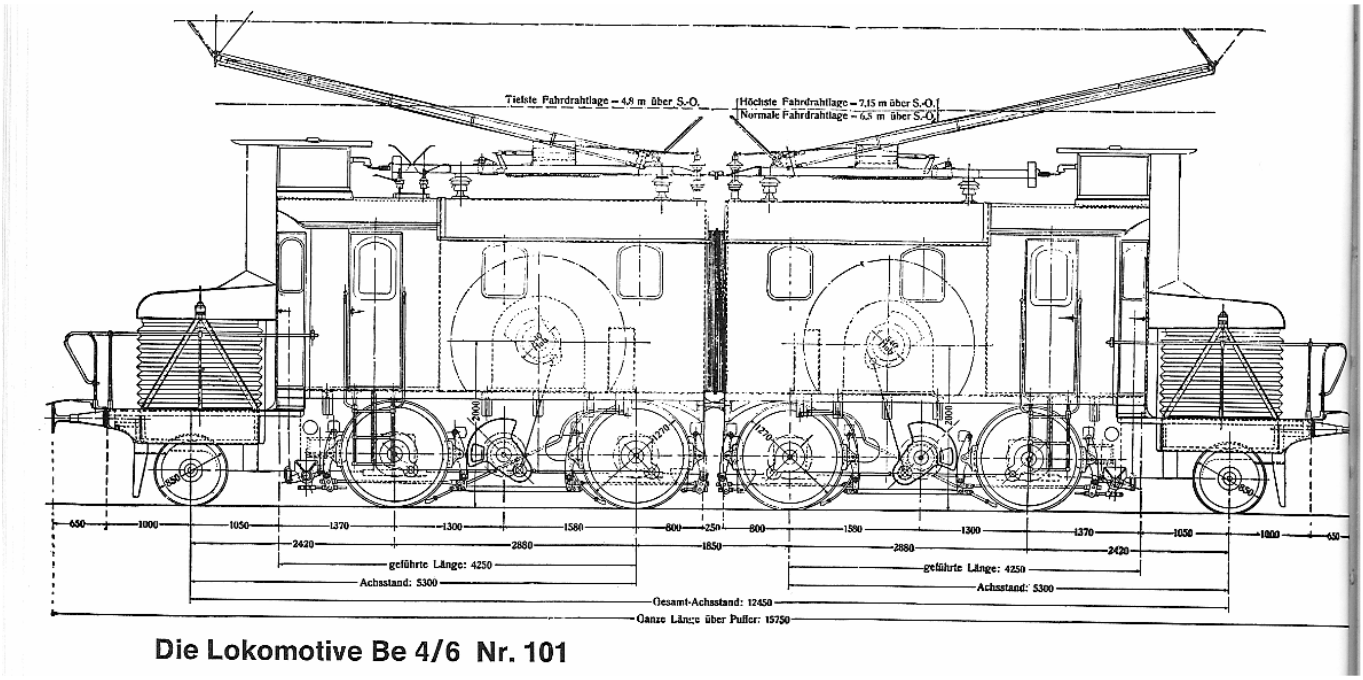



Illustration Claude Jeanmaire

Be 4/6 was the second engine ordered by the BLS for the experimental distance. This engine was ordered from Berlin. The mechanical part was coming from Munich. It could mount a goods train of 400 tons out of 15‰ and 250 tons out of 27‰ with approximately 40km/h. In fact, they were two engines assembled by the back having each one a carrying axle and a driving axle. The two other driving axles were coupled. The two engines were coupled by bellows with transition to allow the passage of the personnel. This fact is interesting because it will be taken again on Ae 8/8. The Be 4/6 had also Westinghouse brakes and hands brakes. The carrying axles did not have brakes. Each half engine had its pantograph. Among the problems it was noticed a frequent overheating. In 1912, it was sold at the Prussian Royal Railway Administration (KPEV).

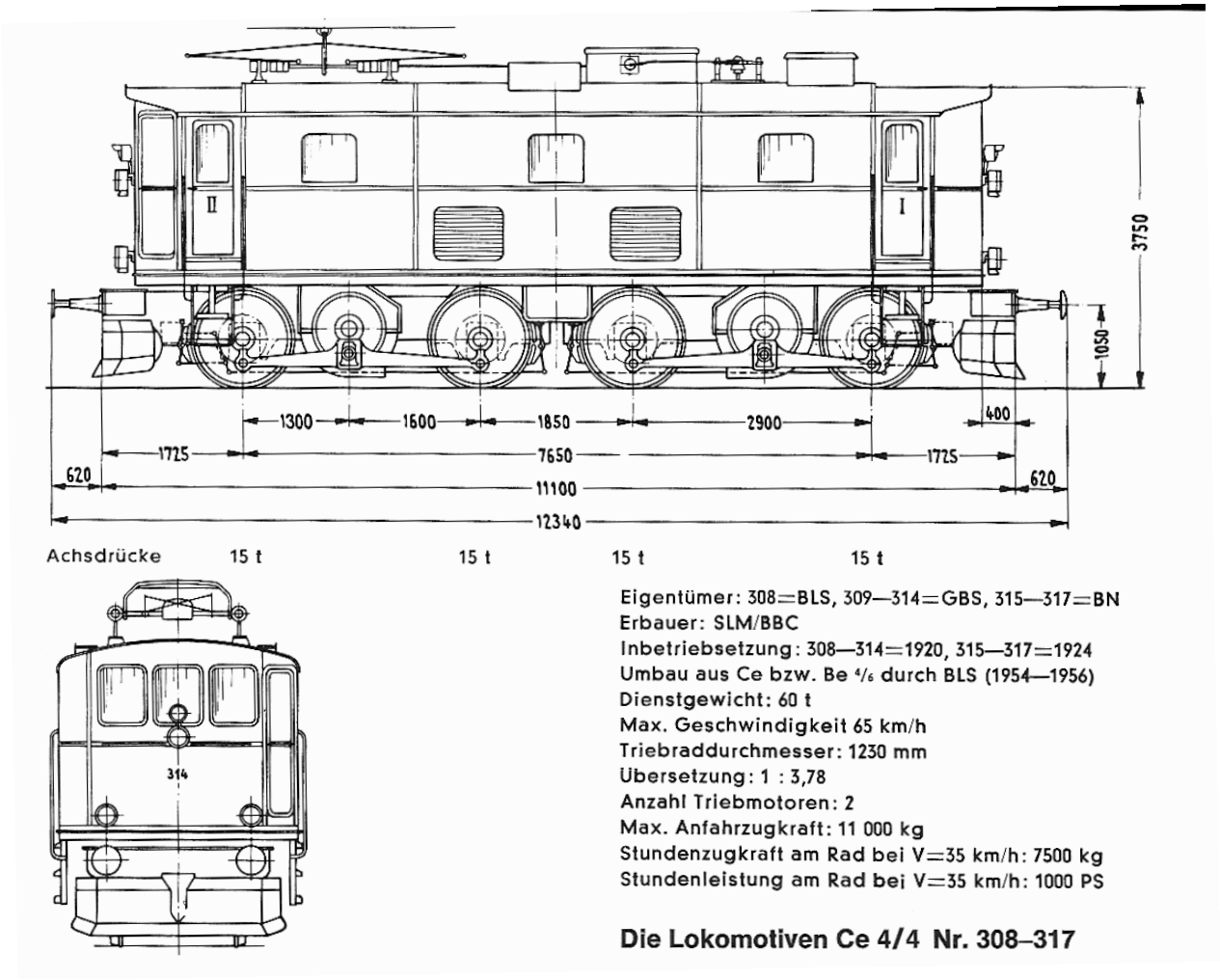



Illustration Claude Jeanmaire

In 1918, 14 engines Ce 4/4 were ordered for company BLS. That followed the line's electrification. These lighter engines could transport people and freight at a maximum speed of 65 km/h. Company SLM (Schweizerische Lokomotiv- und Maschinen- fabrik, Winterthur) manufactured the mechanical part and MFO (Maschinenfabrik Oerlikon) and BBC (Brown, Boveri & Cie., Baden) the electric components. They were to be able to climb a load of 180 tons to 35 km/h on a slope of 25‰. These engines had two bogies and 4 driving axles. These transformers of the engines were cooled naturally. They had 16 positions of walk. Several transformations were carried out by workshops BLS: circuit breaker, order by electropneumatic relay, natural cooler replaced, tachometers on ball bearing, signals of red light, pinions of transmission ratio 1:3.78, ventilators of engines and grilles ventilation, etc.

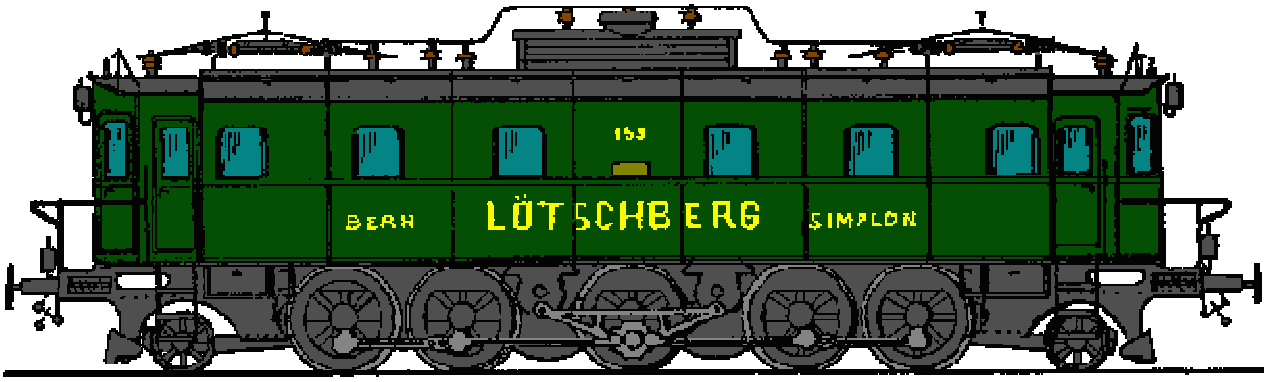
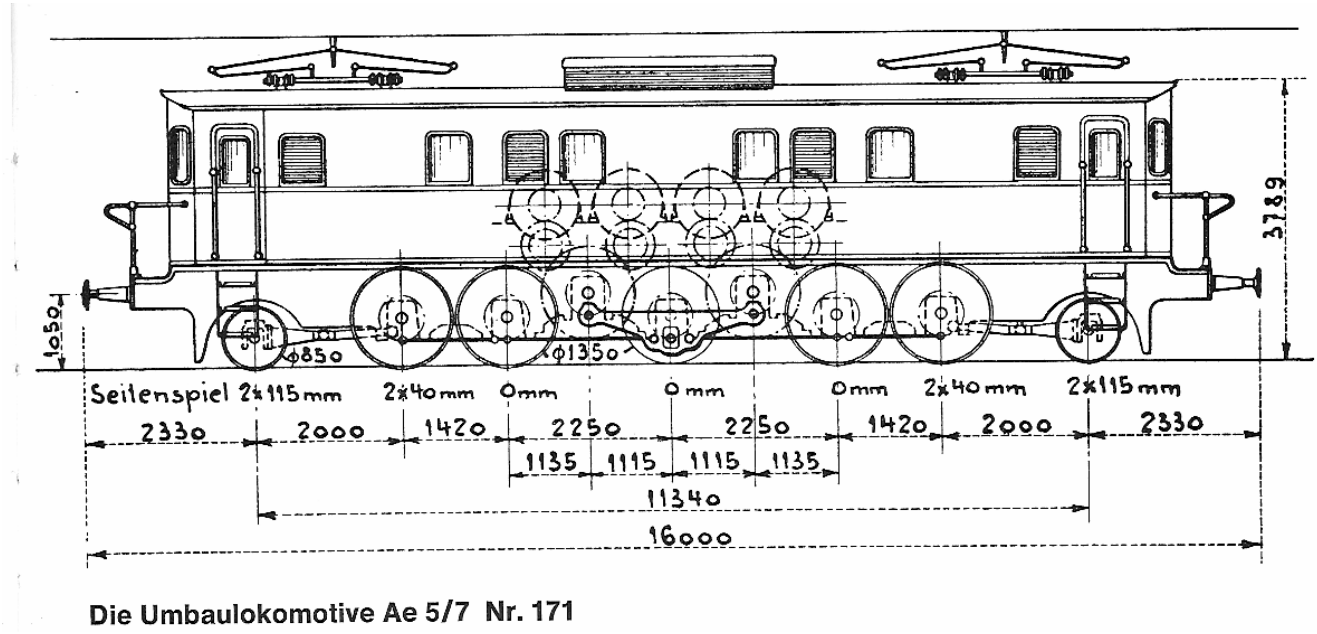



Illustration Bruno Laemmli

Another famous engine was Be 5/7 then Ae 5/7. This engine could draw 330 tons with 50 km/h on a slope from 27‰. For the time, they were most powerful. The gear boxes were manufactured by Citroen. An engine with open box is currently in the "Verkerhshaus" of Luzern.




**Die Umbaulokomotive Ae 5/7 Nr. 171**

Illustration Claude Jeanmaire

In 1941, the engine Be 5/7 151 was transformed into Be 5/7 171. Its maximum speed passed from 75 to 90 km/h with 3000 HP, thanks to more powerful engines.

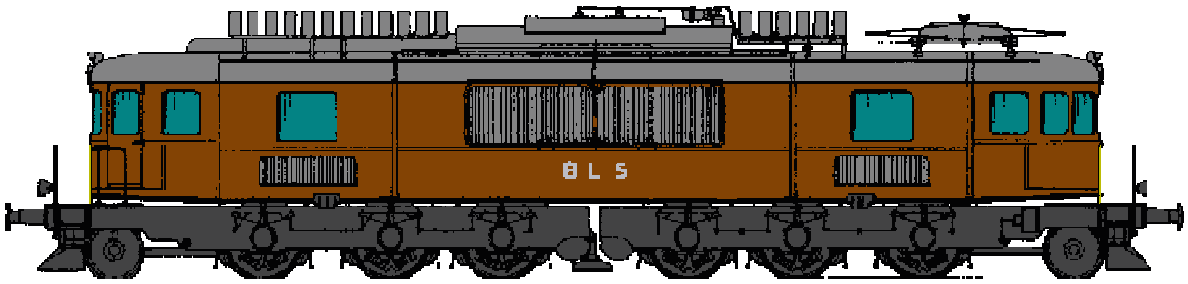
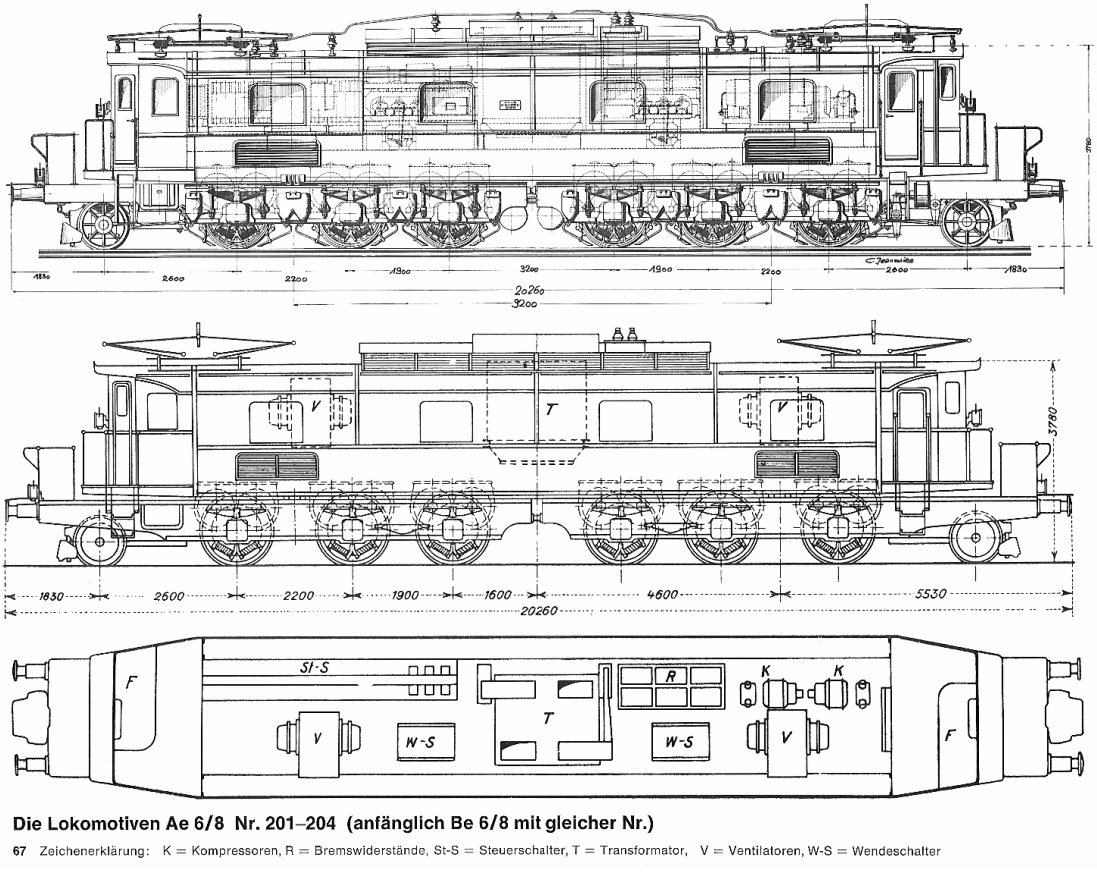



Illustration Bruno Laemmli

In 1926, the BLS acquired the engines Ae 6/8 201-208, considered as strongest of the world. They were built by the French workshops of "Sécheron"[1]. The six driving axles develop 6000 HP and draw 650 tons at 100km/h. These powerful engines proved reliable during long years in heavy transport in mountain.



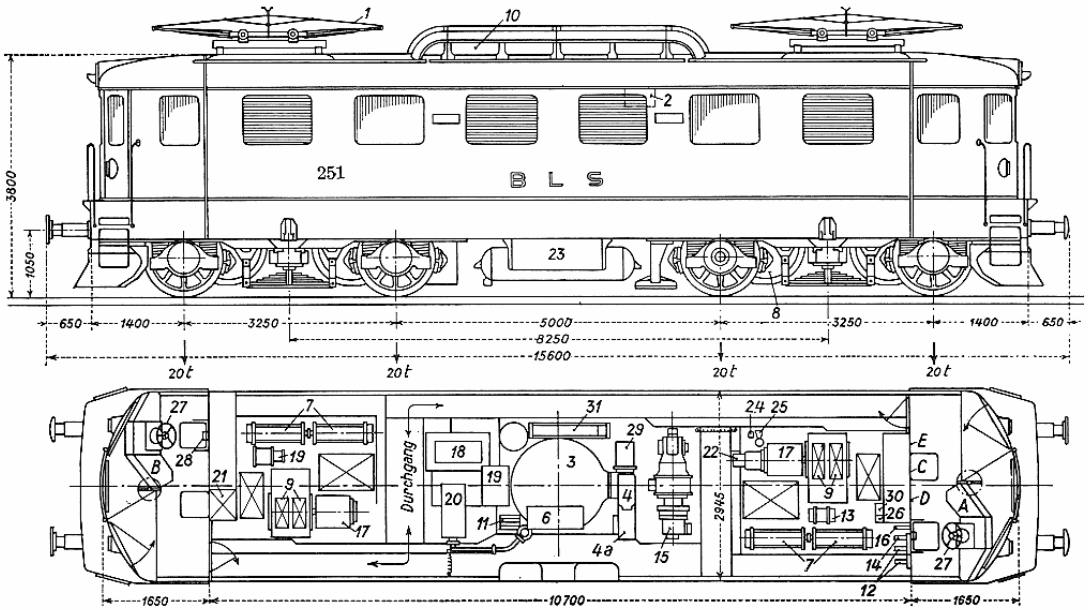

**Die Lokomotiven Ae 6/8 Nr. 201–204 (anfänglich Be 6/8 mit gleicher Nr.)**

67 Zeichenerklärung: K = Kompressoren, R = Bremswiderstände, St-S = Steuerschalter, T = Transformator, V = Ventilatoren, W-S = Wendeschalter

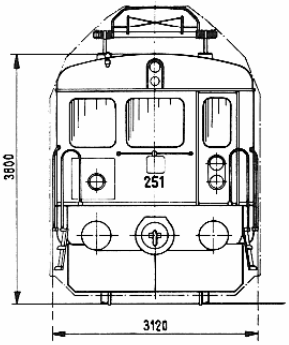
Illustration Claude Jeanmaire

[1] (SAAS), Société Anonyme des Ateliers de Sécheron.

# *2.3. The engine Ae 4/4*




A/B Beleuchtungsschalttafel, C Wechselstromschalttafel, D Gleichstromschalttafel, E Relaistafel, 1 Stromabnehmer, 2 Druckluft-Hauptschalter, 3 Stufentransformator, 4 Stufenschalter, 4a Funkenlöschschalter, 6 Ueberschaltwiderstand, 7 Wendeschalter, 8 Triebmotor, 9 Ohmscher Shunt, 10 Bremswiderstand, 11 4poliger Trennhüpfer, 12 Heizhüpfer, 13 Transformator-Hilfsmotoren, 14 Hüpfer für den Kompressormotor, 15 Kompressor, 16 Hüpfer für die Ventilatormotoren, 17 Ventilatormotoren für Triebmotor-Belüftung, 18 Vorschaltwiderstand für Hilfsmotoren Pos. 17, 19 Beleuchtungsgenerator, 20 Ventilator und Oelpumpe für den Transformator, 21 Oelwärmeplatte, 22 Bremsgenerator, 23 Akkumulatoren-Batterie (36 V, 90 bis 100 Ah), 24 el. pneum. Ventil für Stromabnehmer, 25 Handluftpumpe, 26 Einschaltrelais für Hauptschalter, 27 Steuerkontroller, 28 Stufenschalterhandantrieb, 29 Stufenschaltermotor, 30 Verzögerungsrelais, Bremsrelais, Hilfsrelais (für die Sicherheitssteuerung), 31 Pneumatische Apparate




**Die Lokomotiven Ae 4/4 Nr. 251–258**

**101** Typenzeichnung und Grundriss dieser ersten Bo'Bo'-Lokomotive (Ablieferungszustand) ohne Laufachsen, welche eine neue Ära für elektrische Lokomotiven grosser Leistungsfähigkeit eröffnete. Die Ae 4/4-Maschinen von 1944/45 mussten sich im Verlaufe der folgenden Jahre noch manche Änderung an ihrem ursprünglichen Aussehen gefallen lassen, doch davon im nächsten Abschnitt. Die letzte Lokomotive dieser acht Maschinen umfassenden Serie wurde erst 1955 nachgeliefert.

Illustration Claude Jeanmaire

In 1944, a significant projection took place in the development of the electric engines. This evolution was going to make it possible to build powerful and fast engines: Ae 4/4. For the first time it was built engines without carrying axles. This improvement made it possible to increase maximum speed in steeply sloping sections. For example 400 tons with 75 km/h on slopes of 27‰. These machines form the starting point for the many ones and great series of Bo-Bo engines which are used today in the large European railroad companies and of overseas. Be 5/7 became too slow on the sloping sections on the line Bern Thoune and in the tunnel of Lötschberg. They became also too old and required too much expensive maintenance.

The eight engines Ae4/4 (251-258) were manufactured by company SLM for mechanics and BBC for the electric part. Several technical improvements made it possible to reduce considerably the weight of these engines: new transformer, forefront material, monopiece body with welded joints and use of joints welded for the bogie trucks.

Engine room. Illustration “bls-info.ch”

These engines still innovate by creating a double suspension for the executives of the bogie trucks: a suspension with spiral springs and a suspension with plate. The suspension of the body becomes thus oscillating to compensate the effects due to acceleration.

On the level of lubrication, the engines are equipped with closed oil baths and a flexible clutch is inserted between the two bogie trucks. The other sliding elements are laid out in baths of oil.

Detail bogie. Illustration “bls-info.ch”

The BBC developed a particular transmission with vagueness of torsion passing in the body of the rotor of impulse and the couplings with flexible discs. The clutch disks and the wave of torsion do not require any lubrication and any maintenance.
The Ae4/4 engines have mechanical brakes, double Westinghouse brakes, GPR-Wechsel, a brake of centrifugal machine and a hand brake. All the axes are slowed down by four blocks. The brake of centrifugal machine, developed by the BBC, is electropneumatic. It also makes it possible to clean the treads of the wheels.

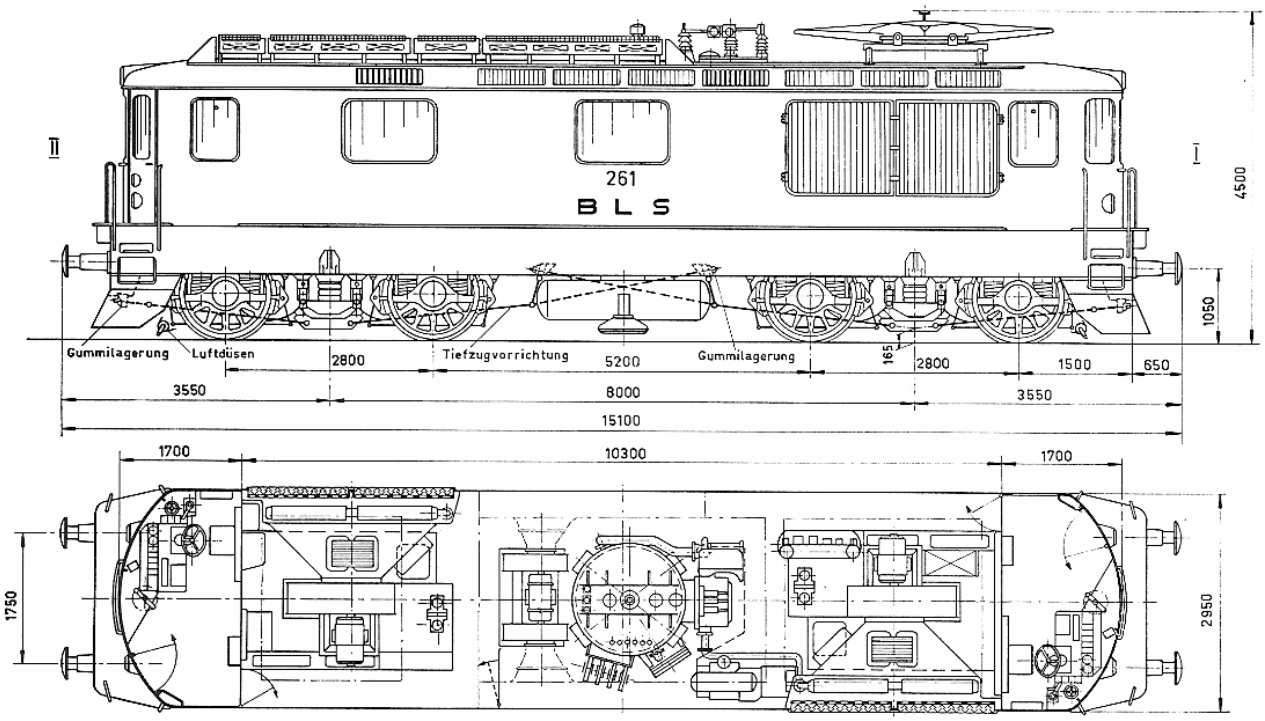
Cockpit. Illustration “bls-info.ch”

For the electric part, the Ae4/4 engines were equipped by switches at high speed of compressed air instead of the principal switches. The rotors of series are compensated

with reels of pole and allow a time output of 1000 HP with 395 V. Cooling takes place by introduction of surrounding air with ventilation's engines.
Numbers 253 and 254 are delivered in 1948 and four years later, the n°255 and 256.
The roofs riveted out of sheet aluminium creating of the problems (rivets, damages by the taps of ice, arcs of short-circuit), the other engines accepted roofs out of sheet steel welded. The roofs were also changed on the other engines.

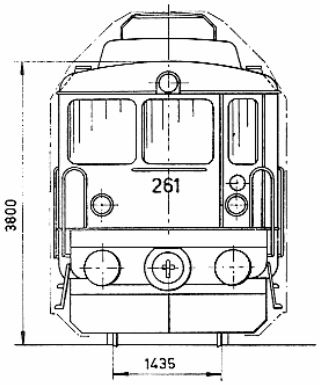
Engine room. Illustration "bls-info.ch"

The electric components gave satisfaction: maintain of the collectors were only necessary after 1'200'000 kilometres, pantograph's brushes wore little, the transformers and controllers gave satisfaction.
There more were changes necessary after 1946 for the switches. The other engines received larger radiators. Two other engines (257 and 258) were ordered in 1954. They were equipped with a reinforced brake of resistance and could resist the load of 220 tons on the slopes of Lötschberg with 27‰.
At that time the same brake of resistance and the principal switch were installed on the six other machines, like the pneumatic device of attachment. The eight engines had some light improvements: replacement of support's plates by rubber blades, ventilation grilles to multiple tubes replaced ventilation's shutters (1963).
From 1965 to 1970, the machines 251-252 and 257-258 were called 4/41 then they were called Re 4/4 261-265.




| | | | |
|---|---|---|---|
| Triebraddurchmesser | 1250 mm | Stundenzugkraft am Rad bei 75 km/h | 22 t |
| Übersetzungsverhältnis | 1 : 3,346 | Stundenleistung am Rad bei 75 km/h | 6240 PS |
| Anzahl Triebmotoren | 4 | (mit zirka 12% Leistungsreserve der Triebmotoren) | |
| Gewicht mech. Teil | 39,7 t | Max. Anfahrzugkraft | 32 t |
| elektr. Teil | 40,3 t | Motorspannung Umax. | 980 V = |
| Dienstgewicht = Reibungsgewicht | 80,0 t | Höchstgeschwindigkeit | 125/140 km/h |
| Achsdruck | 20,0 t | Motordrehzahl bei 125 km/h | 1800 |
| Angriffspunkt der Tiefzugvorrichtung ab SOK | 165 mm | Federantrieb mit 8 Federpaketen | |

Siliziumgleichrichter BBC
Hochspannungssteuerung BBC 32 Fahrstufen
Elektr. Widerstandsbremse
Sicherheitssteuerung und Zugsicherung
Automatische Oerlikon-Bremse R/G
Erbauer: Mechanischer Teil SLM
Elektrischer Teil BBC
Inbetriebnahme Ae 4/4 261–262 1965 2. 1965




**Die Gleichrichter-Lokomotiven Ae 4/4 II Nr. 261–265 (später Serie Re 4/4)**

Illustration Claude Jeanmaire

## *2.4. The engine Ae 8/8*

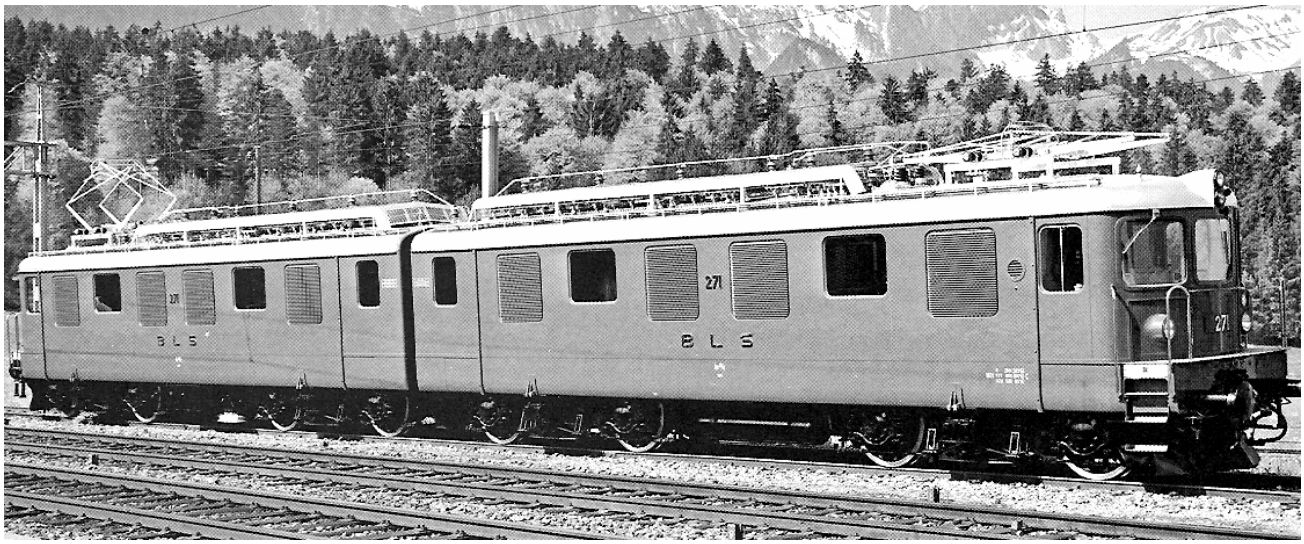



Illustration Claude Jeanmaire

In the years 1950, freight having to pass by Lötschberg reached 900 tons for slopes of 27‰. To draw this weight, several engines had to be harnessed. The BLS then decided to build only one engine by coupling two Ae 4/4. The mechanical part is similar to Ae 4/4. A intercommunication's bellows were installed between the two engines.

Joint, intercommunication's bellow and passage. Illustration "bls-info.ch"

In 1962 and 1963, companies SLM and BBC delivered the engines Ae8/8 271 and 272, for the carrying of heavy goods trains and travellers.

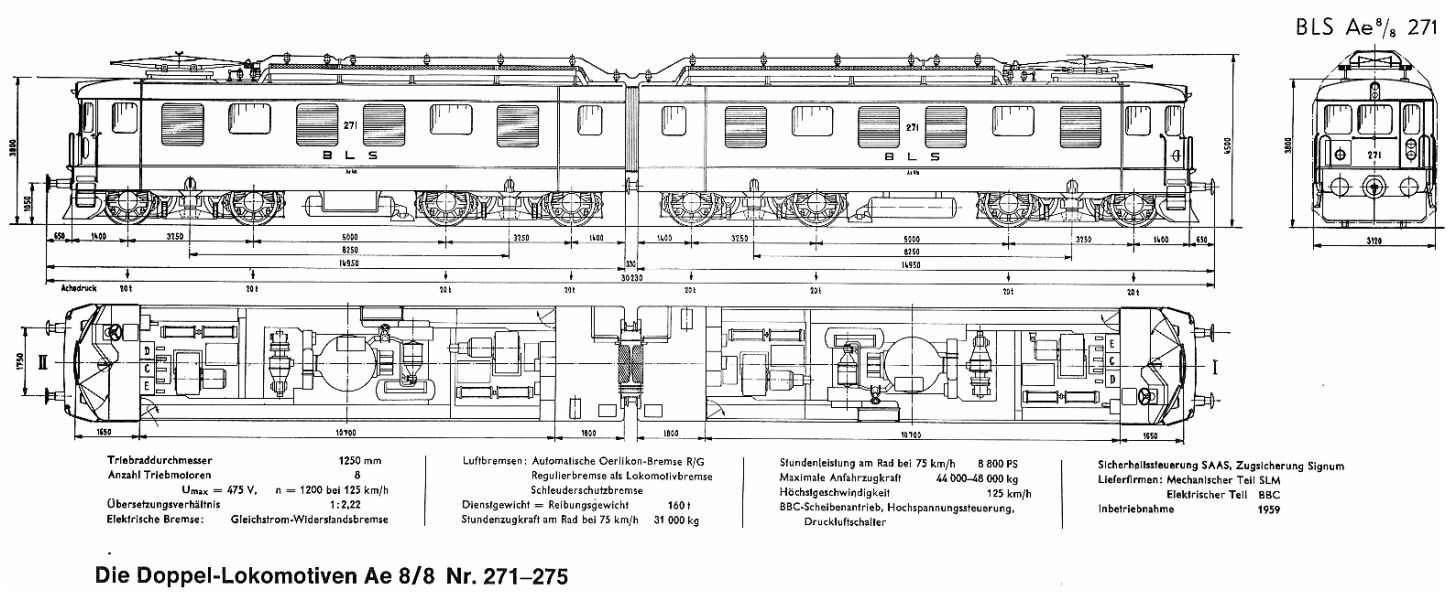



Illustration Claude Jeanmaire

The electropneumatic brake of centrifugal machine, developed on Ae4/4, allowing the compensation of the loads is taken again. It always makes it possible to clean the wheel's treads. This device is very effective to blow snow and makes it possible to obtain good performances in all seasons.

In 1963, Ae 8/8 273 is created and baptized "Bern und Wallis"


Illustration Claude Jeanmaire

In 1963, the shutters of ventilation were replaced by grids with multiple tubes. In 1965, the engines received an electropneumatic controller with 32 positions with an electronic distributor. The rods with mechanical drive were not necessary any more.

The electric output passes from 2' 700 kVa to 3' 080 kVa, giving a time output of 1' 100 HP with 395 V.


Illustration Claude Jeanmaire

The n°274 and 275 (realized with the engines Ae4/4 253-256 in 1966) received new reels of tension for an adaptation of power. To guarantee better ventilation, the zones of transition received new grids with multiple tubes. Loads towed being of 1'300 tons after 1981, the multiple order were inserted in Ae 8/8.

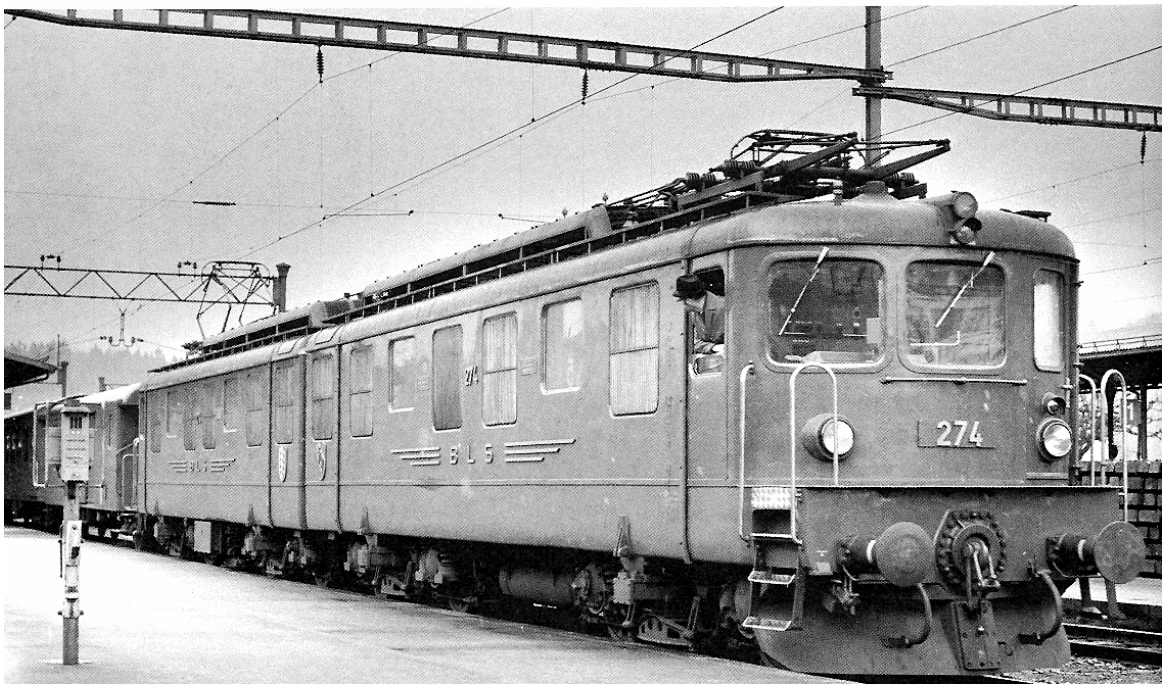



Illustration Claude Jeanmaire

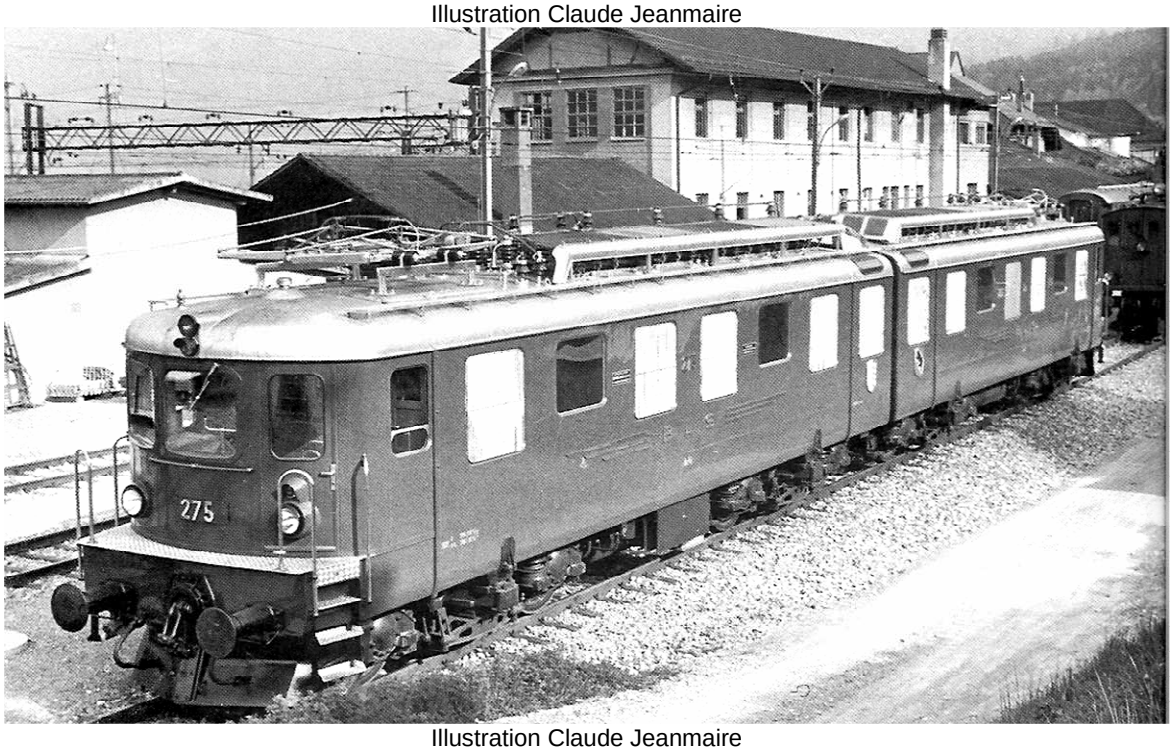



Illustration Claude Jeanmaire

The progressive renewal allowed at the time transport of 1'100 tons with only one engine on slopes of 27‰. The trains having to draw 1'400 tons on the same slopes were to add an engine 6/8 or Re 4/4 to preserve the performances.

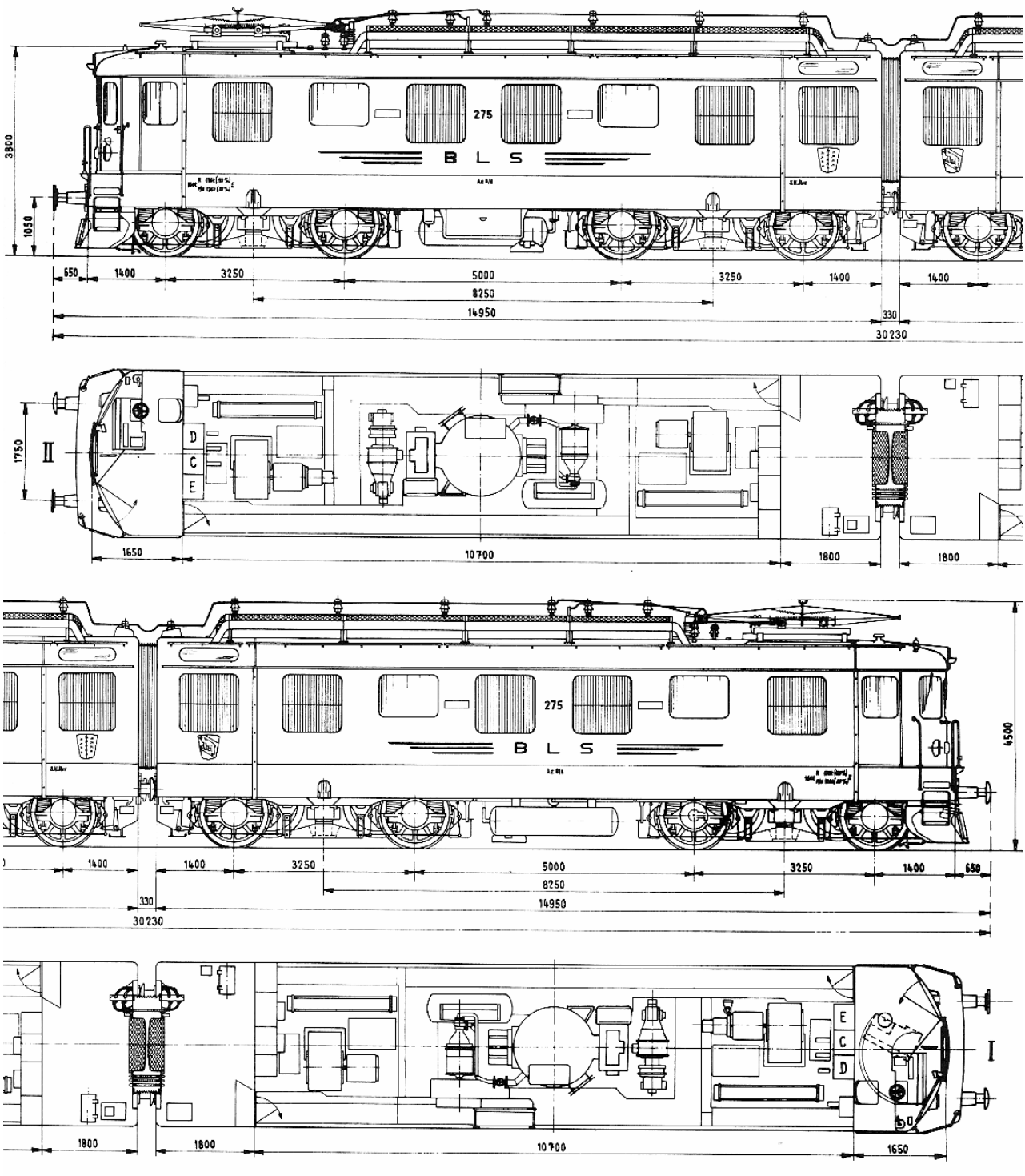



Illustration Claude Jeanmaire

It will be renamed Ae 485

Engine 274 was withdrawn from the traffic in 1995 and the four others in 1996.

Talks were to make it possible to sell the four engines with the Swedish Railroad. Unfortunately, the n° 273 was damaged by fire on Oc tober 6, 1997 in Schwartzenburg. It was repaired and is now in Bönigen.

Illustration. Johan De Reuver

Engines 271 and 272 were entirely destroyed on May 15, 1998 in the fire of the wood deposit of Spiez.


The 275 is currently in Verkerhshaus of Luzerne.


Illustration Fanny Bettex

Company BLS is always owner of the n° 275 but wishe s to preserve only one specimen in operating state. It is the n° 273 which was selecte d. It is thus excluded that an appropriation can be released to restore the n° 275 .

## *2.5. Design features*

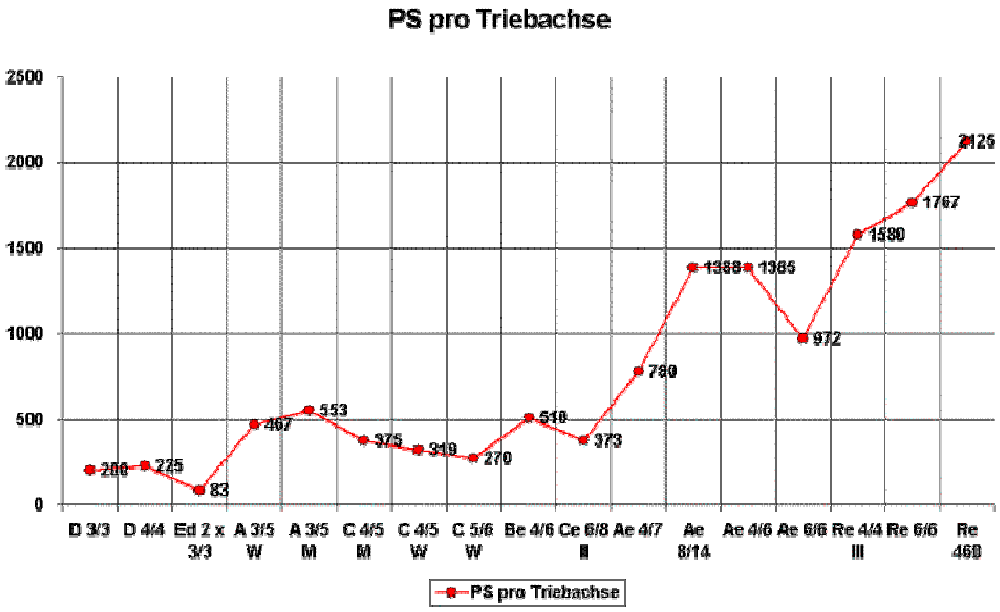
| | |
|---|---|
| Designation | Ae 8/8 |
| Serial number | 271-275 |
| Supply tension of overhead wire | 15'000 V 16.7 Hz. |
| Gauge | 1435 mm |
| Maximum speed | 125 km/h |
| Average speed | 76 km/h |
| Weight in service | 160 tons |
| Adherent weight | 160 tons |
| Length except buffer | 30'230 mm |
| Height | 3'800 mm |
| Width | 4'500 mm |
| Power | 6476 kW – 8800 HP |
| Wheel diameter | 1250 mm |
| Gear ratio | 1:2.221 |
| Wheel arrangement | BoBo+BoBo |
| Total wheelbase | 26100 mm |
| Bogie wheelbase | 3250 mm |
| Motors | 8 |
| Force maximum traction of demarrage | ca 46'000 kg |
| Cut-over date | 1959-1966 |
| Builders | SLM/BBC |

According with the oral discussion with Mr Patrick Belloncle of the BLS Bern[2], the engine Ae 8/8 is entirely built out of heavy steel. The first had an aluminium roof riveted to reduce the weight. The following ones, to which belonged Ae 8/8 275 have a weld steel roof. This roof is covered with a grey metallized painting. The pantographs are out of aluminium and copper. The footboards are out of aluminium. Certain parts out of ferrous metal alloy (handles) are covered with a nickelled or chromed treatment surface. Others out of copper alloy metal (logos of the BLS) are also covered with a nickelled or chromed treatment

[2] Oral conversation with Mr Patrick Belloncle, (BLS Bern), may 30, 2005.

surface. Certain parts are out of organic materials, as the intercommunication's bellows which is out of polymer. The electrical insulators are out of ceramics.

The engine was initially painted in green and then red-brown. Painting was provided by Ripolin©. The engines were repainted every ten years and were washed every 15 days. Lastly, the friction of the air constituted a natural polishing. The last coat of paint applied was a indelible water painting.



## *2.6. Conditions of conservation*

The engine Ae 8/8 275 is exposed in Luzerne's Verkerhshaus in outside. It is subjected to the great variations of temperature, moisture and luminosity. It supports dust, the town air pollution and animals's dejections.


Illustration Fanny Bettex

Painting suffers as well as the metal substrate. The interior of the engine should not certainly be spare. The proximity of the road brings vibrations and acid polluting gases to him. It could also be the target of vandalisms.

Its museum's situation is not favourable. No many panels indicate its situation. The visitors must leave the train's area and much risk to miss it.

Illustration Michel Braekman

Preceding restorations or repairs were made on the engine. In fact, traces of coloured final improvements are visible.

# 3. Diagnosis and treatment propositions

## *3.1. Critical problems*

### Ferrous alloys.

Illustration Michel Braekman

To much places, the coat of paint left or is raised by forming bumps. Painting left following blows, frictions, vibrations or to the action of streaming water. Where painting left, metal is exposed. It is in contact with the external oxygen and active agents: rainwater, salts of snow clearances, acids, gas, pollution, dejections of the animals. The layer of chrome or nickelled protection also left in consequence of shocks or scratches.

There too, naked metal or its tack coat is not protected and corrodes for the same reasons.

Illustration Michel Braekman

When two different metals are in contact, one corrodes more quickly than the other. This corrosion is of galvanic origin. In this case, corrosion often develops below painting and progresses while raising it.

Illustration Fanny Bettex

Preceding restorations or repairs were made on the engine. Traces of coloured final improvements are visible. Painting is tarnished and leaves in scales to many places. Grey metallized Painting of the roof lets appear traces of color brown-red thus that of the corrosion of ferrous origin.

## Aluminium alloys.

The parts of the pantograph are not oxidized. They are only covered with filth and dust.

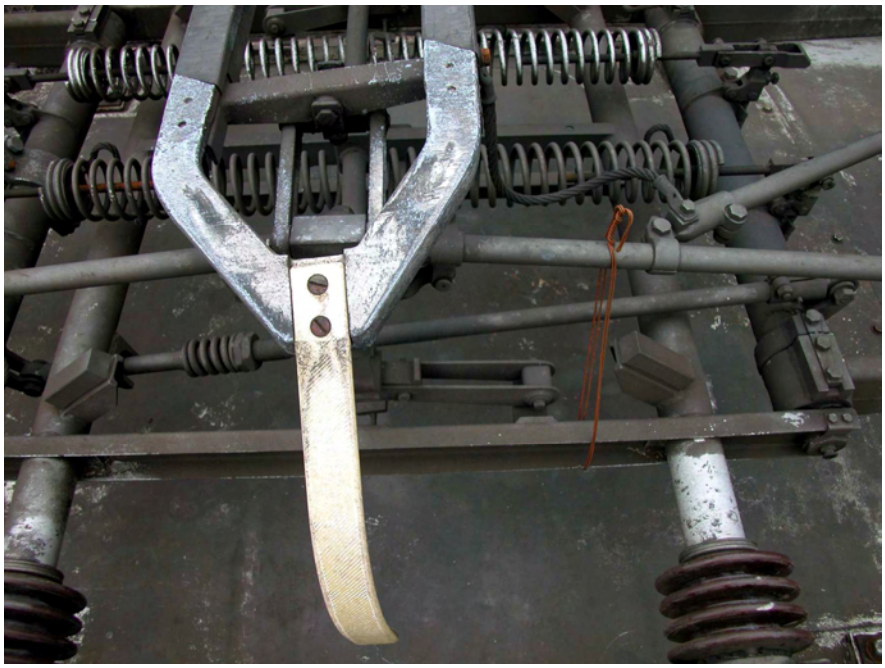


Illustration Wolf Meyer zu Bargholz

## Polymer parts

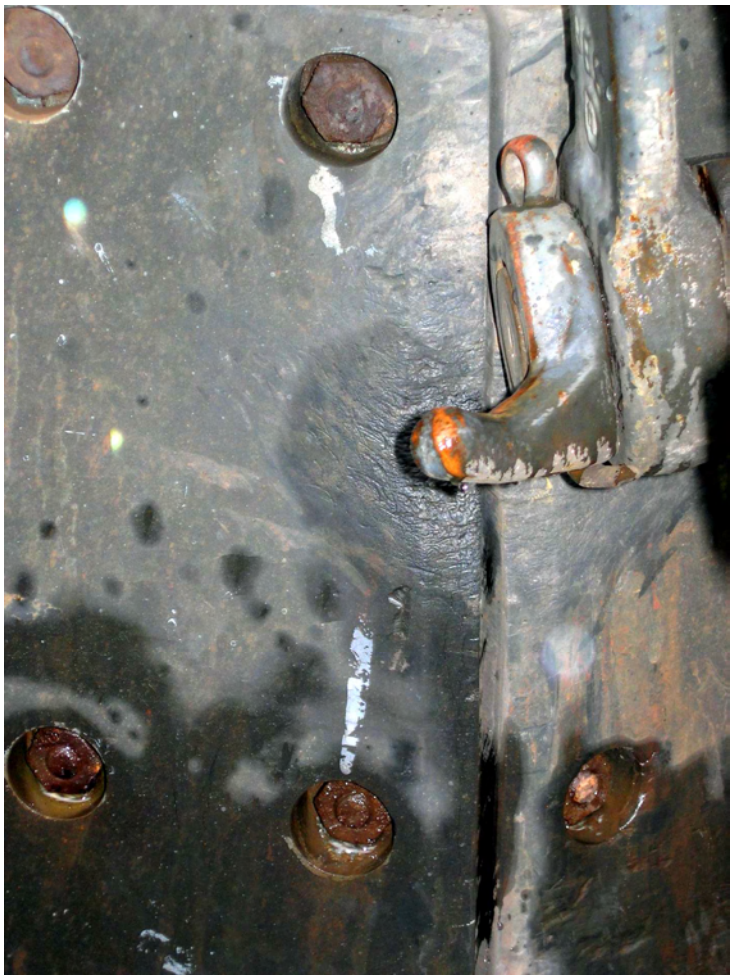


Illustration Fanny Bettex

These parts, present on the shields and composing the intercommunication's bellows start to be cracked under the effect of heat, the luminosity, the rain and the polluting acid agents. Ferrous corrosion also attacks these polymer plates by contact.

## *3.2. Suggested treatments*

The engine is mainly made up of metal parts. It is thus necessary initially to be interested in the various problems related to metal alloys to define the treatments adapted to each case.

Metals are confronted with various deteriorations:

1. The plastic deformation of metal is often caused by men or nature. It prevents legibility or operation. These deformations cause gaps which allow the development of oxidations.
2. The fair wear and tear of metal influences the aesthetic aspect and is characterized by a various matter contribution: pollens, greases, dust and pollutant's agents. These contributions allow the stagnation of moisture. Moisture present supports the chemical weathering of metal, therefore oxidation. Greasy substances protect metal. However, by their viscosity, they attract dust and are favourable with the development of the micro-organisms.
3. Lastly, corrosion is a chemical attack which occurs when the metal parts are in contact with air's oxygen and all the substances which are transported by the air. This attack is sometimes beneficial for metal and forms a protective coating, but in the case of iron or steel, this oxidation is harmful and destroyed in the long run the substrate.

Metals react differently to these attacks and their reaction depends on several factors: the type of metal, the level of pollution, the surface coating.
Several types of corrosion can develop when steel does not have any more good protection. At this time, it is put in contact with rainwater which conveys polluting agents, as the dioxide of suffers or carbon and various salts and acids present in the air.
It is possible to see corrosions on all the surface of metal, of intergranular or intragranular corrosions, pitting or galvanic corrosions.

In first conclusion, it is initially necessary to carry out a cleaning to remove dust, grease and all other concretions likely to retain water, thus supporting the oxidation and the development of the micro-organisms. This work will already make it possible to slow down the phenomenon of oxidation.

Two means can be used simultaneously or successively: mechanics and chemicals means. These two means can be combined between them. It is called the chemical method with mechanical activation.

Mechanics means are: scalpel, steel wool, sandpaper, brushes, microtour, glass fibre, wood sticks, files, sand spreader, toothbrushes, cotton paint, etc.

Chemical means use solvents, detergents or the surface-active to dissolve the filths and concretions.

The polar solvents (water) with slow evaporation make it possible to remove surface concretions and aren't aggressive for paintings and varnish.
The semi-polar solvents (alcohol, acetone, acetate of ethyl) penetrate quickly and evaporate more very quickly. They are able to dissolve surface coatings. They are to be used with very much precaution.
The nonpolar solvents (White-spirit, toluene) penetrate deeply and evaporate slowly. They dissolve dust, grease and don't attack surface coatings.

It is also possible to use chemical processes like the complexants:
The ethylene diamine tetraacetic acid (EDTA) attacks the ions coppers.
The sodium hexametaphosphate (Calgon) attacks copper and iron oxides.
The sodium hydrosulphite combined with the diethylene triamine pentacetic acid (DTPA) attracts the ferrous ions.

Lastly, it is possible to use the ultrasonic's baths and electrolysis to reduce the metal ions contained in the corrosion's products.

Of course, to determine which products and which methods must be used, it is necessary to start by making tests. It is only after analysis of these tests that we will be able to propose an adequate treatment.
Unfortunately, we didn't have the occasion to carry out such tests on the engine. We saw it only once, during a small hour, and the pictures show clearly the weather of this day.
We can thus only make a one theoretical study, see virtual, to imagine the products and methods which we would use in real situation.

## *3.3. Follow-up of the treatment*

How to protect metal surfaces?

After having cleaned surfaces well (metal, organic or polymeric), they must be protected from the external agents (water, air, acids, dust, greases, animal's dejections, mushrooms, micro-organisms, etc).

Three methods exist:

1. The preventive conservation which acts on the environment.
2. The stabilization which acts directly on the object.
3. The conservation-restoration which acts technically on the environment and directly on the object.

As far as possible, we choose the third method, most complete.

A. Environment:

Storage in a closed place, deprived of pollution (dust, carbon dioxide, etc), aired with 40% of relative humidity. One needs a stable temperature and panes anti UV to protect painting. The luminosity will not exceed 150 luxes to avoid a too great degradation.

B. Surface coatings:

To decrease the electrochemical reactions between the surface of metal and the ambient air, we recommend protective surfacing. For this, we can use acrylic resins, microcrystalline waxes or natural substances (paraffin, wax of carnauba).

The choice depends on the type of material and the future environment of the object, as well as legibility, hardness, flexibility, resistance to the ultraviolet rays, heat strength, ageing and reversibility.

All these products are diluted with the majority of solvents and can be applied to the rag, brush, aerographer or spray gun, by steeping or plug.

Pigments can be built-in to improve aesthetics.

Without having carried out tests, it is impossible for us and not ethical recommended to choose a product and a method of application.
We will thus quote some products available.

Paraloïd® B72, B44 and B48 N, Thermoplastic acrylic resin (methyl acrylate Copolymer).
Cosmoloïd® H80, microcrystalline wax.
Microcrystalline wax Renaissance.
Wax of Carnauba®
Paraffin oil, mineral oil.
Petroleum jelly.
Oil Ballistol®, purified paraffin oil
Spray oil of Motorex Gun Care®, White spirit and benzene.
Spray oil of Cito®, oil for weapons.

These products can be used alone or in combination, of course.

## *3.2. Proposal for an exposure's setting*

Three aspects are to be considered:

1. The safeguarding of the object and its integrity.

To improve the conditions of conservation, we recommend to refer to the chapter treating of the preventive conservation, i.e. the direct actions on the environment.
It would need that the engine is with the shelter of the bad weather, of the harmful sun's rays, the polluting and acid agents, of the animal dejection and the variations of temperature and moisture.
At least, one it need a solid shelter outside. But, it is a bare minimum!

2. Legibility and historical exactitude.

The explanatory panel should be packed more, by recalling the history of the engine, its context in the race against the mountain and more specifications technical.
For this reason, it would be well chronologically to place it among the other Swiss engines.

3. Aesthetics.

An exposure with development among the other engines would make it possible to the visitors to understand the technological developments and the reason which pushed the engineers to build engines increasingly more powerful.
This desire was not only a race to performances but the real need to relieve the road traffic and thus the air pollution.

# 4. Conclusion

This work required many working hours. The majority of the documents are in German and the railway technological vocabulary is not our speciality.

Our knowledge in the field of the conservation-restoration, at the end of this first year enabled us to deeply seek the historical circumstances, the strict criteria of preventive conservation and the precaution essential to carry out tests before being able to propose treatments.

The thorough study of various metals, their oxidation and their chemical explanation being expected that for the next year, we abstained intentionally to choice, not being in all knowledge of causes. But we propose a choice of products which we start to learn and which we already tested.

The reader will have perhaps found us a little careful, but discretion is the better part of valour. A serious study is always the precondition necessary to any intervention and allows us to justify it.

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Oral conversation with Mr Patrick Belloncle, (BLS Bern), may 30, 2005.

## *B. Technical glossary*

| Deutsch<br>German | Französisch<br>French | Niederländisch<br>Dutch | Englisch<br>English |
|---|---|---|---|
| **A** | | | |
| Achsabstand | empattement | wielbasis | wheel base |
| Abteilwagen | voiture à compartiments | coupérijtuigen | compartment coach |
| **B** | | | |
| Bahnhof | gare | emplacement | station |
| Bahnkörper | assiette de la voie | aardebaan | roadbed |
| Bahnübergang | passage à niveau | overwegen | level crossing (uk)<br>grade crossing (us) |
| Baugröße | échelle | schaalverhoudingen | scale |
| Breitspurbahn | chemin de fer à voie large | breedspoorwegen | broad gauge line *(uk)*<br>wide gauge *(us)* |
| Bügelkupplung | attelage à boucle | beugelkoppeling | loop and hook coupler |
| **C** | | | |
| Container | conteneur | container | container |
| **D** | | | |
| Dampflok | locomotive à vapeur | stoomlocomotief | steam engine |
| Diesel-Zugbetrieb | traction diesel | diesel tractie | diesel traction |
| Diesellok | locomotive diesel | diesel locomotief | diesel locomotive |
| Doppelkreuzungs-weiche (DKW) | traversées jonction double | dubbele kruiswissel | double slip turnout (uk)<br>double slip switch, diamond crossing with slips (us) |
| Drehgestell | bogie | draaistel | bogie (uk) truck (us) |
| Drehgestellfahrzeug | véhicule à bogies | voertuig op draaistellen | bogie equipped vehicle |
| Drehscheibe | ponts tournants, plaque tournante | draaischijf | turntable |
| Drehstromsystem | système triphasé | draaistroomsysteem | three-phase-system |
| **E** | | | |
| Eisenbahn | chemin de fer | spoorweg | railway (uk)<br>railroad (us) |
| Eisenbahn-Epoche | époque de chemin de fer | spoorwegtijdperk | railroad era |

| | | | |
|---|---|---|---|
| Ellok, Elektrische Lokomotive | locomotive électrique | elektrische locomotief | electric locomotive |
| Epoche | époque | tijdperk | era |

## F

| | | | |
|---|---|---|---|
| Fahrdraht | fil de contact / caténaire | rijdraad | catenary wire |
| Faltenbalg | soufflet | vouwbalg | gangway bellows |
| Feldbahn | voies de chantier | industriële smalspoor | industrial railway (uk)<br>industrial railroad (us) |

## G

| | | | |
|---|---|---|---|
| Gepäckwagen | fourgon à bagages,<br>fourgon à services | bagagerijtuig | baggage coach, luggage van |
| Gleis | voie | spoor | line, track, rails (pl.) |
| Gleisabstand | entraxe de voies | spoorafstand | track spacing |
| Gleisbogen | courbes | boog | curved track radii |
| Güterrampe | quais à marchandises | los- en laadperron | freight platform |
| Güterwagen | wagon de marchandises | goederenwagen | goods wagon |
| Güterzugbegleitwagen | fourgon de queue | goederentrein geleidewagen | caboose |

## H

| | | | |
|---|---|---|---|
| Hakenkupplung | attelage à crochet | haakkoppeling | coupler |
| Hauptbahn | voie principale | hoofdlijn | main line |
| Hauptgleis | pleine voie | hoofdspor | main track |
| Hochbordwagen | wagon tombereau | hogeboordwagen | high sided wagon |
| Höchstgeschwindigkeit | vitesse maximale | maximum snelheid | maximum speed |
| Holzschwelle | traverse-bois | houten dwarsligger | wooden sleeper |

## I

## K

| | | | |
|---|---|---|---|
| Kesselwagen | wagon citerne | ketelwagen | tank wagon |
| Klauenkupplung | attelage à mâchoire | klauwkoppeling | claw coupler |
| Kreuzung | croisement | kruising | plain track crossing (uk)<br>diamond (crossing) (us) |
| Kühlwagen | wagon frigorifique | koelwagen | refrigerated wagon |
| Kupplung | attelage | koppeling | coupler |

## L

| | | | |
|---|---|---|---|
| Langholzwagen | wagonnet pour le transport de grumes | lange houtwagen | timber wagon, lumber wagon |
| Lichtraumprofil | contour de libre passage | profiel van vrije ruimte | loading gauge (clearance area) |
| Lichtsignal | signal lumineux | lichtsein | light signal |
| Lokomotive | locomotive | locomotief | locomotive, engine |
| Lokomotivführer | mécanicien | machinist | (engine) driver (uk) engineer (us) |
| Lokschuppen | rotonde | locloods | engine shed (uk) enginehouse (us) |

## M

| | | | |
|---|---|---|---|
| Maßstab | échelle de réduction | schaal | ratio |
| Mittelleiter | conducteur central | middengeleider | center rail |

## N

| | | | |
|---|---|---|---|
| Nebenbahn | voie secondaire, ligne secondaire | zijlijn, nevenlijn | branch line |
| Nenngröße | échelle | schaalaanduiding | scale |
| Niederbordwagen | wagon à bords bas | lageboordwagen | low-sided wagon |
| Normalspurbahn | voie normale | normaal spoor | standard gauge |

## O

| | | | |
|---|---|---|---|
| Oberleitung | caténaire | bovenleiding | catenary |
| Oberleitungsmast | mâts de caténaires | bovenleidingsmast | catenary mast |

## P

| | | | |
|---|---|---|---|
| Packwagen | fourgon à bagages, fourgon à services | bagagerijtuig | baggage coach, luggage van |
| Periode | période | sub-tijdperk, periode | period |
| Personenwagen | voiture de voyageurs | reizigersrijtuigen | passenger coach |
| Prellbock | butoir, heurtoir | stootblok | buffer stop (uk) bumper (us) |
| Puffer | antémémoire, tampon | buffer, stootkussen | buffer |

## Q

## R

| | | | |
|---|---|---|---|
| Rad | roue | wiel | wheel |
| Radsatz | essieu | wielstel | wheel set |
| Rangierlok | locomotive à manœuvres | rangeerloc | switcher, shunter |
| Regelspurbahn | chemin de fer à voie normale | normaalspoorwegen | standard gauge line |
| Regelspurgleis | voie normale | normaalspoortraject | standard gauge track |
| Regelspurweite | écartements normalisés | spoorwijdte | standard gauge |
| Rungenwagen | wagon à ranchers | rongenwagen | stake wagon |

## S

| | | | |
|---|---|---|---|
| Schiene | rail | spoorstaaf | rail |
| Schienenhöhe | hauteur du rail | hoogte van de spoorstaaf | height of the rail |
| Schienenoberkante | surface de roulement du rail | bovenkant van de spoorstaaf | rail head |
| Schienenprofil | profilé de rail | spoorstaafprofiel | rail profile |
| Schlafwagen | voiture lits | slaapwagen, slaaprijtuig | sleeping coach |
| Schmalspurbahn | voies étroites | smalspoorwegen | narrow-gauge line |
| Schnellzugwagen | voiture de train rapide | sneltreinrijtuigen | express coach |
| Schotterbett | ballastage | ballastbed | roadbed |
| Signal | signaux | seinen | signal |
| Speisewagen | voiture restaurant | restauratiewagen | dining coach, restaurant car |
| Spurkranz | boudin | wielflens | flange |
| Spurkranzhöhe | boudin en hauteur | flenshoogte | height of the flange |
| Spurweite | écartement | spoorwijdte | gauge |
| Staatsbahn-Netz | réseau national | staatsspoorwegnet | state-owned networks |
| Standardkupplung | attelage standard | standaardkoppeling | standard coupler |
| Straßenbahn | tramway | tram, trambaan | tramway (uk) streetcar (us) |
| Stromabnehmer | pantographe | stroomafnemer | pantograph |

## T

| | | | |
|---|---|---|---|
| Trambahn | tramway | tram, trambaan | tramway (uk) streetcar (us) |
| Triebfahrzeug | engin-moteur | tractievoertuig | engine |
| Triebwagen | automotrice | motorspoorwagen | railcar |
| Tunnelprofil | entrée de tunnel | tunnelprofiel | tunnel cross-section |

## U

| | | | |
|---|---|---|---|
| U-Bahn | métro | ondergrondse | underground (uk), |

| | | | |
|---|---|---|---|
| | | | subway (us) |
| Umgrenzung des lichten Raumes | gabarit de libre passage | profiel van vrije ruimte | track clearance |

## V

| | | | |
|---|---|---|---|
| Verkleinerungsmaßstab | rapport de référence, rapport de réduction | verkleiningsfactor | relative size |
| Vorbild | prototype | voorbeeld | prototype |

## W

| | | | |
|---|---|---|---|
| Weiche | aiguillage | wissel | turnout (uk) switch (us) |

## X

## Y

## Z

| | | | |
|---|---|---|---|
| Zahnradbahn | Voies à crémaillères | tandradspoorwegen | rack-railway (uk) cog-railroad (us) |
| Zahnradbetrieb | voie équipée de crémaillère | tandradbedrijf | cog traction |
| Zahnstange | lame heugel | gear | rack |
| Zweischienensystem | système deux rails | tweerailsysteem | two rail system |

.

Source: http://www.bdef.de/frames/fmoropdict.htm.

# C. Charts

## Acrylic Resin Paraloid B 72

*Base*

Copolymer of methyl acrylate and ethyl methacrylate.

100% solids, 50% solids in Toluene

40% solids in Acetone, 10% solids in Toluene/Isopropanol

2% solids in 12 oz. spray cans as Lascaux Fixativ

*Properties*

Pure, medium-hard thermoplastic acrylic resin, lightproof and age resistant, non-crosslinking.

*Glass transition temperature*

approx. 40° C

*Solubility*

Soluble in Toluene and Acetone. Dilutable with Thinner X, Thinner A, Isopropanol, Ethanol, Methoxypropanol (PM). Insoluble in White Spirit.

*Softening point*

approx. 70° C

*Melting point*

approx. 150° C

*Viscosity*

40% solution at 25° C, in cps in Acetone approx. 200, in Toluene approx. 600, in Thinner X approx. 980

*Use*

Paraloid B 72 has been used since the 1950s in conservation as a consolidation agent and as a picture varnish. Extended tests have shown it to be one of the most stable resins used in the conservation of works of art.

Paraloid B 72 is used to consolidate and impregnate mural paintings and oil paintings, as a fixative for charcoal and chalk drawings, pastels, as well as for the consolidation of wood. It is also recommended as an adhesive for glass and ceramics.

*Application*

When working with Paraloid B 72, the right thinning rate is decisive for a successful treatment. Tests should be made in order to determine the thinning rate and the appropriate solvent to provide good penetration and consolidation properties. Since objects show different absorptions, it is advisable to work with lower concentrations and, if necessary, to repeat the application. There is a risk of undesired saturation on the surface of the object when working with too high concentrations.

The solvent retention must be taken into consideration. Especially when using solvents with a low evaporation rate. It may take days or weeks for complete evaporation of the solvent. The result of the consolidation can be judged only after complete drying of the resin.

By adding approx. 0,1% wetting agent P 100, deeper penetration can be achieved.

Excess resin or gloss are to be removed with toluene.

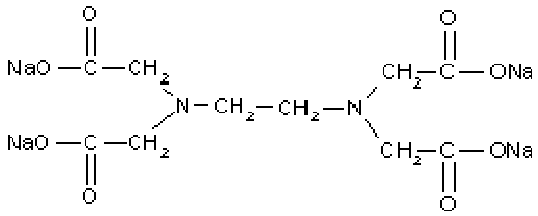
Examples

*a) Mural paintings*

For the consolidation and impregnation of mural paintings (a fresco/secco), limewash and silicate paint, crumbling plaster, etc. a solution of max. 5% in Toluene/Isopropanol is used. It is applied in several layers until the required degree of saturation is reached.

# Product Details of Dissolvine® NA

Versatile chelating agent: spraydryed tetrasodium salt of EDTA.



| | | |
|---|---|---|
| **Chemical Form** | | EDTA-Na4 |
| **Physical Form** | | Micro-granular |
| **Molecular Mass** | | 380.2 |
| **Density** | **kg/m3** | 600 |
| | **lb/gallon** | 0 |
| **Typical pH value** | | 11 |
| **Chelation Equivalents** | **Ca** | 11 |
| | **Cu** | 7 |
| | **Fe** | 7 |
| | **Mg** | 18 |
| | **Mn** | 8 |
| **Specific Properties** | | All purpose chelating agent |
| **CAS number** | | 64-02-8 |
| **Registered in** | | TSCA, EINECS, AICS, DSL, ECL, ENCS, SWISS |
| **MSDS** | | |

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# Wax of Carnauba


La cire de **Carnauba** est extraite des feuilles d'une variété de palmier du Brésil. Les feuilles sont recouvertes par une fine pellicule de cire qui les protège de l'eau pendant la saison des pluies et de la sécheresse pendant l'été. Pour conserver les propriétés naturelles d'un plancher en bois, il est important d'utiliser un produit qui laisse respirer le support.
Il est nécessaire de passer auparavant au moins 2 couches d'huile dure pour renforcer le support et nourrir le bois. Non diluée, l'émulsion à la cire de carnauba constitue une protection supplémentaire contre les frottements, les salissures et l'eau.

Utilisation :
Traitement de surface pour des sols en bois et liège déjà traités (huile dure, cire dure, vernis), en terre cuite, pour des plans de travail et des meubles. Ajoutée à l'eau de lavage, convient aussi pour le soin des planchers huilés et cirés. Pour un sol en dalles lisses, n'ajouter que très peu de cire de carnauba à l'eau de lavage : elle rendrait le sol trop glissant !

Propriétés :
- hydrofuge et anti-salissure
- permet au support de respirer
- antistatique
- brillant
- se dilue dans l'eau
- odeur agréable
- séchage rapide
- facile à utiliser

Composition :
Eau, cire de carnauba, émulsifiant à base d'acides gras naturels

Mode d'emploi :
Application sur des surfaces qui viennent d'être huilées ou vernies : respecter le temps de séchage, avant d'appliquer une couche fine d'émulsion à l'aide d'un chiffon doux, non pelucheux. Sur des surfaces très sollicitées, renouveler l'opération.

Soin régulier :
Pour redonner du brillant aux sols, ajouter l'émulsion à l'eau de lavage : 3 cuillers à soupe pour 8-10 l d'eau tiède.
Les couches trop épaisses ou salies de cire de carnauba s'enlèvent avec de l'eau chaude (70 à 80 ℃). Ne pas utiliser une eau plus chaude qui pourrait dissoudre le traitement de fond (huile dure, vernis).

Séchage :
En application pure : environ 1 heure à 20 ℃

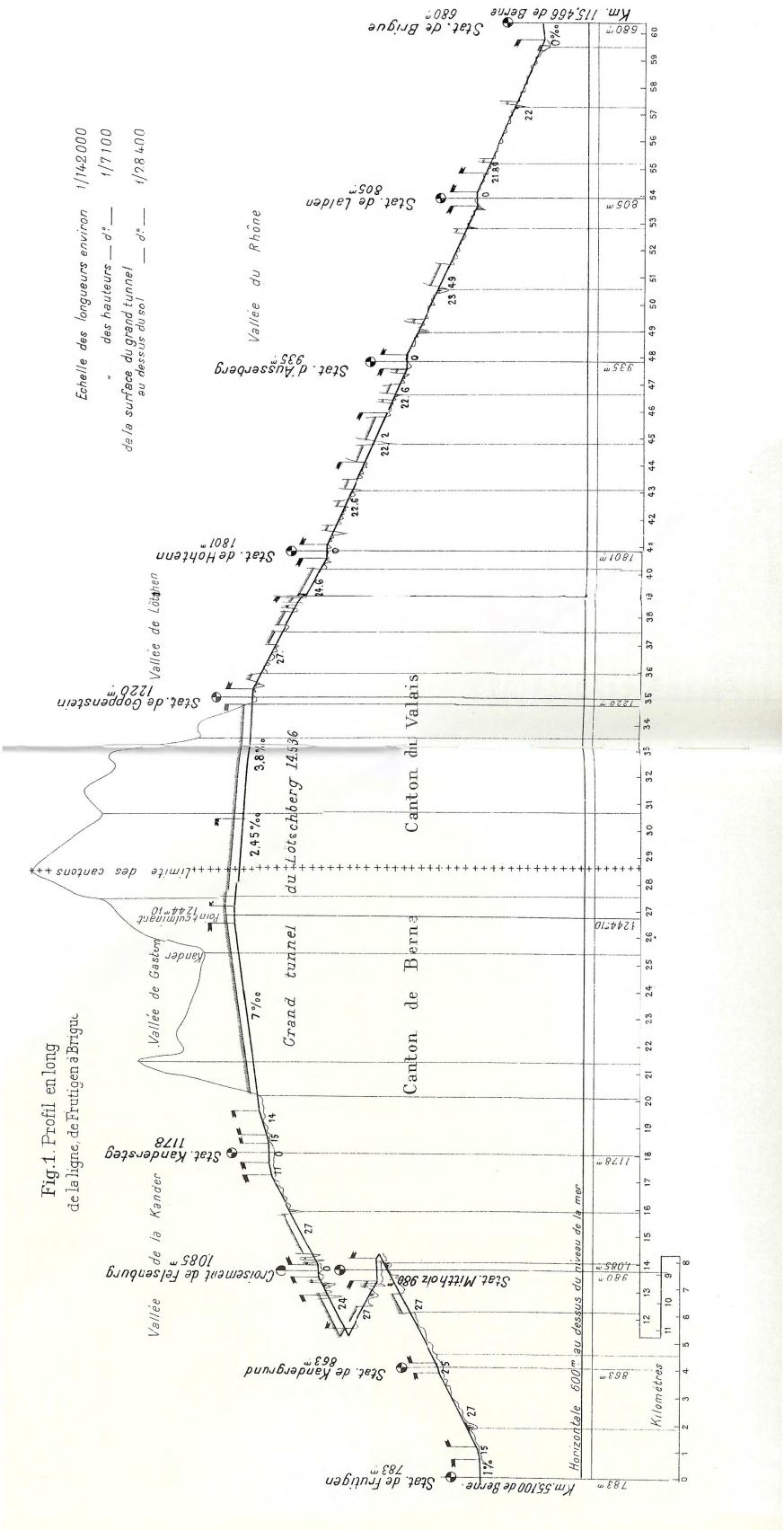
Rendement :
60 à 70 m2 / litre

Stockage :
Au frais, à l'abri du gel et bien fermé le pot se conserve au moins 1 an.

Elimination :
Les résidus secs se mettent à la poubelle.

Stocker hors de portée des enfants.

## *D. Attachment*



# Lokomotiv-Bezeichnung in der Schweiz

## Kennzeichnung der Dampflokomotiven bis 1920

| Bezeichnung | Geschwindigkeit |
|---|---|
| A | über 75 km/h |
| B | 70 - 75 km/h |
| C | 60 - 65 km/h |
| D | 45 - 55 km/h |
| E | Tendermaschinen mit Index im Sinne von a - d |
| E | Rangiermaschine |
| F | elektrische Maschine |
| G | Schmalspurmaschine |
| H | Zahnradantrieb |
| HG | Schmalspurmaschine mit Adhäsions- und Zahnradantrieb |

## Kennzeichnung der elektrischen Maschinen ab 1920

| Bezeichnung | Geschwindigkeit |
|---|---|
| R | über 120 km/h, mit erhöhter Kurvengeschwindigkeit |
| A | über 80 km/h (bis 110 km/h) |
| B | 70 - 80 km/h |
| C | 60 - 65 km/h |
| D | 45 - 55 km/h |
| E | Rangiermaschine |
| G | Schmalspurmaschine |
| H | Zahnradantrieb |
| HG | Schmalspurmaschine mit Adhäsions- und Zahnradantrieb |
| T | Traktor |

### Spezielle Kennzeichnungen

| | |
|---|---|
| e | elektrisches Triebfahrzeug mit Stromabnehmer |
| m | Verbrennungsmotor |
| em | Verbrennungsmotor gekoppelt mit Generator, Antrieb mit Elektromotoren |

Zusätzlich zu dieser Angabe wird die Achszahl der Lokomotive als Bruch angegeben, wobei der Nenner die Anzahl der Achsen nennt, und der Zähler die Anzahl der Triebachsen.

http://www.gotthardbahn.ch/3_DATEN/Daten/bezeichnung.pdf

# Achsfolge-Bezeichnungen

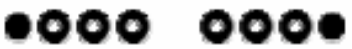
## Bezeichnung der Lokomotiven nach der Achsreihenfolge

 Treibachse, angetriebene Achse

 Laufachse, frei mitlaufende Achse

| Achsfolge | Bezeichnung Schweiz | Deutschland | Amerika |
|---|---|---|---|
|  | 2/2 | B | 4 - Kuppler |
|  | 3/3 | C | Bourbonnais |
|  | 4/4 | D | 8 - Kuppler |
|  | 2/3 | 1 B | Four - Wheel |
|  | 3/4 | 1 C | Mogul |
|  | 4/5 | 1 D | Consolidation |
|  | 5/6 | 1 E | Dacapond |
|  | 2/4 | 1 B 1 | Columbia |
|  | 3/5 | 1 C 1 | Prairie |
|  | 4/6 | 1 D 1 | Mikado |
|  | 3/6 | 1 C 2 | Adriatic |
|  | 2/4 | 2 B | American |
|  | 3/5 | 2 C | Ten - Wheel |
|  | 3/6 | 2 C 1 | Pacific |
|  | 4/7 | 2 D 1 | Mountain (Mohawk) |

Weitere Möglichkeiten bei elektrischen Maschinen der SBB: (mit Index "e")

| | | | |
|---|---|---|---|
|  | (2x) | 8/14 | z. B. Landilok 11852 |
|  | | 6/8 | Krokodile |

Modernere Maschinen der SBB besitzen keine Laufachsen mehr. Die Motoren befinden sich im Drehgestell. Deshalb fügt man, bei der Achsbezeichnung nach deutscher Art, den Index o hinzu.

| | | |
|---|---|---|
|  | 4/4 | Bo Bo |
|  | 6/6 | Co Co |
|  | 6/6 | Bo Bo Bo |

Maschinen verschiedener Bauformen, welche die gleiche Bezeichnung und Achsreihenfolge aufweisen, werden durch einen römischen Index unterschieden.
Z. B.: Re 4/4 I, Re 4/4 II etc.
Personentriebwagen werden zusätzlich mit der Klassenbezeichnung ergänzt.
Z. B.: RAB, RBD, etc.

http://www.gotthardbahn.ch/3_DATEN/daten/achsfolge.pdf