

## SMART SOLUTION FOR RAILWAY SIGNALLING INFRASTRUCTURE

Christian BOUWMEESTER  
Eaton Holec – The Netherlands  
ChristianBouwmeester@Eaton.com

Lionel DELORD  
Hazemeyer France – France  
LDelord@Hazemeyer.com

Kévin GAVERIAUX  
SNCF - France  
Kevin.Gaveriaux@SNCF.fr

### ABSTRACT

*In France hundreds of signalling substations do exist next to the railway. These 3.2 kV substations are placed every 3-5 km of railway.*

*The signalling substations are typically low rating substations:*

$$U_r = 3,2 \text{ kV}$$

$$I_r = 10\text{-}40 \text{ A}$$

$$I_k = 1000\text{-}1500 \text{ A}$$

*Basically a signalling substation consists of two 3.2 kV ring main unit (double fed), fuses and two 3.2 kV step down transformers. Commercially developed ring main units that are in the market place today, all have specifications that go far beyond the requirements of the railway signalling substation: 12 kV, 400 A, 20 kA are the minimum requirements of today's RMU's. Modern RMU's even have remote control opening and closing of the circuit breakers.*

*Although these modern RMU's are reasonably priced for their normal application (distribution purposes), their price level is way beyond the expected price level of a low rating railway signalling substation.*

*This paper describes a dedicated railway signalling substation with the following specifications:*

- Rated voltage 3,2 kV
- Lightning impulse withstand voltage 40/46 kV
- Power-frequency withstand voltage 10/12 kV
- Frequency 50/60 Hz
- Normal current 40 A
- Short-time withstand current 1600 A/0,5 s
- Peak withstand current 4 kA
- Mainly active-load breaking current 40 A

*These signalling substations are delivered as a complete turnkey solution. The only fieldwork that has to be performed is connection of the cables. This way a dedicated solution is offered to a large retrofit market.*

### INTRODUCTION

In France thousands of kilometres of railway exist. Many signalling equipment of the railway is powered by 3.2 kV,

which is transformed down to low voltage at every signalling substation. The 3.2 kV network was built in the 1950's. It allowed solving the following difficulties:

- numerous zones where EDF delivery points were not available;
- lack of reliability of the EDF LV network.

In case of "double cross feeding", this MV network also enabled so called privilege feeding, which increases reliability significantly.

The 3.2 kV cubicles used since 1950 are called "BACA". Two types of cubicles are used. One indoor style, the other one outdoor style, which is the most common model in the installations considering the origin of the 3.2 kV network. The majority of the cubicles installed outside between 1950 and 1975 are extremely antiquated and obsolete.

The two main problems concerned regulations and maintenance.

The cubicles installed on the territory are of different generations. They are all equipped with line switches which do not allow on load switching.

When these cubicles are used in a ring network, no safety key interlocking system has been foreseen between the off load switches.

No key interlocking system between main LV breaker and transformer enclosure is existing.

Some of very old cubicles have:

- No possibility to check the absence of voltage, before any maintenance operation;
- No fixed earthing switch with making and withstanding capability.

Actually the maintenance of these cubicles is very difficult. Replacement of parts is done by picking parts from used cubicles (cannibalisation).

At the beginning of 1998, the approved manufacturer by SNCF decided to stop manufacturing 3.2 kV MV cubicles named « BACA ». French Railways Company has been obliged to find another manufacturer.

Three manufacturers were selected. One with SF6 switching, another with vacuum switching and HAZEMEYER/EATON HOLEC with simple air switching Magnefix MA.

## MAGNEFIX MA, THE SWITCHING HEART

### Epoxy resin insulation

Eaton Holec started experimenting with epoxy resin around 1950, in an era when solid insulation consisted of materials such as porcelain, bakelised paper, phenol-formaldehyde mouldings or even marble.

It was discovered that the combined advantages of very high insulating qualities, very good mechanical properties and ease of forming intricate shapes, made epoxy resin an ideal material for M.V. switchgear. The insulating material serves both as construction material and insulation enclosure.

Now, about 60 years later, application of epoxy resin for M.V. switchgear is taken for granted; even the most advanced concepts seem inconceivable without it.

### Principle

The first commercial series of insulation-enclosed switchgear was developed in 1955 and was called Magnefix MA. Substituting free air by cast resin insulation lead to a drastic reduction in the dimensions of the switchgear used up to that time.



Fig. 1: Magnefix MA type switch

The Magnefix MA switch is a M.V. load break switch where switching off takes place by pulling a contact bridge from the fixed part. This pulling is done by means of a double insulated operating handle which is shown in figure 1. In closed position, the contact bridge is retained in its position by a strong permanent magnet, which explains the name Magnefix. All life parts are fully shielded both in open and closed position.

### Construction

The switch is composed out of single phase switching elements. The fixed part of every element consists of a cast resin frame. In the middle of this frame, a permanent magnet is mounted. Both the arc chambers and the fixed contacts are positioned within the tube shaped end of the frames. See figure 2. The fixed contacts have cable terminals at the bottom end.

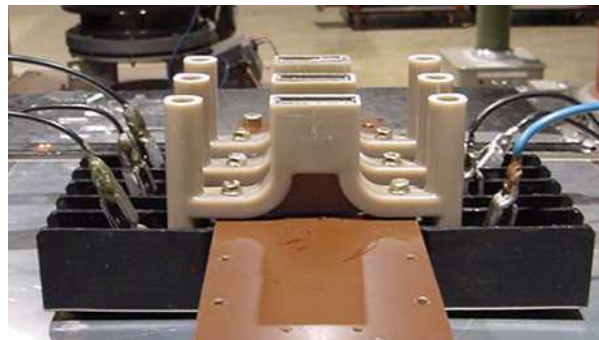


Fig. 2: Fixed part of Magnefix MA

The moving part of the switch, the switching cap, consists of a epoxy resin cap in which the switching bridge and the adhesive bridge are positioned. The adhesive bridge has a adhesive plate which is attracted to the permanent magnet in the fixed part.

The switch bridge (figure 3) contains the movable contacts of the Magnefix. For inspection purposes, the switch bridge can be easily removed from the switch cap without the use of a tool.

For the MA type Magnefix three single phase switching caps are connected to one operating handle which makes it a three phase operated switch.



Fig. 3: Contact bridge of Magnefix MA

### Closing

Closing of the Magnefix MA switch is done by placing the three switching caps including switching bridge over the tube shaped fixed parts and pushing it firmly onto the fixed part. In closed position, the adhesive plate of the switching bridge is kept to the permanent magnet of the fixed part retaining the contacts in closed position. Small springs take care of the contact pressure.

### Opening

By pulling the operating handle of the switching caps the opening springs of the contact bridge are charged, while the contacts pins are retained in their position by the permanent magnet. When the pulling force exceeds the magnetic force, the contact bridge and the contact pins will move away from

the fixed contacts with high speed determined by the opening springs. This is a man-independent opening operation.

The switching cap is removed completely from the fixed part and a clear contact separation becomes visible.

### Certification and standards

Magnefix MA was fully tested in 1955, but a fixed standard for these kinds of products was not available by that time. Ratings that were tested in those days can be found in table 1.

Because of the renewed interest in Magnefix MA by the French Railway Company and by demand of them, Eaton Holec decided to update the certification of Magnefix MA according to IEC 60265-1. The new tested ratings can be found in table 1. These ratings are fully in line with the customer requirements.

Rating		1955	2006
Rated voltage	kV	3	3,6
Impulse withstand voltage	kV		40/46
Power frequency withstand voltage	kV		10/12
Frequency	Hz	50	50
Normal current	A	15	40
Short circuit withstand current	A - s	800 - 1	1600 – 0.5
Peak withstand current	A	4000	4000
Mainly active load breaking current	A	100	40
Short circuit making current	A	400	400
IP-degree			IP 2X
Mechanical endurance			M1
Electrical endurance			E2

Table 1: Old and retested ratings (IEC 60265-1) of Magnefix MA

### Environment

Magnefix MA uses air as switching medium and epoxy resin as insulating material, so it can be designated as an environmental-friendly piece of switchgear.

### **SIGMA 3.2, THE LOW RATING, HIGH QUALITY RMU FOR RAILWAY SIGNALING**

During the period 1998/2006, HAZEMEYER/EATON HOLEC got various projects in 3.2 kV to feed the electrical distribution for the signalisation of the trains. The first ones were turn key projects with cubicles inside concrete substations. Then, for weight reasons, plastic substations were designed and the last project was done with external aluminium enclosure containing MV RMU and step down transformer up to 50 kVA including LV cubicle in a

separate outdoor enclosure.

Based on the Magnefix MA switch HAZEMEYER FRANCE designed a low rating ring main unit for railway signalling applications. Main design requirements from the French Railway Company were:

- compact design, same foundation dimensions as existing switchgear;
- 2 or 3 feeder application;
- built in transformer of 50 kVA max;
- clear and basic operating procedure;
- fully shielded live parts;
- low maintenance;
- fixed earthing switch with making and withstanding capability;
- adaptation of all safety key locking systems used by SNCF.

### Construction

The RMU part of SIGMA 3.2 consists of six 3-phase fixed parts and three 3-phase switching caps of Magnefix MA. These elements can be found in the picture of figure 4.

The single line diagram of SIGMA 3.2 is drawn in figure 5. The dotted arrows indicate that the switching caps can be positioned in the upper fixed part or in the lower fixed part. When for example a switching cap is placed on the fixed part of the top left corner, cable “Coming from ....” is connected to the RMU. By placing two other switching caps on the top middle and top right fixed part, also the transformer and cable “Going to ....” are connected. Both cables and the transformer can separately be grounded by inserting the switching caps on the lower fixed parts (key locks are provided).

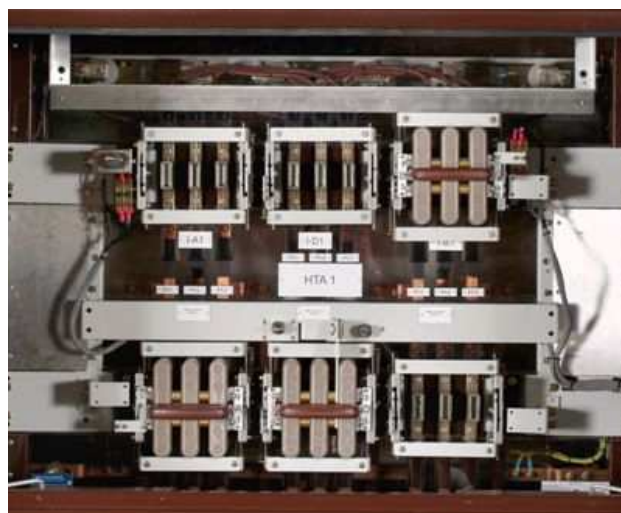


Fig. 4: SIGMA 3.2 ring main unit

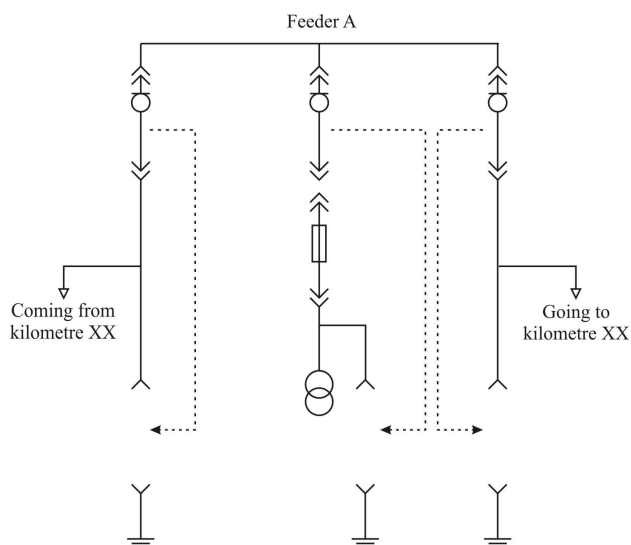


Fig. 5: Single line diagram of one RMU of a signalling substation

When there is no switching cap on a fixed part, shutters prevent contact with any live part. The transformer is protected by fuses.

### Interlocking

The switching caps of Magnefix are all identical. This would mean that two switching caps could short circuit the bus bar of the RMU to ground by inserting a switching cap both in the upper position and in the lower position. Since this is undoubtedly an undesirable situation, a unique interlocking mechanism has been designed. This mechanism makes sure that the first switching cap can only be used for connecting or grounding cable “Coming from ...”, the second switching cap can only be used for connecting or grounding the transformer and the third switching cap can only be used for connecting or grounding cable “Going to ...”. On both sides of a 3-phase switching cap a metal interlocking plate is mounted (see figure 6).

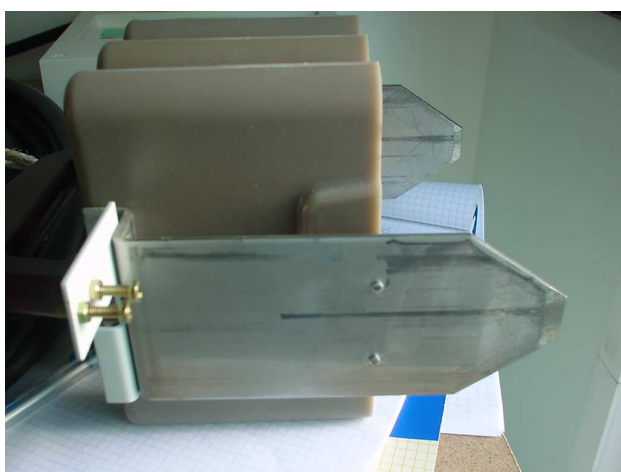


Fig. 6: Interlocking plate of switching cap

These metal plates are inserted in metal casings at the sides of the fixed parts.

The plates have two functions:

1. They open the shutters when the switching cap is placed over the fixed part
2. They prevent a switching cap from for example the transformer to be used for one of the cables.

This is done by a unique pin-pattern on the side of the metal plate.

### Summary of features

SIGMA 3.2 is complete solution for the power supply of signalling apparatus alongside the railway track. It is a dedicated low-rating solution for a low rating application. Why use a state-of-the-art 12 kV RMU with remote switching and 20 kA short-circuit strength, when only 3.2 kV and 1.6 kA is requested?

Although SIGMA 3.2 is a low rating substation, it is definitely not a low level/quality substation. Its main functions are:

- manual open en closing of fully isolated load break switches (type Magnefix);
- manual grounding by the same type of load break switches;
- built in transformer up to 50 kVA;
- over current protection by fuses;
- available with two or three cable fields;
- indoor and out door version;
- low voltage cubicle associated;
- easy replacement by keeping same dimensions;
- low level maintenance.

### WHY SNCF CHOSE SIGMA 3.2

- SIGMA 3.2 enclosures are fully interchangeable with the existing enclosures;
- the SIGMA 3.2 enclosures accepts a dry type transformer up to 50 kVA instead of 25 kVA max;
- fixed earthing switch with making and withstanding capability is integrated;
- adaptation of all safety key locking systems used by SNCF is achieved;
- the use of MAGNEFIX MA brings a very low maintenance to the complete system;
- MAGNEFIX MA is air switching and has the advantage to be environmental safe;
- The SIGMA 3.2 enclosures and systems are completely recyclable;
- HAZEMEYER/EATON HOLEC is also a LV switchboard manufacturer and can deliver and install a complete project.