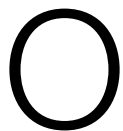




# Speedy protection

ABB surge arresters  
for rail applications  
at formula-one speed  
and beyond

STEPHAN HOFFARTH – The market for high-speed rail is rapidly expanding. According to the International Union of Railways (UIC), the world's high-speed network is expected to grow from currently 13,000 km to well above 30,000 km within the next 10 years<sup>1</sup> – and with it the demand for trains and their components. Equipment mounted on the outside of such rolling stock must be designed to withstand faster air flow. This is especially true for surge arresters, which are generally installed on the train roof, immediately adjacent to the pantograph, as they must protect all downstream electrical equipment against incoming overvoltages. Despite the fact that surge arresters perform very well in the high-speed train market, concern regarding this function has increased. Therefore a more differentiated consideration of this application is necessary.



Overvoltages in electrical railway networks result from the effects of lightning strikes and switching actions and cannot be avoided. They endanger the electrical equipment because, due to economical considerations, the voltage withstand capability of insulation cannot be designed for all possible cases. An economical and reliable service therefore calls for a comprehensive protection of the electrical equipment against unacceptable overvoltages.

The greatest threat comes from lightning strikes. Appropriate protection is used to reduce the overvoltage resulting from such a strike to a safe level. Metal-oxide surge arresters without spark gaps provide outstanding protection in this situation.

In general, the demands on the arresters for rolling stock applications depend on the operational conditions and the type of the electrical equipment to be protected. In modern electrical trains the high voltage of the pantograph is brought inside the locomotive by means of a bushing or a cable. For maximum overvoltage protection, ABB recommends a co-ordinated concept consisting of two different types of arresters<sup>2</sup>:

- 1 A premium arrester with a line discharge class of 3 or 4 installed on the roof close to the current collector.
- 2 A standard arrester with a slightly higher continuous operating voltage mounted inside the locomotive in front of the main power breaker.

In order to meet the requirements of reliability, availability, maintainability and safety (RAMS) the surge arresters have to fulfil the international standard IEC 60099-4 "Metal-oxide surge arresters without gaps for a.c. systems."

Furthermore both types of arresters have to withstand the mechanical loads caused by the train operation. These demands are covered by IEC 61373 "Railway applications – Rolling stock equipment – Shock and vibration tests."

In addition, the surge arrester mounted on the roof should be able to withstand the corresponding operating conditions such as weather influences and mechanical stress due to the airstream.

IEC 60099-4 defines the requirements for conventional applications (for example protection of distribution transformers) but wind speeds above 34 m/s (122 km/h) are considered abnormal service conditions and are therefore not covered.

Despite this lack of standardization and the related absence of an appropriate qualification procedure, surge arresters have been used successfully for many years on high-speed railways. Nevertheless, operators and potential customers are increasingly expressing interest concerning the impact of head wind. Therefore ABB decided to verify the airflow performance of the arresters it supplies for installation on the roof of rolling stock.

#### Verification of airflow performance

It was decided to carry out the tests in a wind tunnel of the German Aerospace Center, DLR<sup>3</sup>. In the course of the ensuing tests, AC surge arresters of types POLIM-H..N and POLIM-S..N and DC surge arrester of type POLIM-H..ND

were exposed to wind speeds up to 100 m/s (360 km/h) → 1.

The test sequence was divided into five parts. Speeds started at a moderate 20 m/s and increased in steps of 20 m/s up to 100 m/s. They thus reflect a wide range of operating conditions ranging from slow freight trains to high-speed trains. To achieve realistic test conditions, all arresters were equipped with the accessories typical to railway applications. Furthermore the devices under test were mounted on a load cell equipped with a strain gauge to permit the quantification of the bending stress at different wind speeds. The behaviour of the arresters was recorded by means of a high speed camera during the verification.

#### Results

None of the tested samples showed damage or lasting deflection from the wind exposure. The measured forces

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during the tests were well below the maximum specified continuous bending moments of the corresponding arrester designs. The sheds of the silicone housings did not display oscillations under the maximum applied wind speed of

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#### Footnotes

- 1 International Union of Railways UIC, High speed rail – Fast track to sustainable mobility, November 2010, ISBN 978-2-7461-1887-4
- 2 ABB Switzerland Ltd – High Voltage Products, Application guidelines for overvoltage protection – Dimensioning, testing and application of metal-oxide surge arresters in railway facilities, PTHA/SA3020EN\_01.09.07
- 3 German Aerospace Center DLR (Deutsches Zentrum fuer Luft- und Raumfahrt), www.dlr.de

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#### Title illustration

Roof-mounted equipment is exposed to considerable aerodynamic forces. The title photograph shows AVE trains of Spanish operator RENFE, capable of travelling at 350 km/h.

1 Test setup of surge arrester type POLIM-H 33N in one of the wind tunnels of the German Aerospace Center DLR



2 Silicone housing of surge arrester type POLIM-H 33 during the test with 100 m/s (360 km/h) airflow



100m/s. The danger of a significant reduction of the creepage distance caused by deformation of the arrester housing can therefore be ruled out.

#### Ready for speed

These tests clearly show that ABB surge arresters of type POLIM-H..N, POLIM-H..ND and POLIM-S..N are well suited for applications on high speed trains. These arresters are not only an ideal

on their products, for example by masking roof-mounted equipment.

Such modifications are primarily aimed at cutting the energy consumption of the vehicle, but do also reduce the wind load on the arresters by reducing their exposure to the airflow.

In this respect ABB will permanently assess its railway arrester portfolio in order to meet the future demands.

ABB railway surge arresters are certified according to the International Railway Industry Standard IRIS Revision 02 <sup>5</sup>

For more information on ABB and railways, please see *ABB Review* 2/2010, "Railways and transportation" or visit [www.abb.com/railway](http://www.abb.com/railway).

## Arresters have to withstand the mechanical loads caused by the train operation, including Formula 1 speed headwinds.

option for the overvoltage protection of fixed installations but also appropriate for all kind of rolling stock applications up to a maximum speed of 100m/s or 360km/h.

Looking further, it should be taken into consideration that the high speed rail industry is intensifying its focus on energy efficiency. At the last international trade fair for transport technology, Innotrans <sup>4</sup>, several manufacturers of high speed trains showed optimized aerodynamics

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#### Footnotes

- 4 International trade fair for transport technology Innotrans 2010, [www.innotrans.com](http://www.innotrans.com)
- 5 International Railway Industry Standard IRIS Revision 02, [www.iris-rail.org](http://www.iris-rail.org)