Heinemann ADR
White paper

Facilitating technology upgrade of electrical protection

Alexandre Zint
Product Manager,
Heinemann hydraulic-magnetic circuit breaker

Michel Braillard
Rail Competency Center and Engineering Manager

Executive summary

The rail industry is highly competitive, and rail operators are under pressure to make their trains safer, more reliable, cost-effective and attractive to travelers. During refurbishment projects, the choice of the electrical protection may be a challenge as it is driven by not only the technology already used but also the space available and the type of mounting. Choosing hydraulic magnetic circuit breakers for circuit protection can help in meeting these objectives, as they perform reliably under the harsh conditions of a rail environment while eliminating nuisance tripping and its associated problems.

Powering Business Worldwide

Keeping costs down and improving efficiency is an increasingly important consideration in today's competitive rail market. With train operators under pressure to do more with less while meeting growing demand for their services, there is an emphasis on identifying and implementing solutions that reduce the total cost of ownership and cut the weight of trains to enhance their sustainability and performance.

Of course, these objectives must be achieved within the confines of strict industry standards. Innovation is welcome, and in many areas is required to achieve desired performance. Yet rail retains a strong emphasis on safety, which means many manufacturers must take extra care when introducing new solutions. The railway is a harsh environment, which places extreme stress on equipment installed on rolling stock. With strong reliability imperative for critical assets such as fire detection, door and braking systems, emergency lighting and signaling, all of which are essential for passenger and staff safety, any innovation which looks to reduce weight must not detract from but enhance current levels of performance.

With electrical equipment central to rolling stock operation, electrical protection is a key consideration for both railways and OEMs as they look to operate and supply effective and safe rolling stock, which experience minimal downtime and are straightforward to maintain.

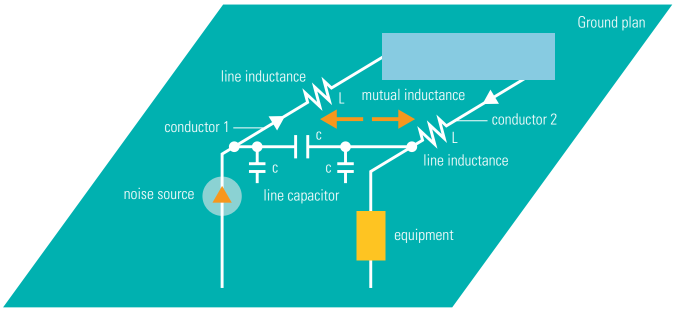
Eaton has addressed the rail industry's needs in this area for more than 30 years, establishing itself as a leading supplier of standard and customized electrical, hydraulic and filtration solutions. Eaton possesses industry-leading expertise in the circuit protection field, an increasingly important and demanding area.

The goal of this paper is to showcase Eaton's latest contribution to this market: the ADR series of hydraulic-magnetic circuit breakers(HMCB). This new product is designed to be compatible with existing cabinets' design which currently support thermal magnetic circuit breakers, enabling users to benefit from the improved performance traditionally associated with HMCB devices but without major modifications to panel design or product integration, a key consideration during retrofit and upgrade projects. Installing this technology can also significantly reduce the weight of these components and fulfils Eaton's objective to build better and safer trains.

What railway-specific challenges impact circuit performance?

Inevitably there are a number of challenges that must be overcome to maximize the effectiveness of electrical equipment and keep trains running safely and on-time.

With trains increasingly designed to make best use of the space available to carry passengers, electrical equipment is usually tightly packed in small enclosures, cabinets or compartments. Units often operate in very close proximity to one another, which can increase the chance of spikes, transients and bursts in the power lines that circuit breakers are designed to protect. In addition, in metro and light rail systems, where stops are frequent and the distance and time between stations is short, there are multiple journey breaks and traction step changes. This, combined with frequent passenger door use, causes hard repetitive switching and subjects the equipment and circuit breakers to constant voltage fluctuations.



Further complications are caused by long wire runs between the circuit breakers and the equipment they protect, with circuit breakers typically assembled on panels within the driver's cab or in electrical cabinets located in the coaches. In some instances, they are housed in low voltage boxes on the under frame of the vehicle, or on the roof, exposing these components to changes in environmental condition which may place them under extra strain and compromise performance. Indeed, sudden, fast temperature fluctuations are common during a journey as the train passes through varying weather conditions, or enters tunnels, which can increase the possibility of changes in current in electrical circuits. Circuit breakers are also subjected to hard mechanical shock, vibrations, accelerations and jerking movements from the train's body shell, which can have a varying impact on performance depending on the location of the circuit breaker panels.

In summary, the potential impact of these environmental issues are as follows:

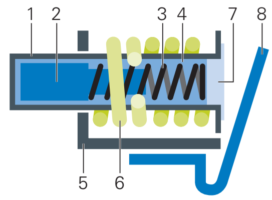
- Breakers may be subjected to extreme electrical and physical disturbances
- Circuit protection may not be optimized to actual power supply and load requirements
- There are several factors that could lead to nuisance triggering
- In the worst case, the protection provided might not be effective

How might operators overcome these challenges?

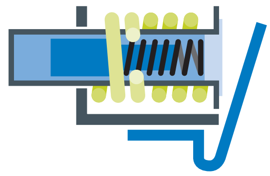
Hydraulic-magnetic circuit breakers are a well-proven solution to many of these issues and are now widely used by manufacturers. They provide circuit protection by offering a fixed tripping current which is insensitive to the ambient temperature variations experienced when the circuit breaker is located outside of the coach or changes in temperature caused by other equipment located in cabinets.

Specifically, HMCBs can deliver precision protection and a controlled response to changes in load current. They also have proven resistance to shock and vibration and experience no degradation in performance over time.

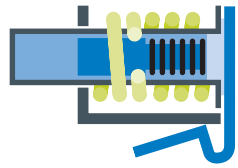
The basic principle of an HMCB relies on a load current passing through a coil of wire which is wound around a hermetically-sealed non-magnetic tube containing a spring-loaded moveable iron core and silicone oil fill. With the load current either at or below the breaker's nominal rating, the magnetic flux produced lacks the strength to move the core, which remains at the end of the tube furthest from the armature.



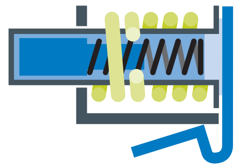
Circuit Breaker with No Load



Circuit Breaker Slightly Overloaded



Circuit Breaker Overloaded



Circuit Breaker Severely Overloaded

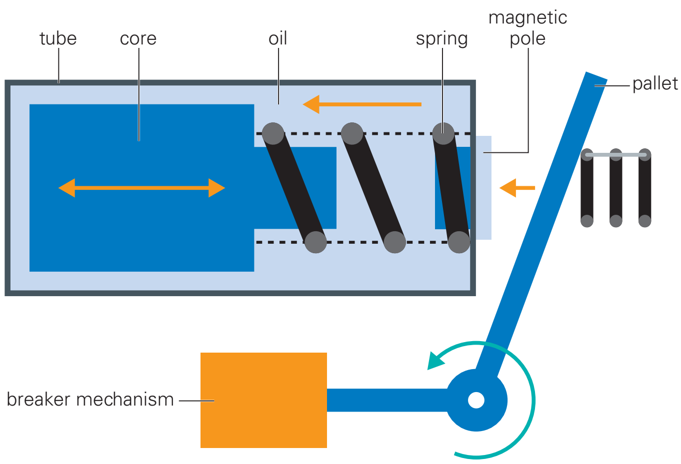
Hydraulic-magnetic circuit breaker parts:

1. Tube	**2.** Core	**3.** Spring	**4.** Fluid
5. Frame	**6.** Coil (sensor)	**7.** Pole piece	**8.** Armature

On overload, the magnetic flux force increases, pulling the iron core into the tube and then towards the pole piece, attracting the armature. The silicone oil regulates the core's speed of travel, creating a controlled trip delay that is inversely proportional to the magnitude of the overload. If the overload current subsides before the core reaches the pole piece, the spring returns the core to its original position and the breaker does not trip. However, if the magnetic flux reaches a predetermined value, the armature is attracted to the pole piece and the breaker trips. The breaker may even trip before the core reaches the pole piece if the critical flux value is reached first. On very heavy overloads, or short circuits, the flux produced is sufficient to pull in the armature regardless of the core position. This provides immediate circuit interruption with no intentional delay - a very desirable characteristic.

This design offers several key technical advantages:

- Nuisance tripping caused by high ambient temperatures is eliminated as the breaker responds only to current variations, not changes in temperature.
- Changes in oil viscosity following increases in temperature onboard trains decrease trip response times, protecting equipment that might become more vulnerable at higher ambient temperatures.
- Transient current surges, another cause of nuisance tripping, can also be eliminated with precision and without reducing the overload protection.
- With the tripping mechanism hydraulically-magnetically controlled, time delay is inversely proportional to the size of the overload. The response is faster on large overloads or even on short circuits where there is greater potential danger.



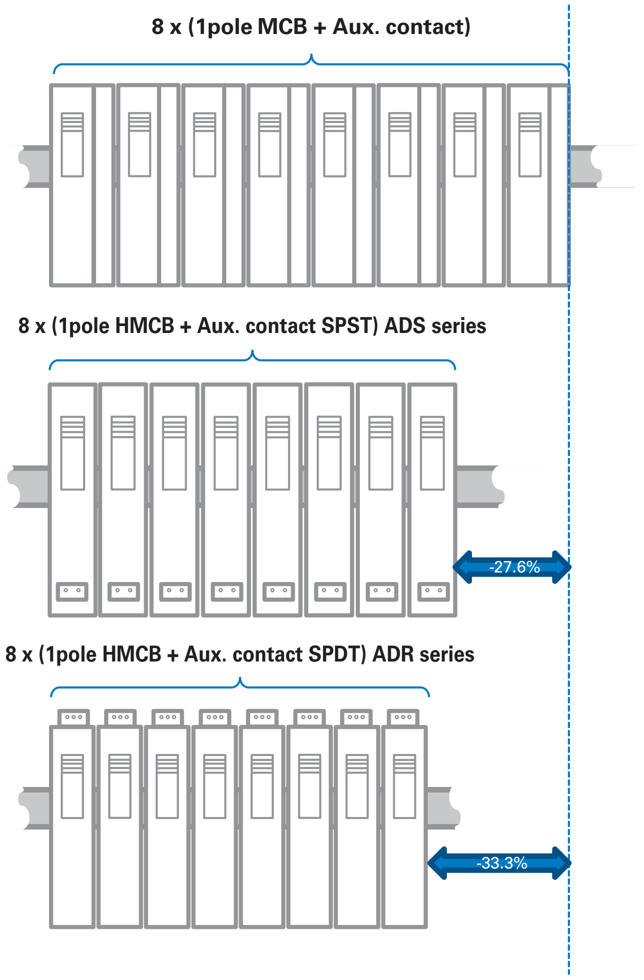
- By adjusting the wire turns and wire section in the load sensing coil, the breaker is easily optimized to meet the demands of any application. This means it can respond fast enough to avoid dangerous overloads but not so fast as to cause nuisance tripping.
- The core's position within the mechanical design, which is controlled by the oil's viscosity and a loaded return spring, can effectively absorb amplified physical shock and vibration from the train body.
- The time delay imposed by the oil's viscosity, the return spring and the natural magnetic gap between the magnetic pole and the armature means the device has an excellent ability to absorb line current fluctuations and avoid nuisance tripping.
- The device will always carry its full rated current, and
- HMCB's precision of response set up and freedom from temperature de-rating means it is possible to specify circuit breakers that are not oversized for any current they would have to carry. As a result the cable cross section can also be optimized, which is a great advantage for the system, as it contributes to an enhanced Total Cost of Ownership (TCO).

With OEMs looking to reduce the overall cost and weight of rolling stock by consolidating areas currently reserved for cabinets, the devices' compact design, which is mainly front facing, provides a physical advantage.

Eaton's new offer: HMCB ADR

While HCMBs are a well-established product in the rail industry, some rolling stock utilizes thermal-magnetic circuit protection which, while still a good choice for protecting circuits, does not benefit from the advantages outlined above.

However, replacing TMCBs with HMCBs is far from straightforward. The HMCB connector is different, and the size of the device is usually bigger, which has required the operator or OEM to modify cabinet designs, and change panels and connecting interfaces. This timely and costly exercise also only produces tangible benefits in terms of reducing the space occupied by technical equipment, an increasingly important consideration during retrofit and upgrade projects.



Addressing this shortfall, Eaton has developed a new HMCB, its ADR series, which effectively provides all of the benefits of HMCB but within the same shell as a TMCB. This significant leap forward simplifies the installation process by enabling engineers to install the device using DIN 35 rail. As well as having the same fixtures, the 17.5mm profile is the same as the TMCB and compares with 19mm for a conventional HMCB. An upgrade to HMCB ADR is therefore now a far more attractive proposition to operators and OEMs.

A further advantage of the new ADR is that it is embedded on the same pole as the SPDT auxiliary switch using a standard connection socket. This permits the user to pre-cable the auxiliary contact with a connector of their choice - a screw, or push-in with different geometries - which helps to save precious time during final assembly or device swap in case of maintenance. The SPDT configuration also enables users to select the required signal by having the option to use NO, NC or both following a standard installation. This flexibility allows further optimization and a reduction of references.

Embedding the auxiliary contact in the same pole can also help to save valuable space by avoiding the use of one or two extra poles for the auxiliary contact, which is common with MCBs.

In addition, HMCB ADR offers enhanced Inrush capability.

Inrush is the current required to energize an AC-powered inductive device such as a transformer, inductor or electric motor. It also applies to AC/DC power supplies that use a simple rectifier/capacitor input stage. However, these initial currents can surge and reach levels quite a lot higher than the normal operating or "steady state" current, prompting the trip.

The development of High-Inrush devices to combat this issue is based on the same principle as the coil system used in HMCB. The addition of a magnetic quench to the coil system used in ADR means the circuit breaker can withstand a surge of up to 22-times the nominal value for a period of one half cycle at 50Hz. The standard is eight-times at 50Hz and below this value the circuit breaker will not trip if the peak lasts for half of this period. As well as transformers, inductors, and electric motors, this solution will prove particularly useful for DC power supplies to high-capacitive or inductive load and fluorescent lamp circuits. Each of these applications require a strong start-up or shutdown current - up to 600% for some motors depending on their type of power - which can be rectified through the various time delay curves available in Heinemann applications.

Other features and advantages of ADR are:

- Optional remote control of the triggering with so called Dual Control (DuCon)
- Mid-trip options for a visible check of triggering reason (manual or electrical)
- Optional handle locking system for Logout/Tagout, and
- Unique captive screw and captive lug mechanism that secures the wiring

Critically the new product meets key railway industry standards: EN 45545-2 and NFPA130 for fire and smoke; IEC 61373 for shock and vibrations; and EN 60077-3&4 for electrical devices is also IRIS-certified according to the new ISO TS 22163.

In keeping with Eaton's commitment to provide a global network of engineers and professionals which are capable of solving even the toughest challenges, clients will have access to dedicated application engineers. They are ready to support cross referencing and identify the most suitable protection device and technology available for a specific customer, including the development of customized solutions. And with Eaton's focus on energy efficiency, customers can rest assured that they'll be able to meet stringent regulations and help to drive the industry towards a sustainable future.

Conclusion

As a leading power management company, Eaton helps its customers become more energy efficient by offering a portfolio of solutions dedicated to improving sustainability and performance. The series Heinemann hydraulic magnetic circuit breaker range has served the rail industry for more than 30 years and is widely recognized as a reliable and effective product in the industry, enabling suppliers to access the benefits outlined in this paper.

The ADR is the next step in the evolution of the Heinemann range. It will provide the benefits of HMCB to more rolling stock, helping operators and manufacturers to transition away from thermal magnetic circuit protection and achieve their goals of weight reduction and improved train performance. Crucially, it will enable them to do this with no impact on train design, making an upgrade possible during scheduled maintenance intervals. This will minimize the time that rolling stock is out of service, and provide the operator with greater operational flexibility, a key consideration at a time when demand for rail transport is intensifying and the threat from other modes is becoming ever more acute.

If you are considering circuit protection design for your next rolling stock project or upgrade, or want more information, visit us online at www.eaton.com/rail, or contact your nearest local distributor. With Eaton's comprehensive knowledge and stockholding of all circuit breaker technologies, you are assured of an unbiased discussion.

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Eaton
EMEA Headquarters
Route de la Longeraie 7
1110 Morges, Switzerland
Eaton.eu

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