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Nexans
ELECTRIFY THE FUTURE

Current trends and developments in global rail, infrastructure and rolling stock

White paper

By:
Yannick Goutille, Global Product Manager for Rolling Stock
Julien Truflandier, Global Product Manager for Railway Infrastructure

CONTENTS

SYNOPSIS

This report offers a general overview of the global Railway Network market, and information on how Nexans continues to provide new products, solutions and services to serve that market.

First, we describe a number of broad trends in the global Railway Industry and how these are affected by global transportation requirements, recent technical developments, energy costs, climate change, customer demand and geographical developments.

Next, we take a closer look at specific developments in infrastructure and rolling stock, and actions Nexans is taking to meet current and future demands.

Overall, key drivers for new developments are population and urbanization, digitalization and innovation, sustainability and economic developments in specific geographies. These changes are affecting infrastructure and rolling stock in a variety of ways.

Finally, we will look at the product ranges Nexans offers, including the latest additions and updates.

About the authors

Yannick Goutille, Global Product Manager for Rolling Stock at Nexans, has twenty years' experience in the cable industry. Before moving into his current role, he held various positions within Nexans' Research Center and Marketing department as Product manager in Shipbuilding and Photovoltaic. He is an expert on several standardization committees for industrial applications.

Julien Truflandier, Global Product Manager for Railway Infrastructure has fifteen years' experience in the cable industry. He has held several positions in Technical Direction and Purchasing. For six years, he has been Product Manager for Oil, Gas & Chemical applications and Key Account Manager. He is involved in several internal and external standardization committees.

INTRODUCTION
BROAD INDUSTRY TRENDS

Research by the International Railway Research Board (IRRB) and International Union of Railways (IUR) shows that demand for long distance rail solutions and more energy-efficient systems for rolling stock and infrastructure will grow as a result of demographic evolutions and lifestyle changes.

According to independent consultancy company SCI Verkehr[1], global freight, passenger and urban rail transport has been growing since 2005. Rail continues to be widely seen as a reliable and efficient mode of transport and there is no reason to assume this will change in the foreseeable future. According to the Unife (Association of the European Rail Industry) World Market Study 2018[2] total track infrastructure has reached more than 1.6 m km of urban and interurban tracks. Growth has largely been in the urban and very high speed track segments Some 40% of all track kilometres are electrified, which means there is significant market potential for further track electrification.

According to the most recent Unife World Market Study[3], spending on rail projects has been taking place as intended since 2015, despite the economic downturn. Another study expects the global connected rail market size to reach USD 143.76 billion by 2030.[4]Demand for more efficient, faster, and cleaner transportation is being driven by rising passenger numbers, higher disposable incomes, and urban development, particularly in developing and emerging nations. Primary drivers promoting the growth of the connected rail systems are demand for rail safety and security, commuter comfort, government initiatives, and technological development. Integration of the Internet of Things (IoT) is also contributing to industry growth. Another recent study puts the global railroad market size at USD 295.80 billion in 2021, expected to expand at a compound annual growth rate (CAGR) of 4.4% from 2022 to 2030. [5]

[1]https://www.sci.de/fileadmin/user_upload/free-downloads/pdf/Pressemitteilung_MC_Electrification_2018.pdf

[2]https://www.unife.org/news-resources/wrms/

[3]https://www.unife.org/wp-content/uploads/2021/04/Forecast-2020-to-2025.pdf

[4]Global Connected Rail Market (2022 to 2030) - Share, Size, Trends and Industry Analysis Report, Research and Markets

[5]Railroads Market Size, Share & Trends Analysis Report By Type (Rail Freight, Passenger Rail), By End Use (Mining, Construction, Agriculture), By Region, And Segment Forecasts, 2022 – 2030, Grandview Research

GLOBAL POPULATION EXPANSION AND URBANIZATION

Global population increase and urbanization on an unprecedented scale are driving growth in the transport market. By 2050, there will be 9.8 billion people on the planet, which is driving demand for efficient, innovative and clean mobility solutions[6].

Today, over half the world's population lives in cities. By 2050, this will have increased to two-thirds of the global population, according UN World Urbanization figures[7]. Europe and the USA are expected to have reached an even higher level of urbanization by then. This impacts the movement of people and goods, especially in areas of high congestion. The need for urban mass transit solutions will rise significantly in coming years. Various regional markets are expected to keep growing steadily. The highest growth rates are expected in Western Europe (3.1%) and Africa/Middle East (3.0%). In South America, a relatively large number of metro and train projects are currently under development. Unife reports that over the past two years the overall rail supply market has seen substantial growth at 3%, primarily driven by the Asian Pacific region, with large projects in India and China. According to SCI Verkehr, the degree of electrification in Asia has risen substantially. China's growth consists of new lines and electrification of diesel. Furthermore, Sub-Saharan Africa is currently an attractive region for rail suppliers with high growth rates, states Unife.

Around the world, rail lines are carrying 10 billion tons of freight and 21 billion people each year. Demand for rail is outpacing capacity and infrastructure, creating bottlenecks and the efficiency of legacy systems. Passenger and freight rail need to change in order to meet current demands in the area of mobility, sustainability and digitalization.

[6]https://esa.un.org/unpd/wup

[7]https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html

SUSTAINABILITY

Efforts to decarbonize transport are progressing rapidly. The Paris Climate Summit (COP 21) saw a broad coalition agree to halt global warming at 2°C, or even 1.5°. 195 countries committed to limiting greenhouse gas emissions to less than 2% in coming years, in line with Intended Nationally Determined Contributions (INDCs)[8]. In 2021 almost 200 countries came together in the UK to commit to take action on climate change and forge the Glasgow Climate Pact, which calls on all countries to present stronger national action plans now, instead of in 2025, the original Paris accord timeline.

Unife comments that rail industry growth will support sustainable improvement of mobility in developed and developing countries, with rail as the backbone of an intermodal transport system that allows urbanization to go hand in hand with sustainable development goals. Across the rail industry, innovations are being introduced to reduce the use of power and resources, such as freight transport through dedicated rail corridors.

Several alternatives to diesel trains are being developed around the world:

- Onboard fuel cells in trains that combine hydrogen and oxygen.[9]
  Germany is currently operating the world's first 100% hydrogen-powered rail line, in Lower Saxony, with 14 zero-emission Coradia iLintTM trains from Alstom.
  Siemens is testing the Mireo Plus H 100% hydrogen powered train in Germany
  Scotland is testing its first 100% hydrogen powered retrofitted train

- Liquefied natural gas (LNG) as an option for dual-fuel locomotives.

- An electric railcar using a rechargeable battery for energy storage, recharged by overhead lines, electrified tracks or at charging stations.[10]

The Flirt Akku battery train made it into the 2021 Guinness Book of Records late last year after covering 224 kilometres in battery mode on the route from Berlin-Gesundbrunnen to Warnemünde in sub-zero temperatures and snowfall.

[8]https://www.un.org/en/climatechange/all-about-ndcs

[9]https://www.eia.gov/energyexplained/energy-and-the-environment/outlook-for-future-emissions.php

[10]https://www.railway-technology.com/features/featurehydrogen-fuel-cells-vs-batteries-how-to-power-the-trains-of-tomorrow-5692017/

DIGITALIZATION

The rail industry is adopting digital technology in order to improve customer journeys and planning with real time information and cross-platform tools, providing enhanced ticketing services and offering travellers a more streamlined experience. Infrastructure management is also being enhanced through digitalization to reduce delays and predict potential problems. Combining Information Technology and Operational Technology with connectivity, Internet of Things and cloud functionality allows systems to autonomously exchange information and initiate actions.

Component-level sensors can provide early warnings when maintenance is required, avoiding breakdowns. According to McKinsey advanced analytics will make condition-based maintenance "an attractive lever to increase maintenance efficiency."[11] Condition-based maintenance could save the global maintenance market around €7.5 billion per year by. A 'must' for regional and urban rail operators and cargo operators, says McKinsey, as these segments will be most affected by increased competition.

A few examples of sensor and 'smartness' applications in rail: Deutsche Bahn and Hyperloop Transportation Technologies (HTT) have developed augmented reality windows. In Seoul, smart cameras track passenger numbers and boarding speed and at central China's Wuhan Railway Station, facial recognition assists boarding. EU-funded research into Lidar sensor technology for railway automation is expected to lead to a train shunting assistance system and automated detection of objects on tracks.[12] Around the world, automated driverless passenger trains are being used to optimize running times. Australian freight company Rio Tinto successfully introduced a fully autonomous freight train in October 2017 and advanced autonomous rail vehicles built by former SpaceX engineers are currently in a testing period before being offered to the rail freight market.[13]

The developing digital ecosystem is bringing new, digital services and business models that rely on connectivity and data. New control technologies, such as communications-based train control (CBTC) and autonomous trains are further improving helping maximize use of assets and controlling costs. Optical Fibre cable demand and the importance of cybersecurity will increase along with the importance of digitalization.

[11] https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/the-rail-sectors-changing-maintenance-game

[12] https://samira-rangier-assistent.de/en/the-driver-assistance-system-for-shunting-freight-trains/

[13] https://moveparallel.com

RAILWAY INNOVATION

China has unveiled its new 600km/h maglev system vacuum tube trains transportation system in Qingdao, Shandong province.[14] The country has the world's largest high-speed railway network and will expand its length to 50,000km by 2025. Innovate UK, part of the Department of Transport's (DfT) wider Accelerating Innovation in Rail (AliR) scheme, is funding a wide variety of innovations to the tune of £7.9 m. Examples include carriages design that can quickly switch from passengers to goods transport, 'intelligent trains', beacons for visually impaired passengers and methods of guiding boarding passengers to empty seats. "In partnership with Innovate UK, we have already invested £35.4 million into over 100 ground-breaking projects," said Wendy Morton, Rail Minister. "We have seen cutting edge technologies such as HydroFLEX developed, the first ever trial of a hydrogen-powered train on the UK mainline. In April 2022, Elon Musk revealed that tunnelling firm The Boring Company would "attempt to build a working Hyperloop". According to Hyperloop Development Program, this form of rail transport could replace two-thirds of European air travel by 2050.[15] Adoption of this mode of transport on a wide scale could lead us to completely rethink travel distances and times and urbanization.

[14]https://www.railtech.com/rolling-stock/2021/07/21/worlds-first-600-km-h-maglev-train-exits-crrcs-factory/

[15]https://hyperconnected.eu/highlights/hyperloop-could-replace-66-of-european-flights-in-2050-hyperconnected-europe-vision-paper-shows/

CURRENT TRENDS IN RAILWAY INFRASTRUCTURE

According to a recent study by Transparency Market Research9, the key driver boosting the rail infrastructure market is increased demand for transportation as a result of rapid globalization. The study also points out that aging transport infrastructure is also a likely driver for the global rail infrastructure market. Dated urban transport can no longer meet today's requirements. Marketwatch10 claims that the global Rail Infrastructure market, valued at 47000 mn US$ in 2017, will reach 61400 mn US$ by the end of 2025, growing at a CAGR of 3.4% during 2018- 2025.

INTEROPERABILITY

In Europe, each country has adopted different systems, specifications and standards for railways. This covers everything from component sizes and track widths to signalling systems and IT standards. For the European Commission, a current key topic is realizing interoperability, enabling, for example compatibility and communication between IT and signalling systems as well as cross-border trains. An important development aiming to enhance rail efficiency is increased interoperability and standardization. In Europe, significant progress is being made. The first Technical Specifications for Interoperability (TSI) related to railway infrastructure, energy, rolling stock, control-command and signalling, maintenance and operation from the European Association for Railway Interoperability (AEIF) was adopted in 2002 and revised in 2008. The Delegated decision (EU) 2017/1474 set out common and specific objectives of all TSIs to be developed or amended with a view to harmonizing them and streamlining the EU railway legislation. In accordance with these, the Commission issued a mandate for drafting, adoption and review of TSIs in 2017. The EU's Fourth Railway Package aims to make the European rail system more efficient and better adapted to changing transport needs. The resulting harmonization of European rail traffic should positively affect rail operators and suppliers.

The European Rail Traffic Management System (ERTMS) is the system of standards for management and interoperation of signalling for railways by the European Union (EU). Its main target is to promote interoperability of trains across the EU, enhancing rail safety, and efficiency and cross-border interoperability by replacing national signalling equipment and operational procedures with a unified pan-European train control and command standard.

ERTMS is conducted by the European Union Agency for Railways (ERA) and covers

- GSM–R (communication)
- European Train Control System (ETCS, signalling)
- European Train Management Layer (ETML, payload management)

ERTMS has three levels. ERTMS levels 2 and 1 are based on physical layer cable, whereas level 3 cable is mainly based on mobile information, satellite, wireless data and cloud.

In its Strategic Business Plan (SBP) 'Electrical equipment and systems for railways' the IEC TC 9 body is preparing international standards for railway which include rolling stock, fixed installations, management systems (including communication, signalling and processing systems) for railway operation, their interfaces and their ecological environment. The standards cover railway networks, metropolitan transport networks (including metros, tramways, trolleybuses and fully automated transport systems) and magnetic levitated transport systems. The standards relate to systems, components and software.

DIGITALIZATION

In rail infrastructure, digitalization can be applied in different areas:

Asset management

Using collected data, an operator could make traffic management smarter, or better understand occupation and utilization levels at different times. Some power companies are already developing systems with IoT and sensors built in for emergency detection. It would be possible to create something similar for rail, which allows ongoing analysis of rail quality, potential damage and so on.

Mobility management

People are becoming increasingly mobile, traveling for work and pleasure. Digitalization opens up new possibilities in customer service, such as ticketing and trip planning. Taking this a step further, Digitization and system integration at multiple levels makes multimodal travel possible: the seamless combination of different transportation modalities, including related information and planning services. This requires the right infrastructure, supported by high-quality, real-time information systems that enable the connection of routes, schedules and fares and possibly allows travel using a single ticket. Furthermore, congestion and power consumption are significantly reduced.

The benefits are smooth, fast journey for the customer, who may be prompted to use routes or vehicles they may not be aware of, or which they might not normally use. They are also provided with up-to-date information, if necessary, across different devices if required. To make multimodal travel work, transportation systems need to be closely connected in both a virtual and physical sense.

Mobility management requires many different systems to work together seamlessly, for which certain networks will need to be upgraded. Also, IT platforms have be do capable of processing across different channels and understanding each other. In some countries, such as France, a single organization may provide rail services, whereas in the UK, for example, there are different operators. This, too, will require a significant degree of harmonization.

Predictive and condition-based maintenance

Predictive maintenance is becoming an important topic for rail companies. With lines becoming denser and faster, any maintenance work needs to be predicted in advance. Currently, considerable effort is being put into investigating how maintenance can be carried out without interrupting traffic. Normally, a group of experts is sent to a site to gauge the quality of installations and schedule maintenance accordingly. If, for example, a cable requires closer inspection, the installation will need to be shut down. This brings considerable costs in the areas of time and money, especially because schedules are interrupted. Often, downtime is planned at night, which is also inconvenient. There is a need to predict when maintenance is required quickly and cost-effectively.

One option is to integrate sensors and some form of intelligence into cables and combine this with data analysis and new installation models. Nexans is looking into these areas and building the required capabilities in our digital lab, as well as leveraging know-how from other parts of the company. The result: control and testing of large installation allowing very precisely scheduled maintenance to take place when and where required.

A 'data spine' is required across the entire network to allow infrastructure managers to introduce route-based maintenance management assessment that can model failure patterns and identify high and low risk components for whole-life asset management, especially for power supply equipment and line-side signal cabinets. This 'smart maintenance' concept which will shift from time-based to condition-based maintenance will require sophisticated information and communication technology based on a track-side cable system which could even incorporate an Automatic Track Warning System (ATWS) to protect staff working on repairs.

Autonomous vehicles

Around the world, there are already many examples of Automated People Movers (APM) at airports and driverless metro trains. The next challenging step is the implementation of this technology in commuter trains and regional trains.

This fast-growing technology area strongly relies strongly on structured cabling and component connectivity. For many years, this has allowed doors on a platform to open in exactly the right place at the right time. Detecting obstacles at speeds of up to 100 km/h is one of the next challenges for autonomous train projects. The sensors installed on the train, as well as the algorithms in charge of analysing the collected data, are decisive. The principle is to use different technologies in order to have diversified data and extract a maximum of information.

Sensor applications

When building a long stretch of railway, which might easily be 100 kilometres, multiple cable drums need to be positioned at different spots along the trajectory. By integrating sensors, drums can be identified, located and delivered more easily. Tracking functionalities also prevent theft.

Fire safety: focus on CPR

On July 1, 2017, the Construction Product Regulation (CPR) applicable to cabling came into in force. This new classification system is to be used wherever electrical systems are permanently installed across Europe. CPR covers all products incorporated into residential, commercial, or industrial buildings and other civil works. Its scope now also includes power and control cables of any rated voltage, as well as communication cables with metal and glass (optical fibre) conductors.

CPR provides a common technical language and a harmonized set of rules for assessment and performance testing of construction products in the EU. It extends responsibility to all of the parties in the supply chain and improves quality monitoring. Before a product reaches the market, manufacturers are obliged to draw up a Declaration of Performance (DoP). Independent product certification bodies and test laboratories identify each product, its intended use and its fire performance characteristics. The highest cable assessment criteria are extremely challenging, as these represent worst-case scenarios. CE-marked cables guarantee enhanced performance, transparency and reliability.

For tunnels longer than one kilometre, European regulations require definition of minimum category of cables in relation to fire performance. To make compliance with CPR easier, Nexans offers B2ca certified products, as well as experience, extended technical expertise, information and support. A full range of fire-resistant, asbestos free and RoHS (Restriction of Hazardous Substances) compliant cables is available.

Nexans is actively participating in CPR European technical committees, and our customers are being duly informed and updated on the evolution of the legislation. Nexans TrackerTM gives quick and easy access to the Declaration of Performance online, allowing direct consultation and download of Regulatory Information related to CPR. User can check compliance of products with the regulation and their performance classes immediately, anytime, anywhere.

Nexans is additionally providing advice and dedicated tools, from training and (online tutorials) to brochures and FAQs. Clear CE marking and consistent labelling, which clearly displays all useful information and is exactly the same for every Nexans product.

https://www.transparencymarketresearch.com/rail-infrastructure-market.html

https://www.marketwatch.com/press-release/rail-infrastructure-market-2018-global-share-trend-segmentation-analysis- and-forecast-to-2025-2018-06-28

CURRENT TRENDS IN ROLLING STOCK

According to Unife, the total worldwide demand for rolling stock was predicted to grow by 1.2 to 2.6% reaching a volume of 66 to 72 bn EUR for the years 2023-2025, after the COVID-19 crisis. APAC accounted for the largest part of the total market with some 44 % market share followed by Western Europe (23%) and NAFTA (15%).

We are seeing three key trends in rolling stock, driven by customer demand, technology developments and legislation.

- Fire safety
- Communication
- Power consumption

Fire Safety

Increased passenger volumes, network density and regulations are all drivers for enhanced passenger safety. In general, rail infrastructure is difficult to evacuate and escape from, making this topic even more important. Operators, partly driven by customer demand, are looking to increase train safety. At Nexans, this has resulted in the development of a specific 'fire resistance' FLAMEX® product range. The goal is preventing fire from spreading through cable trays and ensuring the lowest possible emissions of smoke and toxic fumes, whilst guaranteeing that power and communications systems continue to work for as long as possible.

Fire resistance in buildings, cruise liners, petrochemical plants and other sensitive industrial fields, has been a topic of discussion for years. However, for rolling stock this is a relatively new area, with less than 10 years return on experience. Nexans has benefited from its long experience in different fields addressed with several technologies to build customized solutions for the rolling stock industry. Our INFIT™ technology for FLAMEX® Control and Ethernet Fire resistant cables, for example, has been under development for more than ten years and has resulted in several patents used to create this range of products.

Data Transmission and Communication

Tomorrow, trains will be digital with enhanced communication, monitoring and on-board system intelligence. There is marked interest in close monitoring of a wide variety of functions, which are closely linked to the train itself: speed, consumption of electricity or fuel, routes and so on. Train operators are facing marked growth of on-board data traffic, resulting from enhanced Wi-Fi systems, interactive technology for making seat reservations, intelligent door display systems, passenger information on high definition screens, and luggage monitoring. Furthermore, customers have higher expectations regarding mobile phone and internet access on board, as well as entertainment and multimedia access. This places more pressure on the train operators in terms of customer service.

Traditional on-board cabling deployed with Ethernet CAT 5 can no longer cope with the increased demand in data transmission. In response to this trend, FLAMEX® CAT 6A to 7A cables with higher performance rates have been introduced to the railway market: the data transmission backbone is mainly designed with these cables, whereas cable looms for local networks inside the coaches are locally designed with Ethernet CAT 5 quads. These are lighter and smaller for tight bending and can be installed faster. To support rolling stock customers in this transition, Nexans is offering the latest generation of FLAMEX® CAT 7A cables alongside traditional CAT 5 cables. While data transmission speed of Ethernet CAT 5 cables is limited at 1 Gbps, Nexans FLAMEX® CAT 7 cables for rolling stock can support up to 10 Gbps, bringing customer experience to a whole new level. Nexans can also provide 7A for rail applications, although there are no dedicated rolling stock connectors for 7A yet.

The autonomous vehicle trends and requirements mentioned on page 11 - introducing a variety of sensors, algorithms and technologies to enable obstacle detection at high speeds - also apply to Rolling Stock.

Weight in relation to power consumption

As we have seen in the automotive, aerospace and logistics sectors, weight reduction is essential across transport segments. On a train, cables run everywhere: through doors, floors, the roof, toilets... Every metre of train houses approximately 1km of cable. Reduction of cable weight on board has a significant impact on energy consumption, and also reduces wear and tear of the rolling stock equipment. What's more, payments to rail authorities for track use are also lower when weight is decreased. To accommodate these requirements, Nexans has created thinner cable designs with high performance material. In a building, a larger diameter wouldn't be a problem, but on board there are space constraints and tight bending to consider.

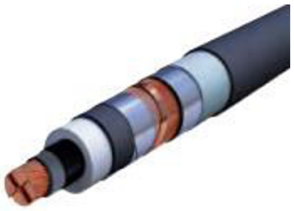
Nexans has developed family of cabling using material that operates at higher performance levels, so that power throughput – and cable volume – can be decreased. This is particularly the case with FLAMEX® Control EN 50306 and Power high temperature EN 50382 series. A specific flexible aluminium cable line was also created to tackle this challenge in the rolling stock industry. Nexans has been focusing on rethinking concepts and also introducing incremental improvements, improving designs, materials and more. This is largely done with our engineering departments at plants in France, Germany and China. All products are developed in-house, and our capabilities are fully utilized.

Nexans also has the ability to test and develop complex hybrid jumper cables, including control and communication along with power in a single jacket leading to weight reduction. Installation needs to be easy and the cables have to withstand the operational mechanical stresses of rail use. This has implications for cable design and requires millions of test cycles.

WHAT DO THE INFRASTRUCTURE AND ROLLING STOCK INDUSTRIES EXPECT FROM A CABLE MANUFACTURER?

- A full range of CPR approved power, signalling and communication cables and solutions to meet all current and future infrastructure needs, trackside as well as at stations, control centres, etc.
- Because of the international nature of railway expansion worldwide, a regional supply base, with firm guarantees that a certain percentage of supply will be locally manufactured or easily available.
- Innovation to ensure faster and easier installation of key elements such as axle counters, and, if required, full compliance of cables with national standards, and also the ability to evolve and adapt to changing infrastructures (including backward compatibility with existing networks).
- Solutions to problems such as copper theft, and advanced safety assurances in terms of fire-resistance, not only for safety cables, but also for medium-voltage and telecom cables.
- New installation methods that can reduce time and cut costs.
- Optical fibre universality in the IP world, coupled with ruggedness in the field.
- Reduction of complexity in cable and system procurement, a simplification of references for buried cables, and harmonization of specifications and designs.
- Advanced technical knowledge from a trusted supplier, since in many cases operators are losing their expertise, acquired over years, as a result of generational attrition of their own in-house experts.
- Customized supply chain services such as inventory management.
- Tracking systems based on RFID or GPS chipsets

NEXANS RAILWAY INFRASTRUCTURE SOLUTIONS



Traction-feeder cables

These cables are for MV and HV energy transmission to and from transformer substations and for powering catenaries and systems. The cables are installed along the tracks, and a new generation with halogen-free materials and compliant with CPR regulation can be installed in tunnels in urban areas .

Power distribution cables and components

These standard cables handle 16.7/50/60 Hz current and can be installed as easily as traditional energy networks. A wide range of earthing cables is available with optional metal-hybrid constructions.

Signalling cables

These energy and telecommunication copper cables provide LV power and bidirectional communications for trackside equipment and vital relay stations. These are available in multi-conductor or multi-pair/quad versions.

Axle counter cables

Armoured and unarmoured 90 kHz multi-conductor cables provide information on train position, circulation path, length, number of cars and train integrity.

Optical-fibre cables

To handle data exchange for Automatic Train Control, these cables are available in LAN, MAN, and WAN versions with special protection in tunnels and against fire. New solutions are available using micro-bundles, which are compact and cost-effective.

Optical IP switches

These are used to interconnect Ethernet-based track devices for communication and monitoring. The switches feature 3 fibre optic uplink ports and 8 copper ports and can supply IP cameras, phones, WLAN access point with Power over Ethernet (PoE).

INNOVATIVE SOLUTIONS FOR COST-EFFECTIVE UPGRADES AND SAFETY

Eurobalise cables for interoperability

These fully compliant ERTMS cables combine reliability, mechanical strength and electromagnetic compatibility for carrying HF signals for the overall traffic control system. Phased in with GPS, ERTMS will improve safety and efficiency, and promote standardization and interoperability.

Nexans originally developed halogen-free signalling cables for Level 1 ETCS Eurobalise applications to connect trackside signalling equipment to radio transmit vital data to the train's onboard computer. They are now fully operative on Level 2 installations as well.

Eurobalise cable has a low mutual capacity of around 42.3 nF / km, which is low enough to transfer data and energy over long distances (up to several kilometres) It is also designed to survive between and along the tracks.

Flame-retardant, fire-retardant, fire-resistant cables for protection

Three different cable categories have been developed by Nexans

- Flame-retardant cables that self-extinguish in case of a flame application to a single cable
- Fire-retardant cables that do not propagate the fire and with a low smoke and gas generation
- Fire-resistant cables which ensure the operation of vital equipment during a fire, such as keeping emergency exit lights and exit signs lit, signalling information flowing, and fire-fighting equipment operating.

For these critical safety systems in substations or tunnels, Nexans has developed special fire- Resistant Medium-Voltage Cables, Optical Fibre cables, LV, signalling cables all in Fire resistant options.

In recent years, special projects have been deployed within Nexans to develop Flame or Fire- retardant cables complying with fire requirements of the new European Construction Public Regulation (CPR), in particular cables meeting the required classification for cables installed in tunnels longer than 1 km, the Euroclass B2ca, s1a, a1. Since 2017, Nexans has been offering a comprehensive range of cables that are CPR approved, either for power (LV – HV), control or signal applications.

NEXANS ROLLING STOCK SOLUTIONS

FLAMEX® cables for Rolling Stock are halogen-free, non-toxic, non-corrosive, low smoke, flame and fire-retardant. They comply with EN 45545-2, the European standard covering fire behaviour of materials and products in railway rolling stock. Besides complying with fire safety requirements from EN 45545-2, FLAMEX® solutions meet various international standards such as NFPA 130 and GOST-R 31565.

Nexans assures compliance to standards through rigorous testing in its research laboratories that are ISO 17025 certified. Robust and durable, the cables are tested for 20,000 hours of peak operation to ensure high levels of safety for passengers and equipment. The range is also asbestos free and RoHS (Restriction of Hazardous Substances) compliant.

THIN TO ULTRA THIN CONTROL WIRES & CABLES

Space concerns of manufacturers and energy concerns of operators have inspired development of smaller, lighter products. Single or multi-core, shielded or unshielded, for all command and surveillance functions, compliant with the performances and design requirements of the EN 50306 series.

To ensure easy installation, the cables are fully compatible with connectors designed for rolling stock projects, such as X-coded M12 connectors. Furthermore, the easy-to-strip insulation and sheath also make it possible to install and connect cables easier and faster. These products meet the highest hazard level class HL-3 from the EN 45545-2.

FLEXIBLE AND ROBUST POWER CABLES

Rolling stock power cables

FLAMEX® EN 50264 power cables are designed with cross-linked insulation and/or outer sheath to provide high resistance to chemicals, mechanical stress and extreme temperatures. These cables are installed in switching station and control panels through cable ducts, pipes and tubes. Shielded power cables are used for sensitive installations in which enhanced electrical screening (EMC) is required. These products meet the highest hazard level class HL-3 from EN 45545-2.

High-temperature flexible power cables

FLAMEX® EN 50382 power cables are particularly recommended in high-temperature applications, to save cable weight. To deal with extreme operating temperatures from -50° to 150° C, these power cables are designed cross-linked silicone insulation & sheath. FLAMEX® EN 50382-2 silicone-based cables provide further weight savings compared to regular power cables, allowing higher working temperature. These cables are used to feed high-voltage machines, transformers, motors or generators, where high temperatures prevail, and flexibility is required.

Solutions for the HV roof line

Tailor-made to carry electricity from the pantograph to the locomotive's transformer, Nexans solutions include flexible 26/45kV HV cables with the well-known FLAMEX® Panto, bushings or T-connectors. These high voltage components can also be supplied with the required cable length as a pre-mounted, pre-tested cable assembly before installation on board of the vehicles.

HIGH RATE COMMUNICATION CABLES

Ethernet, Databus or Coaxial cables

A pressing need for train management has led to significant advances in data cable designs. Nexans is extending the scope of Ethernet cables toward higher data transmission to keep supporting customers' challenges. Designed to cope with transmission rate up to 10 Gigabit, Ethernet cables will replace communication protocols step by step, with Profibus, MVB, WTB for passenger video services/surveillance and the monitoring of vital equipment for train operation. A braided shield ensures the cables can withstand heavy electromagnetic disturbances, ensuring reliable signal transmission.
Its cross-linked outer sheath provides fire performance and high resistance to chemicals, mechanical stress and extreme temperatures required in rolling stock.

Optical fibre cables

Instead of a copper-based twisted-pair bus cable, customized multimode optical fibre cable delivers high bandwidth for onboard services: video, interactive passenger information, Wi-Fi and Internet. These solutions are designed for fixed installation or intercar links.

FIRE RESISTANT CABLES

In the rail industry, tunnels and rail cars can quickly become potentially lethal enclosures if a fire breaks out. It is essential to maintain power and control system operation to ensure that passengers can leave the train in a safe place.

Safety is a key concern for Nexans and our customers, transit authorities and manufacturers. Addressing this concern is our top priority. Increasing safety demands are a driver for finding better ways
to assure electrical circuit integrity and improve fire performance. A new product line is emerging with FLAMEX fire-resistant cables that ensure circuit integrity of key components per the EN 50200. Power, Control and Communication cables are of course compliant with EN 45545-2 meeting the highest hazard level class HL-3.

Solutions for Control & Communication networks

The FLAMEX® Control and Ethernet FR product range ensures circuit integrity, keeping control of the critical emergency functions in the most demanding fire situations. These products are designed with INFITTM technology. Apart from offering high fire performance, this technology makes the preparation and the connection of wires easier and faster, compared to older taping technologies. What's more, this product line helps save weight on board by getting rid of heavy mechanical protections and moving to updated communication systems.

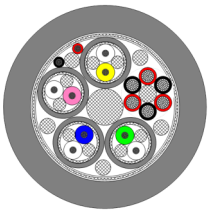
Leading this range is the FLAMEX® Ethernet FR which can reach data transmission performances for Category 5 as described in the ISO/CEI 11801, showing no loss of data train and no drop of the transmission parameters when burnt. This performance is achievable thanks to Nexans unique technology for fire resistant cables.

Solutions for Power networks

FLAMEX® FR product line meets fire resistance requirements prescribed by EN 50200 or IEC 60331 standards. These cables enable the continuous flow of power (up to 6 kV) required for emergency systems to function reliably when needed most, providing improved safety for operators and fire response personnel. As for other FLAMEX® types, these cables help limit the spread of potential fires and the release of harmful smoke.

CUSTOMIZED SOLUTIONS FOR JUMPERS

In order to link cars/bogies/wheels, strong and flexible jumper cables carry information (through Ethernet, databus, coaxial components) and energy (for control and power) in an open, moving environment for millions of cycles. Nexans engineering teams work in partnership with customers and component suppliers to take the right design decisions. This allows delivery of reliable jumper assemblies and minimizes the potential risk of failure after years in operation.



CUSTOMISED SERVICES

Innovation is no longer an option for industry. Digital transformations, a growing regulatory environment and profitability require rethinking traditional business and technology approaches to help sustainable performance.

This is why Nexans has developed a unique program of services to support the operational and financial performance for industrial operators. A program based on engineering, digital, innovation, business and logistical expertise, and leading know-how to help cope with your future industrial challenges.

For rolling stock, Nexans can provide customized solutions, from supply chain to recycling. In each step of the rolling stock process, Nexans engineers support partners' performance.

We offer dedicated services areas around two pillars:

- Supply Chain and Operations
- Business Support

Each of these areas, and the related services, are discussed below.

RETHINKING SUPPLY CHAIN AND OPERATIONS

Rolling stock players, in particular OEMs and their subcontractors, are seeking to reduce their total cost of ownership. Where electrical cable is concerned, Nexans uses analysis tools to carry out diagnostics and propose personalized solutions combining RFID technology and modern supply chain methodologies. The aim: reduction of costs in operation, improved cash flow, freeing up warehouse space and simplifying project management.

Your performance depends on perfect project execution, so you need to rely on solutions designed to increase supply chain reliability while minimizing your costs and working capital requirement.

SERVICE 1: SMART INVENTORY MANAGEMENT

An RFID-based solution allows reliable automatic stock replenishment, fast and easy physical stock counting and incoming goods reception processes. Our multi-supplier, multi-product solution is based on efficient demand-driven supply models and the usage of advanced RFID technology to easily monitor your stocks and manage your inventories in real-time. Your entire portfolio of supplies can be managed through one platform and a single system.

Benefits:

- Reliable demand driven automatic stock replenishment
- Lowest possible inventory levels
- 100% Material availability
- Simplification and acceleration of incoming goods reception process
- Fast and easy physical stock counting
- Transparency throughout the end-to-end value chain
- 40% inventory reduction

SERVICE 2: VIGISHIELD

In recent years, cable theft has intensified around the world, largely as a result of rising global copper prices. With the cost of raw copper reaching close to $10,000 per ton, these thefts represent billions of euros in losses for the various players in the industry. A conservative estimate of annual total value of damage from copper wire theft is $900 million in the United States alone... Anticipating these risks and providing protection against them, Nexans currently provides a range of new solutions to our customers, from manufacturing all the way through to operation.

Nexans is offering VIGISHIELD customers:

- permanent surveillance of their cables, wherever they are in the world,
- total control of their projects and deadlines
- significant reduction of their direct and indirect costs due to cable theft.

SERVICE 3: ULTRACKER

Nexans ULTRACKER is made up of four main digital solutions. This global offering features industry-leading technologies including software that allows customers to access live updates about their cable delivery status, drums geolocation and anti-theft alarms. Thanks to this unique solution, customers have real-time detailed information on their products.

- ULTRACKER VENDOR-MANAGED INVENTORY (VMI) raises supply chain efficiency of customers by synchronizing demand with product availability while avoiding supply disruption and excess inventories. Thanks to this orchestration process, supply chain data such as consumption forecast, stock, and order booking are exchanged through a dedicated software platform that acts as an interface between Nexans and its customers' information systems. The system automatically triggers supply and replenishment to meet customer demand.

- ULTRACKER SMART INVENTORY MANAGEMENT (SIM) tracks the history of stock movements to help customers monitor and manage cable stocks in real time and triggers alerts to reduce the risk of product shortage or overstock. This automated inventory system boosts performance and speed and helps reduce costs, decreasing environmental impact and the working capital required by clients.

- ULTRACKER TRACK'N TRACE is a digital service developed with Nexans' technology partner Shippeo, a global leader in supply chain visibility. The solution uses automation and artificial intelligence to deliver industry-leading supply chain solutions. In collaboration with Shippeo, Nexans provides real-time asset tracking worldwide, incident management, and accurate arrival time predictions and delivery updates.

- ULTRACKER DRUMS uses edge-computing technologies to enable real-time geolocation of cable drums thanks to multi-sensor GPS devices embedded inside the drums. Nexans pioneered these technologies and provides unique advantages to its customers, such as shipments follow-up, theft detection, remote monitoring of installation projects, residual length management, and a streamlined drum pick-up process. It results in reduction of cables drum theft and loss by 90% while improving the drum usage rate by 25%, as well reducing waste globally. Nexans has recently partnered with Orange Business Services, a worldwide provider of Internet of Things (IoT) connectivity, to support the scale-up of this service all over the world.

Nexans has built long-lasting relationships with its partners and continues to advance its customer-centric innovations, and ultimately customer satisfaction. Nexans' ULTRACKER allows customers to stay up to date with the latest supply chain technology and industry demands, while keeping transportation costs down. Nexans will continue refining its worldwide offering of solutions by combining the ULTRACKER TRACK'N TRACE and ULTRACKER DRUMS functions in a single platform, allowing customers to access resources from a single point of entry.

RETHINKING BUSINESS SUPPORT

Nexans can help you to limit the impact of the unexpected. Execution flaws, metal price fluctuations, project cancellations or delays can significantly impair your financial performance. Thinking ahead allows you to mitigate these risks, but also reduce your ecological footprint.

SOLUTION 1: RECYCLING

One of the challenges our customers face is cable waste. In fact, 3% of cable value purchased ends up as scrap and 30,000 tons of scrap is recycled each year. By choosing Nexans recycling services, you can receive money back in exchange for your leftover cables, while making a positive contribution to the environment. For over 35 years, Nexans as a recycling expert has collected and recovered copper and aluminium cable waste from production plants and from cables at end-of-life across Europe.

This offer targets the 'obsolete' stock of cables that cannot be installed on new rolling stock equipment 5 years after the manufacturing date. Following inspection, Nexans will issue a credit note for your obsolete and leftover cables and scrap at the fairest market value through its own controlled waste recovery channel. Logistics and release of administrative certificates are included (ISO 9001, OHSAS 18001, ISO 14001, ICPE).

Benefits:

- Reduced impact of losses associated with incorrect forecasts
- Nexans bears the metal risk (between redemption and eventual resale)
- Cash recovery at the end of construction
- Free storage space

$$\text{Buy value} = \text{Qty}\,(\text{LME}_{\text{Low}} - D)\,Y - T - L$$

Qty : Cable scrap quantity (t)

LME Low : Official (Cu or Al) LME Lowest converted in Euros D : Discount according of the quality of the granules

Y : Yield or metal content (% obtained after grinding) T : Treatment (Process costs)

L : Logistics costs

SOLUTION 2: HEDGING

The extremely volatile price of copper puts project profitability at risk. Nexans can help mitigate this thorough its power as one of the world's largest private copper traders (550,000 tons per year).

Our metal hedging platform enables securization of sourcing through long-term contracts with copper cathode suppliers, offering price stability up to five years and a competitive cost of service. Our metal management consulting service offers advices on options for hedging strategies and management of project evolutions (for example timing and quantities).

NEXANS: GLOBAL EXPERT IN RAIL SOLUTIONS

Nexans is a highly experienced, vertical market supplier that can manufacture the hundreds of specialty products necessary to outfit a complete train set. Nexans addresses the projects of OEMs, subcontractors, transit authorities, and system suppliers around the world from its European and Asian facilities.

Nexans wants to be part of current changes by playing a role that extends beyond cable. During its half-century of involvement in the rail industry, the company has gained valuable experience by working closely with rolling stock engineers and operators to find solutions which respect their many priorities, from cost, efficiency and safety concerns to wider issues of reducing CO2 emissions.

Together with its customers, Nexans is anxious to see "sustainable mobility" achieved for main line high and ultra- high-speed lines, but also for revamping regional lines. It also recognizes that rail transport has major advantages in the urban context. It has special experience in metros, tramways, light rail, and driverless people movers and can contribute to the development of intermodal urban mobility systems to meet the expectations of tomorrow's citizens, especially in terms of today's information-rich travel experience.

Nexans recognizes that expensive breakdowns, accidents, and short cabling and equipment lifespans pose real threats to long-term viability and growth. That is why the products, technologies and systems that Nexans offers are intended to improve efficiency, prolong product life, and assure the highest standards of safety.

Nexans sees its role in the coming years as a "privileged supplier" to rolling stock, as this field continues to demand a global procurement policy, integrating buying, standardization and interoperability. More than ever, Nexans strategy is to go "beyond cable" to add value to products, do innovative research, and provide a host of relevant services, reducing the Total Cost of Ownership of the electrical function for its clients.

About Nexans

As a global leader in advanced cabling and connectivity solutions, Nexans brings energy to life through an extensive range of best-in-class products and innovative services. For over 120 years, innovation has been the company's hallmark, enabling Nexans to drive a safer, smarter and more efficient future together with its customers.

Today, the Nexans Group is committed to facilitating the energy transition and supporting the exponential growth of data by empowering its customers in four main business areas: Building & Territories (including utilities, smart grids, e-mobility), High Voltage & Projects (covering offshore wind farms, submarine interconnections, land high voltage), Telecom & Data (covering data transmission, telecom networks, hyperscale data centres, LAN), and Industry & Solutions (including renewables, transportation, Oil & Gas, automation, and others).

Corporate Social Responsibility is a guiding principle of Nexans' business activities and internal practices. In 2013 Nexans became the first cable provider to create a Foundation supporting sustainable initiatives bringing access to energy to disadvantaged communities worldwide. The Group's commitment to developing ethical, sustainable and high-quality cables drives its active involvement within several leading industry associations, including Europacable, the National Electrical Manufacturers Association (NEMA), International Cablemakers Federation (ICF) or CIGRE to mention a few.

Nexans employs more than 26,000 people with an industrial footprint in 34 countries and commercial activities worldwide. In 2017, the Group generated 6.4 billion euros in sales. Nexans is listed on Euronext Paris, compartment A.

For more information, please visit *www.nexans.com*

Contacts:

Press
Angéline Afanoukoe

Tel. +33 1 78 15 04 65
angeline.afanoukoe@nexans.com

Current trends and developments in global rail, infrastructure and rolling stock

White paper

September 2022

Nexans
ELECTRIFY THE FUTURE