Hitachi Metals
NEWSLETTER
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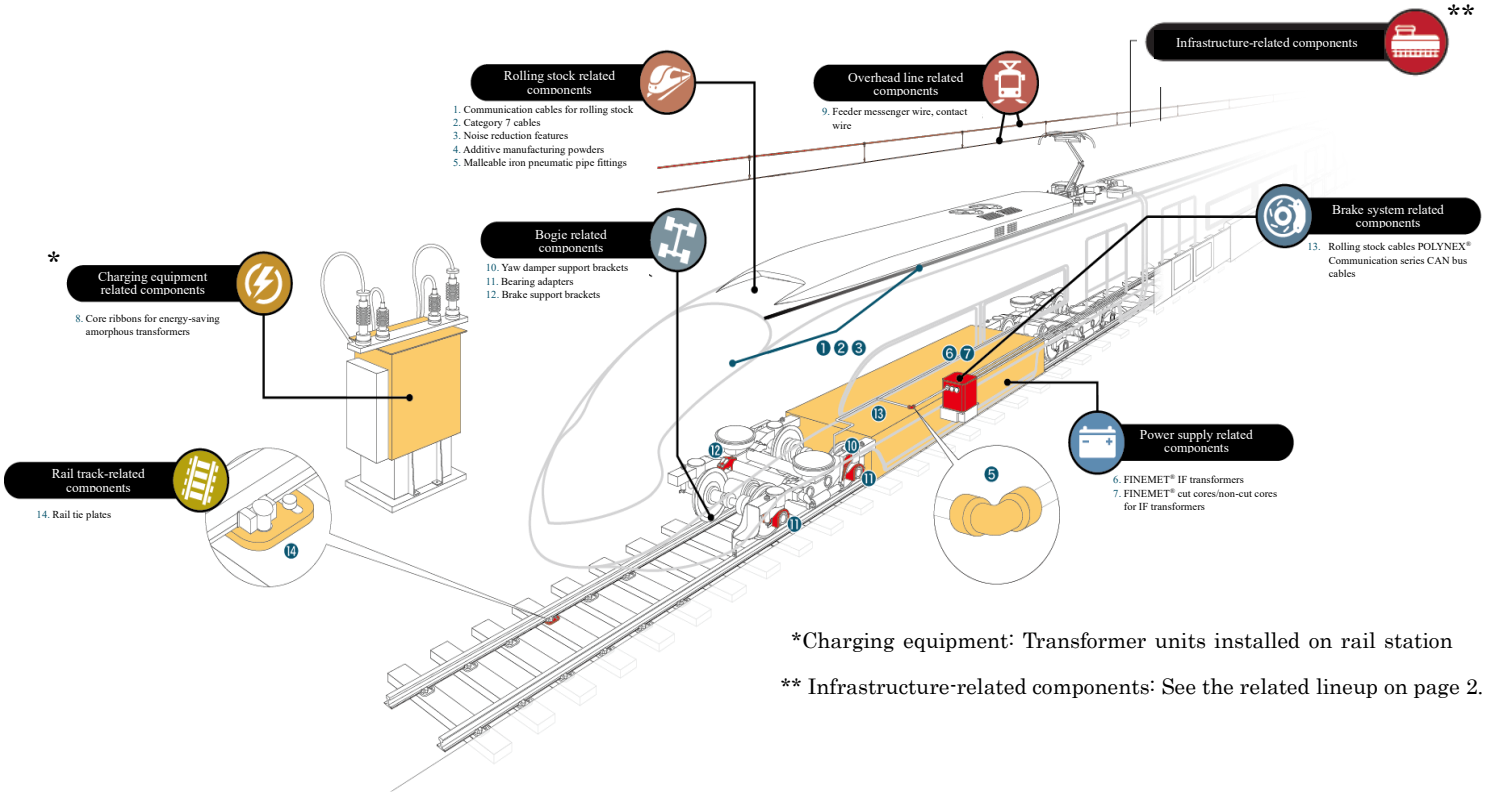
Hitachi Metals, Ltd.

Advanced materials lineup for ever-more sophisticated rail systems
-Hitachi Metals' solutions for the mobility revolution-

Hitachi Metals, Ltd. ("Hitachi Metals") is a long-established supplier to the rail industry, providing related products and services to promote the advancement of the rail system, and contribute to the development of the industry. Hitachi Metals has developed an extensive lineup for a range of functions from rolling stock to infrastructure and service systems.



*Charging equipment: Transformer units installed on rail station

** Infrastructure-related components: See the related lineup on page 2.

Hitachi Metals' lineup of rail system-related products

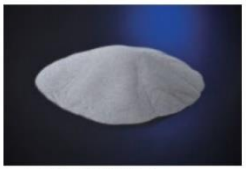
Rolling stock related components

Rolling stock wires and cables

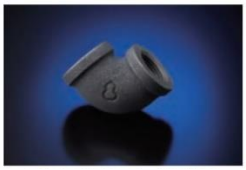
Communication cables for rolling stock

Category 7 cables

Noise reduction features



Additive manufacturing powders*



Malleable iron pneumatic pipe fittings

Power supply-related components

FINEMET® IF transformers

FINEMET® cut cores/non-cut cores for IF transformers

Charging equipment-related components

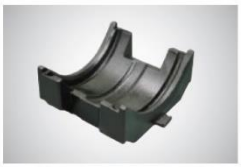
Core ribbons for energy-saving amorphous transformers

Overhead line-related components

Feeder messenger wire and contact wire

Bogie related components

Yaw damper support brackets



Bearing adapters

Brake support brackets

Brake system related components

Rolling stock cables POLYENEX® Communication series

Rail track related components

Rail tie plates

Infrastructure related components

Railway signal cables

Dust-resistant flexible fiber optic cables

Metallic communication cables

MPO** optical cables

Low-loss high-frequency coaxial cables with highly foamed insulation

MPO optical cassette

Leaky coaxial cables with highly foamed polyethylene insulation

ZlockII® mechanical joints for stainless steel piping
Coaxial cables

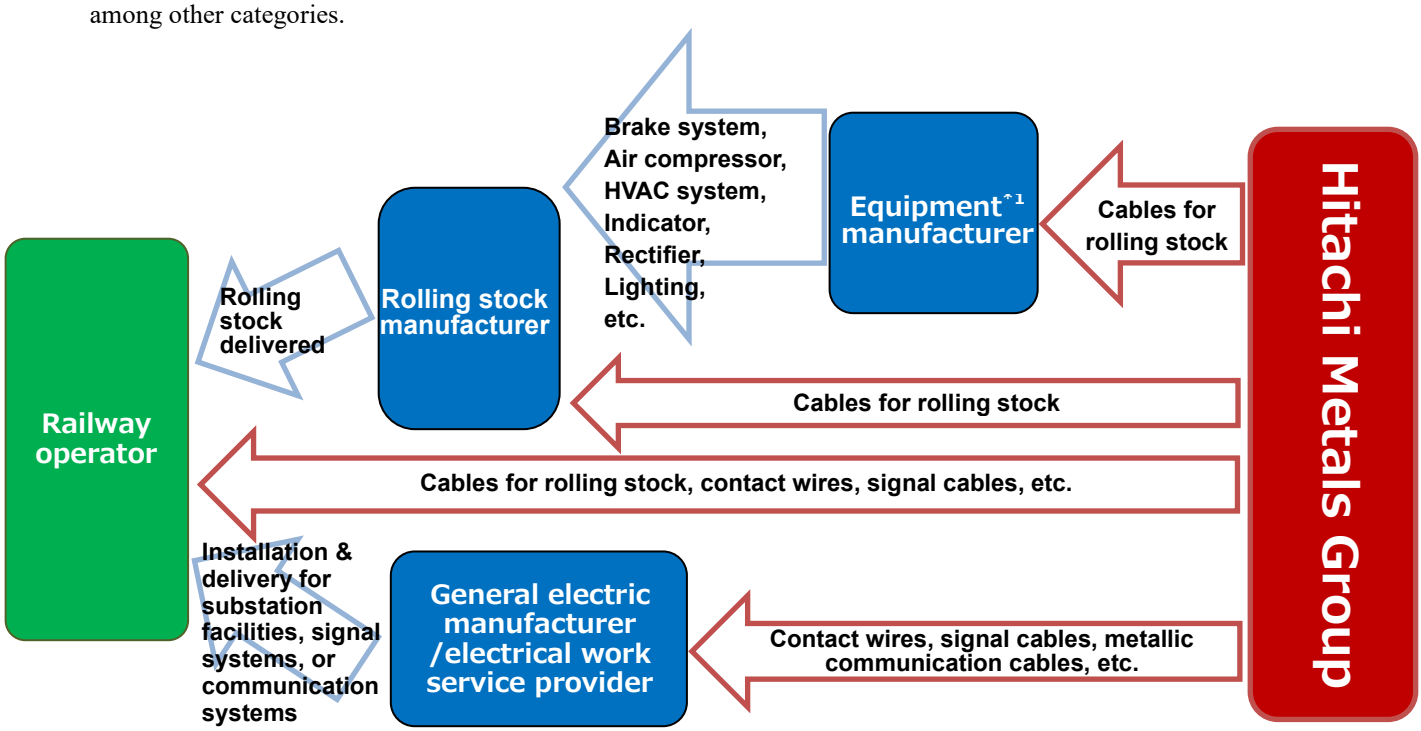
*Additive manufacturing powders (known as metal powders for 3D printing):
One anticipated use of this technology is to reproduce old repair parts, such as for steam locomotives (SL), when the related molds and dies are no longer available.
**MPO: Shortened form of “Multi-fiber Push On.” MPOs are fiber connectors comprised of multiple optical fibers.

In the special feature of this issue, this letter presents how Hitachi Metals’ advanced materials technologies contribute to the rail industry, with a focus on product features and developers’ points of view.

How come the railway industry needs the high-performance components? How has the related market developed?

★The rail industry is supported by numerous subindustries

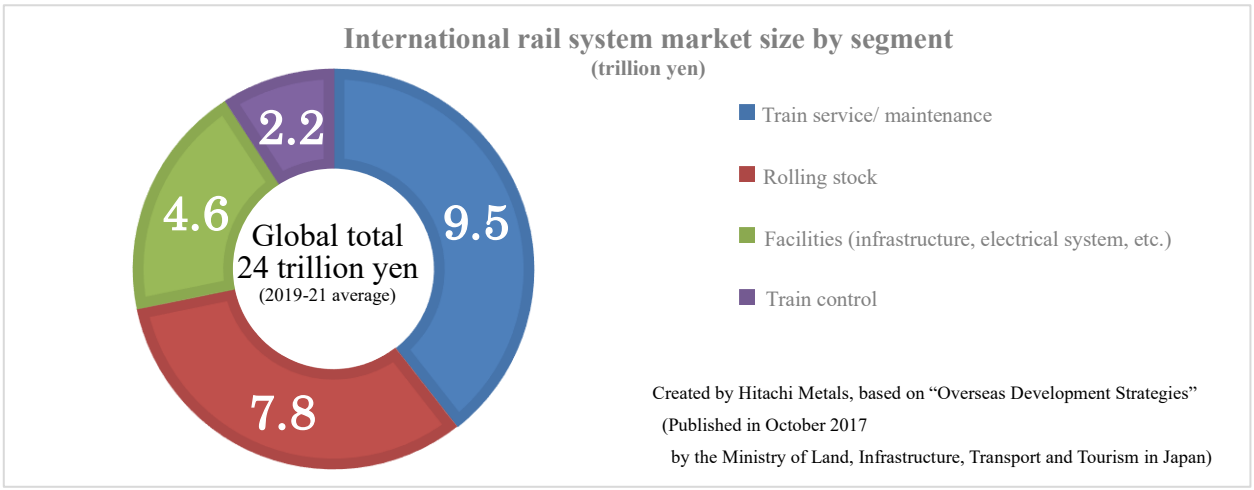
In general, the rail industry is supported by a myriad of subindustries including manufacturers of rolling stock components. As one of such manufacturers, Hitachi Metals has an extensive product lineup containing various categories, as described above. Hitachi Metals is a long-established supplier of components related to rolling stock, train service, and maintenance. In particular, Hitachi Metals offers more than ten lines of electric wires and cables, among other categories.



The rail industry is surviving the effects of the COVID-19 pandemic and is expected to grow while facing global challenges related to carbon neutrality and transportation efficiency. Given this, demand for high-performance components will continue to increase steadily in the future.
As a rolling stock components supplier, Hitachi Metals has built a solid track record and firm customer trust over many years in delivering advanced high-performance products to markets inside and outside of Japan, while enhancing and demonstrating its technical capabilities.

Expand market to meet international customer needs

Drawing on the proven track record and customer trust as well as Hitachi Metals' technical capabilities that have achieved such success, Hitachi Metals will expand the market to meet international customer needs.

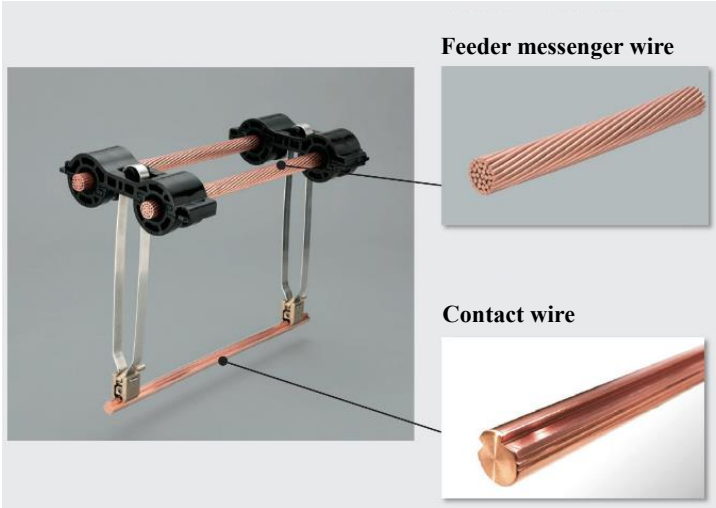


With respect to market size, train service and maintenance is larger than other segments.
This landscape places Hitachi Metals in an advantageous position to expand its market,
by capitalizing on its lineup covering a comprehensive range of products for train service in addition to rolling stock.

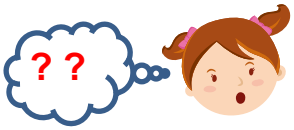
Hitachi Metals will demonstrate the advanced component and technical capabilities
to solidify the position to meet global rail system market needs!

The rail industry has recently been seeking ever-higher performance components in order to address an increasing number of governments setting flame retardancy standards as a fire safety measure for rolling stock, as well as to respond to growing trends toward automation, electrification, and digitization. Demand for increased performance and convenience is also rising for components related to train service and maintenance, specifically for upgrading and automating overhead line monitoring systems to improve safety management performance.

This feature story focuses on contact wires, one of the signature products of Hitachi Metals, among a diverse range of components for train service and maintenance, the largest market segment of the rail industry. Contact wires are an essential element of the train power feeding system. As an important social infrastructure item, this product requires a long period of time to develop and obtain government approval. It is one of the most indispensable functions of the rail system. The letter will focus on the significance and development background of this function.
The letter will also introduce other electric wires and cables for rolling stock as well as components for large-capacity transformers used in power inverters.



Structure of train pantograph



What is a contact wire?

The contact wire is an element of overhead line equipment used for electric locomotives and trolleybuses to feed electrical energy to the on-board current collector. Therefore, **this is one of the most important functions of the electric train system.** As a current collection function, contact wires are mainly made from copper (Cu), which has good conductivity. Recently, in order to increase resistance to wear due to pantograph*[2]-related vibration fatigue and severe outdoor exposure conditions, manufacturers have begun to add tin (Sn) and other ingredients to be able to extend the product service life.

How long is the product life cycle of contact wires?

The contact wire is in direct contact with the pantograph slider when feeding electricity. This causes the contact wire to suffer mechanical and electrical wear. Mechanical wear is caused by abrasion between the contact wire and the pantograph slider. Electrical wear is induced by electric arcs*3 often resulting from inappropriate contact or separation between the two items.
Since electrical wear causes larger dissolution loss than mechanical wear, the life of areas affected by electrical wear tends to become shorter. To address this issue, it is necessary to appropriately control the wear of contact wires. As a way to understand the strength of a worn contact wire, the remaining cross-section area is calculated by multiplying standard tension by the safety rate adjusted to factor in possible disconnection-related load and various other variation coefficients including for tension. (Load requirement for contact wire = overhead line tension * safety rate (2.2) [e.g.: An overhead line tension of 2.0 tons * 2.2 = A load requirement of 4.4 tons for contact wire]) Railway companies use the obtained remaining cross-section area to calculate the “remaining diameter” and use the value for wear management.

Extending service life of contact wires (development of wear-resistant material)

One of the challenges faced by many manufacturers of contact wires is to develop materials to increase the wear resistance of the product, aiming to provide maintenance-free solutions to users—railway companies. This means taking on the huge challenge of extending the service life of contact wires. Increased wear resistance enables a longer replacement cycle. This helps railway companies reduce overhead line management and maintenance cost and increase user convenience, representing a step closer to the ideal maintenance-free solution.
By adding a small quantity of tin, indium (In), or other ingredients to copper, the primary ingredient, materials for contact wires have been developed to have higher strength and wear resistance while maintaining high conductivity. These high-performance contact wires are adopted principally for the overhead lines of the Shinkansen system.

Contact wire manufacturer providing solutions (for wear management) to customers!

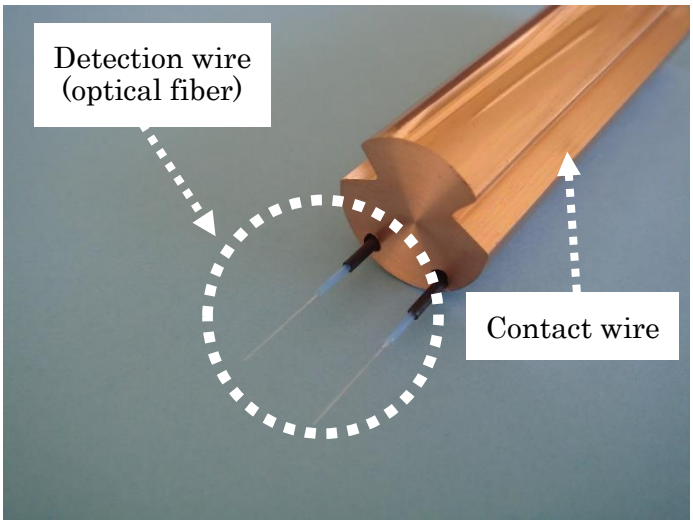
Management and maintenance of contact wires, including wear management, is a responsibility of the user railway company. Many railway companies conduct adequate wear management, chiefly through vehicle inspection and micrometric measurement of the remaining diameter of contact wires in operation. The problem is, however, these duties are very costly.
Hitachi Metals has provided several solutions to this problem. One example was the contact wire with insulated electric wires built in for wear detection, which was launched in 1989 by Hitachi Cables, Ltd. (presently Hitachi Metals, Ltd.). This product was designed to offer a solution enabled by materials technology for decreasing manhours for maintenance and facilitating operation process automation. The contact wire with built-in detection wires was installed along the full length of the Tokaido Shinkansen line after obtaining government approval about ten years after application. As a result, the number of disconnection troubles caused by worn contact wires has been reduced to zero on the line. Since then, the product has continued to fulfill its important duties in maintaining the rail system to this day.

In order to duly serve their purpose of ensuring functional infrastructure, contact wires are required to meet very strict quality standards.
In addition to the above, there is one more essential requirement contact wire manufactures are expected to meet, which is the ability to meet requests for quick delivery. Recognizing that the product is a critical component of social infrastructure facilities, manufacturers should be able to deliver urgent orders, in preparation for the unexpected and increasingly frequent occurrence of disasters.
Hitachi Metals has responded to many such urgent orders received for recovery from disaster damage and delivered orders as quickly as possible. Promoting these efforts, Hitachi Metals’ contact wire business has established itself as a leader in the Japanese market.

Generally, it takes five to ten years before contact wires are installed and enter service after development. This is because the product is a critical component of social infrastructure facilities, and as such, it must pass a lengthy and stringent review process before being granted approval. As a manufacturer of products that are indispensable to society, Hitachi Metals makes persistent efforts to come up with new proposals and developments from a long-term point of view.

>Fiber-optic contact wire wear detection system developed to facilitate automation of rail security management

In the electric railway system, including for Shinkansen lines, the train vehicle receives electric current fed from the overhead line (contact wires) through the pantograph mounted on the roof while on the track. The contact wire is in direct contact with the pantograph. Due to this structure, the contact wire is inevitably susceptible to abrasion wear, which may cause broken wires resulting in a stoppage of train service in the worst-case scenario. As a measure to solve this problem, a contact wire wear detection system was developed. The previous model was equipped with metallic wires built in to monitor abrasion wear by sensing the current flow, and this configuration limited the detection functionality to non-service nighttime hours when it was not disturbed by noise from the running train.



To address this issue, Hitachi Metals launched a joint project with Central Japan Railway Company (JR Central) to develop a new model adopting optical fibers for the detection wire. This was designed to enable around-the-clock real-time monitoring of the wear status of contact wires. The new fiber-optic contact wire wear detection system was successfully commercialized in 2021. Using this contact wire, broken wires can be prevented, and even in case of a break, the affected location can be promptly identified.

I see. The around-the-clock security monitoring system is enabled by adopting optical fibers. What is the mechanism of this system?

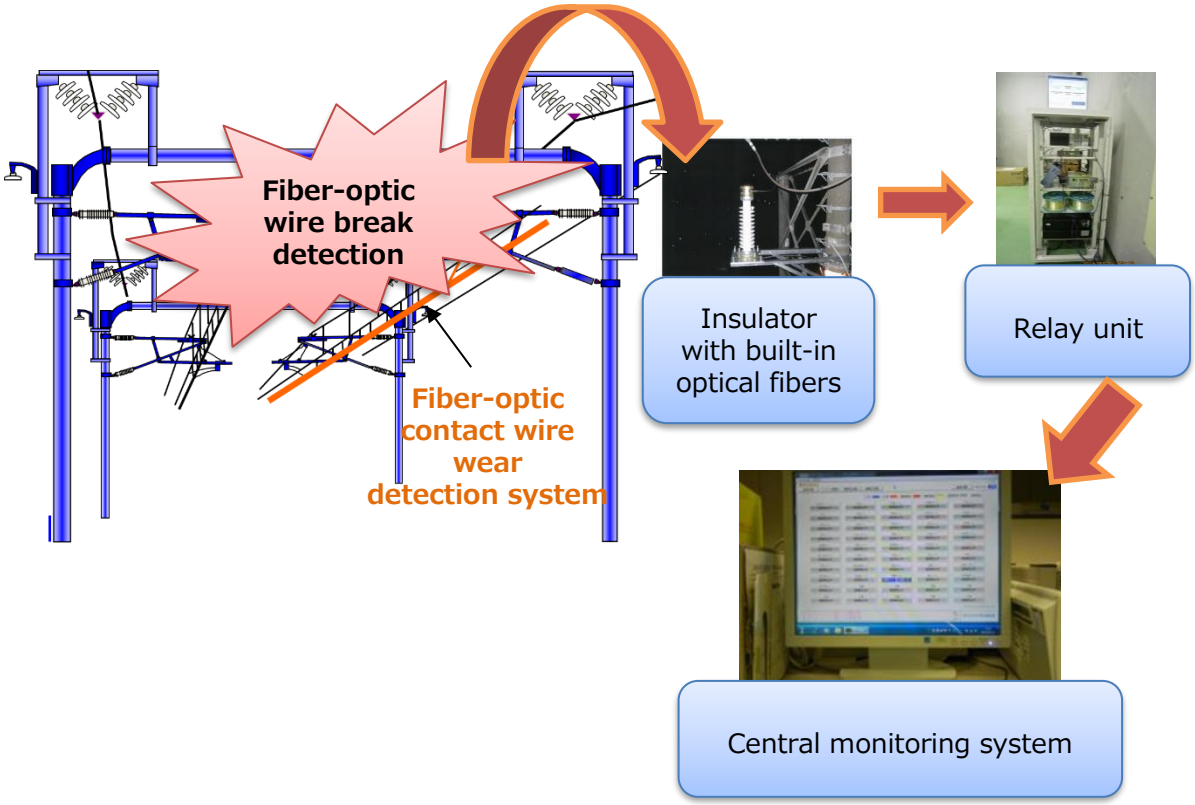
What is the major role to be played by optical fibers in operating the new system?

The new system has been developed to upgrade the existing contact wire wear detection system by introducing optical fibers to replace metal electrical wires.
As described earlier, in the existing system, wear monitoring is performed by sensing electrical signals, which is effective during nighttime hours when the power for the overhead line is shut off. If any problem takes place during daytime hours when the Shinkansen and other trains are on the track, this system cannot send appropriate signals. In contrast, with the new fiber-optic contact wire wear detection system, the built-in optical fiber detector enables around-the-clock monitoring. This is particularly useful in the event of earthquake, storm, or other natural disaster, which may cause serious damage to contact wires, inducing severe wear resulting in an unexpected disconnection. Therefore, contact wires with a built-in optical fiber detector can significantly contribute to efficient management and maintenance of the wires.

How does the fiber-optic contact wire wear detection system work effectively even during daytime hours?

The built-in optical fibers are designed to work as a sensor, as opposed to the technology's more popular use for communications. The fiber-optic wire (sensor) is inserted into the wear limit position of the contact wire to allow the inserted wire to break when the wear progresses to pass the threshold. The information of the broken wire is transmitted to the central monitoring system via relay units. The new system uses light traveling in an optical fiber to monitor the wear and detect breaking of the contact wire. This enables you to perform contact wire monitoring while avoiding it being disturbed by electrical current flowing in the wire even during daytime train service hours.

Wear detection system for Shinkansen train track lines
(Implementation example of fiber-optic contact wire wear detection system)



■ Comments of development engineer

(Hiroyoshi Hiruta, Ibaraki Works, Advanced Components & Materials Division)

>>Will you share a behind-the-scenes story about the long-term development project?

The project of developing the fiber-optic contact wire wear detection system was started in the year 2000 when implementation of the existing system was completed for the entire length of a Shinkansen line. The story began when I received inquiries from JR Central, the related Shinkansen train operator, about expectations for development of a constant monitoring system for overhead lines. And, the responsible person from the customer suggested the possibility of using optical fibers to develop a new system.
The person's ideas were intriguing in a couple ways: a technical challenge associated with adopting optical fibers for wear detection wires, for which there was no precedent; and the significance of developing an around-the-clock monitoring function for the purpose of increasing customer convenience as well as helping prevent social disruption by reducing the risk of stoppage of train service. I was confident that Hitachi Metals would be able to take on this challenging and interesting project. I also thought of inventing unique, unrivaled products in order to win an exclusive supply contract with JR Central for the Shinkansen line.
So, I immediately agreed to the client's request and launched a joint project.
About 20 years ago when the project was started, I received a lot of negative opinions about the project, typically including ones criticizing it as being "ideal but not practical," not only from within the company but also from the client. I had few supporters. Even today when the supply agreement has been concluded, some people express their surprise about the success of the project. This reflects the extreme difficulties I have faced during the past 20 years while working on the project.

>>What were the highlights of the development?

The most difficult technical challenge was related to the handling of optical fibers. An optical fiber is made mainly from glass, a fragile material. My team had to develop an effective technique to handle this sensitive material in performing a sequence of procedures from inserting it into the metal contact wire made mainly from copper, to reeling the wire on a wooden drum, and reeling it out to install it on the overhead line for Shinkansen train track lines. An optical fiber is very thin, and as such a fiber-optic wire easily breaks due to even slight stress. Hitachi Metals was not primarily responsible for installing the overhead lines for Shinkansen train track lines, which was undertaken by electrical constructors for the rail system. However, as a manufacturer of contact wires, my team played a leading role in fulfilling the overhead line installation task by establishing proprietary methods. The team of Hitachi Metals persisted in developing effective processes to handle the contact wire with built-in fiber optic wires in order to carry out installation work appropriately while reducing stress imposed on the fiber-optic wires, trying and testing many approaches with "a focus on materials." I attended nighttime installation work numerous times. Contact wires are an important component of social infrastructure facilities. As such, suppliers receiving a high-volume order for the item are required to meet strict conditions and standards, which entails a long period of trial installation. Specifically, my team had about ten years of trial installation to confirm the satisfactory operation of the fiber-optic wires over time. Therefore, it has taken about 20 years from development to introduction. As described above, the contact wire business involves a lengthy and often painstaking process before approval is obtained. I believe that it is important for the project team to be patient, have a long-term view and look at a hopeful future. The team of Hitachi Metals is engaged in day-to-day development activities in order to offer better proposals and solutions to support social infrastructure.

For the past 20 years, I have been working continuously together with constructors on site, being committed to the *sangen shugi* (3-principles theory to achieve a manufacturing success: visit the actual site; touch the actual article; and observe the actual situation). I believe such collective persistent efforts have brought all concerned where we are today, when the installation plan is ready to be implemented.

>>Hitachi Metals' products are appreciated by many customers. What do you think makes them particularly appealing?

While working on the fiber-optic contact wire wear detection system, Hitachi Metals promoted other development projects for systems supporting overhead lines at the same time, especially looking to make proposals for other suitable contact wire wear management methods aimed at automating rail maintenance operations. Hitachi Metals' offerings of system-related products range broadly from fittings for contact wire ends, insulators[*4] with built-in optical fibers, connection boxes for fiber-optic cable circuits, to relay units for local monitoring, the central monitoring system to consolidate data collected from relay units, and a lot of other support equipment. These are all manufactured in Hitachi Metals. Hitachi Metals' products are designed to offer good versatility. I think this is the advantage appreciated by many customers, who find the products easy to introduce in their operations.

Following the fiber-optic contact wire wear detection system, Hitachi Metals is ramping up development and proposal activities to offer new products directed at more advanced automation solutions, such as contact wires supporting high-speed operations. Also, Hitachi Metals is endeavoring to address various needs of railway companies, the end user. I may not be able to offer perfect solutions to their issues. I believe, however, it is important to continue to present possible solutions to them, pay careful attention to their needs and explore different approaches. In addition to technical issues, the team of Hitachi Metals should also proactively attend to their requests related to delivery and services. Such efforts will deepen the relationship of trust between the company and the end user.

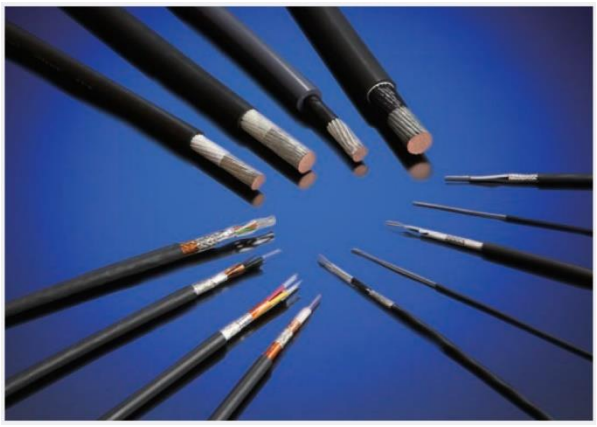
>>What is the plan for implementing the system?

This system will be installed along the entire length of the Tokaido Shinkansen line, scheduled for completion by fiscal 2030. The product of our long-term research and development endeavor will enter the real world to fulfill its role. Going forward, Hitachi Metals is planning to expand the range of contact wire products by developing and launching products for lines other than high-speed rail lines, looking to further contribute to increasing the safety and promoting the operational process automation of nationwide rail systems.

Twenty years constitutes a significant length of time, comparable to the duration of time required for a human being to grow from birth to adulthood. The recent technology has been made possible only after arduous endeavors made over such a long time while overcoming numerous hardships before it was ready to be implemented—like many other social infrastructure development projects. The development of society and improvement of people's lives is supported by collective behind-the-scenes day-to-day efforts of on-site and off-site engineers and others, who are development professionals with high aspirations and strong commitment.

Hitachi Metals will continue leveraging its technologies in order to accelerate its contribution to achieving a smarter society. In addition to contact wires, the topic of the feature story, this article gives an introduction of other railway-related products (see pages 1 and 2). The following are reports on two exemplary products designed to be conducive to more sophisticated rail systems.

>POLYENEX® rolling stock cables compliant with European fire safety standards and responsive to many different needs!



POLYENEX® EN standard rolling stock cables

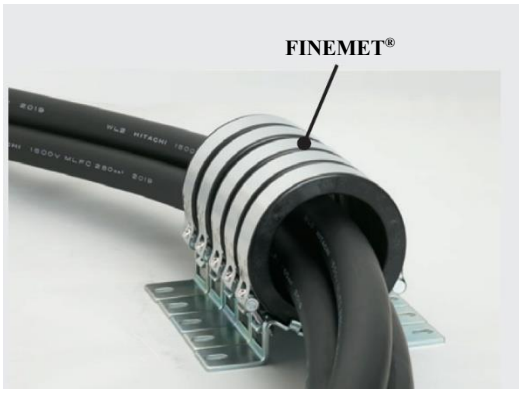
As the development of railway networks continues to advance while pursuing automation technology, demand for ever-more sophisticated railway vehicles and components is growing globally. Hitachi Metals' POLYENEX® and other series of rolling stock wires and cables have obtained major international fire safety certifications, including EN, BS, and DIN standards.*5 These products have good flame retardancy, being less likely to cause fire spread and emit smoke and toxic gases, while exhibiting resistance to oils and fuels and other environmental factors. These properties have been achieved by leveraging Hitachi Metals' proprietary resin materials technologies.

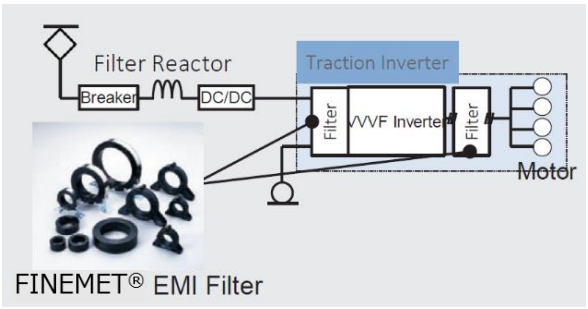
POLYENEX® communication series containing Ethernet®*6 cables and data bus cables are also compliant with major fire safety standards.

POLYENEX® rolling stock cables can help prevent fire spreading and reduce emissions of smoke and toxic gasses. By enhancing Hitachi Metals' lineup of rolling stock wires and cables and utilizing a wealth of experience, Hitachi Metals will continue to contribute to the development of the rail industry around the world, with a focus on automation solutions in response to market needs.

>Soft magnetic material FINEMET® contributes to advanced rail systems by helping achieve lighter-weight and more efficient transformers!

In recent years, power supply circuits for EVs, rail systems and renewable energy-powered systems have been becoming smaller and lighter, which gives rise to demand for higher-efficiency silicon insulated-gate bipolar transistors (Si IGBTs)*7, while driving the development of a new breed of semiconductors, such as silicon carbide (SiC) and Gallium nitride (GaN). In response to this trend, related components need to be able to operate at an ever-higher frequency. One major challenge for meeting this requirement is associated with increased core loss*8 in magnetic steel sheet used in transformers and reactors operating at high frequency bands, which causes undesirable temperature elevation. Measures available to solve this problem require compromised size reduction plans. Other issues identified include smaller and lighter devices operating at high frequency bands generating noises that go beyond the noise control capacity of the existing products.





Application for inverter

Against this background, FINEMET® is drawing increasing attention for its possession of both high permeability*9 and magnetic flux density*10, a feature ideal for applications in transformers, reactors, common mode chokes, among others. Demand for these applications is rapidly growing particularly in railway and EV-related sectors. FINEMET® is expected to contribute to advancing the automation of rail-related systems, specifically by enhancing noise reduction of inverters and downsizing EMI filters.

This material is also suited to application for intermediate frequency transformers. Particularly, its low loss performance and high saturation flux density help reduce loss in transformers as well as increasing the efficiency and reducing the size of the auxiliary power supply.

FINEMET® non-cut core and cut core
for intermediate frequency transformers

Hitachi Metals boasts an extensive lineup of products related to rail systems, offering component items as described in the feature stories as well as material items as presented on the first two pages. Hitachi Metals will continue to upgrade the lineup to contribute to higher functionality of rail system infrastructure.
Hitachi Metals is taking on various new challenges that will require the company to do something more than an extension of the existing businesses. To this end, Hitachi Metals strives to upgrade the product capabilities, in order to present suitable approaches to address many different needs of society at large as well as a range of customers leading up to end users and innovate product development and creation processes to create new product value that can open the way to the future. To duly fulfill the role as a materials specialist, Hitachi Metals will strive to enhance and upgrade the quality of the products and technologies, with the aim of better responding to customer needs and thus contributing to the development of society.

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References:

1. Equipment: In the manufacturing of transportation equipment, including rolling stock, refers to the process of installing motors and other internal and external systems as well as furnishings appropriately in the vehicle structure, and also the items used for this purpose and fixed or attached as a structural part.
2. Pantograph: A type of current collector used in rolling stock. Typically characterized by a diamond-shaped frame structure. The term has Greek roots representing "all, every" and "to write," and is associated with the resemblance to the mechanical pantograph used for copying handwriting and drawings. Its mechanism is characterized by the accordion-like compression and extension movement forming a rhomboidal pattern.
   The term is broadly used to refer to systems with a pantograph mechanism.
   At present, the single-arm design is commonly adopted as a weight-saving measure.
3. Electric arc: An electrical breakdown of a gas that produces a prolonged electrical discharge between electrodes, emitting flashes of light (sparks) at high temperatures.
   A well-known example of this phenomenon is observed when a live cable is unplugged.
4. Insulator: For the purpose of overhead electrical lines, installed to insulate the lines from support towers.
5. EN stands for European Norm; BS for British Standards;
   and DIN for "Deutsches Institut für Normung;" i.e, German Institute for Standardization.
6. Ethernet: a trademark registered by Fuji Xerox Co., Ltd. (presently FUJIFILM Business Innovation Corp.)
   A computer networking standard. Widely used in homes and businesses, it is the world's most commonly used technology for local area networks (LAN).
   Designed to enable efficient usage of Internet communication lines by numerous LAN-connected computers.
7. IGBT: Insulated-gate bipolar transistor. A type of semiconductor device for reducing power consumption. A major conversion element for large-capacity power inverters.
8. Core loss: Eddy-current loss and hysteresis loss due to coil-induced alternating magnetic fields according to the core's physical properties; an issue identified in devices such as inductors and transformers with soft magnetic cores.
   Known as a factor causing a lower efficiency in electric motors, kinetic generators, and transformers.
9. Permeability: Measure of magnetization obtained by a soft magnetic material in response to an applied external magnetic field.
10. Magnetic flux density: Measure of magnetic fluxes flowing in the core. May be specified as "operating magnetic flux density" to indicate the level at the time of operation.

About Hitachi Metals NEWSLETTER

Hitachi Metals NEWSLETTER is published to introduce signature products and technologies of the Hitachi Metals Group. Stories are aimed at enabling many readers to gain in-depth understanding.

We hope that this communication tool will help many people gain a better understanding of the Group.